# Stakeholder-Assisted Modeling and Policy Design for Engineering Systems

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TO MY ETERNAL BELOVED, MY SOULMATE,
MY REASON FOR EXISTENCE
ROSHANAK

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**Stakeholder-Assisted Modeling and Policy Design Process for Engineering Systems**

by
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**Submitted To The Engineering Systems Division In Partial Fulfillment Of The Requirements For The Degree Of Doctor Of Philosophy In Technology, Management And Policy**
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## Abstract

There is a growing realization that stakeholder involvement in decision-making for large-scale engineering systems is necessary and crucial, both from an ethical perspective, as well as for improving the chances of success for an engineering systems project. Traditionally however, stakeholders have only been involved after decision-makers and experts have completed the initial decision-making process with little or no input from stakeholders. This has resulted in conflict and delays for engineering systems with brilliant technical designs that do not address the larger context of the broader social goals. One of the fears of experts is that the involvement of stakeholders will result in technical solutions that are of poor quality.

The hypothesis of this research is that an *effective* involvement of stakeholders in the decision-making process for engineering systems from the problem definition stage through the system representation can produce a system representation that is *superior* to representations produced in an expert-centered process. This dissertation proposes a Stakeholder-Assisted Modeling and Policy Design (SAM-PD) process for effectively involving stakeholders in engineering systems with wide-ranging social and environmental impact. The SAM-PD process is designed based on insights from existing engineering systems methodologies and alternative dispute resolution literature.

Starting with a comprehensive analysis of engineering systems methodologies, the role of experts in engineering systems decision-making and existing stakeholder involvement mechanisms, this research explores the role of cognitive biases of engineering systems representation through actual experiments, and concludes that the process of defining a system through its boundaries, components and linkages is quite subjective, and prone to implicit value judgments of those participating in the system representation process. Therefore to account for stakeholder interests, concerns and knowledge in engineering systems decision-making, it is important to have a collaborative process that enables stakeholders to jointly shape the problem definition and model outputs necessary for decision-making.

Based on insights from the literature, this research developed a collaborative process for engineering systems decision-making, and explored its merits and drawbacks in applying it to the Cape Wind offshore wind energy project involving actual stakeholders in the system representation process. It further explored the potential application of such a process to the Mexico City transportation/air pollution system and the Cape and Islands Renewable Energy Planning project.

The Cape Wind case study showed that a stakeholder-assisted system representation was superior to the equivalent expert-centered system representation used by the permitting agency as a basis for decision-making, in that it served as a thought expander for stakeholders, captured some effects that the expert-centered representation could not capture, better took into account social, economic and political feasibility and was more useful in suggesting better alternative strategies for the system.

The case studies also highlighted the importance of the convening organization, institutional readiness for collaborative processes, the importance of stakeholder selection and process facilitation, the potentials of system representation as a basis for stakeholder dialogue and the importance of quantification versus evaluation of system representations.

The basic implication of this research is that it would be myopic of engineering systems professionals to shift the burden of stakeholder involvement to decision-makers, and keep the analysis a merely expert-centered process. Due to the many subjective choices that have to be made with regards to system boundaries, choice of components, inclusion of linkages, nature of outputs and performance metrics and assumptions about data and relationships, system analysts are in fact not producing the analysis that will help the decision-making process. The best airport designs done with multi-tradeoff analysis and intricate options analysis may lead to nowhere if stakeholders affected by the project do not see their interests reflected in the analysis. The notion is that a good systems analysis is not one that impresses other engineering systems professionals with its complexity, but one that can actually address the problems at hand.

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## Introduction

*Citizen participation [is] a device whereby public officials induce nonpublic individuals to act in a way the officials desire.*

*-- Senator Daniel P. Moynihan*[1]

*Grown-ups like numbers. When you tell them about a new friend, they never ask questions about what really matters. They never ask: "What does his voice sound like?" "What games does he like best?" "Does he collect butterflies?". They ask: "How old is he?" "How many brothers does he have?" "How much does he weigh?" "How much money does his father make?" Only then do they think they know him.*

*- The Little Prince (Antoine de Saint-Exupéry)*

### At the Outset

The central idea of this dissertation is that current stakeholder involvement approaches for large-scale engineering systems are inadequate, and that *effective* stakeholder involvement in the representation, design and management of complex engineering systems[2] an essential part of decision-making. The emphasis on *"effective"* refers to the fact that not all stakeholder involvement results in improved decision-making.

An interesting example of the shortcomings of current public participation practices for engineering systems is the Cape Wind Offshore Wind Energy Project in Nantucket Sound, Massachusetts. It is a current, and yet strikingly classic case where "public participation" in the form of public hearings becomes a battlefield between different positions on a

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[1] Senator Moynihan (1927-2003) was a Democratic senator from New York, and the author of over 14 books on public policymaking. He has also been credited with the famous "everyone is entitled to their own opinions, but not their own facts" statement. The cited quote was featured in "The New York Public Library Book of 20th Century American Quotations," by Stephen Donadio, 1992."

[2] Here we define engineering systems as complex large-scale technical systems embedded within a sometimes even more complex social setting, with uncertain and often emergent long-term social, economic, environmental impacts.

sociotechnical system. The result is conflict, politicization of the decision-making process, distrust in the ability of the decision-maker to account for public interest and the undermining of the scientific and technical analysis process. The following is a short narrative on the highlights of an actual public hearing for the Cape Wind project held in Cambridge, Massachusetts in late 2004.

**The Public Hearing Spectacle**

Cambridge, MA December 16, 2004 Third Draft Environmental Impact Statement Hearing held by the U.S. Army Corps of Engineers/New England District on the Cape Wind Offshore Wind Energy project, a proposal to build 130 wind turbines offshore in Nantucket Sound.

*With the hearing scheduled for 7:00 p.m., more than 700 individuals lined up since 5:00 p.m. to register for the two-minute slot alotted for individual comments. Small and large signs supporting or denouncing the Cape Wind project float around the corridors. A group of proponent activists dressed in Yachters clothes (portraying the opponents of the project), and calling themselves "Yachters Against Windmills Now (Y.A.W.N.)", roam the corridors chanting:" Cape Wind makes our blue blood boil...Lets get our energy from Middle East oil!..Walter Cronkite, Stick to the News...We'll spend millions to protect our views!" Carrying signs that said" "Global Warming: A Longer Yachting Season.", the activists were met with hostile remarks by the opponents of the project, carrying S.O.S (Save our Sound), and "No Steel Forrest in Nantucket Sound" signs.*

*Both opponents and proponents have set up information booths in which they distribute "facts on the project" to the public. Less than 1 in 10 participants choose not to wear any signs for or against the project. With the hearing beginning, one by one members of the public start to speak on their support or opposition of the project, with many giving emotional testimonies. The comments are met with the applause from the part of audience. With the time for every comment elapsing, loud shouts of "Time! Time!" erupts from the part of audience opposed to the speaker's position.*

*Substantial comments on the DEIS from independent experts are also limited to the two-minute slots, although they can later submit their comments via email. One of the participants, a proponent of the Cape Wind project, decides to sing a song to the tune of the 1960s "Blowin in the Wind" within the two minute slot. "How many tonnes of CO2 does it take...before we go back to the wind...how many soldiers have to die in Iraq...efore you issue a permit...the answer my friend is blown in the wind..the answer is blown in the wind."*

*Another proponent, who flew all the way from Washington DC, comments "You cannot NIMBY anywhere, any time, and expect to have electricity everywhere, all the time. I ask the opponents to accept their fair share of the burden of energy projects. Minority communities have accepted more than their fair share of pollution."*

*A resident of Hyannis, whose cousin died fighting in Iraq, blasted wind farm supporters for using the war in Iraq as an example of why a power source like the Nantucket Sound wind farm is needed. "Stop selling out our soldiers for a wind factory. My cousin didn't die to make Jim Gordon [the Cape Wind CEO] rich," she said and went back to her seat crying, while a proponent of the project chuckled "quite a Broadway performance, you have talent lady."*

## 1.1 Motivation and Context: Engineering Systems and Public Policymaking

Those of us living in democratic societies are often reminded that our voices will be heard in one form or another when it comes to decision-making that affects our lives. Of course this voice is often not direct, and not everyone's voice is in reality represented. George Orwell's "all animals are equal but some animals are more equal than others"[3] may have been intended for a different system, but it can be used to describe the more prominent role of interest groups in shaping public policy. Hence the idea of public participation goes beyond the election of public officials, and refers to the more direct role of the public in general and stakeholders, in particular, in influencing decisions that affect them. The term "stakeholders" in this context is defined as the subset of the public at large that includes all those who have an active stake or professional interest in the system. This includes policymakers, private sector actors, non-profit organizations, citizen groups, financial institutions, scientific advisory groups, independent experts and government advisory organizations that are crucial to the success of any negotiated policies[4].

The realization that stakeholder involvement is necessary is not recent, but the awareness of its importance has made its way into the mainstream just over the past four decades. Still, four decades seems to be ample time for stakeholder involvement to be well integrated into public decision-making practices. Particularly with regards to science- and technology-intensive decision-making processes, such as decisions made for engineering systems, the track record of success in such integration has been mixed. Despite the existence of a number of different official and regulatory channels in most advanced industrial countries, public participation in science- and technology-intensive decision-making processes has been ad hoc and often ineffective, leaving both the public and experts wary and suspicious of such processes. Stakeholder involvement has often been perceived by stakeholders as an effort by decision-makers to give the illusion that public

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[3] Orwell, George, "Animal Farm", Harcourt Publishers (November 20, 1990) ISBN: 0151072558

[4] The line that separates stakeholders from the rest of the public is arbitrary and subjective. Essentially since not all the 6 billion human beings living on the planet can be involved in every decision, we reduce the target audience by limiting it to those who will be more directly affected or more directly interested in the decision, even if they do not express an open interest. Practically however, stakeholder involvement is limited to those stakeholders who are at least somehow interested to be involved, and those who have resources that allow them to part-take in a decision-making process in any way.

concerns are taken into consideration, while in fact they have not. Decision-makers have made many efforts to dispel such perceptions by making increased efforts at reaching out to the public, again with mixed results. Success has been more tangible at local decision-making levels, and relatively rare on large-scale regional or national projects.

From a rational perspective, all stakeholders should support stakeholder involvement. Decision-makers are interested in making decisions that address existing problems, while keeping their constituents happy. Scientists and experts would like their expertise to be used more effectively in decision-making processes, and not be overshadowed by politicization of such decisions. And citizens wish to have a share in decisions that affect their lives. There is ample evidence that when done right, stakeholder participation has resulted in decisions that are seen by decision-makers, experts and the concerned public as "good" decisions. We will look at these cases in later chapters. Surprisingly, the mere mention of stakeholder processes for a particular decision creates dismay among many decision-makers, experts and often even the public itself.

Why is there so much resistance and hesitation when it comes to stakeholder involvement, if its intrinsic merits are broadly accepted? One possible answer is that many of the current approach to stakeholder involvement is inadequate and either fails at producing agreements, or fail at creating technically sound solutions. In making decisions for complex engineering systems, the challenge seems to be to design a process that can bring together different stakeholders with conflicting positions and ideologies, varying technical backgrounds and voice to the table in an effective manner, so that the decision can be scientifically and technically sound, socially "wise" and publicly acceptable.

Traditionally, decision-makers have only involved experts directly in the decision-making process for complex engineering systems, and even that on a limited basis. Environmental impact assessments and management and operation strategies for engineering systems such as transportation and energy systems are good examples of cases where decision-makers regularly use expert opinion as the main basis for their decisions. What decision-makers often expect from scientific and technical experts is a clear analysis of the behavior of the system, and the impact of different alternatives. These expectations however are often unrealistic. From a technical and scientific perspective, there is often large uncertainty in the relationship between the different components of the system, and more so when predicting how a system would behave in the long-term. Furthermore, the selective inclusion of some experts and the exclusion of others by decision-makers, can also exacerbate the problem, by creating an atmosphere of adversarial science, where one expert is pitted against another like Gladiators in an arena. However, in the arena of scientist-scientist battles there are rarely victors.

The expert analysis of engineering systems is further complicated by *evaluative complexity* (Sussman, 2003). This type of complexity refers to the fact that such systems are nearly always embedded in a complex institutional and social system, the behavior of which is also not intuitive, and even harder to analyze. Engineering Systems are characterized by the interactions of technology and institutions within a set of social and ecological systems. While technical experts are adept at analyzing the technological components, most are not experts in social and institutional issues. By emphasizing technical feasibility and optimality in the first stages of policy design process, the social and institutional feasibility of recommendations are often neglected, resulting in potentially inadequate policies for the system as a whole. Such a process fails to take into consideration stakeholders' concerns and interests as well as their local and experiential expertise. As a consequence, recommendations resulting from such a process often encounter resistance among stakeholders who have little or no understanding of the underlying logic of the recommendations. According to Venix (1990), "Even in the modern age of science and industrialization social policy decisions are based on incompletely-communicated mental models. The assumptions and reasoning behind a decision are not really examinable, even to the decider. The logic, if there is any, leading to a social policy is unclear to most people affected by the policy."

*The preceding discussion would suggest that a better process design, that is actively designed to address the above challenges, might offer improvements to current stakeholder processes. In fact, it is the purpose of this dissertation to propose a decision-making* *process in which stakeholder participation is not an add-on, but an integrated part of the decision-making process, from problem definition to system representation, design and decision-making.*

## 1.2 Significance of Dissertation Topic

This dissertation proposes the engagement of stakeholders in the modeling and policy design for engineering systems. Examples of engineering systems include urban and regional transportation systems, energy systems, nuclear waste disposal and storage systems and similar systems, which are characterized by high scientific and technical complexity as well as large uncertainty, and where many diverse stakeholders are affected by decisions made for the system.

There are many important reasons why an integrated stakeholder participation process is central to decision-making for engineering systems. Stakeholder participation can result in benefits such as incorporation of public values into decisions, increasing the substantive quality of decisions, resolving conflict among competing interests, building trust in institutions and policymakers and educating and informing the public (Beierle, 1999)

In the following paragraphs, we will look at the importance of stakeholder participation from a variety of perspectives.

*A) Ethics*: Many people agree that stakeholder participation in the public decision-making process is an inherent right of citizens in a democratic society. Decision-making on engineering systems is no exception, given the broad impacts such systems have on society at large. While not everyone affected can be involved, stakeholder participation can strike a balance between direct democracy and representative democracy.

*B) Policy Implementation:* Complex large-scale engineering systems are characterized by high scientific uncertainty as well as high societal stake. When dealing with such systems, many decision-makers have drawn on scientists and experts for advice on policy issues. However, due to lack of direct interaction between experts and stakeholders, the recommendations fail to take stakeholder interests into account. This can result in the loss of effectiveness of the recommendations. But most often leads to an increase in societal conflict on the issue.

C) *Adaptive Management:* One of the characteristics of complex engineering systems is emergence, or behavioral complexity that is difficult to predict at the outset due to high uncertainty in the potential long-term behavior of the system. For that reason a design strategy or decision made at one point in time may be inadequate for the system at later times. To be able to adapt to emergence, it is vital that a broad-based group of stakeholders takes responsibility for managing the system over time. This is only possible if stakeholders have been involved from the outset. Stakeholder involvement allows stakeholders to take responsibility for the long-term management of the system.

D) *Reducing the cost of conflict:* Aside from an ethical imperative for deliberative- and inclusive governance, a stakeholder-assisted policy design process for engineering systems can go a long way in minimizing the costs of conflict for such systems, by providing a formal structure for stakeholders to have their interests and knowledge considered in the design process. There is a large cost of conflict for large-scale engineering projects in particular, and for society as a whole. One interesting case is the proposed Mexico City airport project in 2002. The Mexican government went forward with a proposed $2.8 billion Texcoco Airport Project, paying more than $60 million in engineering consulting costs, without adequate involvement of the affected population (mainly subsistence farmers) in the region. About 1,000 armed farmers, calling themselves the People's Front for the Defense of Our Land, took the construction workers and engineers as hostage for many days threatening to kill them if the government went ahead with the project. The project was withdrawn by the government of President Fox, marking his first major political defeat, and providing no option of renegotiation with the farmers. Current alternative sites would be at least 2.5-4 times more expensive, so plans for the new airport have been suspended.

While they may vary in form, such conflicts are not limited to developing countries. In the United States in 1999, opponents filed lawsuits against 42% of large-scale project permits approved through NEPA (National Environmental Protection Act). These included new roads, watersheds, logging operations, energy facilities, telecommunication developments and industrial sites. Direct litigation costs for such projects can range from \$2-\$7 million[5] per case, and can delay projects for months and sometimes for years[6]. The annual cost of disputes over such projects is in the billions of dollars, and has resulted in bitter community relations, implementation problems and delays that have increased the cost of the projects by several folds. Similar implementation problems exist for managing existing engineering systems. For example, while transportation-related emissions in Mexico City make up 70% of total pollutant emissions, the many air quality strategies that have been designed by the relevant agencies have been largely ineffective due to stakeholder resistance towards implementation. Past experience has shown that the inclusion of stakeholders in the decision-making process can mitigate such conflicts, avoiding immense costs that can't be offset with the best engineering design.

E) System Representation and Cognitive Biases: Research on cognitive or mental maps show that the representation of a system, and the framing of the problem is heavily dependent on the modelers' personal mental maps. The isolated scientific and technical analysis of an engineering system can result in a biased representation of the system, resulting in lower-quality recommendations, which do not fully address the important aspects of a problem. Therefore, having multiple perspectives on the system shape the collective mental map of the system can improve the representation of the system from a scientific point of view. While the main purpose of scientific and technical advice is to supply inputs into the scientific and technical aspects of the overall policy design, good expert advice should also try to provide a minimum scientific or technical literacy to decision-makers so that they can correctly use that advice. One can also point to the

[5] http://www.sacbee.com/static/archive/news/projects/environment/graphics/graphic3a.html (accessed May 2004)

[6] The Super 7 highway project in Connecticut has been under several injunctions for the past 20 years.

responsibility of expert advice to improve cognitive or mental maps[7] of decision-makers and stakeholders as well as applying scientific thinking to the non-scientific parts of the important choices in the policy design (Dror, 2003).

It has been argued that interaction among stakeholders, experts and decision-makers while not changing values and interests, can result in a more holistic view of a given issue for all involved. This will improve the chance that decisions are robust in the longer term, given that their underlying rationale is transparent to most people involved.

### 1.3 Dissertation Objective: A Better Engineering Systems Decision-making Process

As previously noted, the lack of stakeholder involvement can lead to technical optimality overshadowing social and institutional feasibility. According to Cahn (2000), "the formal inclusion of stakeholder representatives, and by extension the public at large, goes far toward resolving the primary tensions between science and policy. Formally linking policy staff and scientists with stakeholders creates an important linkage between technocrats and the public."

One of the ways to accomplish this is to initiate a stakeholder-assisted policy design and modeling proces, where the experience and local understanding of issues embodied in the stakeholder can be captured within the model, to the extent that it does not undermine its scientific credibility.

Recommendations resulting from such a process have the potential of being accepted more readily, since stakeholders feel more ownership in the policy analysis and modeling process. Therefore, at later stages of the policy making process, the model can then be used as a negotiations tool between the different stakeholders. The challenge is to create a model that sufficiently represents the complexity of the system, while still being

[7] Mental maps are the subjective interpretation of human beings of a given system based on limited and scattered information, which they connect to form a consistent image that enables them to interact with that system. Often, new information that does not fit into an individual's mental model of a system is unconsciously discarded by the mind.

understood by all the participants who are involved in the modeling process, and produce reasonable and useful recommendations.

## 1.4 Methodology

The main thrust of this research is to propose a process by which experts, stakeholders and decision-makers can interact for making decisions on engineering systems, in an integrated manner. Specifically it proposes to join existing engineering systems analysis methodologies such as the CLIOS process proposed by Dodder et. al (2005) with joint fact-finding processes, creating a stakeholder-assisted modeling and policy design (SAM-PD) process. To address the various challenges discussed in the previous sections, SAM-PD makes use of insights from the currently dissociated literatures on systems thinking, negotiation and conflict resolution, scientific communication and linguistics.

SAM-PD is custom-designed to allow effective interactions among decision-makers, experts and stakeholders. The systems-centric, holistic approach of SAM-PD sets it apart from other stakeholder processes, which have been mainly developed within the field of negotiation and conflict resolution, with little emphasis on the engineering/scientific systems aspect of the problem.

Specifically, SAMPD uses:

- A **CLIOS Process** as a conceptual framework for studying the complex sociotechnical system in question.
- **System Dynamics Software,** as a visual modeling platform for the CLIOS Process.
- And a **Model-Assisted Joint Fact Finding** approach as an organizational structure for the policy design and implementation stage of the process.

<u>A) CLIOS Process</u>

The modeling effort in the SAMPD process uses system dynamics as a tool to build a modeling framework based on the CLIOS Process, as proposed by Dodder et. al (2005).

The CLIOS Process is an approach to fostering understanding of complex sociotechnical systems by using diagrams to highlight the interconnections of the subsystems in a complex system and their potential feedback structures. The motivation for the causal loop representation is to convey the structural relationships and direction of influence between the components within a system. In this manner, the diagram is an organizing mechanism for exploring the system's underlying structure and behavior, and then identifying options and strategies for improving the system's performance.

Within the context of this dissertation, systems representation is the act of laying out the structure of a system and the linkages between its components, with the aim of characterizing its behavior and understanding its structure. In simpler terms, a system representation is a way to capture our knowledge of a system, its components and interconnections in its simplest form. The type of representation we are using in this research is known as a CLIOS diagram (a variation of a what is also known as a causal loop diagram), which is essentially a picture containing words that describe system components and directed arrows connecting those components.

B) System Dynamics

The idea of non-technical stakeholders helping in the modeling process can be deemed as unrealistic, if one imagines the thousands of lines of code, or the hundreds of pages of spreadsheets that come to mind when thinking about a model. However an alternative approach is a visual model such as one created using System Dynamics, which is a useful tool for system representation using CLIOS diagrams. Figure 1.1 shows a CLIOS diagram drawn with system dynamics software.

This simple diagram shows an interesting behavior. We know that increases in population and economic activity creates increased demand for transportation. If the current infrastructure availability, in this case highway or road capacity stays constant, there will be increased congestion. Normally this prompts further investment in highway development and road construction to ease the congestion. While this indeed helps congestion in the short run, it will make transportation more attractive since less congestion can lead to shorter travel times and easier travel. That in turn has the effect of increasing transportation demand, which in the longer run increases congestion. This simple diagram therefore, gives us an understanding of why it is that cities like Houston, Texas, with the largest transportation infrastructures in the U.S. still experience one of the highest congestion levels in the nation.

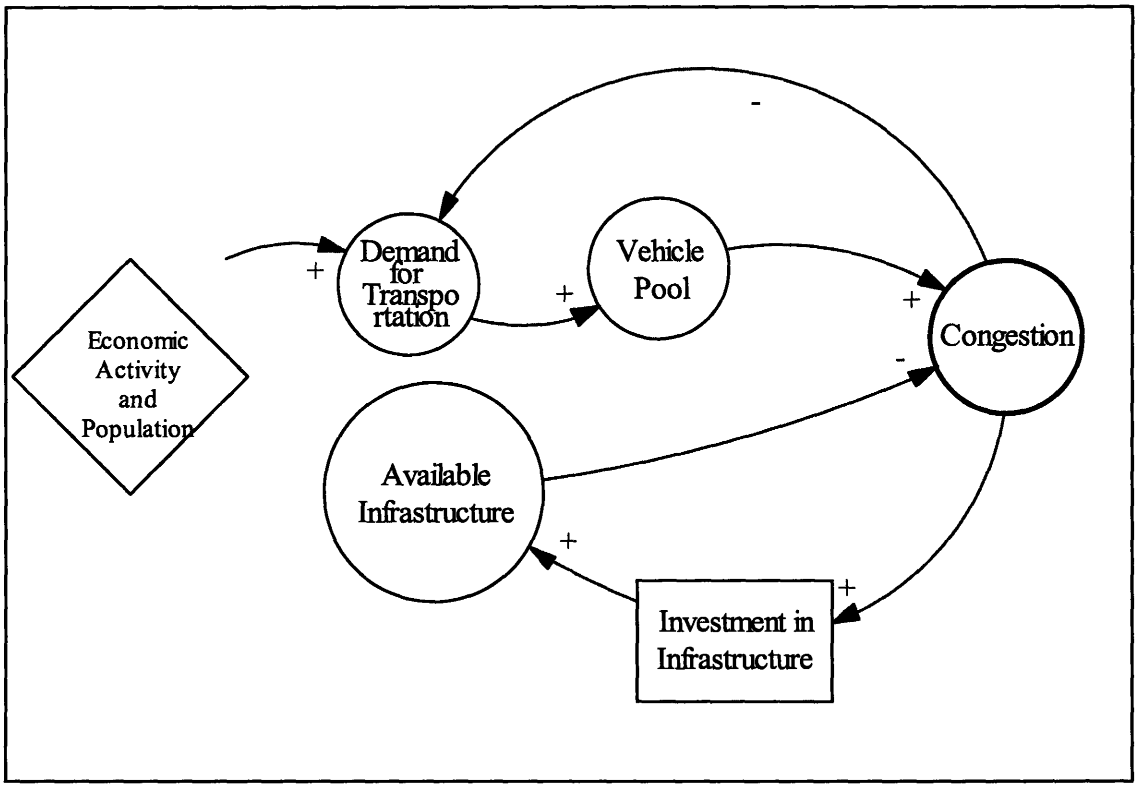


**Figure 1.1 CLIOS Diagram for a Transportation System focused on the impact of infrastructure investments on congestion.**

System Dynamics is used as a visual modeling language that can act as an accessible interface between technical modeling and stakeholders. It consists of stocks and flows and causal loops, which can explain how the different elements of a complex system are linked together. Its **qualitative representation** combined with its **quantitative output,** make it a suitable tool for SAMPD.

System dynamics also has the ability of performing extensive multi-variable sensitivity analysis. This means that if we are not certain of the inputs into the model, we can provide a range for each, and the System Dynamics model will calculate all the possible combinations.

One of the major strengths of system dynamics is in simulating effects that are delayed in time. This helps us model how an event or series of events 5 years ago might have contributed to the status of things today, or how current policies might start to pay off in a couple of years and not immediately. The visual nature of system dynamics helps a deeper understanding of the underlying issues through causal loops. Thus, several models with differing levels of detail can be constructed easily for different stakeholders and policy-making bodies. System dynamics can be used in conjunction with other quantitative methods such as probabilistic risk assessment, real options analysis, optimization methodologies and qualitative methodologies such as scenario analysis to enable a more comprehensive quantitative analysis of engineering systems. This will be further discussed in Chapter 2.

C) Model-Assisted Joint Fact Finding Process

An important part of the SAM-PD process is model-assisted joint fact-finding. The purpose of joint fact-finding is to develop shared knowledge and agreement about the system and its boundaries and important issues that ought to be considered in the scientific analysis. It is a step by which stakeholders initiate the process of gathering information, analyzing facts, and collectively making informed decisions (Ehrman 1999).

Joint fact-finding rests on the following main principles:

- The process of generating and using knowledge is a collaborative effort among decision-makers, independent scientists and other stakeholders and their representative experts from all sides of the conflict.
- Information, expertise and resources will be shared among all participants.
- Participants arcommitted to finding a set of solutions to their conflict.

## 1.5 Research Focus

While this dissertation proposes a decision-making process for engineering systems that spans from problem definition through implementation and monitoring, its case studies mainly focus on the effect of stakeholder involvement in systems representation.

***Why stop at systems representation?***

The basic rationale for the choice of systems representation as the focus of this dissertation is as follows.

1) Systems representation is one of the most important stages in any decision-making process. It is the stage at which a problem is defined, and the overall design and operation goals of an engineering system are specified. A system representation describes the boundaries of a system, its components, important performance metrics and the interconnections between the different parts of a complex system. A good representation is the foundation of later systems analysis stages, such as quantitative modeling of the representation, design and selection of alternative strategies and implementation of those strategies.

2) Furthermore, the impact of stakeholder involvement in the final decision is hard to measure in the short-term; since the adequacy of collaboratively designed strategy to address a problem can only be known in hindsight, years after the implementation. However, given the importance of the system representation stage, any improvements within this stage can positively affect all subsequent stages of the process.

3) Many of the disagreements that emerge at later stages have their roots in the representation of engineering systems and the choice of performance metrics.

***Hypothesis:*** The hypothesis of this research is that stakeholder-assisted representation of engineering systems can result in a systems representation that is *superior* to expert representations with limited stakeholder involvement. Here superior is defined in terms of:

- Inclusion of a plurality of views
- Usefulness of representation as a thought expander for stakeholders
- Usefulness of representation for suggesting strategic alternatives for improved long-term management of the system
- Capturing effects that expert-only representation couldn't capture.
- Completeness of representation (taking into consideration technical, social, political and economic considerations)

Table 1.1 shows how the hypothesis will be evaluated. Here the independent variable is stakeholder involvement in engineering systems and dependent variables are the criteria of superiority for representations created by stakeholders when compared to expert-centric representations. In the case of the hypothesis the independent variable is limited to stakeholder participation in the decision-making process starting from problem identification to systems representation, including identification of major uncertainties and risks.

## 1.6 Case Study: Permit Process for the Cape Wind Project

Currently, there is a proposal by a private company to build an offshore wind farm in Nantucket Sound in Federal waters that is intended to provide an alternative and renewable energy source for Cape Cod. The proposal is under review by the U.S. Army Corps of Engineers, which has jurisdiction over the permitting process. As the public hearing excerpt at the beginning of the chapter shows, the issue has raised a lot of controversy, and citizens groups in the area have taken opposing sides on whether or not a permit should be issued. In addition to technical/scientific complexity in the Environmental Impact Assessment, there are issues such as the impact of the wind-farm on the local economy, real-estate values, and aesthetics. This has lead to an adversarial atmosphere with the opponents aiming to litigate against the developer. This case is suitable for exploring the hypotheses of the dissertation. Particularly, the proximity of the area to MIT, and the ability to invite actual stakeholder groups to attend face-to-face sessions make the application of the SAM-PD process viable.

**Table 1.1 Validating the Research Hypothesis**

| Independent Variable | Dependent Variable | Measurable Indicator | How to Measure |
|---|---|---|---|
| Stakeholder involvement in the system representation | Inclusiveness of a plurality of views | Degree of diverse stakeholder, decision-maker and expert views included in the representation of the system | - Trace system representation elements to individual stakeholder, decision-maker and expert inputs to assess to what degree the final representation includes views of diverse participant groups as compared to a representation that is done by one group of experts alone. |
| | Usefulness of representation in suggesting strategic options and as a thought expander for participants | - Degree of insights that can be gained from creating and analyzing the representation<br>- Change in understanding of the system and its most important aspects | - Comparison of the number and quality of strategic options between the stakeholder-assisted representation and the expert-created representations<br>- Solicit feedback from stakeholders on their improved understanding of the system when compared to the expert representation of the same system. |
| | Usefulness of representation for modeling (quantification) of the system, that could subsequently be used as a platform for negotiation | Suitability of representation to evaluate different strategic options | - Comparison of stakeholder-assisted representation and expert-created representation in terms of quantifiable information and outputs that are useful for decision-making.<br>- Survey participants on the potential advantages of stakeholder-assisted representation with expert-created representations in terms of suitability a better basis for making informed negotiations on the merit of a range strategic options for the system. |
| | Completeness of representation | Inclusion of technical, social, political and economic considerations, and capturing system components and links that were not captured in the model created by experts alone. | - Comparison of the inclusion of overall technical, social and economic aspects of the system that were not included the |

## 1.7 Engineering Systems Context of Research

One of the key questions that this dissertation has to answer is how stakeholder involvement in engineering systems design fits within the large picture of engineering systems as a field, and what intellectual bases it is being built on.

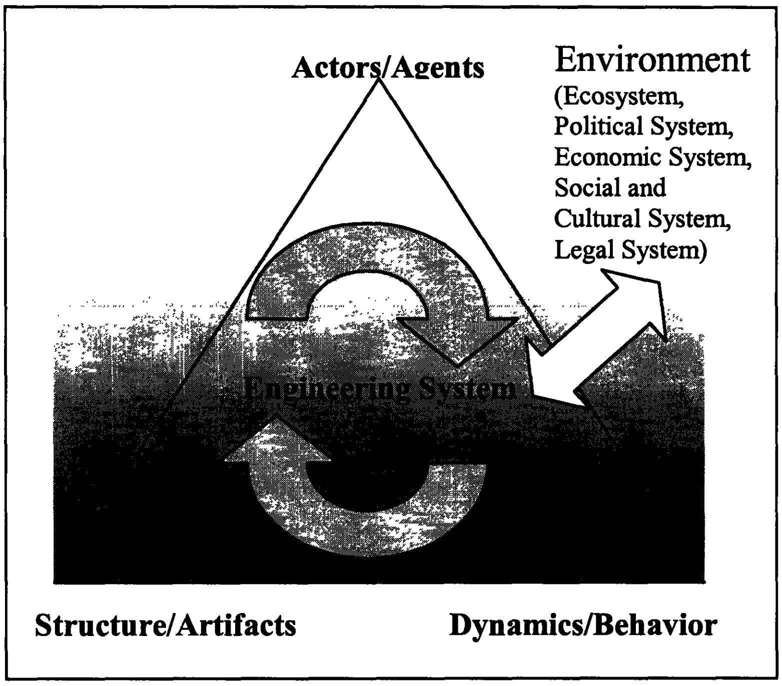


**Figure 1.2 The Different Aspects of Engineering Systems**

An engineering system is defined through four main aspects: Its (man-made) structure and artifacts (technology, architecture, protocols, components, links, boundaries, internal complexity), its dynamics and behavior (emergence, non-linear interactions, feedback loops) and its actors/agents (conscious entities that affect or are affected by system's intended or unintended effects on its environment). Finally the environment it operates in also defines an engineering system[8]. Here environment refers to the social, cultural, political, economic and legal context within which the system is operating.

A proposed taxonomy of engineering systems studies can therefore consist of:

- **Structural studies**: Research on architecture, technological artifacts, protocols and standards, networks, hierarchies, optimization and structural "ilities etc.".

[8] On could add system goals as an important environmental constraint that defines an engineering system.

- **Behavioral studies**: Research on non-linearity, dynamic or behavioral complexity, dynamic "ilities", material/energy/information flows, dynamic programming, emergence etc.
- **Agent/Actor System Studies:** Research on decision-making under uncertainty, agent-based modeling, enterprise architecture, human-technology interactions, labor-management relations, organizational theory, lean enterprise etc.
- **Policy Studies:** Research on the interactions of the engineering system with its environment, including institutional context and political economy, stakeholder involvement, labor relations and social goals of engineering systems, as well as ecosystem and sustainability research.

The stakeholder-assisted modeling and policy design (SAM-PD) process research fits within the last category. It explores the impact of stakeholder involvement on engineering systems design and management and its consequences for social and environmental goals of the system. Particularly it looks at how changes in the decision-making mechanism of actors/agents can impact system structure and behavior, and how it can in turn change the effects of the engineering system on its environment.

The SAM-PD research is developed on the following engineering systems foundations:

- **Sociotechnical Complexity**

One of the primary theoretical foundations of engineering systems is understanding the different kinds of *complexity* that affect each of the four above-mentioned aspects. Engineering systems exhibit internal (structural) complexity, behavioral (dynamic), complexity evaluative complexity and nested complexity. Internal (structural) complexity refers to the complex structure and hierarchy of artifacts of the engineering system.

Behavioral (dynamic) complexity deals with the interactions of the artifacts and the components within the engineering systems structure. Evaluative complexity refers to the fact that different stakeholders value different system performance measures differently. Nested complexity refers to the realization that complex technical systems are often nested within complex institutional structures making the understanding of the relationship between institutions and the technical system a necessity. The SAM-PD process builds on the notions of nested complexity and evaluative complexity, in that it addresses the interactions between the institutional environment and the technical system, and involves stakeholders to jointly develop system representations and system performance goals based on a plurality of values.

- **Decision-making under Uncertainty**

Another important engineering systems foundation is *decision-making under uncertainty*. Stakeholder involvement research focuses heavily on the fact that the communication of uncertainties and risk are essential in the decision-making process for engineering systems, particularly to those bearing the risks.

- **Engineering Systems *Design***

Related to the above two points is the issue of engineering design, one of the foundations of engineering systems as a field is the concept of *engineering system design*. The design of engineering systems is substantially different than the design of single technological artifacts, due to the existence of wide-ranging social and environmental impacts of the system, issues of emergence and the lack of a single *designer* or *architect* for systems of such scale that develop in unpredictable ways. Stakeholder involvement modifies the concept of design from an expert-centric perspective to a more inclusive process that also takes broader societal goals into consideration.

## 1.8 Dissertation Structure

Beyond this introductory chapter, this dissertation is divided into six major parts. Part I (Chapters 2 and 3) deals with engineering systems and technical complexity. This will include a discussion of complexity in engineering systems, systems analysis methodologies, and the role of expert analysis in the decision-making process for engineering systems.

In Part II (Chapters 4 and 5) we will look at engineering systems, stakeholders and conflict. Here we are concerned with the role of conflict and public Interest in the decision-making process for engineering systems. We will take a brief look at cases such as the Mexico City Airport, the Connecticut Super 7 highway, and the Yucca Mountain Project as examples of conflict in engineering systems decision-making. We will then take a look at traditional decision-making processes for engineering systems that give rise to such conflicts. We will then review existing stakeholder involvement mechanisms in engineering systems decision-making and examine their merits and drawbacks.

In Part III (Chapters 6 and 7), we will move into the main methodological contributions of this dissertation, examining systems representation and their role as an expert/stakeholder/decision-maker interface and SAM-PD as an alternative stakeholder involvement process using stakeholder-assisted systems representations as its basis.

Part IV (Chapters 8 and 9) will examine the applicability of the SAM-PD methodology developed in the previous part to the Cape Wind case study. The hypothesis of the dissertation will then be validated and the merits and drawbacks of the SAM-PD methodology are discussed.

In Part V (Chapter 10) we will look at the application of SAM-PD to other types of engineering systems such as the Mexico City Transportation/Air Pollution system and the Cape and Islands Collaborative Energy Planning process.

In Part VI (Chapter 11), the concluding part of this dissertation, we will examine the implications of this research for engineering systems design and decision-making.

### 1.9 Chapter Summary

This chapter provided the foundations for the rest of the dissertation, looking at the rationale for stakeholder involvement and providing a summary of the proposed Stakeholder-Assisted Modeling and Policy Design process that can streamline stakeholder engagement in the design of policies for engineering systems. In the next chapter, we will look at engineering systems and the implications of technical complexity in engineering systems analysis.

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# ➲Chapter 2
## Engineering Systems Analysis

*"General systems theory says that each variable in any system interacts with the other variables so thoroughly that cause and effect cannot be separated. A simple variable can be both cause and effect. Reality will not be still. And it cannot be taken apart! You cannot understand a cell, a rat, a brain structure, a family, a culture if you isolate it from its context. Relationship is everything."*

-Marilyn Ferguson
*The Aquarian Conspiracy*

### 2.1 What are Engineering Systems?

A system can be defined as "a dynamic entity comprised of interdependent and interacting parts, characterized by inputs, processes and outputs"[9]. There are many types of systems in and around us, and how a particular system is defined largely depends on where we draw its boundaries.

This dissertation is focused on *engineering systems,* in which technologies interact with the natural and social environment in non-intuitive ways. Engineering systems

- are composed of a group of related component and subsystems, for which the degree and nature of the relationships is not clearly understood.
- have large, long-lived impacts that span over a wide geographical area.
- have integrated subsystems coupled through feedback loops
- are affected by social, political and economic issues. (Dodder et. al, 2005)

Examples of systems that fall within this category are transportation systems, telecommunication systems, energy systems, the World Wide Web, water allocation systems, chemical industries etc. CLIOS have wide-ranging impacts, and are characterized

[9] INCOSE definition

by different types and levels of complexity, uncertainty, risk, as well as large number of stakeholders. In order to study and analyze an engineering system, a deep understanding of each of these aspects is necessary. In the following paragraphs, we will look at each of these aspects more closely.

**A) Complexity**

There are many definitions of complex systems, but in this context we consider a system as complex when "it is composed of a group of interrelated units (component and subsystems, to be defined), for which the degree and nature of the relationships is imperfectly known, with varying directionality, magnitude and time-scales of interactions. Its overall emergent behavior is difficult to predict, even when subsystem behavior is readily predictable"(Sussman, 2003). Sussman also defines three types of complexity in systems: behavioral (also called emergence), internal (also called structural) and evaluative (Sussman, 2003):

*Behavioral complexity* arises when the emergent behavior of a system is difficult to predict and may be difficult to understand even after the fact. For instance, the easiest solution to traffic congestion seems to be to build new highways. New highways however cause additional traffic by attracting "latent transportation demand", due to the increased attractiveness of private autos, thus leading to more congestion in the long run.

*Internal or structural complexity* is a measure for the interconnectedness in the structure of a complex system, where small changes made to part of the system can result in major changes in the system output and even result in system-wide failure. A good example of this type of complexity is the side effect of chemotherapy, which in addition to destroying cancerous cells, also suppresses the immune system of the body resulting in death by infection in cancer patients.

*Evaluative complexity*: This type of complexity is due to the existence of stakeholders in a complex system, and is an indication of the different normative beliefs that influence views on the system. Thus, even in the absence of the two former types of complexity, and even if one were able to model the outputs and the performance of the system, it would still be difficult to reach an agreement on what "good" system performance signifies. This type of complexity is one of the primary motivators for engaging stakeholders in systems modeling and policy design, and is an essential part of this dissertation.

Valuing different outcomes: There are many different criteria to value particular outcomes. Some of the social and economic valuation approaches for outcomes include:

- *Utilitarian:* This criterion is one of neoclassic economics. Essentially the goal here is to maximize the sum of individual cardinal utilities. W(x) = U1(x) + U2(x) + ... + Un(x)

  Of course this can only function if Ui is cardinal (and if the U's are interpersonally comparable).
- *Pareto optimality:* The goal here is to reach an equilibrium that cannot be replaced by another one that would increase the welfare of some people without harming others
- *Pareto efficiency:* This occurs when one person is made better off and no one is made worse off.
- *Compensation principle*: A better-off person can compensate the worse-off person to the extent that both of them are better off. (Kaldor-Hicks)
- *Social welfare function:* Here the state evaluates the outcome based on overall social welfare, taking into account distributional issues.

Which criteria are used to evaluate outcomes, and how they are measured has to be determined by the consensus or overwhelming majority agreement of stakeholders. Otherwise the valuation can only be considered that of the experts and decision-makers alone.

*Nested Complexity*: Finally, engineering systems exhibit nested complexity. This idea refers to the fact that a technologically complex system is often embedded or nested within in a complex institutional structure. This added dimension of complexity is what makes the design and management of an engineering system a great challenge.

**B) Scale**

Large-Scale systems are characterized by a large number of components, often stretching over a large geographical area or virtual nodes, and across physical, jurisdictional, disciplinary and social boundaries. Often their impacts are considered long-lived, significant and affect a wide range of stakeholders (Dodder et. al, 2005).

**C) Integration**

Subsystems within a CLIOS are connected to one another through feedback loops, often reacting with delays. According to Sterman (2000), the existence of multiple interacting feedbacks makes it harder to understand the effect of one part of the system. In such a system, an institutional decision may impact technological development, also impacting environmental, economic and social aspects of a system.

**D) Environmental Interaction**

Systems may be characterized as either closed or open. A closed system is one that is self-balancing and is independent from its environment. Open systems interact with their environment in order to maintain their existence. Most engineering systems are affected by the environment they operate in and in this sense, can be considered open systems.

**E) Uncertainty and Risk in Engineering Systems**

One of the main products of complexity in a system is uncertainty in its initial state, its short and long-term behavior and its outputs over time. Webster's dictionary defines uncertainty as "the state of being uncertain". It further defines uncertain as "not established beyond doubt; still undecided or unknown". Uncertainty refers to a lack of factual knowledge or understanding of a subject matter, and in this case to the inability to fully characterize the structure and behavior of a system now or in the future. In analyzing complex systems, uncertainty can apply to the current state of a system and its components, as well as uncertainties on its future state and outcomes of changes to the system. Essentially there are two categories of uncertainty: Reducible, and irreducible.

Reducible uncertainty can be reduced over time with extended observation, better tools, better measurement etc., until it reaches a level when it can no longer be reduced. Irreducible uncertainties are inherent uncertainties due to the natural complexity of the subject matter. We can distinguish the following types of uncertainty (Walker, 2003):

*Causal Uncertainty:* When scientists draw causal links between different parts of the system, or between a specific input and an output, there is an uncertainty in the causal link. For instance the relationship between air pollution concentration and respiratory problems is associated with causal uncertainty, given that the same air pollution concentrations can result in different levels of respiratory problems. This occurs because other, sometimes unknown factors can influence the causal link. There is also the important difference between correlation and causation, in that an existing correlation does not necessarily indicate causation. Another source of causal uncertainty is the existence of feedback loops in a system. Causal uncertainty is strongly dependent on the "mental map"[10] of the person drawing the linkages.

*Measurement Uncertainty:* When measuring physical or social phenomena there are two types of measurement uncertainty that can arise. The first is the reliability of the measurement, and the second is its validity. Reliability refers to the repeatability of the process of measurement, or its "precision" whereas validity refers to the consistency of the measurement with other sources of data obtained in a different ways, or its "accuracy". The acceptable imprecision and inaccuracy for different subject matters can be very different. For instance, the acceptable inaccuracy for a weather forecast is different than the inaccuracy of measurements for the leakage rate of a nuclear waste containment casket, given the different levels of risk involved. Therefore, defining the acceptable uncertainty in measurements is a rather subjective decision.

*Sampling Uncertainty:* It is practically impossible to measure all parts of a given system. Measurements are usually made for a limited sample, and generalized over the entire system. Such generalization beyond the sample gives rise to sampling uncertainty. Making

[10] A mental map is the subjective interpretation of a person or a group of people of the boundaries of a system, its linkages, its components and its behavior.

an inference from sample data to a conclusion about the entire system creates the possibility that error will be introduced because the sample does not adequately represent that system.

*Future uncertainty:* The future can unfold in unpredictable ways, and future developments can impact the external environment of a system, or its internal structure in ways that cannot be anticipated. This type of uncertainty is probably one of the most challenging types of uncertainty, given that there is little control over the future. However, it is possible to anticipate a wide range of future developments and simulate the effect of particular decisions or developments in a system across these potential futures. In CLIOS, the effects of new technologies often cannot be adequately determined a priori. Collingridge (1980) indicates that historically, as technologies have developed and matured, negative effects have often become evident that could not have been anticipated initially (automobile emissions or nuclear power accidents and waste disposal). Despite this ignorance, a decision has to be made today.

*Modeling Uncertainty:* Scientists use models to predict values for some variables based on values for other variables. A model is based on assumptions about the initial state of a system (data), its structure, the processes that govern it and its output. Any of these assumptions has inherent uncertainties that can affect the results, which the model produces. The parameters and initial conditions of a model can often be more important than the relationships that govern the model in terms of the impact on the output. The "Limits to Growth" Models of the 1970s show how long range models are not capable of characterizing long-term interactions between the economy, society, and the environment in an engineering system. Additionally, individual and institutional choices can make socio-economic models inherently unpredictable (Land and Schneider 1987).

In real life, uncertainties cannot be reduced indefinitely and the reduction of uncertainty is associated with costs. Therefore an acceptable level of uncertainty for decision-making has to be determined subjectively. The subjective nature of such a determination is one of the main rationales for stakeholder participation in decision-making.

*Risk* is the combination of the concepts probability (the likelihood of an outcome) and severity (the impact of an outcome). In fact, acceptable levels of uncertainty in the analysis of a system depend on acceptable levels of risk associated with that system. The concept of acceptable risk is essentially a subjective, value-based decision. While there are methodologies, such as probabilistic risk assessment, that try to provide an objective assessment of risk, it is the perception of the risk bearing individuals, organizations or communities that determine how much risk is acceptable. While many experts focus on providing the public with probabilities of possible outcomes for a system, Sjöberg (1994) indicates that the public is more concerned with the severity than with the probability. Allan Mazur (1981) emphasizes the role of the media in affecting risk perceptions for people. He argues that the more people see or hear about the risks of a technology, e.g., the more concerned they will become. This effect could occur both for negative coverage as well as positive coverage.

### 2.2 Engineering Systems Analysis Methodologies

In this section we will look at how engineering systems have been traditionally analyzed, and what approaches can be used for engineering systems decision-making.

When analyzing an engineering system, it is necessary to look at the entire system in a holistic fashion. One of the major milestones favoring this type of systemic approach in the analysis of complex systems is *Systems theory*. It was first proposed as an alternative to reductionism in the 1940's by the biologist Ludwig von Bertalanffy who published his General Systems Theory (Bertalanffy, 1968). He emphasized that real systems were open and that they exhibited behavioral complexity or emergence. Rather than analyzing the individual behaviors of system components in isolation, systems theory focuses on the relationship among these components as a whole and within the context of the system boundaries. According to Bertalanffy, a system can be defined by the system-environment boundary, inputs, outputs, processes, state, hierarchy, goal-directedness, and its information content (Bertalanffy, 1968).

While systems theory provides the fundamental concepts for understanding a complex system, it does not provide a common methodology for how to analyze such a system. In the 1960s and 1970s, systems analysis evolved as an approach to analyzing complex systems. The American Cybernetics Society defines systems analysis as "an approach that applies systems principles to aid a decision-maker with problems of identifying, reconstructing, optimizing, and managing a system, while taking into account multiple objectives, constraints and resources. Systems analysis usually has some combination of the following: identification and re-identification of objectives, constraints, and alternative courses of action; examination of the probable consequences of the options in terms of costs, benefits, and risks; presentation of the results in a comparative framework so that the decision maker can make an informed choice from among the options"[11]

There are many systems analysis tools and systems analysis processes that have been proposed for analyzing different aspects of complex systems.

Here we will look at Systems Engineering, Systems Dynamics and the CLIOS process as important ways to analyze CLIOS. In the following sections, we will take a look at each of these approaches.

**A) Systems Engineering**

Systems engineering is a discipline that develops and exploits structured, efficient approaches to analysis and design to solve complex engineering problems. Jenkins (1971), defines the following stages for a systems engineering approach to solving complex systems: Systems Analysis, System Design, Implementation and Operation.

[11] Web Dictionary of Cybernetics and Systems, American Cybernetics Society, http://pespmc1.vub.ac.be/ASC/indexASC.html

**Table 2.1 – A Systems Engineering Approach for Dealing with Complex Engineering Systems (Jenkins, 1971)**

| | |
|---|---|
| • System Analysis | 1. Recognition and formulation of the problem<br>2. Organization of the project<br>3. Definition of the system<br>4. Definition of the wider system<br>5. Definition of the objectives of the wider system<br>6. Definition of the objectives of the system<br>7. Definition of the overall economic criterion<br>8. Information and data collection |
| • System Design | 1. Forecasting<br>2. Model building and simulation<br>3. Optimization<br>4. Control |
| • Implementation | 1. Documentation and sanction approval<br>2. Construction |
| • Operation | 1. Initial operation<br>2. Retrospective appraisal of the project |

For each of these stages, a different number of systems engineering tools and methods exist that can help analyze different aspects of the system. These methods include such elements as trade-off analysis, optimization methods (operations research), sensitivity analysis, utility theory, benefit-cost analysis, real options analysis, game theory and diverse simulation methods such as genetic algorithms or agent-based modeling[12]. At any stage of a systems engineering analysis of a complex system a combination of these tools and methods can be used. In the following paragraphs, we will consider each of these tools and methods and comment on their strengths and weaknesses.

*A.1) Trade-off analysis:* When dealing with a complex system, there are multiple values that we would like to maximize. Often, these goals and objectives can be in direct conflict with one another and maximizing one can adversely affect the other. Tradeoff analysis

[12] The Institute for Systems Research, What is Systems Engineering, http://www.isr.umd.edu/ISR/about/definese.html#what

allows us to find those outcomes in the systems, which have combinations of values that are acceptable for us, and which maximize the overall value of the system as a way to deal with evaluative complexity. Multi-attribute tradeoff analysis can be used for cases where there are multiple objectives in a given system. The drawback with tradeoff analysis is that many benefits are not continuous in nature. For instance, in the case of offshore wind energy there is a tradeoff between an open vista and cleaner energy; Either there is an open vista or there is cleaner energy, the tradeoff is thus not a continuous curve and cannot be well-represented using tradeoff analysis.

*A.2) Optimization:* Optimization is the maximization or minimization of an output function from a system in the presence of various kinds of constraints. It is a way to allocate system resources such that a specific system goal is obtained in the most efficient way. Optimization uses mathematical programming (MP) techniques and simulation to achieve its goals. The most widely used MP method is linear programming, which was made into an instant success when George B. Dantzig developed the simplex method for solving linear-programming problems in 1947. Other widely used MP methods are integer and mixed-integer programming, dynamic programming and different types of stochastic modeling. The choice of the methodology depends mainly on the size of the problem and the degree of uncertainty. Table 2.1 shows what methods are used for certain and uncertain conditions, in the strategy evaluation and generation stages of systems analysis.

**Table 2.2 Mathematical Programming and Simulation Modeling Methods for Engineering Systems**

| | *Strategy evaluation* | *Strategy generation* |
|---|---|---|
| *Certainty* | Deterministic simulation<br>Econometric models<br>Systems of simultaneous equations<br>Input-output models | Linear programming<br>Network models<br>Integer and mixed-integer programming<br>Nonlinear programming<br>Control theory |
| *Uncertainty* | Monte Carlo simulation<br>Econometric models<br>Stochastic processes<br>Queueing theory<br>Reliability theory | Decision theory<br>Dynamic programming<br>Inventory theory<br>Stochastic programming<br>Stochastic control theory |

Statistics and subjective assessment are used in all models to determine values for parameters of the models and limits on the alternatives.

Source: *Applied Mathematical Programming* by Bradley, Hax, and Magnanti (Addison-Wesley, 1977)

Another type of optimization methods is the *Genetic Algorithm* (GA) methodology. A genetic algorithm is an optimization algorithm based on Darwinian evolutionary mechanisms that uses a combination of random mutation, crossover and selection procedures to breed better models or solutions from an originally random starting population or sample (Wall, 1996).

Optimization methods are tools that are suitable to analyze large-scale networks and allocation processes, but may not fit all purposes. Often when social considerations exist, the goal is not optimization, but satisfaction of all stakeholder groups involved. Also, when optimization occurs, there is no room for flexibility in the system, making the system vulnerable to changes that happen in its environment over time.

*A.3) Game Theory:* Game theory is a branch of mathematics first developed by John von Neumann and Oskar Morgenstern in the 1940s and advanced by John Nash in the 1950s. It uses models to predict interactions between decision-making agents in a given set of conditions. It has been applied to a variety of fields such as economics, market analysis and military strategy. It can be used in a complex system where multiple agents (conscious decision-making entities) interact non-cooperatively to maximize their own benefit. The underlying assumption for game theory is that agents know and understand the benefits they can derive from a course of action, and that they are rational.

*A.4) Agent-Based Modeling:* Agent-based modeling is a bottom-up system modeling approach to predict and understand the behavior of non-linear, multi-agent systems. An agent is a conscious decision-making element of the system that tries to maximize its local benefit. The interaction of agents in a system is a key feature of the agent-based systems. It assumes that agents communicate with each other and learn from each other. The proponents of this approach argue that human behavior in swarms (or society) within a CLIOS can only be predicted if individual behavior is considered a function of information exchange among individuals who are trying to maximize their profits(Cetin and Baydar, 2004). The main draw back of agent-based modeling approaches is that the initial assumptions about an individual's behavior can pre-determine the aggregate systems behavior, making the outcome very sensitive to the initial assumptions of the system.

*A.5) Benefit-Cost Analysis and Discounted Cash Flow:* Benefit-cost analysis (also called cost-benefit analysis) is a methodology developed by the Army Corps of Engineers before World War II that allows decision-makers choose projects that produce the greatest net benefit for every dollar spent. This method has been used to analyze the feasibility of complex large-scale projects by the public sector and the private sector. It uses the net present value (NPV) as a basis for decision-making and is used extensively to this day. The underlying assumption for this kind of analysis is that benefits and costs can be converted easily to monetary benefits and can be compared across heterogeneous projects. This can be a particularly bad assumption when dealing with social systems, where benefits are less tangible in monetary terms and evaluated differently by different stakeholders. Also, the choice of the discount rate and distributional effects are hard to capture with this methodology.

*Utility theory:* Utility is an economic concept that realizes that benefits of a specific good or service are not uniform across the population. Utility is a measure of the satisfaction gained from gaining goods or services by different individuals. It can complement benefit-cost analysis, by including the decision-makers preferences as a measure for comparison of large-scale projects. One of the problems with utility theory is that people's preferences can change very fast, and often there are conflicting utilities among the different decision-makers and stakeholders making it difficult to use a single utility for a course of action or a system outcome.

*A.6) Real Options analysis:* Real option analysis is the application of financial option pricing to real assets. Instead of the now or never investment options that are used in a traditional NPV analysis, real options analysis provides an opportunity but not an obligation for the decision-maker to make use of opportunities that arise under uncertain conditions. Similar to stock options, the decision-maker spends an initial investment that provides them with an opportunity to act under certain conditions to improve the value of the system they manage (Amram and Kulatlaika, 1998). A drawback of the real options analysis is that it depends on a known volatility profile for any given system, something that is a far stretch for most complex systems where historical data is not necessarily predictive of future behavior.

**B) System Dynamics**

System dynamics is a tool for modeling complex systems with feedback that was developed by Jay Forrester at the Massachusetts Institute of Technology in the 1960s. He developed the initial ideas by applying the concepts from feedback control theory to the study of industrial systems (Forrester, 1961). One of the best-known and most controversial applications of the 1960s was Urban Dynamics (Forrester, 1969). It tried to explain the patterns of rapid population growth and subsequent decline that had been observed in American cities like New York, Detroit, St. Louis, Chicago, Boston and Newark. Forrester's simulation model portrayed the city as a system of interacting industries, housing and people and was one of the first systems models for a sociotechnical system. Another widely known application of system dynamics was the "Limits to

Growth" study (Meadows et al. 1972), which looked at the prospects for human population growth and industrial production in the global system over the next century. Using computer simulations, resource production and food supply changes in a system with growing population and consumption rates was modeled. The model predicted that societies could not grow indefinitely, and that such growth would bring the downfall of the social structure and result in catastrophic shortages of food for the world population. Given that the results of the model were highly dependent on initial assumptions as well as the designed structure, most of the predictions were not confirmed by observation in the years since, and many in the academic community have used this as evidence to discredit the value of system dynamics in modeling large-scale engineering systems. Therefore, System Dynamics has in recent years shifted mostly towards solving specific problems rather than modeling entire large-scale system. While System Dynamics has made substantial progress in the past four decades, those academics not in the field still consider its merits limited, mainly because of the early large-scale experiments by Forrester and Meadows.

System dynamics uses causal loop diagrams to represent relationships and causal links between different components in a system.

In addition to qualitative representations, system dynamics also uses control theory for quantification. It uses of stocks and flows along with feedback loops and delays, which can explain how the different elements of a complex system are linked together. Its qualitative representation combined with its quantitative output, make it a suitable tool for modeling sociotechnical systems. In terms of quantitative capabilities, System dynamics has the ability of performing extensive multi-variable sensitivity analysis. This means that if we are not certain of the inputs into the model, we can provide a range for each, and the System Dynamics model will calculate all the possible combinations and provide a range of values as the output.

One of the major strengths of system dynamics is in simulating effects that are delayed in time. This helps us model how an event or series of events 5 years ago might have contributed to the status of things today, or how current policies might start to pay off in a couple of years and not immediately.. System dynamics emphasizes quantification of a systems model as the only way to gain insights from its behavior. The CLIOS process, which uses a similar concept for representing complex systems, emphasizes qualitative insights. We will look at the CLIOS process in more detail in the upcoming section.

### 2.3 The CLIOS Process

The CLIOS process, proposed by Dodder et. al (2005), is the systems analysis approach used in this dissertation. The CLIOS process is an approach specifically designed for the study of engineering systems. The rationale for choosing this approach is its specific design to take into consideration technical aspects of engineering systems along with their institutional side. An important distinction of CLIOS with Systems Engineering and System Dynamics is the explicit interactions between the institutional sphere and the physical system, which enables decision-makers and stakeholders to understand the impact of their decisions and interactions on the system and provide for an opportunity of organizational improvements that allow system improvement strategies to be implemented far more effectively. Additionally, while all of the other systems approaches could benefit from stakeholder involvement, not all of them are designed to incorporate non-technical values and information. The CLIOS process however has this potential.

The CLIOS Process proposes the idea of a "nested complexity" when the physical system is being "managed" by a complex organizational and policymaking system. Figure 2.1 shows the concept of nested complexity.

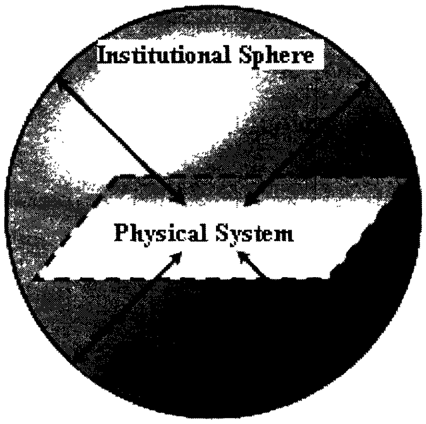


**Figure 2.1 Nested Complexity: A complex physical system is nested inside a complex institutional sphere (Dodder et. al, 2005).**

While engineering and economic models can approximate the physical system, the organizational and institutional system it is embedded in requires a more qualitative framework of analysis. Figure 2.2 outlines the twelve steps of a CLIOS Process.

The CLIOS Process has three stages:

1) Representation
2) Design, evaluation, and selection, and
3) Implementation.

These stages cover a total of twelve steps (See Figure 2.2). Throughout each stage and at every step, tools that are appropriate to the question at hand are used to investigate the system. The tools used for a CLIOS process can essentially be the same as those mentioned under Systems Engineering tools and methods, as well as system dynamics. A more detailed discussion on the CLIOS process can be found in Dodder et. al (2005). In the following paragraphs we will take a more detailed look at the process and its steps, based on the above-mentioned paper.

In the next sections we will look at the different stages and their respective steps in more detail.

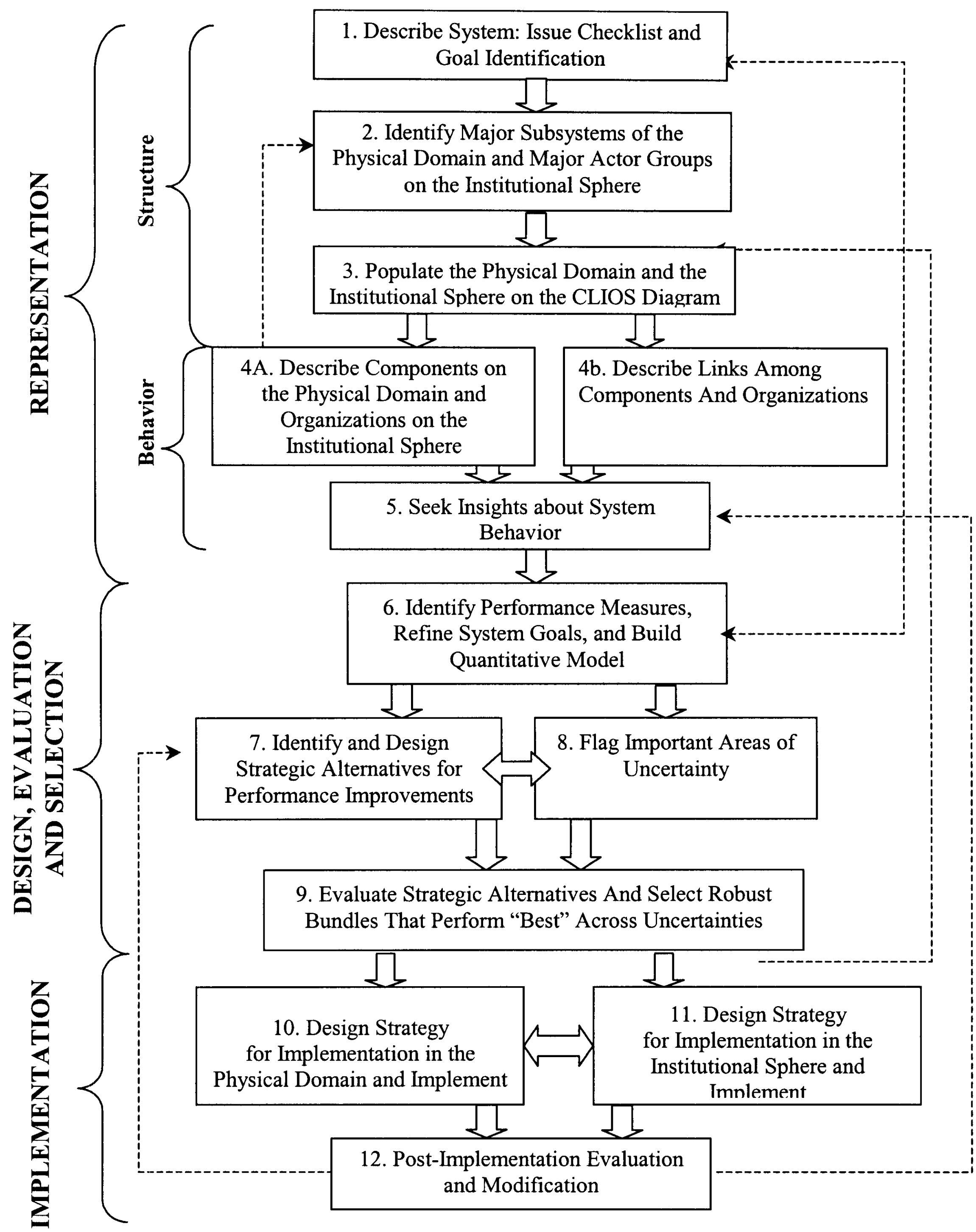


**Figure 2.2 The Twelve-Step CLIOS Process**

## 2.4 CLIOS Representation Stage (Steps 1-5)

The representation stage of the CLIOS process sets the tone for the rest of the process. Here we identify system goals and issues, define system components and interlinkages, identify institutional actors and their relationships and seek insight about the behavior of the system based on a system representation.

In the representation stage, we are concerned with the following questions.

- What are the technical, economic, social, political and other subsystems?
- How are the physical subsystems embedded in a political and institutional structure?
- In the physical system, can we break out several relatively independent types of physical systems that are "layered" upon one another? Can this be done for the policy system as well?
- What is the degree and nature of the interaction between subsystems?
- Are the connections weak or strong?
- Are there important feedback loops between subsystems?
- What insights can we gain into emergent behavior?
- In the *evaluation* and *implementation* stages, we then build upon the insights drawn from the CLIOS representation, utilizing it to measure the system's performance along its various dimensions and to identify strategies for system improvement

In the next paragraphs, we will look at each of the steps in more detail.

*Step 1- Describe System: Issue Checklist and Initial Goal Identification*

In the first step we identify a problem with an existing system, or define a purpose for a new system. We identify the major characteristics and issues through a checklist and proceed to define the initial goals of the system.

This step also entails a preliminary "bounding" of the system that encompasses the problem. Here we identify (geographical, temporal, structural) boundaries of the system we study while acknowledging the critical elements that affect the system and exist beyond the boundaries.

We create a checklist of important systems issues that serve as a basis for the rest of the analysis. The checklist contains preliminary answers the following questions.

- What purpose does the system have? What are the irresolvable problems of the system?
- What is the temporal and geographic scale of the system?
- What are the core technologies at the hart of the system?
- What are the natural physical conditions that impact or are impacted by the system?
- What are the key economic and market issues?
- Are there any important social or political issues or controversies that relate to this system?
- Who should be involved in the analysis, design and implementation of solutions?

*Step 2- Identify Major Subsystems in the Physical Domain and Major Actor Groups on the Institutional Sphere*

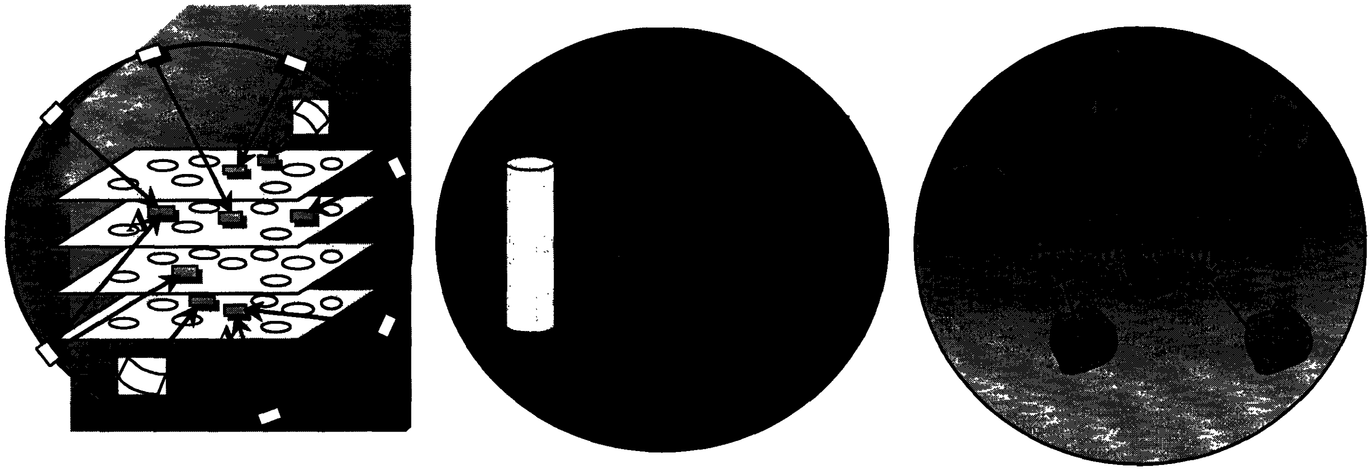

**Figure 2.3 Engineering Systems (left) are made up from a physical domain (center) embedded in an institutional sphere (right).**

An engineering system consists of a physical domain nested in an institutional sphere (See Figure 2.3). In the physical domain we have infrastructures, physical systems etc., and on the institutional sphere we have actors that influence the physical domain (or are impacted by it) in one form or another.

In this step we have to identify major subsystems in the physical domain. Subsystems may be connected through common drivers, but are rather independent parts of the physical domain. In a transportation planning system, subsystems could include environment, land-use, transportation and economic activity.

Parallel to the physical domain we identify the major actor groups on the institutional sphere.

*Step 3- Populate the Physical Domain and the Institutional Sphere in the CLIOS Diagram*

In this step we populate the physical subsystems with detailed components. If there are too many components, we can layer each subsystem into additional layers, so that the relationship between components can be better organized (Figure 2.4).

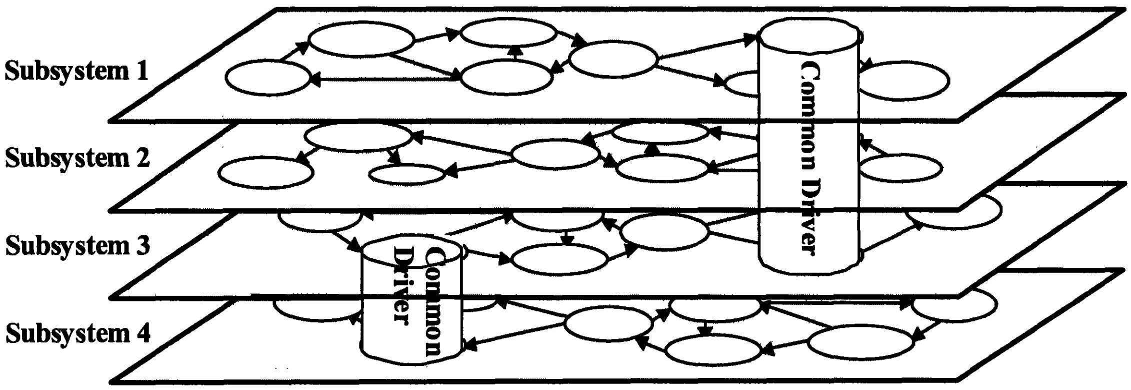


**Figure 2.4 Populating the physical subsystems**

Concurrently, we identify individual organizations and actors on the institutional sphere. Due to the difficulty of analyzing a three dimensional sphere, we flatten the sphere into a two-dimensional plane, much like a geographical map is used to represent the globe (Figure 2.5).

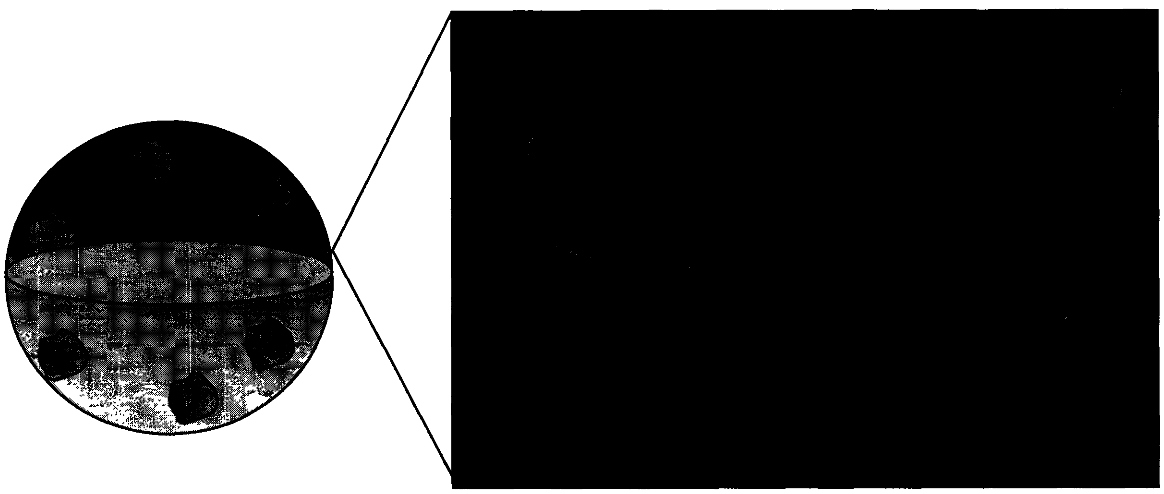

**Figure 2.5 Populating the institutional sphere (left) on a two-dimensional plane (right).**

*Step 4a- Describe Components in the Physical Domain and Actors on the Institutional Sphere*

Up to this point, the components have been considered as generic elements in the subsystems. In this step we more carefully characterize the nature of the individual components.

In this step, we describe the nature of the individual components in the physical domain.

There are three types of components:

- *Policy levers* (indicated by rectangles) are the components directly controlled or influenced by actors in the institutional sphere.
- *Common Drivers* (indicated by diamonds) are components shared across multiple layers of the physical system. They may also be influenced by macro-level factors outside of the CLIOS boundaries.
- Regular *components* (when not policy lever or common driver) are indicated by circles.

*Step 4b- Describe Links between Components in the Physical Domain and between Actors on the Institutional Sphere*

Similarly, as the components were characterized and divided into different types, we also need to characterize the nature of the links. In this step, we describe the links in the physical domain and within the organizations/actors on the institutional sphere. It is important to describe each actor based on their influence on the physical system and their mandate/interest in different parts of the physical system. Description will be in the form of text accompanying the diagram but not necessarily shown on the diagram.

*Link characteristics*

- Directionality of influence
- Magnitude and direction of influence between subsystems

- Time frame of influence (immediate, long term…)
- Uncertainty in the effect of one component upon another
- Functional form (e.g., linear, nonlinear, threshold, …)
- Adaptive
- Human agency
- Type of Link
    - Causal: Shows causation between two components
    - Information/Financial: Shows information/decision/financial flow between two components
    - Material: Shows material/physical flow/impact between two components
    - Policy: Usually associated with relations among organizations/institutions
        - Hierarchical
        - Command and control
        - Advisory and Info-sharing
- Classes of Links
    - Class 1 Links: Between components within the physical system
        - Engineering- and microeconomics-based methods
        - Usually quantifiable
    - Class 2 Links: Between the components within the policy system and components within the physical systems (also called projections)
        - Quantitative analysis is less useful
        - Human agency and organizational interests come into play
    - Class 3 Links: Between actors within the policy system
        - Organizational theory and institutional and policy analysis

At the end of this step, we should have a CLIOS diagram that looks similar to Figure 2.6.

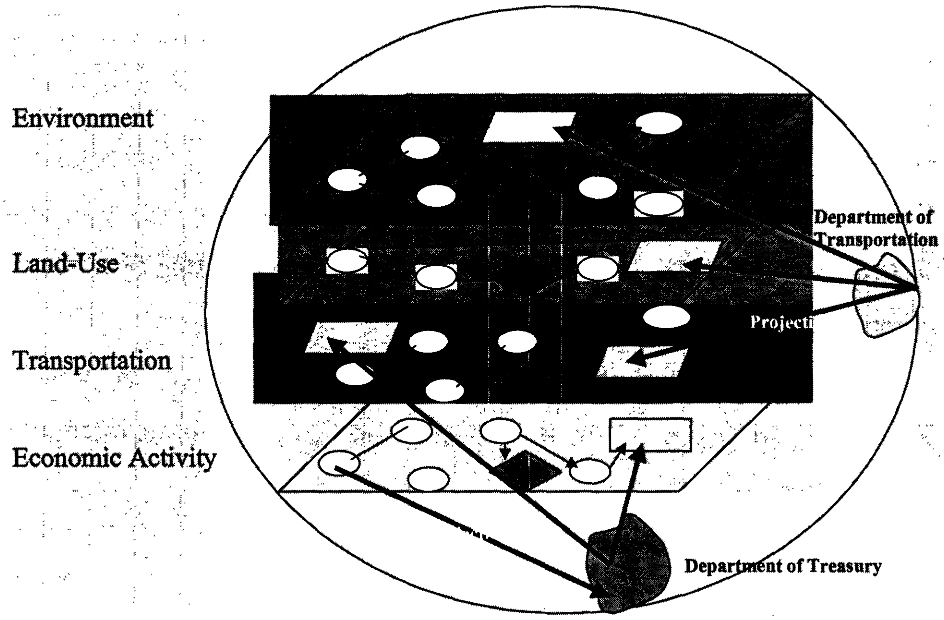


**Figure 2.6 CLIOS diagram at the end of Step 4.**

*Step 5- Seek Insight about System Behavior*

Once the general structure of the engineering system has been established, and the behavior of individual components and links has been relatively well characterized, the next stage is to use this information to gain a better understanding of the overall system behavior, and where possible, counterintuitive or emergent system behavior. This step entails essentially tracing through the system at its different levels – the physical layers and policy spheres. However, many of the most important insights about the system behavior will come during the process of creating the diagrams, and the discipline of bringing a systems mindset to a large complex system. The following questions can guide the search for insight.

a) Within the physical system we can ask the following questions (Class 1):

- Are there strong interactions within or between subsystems?
- Are there chains of links with fast-moving, high-influence interactions?
- Are some of the paths of links non-linear and/or irreversible in their impact?

- Can strong positive or negative feedback loops be identified?

b) Between the institutional sphere and physical domain (Class 2):
We can look at components within the physical systems influenced by many different organizations on the institutional sphere. We can then ask the following questions:

- Are they pushing the system in the same direction, or is there competition among organizations in the direction of influence?
- Are there organizations on the institutional sphere that have an influence on many components within the physical system?

c) On the Institutional Sphere

- Are the relationships between organizations characterized by conflict or cooperation?
- Are there any high-influence interactions, or particularly strong organizations that have direct impacts on many other organizations within the institutional sphere?
- What is the hierarchical structure of the institutional sphere, and are there strong command and control relations among the organizations?
- What is the nature of interaction between organizations that both influence the same subsystems within the physical system?

**2.5 CLIOS Design, Evaluation and Selection Stage (Steps 6-9)**

In the design, evaluation and selection stage, we move beyond the qualitative analysis and try to evaluate the current performance of the system through performance metrics. We are then concerned with devising strategies that could improve systems performance and evaluating their effects. Specifically we are concerned with answering the following questions.

- How is performance measured for the entire engineering system as well as the subsystems?
- How do key stakeholders and decision-makers' measures or rank different types of performance?
- What are the tradeoffs among the various dimensions of performance?

- What forms of quantitative/qualitative models are necessary to evaluate the system?
- What tools can be used to build such models?
- What strategic alternatives can improve system performance, and what ranges of uncertainties exist?
- How can the performance of strategic alternatives be evaluated using the models?
- What combinations or *bundles* of strategies perform best across the identified range of uncertainties?
- How do we select among these bundles?

*Step 6 - Identify Performance Measures, Refine System Goals and Build Quantitative Model*

In the design, evaluation and selection stage, we move beyond an understanding of the system to exploring ways to address existing problems, or developing alternatives for system design or management.

Based on representation insights, we define performance metrics for the system, design strategic alternatives and identify uncertainties in the system. We then evaluate the performance of the alternative strategies under the uncertainties, and refine them into robust bundles that perform well across the uncertainties. Evaluation can be done through a combination of quantitative- and qualitative methods, for the physical system and the institutional sphere respectively.

In this step we need to identify those system components that matter for the performance of a subsystem. Diagrammatically, we represent this for any of the system elements – components, common drivers, or policy levers – by a double line for the border. "Performance" will depend heavily upon the viewpoint of the analysts, decision-makers, and stakeholders. However, it is also important that each of these actors involved in the engineering system understand other actors' measures of performance. One may even find that difficulties in defining performance measures that capture all of the phenomena of interest, lead one back to the first step, to challenge the initial description and bounding of the system.

Once the performance metrics are defined and system goals are refined, one can proceed to build a quantitative model that can be used to evaluate/quantify the current state of the system (baseline), as well as be able to evaluate the impact of potential alternatives on the system. The quantified model can be based on the systems representation built in the representation stage, or it can be constructed from scratch using insights from the qualitative representation. The CLIOS toolset provides different methodologies that can be used to evaluate various parts of the engineering system.

*Step 7 - Identify and Design Strategic Alternatives for System Improvement*

As the performance measures for the system and subsystems are established, it will naturally lead to questions about how the physical system's performance can be improved. Indeed, performance improvements can be identified using the CLIOS representation in two directions. In terms of the diagram of nested complexity, we can think through alternatives from the "outside in" or from the "inside out."

Thinking through system performance from the "inside out" (from the inner physical layers to the outer policy sphere), is a more bottom-up engineering approach, in which we look first at the physical system, and ask how the subsystems in the physical system, through changes to the components or perhaps, in some cases, changes to the links between them, can lead to better performance. This approach usually leads to more technology-driven policy alternatives such as technology mandates and standards, since there are clear specifications about the performance goals that need to be reached. Once the improvements "inside" the physical system are identified, one then looks "out" at the institutional sphere, to highlight the interventions that need to be made by the institutional sphere to accomplish those changes to the physical system.

The alternative method is to look at the impact of policy alternatives from the "outside in." This approach to identifying system improvements is common when speaking of policy measures that rely on incentives or disincentives such as taxes, subsidies, voluntary agreements, and restrictions on certain behaviors. Implicit in these types of alternatives is usually an assumption about how an institutional change, beginning on the policy sphere, will cascade through the physical system, and what target for the performance measure will be reached. Following this process can also reveal where policy alternatives are counterproductive, diminishing the performance in other parts of the system.

*Step 8 - Flagging Important Areas of Uncertainty*

A parallel activity to the identification of alternatives for system performance improvements is to look for the uncertainty in the performance of the engineering system, both at the subsystem and the engineering system-wide level. This includes both uncertainties in data as well as in systems behavior. In identifying the important uncertainties, one must rely on the insights gained in Step 5, in which we looked for chains of strong interactions, areas of conflict between policy organizations, or emergent behavior from positive feedback loops. For example, such signals included individual links or loops that had large magnitude, fast-moving, non-linear or irreversible influences on other components within the system. Scenario planning is a way to deal with future uncertainties in a system.

Also important at this stage is to consider flexibility as part of the design. If the uncertainties are such that currently designed alternatives may be inadequate to respond to potential changes that may emerge over time, we have to identify ways to intervene in the system at later times, to fine-tune it.

*Step 9 - Evaluate Strategic Alternatives and Select Robust Bundles that Perform "Best" Across Uncertainties*

Once uncertainties and areas of improvement are identified, we have to evaluate the proposed alternatives across a range of uncertainties. This will allow for the identification of the more robust alternatives. Robustness is defined as the ability of an alternative to perform reasonably well under different scenarios of the future. This represents a different approach than that of identifying an optimal alternative, which may only perform optimally under a constrained set of conditions. In fact, we would argue that achieving "optimal performance" is an unrealistic goal for an engineering system. Given the range of performance measures involved, different stakeholder views, and trade-offs needed to obtain the necessary support for alternative implementation, simply finding a feasible alternative (one that works) may be the best expectation. One way of displaying robustness is with a matrix, where the columns represent different scenarios and the rows represent policy alternatives; then we can see how the alternatives perform compared across a range of futures.

| | ***Scenario 1*** | ***Scenario 2*** | ***Scenario 3*** |
|---|---|---|---|
| ***Alternative 1*** | 0 | – | ++ |
| ***Alternative 2*** | + | ++ | + |
| ***Alternative 3*** | + | 0 | + |

By combining strategy alternatives that perform well in various parts of the system , we can design bundles of strategies that perform best across the different range of uncertainties

## 2.6 CLIOS Implementation Stage (Steps 10-12)

Once we have identified suitable bundles of alternatives, we need strategies to implement them. Strategies are needed both for the physical system implementation, as well as within the institutional sphere. With the implementation strategies designed we can implement the alternatives and monitor the system for improvements. If needed, we can go back to different parts of the process to refine the analysis, the alternatives and the implementation strategies.

Specifically, in this stage we are concerned with the following questions:

- How do these performance improvements actually get implemented, if at all? What compromises have to be made in the name of implementation?
- What actors/organizations on the institutional sphere have an influence on the parts of the system targeted for intervention?
- What implementation strategies are needed to implement the selected bundles in the physical domain?
- What implementation strategies are needed to implement the selected bundles in the institutional sphere?
- Once implemented, what system monitoring capabilities do we have?
- Did the strategic bundles address the problem at hand? If not why? Does the problem need to be redefined? Are different bundles needed? Should implementation strategies be modified?

*Step 10 - Design Strategy for Implementation in the Physical Domain And Implement*

Once robust bundles are chosen, the next crucial (but often overlooked) step is to design a strategy for implementation. Many policy analyses come to an end at Step 9 with a list of recommendations, but with little guidance as to what obstacles might arise in the implementation of these recommendations, how these recommended alternatives can or should be combined into a coherent and integrated strategy, or how the realities of implementation will affect the design of the alternatives and strategies. Hence strategies that enable the implementation of the strategic bundles within the physical system and the institutional sphere are designed. Here negotiation and compromises among the actors may be necessary. In the CLIOS process, identifying a strategy for implementation requires taking the set of good alternatives and identifying combinations of policy alternatives that fit together in a comprehensive strategy. Once the strategies have been designed, implementation can proceed.

Using the commonly agreed implementation strategies for the physical system, we can proceed to implement the selected bundle in the physical system.

*Step 11- Design Strategy for Implementation in the Institutional Sphere and Implement*

The structure of the institutional system itself may affect the ability to implement a strategy. Therefore, to implement the selected bundles we also need to devise implementation strategies for the institutional sphere, often modifying the institutional architecture and structure.. For this reason, we consider Step 11 to be a parallel activity to Step 10, with institutional changes and architecture explicitly being a central part of the overarching strategy for implementation. Here one can evaluate the institutional arrangements that govern the management of the engineering systems. Based on these once can design and implement a set of institutional strategies that facilitate the implementation of the alternatives.

*Step 12 - Post-Implementation Evaluation and Modification*

Once strategies have been implemented, the following step is to monitor and observe whether the intended improvement in system performance actually occurred. One should also be careful to identify any unintended degradation in the performance of one subsystem, due to policies aimed at another subsystem. The capability to monitor the success of policy alternatives is often absent, and therefore one may include monitoring systems as part of the strategy for implementation.

If the policy failed to achieve improved system performance, one should return to the CLIOS representation to assess where and in what manner the failure actually occurred. Looking first at the physical system, one could ask if there was any unanticipated emergent behavior that altered the performance of the system or if any of the links were misrepresented or functioned differently than expected. The lack of performance improvement could also indicate a failure within the policy system. For example, are policy actors working in coordination or competition with one another (as identified in Step 5), or were there fundamental disagreements on the performance measures, and therefore the type of performance that was desirable (Step 6)?

## 2.7 Critique of Engineering Systems Methodologies

Like methodologies in any other field, engineering systems methodologies all have their limitations and drawbacks. In this section we will discuss some of these shortcomings in more detail.

*System engineering* methodologies mainly came out of the Apollo missions of the 1960s, and were designed to enable complex engineering projects such as putting a man on the moon. Later applications were developed in military settings for large-scale projects with often unlimited funding and hierarchical command structure. As such there is little emphasis on distributional issues, organizational impact on technological systems and issues of evaluative complexity. In the case of the Apollo missions for example, the final goal that all decision-makers, engineers, physicists and others involved agreed on was to beat the Soviet Union in reaching the moon first. While people may have differed on how this goal should be accomplished, the underlying values were not different. Therefore traditional system engineering approaches are not suitable to engineering systems with wide-ranging social and environmental impact where the identification of commonly agreed performance metrics in itself is a challenge.

*Optimization methods* are useful tools for static systems with no social interactions. They may be useful for finding the best set of routes for airplanes in a air transportation network system or determine optimal production capacity for manufacturing firms. They are however quite useless for engineering systems with social and environmental impact, since it would be impossible to find a set of criteria to optimize that everyone would agree on, provided that optimal solutions exist at all. Instead engineering systems solutions are most often focused on feasibility rather than optimality.

*System Dynamics* is a very promising systems methodology with important limitations. For one, reducing complex systems into stock and flow structures often results in the loss of important information and may lead to strategies for a system that do not address the issue in its full complexity. Additional issues are the incompatibility of social considerations with stock and flow structures. In most cases the relationship between two components is far more complicated than current system dynamics models can allow for modeling. Another criticism is the quantification of hard-to-quantify issues and values that arise in sociotechnical systems. Also important is the lack of emphasis on structures. Essentially, in a System Dynamics model structure is inferred from dynamics and not the other way around.

Most criticism that comes from outsiders to the System Dynamics community focuses on its early days in the 1960s and 70s. The uncompromising emphasis of Jay Forrester that any system could be modeled with System Dynamics led to skepticism of the field by many social scientists. Particularly, when the field tried to address complex social issues by creating large-scale models and expand its application to many areas where social science scholars had emphasized the inadequacy of simplified system models that could cover the true reasons for emerging problems. However, the field has extensively evolved over time. Essentially the field has shifted away from large-scale systems modeling to problem-centered models and mostly focused in the business community. The survival and growth of the field for over forty years shows its intrinsic values when bearing its limitations in mind.

The *CLIOS process* is too recent, and too theoretical at this point to be evaluated in terms of its strengths and weaknesses. There are many elements that can be considered an improvement over other engineering system approaches. Particularly, by not committing to a single systems analysis tool, it enables the application of different tools in different contexts. A commonly posed criticism for processes such as the CLIOS process, which also apply (maybe even more) to SAM-PD process is the rational engineering structure that may not reflect the realities of complex sociotechnical systems decision-making.

With regards to systems thinking as a whole, there is always a criticism, particularly from the social sciences that many of the abstractions used to study systems as a whole leave a lot of important details out, covering important relationships that obscure the real causes of issues and dynamics in a system.

## 2.8 Chapter Summary

In this chapter we looked at what constitutes an engineering system, and what its characteristics are. We then explored the different types of uncertainties that can arise in its analysis. We further looked at Systems Engineering, System Dynamics and the CLIOS process as different approaches developed to analyze and improve the performance of engineering systems. The chapter also included a brief look at different tools and methods that can be used in each of three approaches to analyze different aspects of a system. In the next chapter we will look at the role of science and technical expertise and their interactions with stakeholders and the public at large in designing policies for engineering systems.

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# ➲Chapter 3
## The Role of Expert Analysis in Decision-Making

*"Whatever social or political values motivate science-intensive disputes, they often focus on technical questions that call for scientific expertise. This is tactically effective, for in all disputes broad areas of uncertainty are open to conflicting scientific interpretation. Power hinges on the ability to manipulate knowledge or to challenge the evidence that is presented to support particular policies. Both project proponents and critics use the work of "their" experts to reflect their judgments about priorities or about acceptable levels of risk. Expertise becomes one more weapon in an arsenal of political tools.*

*--- Dorothy Nelkin, in Controversies and the Authority of Science*

Experts often provide scientific and technical advice that informs decision-makers of alternatives and their respective merits and drawbacks. Yet the role of scientists and experts in the decision-making process is far from clear. Particularly the relationship between experts and decision-makers, between experts and society and among experts can affect the quality of decisions made for engineering systems. In this chapter we will provide an overview of the role of science, scientist and other technical experts as part of the engineering systems decision-making.

### 3.1 The Role of Technical Expertise in Engineering Systems Policymaking

The role of technical expertise in policymaking, specifically in the management of complex socio-technical systems has been increasing in the past two to three decades. According to Adler et al. (2000), due to increased public pressure to resolve complex, and often controversial issues dealing with large-scale natural or engineered systems, policymakers have sought better knowledge on which to base their decisions. As a result, scientists have been more actively engaged in the creation and evaluation of knowledge used for policy purposes. In their comprehensive survey of the literature on the general practice of policy formulation and issues surrounding the role of science in policy, Meidinger and Antypas (1996) argue that the role of science has been constantly on the increase in policy processes for complex systems.

However, there is increased concern that by its inability to reach out to stakeholders, science does not have a significant impact on the dynamics of the decision-making process and that the final products of the decision-making process may show little inclusion of scientific findings (Susskind, 1994).

While scientists blame this on the politicized nature of the public policy sphere and exculpate themselves by asserting they have provided "quality science", the question remains whether scientific analysis that has little bearing on the policy process is indeed good science from a policy perspective. According to Meidinger and Antypas (1996), recent experience has demonstrated that the production of more scientific knowledge for policy often leads only to more questions and more controversy in areas that are already controversial. Rarely has science settled science-policy disputes, thereby raising questions about that actual role of science in the policy process.

Susskind (1994) argues for five main roles for scientists in science-intensive disputes: Trend spotting, theory building, theory testing, communicating science and applied policy analysis. While his argument draws on global environmental issues as a case, these roles can be extended to many other engineering systems policy issues.

According to Dror (1999), one main function of science advice is to supply inputs into the science-related aspects of choices. However, good science advice should fulfill four additional functions regarding high-level decision-making and choice processes such as:
(1) Provide a minimum of science literacy essential for correctly using or rejecting science advice;
(2) Improve cognitive maps of decision-makers and stakeholders
(3) Revise decision agendas
(4) Apply scientific frames of thinking to the non-scientific dimensions of main choices.

He further argues that:

*"Providing a balanced understanding of the scientific bases of main issues on the political agenda, including a feeling for the ambiguities and uncertainties involved, is the most important service science advice can provide the public at large. The counteracting of "magical thinking" and pseudoscience, and consequently the upgrading of public discourse as a whole, is another important task. Both policy-makers and the public at large tend to lack the necessary scientific literacy to understand many of the complex scientific issues being faced today The vast majority of senior governmental decision-makers in nearly all countries lack the minimum of science literacy required to be able to understand and use or reject science advice correctly. Furthermore, they are often unable to utilize scientific modes of thought to better comprehend complex issues. And most parts of the public in all countries are quite unable to evaluate the meanings and judge the validity of the many claims made in the name of science on topical issues, such as environmental policies, uses of biotechnology, hazardous chemicals and so on. Therefore, an important function of science advice is to provide decision-makers and the public at large with at least minimum levels of science literacy and science advice sophistication. This, in turn, requires from science advisors much more than knowledge of science."* (Dror, 1999)

### 3.2 Challenges for Effective Use of Science in Engineering Systems Policy

In their comprehensive analysis of science-intensive disputes, Adler et al. (2000) highlight the different obstacles that can prevent an effective decision-making process.
We have summarized and categorized their insights in Table 3.1. The issues can arise over available scientific data, expertise, the decision-making process and the proposed recommendations.

In this dissertation, we argue that improvements in the process can help address issues on all of the four levels mentioned in the preceding paragraph. Figure 3.1 represents the traditional decision-making process for engineering systems and highlights the interactions between scientists/experts, decision-makers and stakeholders at large. As Figure 3.1

shows, there is a separation between the science sphere and the public policy sphere, in which the decisions are made. In many cases, the scientific and technical complexity of the natural or engineered systems in question necessitates a level of technical and scientific analysis, which has traditionally resulted in the exclusion the majority of the stakeholders from participating in the scientific analysis process.

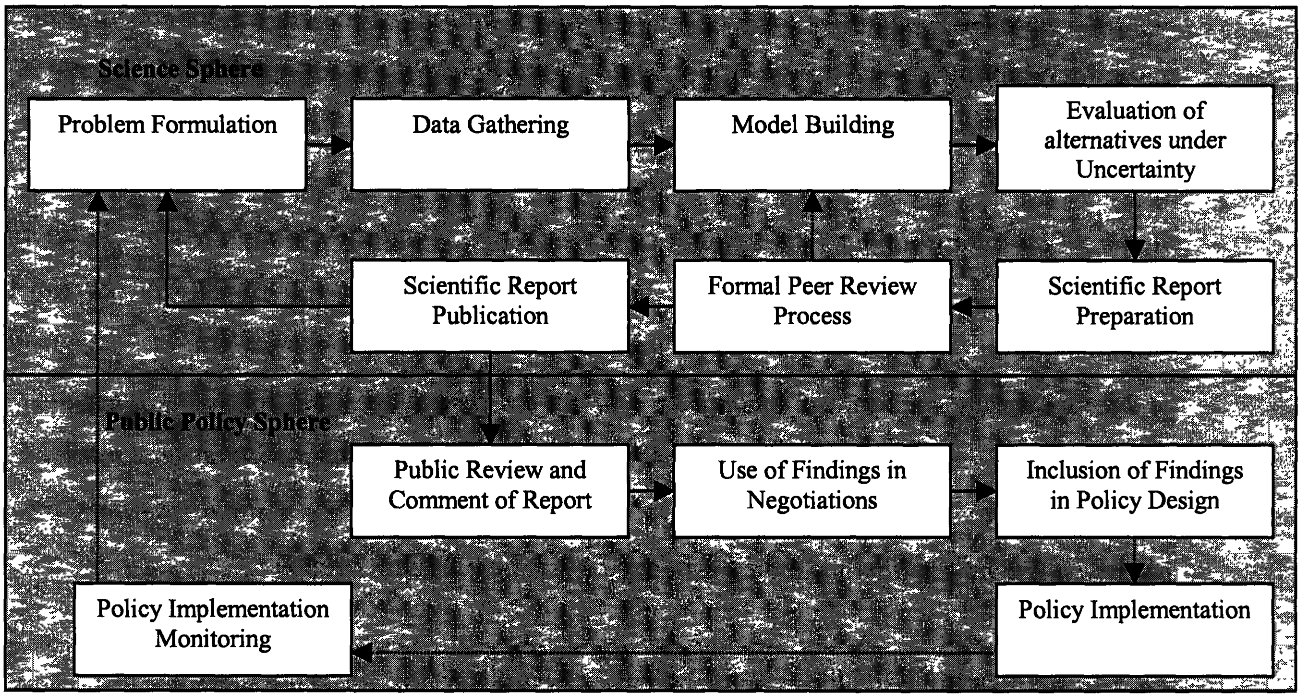


**Figure 3.1. Traditional scientific/technical analysis process for engineering systems. Dotted lines show stages that are potentially part of the process, but are often not carried out.**

Table 3.2 shows some of the problems with the current division between the science sphere and the public sphere that can negatively impact the role of science in decision-making and potential solutions to the problem at the different stages of knowledge generation and flow.

**Table 3.1 Obstacles to effective decision-making in science-intensive disputes (Based on Adler et. al (2000)**

| Issue | **Potential problems** |
|---|---|
| Problem definition | ❑ Poor framing of issue |
| Scientific data | ❑ Lack of access for all stakeholders<br>❑ Inadequacy of existing data<br>❑ Significance of presented data<br>❑ Irrelevance of data<br>❑ Restricted nature of data (confidentiality)<br>❑ Inconclusiveness of data<br>❑ Data not yet verified or not yet usable<br>❑ Commissioned and biased data<br>❑ Technical and scientific uncertainty<br>❑ Outdated data<br>❑ Data overload of stakeholders |
| Expertise | ❑ Multi-disciplinary nature of problem<br>❑ Unevenness in scientific understanding among stakeholders<br>❑ Differential stakeholder tolerance of complexity<br>❑ Commissioned and partisan expertise<br>❑ Theories unsupported by actual data<br>❑ Pseudo-expertise<br>❑ Unrealistic expectations from scientists |
| Process | ❑ Stakeholders engaged after scientific analysis complete or near-complete<br>❑ Stakeholder using science as a cover for other agendas |
| Recommendations | ❑ Lack of economic and social feasibility of recommendations |

Based on insights from Table 3.2, one can identify important factors that affect the effectiveness of scientific advice in the policy process for engineering systems.

### 3.3 Perceived Scientists/Expert Bias and Scientific Advocacy

While there is an underlying assumption that scientific activity is by its definition objective, much debate has risen over the role of value judgments and scientists' biases in scientific advice for public policy issues and regulatory purposes. According to Jasanoff, regulatory or "mandated" science can be understood as "a hybrid activity that combines elements of scientific evidence and reasoning with large doses of social and political judgment". Values enter in various ways, including problem definition, organization of knowledge, choice of research methodology, prioritization of critical issues and dealing with risk (Jasonof, 1991). Majone (1984) introduces the concept of "trans-science", which is characterized by "questions that can be stated in the language of science but are, in principle or in practice, unanswerable in purely scientific terms". He then looks at the contrasts between the U.S. and the ex-Soviet science behind regulation of toxic elements.

While in the U.S. scientists, deem a substance to be non-toxic as long as it exists in levels that do not overload the human body's defense mechanisms or its ability to recover, Soviet science deemed a substance toxic if it evoked any physiological response at all. While the science in both cases is the same, the judgments on acceptable levels of risk are entirely subjective and relate to sociopolitical contexts in which scientists operate. (Majone, 1984). There are many sources of bias for scientists/experts. Anderson (2000) refers to issues of educational background, and dominant values and perspectives in the field of expertise, while Longino (1990) argues that scientists can be influenced by their social, political, economic and religious values.

The subjectivity of scientific advice for public policy has not escaped stakeholders and the public at large. Limogenes (1993) argues that "confidence in the power of expertise has now vanished. For more than fifteen years, analysts of public controversies have pointed out that the involvement of scientists in public disputes has promoted the political polarization of controversies, that expert knowledge has been almost routinely deconstructed in the course of litigations, and that expert interventions have tended to be seen as ritualistic or manipulative schemes, thus losing much of their credibility".

Being aware of the potential criticism against their biases, many "pure" and "conscientious" scientists prefer to stick to their science. Mooney and Ehrlich (1999) indicate that in the minds of such scientists the policy process is a linear clean process, where experts do science, advocacy groups translate the science to meet their own particular goals, and policy makers sift the information received and balance it with general societal issues and constraints, and then make policy. This division of tasks however, may not hold in real controversial science-intensive decision-making processes.

**Table 3.2. Potential problems in different stages of the conventional technical analysis for engineering systems**

| Problems | Process Stages | Possible solutions |
|---|---|---|
| Perceived sponsor and/or organizational bias on problem definition, choice of alternatives and findings | All stages in the scientific sphere | Independent funding for policy-related research, strong oversight on analysis and inclusion of stakeholders throughout the scientific analysis process. Elicit stakeholder inputs in choosing alternatives. Use multiple criteria for comparison, refrain from optimization |
| Perceived Bias in Model Assumptions | Model Building, Formal Peer review Process | Use of a wide range of sensible assumptions and incorporate a sensitivity analysis, agree on acceptable range of uncertainties with stakeholders. Choose wide range of reviewers and include reviewer comments and responses to critique in the final report |
| Uncertainty in baseline data | Data gathering, Model Building | Bounding some uncertainties by bounding social-eco system interaction, provision of funding for good initial data, measuring possible impact and change rather than emphasizing baseline conditions |
| Uncertainty in relationships between system components | Model Building | Early stakeholder engagement and use of stakeholder inputs to gain better knowledge of the system. Use of stakeholder values to bound acceptable uncertainty. Continuous reevaluation as more is known. |
| Uncertainty in future projection | Model Building, Evaluation | Use scenario analysis to bound possible future developments and draft robust strategies that perform well across different futures |
| Exclusion of issues of interest to stakeholders | Problem definition, Evaluation of Alternatives | Inclusion of stakeholders early in the scientific analysis process starting from the problem definition |
| Politicization and selective use of scientific findings | Public review and comment on findings, Use of findings in negotiation, Inclusion of findings in policy design | Make language as unambiguous as possible and clearly explain the significance of uncertainties and the areas of the analysis they impact to avoid selective use. Promptly respond to media characterizations of the findings to prevent misrepresentation. Include stakeholders from early on in the process, make entire process transparent |
| Weak Stakeholder Understanding of the Scientific Process and Findings | Public review and comment on findings, Use of findings in negotiation, Inclusion of findings in policy design | Early involvement of stakeholders in the scientific analysis. Active efforts to explain the scientific complexity and consideration of stakeholder lay knowledge in the process. Create an accessible version of the report with the important highlights for public understanding of the issues considered. Use an accessible report format, supported by easy to interpret figures and graphs. Maximize communication using new participatory techniques. |
| Stakeholder resistance towards implementation | Policy implementation | Change the process towards a more participatory process from the beginning and take into account stakeholder inputs and interests at all stages of the policy-making process. Take into consideration social and political feasibility in addition to technical feasibility of alternatives. |
| No feedback between policy process and scientific analysis (open system) | All stages of the process | Change the process towards a more participatory process from the beginning and take into account stakeholder inputs and interests at all stages of the policy-making process. Continuing improvement and input of science during the process. Use of scientific models in the negotiation and policy design stage. |

On the opposite side, Weiss (1991) argues that there are good reasons for researchers to actually use their knowledge as advocacy in order to have a greater impact on policy. He argues that given the existence of values in the scientific advice process, it is more honest and productive for scientists to explicitly state their biases. He believes that the subjective give and take involved in using research as argumentation among different scientists may ultimately contribute to a more comprehensive picture to be formed of the issue at hand.

A drawback of this argument is that often there are subtle biases, such as disciplinary biases, educational backgrounds and institutional culture, that are not obvious to the scientists themselves. According to Susskind (1994), adversarial science can seriously undermine the effectiveness of science in decision-making. However, he argues that there actually are legitimate sources of scientific disagreement, which can be countered by setting up representative scientific committees from all sides of the issue.

One possible solution, which is advocated in this dissertation, is the joint expert, stakeholder and decision-maker engagement in the scientific analysis process.
While stakeholders and decision-makers may not be able to perform atmospheric modeling, they are able to contribute in terms of data, resources and institutional and social feasibility. The inclusion of all science producers in a research consortium that works towards a solution for the system can help formulate more diverse, more robust solutions that are accepted across the board. Different perspectives, disciplines and backgrounds can help the group to look at the system in many more ways than any of them could individually. Additionally, the interaction provides a chance for everyone to understand the scientific analysis process, and to agree on the bounds of uncertainties acceptable for making decisions. Science-producers should not stop at the general recommendation level. They should be involved in all stages of the decision-making process, even post-implementation to review the effectiveness of policies. It is imperative that the scientific analysis team find ways to improve the chances of a recommendation being implemented by finding a "champion" for the cause without compromising scientific and technical neutrality.

Lach et al. (2003) conducted interviews among scientists, decision-makers and various stakeholders on what role they think scientists should play in the decision-making process. Tables 3.3 and 3.4 show the how the interviewees perceived of the preferred role for scientists and factors that influence scientific credibility.

**Table 3.3 Mean scores showing preferred role for scientists in natural resource decision-making, and *F*-test results (Lach et al, 2003).**

| Scientist role | Scientists | Managers | Interest groups | Attentive public | *F*-test |
|---|---|---|---|---|---|
| Scientists should only *report* results and leave others to make management decisions | 2.86 | 3.18 | 2.45 | 2.72 | 7.588*** |
| Scientists should report results and then *interpret* for others involved in management decisions | 4.18 | 3.92 | 3.99 | 3.86 | 3.696** |
| Scientists should work closely with managers and others to *integrate* scientific results into management decisions | 4.09 | 4.30 | 4.20 | 4.28 | 1.867 |
| Scientists should actively *advocate* for specific natural resource management decisions | 2.20 | 2.19 | 3.21 | 2.95 | 28.847*** |
| Scientists should *make decisions* about natural resource management | 1.66 | 1.79 | 2.65 | 2.47 | 32.110*** |
| | $n = 154$ | $n = 167$ | $n = 117$ | $n = 190$ | |

*Note:* Survey question: We would like to know what you think should be the proper role of scientists in natural resource management decisions. Please indicate your level of agreement or disagreement with the following statements. Scale: 1, strongly disagree; 2, disagree; 3, neutral; 4, agree; 5, strongly agree. Significance level: *** $p < 0.001$; ** $p < 0.01$.

Table 3.3 provides some interesting insights that are worth noting:

- Among the Decision-makers (managers) there seems to be a stronger inclination towards keeping scientists out of the entire decision-making process.
- Scientists, decision-makers, interest groups and representative stakeholders all agree that scientists should produce the scientific results and help integrate and interpret those decisions by actively working with those involved in decision-making.
- Not surprisingly, interest groups support scientists' advocacy more than other interviewee groups.
- Scientists and decision-makers are strong opponents of scientists making the decisions in the science-intensive process (in this case natural resource management).

**Table 3.4 Mean scores showing factors perceived to be important to individual scientist credibility, and *F*-test results (Lach et al, 2003).**

| Factor | Scientists | Managers | Interest groups | Attentive public | F-test |
|---|---|---|---|---|---|
| The quality of the methodology used in their scientific research | 4.70 | 4.18 | NA | NA | 5.28** |
| The scientific data and information generated in their research | 4.64 | 3.73 | 3.90 | NA | 39.31*** |
| Their reputation in their field of research and specialization | 4.35 | 4.00 | 4.03 | 3.89 | 7.60*** |
| Quality of the scientific and professional journals in which they publish | 3.94 | 3.11 | NA | NA | 6.44** |
| Their ability to make significant contributions to interdisciplinary research | 3.95 | 3.99 | NA | NA | 0.87 |
| Their experience and knowledge about the management of public lands | 3.62 | 4.18 | 4.18 | 4.30 | 19.97*** |
| The applied and practical character of their research and findings | 3.41 | 3.40 | 3.97 | 3.88 | 26.52*** |
| The length of time they have spent working in their area of research and specialization | 3.35 | 3.53 | 3.70 | 3.77 | 6.44*** |
| My personal familiarity and interaction with them | 3.14 | 3.38 | 3.42 | 3.22 | 1.74 |
| The quantity of their publications | 2.96 | 2.25 | NA | NA | 5.28** |
| **The scientist's ability to communicate effectively with...** | | | | | |
| Resource managers | 3.86 | 4.40 | NA | NA | 11.89*** |
| Legislators and elected officials | 3.19 | 3.66 | 3.52 | 3.97 | 14.59*** |
| The general public | 3.13 | 3.71 | 3.86 | 4.15 | 27.45*** |
| Interest groups | 3.00 | 3.74 | 3.78 | 3.86 | 20.00*** |
| Media representatives (TV, radio, newspapers) | 2.92 | 3.36 | 3.44 | 3.84 | 18.21*** |

*Note:* Survey question: We are interested in your opinion about the importance of the following as indicators of credibility of individual scientists who work on natural resource issues and ecological questions. Scale: 1, not important; 2, little importance; 3, moderately important; 4, important; 5, very important. Significance level: *** $p < 0.001$; ** $p < 0.01$.

Similarly, Table 3.4 provides interesting insights into what factors contribute to the credibility of scientists in the science-intensive policy process:

- Scientists and decision-makers (here resource managers), believe that credibility comes with quality of their methodology and the data that they have produced.
- Non-scientists believe scientists are more credible when they do have practical experience in the decision-making problem (in this case resource management).
- Scientists and managers care more about the reputation of the scientists providing the advice than the involved public stakeholders.

- Scientists put a lot of emphasis on the reputation of the journals studies have been published in, while others have less emphasis on this aspect.
- In terms of communication, scientists put little emphasis on communicating with the media, while the involved public stakeholders believe this to be very important in the credibility of the scientists.
- Decision-makers tend to believe that they are the most important audience of scientific communication.
- In general, scientists tend to follow the same mindset for scientific credibility in the case of decision-making processes that they apply to science for science situations, while decision-makers, stakeholders and interest groups have more of an emphasis on science that is useful to them in the decision-making process.

### 3.4 Communicating Science and Scientific Uncertainty

According to Bird (2000), the lack of a general understanding of science both in society as a whole and among policy-makers is notorious. Yet even for science professionals, significant useable knowledge of scientific information outside one's own field of expertise is fairly limited. Public understanding of science and technology is clearly only one element in the development and implementation of scientific advice. Normally scientific advice develops out of the interactive communication of scientific information to policy-makers by science experts. He also points to a potentially more fundamental and two-fold problem. On the one hand, policy-makers and stakeholders rarely have a strong or even adequate science background and mechanisms for assuring that they obtain the science and technology information that they need are limited (Brademas, 2001). On the other hand, science professionals, especially those who conduct research in academic settings, are generally not good at communicating science to those beyond their peer group (Valenti, 2000; Garrett and Bird, 2000). Furthermore, scientists rarely acknowledge the importance of providing information to the public who fund science (Rensberger, 2000). More importantly, scientists do not generally recognize their role in enabling the broader set of stakeholders to participate effectively in public policy decisions that depend on science. In addition, most scientists are not trained to present scientific information to those outside their professional community, whether policy-makers or the public at large.

Arlid Underdal argues that scientific information is often in greatest demand when cause and effect relatonships are most obscure. This means that science often operates under a handicap in policy situations because it deals only with the most complex questions. While scientists are trained to think in an uncertain world, stakeholders need to know that a recommendation will *definitely* solve the problem in question. This becomes more and more of an issue when the stakes in a problem are high, and when decisions impact many stakeholders. She further argues that scientists are also under conditions of time pressure in which only probabilistic science with tentative conclusions can be produced (Underdal, 1989).

The decision maker's need for certainty in the short term and the scientist's inability to deliver it largely explains the perceived "uneasy partnership" between science and policy. One consequence of this is that many engineering systems decisions must be made in the face of fundamental uncertainty where the range of possible consequences is unknown. As an illustration, based on an interpretation of the uncertainty literature, we have proposed the conceptual representation shown in Figure 3.2. The figure shows that the scientific uncertainty for any engineering system starts at a non-infinite level and drops rapidly at first, reaching stages where the uncertainty is reduced dramatically when a threshold of knowledge on the problem is passed. The rate of uncertainty reduction however decreases over time, until it smoothes out in the long-term, with an irreducible uncertainty remaining for the system under study. A negative exponential that levels off at a certain stage can also approximate this trend. Exactly what levels of uncertainty are acceptable for decision-making purposes depends on the severity of potential outcomes and the resources and time available for scientific research.

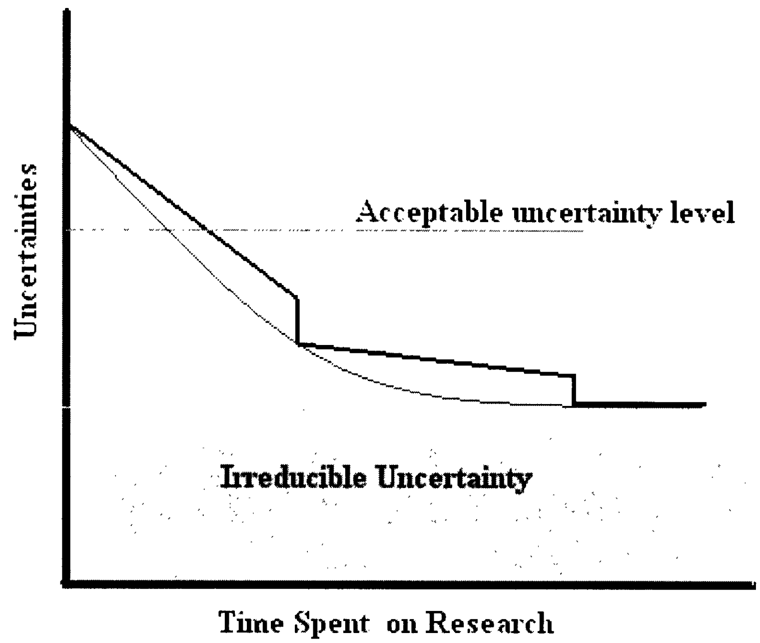


**Figure 3.2 Proposed model for the relationship between scientific uncertainties in an engineering system and the time spent on Scientific/Technical Research**

*Science Communication Strategies*: In engineering systems decision-making, the scientific analysis used to arrive at the recommendations is often so complex, that non-experts (or sometimes even outside experts) cannot understand the rationale behind the results. Therefore it has been suggested that scientists/experts try to find ways to communicate scientific knowledge in a way that enables decision-makers and stakeholders to make informed decisions.

Lach et. al (2003), asked different stakeholders, scientists and decision-makers involved in science-intensive disputes about the importance and value of different scientific communication strategies that scientists could use. Table 3.5 shows the results of their study. Not surprisingly, scientists prefer to communicate the results of their studies either in academic journals or at professional conferences, while decision-makers and stakeholders prefer that scientists directly communicate to stakeholders.

**Table 3.5 Mean scores of perceived importance of various communication strategies, and *F*-test results (Lach et al, 2003).**

| Strategy | Scientists | Managers | Interest groups | Attentive public | *F*-test |
|---|---|---|---|---|---|
| Publish research results in academic journals | 4.36 | 3.91 | 3.94 | 3.88 | 8.60*** |
| Present research results at professional meetings | 4.16 | 3.74 | 3.78 | NA | 6.83*** |
| Communicate research results directly to the public through organization/agency publications | 3.68 | 3.93 | 3.68 | 3.92 | 3.80** |
| Communicate research results directly to the public through trips or on-site demos | 3.61 | 4.25 | 3.87 | 3.99 | 11.39*** |
| Communicate research results to the mass media (newspaper, television, radio, etc.) | 3.43 | 2.40 | 3.11 | 3.24 | 28.09*** |
| Communicate research results directly to the public through the Internet | 3.41 | 3.01 | 3.05 | 3.25 | 4.66** |
| Testify at public planning hearings for natural resource agencies | 3.32 | 3.07 | 3.61 | 3.74 | 13.57*** |

*Note:* Survey question: We are interested in how you report and communicate your research on natural resource and ecological issues with various audiences. How important do you consider these activities? Scale: 1, none; 2, limited; 3, somewhat; 4, important; 5, very important. Significance level: *** $p < 0.001$; ** $p < 0.01$.

Realizing that communication is necessary is not sufficient. Most scientists are not trained to communicate science to non-peers. As Dr. Neal Lane, head of the National Science Foundation, one of the most prestigious scientific entities in the U.S., states: "With the exception of a few people … we don't know how to communicate with the public. We don't understand our audience well enough – we have not taken the time to put ourselves in the shoes of a neighbor, the brother-inlaw, the person who handles our investments -- to understand why it's difficult for them to hear us speak. We don't know the language and we haven't practiced it enough (cited in Hartz and Chappell 1997)."

In this regard, it is important to learn from the experience of scientific communicators in museums and popular science writers (such as Carl Sagan, or Martin Reese), who are able to explain complex scientific concepts in simpler, yet still accurate terms.

### 3.5 Interactions among stakeholders, decision-makers and scientists/experts

Based on a categorization of stakeholders by Karatzas (2001), the stakeholders in a science-intensive dispute consist of scientists/experts who provide advice, decision-makers in government or regulatory organizations that are very often called upon to make decisions based on complex issues with social and economic implications, and stakeholders in the form of individuals or organized groups that try to influence the impact of the decision on their lives. Additionally, the role of the media is important, given the need to inform public opinion. Communicative interaction among all these groups is essential in shaping the decision for an engineering system.

*1) Scientist-Decision-maker interactions:* As discussed earlier, more and more decision-makers consult scientists/experts on engineering system policy. They ask particular questions, which scientists try to answer to the best of their ability within the timeframes required. However, according to Nelkin (1987) science-intensive disputes are never only about the technical issues involved. While the terms of the debate may be technical, the underlying issues "are a means of negotiating social relationships and of sustaining certain values, norms, and political boundaries at a time of important scientific and technological change". Questions of equity or justice arise over the allocation of resources or the distribution of economic and social costs of recommendations. Many of the recommendations that the scientific community comes up with do not consider societal or political feasibility. Once scientific results are submitted to the decision-makers, scientists often leave issues of social and institutional feasibility to decision-makers, often without helping them to integrate scientific findings with such considerations. Given that the process is not really iterative, decision-makers are stuck with recommendations that may not be socially or institutionally feasible at all. Thus, they may turn their backs on science and make their decisions based on institutional interests, giving the appearance that the science has been used as a basis. This can also lead to many scientific recommendations becoming ineffective in the actual policy-making process. The actual framing of the question, the format of the output, and the consideration of social and institutional issues should be integrated into the initial scientific analysis process as important considerations.

2) *Scientists-Stakeholder interactions:* Scientists are used to working in their own defined scientific environments, where the rules of interaction are relatively clear. They have traditionally been wary of being involved in the actual policy process, fearing that their scientific objectivity may be questioned. Therefore, they have often interacted only with decision-makers, in the form of scientific advice, and avoided direct interactions with

stakeholders. This type of scientific analysis however, which is not directly responsive to stakeholder concerns and knowledge, often leads to the ineffectiveness of science in playing its intended role as the central piece of decision-making and moves the process towards an adversarial and politicized atmosphere, unlikely to produce robust and stable solutions. Stakeholders often have knowledge of the system that can be used to formulate more effective recommendations. Additionally, the engagement of stakeholders can result in their increased acceptance of the recommendations, given the feeling of process ownership that is developed. Most scientific analysis processes assume that once scientifically sound recommendations are out there, someone will implement them. This is often not the case, given that recommendations require actual implementation plans that have to be drawn up by people who are familiar with the scientific analysis. This normally requires interdisciplinary trained experts, with good technical and scientific grounding, as well as extensive knowledge of the policy process, who can serve as an interface between scientists and society. This highlights the importance of engaging stakeholders and decision-makers from early on, so that sound and practical implementation schedules can be drawn up.

*3) Scientist/Scientist interactions:* Even more surprising than the lack of stakeholder engagement, is the limited cooperation among scientists and experts. As previously indicated, in the traditional science-intensive decision-making process contesting groups have the opportunity to generate competing scientific and technical knowledge to promote their positions in the decision-making process. This type of competing scientific analysis has been called "adversarial analysis" or "dueling scientists." Ozawa (1991) cites several risks that can arise with adversarial analysis in a decision-making process. First of all he argues that the contesting groups can withhold or manipulate information to aid their respective cases, which may result in poorly informed policy decisions. Furthermore, he indicates that the knowledge claims made by any one group can become suspect in the eyes of contesting groups, which can delay or prevent a consensus in the process. This emerges from the fact that participants are denied a mutually acceptable foundation of knowledge upon which to negotiate policy agreements (Ozawa, 1991). Instead he proposes an alternative approach where the different groups involved in a science-intensive dispute collaborate to assemble and oversee a joint research team, that aims to construct a single technical analysis of the disputed issue that will be acceptable to all of the stakeholders. Members of such a research team can be selected by representatives from all stakeholders and their progress can be continuously monitored by all those involved in the decision-making process. Resources (finances,information, and equipment) are pooled to support the research and the results are accessible to all the participants (Ozawa, 1991). Pooling resources among scientific knowledge producers and working together to solve a common problem could enhance the depth and the scope of scientific knowledge that can be used as the basis for an informed decision. The issue of pooled resources becomes very important in terms of available information for analysis, given that shared information can reduce many uncertainties that arise from unavailability of data. Unfortunately, most of the time this becomes an issue with financing research projects and competing grants for similar research, undermining effective cooperation.

### 3.6 System Representations and System Models as Boundary Objects in Science-Intensive Disputes

Scientific models are simplified representations of the important structural elements and dynamics of a system that allow us to better understand it. According to Adler (2000), most science-intensive decision-making processes benefit from some form of modeling in order to define problems, review impacts, or illustrate alternatives.

While scientific models are often thought of as descriptive and predictive of a system's behavior, they can also help improve communications in science-intensive disputes. In other words, models can serve as "boundary objects". Boland and Tenkasi (1995) define a boundary object as a visible representation of individual or community knowledge or perspectives that enables the communication of those perspectives to others in a different community. This concept supports the idea that an artifact, such as a systems model that takes into account various perspectives, can mediate collaboration and serve as an interface among stakeholders, scientists and decision-makers.

While models are useful, it is not wise to believe that it would be possible to expect a singular value generated by a model predicting a future state with absolute certainty. Stakeholders have to understand the uncertainties involved in the modeling and its assumptions. Models can help differentiate among alternatives, but cannot enumerate the one true and correct answer. Therefore it is important to think of models as illustrative rather than predictive (Adler, 2000).

The use of models becomes even more confusing to the stakeholders, when opposing parties bring different models to the table based on differing assumptions about inputs, interactions between variables, and outputs. The models then are staged to be in opposition to one another, when in reality they rely on different assumptions, system boundaries and initial values, and are essentially incomparable. That is why it makes more sense to develop models jointly, with various experts cooperating in its development. When such a joint development is not possible, the assumptions in the competing models have to be clear for all the experts involved.

According to Dürrenberger et. al (1999), good models for science-intensive decision-making processes:

- should have manifest links to locally and/or personally tangible issues
- should have a high degree of visualization and interactivity
- should have simple structures, be transparent and have short operating/running times.
- should not be regarded as a substitute for other types of information outputs

Also, developing models should not be an entirely expert matter. Specifically when it comes to defining the system boundaries (problem definition) and the outputs required to make an informed decision, stakeholders and decision-makers should be able to have their say.

*System representations:* An engineering systems decision-making process may require the use of multiple models, each dealing with a different part of the system. It is useful to have a system-wide model that combines results and models from the physical, biological, economic and social aspects of the system, and the interactions between them, to evaluate the how changes in any of these aspects can affect the system as a whole. These system-wide models constitute the core focus on models in this dissertation. Developing a system-wide model that can organize the different types of information about the system requires the presence of system modeler(s) in the decision-making process. The role of such an individual or group of individuals is to help integrate different models and types of information into a system-wide representation that will allow decision-makers, scientists and stakeholders to make decisions on the system as a whole.

### 3.7 Obstacles to Increasing the Role of Expertise in Decision-making

The literature presented in this chapter is by no means comprehensive, nor can it be with an engineering systems audience in mind. The picture presented in this Chapter essentially presents arguments *for* a more aggressive science role in the public sphere, but does not address the major obstacles that make such a role improbable within the current institutional structure. For one, the discussion does not emphasize the role of the embedded scientific culture and the existing reward and incentive structure that undermines the involvement of science in public decision-making. In addition to the centrality of the notion of objectivity and non-advocacy to credible science in the eyes of scientists and experts, few incentives exist for such a change to occur. The following are some of the main issues that need to be addressed for a more active role of science/expertise in public decision-making processes, with particular emphasis on engineering systems.

*1) Politicization of technical analysis:* Most experts wish to refrain from being seen as advocates in the eyes of their peers or society. Yet, any recommendation-based technical report is often considered as strengthening the arguments of one side within an engineering system controversy. A good example of such an instance is Ted Postol's Patriot Missile report that sparked a controversy at MIT, and led to serious endangerment of Postol's academic position. Postol, an MIT Professor in the Science, Technology and Society program gave testimony in front of the U.S. Congress on the ineffectiveness of the Patriot missiles during the first Gulf War, which was vehemently criticized by experts hired by the manufacturer, or representing the arms industry[13]. The controversy sparked a feeling of discomfort within the MIT community, with the MIT administration looking to resolve the

[13] See "The Patriot Missile. Performance in the Gulf War Reviewed" http://www.cdi.org/issues/bmd/Patriot.html

issue by forming independent committee. Due to the importance of the multi-million dollar deal that was supposed to integrate Patriot missiles in the National defense budget, it took the committee five years to come to a conclusion. During this time Postol and his department came under attacks by Lockheed Martin and Raytheon, who implicitly threatened to reduce the amount of research funding made available to MIT if Postol stayed on as a faculty member.

*2) Obstructionism and irrationality of stakeholders:* Another obstacle on the side of experts is the belief that there are always stakeholders who would want to stop a process dead in its tracks no matter what the facts. Therefore, many experts do not wish to involve themselves in a process where they feel their expertise is viewed as a bargaining chip.

*3) Knowledge disparities and integration of stakeholder (local) knowledge*: Another challenge to all the preceding discussions is the knowledge disparities among stakeholders that would make it difficult for experts to engage them when presenting their findings. Many experts are only trained to present their technical findings to audiences with similar backgrounds, and fail to interact effectively with stakeholders who may not be trained technically. Also important is the weight of stakeholder or local knowledge when compared to expert knowledge in the policy process. Experts are not comfortable with accepting stakeholder knowledge that has a different source of legitimacy than what they are used to.

*4) Incentive structure:* In the time it takes academic experts to participate in a single public policy process, they can publish several papers on more tractable issues. In addition to not being awarded for involving themselves in such processes, they are looked down on by their peers and the academic system. Most academic institutions and technical advisory agencies do not reward the interaction with stakeholders, and may in fact give preference to experts that focus on their publications.

### 3.8 Chapter Summary

In this chapter we looked at the role of science in science intensive disputes, and looked more closely at the different challenges that scientists, decision-makers and stakeholders face in reaching informed decisions in the face of uncertainty and bias. We explored issues of communicating uncertainty and the use of models for science-intensive disputes. The discussions all pointed to the argument, that while a collaborative process, where decision-makers, stakeholders and scientists all work together to reach informed decisions can overcome many of the obstacles that science-intensive disputes can pose, it cannot address all of them. Many of these obstacles have to be overcome by institutional and legal changes that go beyond a single process.

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# ➲Chapter 4

## Stakeholders Involvement in Engineering Systems

*"Our public men have, besides politics, their private affairs to attend to, and our ordinary citizens, though occupied with the pursuits of industry, are still fair judges of public matters; for unlike any other nation, we regard the citizen...[as] able to judge proposals even if we cannot originate them; instead of looking on discussion as a stumbling-block in the way of action, we think it an indispensable preliminary to any wise action at all.*

*-- Pericles, Athenian Statesman 5th Century B.C.*

### 4.1 Institutional Support for Public Involvement throughout History

Public involvement in decision-making is not a new idea. It has existed in one form or another throughout human history.

In the earlier days of civilization, Tribal elders met to collectively discuss pending decisions and consulted other members of the tribe to add their views and contribute with their domain knowledge. Public participation in decision-making was part of the democratic structure of Greece from 7th Century BC until their conquest by the Romans. Ancient religious traditions have also valued public participation in decision-making. In synagogal Judaism, leadership was defined as an egalitarian exercise, which featured the interaction of a multitude of counselors in making important decisions for the community[14]. Rabbinical traditions of "Halacha", such as those expressed by Rabbi Rashba in the 13th Century, indicate the need for representatives of different interests in the community to come together to make decisions on issues important to the community as a whole. He indicates that "otherwise no community would ever be able to do anything--plan a budget or pass legislation--without assembling all the taxpaying citizenry (in questions

[14] Source: Personal Q&A with Rabbi S. Hazan, Askmoses.com Rabbinical Staff on questions on Judaism on May 26, 2004.

that entail expenditures), until a consensus can be reached--a consensus which would have to include the women as much as the men, since how can anyone dispose of their money without their permission?"[15]

Based on the same Judaic traditions, plurality and collective decision-making were also the norm in the earliest Christian churches, before the more centralized religious authorities, such as the Vatican, consolidated power.

In Islamic scriptures, two modes of public consultation are mentioned. In the first one, community leaders are asked to consult with their companions, but the final decision is their own. In the other, the community is encouraged to administer its affairs by mutual consultation, making a public consensus for decisions mandatory. In the Qur'an there is a strongly-worded verse commanding the faithful to consult with one another on different issues that related to society.[16]

As societies became more united under centralized feudal powers in the Middle Ages, the ideas of public participation faded in the social structure. According to Nicolai Machiavelli, the famous medieval consultant to the King of Florence, consultation with the public on any issue would be a conceived as a weakness that could endanger the throne[17]. On the other hand, in 1215 AD, the Magna Carta opened the door to a more participatory system in England. Forced by British Nobles, King John created the English "Parliament", or law-making body, and stated that the written laws held a higher power than the king.

From the age of enlightment onwards, the history of public involvement in decision-making is essentially the same as the history of democracy. The first representative colonial assembly in America was held at Jamestown, VA in 1619. According to the British Petition of Rights (1628) the King was unable to tax without the parliament's

[15] S. Morrel, "The Constitutional Limits of Communal Governmnent in Rabbinic Law," *Journal of Jewish Social Studies* 33 (1971).
[16] "The Qur`an" Surah 42 verse 38
[17] Niccolo Machiavelli, *Discourses*, Chapter 14

permission and the Bill of Rights (1689) emphasized freedom of speech and banned cruel punishment, paving the way for parliamentary democracies in the centuries to come.

In the 18th Century, Jean Jacques Rousseau wrote "The Social Contract", in which he states that a government failing to serve its constituents should be overthrown and substituted by a government that serves them. Twenty years later, in 1787, the American Constitution and Bill of Rights were established, permitting the states to allow white male property owners to vote or to hold an elected office through a democratic process. With the French revolution in 1789, the first citizen councils were established in Europe, and a new era for democracy was begun. In 1893, New Zealand became the first country in the world to establish a system of universal suffrage. Following World War II, the newly established United Nations issued the Universal Declaration of Human Rights, guaranteeing all people in all countries their basic rights and encouraging democratic governance.

Still, the increased role of representative democracy did not necessarily mean the increased participation of the public in decisions that affected them. Even in truly democratic countries, except for elections that were held at the end of each term, citizens had little or no say in how the government(s) made public decisions. Numerous executive agencies were set up by each government to make decisions on ever increasing social, economic and legal issues that arise with the advent of the technological society. When making decisions on science and technology-intensive systems, governments primarily relied on advice of scientific and technical "experts" they themselves appointed to the task, and merely announced the decisions to the public. As societies became more complex, and the impact of advanced technologies on the environment and societies became more and more uncertain, the interest in public participation in decision-making, particularly in the context of developed countries with representative democracy, increased significantly. In the United States, the social movements of the 1960s were an impetus for more participatory democracy. (Hoberg, 1992)

With the Congressional passage of the National Environmental Protection Act (NEPA) in the United States in 1968, a statutory basis for citizen lawsuits was created that "gave citizen groups a bewildering multitude of legally actionable standards by which to measure agency behavior" (Hoberg 1992). The ability of citizen groups to file suits against government agencies in the court of law has had a dramatic effect on the way government agencies view the importance of public participation in decision-making processes.

By 1979, the Environmental Protection Agency had revised its public participation regulations to provide more effective public involvement in planning and carrying out water pollution control, solid waste management, and drinking water programs in all programs under the Clean Water Act, the Resource Conservation and Recovery Act, and the Safe Drinking Water Act.

Beginning in the 1970s, government agencies in the U.S. and Germany started using citizen juries for complex scientific issues policy analysis. A citizens' jury consisted of a group of 12-16 randomly chosen citizens as jurors and created an opportunity for jurors to consider how to best deal with a public policy problem. In the Netherlands, such a jury is currently required for most important policy decisions.

The legal systems of countries have an enormous impact on the ways stakeholders are involved in decision-making. Most European legal systems can be viewed as examples of bureaucratic legalism. They emphasize a hierarchical, and bureaucratic supervision of legal decision makers, a small role for aggressive legal advocacy judicial domination of the adjudicative process, and a restricted role for judicial policy making (Kagan, 2001). In European countries, the executive branch makes decisions that cannot be taken to court by individuals who are dissatisfied with the decision. The scientific arguments underlying the decisions are shielded from "competing science", and it is up to the executive branch to preserve the interest of citizens. In fact the assumption is that the executive branch, in designing or implementing policies is above personal, partisan or institutional agendas, and is acting on behalf of the public. It is in this atmosphere that a person like Habermas has advocated a deliberative public sphere, where the executive branch is held accountable for decisions, and where dialog among stakeholders is incorporated in the policy process

(Habermas, 1962)[18]. There is no motivation on behalf of the executive or legislative branch to cave in to such demands, given that the only recourse citizens have at their disposal are the next elections, which often do not change actual policymakers (bureaucrats) in the executive branch. In Europe, it is thus the rebellious and those with more leftist tendencies that advocate such an approach. *Adversarial legalism* on the other hand, is a hallmark of Anglo-Saxon societies such as the UK (not really considered part of Europe by most) and the U.S. According to Kagan (2001) , in an adversarial legal system, "competing interests and disputants readily invoke legal rights, duties, and procedural requirements, backed by recourse to formal law enforcement, strong legal penalties, litigation, and/or judicial review." Additionally he points out that adversarial legalism results in "a style of legal contestation in which the assertion of claims, the search for controlling legal arguments, and the gathering and submission of evidence are dominated not by judges or government officials but by disputing parties or interests, acting primarily through lawyers." (Kagan, 2001)

This becomes important in the policymaking arena, particularly because of the ability of marginalized groups to take Federal agencies to court for not having adhered to their mandate. The court can then rule based on the "spirit" of the legislation, whether the complaints are valid. Federal agencies therefore are tending more and more towards participatory processes to minimize the potentials for legal action against them. As more and more complex and contested issues emerge, this has resulted in a gradual realization that collaborative processes may in fact be better ways of wise decision-making. In this respect, the combination of an adversarial legal system, and a representative democracy has created a natural need for more formalized deliberative democracy on the local, state and national scale. That may in part explain of why Montana, a (conservative) state with constant conflict among miners and mining companies (for instance the famous case of Butte, MT[19]), and a rich history of confrontation with the Federal government was one of the first states to realize the importance of collaborative processes in resolving conflict.

[18] Habermas, J., *The Structural Transformation of the Public Sphere* (1962)
[19] Butte, Montana has a history of mining labor conflict, that often turned to violent and deadly confrontations between labor and police. See http://www.butteamerica.com/labor.htm

With the exception of some state-level initiatives, public involvement in the U.S. is still relatively limited in terms of the level of participation of stakeholders, and its impact on the decision-making process. Often, stakeholders are only informed of decisions, and do not have an active voice in shaping the decisions. In the following section we will look at the different types and levels of public involvement used in the public decision-making process.

**4.2 Who is a Stakeholder Anyway?**

So far we have interchangeably used the terms "public participation" and "stakeholder participation". But there are important differences. Public participation normally does not differentiate among different members of the public. Generally, the public refers to the citizens at large.

Stakeholders are often a subset of the public. The Merriam-Webster definition for stakeholder is" A person, group, or business unit that has a share or an interest in a particular activity or set of activities". In the context of this dissertation, stakeholders can include national, federal, state, provincial and local government decision-makers, advisory government agencies, private sector actors, citizen groups, environmental groups, labor unions, trade associations, as well as academic experts and consultants. For that reason, on the theoretical level stakeholder involvement is seen as more inclusive and targeted. However, in reality stakeholder involvement processes can serve to eliminate the "fringe elements" or to undermine the participatory capacity and negotiation power of the least powerful (English et al., 1993).

Additionally, we are using "involvement", "engagement", and "participation" interchangeably. A differentiation among these is really desirable, but can lead to confusion, since it is used interchangeably throughout the literature. Generally, the way we see it, the difference lies with the "proactivity" of the involvement process.

### 4.3 Levels of Stakeholder Participation

Public participation can happen at different levels, with different goals and outcomes. One of the first people to work on different public participation levels and their implications was Sherry Arnstein. She illustrated that different levels of participation had widely differing consequences for the decision-making process. According to Arnstein, "there is a critical difference between going through the empty ritual of participation and having the real power needed to affect the outcome of the process. This difference is brilliantly capsulized in a poster painted last spring [1968] by the French students to explain the student-worker rebellion" (See Figure 4.1)

Arnstein proposes a participation ladder that is to serve as a typology of eight levels of participation that is reproduced in Figure 4.2.

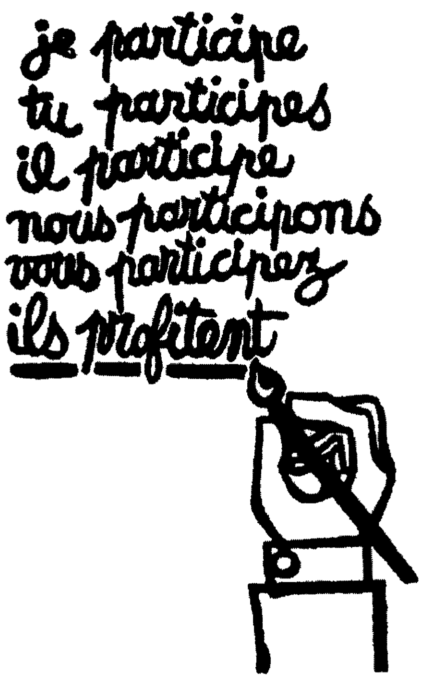


**Figure 4.1 French student poster. In English, "I participate, you participate, he participates, we participate, you participate...they profit." (Source: Arnstein, 1969)**

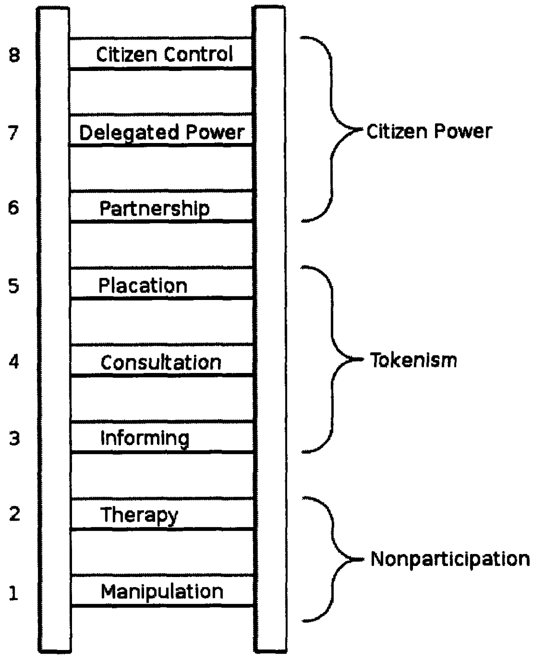


**Figure 4.2 Eight rungs on the ladder of citizen participation (Arnstein, 1969)**

In the lower levels of participation (characetrized as nonparticipation by Arnstein), Manipulation and Therapy are not ways to enable people to participate in planning or conducting programs, but to enable powerholders to "educate" or "cure" the public. In the third and fourth levels of "tokenism", stakeholders are able to hear and have a voice through *Informing* and *Consultation.* They however lack the power to insure that their views will be in any way considered by decision-makers. In *Placation,* stakeholders develop the right to advise decision-makers, but the latter still control decisions. At a higher level of participation (the citizen power levels), stakeholders can enter a *Partnership* that enables them to negotiate and engage in trade-offs with decision-makers. At the *Delegated Power* and *Citizen Control* levels, stakeholder achieve decision-making control. In this dissertation, we are mostly concerned with moving from Arnstein's *Informing* and *Consultation* levels to higher levels of involvement, i.e. active stakeholder participation in engineering systems analysis and decision-making process (*Partnership* and *Delegated Power* levels). For engineering systems, a *citizen control* participation level is a revolutionary concept that would require the current ways of thinking to change dramatically. Here, the experts and decision-makers would give up control over the decision-making process fully to stakeholders. This would require a paradigm shift in the legal structure, and in expert mindsets and may not be feasible within the societies we live in now. Within the limits of this dissertation, we intend to focus on those levels of participation that do not require significant changes in the institutional structure and can be achieved by modifying existing practices. We leave the revolutionary changes as areas of future research.

Hale (1993) divides public involvement into three categories based on the intended outcome: public awareness (increasing public knowledge that a problem or issue exists), public education (providing information so the public can understand government policies and actions), and public participation (the public has an opportunity to assist in decision-making or takes some action to support policy implementation). The following are different types of public involvement that fall within the first two categories (Nagy and Bowman, 1994):

Notice & Comment Procedures: In this type of involvement, government agencies (or other decision-makers) provide broad public notice of proposed decisions and adequate time for the public to educate themselves about the issue before opening the floor for oral or written comments. Normally, while government agencies have to acknowledge the receipt of the comments, they do not have to act on them.

Public Hearings: Whenever a decision is to be made, a public hearing can be organized before the decision is finalized. The public is informed about the scope and potential consequences of the decision and participating citizens can provide their opinion. These hearings are normally exclusively informative and the communication is one-way. There are however some hearings, where different parties can express their interests and concerns, and where open discussions take place. Still the hearing can provide decision-makers with stakeholder views, but on which they do not have to act.

Advisory Committees: Advisory committees are often established to help the government in national or regional decision-making processes on science- and technology-intensive systems. The government is obliged to seriously consider the recommendations of the advisory committee in their decision. The composition of the advisory group usually consists of experts, but can also include citizen groups such as environmental groups and other organized stakeholder entities.

Stakeholder participation in decision analysis: This is a more direct stakeholder participation form, whereby stakeholders are jointly involved in the analysis of an engineering systems, but the final decision rests with the decision-making bodies. In this form of participation the recommendations that collaborative stakeholder processes produce inform the final decision, but do not have any inherent authority.

Stakeholder participation in decision-making: This is the most aggressive form of stakeholder involvement. In this type of process, representative stakeholders are engaged in the decision-making process and contribute to the final form of the decisions. Still every effective public participation process should also have public awareness and public education aspects aimed at the segment of the public that does not directly participate in the process.

*Citizen Juries:* One special case of stakeholder participation is the concept of a citizen's jury. As described earlier, citizen juries consist of a group of stakeholders randomly chosen to look at a public policy issue. The selected citizens are given detailed, balanced information about the issue, hear a wide range of views from witnesses, and are able to question these witnesses as well as seek out any additional information they might want[20].

## 4.4 Rationale for Stakeholder Participation

The basic rationale for stakeholder involvement is that there is an evaluative complexity in systems analysis that cannot be dealt with objectively by any set of experts. How we value

[20] Source: Land & Water Australia research project ANU11, July 2001
http://www.lwa.gov.au/downloads/publications_pdf/PF010167.pdf

different outcomes is a subjective matter, an agreement on which is only possible through stakeholder dialogue and negotiation.

Furthermore, many socioeconomic systems decisions generally involve complex scientific and technical issues and a wide array of stakeholders, scientific uncertainty, value conflicts, ecosystem dynamics, and social dynamics, so that environmental decisions are especially prone to challenge (Stave, 2001). Therefore stakeholder participation is essential in drafting better policies. Communicating the complexity of a resource system to a broad stakeholder audience can be difficult, however, because of the dynamics of the system, differences in technical expertise of the audience, and potentially conflicting perspectives among stakeholders. Resource supplies and demands may vary over time and in response to other variations in the system. Changes in one part of the system can feed back to cause unexpected changes in other parts of the system. Interventions often have non-linear, indirect, or synergistic effects. A given outcome can have multiple causes and delays between actions and effects can make it difficult to identify policy options. Understanding the way systems work also requires a certain amount of technical knowledge, which may not be shared by all members of the audience. Finally, stakeholders may hold conflicting ideas about the way a system works, the causes of problems and acceptable solutions.

Many of the reasons for stakeholder involvement were mentioned in Chapter 1. Here we add more detail to some of those issues and expand the rationale to other factors that make stakeholder participation a necessity.

Subjective nature of engineering systems analysis: Objectivity in engineering systems analysis may be more of a myth than reality. Lawrence Susskind expresses the idea in the following way:

> *"There are always non-objective judgments that need to be made before any kind of technical analysis can be undertaken (scope of area to study, time frame within which to do the analysis, choice/weight to give to key variables, ways of handling uncertainty, etc.). Since these swamp a lot of the technical assumptions that are made, and these technical assumptions will have (differential) consequences for*

*real people's lives, they need to opened up to public scrutiny. Unless they are transparent and open to public review, scientific studies will have impacts for which no one is accountable" (Lawrence Susskind, Dissertation Feedback Email, 09/24/2004)*

*Ethical considerations*: As indicated in the previous chapter, the primary reason for stakeholder involvement in public decision-making processes is an ethical and moral one. From a normative and ethical perspective, in a democratic society, decisions that affect diverse set of stakeholders should be open to their inputs. In the words of the National Research Council (NRC), public involvement "is critical to ensure that all relevant information is included, that it is synthesized in a way that addresses parties' concerns, and that those who may be affected by a risk decision are sufficiently well informed and involved to participate meaningfully in the decision" (NRC, 1996).

*Community-Based Knowledge Integration:* Additionally, it has been argued that "public participation facilitates the contribution of essential community-based knowledge, information, and insight that is often lacking in expert-driven risk processes" (Ashford, 1999).

In their study of stakeholder processes, Yosie and Herbst (1998) point to the following factors contributing to an increased need for stakeholder participation in decision-making processes:

1) Lack of public confidence and trust in behind the door decisions of agencies
2) Increased environmental and legal awareness of citizens
3) Limitations of current processes in taking into consideration stakeholder needs
4) Increased diffusion of information and the existence of uncertainty in scientific information
5) Consideration of stakeholder interests and knowledge in devising better policies

More importantly, they argue that stakeholder participation can be seen as a "social peer review" for expert analysis of engineering systems (Yosie and Herbst, 1998).

*Meeting Social Goals:* Beierle (1998) proposes six social goals for stakeholder participation. These include:

- Educating and informing the public
- Incorporating public values into decision-making
- Improving the substantive quality of decisions
- Increasing trust in institutions
- Reducing conflict
- Achieving cost-effectiveness.

*Implementation of Policies:* Case studies also show that stakeholder participation can also result in better implementation of recommendations. Pretty (1993) cites evidence from the Philippines in which the success of two similar and parallel irrigation projects in the Philippines was evaluated (one with participation, the other without). It was found that under similar conditions, yields were 10-22 per cent higher in the project with participation and that water use and maintenance of structures were more efficient.

*Interagency coordination:* What gets often forgotten are the benefits that stakeholder participation processes can have for coordination among government agencies themselves. Problems of interagency coordination have often been overlooked in many studies looking at stakeholder participation. Yet these coordination problems are often a major contributor to the failures of engineering systems policy (Ashford, 1999). An adequately designed stakeholder process can ensure that government agencies are able to share resources, opinion and information among themselves as well as with other stakeholders.

### 4.5 Existing Public Participation Methodologies for Engineering Systems

There have been many efforts that focus on enabling stakeholders to interface with the technical analysis of an engineering system, while contributing to understanding of the social and institutional impacts of decisions. In this section, we will examine the most prominent methodologies proposed to engage stakeholders in the decision process for science and technology-intensive systems.

**A) Group Model-Building Using System Dynamics**

The visual nature of system dynamics helps a deeper understanding of the underlying issues through causal loops. Thus, several models with differing levels of detail can be constructed easily for different stakeholders and decision-makers. Figure 2.5 shows a sample system dynamics diagram showing in simple terms the impact of transportation on environment and land-use.

System dynamics has been applied to a number of environmental studies, such as natural resource management, energy system planning, environmental impact assessment, and solid-waste management (Meadows et al., 1973; Naill et al., 1992; Vizayakumar et al., 1991, 1993; Mashayekhi, 1993; Clemson et al., 1995).

According to Stave(2001), System Dynamics offers a consistent and rigorous problem-solving framework for identifying the scope of the problem, eliciting participant views about problem causes and system connections and identifying policy levers.

Hoggarth (1987) is one of the first people who suggested the merits of group model-building using System Dynamics. In his opinion however, we have to be careful when talking about eliciting knowledge from group members. First, we ought to be aware that people can easily be led to believe things and that the opinions they hold may be strongly affected by what others think and the context in which they find themselves. As Hoggarth points out: "It has been suggested, for instance, that illusory correlation persists in situations where people do not receive good feedback concerning their judgments and where others share the same illusions. Thus instead of feedback concerning actual outcomes, each person both reinforces and is reinforced by the illusions of the others. In many organizations, common beliefs are precisely of this nature". He further indicates that group model-building using system dynamics can help in making the mental maps of participants explicit and put their problem definitions to the test, by surfacing implicit causal assumptions they may have for a given system.

Vennix has been one of the proponents of group model-building in corporate decision-making, focusing on building system dynamics models that help tackle a mix of interrelated strategic problems to enhance team learning, foster consensus, and create commitment. In his view, as the "command and control" organization evolves into one of decision-making teams, these teams have become the critical building blocks upon which the performance of the organization depends. When the complexity of decision making and the interrelation of several strategic problems facing the company increases, different people within an organization develop different views on the problem definition. As a result, he emphasizes the importance of "learning teams" where different people converge on a single representation of a problem through testing their ideas and assumptions (Vennix, 1990).

Building models with a group of stakeholders has become an established approach to support strategic decision-making in many corporate settings. Involving relevant stakeholders helps generate a comprehensive set of information regarding the issue, fosters a feeling of ownership towards the process and the decisions and creates commitment to implement these recommendations among the different levels of management. (Richardson, 1994)

In the last decade, the System Dynamics community has made considerable progress in developing tools and techniques to support a group model-building process. Graphical facilitation techniques and graphical functions are used in combination with guidelines for structuring and facilitating group sessions, group knowledge-elicitation techniques and appropriate consulting roles (Morecroft and Sterman 1994, Richardson and Andersen 1995; Vennix 1996). Success stories abound on the application of these refined approaches to support corporate decision-making.

An important objective of most System Dynamics modeling efforts is to support strategic decision-making. In his paper, Huz describes a qualitative modeling project, with causal loop diagram representation, where the primary goal was to establish consensus regarding the problem situation and commitment to the action necessary for change. Conducted with a group of mid-level managers of a company at the beginning of a period of organizational change, consensus and commitment with regard to the problem were successfully established, but that the project was not successful in creating a full consensus on the course of action, given that alternatives could not be evaluated using a qualitative model (Huz, 1996).

In his later paper, Vennix (1996) explores group-model building exercises further. One of the main challenges in group model-building is the problem definition. The problem that is modeled can be reasonably well defined, but it can also take the form of an ill-defined problem, in which case the opinions in the group on courses of action can diverge considerably. He proposes the use of social psychology and small-group research in understanding why people form different views of the same problem.

Richardson (1998) has focused efficient group model-building strategies, that go beyond conceptualization, and venture into actual group model-building for a system. He has used three public policy cases of non-technical nature to explore group model-building. The cases included the burgeoning cost and caseload of foster care in New York State, unexplained increases in Medicaid costs in the state of Vermont, and homelessness policy initiatives in New York City. One of his main contributions, which will be built on in this dissertation is his definition of different roles in a group model-building effort. He defines five management roles in the process, the *facilitator,* the *modeler/reflector,* the *process coach,* the *recorder,* and the *gatekeeper.* When resources are limited, it is possible to merge several of these roles into one person, but with large models and a large number of stakeholders, as is the problem with engineering systems these roles are often best handled by separate individuals, who may themselves be stakeholders. The modeling tasks for Richardson's three case studies involved eliciting information from the reference group and about the structure and behavior of the problem, formulating that information in a model, presenting and explaining that model formulation back to the reference group, eliciting their reactions for model corrections and refinements, and carrying out the necessary revisions and extensions. The modeler in this case took on the role of process coordinator, knowledge elicitor, group facilitator, and system dynamics educator (Richardson, 1998).

Stave et al (2001) facilitated a group model building exercise to support an ad hoc stakeholder advisory group. The group's charge was to develop policy recommendations to address the rapidly worsening and interconnected problems of traffic congestion and regional air quality in the Las Vegas, Nevada metropolitan area. The group was to meet once per month for a year and was asked to make recommendations to the Board at the end of the year about how it should address the transportation problem in the region. The advisory group consisted of elected officials representing the county and four cities within the county, representatives of the business community and tourism industry, environmentalists, bus riders, other public agencies, and community residents.
These stakeholders had no particular knowledge of the transportation system other than their observations as system users. Key issues of transportation systems were identified in brainstorming sessions and a diagram of system elements and their interconnections was constructed using the list prepared by the group. A model was created by the modeling group and was presented in two working group sessions and two full group sessions. Stakeholders then simulated the effects of the different alternatives to find the solution with the least cost and highest emission reduction. Stave argues that system dynamics could provide two kinds of benefits for public involvement: a structure for deliberation and education that is at least as good as other structures now in use, and a tool for incorporating technical analysis in the process in a way that is better than what is currently in use. Stave argues that such an approach yields a better overview of the system, a more neutral framework for negotiation and therefore a platform for consensus (Stave, 2000). The problem with this case study however may lie in the fact that in engineering systems, there are often conflicting objectives, so that the strategy with the highest emission reduction potential at the lowest cost may not be a socially feasible one. Therefore, it does not take into consideration issues of negotiation and conflict resolution, which is an inherent part of any stakeholder process.

In general the group model-building literature focuses more on the system representation and modeling, without emphasizing the negotiation process associated with high stake, high uncertainty issues.

**B) Open Design**

The Dutch "Open Design" methodology is an attempt at involving stakeholders in decision-making within the field of architecture. While the main application has been architectural design, the concept can be applied to many other systems where a multitude of stakeholders jointly design solutions for a given problem. In the 1970s the design process in building projects was limited to one or at most several professional designers. At the present time, design teams consist of all the parties involved in the preparatory work, as well as representatives from the clients and other affected stakeholders. This has led to a more collaborative design process, where all participants in the design team put forward their ideas and alternatives, discuss and evaluate combinations of solutions and select the best possible design. With more and more participants involved in the actors are involved in architectural design the distinction disappeared between the decisions made by professional designers (the limited group of experts and specialists) and the decisions made by non-experts (the group of involved stakeholders and users) (Van Loon, 2000).

The Open design approach to multi-stakeholder participation in architectural design has been developed by Van Loon (1998) and Van Gunsteren and Van Loon (2000). The traditional expert design process for large, complex construction projects, has two fundamental shortcomings: (1) The possible contributions of layman-users and other excluded stakeholder parties are ignored; (2) Even if such contributions would not add to the value of the design, their exclusion has resulted in decreased acceptance of expert designs. The Open Design Process uses collaboration between experts and non-expert stakeholders to reach mutually acceptable choices and can be visualized as shown in Figure 4.2. (Van Loon, 2000)
The arrows represent the influence stakeholders can exercise on the options and choices for a given system.

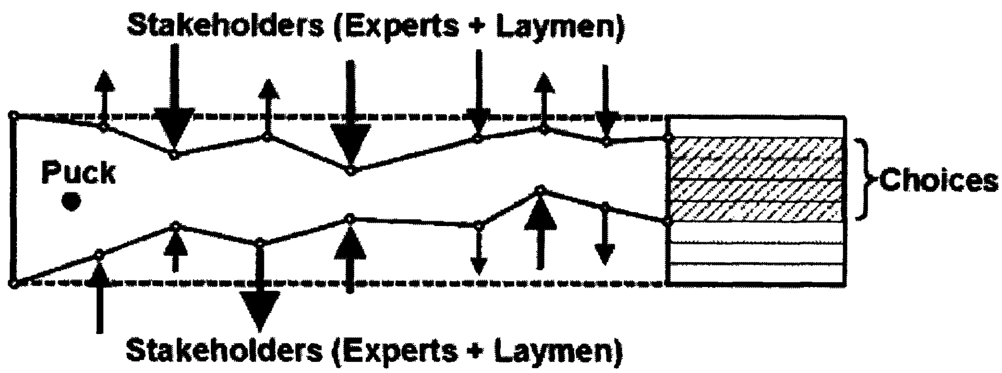

**Figure 4.2 Multi-Stakeholders Design (Van Loon, 2000)**

The assumption behind "Open Design" is that the outcome of a decision process where stakeholder interests and knowledge is incorporated is open-ended by its nature, and that there is no optimal decision for such systems (Van loon, 2000).

An important part of the "Open Design" process, is open process management. Given that the essence of open design is the genuine acceptance of an open-ended outcome, process manipulation by the facilitator or any of the participants is rejected. The behavioral code for "Open Design" is based on the behavioral theory of Argyris and Schön (1978, 1996), where unilateral and manipulative behavior is defined as Model I (MI) behavior, and non-manipulative behavior, valuing free choice of individuals based on valid information and internal commitment, is called a Model II (MII) behavior. The latter is the behavioral code for "Open Design" process managers. The "Open design" literature also focuses on common problems of open process management, such as uneven contribution by participants, and the lack of power to force cooperation amongst individuals and proposes some ideas for dealing with these and other difficult process issues.

**C) Participatory Geographic Information Systems**

For many environmental decision-making problems, there is a significant spatial component that can often be best represented within a geographical information system (GIS). A GIS is a computerized mapping and database system capable of processing and storing spatially referenced data, and is widely used for environmental decision-making. Traditionally, GIS has been used by GIS professionals to integrate spatial and attribute data, conduct analysis, construct scenarios, and disseminate results. The public only participates by commenting on the outcome at the last stage. Not surprisingly, GIS has been criticized as "top-down, technicist, elitist, and non-participatory" (Harris and Weiner, 1998). Participation in GIS is limited both by a resistance by experts, as well as a lack of access to the required hardware, software and expertise on the side of public stakeholders. In order to deal with this issue, a number of methodologies catagorized under participatory GIS have been developed over the last few years. Participatory GIS is a "spatial decision-making tool attempting to utilize GIS technology in the context of the needs and capabilities of communities that are involved with, and affected by development projects and programs" (Abbot et al., 1998). In particular, web-based GIS seems to be one of the promising trends in participatory GIS. Carver et. al (2001) argue that an online PGIS system can only be successful if:

(1) it allows public exploration and experimentation with the data and information sources available and provides the opportunity to look at different scenarios and solutions to given decision problems;

(2) it is understandable by all segments of stakeholders (technical and non-technical) that wish to be involved.

(3) it provides information and data that are both explicit, transparent and non-partisan;

According to Kingston (1998), by providing access to appropriate data, spatial planning models and GIS via user friendly web browsers the WWW has the potential to develop into a flexible medium for enhanced public involvement in the planning process.

A web-based system for siting environmental decisions, such as the determination of a location for the Stellwagen Bank National Marine Sanctuary has been developed by Adams (2004) at the Massachusetts Institute of technology. The system uses stakeholder inputs in terms of their system utilities to determine the optimal site for the sanctuary (Figure 4.3).


**Figure 4.3 Web-based Participatory GIS Application for Siting of Marine Sanctuary. MIT Case study on marine reserves in the Stellwagen Bank National Marine Sanctuary (Source: MIT Sea Grant E-Site http://dogfish.mit.edu)**

There are currently important technical issues also need to be considered when implementing an on-line participatory GIS, which are discussed in detail in Kingston et al (2000). Among the most important ones are the download time for information over dial-up lines, the type of browser, and the difficulty of navigating such sites for people with little computer skills and last but not least the limitations of web-access for special segments of stakeholders.

Case studies have shown that spatial scale can have a significant effect on the manner in which the public respond to particular decision problems. While at local scales a majority of stakeholders are interested in participating in the decision-making process, fewer people are eager to participate in the decision-making process at the regional or national scale. This is despite the fact that issues such as nuclear waste disposal, the complexity and importance of the decision is far greater, and the number of affected stakeholders is much larger. This phenomenon is called the "inverse-scale effect" (Carver et. al, 2001).

**D) Participatory Integrated Assessment**

Environmental decision-making is one of the first areas where there has been an increased impetus to engage stakeholders in the decision-making process, particularly within the framework of the emerging methodology of "Participatory Integrated Assessment" or PIA. Integrated Assessment (IA) is defined as "an interdisciplinary process of combining, interpreting and communicating knowledge from diverse scientific disciplines in such a way that the whole cause-effect chain of a problem can be evaluated from a synoptic perspective with two characteristics: (i) it should have added value compared to single disciplinary assessment; and (ii) it should provide useful information to decision makers" (ULYSSESS Project). Given the fact that integrated assessment has usually been limited to the scientific aspects of an environmental problem, there has been an increased interest in a participatory version of integrated assessment. ULYSSES (Urban Lifestyles, Sustainability, and Integrated Environmental Assessment) is one of the most comprehensive efforts to involve citizens in global climate change debates. The basic rationale of ULYSSES is that integrated assessment can be improved by combining expert knowledge with public participation. For this purpose stakeholders in small focus groups are supplied with relevant scientific information on global climate change. Subsequently, they are given access to computer models that simulate the effect of different sets of policies over time. Citizens then analyze and discuss the impact of different strategies to counter global climate change. The range of arguments and judgments expressed by citizens is then condensed and provided to decision-makers to be taken into consideration in the final design of policies (Gerger et al. 1999). Figure 4.4 shows a typical ULYSSES setup, where participation can be assisted by either a computer or by flipcharts.

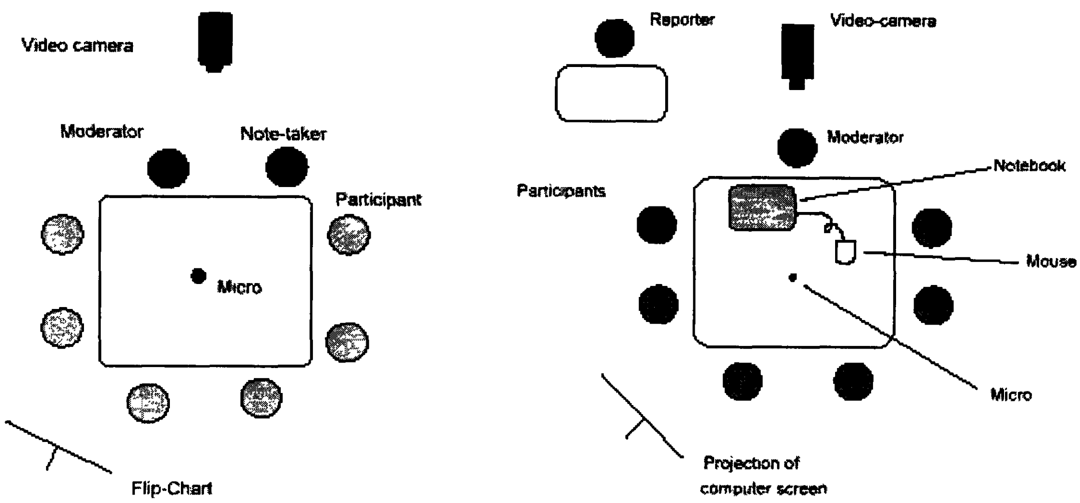


**Figure 4.4 The ULYSSES setup for participatory integrated assessment meetings. Source: http://zit1.zit.tu-darmstadt.de/ulysses/tutorial.htm**

The approach is mostly geared towards educating the public on the issues of global climate change, since citizens have little or no authority over the actual decision-making process and do not have negotiating power for policy implementation. Here citizens do not have a deep understanding of the underlying science and models that are used for the decision-making process. There are many critics of this approach. Darier et al. question the assumption that public participation in integrated assessment after the science has been done is necessary or even useful. They propose the idea of a "folk integrated assessment". arguing that it is unclear why the scientific framework puts the expert in a superior and exclusive position. Citizens get bored, and feel uninterested when the scientific concepts of global climate change are introduced (Darier et. al, 1999).

Using research on focus groups dealing with climate change, Darier found four different responses towards scientific representation of the concept of global climate change:

(1) Polite, but passive interest;

(2) Surprise and alarm towards the scientific analysis;

(3) Deference to scientific expertise and

(4) Skepticism towards the scientific analysis and its accuracy (Darier et. al, 1999).

They instead propose a refocusing on a public-centered perspective, in which citizens' discussions and their lay knowledge is used later in constructing the scientific model of the process. While the concern with the public's capacity to understand scientific information may be legitimate, such an approach will not help citizens to understand even the basics of the scientific issues involved in global climate change. Any integration of lay knowledge would also be detached from the technical analysis, thus making participation more of a formal- rather than a substantial effort (Darier et. al, 1999).

**E) Joint Fact-Finding (Humble) Analysis**

Joint fact-finding is a process by which stakeholders, experts and decision-makers come together to deal with the "factual" scientific/technical issues of a dispute. The purpose of joint fact-finding is to develop shared knowledge and agreement about the system and its boundaries and important issues that ought to be considered in the scientific analysis. It is a step by which stakeholders initiate the process of gathering information, analyzing facts, and collectively making informed decisions (Ehrman 1999).

Joint fact-finding rests on the following main premises:

- The process of generating and using knowledge is a collaborative effort by decision-makers, independent scientists and other stakeholders and their representative experts from all sides of the conflict.
- Information, expertise and resources will be shared among all participants.
- Participants are committed to finding a set of solutions to their conflict.

Joint fact-finding may fail in situations when one or more of the above principles is violated in the process. Therefore, it is more advisable to engage in a collaborative process before an issue is so polarized that it is impossible to convince people that a win-win situation is possible (Ehrman 1999).

In a joint-fact finding process a group of analysts and experts chosen by the stakeholders works closely with the stakeholders in analyzing the issues they deem important for decision-making. In his book "Humble Analysis", Andrews (2002) has looked at ways to implement a joint fact-finding process for finding regional electricity alternatives in the New England states of the U.S. Figure 4.5 shows the interaction between analysts and stakeholders in a joint fact-finding process for this purpose.

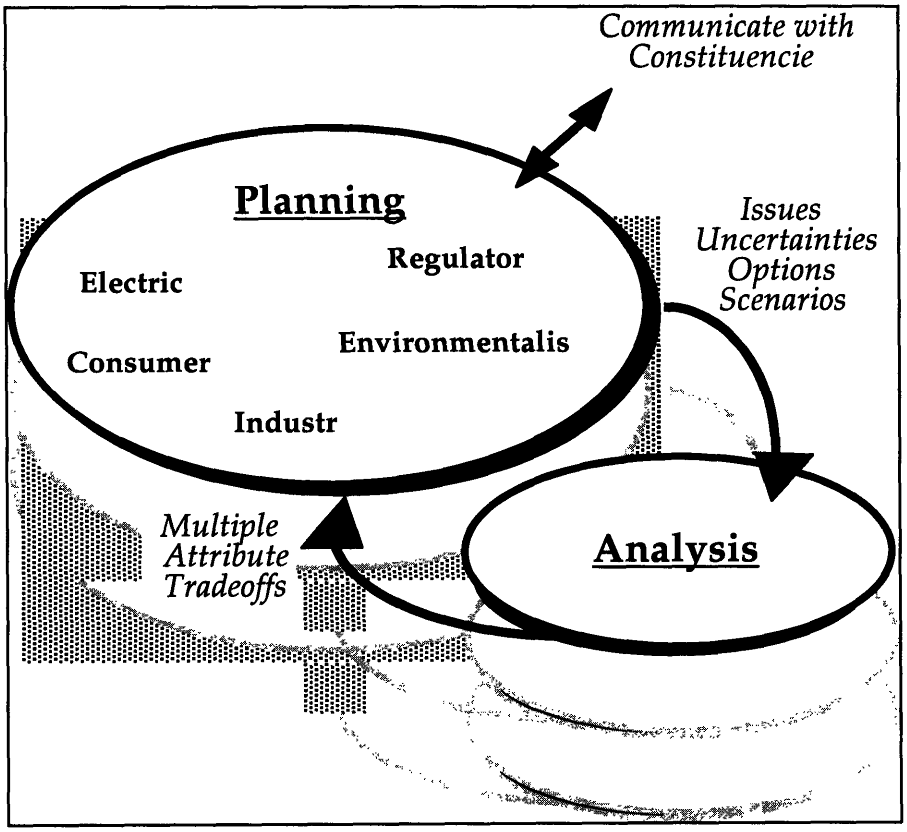


**Figure 4.5 Joint fact-finding process for regional electricity alternatives problem.**
Source: Andrews, 2002

Joint fact-finding can occur in two ways. In the first approach, experts hired by the negotiating group, whose credibility and lack of bias is accepted by all the stakeholders, gather and analyze the data. In the second approach, stakeholder representatives bring in their own experts, who then work together for data gathering and analysis. The main challenge of joint fact–finding is deciding on how the such findings would fit into a possible decision or final agreement (Rebori, 2000).

**F) Adaptive Environmental Management**

Adaptive environmental management essentially started in the 1978 when C.S. Hollings, a Florida professor, introduced the idea that computer models may help synthesize the different objectives of various stakeholders and decision makers dealing with water resources engineering analyses (Hollings, 1978). This was at a time when the term "Computer" referred to a room-sized device rather than a desktop or laptop entity. As such, the idea was both revolutionary and challenging to do. The process proposed by Hollings is built on three bases: planning principles, collaborative negotiation, and technical system models.

1. Planning principles:
   - identify objectives
   - formulate alternatives
   - measure effects
   - evaluate alternatives
2. Collaborative negotiation: The planning process is done through collaborative negotiations with the ultimate goal being an agreement on strategies.
3. Technical Models: Computer modeling is used to identify how the multiple elements in an environmental system, such as a water resource system relate to one another (Hollings, 1978).

### 4.6 Pros and Cons of Stakeholder Participation in Decision-Making

Like any other societal decision, there are tradeoffs when involving stakeholders in the decision-making process. Table 4.1, which is based on the experience of the United Nations ESCAP program, shows some of the pros and cons of stakeholder participation in decision-making.

**Table 4.1- Pros and Cons of Stakeholder Participation in Decision-Making**

| | **Positive side of stakeholders participation in decision making processes** | **Negative side of stakeholders participation in decision making** |
|---|---|---|
| Quality of the planning | **Improvement**<br>(Review of policies from various aspects increases the possibility of environmental programs having the desired results and reduces the risk of failure) | Stakeholders may just want to stop the process for their own personal interests, using a collaborative process as a way to obstruct decision-making. |
| Wider Representation | **Wider aspects**<br><br>(A diverse range of values and opinions come to the table, PI can improve problem solving;) | **Misrepresentation**<br><br>(Some participants may not actually have any direct stake in the policy decision and may use the process for political ends.) |
| Relationships among stakeholders | **Improved relationship with local community**<br><br>(Stakeholders participation provides the developer (government or private sector) with a "license to operate" in a given area, through the development of "partnership" with local communities;) | **Distorted interest**<br><br>(Possible conflicts between individuals, groups and organizations undermining sustainable development;)<br>(Many government workers are inclined to view the public and industry as the problem and are unwilling to consider abrogating their own power or control.) |
| Timing | **Long-term benefit** | **Time consuming process**<br><br>(The more participants, the longer the process of decision making) |
| Costs | **Reduction of future risks**<br><br>(Reduced risk of serious confrontation, thereby minimizing long-term project costs and delays;) | **Financial and other resource costs of promoting the stakeholder participation**<br>(Expensive process (advertising, public presentations, etc) of getting the public and private enterprise to understand an issue and actively participate in an environmental program)<br>(Negotiation skills to resolve conflicts of interest among different participants)<br>(Facilitation skills to prevent unbalanced representation or takeovers by powerful interest groups) |

**Source:** (Reference: ESCAP public involvement: Guidelines for Natural Resource Development Project)

One of the frequently expressed concerns with stakeholder participation in science-intensive decision-making processes is that the quality of the final decision can be eroded due to too much focus on stakeholder interests. While there is little consensus how the *quality* of a decision could be measured, it can be assumed that the scientific/technical optimality of the decision is a major component in this regard.

A study by Beierle (2000), compared a set of 239 small-scale environmental decision-making processes to explore whether such concerns would be valid. He used cost-effectiveness, joint gains, stakeholder perceptions of the process, the suggestion of additional feasible alternatives by stakeholders, the addition of information by stakeholders, inclusion of innovative ideas, improvement of the technical analysis, holistic perspectives, and increased access to information and expertise as criteria for the quality of the decision. The results showed that across these broad criteria the majority of cases would suggest that stakeholder processes resulted in decisions that were better than decisions made in similar cases without stakeholder participation. The analysis further indicated that consensus-seeking stakeholder processes made higher quality decisions than non-consensus seeking processes.

### 4.7 Insights and Challenges from Past Stakeholder Process Experiences

From their study of participatory stakeholder processes, Yosie and Herbst (1998) draw five important insights:

*1. Stakeholder processes are continuously evolving:* While stakeholder processes are not new, they represent an evolution from previous methods of public input solicitation. They have originated from concepts that have evolved over time such as the "maximum feasible participation" that was used in the 1960's anti-poverty programs, the evolution of the shareholder concept in the private sector, the growth of environmental dispute resolution in the 1970's and 1980's, and expanded requirements for public participation in governmental decision-making processes

*2. Stakeholder processes do not follow a robust structure:* Due to the specificity of locations and cases, the management of stakeholder processes is often on an ad-hoc basis, with no robust process design and lack of historical insights.

*3. The goal of stakeholder processes is often unclear:* There is confusion whether the process is the means to decision-making or an end in itself. Expectations from a stakeholder process are not usually well-defined. This can result in prolonged processes, since it changes the nature of the problem that the process is trying to solve.

*4. Stakeholder processes are hard to evaluate:* It is hard to provide an objective metric for failure or success of stakeholder processes. As an example, they mention the case of superfund legislation, where members of the National Commission on Superfund achieved agreement on a broad number of issues, with the hope that it would result in legislative changes to the statute. However, the administrative changes in the $104^{th}$ Congress removed the political support from many of their recommendations, and made the agreements useless. Would this be considered a failure of the process or would the process still be considered successful?

Keeping these challenges and insights in mind it is possible to design more robust stakeholder processes that can be applied to many different cases and systems.

### 4.8 Contributions of this Dissertation to the Stakeholder Participation Literature

Most stakeholder participation methodologies proposed in the literature fail to address one or more of the following fundamental aspects of stakeholder participation in engineering systems decision-making.

*Multi-agency, Multi-disciplinary, Multi Stakeholder Coordination and the Systems Perspective:* Engineering Systems consist of many different parts. If we are concerned with air pollution in a metropolitan area, we may need coordination between different government agencies, experts from diverse fields such as transportation, urban planning, energy systems, management, economics, atmospheric chemistry, and public health. Unless there is a *systems approach* in organizing information and workflow among these different groups, it will be difficult in bringing these diverse actors together and reach an agreement on any part of the analysis and subsequent recommendations. This dissertation provides a systems approach that can serve as a basis for the collaborative process, providing process structure and progress assessment capabilities.

*Emergence and Adaptive Management:* Engineering systems evolve over time. A decision made today may not address the issues of an engineering system in the longer term.

Therefore, there is a need to return to the decision-making process. If there is no commonly agreed decision-making platform that we can go back to, we may have to start the entire analysis process again. In this dissertation, we propose using a system representation that can be modified for similar problems, or for adaptive management of the same system later on. It will do so by maintaining process information within the system representation and the accompanying process documentation.

*Relevant Decision-making Information:* Many decision support models for public participation do not take stakeholder decision needs into consideration. Rather they provide existing model outputs as a basis for stakeholder negotiation. Most often these may be inadequate for stakeholders to be able to make decisions among different alternatives. The public participation process proposed in this dissertation allows stakeholders to design what kinds of outputs are necessary to make the decisions. Models can then be constructed to meet the data needs of the stakeholders.

### 4.9 Critique of Stakeholder Involvement in Engineering Systems

There are basically two sets of critiques that arise based o the previous discussion on stakeholder involvement in engineering systems. The first set comes from a social science perspective, which sees engineering systems methodologies as being peripheral to a stakeholder process. According to this view, models of engineering systems may be useful to some extent in the process, but cannot form the core of the process. There are two main reasons that are given for this: 1) The amount of uncertainty in the models is such that any results can only be considered as guidance rather than actual system outputs and 2) Models reduce reality to a level of abstraction that obscures the true nature of conflict, and does not address its roots. Therefore the usage of systems tools in a collaborative process as a basis for dialogue may not help stakeholders address their real concerns, which cannot be captured through systems methodologies and within conceptual or quantitative models.

The other critique comes from the engineering systems perspective, which views the entire field of collaborative processes as a subjective black box with no firm theoretical foundations. Engineering systems professionals see their field as an effort to address the technical complexity of engineering systems that span across multiple engineering disciplines. From this perspective, systems methodologies, although diverse, form the methodological foundations of the field and can address different aspects of behavioral and structural complexity found within most engineering systems. The issue of stakeholder involvement is off limits to engineering systems and should be done within the realm of the social sciences. Much of their concern revolves around the fact that stakeholder processes are unpredictable, messy, with a strong potential for obstructionism and agreements with poor technical quality. The dependence of such processes on the skills of facilitators and the diversity of opinions among stakeholders make a collaborative process seem like a waste of time and money. It is often argued that such processes cannot eliminate conflict since there will always be someone who will be unhappy about the system. If conflict resolution is valuable, and they agree it is, it should occur outside the technical process and by decision-makers, not experts. In short, engineering systems as a field does not currently view the integration of collaborative processes in the design of engineering systems as valuable.

While there is some validity to both views, we would argue that collaborative engineering systems processes are inevitable. So is the usage of systems methodologies as their core. Without stakeholders much of the technical recommendations can be useless, since implementation hinges on the collective will of stakeholders. Without systems approaches, being aware of their limitations, there is little interface and common basis between stakeholders and experts in a collaborative process, and little possibility for the technical quality control of the recommendations. The point of this dissertation is therefore not to negate existing challenges, but to take the first step in addressing them. With field of engineering systems being currently shaped by the contributions of its experts, it is an opportune time to influence its boundaries and intellectual focus to encompass stakeholder involvement as one of its core dimensions, setting it apart from the Systems Engineering and Operations Research fields.

### 4.10 Chapter Summary

In this chapter we initially took a look at public involvement in decision-making throughout history and distinguished among different involvement levels that can be seen at the present time. We then looked at the general rationale for involving stakeholders, pointing to the subjectivity of mental maps, or personal perceptions and their impact on representing a problem. In later sections, we looked at different public participation methodology in engineering systems, which included group model-building with System Dynamics, the Dutch "Open Design" methodology, participatory Geographic Information Systems for spatially important problems, participatory integrated assessment and joint fact-finding. The chapter concluded by assessing the pros and cons of public participation in decision-making for engineering systems and provided some insights from past experience with stakeholder participation processes.

In Chapter 5, we will look at the concept of system representation, as it pertains to engineering systems and stakeholder processes.

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# ➲Chapter 5

## Systems Representation and Decision-making

*By relieving the mind of all unnecessary work, a good model sets it free on more advanced problems, and in effect increases the mental power of the [human] race.*

*-- Alfred North Whitehead*

In this chapter we explore the concept of a systems representation, the impact of values and beliefs on representations and vice versa, how system representations shape the modeling process, and the where conflict arise within representations of engineering systems. We also look at the role of modeler biases in creating systems representations and the potential impacts of these biases on the design and modeling of the system. We then discuss the importance of system representation as a "boundary object" in engineering systems design, where stakeholders, decision-makers and experts can jointly strive towards a commonly agreed representation of a system of interest.

It is important to clarify some of the distinctions made in this chapter. A model can be any objective or subjective simplification of reality intended to promote an understanding of that reality. As George Box put it, "All models are wrong. We make tentative assumptions about the real world which we know are false but which we believe may be useful." (Box, 1976). Models can be conceptual (qualitative) or quantitative. Often times a conceptual model is used as a basis of quantification. In this dissertation, we refer to the conceptual portrayal of system components and their interconnections using a diagram as systems representation, and we refer to the quantification of a systems representation as systems modeling. There are many other ways of representing systems, that are beyond the scope of this dissertation. Yet it is important to realize that all types of representations are based on abstractions of reality, within the context of values and expressed as a combination of words and imagery.

### 5.1 Representations and the Abstraction of Reality

We often use representations to communicate our perceptions of an external reality.

By definition, representations are approximations of personal or collective abstractions of reality. Figure 5.1 shows the famous pre-historic paintings in the Lascaux caves, where the painter has tried to represent his/her experience from an actual hunt scene with basic representations. The representation serves as a trigger to a more or less common experience between the painter and all other individuals looking at the painting. What the pre-historic onlooker actually sees is not the simple figures on the wall, but a vivid memory of an actual hunt scene they may have experienced. This aspect of representation, namely its ability to serve as an abstraction of reality is what makes it the perfect tool for organizing knowledge. There are essentially two types of representations: Internal representations (in our brain), and external representations (through which we communicate our internal presentations to other human beings).

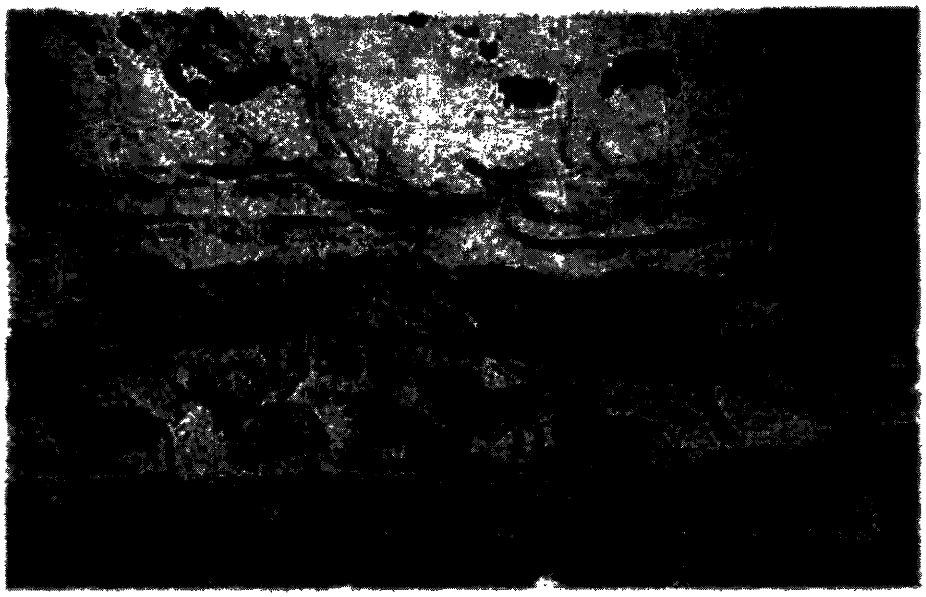

**Figure 5.1 Lascaux Cave Representations of Hunt Scenes by Prehistoric Humans**
**Source: http://www.students.sbc.edu/matyseksnyder04/horse%202.jpg**

### 5.2 Internal Representation: Mental Maps

Internal representations are the mental images or *maps* of individuals of an existing (or sometimes imaginary) external reality. The term "mental map" has been used in many contexts and was first used by Craik in *The Nature of Explanation* (Craik, 1943). Mental maps are gradually evolving heuristics that we use to categorize the knowledge we gain from the outside. They are influenced by our *values, beliefs* and *experiences. Values* reflect what we consider as acceptable or unacceptable states of a component in a system (or the system as a whole), whereas beliefs mostly influence how we perceive the relationship between the different components to be. Mental maps are heuristics that allow us to understand and categorize the world around us. Mental maps are created from knowledge of prior experience and feedbacks we have received from interacting with our environment as a whole, or a particular external object. By definition, a mental model contains the minimum information necessary for us to have a satisfactory understanding of a perceived reality. Mental maps generally have a very strong visual component. Interestingly, a change in our mental maps brought about by internalizing an external representation could also result in a change in the *beliefs* we hold. In its broadest sense, this process is called *learning* (Davidson and Welt, 1999).

The ability of individuals to continuously update their mental maps with new information is often called "open-mindedness". Conversely, a person with a rigid mental map may never benefit from the experiences that allow him/her to create a more informed mental map. Internal representations often find expression in external representations. While the internal representation of nearly all concepts is unique to each individual, it is possible for a group of individuals to agree on common external representations that reflect their internal mental map of the subject or object at hand.

### 5.3 External Representation: Words and Imagery

Once we have a mental map of a system, we can express the information captured in our mental map in two major ways: Through words (spoken or written), and through figurative representation (images, graphs, diagrams, maps, physical structures and pictures).

Pictures and images convey multiple features of a subject/object simultaneously, while words convey information in a sequential manner. While pictures are directly stored in our brains, most of the time verbal information is interpreted using our mental maps and later referred to as contextual information.

Images and pictures that we produce on an object can also reflect our values and beliefs. Figures 5.2 and 5.3 represent the simulation of the visual impact of the Cape Wind Offshore Wind project, as produced by the opponents and developer. While showing the wind turbines from the same vantage point from the same exact location, the images differ in the contrast of the wind turbines against the horizon, as well as the zoom that was chosen to represent the turbines.

**Figure 5.2 Cape Wind Visual Simulation (Opponents) Source: www.Windstop.org**

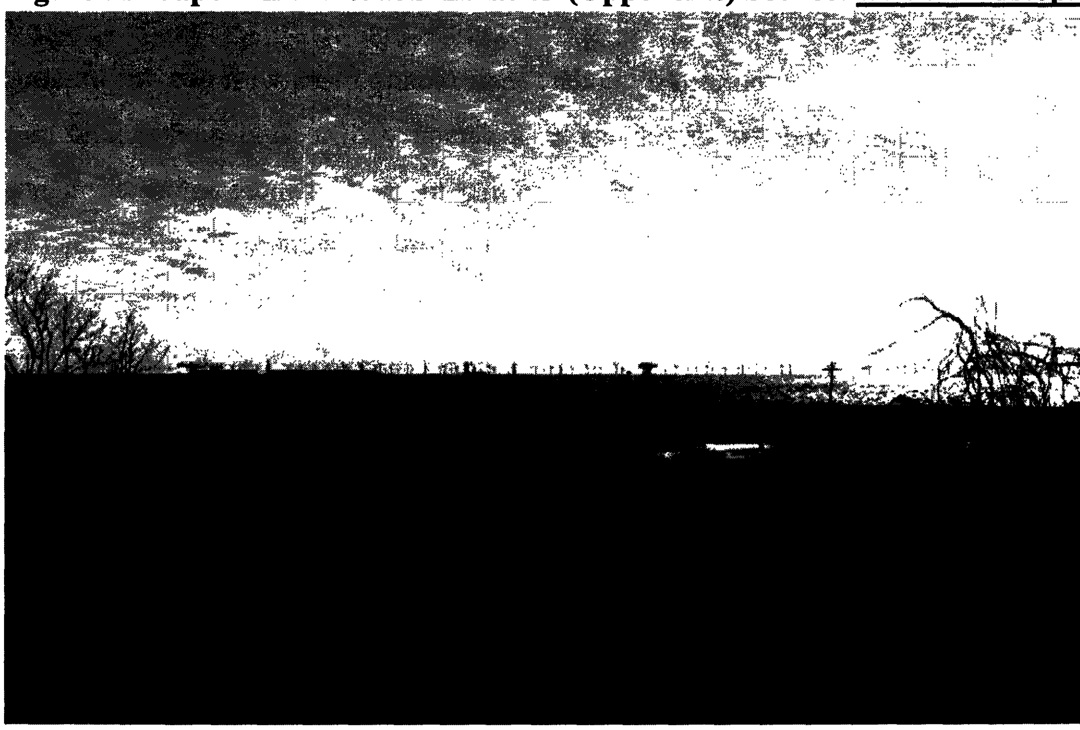

**Figure 5.3 Cape Wind Visual Simulation (Developer) Source: www.capewind.org**

## 5.4 Representations, Beliefs and Value Systems

One of the principal roles of internal mental maps is to explore possible actions/strategies and their potential consequences before the actual realization of the action (Marks, 1999). As Figure 5.4 shows, mental processes based on mental maps and existing schemas of a problem precede actions and are impacted by external stimuli.

The ability of our minds however to conduct these thought experiments in a risk-free manner within the boundaries of our mind become more and more limited when the system under consideration becomes complex. In these cases, external representations can help capture many of the complexities of the system, while still retaining the values and goals of the individual. In collectively constructed external imagery, the value sets can be a combination, synthesis or co-existing set of values of the individuals involved.

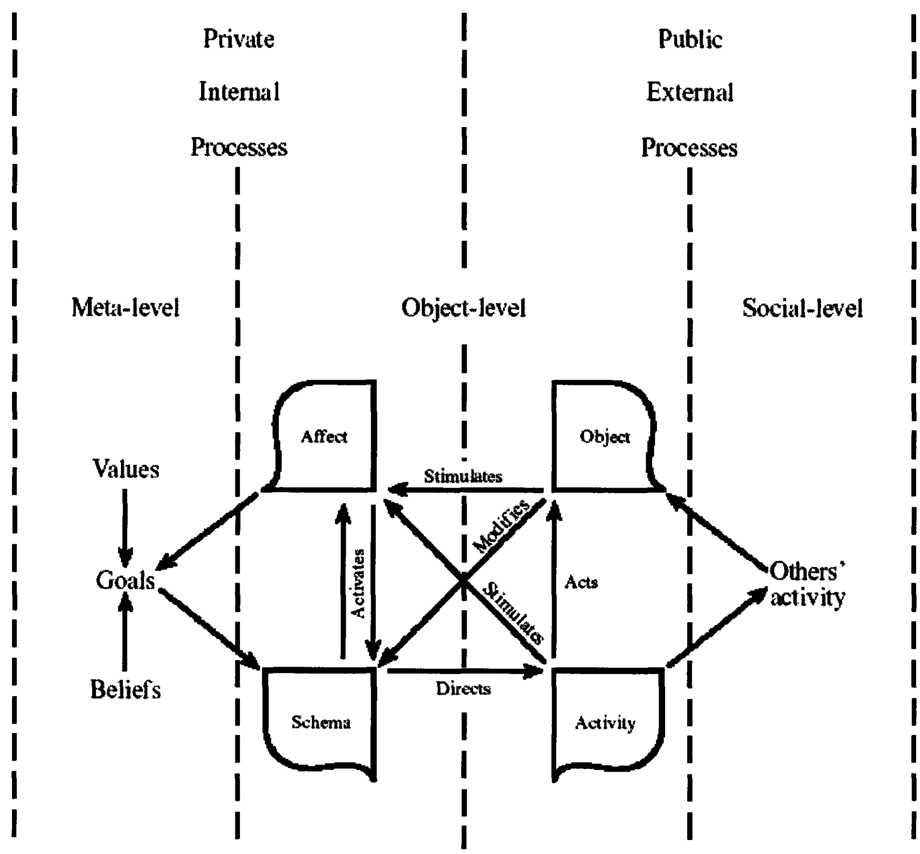


**Figure 5.4 The Relationships between values, representation and actions in human beings (Source: Marks, 1999)**

## 5.5 Representation and Bias

The dilemma of partial cognitive abilities for understanding and perceiving an external system, particularly one that is new and unknown to us, is beautifully shown in a famous poem of Jalal ud-din-i Rumi (1207-1273 ce), called "Elephant in the Dark".

In Rumi's poem the elephant could have been any large-scale engineering system we are confronted with today. The darkness could be taken as the cloud of complexity and uncertainty that obstructs a clear holistic view of the system. The different vantage points of the observers can be likened to the different value sets, areas of expertise and knowledge levels that stakeholders, decision-makers, and experts possess when dealing with an engineering system. In fact, it can be argued that even given the same set of information and level of knowledge, system representation is heavily impacted by the mental map (how people see a system) of the group doing the representation. As we will see in experiments described later in this chapter, this becomes particularly important in engineering systems representation.

A commonly agreed representation of the elephant in Rumi's poem would indeed be possible if it were day, or if as Rumi suggested, everyone had candles and looked at the elephant from all vantage points. The metaphor of the candle is the system representation that takes different perspectives on a system and integrates them all into a coherent larger picture, where everyone can understand those parts that are outside of their vantage point.

**ELEPHANT IN THE DARK**

**in , "Masnavi", by Jalal ud-din-i Rum 1257 C.E**

***Some Hindus have an elephant to show.***
***No one here has ever seen an elephant.***
***They bring it at night to a dark room.***

***One by one, we go in the dark and come out***
***saying how we experience the animal.***

***One of us happens to touch the trunk,***
***"A water-pipe kind of creature is the elephant."***

***Another, the ear, "A very strong, always moving***
***back and forth, fan-animal is the elephant."***

***Another, the leg, "I find it still,***
***like a column on a temple."***

***Another touches the curved back.***
***"A leathery throne."***

***Another, the cleverer, feels the tusk.***
***"A rounded sword made of porcelain."***
***He's proud of his description.***

***Each of us touches one place***
***and understands the whole in that way.***

***The palm and the fingers feeling in the dark are***
***how the senses explore the reality of the elephant.***

***If each of us held a candle there,***
***and if we went in together,***
***we could see it.***

### 5.6 Engineering Systems Representation

System representations are ways of organizing knowledge about the system to better understand its behavior and structure, and can serve as an interface for dialogue and communication between the different individuals interested in different aspects of a system.

For an engineering system, system representations are determined by the system boundary, components, and the interconnections among them. Figure 5.5, reproduced from Chapter 1, shows a typical CLIOS system diagram.

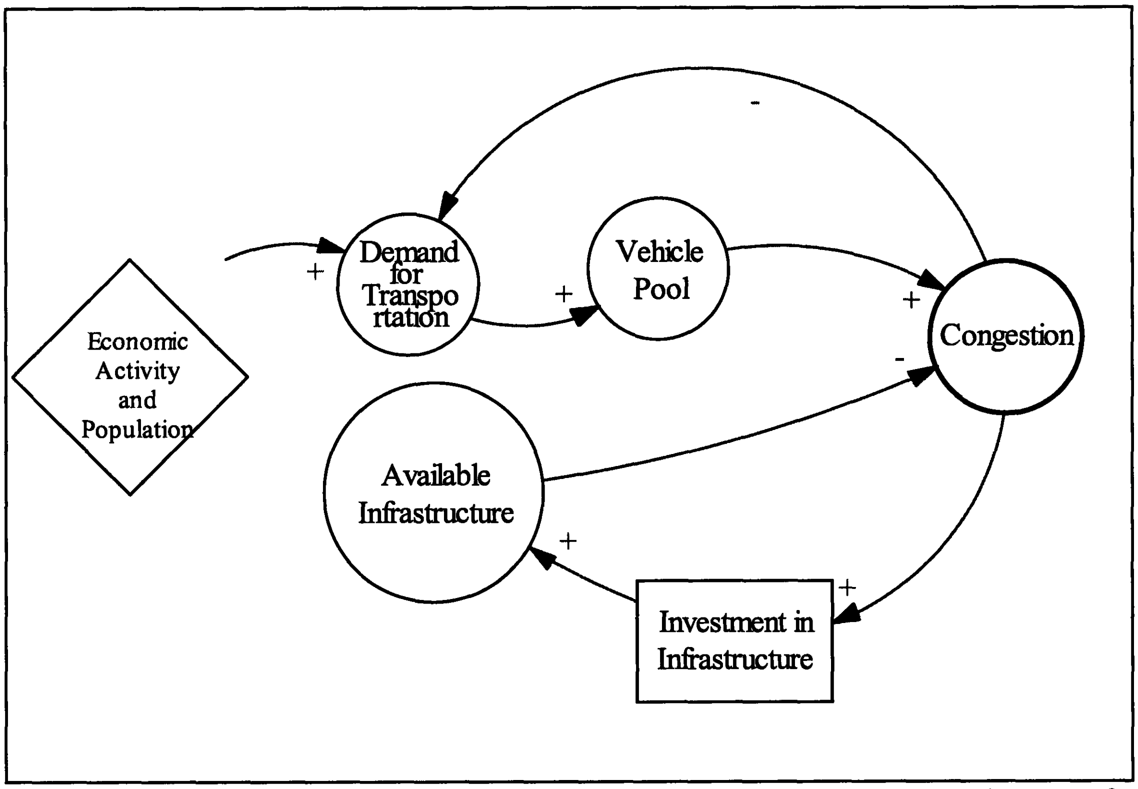


**Figure 5.5 CLIOS Diagram for a Transportation System focused on the impact of infrastructure investments on congestion.**

Here the boundaries of the system are drawn around the transportation demand, infrastructure availability and congestion, which are the main components under study. As explained in Chapter 1, this system representation can address the question "Can we build our way out of congestion?" But it cannot provide us with information about the impact of public transportation availability on congestion (insufficient level of detail) or the impact of transportation on air pollution (outside the boundaries of the system).

*Causal Loop Diagrams:* The above representation is a causal loop diagram (CLD). It shows the cause and effect relationship between the different components. Causal loop diagrams are used in System Dynamics and CLIOS process, making it possible to use system dynamics software to portray CLIOS diagrams. CLD's can be used to gain qualitative insight on how the different parts of a system interact. Unless quantified, a causal loop diagram cannot tell us how strong each of the linkages are or the functional form that the relationships take.

*Stock and Flow Diagrams:* Another type of engineering systems representation is a stock and flow diagram (SFD). SFD diagrams are ways of representing the structure of a system with more detailed information than CLDs. Stocks are fundamental to generating behavior in a system; flows (Rates) cause stocks to change. Stock and flow diagrams are the basis of building a system dynamics simulation model. While CLDs can represent both the behavior and structure of a system, SFDs mostly focus on the behavior or dynamics, providing an indirect understanding of the system structure through its behavior. Figure 5.6 shows a stock and flow diagram for a commercial marketing problem. Here, the stocks (potential customers and customers) are linked by a flow link that is regulated by a rate (fraction of buying).

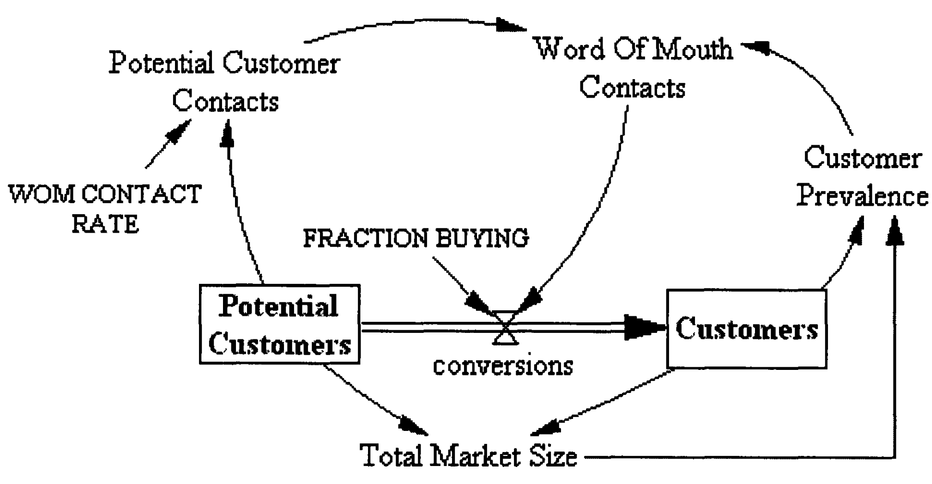


**Figure 5.6 A Stock and Flow Diagram for a Generic Marketing Problem**
**(Source: Vensim Documentation, www.vensim.com)**

In this dissertation we limit our analysis to causal loop diagrams, since a quantitative analysis of an engineering system is not within the scope of the research. Our aim is to foster insight and enable communication among stakeholders, and for that purpose a causal loop diagram is far more effective.

*Virtues of Causal Loop Diagrams:* Jim Hines, a Professor of System Dynamics at MIT, expressed the following opinion on the virtue of causal loop diagrams(Hines, 2000):

*"In consulting, I usually start with causal loop diagrams before going on to stock and flows. The exception is when I see immediately a very clear and important stock and flow structure (the iThink folks might call this a "main chain") in which case, I might dive into the stock and flow right from the start. In teaching the SD applications course here at MIT, we encourage students to start with causal loop diagrams. One reason for this is that students who start with stocks and flows often never complete any important feedback loops. Other reasons to start with causal loop diagrams include:*

- *CLD's are usually more dramatic and hence capture the interest of students and clients alike (its good to start with a bang).*
- *Causal loop diagrams lead to insights on their own more frequently than stock and flow diagrams do. (Note, I am distinguishing between stock and flow diagrams and the simulation model).*
- *Causal loops are easy to develop at a relatively high level of abstraction - this means that they can provide an overview of the system you are modeling, before getting down to the nitty gritty.*
- *Causal loop diagrams are fuzzier, so they can be drawn even if you are not yet clear on every single concept (this is a common state at the beginning of the project).*
- *Causal loop diagrams are cheap relative to simulation modeling (and cheap relative to an equation-level stock and flow diagram). This means you can more quickly get a comprehensive feel for the problem area. And inexpensively generate some initial insights."*

*Drawbacks of Causal Loop Diagrams:* While causal loop diagrams have the advantage of simplicity, many systems experts warn against their misleading nature. The particular problems cited are the lack of distinction among types of links and the lack of characterization of the strength of links as well as their long-term polarity (Richardson, 1986). As illustrated in Chapter 2, the CLIOS process has tried to address these shortcomings by providing ways to distinguish links in terms of their characteristics, relative strength and stopping at individual link polarity assignments (thereby refraining from pre-assigning loop polarities). Yet we do realize that for the quantification of representations into quantitative models, a transition into a stock-and flow structure or other model structures may be necessary. One could also argue that a system representation should only be used as a qualitative information and knowledge-organizing tool, rather than as the basis of a quantitative model. This is an interesting area for further research and lies beyond the scope of this dissertation.

## 5.7 Experiments in Engineering Systems Representation

One of the hypotheses expressed in section 5.5 was that the representation of an engineering system is far from objective, and depends on the values, cognitive limits and perspectives of those present during the representation. This hypothesis was explored in two experiments we did with MIT and Cambridge University students. The first experiment dealt with biases in identifying components and linkages in identical systems by different teams of graduate students, and the second dealt with the ability of experts to look beyond their specific parts of the system to encompass interconnections with other parts of the system outside of the boundaries of their own analysis.

### A) Cognitive limits of components and linkages for a unique system boundary

In Fall 2002, an assignment on the representation of the transportation-air pollution system in the Mexico City was handed out to graduate students in the "Introduction to Technology and Policy" course taught by Prof. Joseph Sussman at the Massachusetts Institute of Technology. The assignment followed lectures on the basics of CLIOS representation and the Mexico City transportation-air pollution linkage.

Student teams had little or no prior knowledge of the system. All students were given written technical and institutional background material, and asked to represent the transportation subsystem of the Mexico City with CLIOS causal loop diagrams to serve as a blueprint for modeling the transportation-air pollution system. Pre-assigned student teams consisted of 4 to 5 individuals, with similar educational backgrounds, with nearly all students' first year graduate students in the Technology and Policy program at MIT. Most had engineering undergraduate degrees and work experiences between 0-2 years. Half of the student group was American and the rest were international students. Women made up around 40% of the class, and were represented nearly equally in all teams. The time for the assignment was set at two weeks for all teams.

Figures 5.7-5.10 show the different representations developed by the student teams.

What these representations clearly show is different emphases on what components are more important to be included, and what interconnections exist among them. If each of the above transportation subsystem representations were used as a basis for a quantitative transportation-air pollution model, they would result in different analyses, and policy recommendations.

The focus of the representation of Group 1, shown in Figure 5.7 is the link between fleet size, fuel quality, Inspection and Maintenance (I&M), congestion and their effect on air quality. Group 2 has its focus on the link between Metro electricity consumption, fleet age and fleet usage, congestion and freight transit. Group 3 takes into account only the effect of congestion and Metro electricity consumption on the air quality. Group 4, adds more sophistication by including policy levers that can affect air pollution through better emission standards, and better urban planning. While most groups focus on the impact of congestion on the environment, three out of four explicitly addresses the loss of productivity as a main issue to consider when thinking about the air pollution problem.

In fact, if all the above are integrated they provide a better picture of the drivers and components that affect air quality in Mexico City. Yet the combined representation enables decision-makers to also draw on resources of stakeholders who would be more concerned with economic impacts of congestion rather than its air pollution impact. This would enable dual-purpose strategies that could address both problems at the same time, with more institutional backing than if the problem were framed only as an environmental problem. Table 5.1 shows some other quantitative differences among the representations.

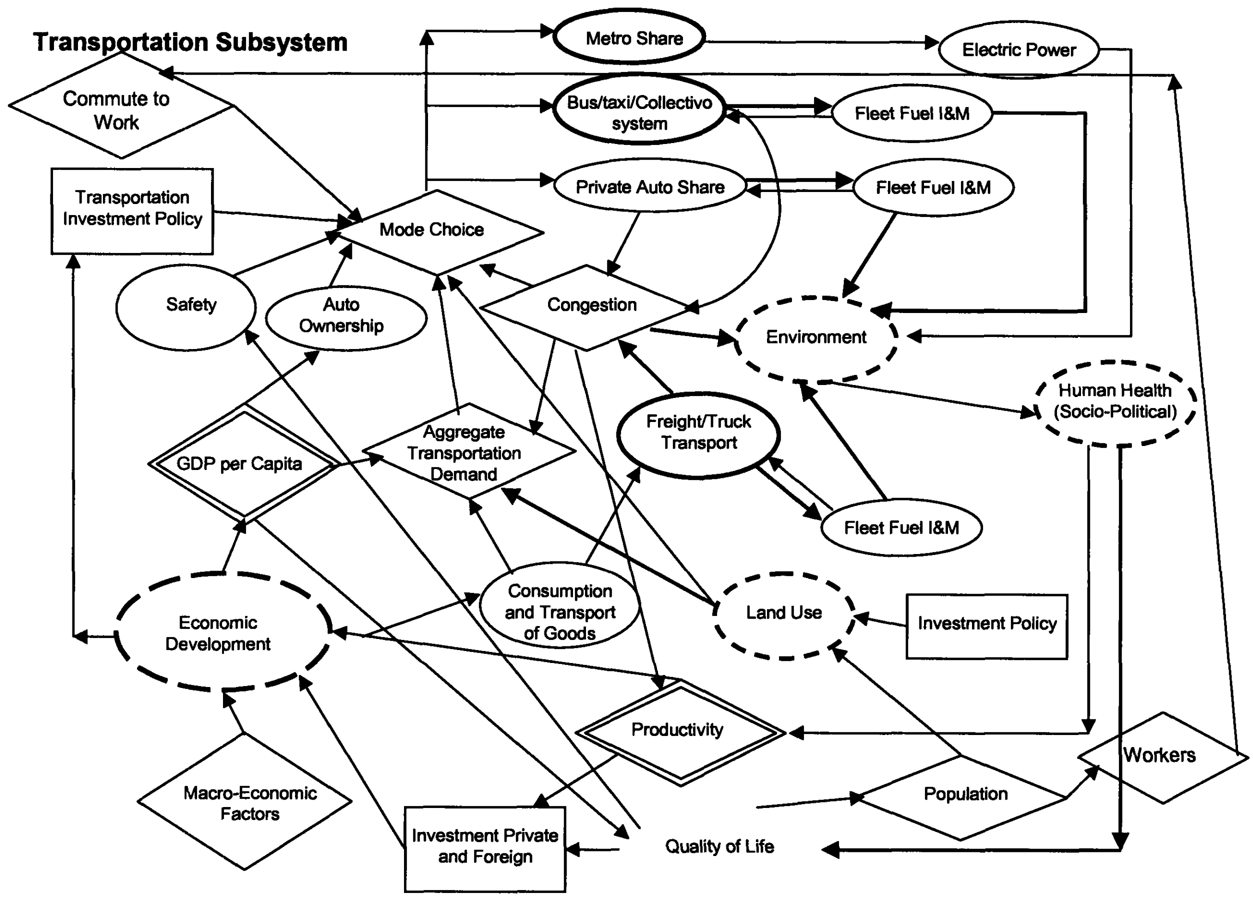


**Figure 5.7 Group 1 Representation of the Mexico City transportation subsystem**

Transportation Subsystem

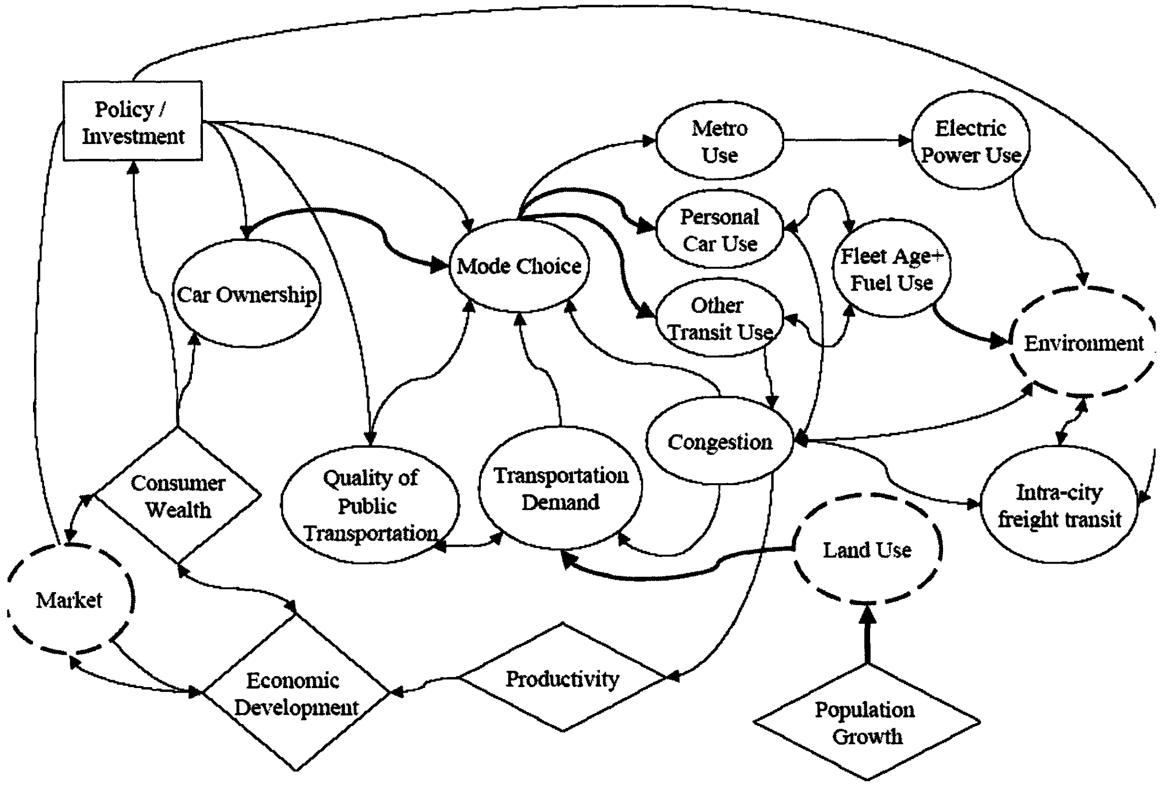


**Figure 5.8- Group 2 Representation of the Mexico City transportation subsystem**

Transportation Subsystem

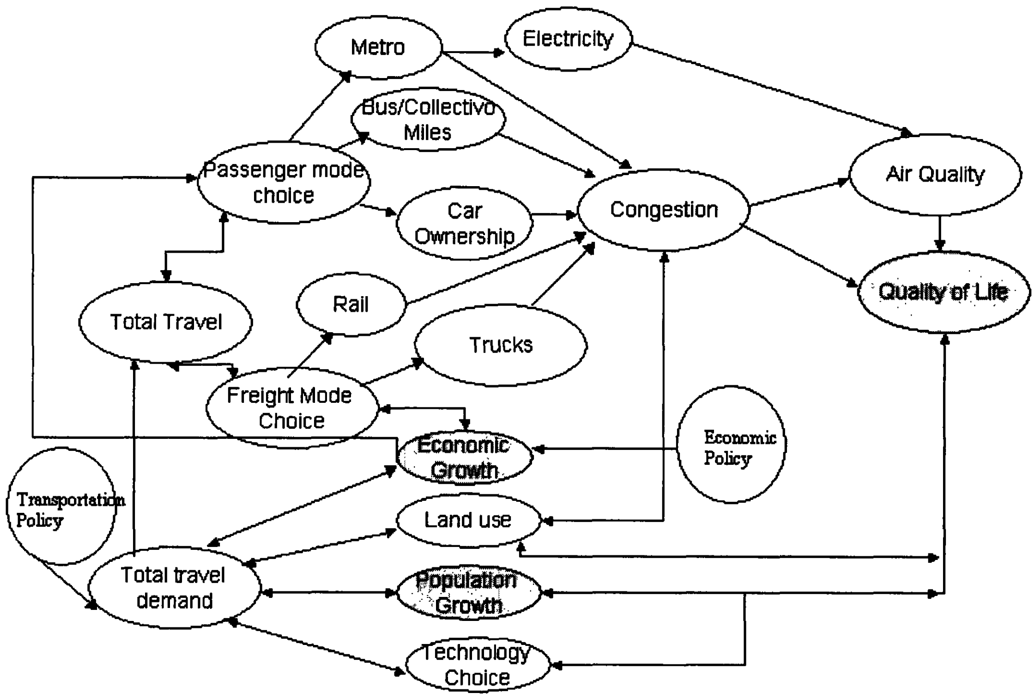


**Figure 5.9- Group 3 Representation of the Mexico City transportation subsystem**

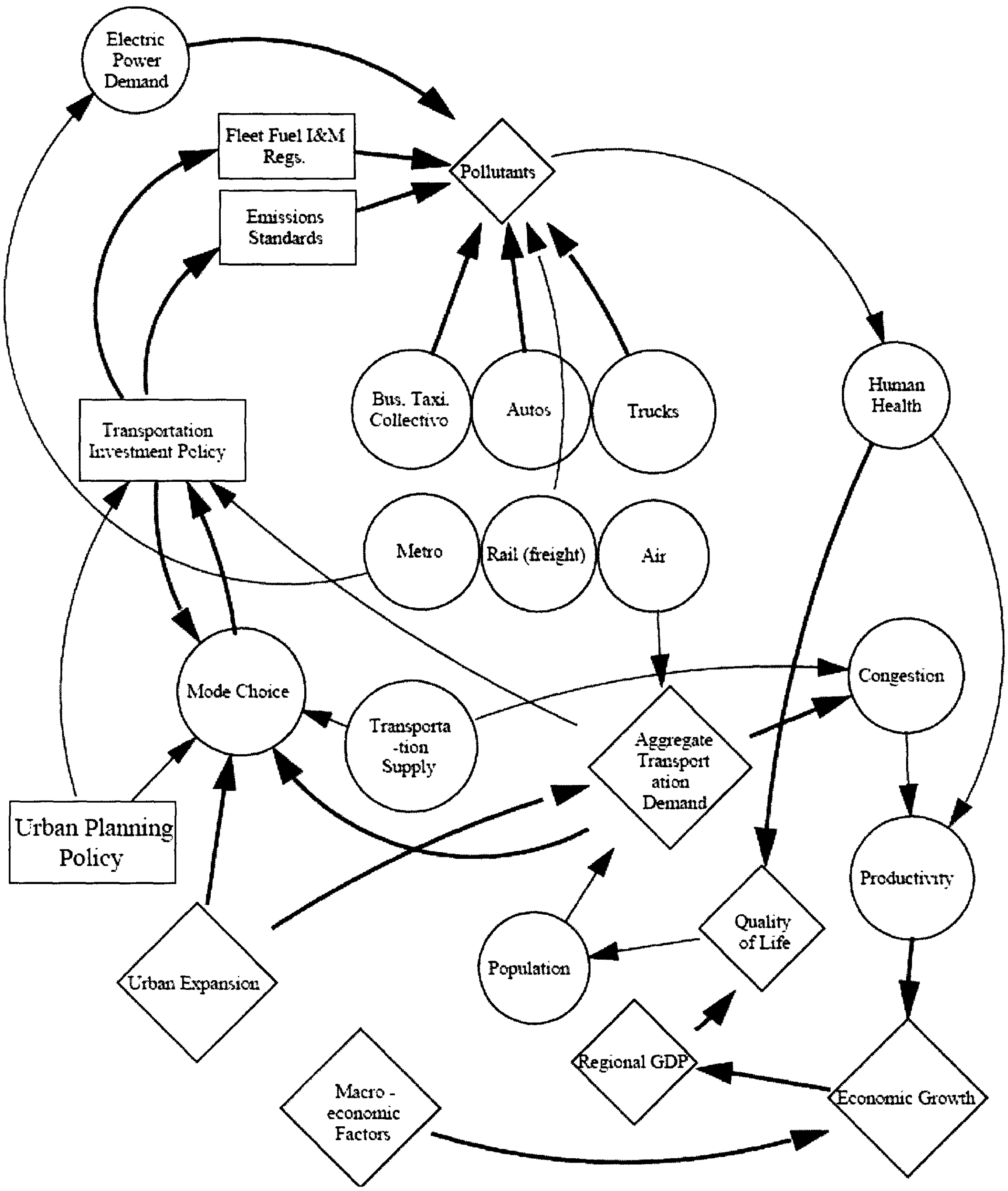


**Figure 5.10- Group 4 Representation of the Mexico City transportation subsystem**

**Table 5.1 Representation Characteristics**

| Characteristic/Team | Group 1 | Group 2 | Group 3 | Group 4 |
|---|---|---|---|---|
| Number of Policy Levers | 4 | 1 | 3 | 2 |
| Common Drivers | 9 | 4 | 0 | 5 |
| Other Components | 17 | 15 | 16 | 17 |
| Total Components Identified | 30 | 20 | 19 | 24 |
| Total Linkages Identified | 47 | 45 | 41 | 33 |
| Link to Component Ratio | 1.6 | 2.3 | 2.2 | 1.4 |

What this experiment shows in general is that there is a cognitive bias that impacts both the number and type of components (see Chapter 2 for types of components) identified and the interconnections between them. The level of detail that is followed for particular linkages also varies within the individual representations as well as across different groups. A counter-argument can be made that as experts develop competency in their chosen field, they develop common mental maps, which reduce these differences among different representations, and the subsequent models.

**B) Partial System Cognition**

A different experiment was performed with a group of Cambridge University (UK) students enrolled in the Technology and Policy program. The group of students included both British and international students, mostly with undergraduate degrees in engineering and 0-2 years of work experience. In the "Introduction to Technology and Policy" course TP3 taught by Prof. Joseph Sussman, similar to that of MIT in the previous experiment, students were again asked to do a CLIOS representation of the air pollution problem in Mexico City, after hearing lectures on the topic and being provided with written background materials on the subject. This time, each of the groups was assigned one "subsystem", to look at. In effect, each of the subsystems was made into a system for the groups to represent. These included pre-assigned systems of 1) freight transportation, 2) automobile transportation, 3) public transportation, surface (bus, taxi, colectivo), 4) public transportation, Metro, 5) PEMEX (the Mexican national energy company) and 6) Electricity Utilities.

*Insert Figure 5.11-Figure 5.17*

Generally (with the exception of the group that was assigned PEMEX, the national oil company of Mexico), the groups did well in identifying detailed components and linkages within their assigned systems. What was interesting however was the way they captured the interconnections of their assigned system with other parts outside of its boundaries that make up the Mexico City air pollution problem. Only two groups out of six captured most of the interconnections with other systems adequately. This illustrates the difficulty that field experts may face when there are multiple subsystems representations, each looking only at one part of the system, without having the larger system to look at.

This experiment illustrated two main points for us:

1) Choosing the system boundaries are crucial in addressing the right problem.

2) Difficulty to capture all the necessary interactions between their area of system focus with others outside of their system boundaries, if they do not start from a holistic systems representation that addresses the problem as a whole.

### 5.8 Stakeholders, Conflict and Systems Representation

System representations are the foundations on which policy and strategy recommendations for large-scale engineering systems are designed. They reflect how we frame a problem, how we define the system boundary within which it is to be understood, how we identify key components and linkages, and how we measure its performance. It is based on our representations of the system that we identify alternatives for design or management of the system to improve its performance. As such, systems representation may be the most important part of engineering systems analysis and design. As the review of the literature, and the above experiments suggest, stakeholder participation in the representation of an engineering system is imperative, if we are to consider their concerns and knowledge within the decision-making process. Many conflicts in the process are the result of inadequate problem definition, and performance measure identifications (i.e. what do we consider as good performance for the system) in the representation. By involving stakeholders in the system representation process we can hope to build a solid foundation on which to build the rest of the decision-making process.

Additionally, because of the biases inherent in the mental map of any one individual, one could argue that the more minds work on a representation, the more comprehensive and accurate it becomes. This is essentially the hypothesis of this dissertation. But it would be myopic not to consider some of the challenges that have so far slowed the involvement of stakeholders in representation processes. In the next section, we will take a more detailed look at these challenges.

**5.9 Challenges with Involving Stakeholder in Engineering Systems Representation**

The old saying "*Too Many Cooks in the Kitchen Spoil the Broth*", is not irrelevant in stakeholder processes. The incremental value of adding a new perspective is offset to some extent by *increased process complexity.* In this section we identify major challenges that have to be considered when designing a stakeholder-assisted representation process.

*1) Increasing conflict:* We said earlier that one of the major goals of involving stakeholders in the representation of complex engineering systems is to reduce conflict. Yet when we engage stakeholders in the representation process, we are *shifting* some of the conflict from the implementation and decision-making phase of projects to the design and analysis phase of engineering systems. Conflict in representation often takes the form of increasing degrees of disagreements in what the "important" system components are and how they are interconnected. More importantly, the decision of what "performance metrics" should be included in the representation is subject to evaluative complexity. Here performance metrics refer to components that constitute the intermediate and final outputs of a representation, if it were quantified. In the next section, we will discuss where conflicts can arise in the representation process. However, it should be noted that in a well-designed collaborative representation process, the intensity of conflict is reduced substantially, and its destructive energy is channeled into creating a representation that is rigorous enough to better withstand criticism from different perspectives. Therefore, while we are adding to the complexity of the representation process, we are reducing the overall conflict level of the entire decision-making process. This overall reduction of conflict can often change the fate of the engineering systems project from impasse and deadlock to seamless social and institutional implementation.

2) *Process Obstruction:* There are always individuals within the stakeholder group who are unwilling or unable to work collaboratively with others. Many times they try to dominate the discussions, and create obstructions if not managed effectively. A good process has to ensure that its structure and ground rules are designed to minimize obstructionist efforts.

3) *Heterogeneous knowledge and expertise backgrounds:* When bringing together decision-makers, experts and citizen group representatives, the heterogeneity of stakeholder backgrounds is a given. Even experts from different fields could be considered laypersons when it comes to fields outside of their expertise. One challenge is for the representation process to both be technically accurate, while being accessible to stakeholder at the same time.

4) *Representation Validation:* Another important consideration is the validity of the representation created from a technical standpoint. This is primarily ensure within a well-designed process by having participating experts sign off on the jointly created representation. Yet it is still imperative to initiate an outside "peer review" process by independent experts who can vouch for the relative validity of the engineering systems representation.

5) *Increased Process Time:* One other issue with involving stakeholders is the perceived increase in the length of representation process. While it may seem shorter to have a limited group of experts focus on the representation, they may have a harder time getting access to data outside of their own reach, and to convince non-participating stakeholders of the merits of their representation. There is limited comparative empirical research on the relative length of stakeholder-assisted representation and expert-based representations, that could shed light on how serious this drawback is. It can be argued that involving

stakeholders from the beginning can reduce the overall time of the decision-making process (from problem definition to project implementation).

6) *Increased Representation and Modeling Costs*: A more comprehensive representation is not essentially a better representation. Many experts make judgments on what parts of the system may be less important to consider. By reducing the size of the problem, they make its analysis more feasible. Many engineering systems experts are worried that the inclusion of stakeholder concerns in a representation may only add to the costs of the analysis without substantively improving the analysis. Furthermore, many of the social and economic considerations included by stakeholders may be difficult to quantify. In large-scale engineering projects, adding more details to the scope of environmental impact assessment process can increase the costs of the technical process dramatically and prolong its completion. In order to address this concern, we should make a distinction between the representation as a whole, and the part of a presentation that has to be quantified for decision-making. Often times many components on the system representation only serve as a context for decision-making, providing us with a perspective on the various impacts of an alternative. Much of the scope may also have a qualitative analysis component, which can be done in parallel by social science experts rather than technical experts. Additionally, many times stakeholders have funds at their disposal that is used for competing or adversarial expert analysis. Many government advisory agencies have access to data that would be an asset to the project. Other stakeholder groups may have budgets they could contribute to the analysis process, thereby reducing the financial load of the additional technical analysis. This concept is known as "resource pooling", and is one of the advantages of the feeling of ownership that results from involving stakeholders in the decision-making process.

### 5.10 Designing an Effective Stakeholder-Assisted Representation Process

The stakeholder-assisted representation process includes a series of meetings, in which a problem is defined, the system boundaries that can address it are selected, components and their interconnections are identified, and information on the problem and the relevant system are shared and organized within a systems representation by the participants. Generally, for such a process to work well, formal and informal procedures and rules have to be defined in a way that facilitates the interactions of stakeholders in the representation process, and establishes clear guidelines on how information is shared and used in the representation. In addition to the initial design of the process, it is necessary for a facilitator to guide discussions, so that the process can actually progress. Any stakeholder process consists of a brainstorming and idea formation stage, which is divergent in nature. Since the goal of involving stakeholders is to converge on a common systems representation, effective facilitation is needed to ensure that this goal is reached. This is particularly true for drawn out, and lengthy processes and complex representations (Dean et al. 1998).

There are essentially three distinct stakeholder-assisted representation approaches that one could identify:

*1) Indirect Stakeholder Involvement:* Extracting inputs from individual stakeholders through surveys and interviews, as well as other means of extracting stakeholder inputs. Experts then construct a systems model based on the inputs, which is then sent to individual stakeholders for feedback. This is the least participatory form of stakeholder involvement in representation. It will also be harder to involve stakeholders in the consequent quantification and alternative design stages of the decision-making process. On the other hand, it minimizes conflict in the representation stage, and shifts it to future stages of the decision-making process.

*2) Direct Stakeholder Involvement:* Stakeholders jointly create the systems representation starting from scratch. This has the highest learning value for stakeholders, but is also the hardest to facilitate due to rapid convergence of dialogue and beginning of conflict. It may however create more trust among stakeholders after an initial time period, reducing the conflict in the overall decision-making process.

*3) Hybrid Indirect-Direct Stakeholder Involvement:* Initially starts with the indirect involvement, but once an initial representation is constructed, stakeholders are invited to refine it. One of the advantages of this approach is that with the initial representation available, stakeholders dialogue remains more focused than direct involvement. It is also more likely to reduce conflict at the representation stage, while allowing stakeholders to shape the final representation together. With the bulk of the representation ready from the beginning, the process will also become shorter, reducing the load on facilitation. The drawbacks may be reduced learning on behalf of stakeholders, and reduced feeling of ownership for some stakeholders.

Selection of the appropriate approach depends on what tradeoffs we are willing to make for the process. In cases where conflict is not as pronounced, the direct approach may be the most valuable. In cases where stakeholder inputs are desirable but no possibility of a stakeholder process exists, one could use the indirect approach.

In this dissertation, we have used the hybrid approach as a way to reduce the effects of obstructionism, reduce the load of facilitation, and minimize conflict in the representation stage.

## 5.11 Limitations of System Representation as a Basis for Collaborative Processes

Despite the above-mentioned advantages for system representations to serve as a basis for collaborative processes, there are serious limitations that a representation-centered process imposes on stakeholders. For one, there are many stakeholder concerns that cannot be expressed in terms of boxes and arrows. Feelings of injustice, of non-representation and moral wrong cannot be expressed adequately in a "logical" causal loop diagram. Additionally subjective issues such as Aesthetics, fairness etc. lose their real meaning when put into a causal loop diagram. Therefore, a system-representation centered process does not allow for the more emotional concerns of stakeholders to be taken into consideration. This would limit the application of such a process in cases where the emotional load is far more important than the rational concerns.

On the other hand, we would argue that for some cases this framing of the problem, while imposing some structure on the discussion format, can help address many of the problems associated with collaborative processes, as seen from an engineering systems perspective. While there may be other venues and channels for stakeholders to express their emotional concerns, a system representation-centered process could help uncover the underlying tangible interests of stakeholders within the technical process. To what extent this is feasible has to be seen in actual practice, but the basic approach of this research is that in addition to a change of attitude in experts, there needs to be a change of attitude among stakeholders as well for such processes to succeed. It is too early to predict whether such an approach is doomed from the start, or whether it can be useful in some cases while not useful in others. This should be part of the future work on this research.

### 5.12 Chapter Summary

In this chapter we looked at the concept of representation in general, and the concept of engineering systems representations in particular. We explored the role of values, beliefs, and different types of cognitive biases in constructing systems representations. We then looked at ways to involve stakeholders in the representation of engineering systems and identified challenges associated with such involvements. We intoruced effective stakeholder involvement approaches for engineering systems representation, and discussed their relative merits. In the next Chapter, we will look at the Stakeholder-Assisted Modeling and Policy Design (SAM-PD) process that forms the core methodological contribution of this dissertation. A major part of this process focuses on stakeholder-assisted representation of engineering systems. In Chapter 8 we will then look at the Cape Wind case study as a way to explore the insights from the current chapters applied to an actual process.

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# ➲Chapter 6
## Stakeholder-Assisted Modeling and Policy Design

*The idea is to try to give all the information to help others to judge the value of your contribution; not just the information that leads to judgment in one particular direction or another.*

*-- Richard P. Feynman*

If the previous chapter could be considered as providing a conceptual framework for this dissertation, this chapter can be considered as its core methodological contribution. After discussing the different aspects of stakeholder involvement in engineering systems decision-making at length from a variety of different angles, here we are proposing a process that aims to facilitate that involvement. The process, called Stakeholder-Assisted Modeling and Policy Design (SAM-PD), combines insights from earlier discussions into a comprehensive process that facilitates stakeholder involvement from problem definition to post-implementation monitoring and adaptive management.

### 6.1 The Stakeholder-Assisted Modeling and Policy Design Process (SAM-PD)

As the insights from the literature indicate, ideally a "good" or desired outcome of a successful stakeholder process for Engineering Systems decision-making would have the following attributes:

- It would produce a package **holistic (system-wide)** decisions based on the **best available science** (within an agreed timeframe and available resources) **agreed upon** by the overwhelming majority of key stakeholders.
- The policies would have taken into account **the values and the local knowledge** of the key stakeholders that have emerged in a collaborative process through facilitated dialogue.
- The policies would actually address the problem at hand **effectiv**ely over time.
- The policies would be **adaptive** as to integrate **emerging** scientific data and **changes** to the **system and the environment**

- Implementation of policies would meet little resistance by the affected stakeholders and would ideally not result in extensive litigious action, resulting in **robust** solutions.

Based on these insights, we have designed the Stakeholder-Assisted Modeling and Policy Design (SAM-PD) process. SAM-PD uses insights from systems thinking and alternative dispute resolution (ADR) to provide an integrated engineering systems decision-making process that enables stakeholders, decision-makers and scientists to make collabarotive decisions. The process is based on a holistic analysis of engineering systems within a collaborative framework. As noted earlier, SAM-PD uses a consensus-building process as its collaborative framework, and a CLIOS process for its systems analysis stage. Figure 6.1 shows the concept of the SAM-PD process as a synthesis of the two processes.

- **SAM-PD in a Nutshell**

**In SAM-PD, representative stakeholders, decision-makers and scientists jointly engage in defining the scope of engineering systems policy issues they have a direct interest in. They use a collaborative process to represent the system that addresses the issue at hand through a holistic systems analysis perspective that allows them to better understand the interactions among different parts of the system and between the different technical, social and economic layers of a system. Based on that representation, they collectively design alternatives and evaluate their effects on the system using the system model they created. Finally in a consensus-seeking negotiation based on the quantitative results from the model as well as qualitative insights gained throughout the process, they forge policies that address the identified problem, taking into account stakeholder concerns and knowledge and cognizant of the uncertainties inherent in the scientific/technical analysis.**

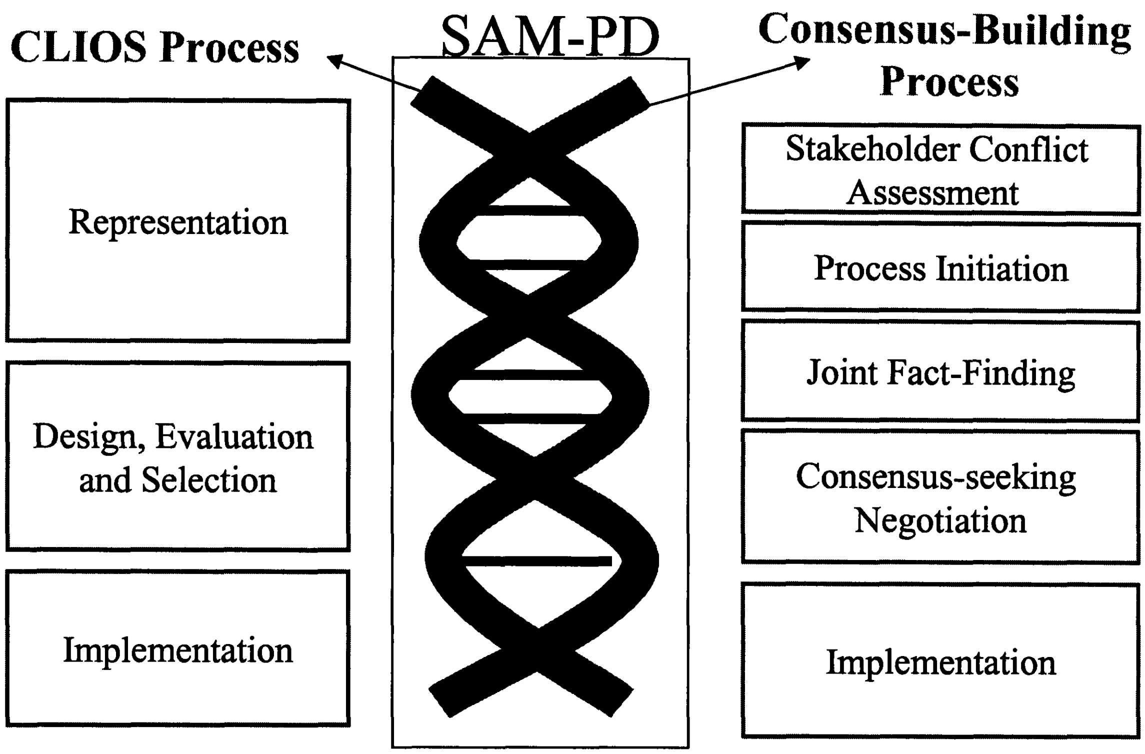


**Figure 6.1- The SAM-PD Double-Helix, connecting the CLIOS process and the Consensus-building Process strands. The links holding the strands together include stakeholder-assisted representation and model-based negotiation, Participation Level Point (PLP) heuristic, the Stake-Power-Knowledge (SPK) framework, discourse integration and pragmatic analysis.**

The PLP heuristic, the SPK framework, discourse integration, pragmatic analysis, stakeholder-assisted system representation, and model-based negotiation will be discussed in detail later in this chapter.

## 6.2 The SAM-PD Process

SAM-PD is a five-stage iterative consensus-building process that uses a systems representation as the basis of dialogue and negotiations among stakeholders.

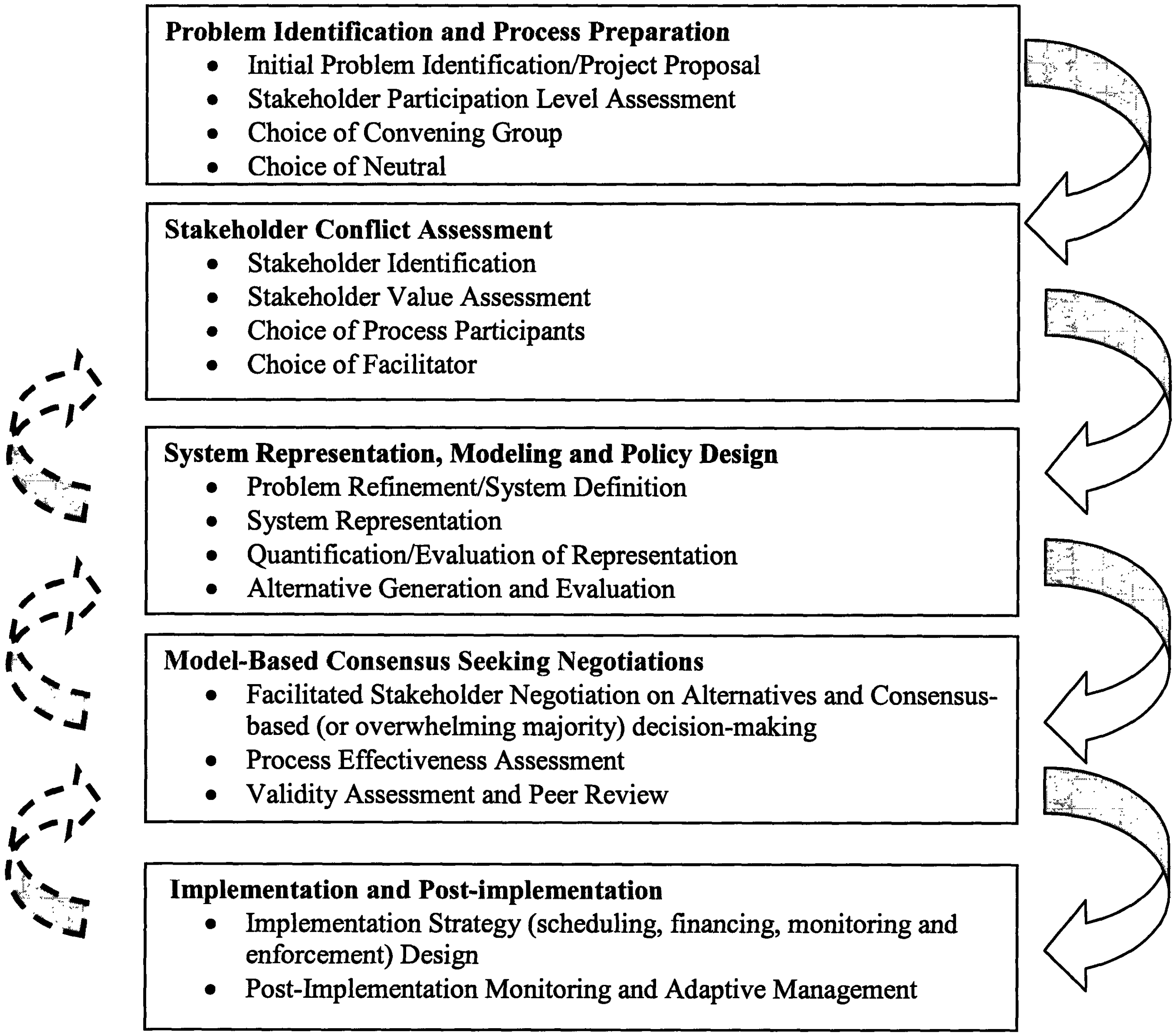


**Figure 6.2 The SAM-PD Process Diagram**

### *6.2.1 Mapping the structure of SAM-PD versus the CLIOS Process*

The CLIOS process presented in Chapter 2 serves as the systems analysis element of SAM-PD. As shown in the Figure 6.3, the three stages of the CLIOS process are parallel to the last three stages of the SAM-PD Process. The grouping of steps in the stages also varies slightly, with CLIOS steps 1-8 (instead of 1-5). Also, there are some structural differences however between the two that are a result of the first two stages of the SAM-PD process. In the CLIOS process, institutional analysis occurs parallel to the physical systems analysis. Within the current structure of the CLIOS process, institutional analysis is done from an objective, outside perspective. That is, it is not the stakeholders analyzing themselves, rather experts who analyze the institutional sphere as they would do for the physical system. With the stakeholders becoming part of the analysis team, many of the institutional analysis steps take the form of the first two stages, and the three subsequent stages are mostly focused on the physical system (which can also include regulatory processes).

### 6.2.2 *Mapping the structure of SAM-PD versus the Consensus Building Process*

The Consensus-building process (developed by Lawrence Susskind at the Consensus Building Institute[21]) presented in Chapter 4 serve as the stakeholder-process elements of SAM-PD. Most of the steps of SAM-PD correspond directly to those of the consensus-building process, with the distinction that a systems approach is used throughout the process, and system models are used as a basis for joint fact-finding, alternative negotiation and evaluation, consensus-seeking negotiation and adaptive management of the process. Figure 6.4 shows the two processes and their corresponding steps side-by-side. Essentially, the SAM-PD process is a consensus-building process applied to engineering systems decision-making, with a system-centric view.

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[21] See http://www.cbuilding.org/

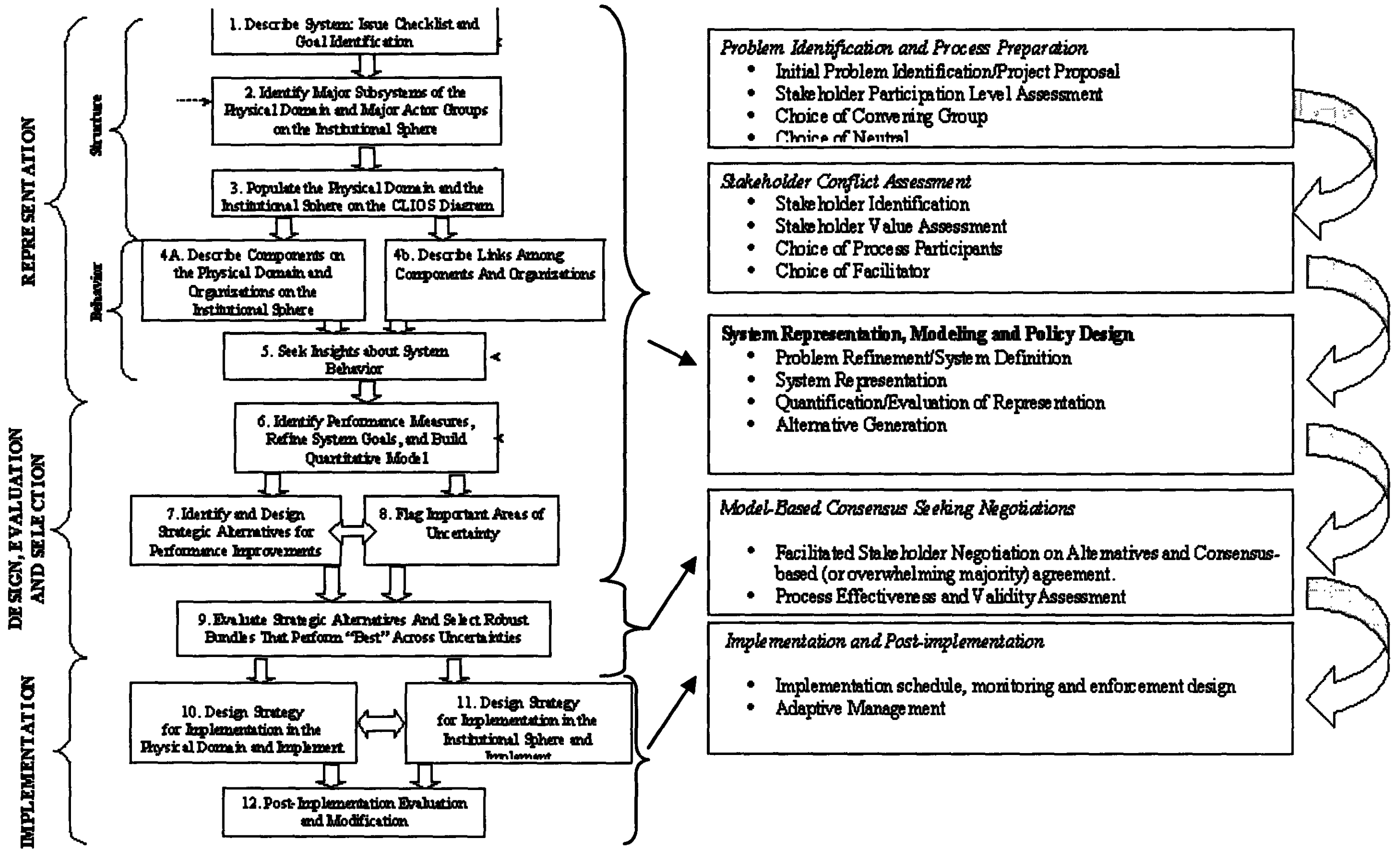


**Figure 6.3- Mapping the CLIOS and SAM-PD Processes**

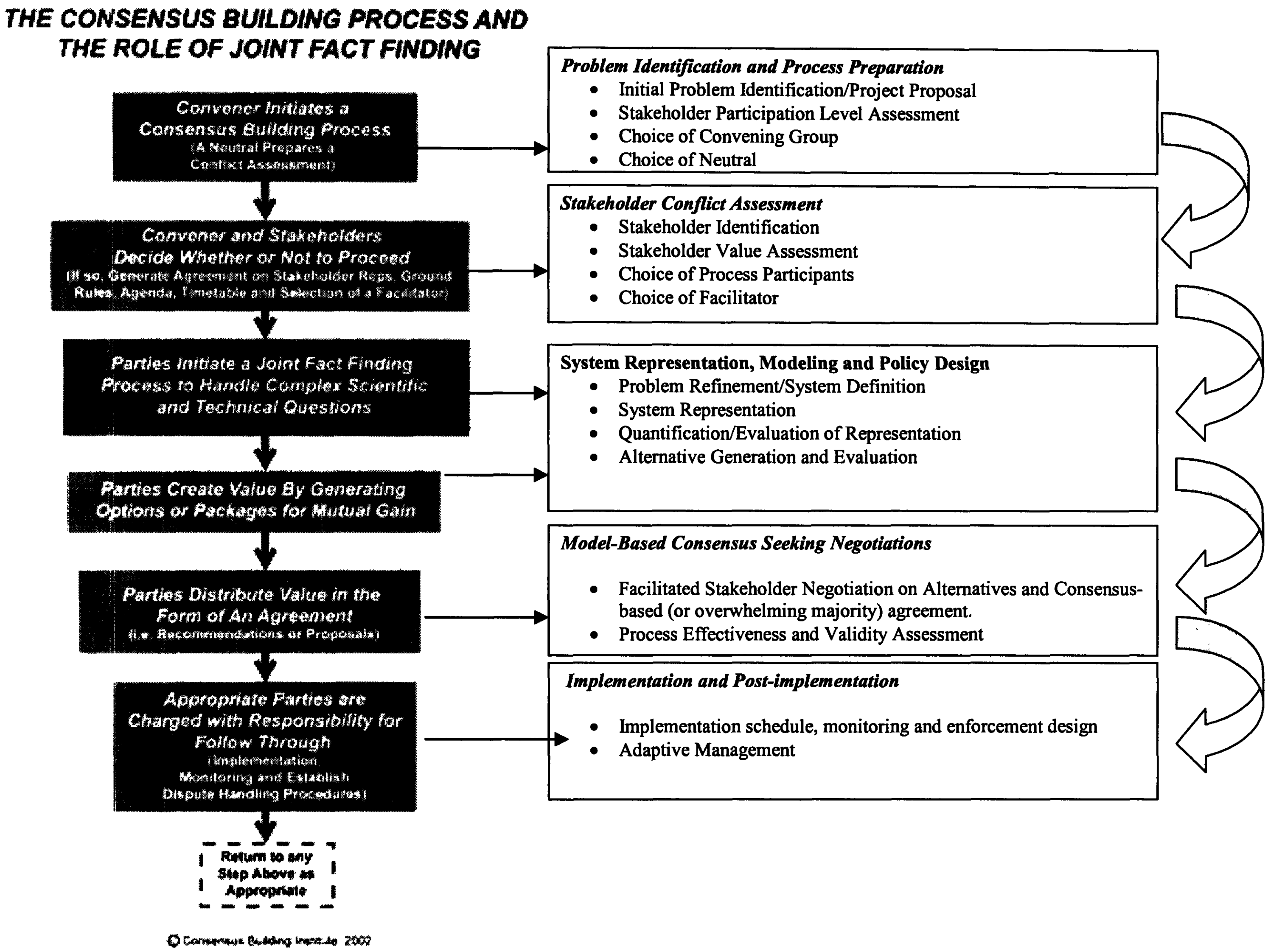


**Figure 6.4- Mapping the Consensus-Building Process (developed by the Consensus Building Institute) and SAM-PD Processes**

In the next sections, we will look at the detailed steps within each of the five stages.

## 6.3 Problem Identification and Process Preparation Stage

As seen in Figure 6.2, the first stage of the SAM-PD process is *Problem Identification and Process Preparation*. In this stage, a problem in an existing system is identified, or a new system is proposed. With the initial decision question defined, decision-makers assess the need for stakeholder participation and form a *convening* or managing group for the process. If a collaborative process is warranted, the convening group chooses a neutral who can prepare the groundwork for the actual process.

### *6.3.1 Problem Identification/Project Initiation*

Engineering systems decision-making processes start when a new system is desired to serve a particular need, or when problems emerge in an existing system. Often, the official decision-making process starts later than this point. Often, a decision-making process starts with the identification of a problem in the management of an existing system or the official initiation of a new project, discussed in the following section.

#### *a) Strategic Resource Management/Regulation*

Many existing large-scale engineering system exhibit weak performance, or exerts unintended impacts on their environments at some point over their lifetimes. At such times, agencies and organizations managing important parts of the system begin to think of interventions that would improve the performance of such systems, or address the problems that have emerged. For the type of engineering systems we are concerned with in this dissertation, that is systems that have significant social and environmental impact, it is often a combination of public and private institutions that initiate the problem identification.

In these cases, government agencies with mandate to manage and regulate different parts of the system decide to define/redefine resource management strategies after an actual set of problems or the potential of a future problems is identified in the system, either by the public/media and/or the agency's experts. An example of this type of process is the strategic management of air quality in Mexico City, strategic management of spent nuclear fuel in the U.S., national and regional energy policy, and existing infrastructure improvements.

*b) Permitting Processes*

Most newly proposed engineering systems need to go through some form of a permitting process. For large-scale projects, such processes often include an environmental impact assessment. In such cases, a developer or a government agency initiating a project has to go through a permitting process for the project, where the an assessment of the potential social, economic and environmental impacts of the project and available alternatives have to be studied before a permit for the project is issued. A permitting agency reviews the permit application and can approve or refuse an application for a new engineering system. In the U.S., this type of process takes the form of the National Environmental Policy Act (NEPA) process. A recent project undergoing a NEPA process is the proposed offshore wind farm project in Nantucket Sound, in Cape Cod, Massachusetts that will serve as the central case study in this dissertation.

In the SAM-PD process, we refer to organizations that have a regulatory or management role over the engineering system as decision-makers. It is important to realize that not all government agencies that manage parts of the system have a decision-making mandate. Many times, it is a single government agency that has the final say on the system in question. Decision-makers may have a stake in a specific outcome, but will be mostly concerned with effective management of the system in way that satisfies their organizational mandate. Normally, decision-makers follow established procedures for addressing a permit application, but there are less defined procedures for strategic resource allocation problems. Stakeholder participation in these procedures are often in the form of public hearings.

6.3.2 Stakeholder Participation Level Assessment

**The PLP Heuristic:** Virtually all Complex Large-Scale Engineering Systems have a multitude of stakeholders and would benefit from some level of stakeholder participation in the decision-making process. Decision-makers need to identify what level of stakeholder participation is necessary for the particular problem. As a heuristic tool, we have developed the PLP (Participation Level Points) heuristic (shown in Table 6.1), which links system/stakeholder characteristics with the participation ladder categories proposed by Arnstein (1969). The premise of the PLP heuristic is that some problem/system characteristics increase the desired level of stakeholder participation.

The PLP heuristic provides a direction, not an answer. As such, it is always wiser to err on the side of higher stakeholder participation than to settle for lower stakeholder participation levels. If the PLP of a system is 4 or higher, stakeholder participation in the system representation and modeling stage is advised. Given that the different questions in Table 6.1 do not necessarily carry the same weight in different contexts, decision-makers need to use their own judgment to judge whether this heuristic is appropriate for their particular system. Paradoxically, there may be a need for a basic, more limited stakeholder consultation to determine whether stakeholder involvement is necessary, and if so at what level. It is important to note that in any decision-making process there are different levels of participation for different stakeholders, depending on their stake, power and knowledge. The PLP only points to the highest level of participation desirable in the project. As part of future work on SAM-PD, we plan a calibration of the PLP heuristic with past engineering systems cases, to make it a more reliable heuristic.

If the PLP of a system is lower than 4, then there is little use for the SAM-PD process in the decision-making process. SAM-PD is suitable for systems where the degree of conflict, uncertainty, distrust, information heterogeneity has evolved to an extent that makes more aggressive stakeholder participation a necessity. Sometimes, a system's PLP changes over time, with more controversy and uncertainty emerging over time. If such changes in the system characteristics are expected, the PLP can be evaluated with the potential changes in mind.

### 6.3.3 Choice of Convener

If the PLP heuristic indicates the need for a collaborative process (PLP≥4), the decision-makers need to identify a suitable convener group. The convener group is the entity that manages the collaborative process, by formally inviting stakeholders and brining them together, providing facilities for the duration of the stakeholder process, providing funding for major parts of the process, and choose the neutral. For these reasons, the convener group should have credibility, authority and trustworthiness in the eyes of the potential stakeholders. It should also possess sufficient funds and resources to ensure that the process can be carried out through to the end.

### 6.3.4 Choice of Neutral

The *Neutral* is the main person in charge of stakeholder identification and selection, stakeholder conflict and value assessment. The convener group chooses the neutral to perform a conflict assessment for the project. The neutral then assembles a team and starts the stakeholder identification process.

It is wise to choose the neutral from outside the convening organization, preferably a professional in the field of negotiation and conflict resolution, with a robust knowledge of stakeholder conflict assessment practices. Given that it is desirable to preserve knowledge in the process, and that stakeholders will interact with the neutral during the conflict assessment process, it would be advantageous for the neutral to be a prime candidate for the facilitator position later in the process, but this doesn't always have to be the case.

**Table 6.1 The PLP Heuristic**

| Step 1: Examine System Characteristics | Yes | No |
|---|---|---|
| Is the system in question spread over multiple jurisdictions? | 1 | 0 |
| Does the problem affect a multitude of heterogeneous stakeholder groups? | 1 | 0 |
| Has the issue already stirred visible controversy? | 1 | 0 |
| Are cost distribution issues important? | 1 | 0 |
| Is all the funding necessary for building/managing the system available to the decision-makers/project developers? | 0 | 1 |
| Is uncertainty in scientific information a source of controversy? | 1 | 0 |
| Are environmental justice issues relevant? | 1 | 0 |
| Is there distrust of the decision-makers' ability to adequately represent stakeholder interests? | 1 | 0 |
| If marginalized in the decision-making process, do stakeholders have the ability to adversely impact the implementation or management of the project/system in a significant way? | 1-2 | 0 |
| Do some stakeholders have access to useful information/data or financial/human resources they would be likely to share if they were involved? | 1 | 0 |
| Is adaptive management of the system over time imperative? | 1 | 0 |
| Is significant process obstruction by stakeholders likely if they are involved? | -1 or-2 | 0 |
| Participation Level Points (PLP) | Sum | |
| ***Step 2: Determine Level of Participation (Based on a modified Arnstein's Ladder(1969)*** | PLP | |
| *Public Participation in Final Decision* | 9 or above | |
| *Public Participation in Assessing Risks and Recommending Solutions* | 6-8 | |
| *Public Participation in Defining Interests, Actors and Determining Agenda* | 4-5 | |
| *Restricted Participation (Feedback in Public Hearings, Commenting opportunities)* | 3 | |
| *Public Right to Object* | 2 | |
| *Informing the Public* | 1 | |
| *Public Right to Know* | 0 | |

## 6.4 Stakeholder Assessment Stage

The Stakeholder Assessment stage is one of the most important stages in the SAM-PD process. The success or failure of the process may depend on which stakeholders are engaged and at what level.

### 6.4.1 Stakeholder Identification

Engineering systems often impact a multitude of stakeholders, some obvious, some less so. The obvious ones are the people who are advocating a project/management strategies, and the vocal people or groups who oppose that proposition as well as government agencies that have the mandate of making decisions on the issue. Usually, however there are a number of other stakeholders who are likely to be affected by and therefore concerned about any decision that is made, and may try to reverse the decision or block its implementation, if their concerns are not integrated into the decision-making process. (CRC, 1998)

Given the limitations on how many stakeholders can physically participate in a collaborative process, it is necessary for the neutral and the convening group to assess at what levels individual stakeholders or their representatives should be involved.

Effective stakeholder identification is therefore imperative to determine who will be directly or indirectly affected, positively or negatively, by a project or a system management plan, and who can contribute to or hinder its success. It is important for the project sponsor/system manager to be comprehensive in identifying and prioritizing all relevant stakeholders, including those that are not usually present at the table (Susskind and Larmer, 1999). Those identified will then need to be consulted to varying degrees, depending on their impact potential on the system, as well as their potential to contribute to the policy process through knowledge, resources or compliance with implementation. Stakeholders can be categorized based on their influence/power, stake, and knowledge

- Decision-makers **(High Stake, High Power, and Differing levels of knowledge)**: Representatives from organizations that have a mandate to manage some part of the system or issue a permit for a new project, as well as other organizations with mandates over other systems interconnected with target system, whose help is required in effectively managing the system.

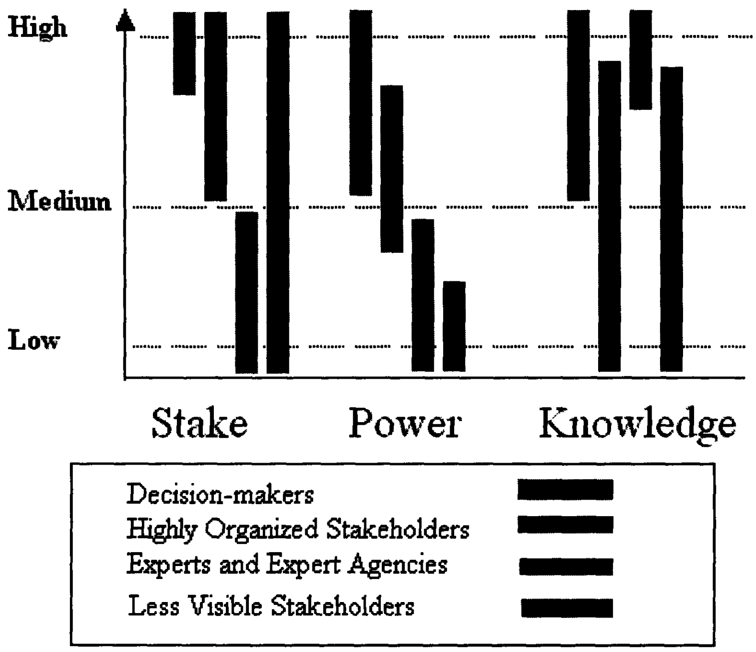


**Figure 6.5 The SPK Framework**

- Stakeholders with economic/political influence **(High Stake, Medium to High Power and Differing Levels of Knowledge)**: These include affected industry, private corporations, landowners, labor unions, nationally recognized and highly organized NGOs and other groups with strong political influence.

- Knowledge-producers **(Low Stake, Low Power, High Knowledge)**: Scientists, Engineers and Consultants working in the academia, technical consulting firms, local, state and federal science agencies and scientific and technical offices of government agencies and scientific arms of NGOs that have a stake in the process, but have no specific mandate.

- Other affected Stakeholders **(High Stake, Low Power, Differing Levels of Knowledge)**: These include smaller groups of stakeholders directly or indirectly affected by system management strategies or the proposed project. These can include less organized neighborhood groups, local environmental groups, small business owners etc., depending on the type of system or project that is initiated.

The SPK framework provides a rough mental guideline for the stakeholder classification process. Stakeholders can be assessed on their stake, power and knowledge (expert or local) on the decision. Stakeholders with high stakes in the collaborative process, even if they lack any power or knowledge can add legitimacy and community acceptance. Stakeholders with high knowledge can add to the scientific/technical /contextual validity of the analysis, while stakeholders with power (that is mandate or resources) can increase the viability of the process. Stakeholder with lower stake, power and knowledge can be involved through feedback systems, information websites, media releases and outreach campaigns.

Of course it is important to realize that such a categorization, while useful as a rough map, should not be the exclusive criteria for selecting stakeholders for participation, given that even smaller actors can sometimes be effective in undermining a process.

### 6.4.2 Stakeholder Value Assessment

Once a basic stakeholder list is prepared, it is imperative to establish the stakeholders' interests/values regarding the system/project, eliciting how they view the system/project, and the issues they would like to have considered in any policy process. This stage will help generate a set of information on the basis of which a tentative systems representation can be built.

As indicated in Chapter 5, in this dissertation we use a *hybrid* direct-indirect stakeholder involvement process. We indicated that one of the advantages of this approach is that with the initial representation available, stakeholders dialogue remains more focused than direct involvement. It is also more likely to reduce conflict at the representation stage, while allowing stakeholders to shape the final representation together. With the bulk of the representation ready from the beginning, the process will also become shorter, reducing the load on facilitation. The drawbacks may be reduced learning on behalf of stakeholders, and reduced feeling of ownership for some stakeholders.

The following approaches for eliciting stakeholder inputs are available to the neutral:

- Stakeholder Conflict Assessment Surveys
- Interviews
- Media Articles and Press Releases
- Stakeholder Websites
- Formal and Informal Hearing Transcripts

*Stakeholder Value Assessment Survey*

Once a basic stakeholder list is prepared, it is imperative to establish the stakeholders' interests/values regarding the system/project, eliciting how they view the system/project, and the issues they would like to have considered in any policy process.

*Media articles, press releases and interviews*

In many cases it is difficult to reach all the key stakeholders for commenting. There are some indirect ways for considering the views of stakeholders on the system. One of the ways to expand the range of stakeholder inputs is to study newspaper articles, television programs and press releases that exist on the system in question. In addition to positions, there are often statements that express the underlying values and concerns of stakeholders that can be extracted.

*Stakeholder group websites*

Most organized stakeholder groups in the U.S. and other developed countries have some of their views presented on their websites. These are usually far more comprehensive than those that can be found in newspaper articles. Similar to newspaper articles, websites only represent the voice of those already vocal. However, in many cases it can be a good supplementary source of information, should it not be possible to access some stakeholders for direct input elicitation.

Many stakeholder organizations also have comment sections on their websites where individual stakeholders (usually those that support the position of that particular stakeholder group) leave feedbacks or comments.

*Formal and informal hearing transcript*

In many cases, formal or informal hearings are held at different stages of decision-making. Transcripts of these hearings, when available, can shed further light on stakeholder views on the system. Given that such hearings are usually open to the public, they are a good source of capturing stakeholder inputs from less organized stakeholder groups.

### 6.4.3 Selection of Process Participants and Individual Participation Levels

The answers to the questions in the previous step, along with the initial categorization of stakeholders should provide a basis for the selection of participants for the collaborative process. Stakeholders not included in the initial interviews, but mentioned by a considerable number of other stakeholders should be contacted and interviewed. Stakeholders in each category should be ranked according to their importance to the process and chosen based on the criteria of authority, political power, intensity of interest, potential for knowledge contribution, potential for resource provision and potential to undermine agreements if excluded. This is essentially a case-by-case decision, but given the structure of the collaborative process, the process would be most effective if the number of participants did not go beyond a certain limit. While there is no fixed limit to the size, having larger groups can result in unmanageable group dynamics, while very small groups can result in many of the different stakes not being covered by those present.

There should be a balance among the four categories of stakeholders in the core group present at all stages in the process.

While it is imperative to have the most crucial stakeholders participate in the process as a core group, some of the sessions could be held with additional stakeholders who can contribute in particular stages, but not be present at all stages. Some may be chosen to participate in all of the stages of the process, while others may be asked to provide feedback in different stages of the process, and be kept informed. Every effort should be made to have the most crucial stakeholders in the process from the very beginning, but if at any time a key stakeholder is identified who has been left out, they should be consulted and possible included in the process. The process should be designed so that inputs from stakeholders not directly participating in the process could be considered for inclusion at any time.

After the selection occurs, selected stakeholders are invited to participate in the collaborative process. Many of the selected stakeholders will be skeptical whether or not to participate in the process, unsure of how it might benefit them. Here, it is the task of the neutral to present a compelling case for the benefits of the collaborative process. Selected stakeholders should be invited to attend the introductory session, where the decision whether or not to proceed with a collaborative process is made. Given that they still have the option not to participate after the introductory session, many selected stakeholders may agree to attend such a session. Before the introductory session, the neutral provides the selected stakeholders with a list of all the participants and provides them with a synthesis of the interviews, where individual participants can understand the interests, concerns and positions of other participants, categorized under each set of questions.

#### 6.4.4 Choice of Facilitator

In the first face-to-face stakeholder meeting of the SAM-PD process, selected stakeholders who have accepted to participate come together for an introductory session aimed at building initial trust and getting to know other stakeholders and their interests and points of view. The convener presents some background material on the basics of the consensus building process, and explains what the group can expect as an outcome of such a process. The group of stakeholders jointly decides whether or not to proceed with the process. Individual stakeholders may opt out of the process. If the remaining participants choose to proceed with the willing group of participants, the group can then proceed to choose a neutral facilitator (who can be the neutral chosen previously by the convener or any other person agreed on by the group). The facilitator is the person responsible for facilitating dialogue amongst stakeholders in all subsequent stages of the collaborative process. The ideal facilitator for such processes is a person who is competent in negotiations and conflict resolution theory and practice, and has a basic understanding of the system/project in question, and is known by stakeholders as objective and neutral to the outcome. As the term neutral applies, the facilitator should have a record of professional facilitation and a clear impartiality in the eyes of the various stakeholders. Once chosen, the facilitator initiates the next stage of the collaborative process, which is the joint fact-finding stage. Once the facilitator is chosen, the ground rules for the process have to be set. These include how sessions will be conducted, how decisions get made and how communication between sessions is established. It may also be useful to establish a neutral information repository for the entire group to deposit information about the system, as well as proposals for strategies and alternatives (Susskind and Cruikshank, 1987).

In a consensus-based process, the usual decision-making rule is by consensus of all those present. Given that this may result in one party sabotaging the process, it would be useful to agree to overwhelming majority. In the end, while some parties may not agree with individual decisions, a consensus is sought on the package of decisions that are produced by the whole group. In other words, consensus is actively sought and encouraged, but it is not the prerequisite for reaching final agreements.

### 6.5 Extracting Contextual Knowledge from Stakeholder Statements

With the direct and indirect stakeholder input solicitation sources discussed in section 6.4 it is possible to extract the components necessary to build a CLIOS diagram of the different physical subsystems, and the institutional sphere. In this section we propose using insights from *Discourse Integration* and *Pragmatic Analysis*, approaches that are used to understand the meaning of written statements within the fields of linguistics, as a way to extract representation-related information from stakeholder comments.

### *6.5.1 Discourse Integration and Pragmatic Analysis*

It is not surprising to say that language is an incomplete means of communication. This is more the case when we do not have additional cues, such as body language, tone and interaction to understand an individual's statements. This is particularly important for cases where stakeholder inputs are elicited form surveys, newspaper articles, or other written material, where stakeholders cannot be asked to clarify their remarks.

In order to reduce the subjectivity of the process of converting stakeholder statements into system representation elements, we can use insights from two basic approaches in linguistics called discourse integration and pragmatic analysis. The use of insights from these approaches has been based on "Principles of Critical Discourse Analysis" by Van Dijk (1993), which is considered on the classic works dealing with understanding citizen discourse and underlying values[22].

Pragmatic analysis focuses on the structure of an individual sentence. Information is extracted by looking at the position of words, and the relationships within the sentences themselves. Discourse integration reinterprets the sentence, with the context of the statement in mind. That is who has expressed the sentence, what other sentences came before it, or within what context the statement was expressed. The entities involved in the sentence must either have been introduced explicitly or they must be related to entities that were, and the overall discourse must be coherent. This is mostly the case for both surveys and written transcripts in hearings and websites. A combination of these two will allow us to keep only those parts of the statements that contain useful information for the system representation.

[22] Dijk, T.v. "Principles of critical discourse analysis" *Discourse and Society,* 1993

Generally stakeholder statement can contain an intricate combination of implicit and explicit values and positions, information on the system and "mental maps". A mental map is the way a person perceives the outside world and the way its components interact and function. Our purpose is to extract the underlying values, the proposed drivers of those values and qualitative and quantitative information that can be used to represent the system and quantify it (model) later in the process.

*6.5.2 Applying Discourse Integration and Pragmatic Analysis to SAM-PD*

Let's consider the following statement.

> " *Supporters of the project say that any bird deaths would be minimal compared with the millions of birds that die each year colliding with skyscrapers and cellphone towers. Opponents, meanwhile, have said any bird deaths are unacceptable.* "
>
> (Excerpts from The Boston Globe, October 17, 2004, Sunday THIRD EDITION"Report On Possible Risks From Wind Farm Fuels Ire", by By Beth Daley)

Pragmatic analysis looks at the structure of each of the sentences.

1) *Supporters of the Project say that any bird deaths would be minimal compared with the millions of birds that die each year colliding with skyscrapers and cellphone towers*

Here the structure of the sentence is as follows:

"X (supporters of the project=subject, stakeholder groups) *say* (plural subjects) *that* (objective expression) (qualifier=any) (value/performance measure=bird deaths) (adjective=minimal) (conditional=if compared to) (value/performance measure=birds that die each year) (by means of action/component=colliding with skyscrapers and cellphone towers).

2) *Opponents, meanwhile, have said any bird deaths are unacceptable.*

"Y (opponents=subject) *meanwhile* (relationship= have said) (qualifier=any) (value/performance measure=bird deaths) *are* (position=unacceptable).

We can extract from the excerpt that there are two differing views on a particular topic.

From *discourse integration* we can connect the contexts of the two sentences, inferring positions from the proponents also. The implicit position of the proponents is that bird deaths would be minimal and thus based on a presupposition of affirmation, acceptable. We can also derive the causal components of the "bird deaths". In the first sentence we see skyscraper and cellphone tower explicitly mentioned, but unless we pay attention to the subject "supporters of the *project*", we cannot derive the implicit causation that comes from the *project.* The general knowledge that "*the project*" refers to a wind farm is part of the discourse integration that comes from previous parts of the article.

In summary, the following information can be extracted from the statement using discourse integration and pragmatic analysis in Table 6.2.

**Table 6.2 Extracting Contextual Information from Stakeholder Statements**

| Type of Information | Information |
|---|---|
| Performance measures | Bird deaths per year (Total versus Wind-farm induced) |
| Positions | Values:<br>Only zero is acceptable (Opponents)<br>Has to be measured relative to other projects (Proponents) |
| Causal Component | The wind farm (through its turbines) (Opponents and Proponents)<br>Skyscrapers and cellphone towers (Proponents) |
| Data | Bird death from other man-made structures in the millions |

Not every statement contains useful information for systems modeling purposes, but nearly every statement provides information on the context within which discourse integration and pragmatic analysis can be performed. It is important to realize however that there is the possibility that stakeholders may not talk about the underlying values openly. Therefore, the emphasis on the totality of statements as a whole, rather than emphasis on individual statements, is important in understanding stakeholder interests and concerns. This approach can also be dangerous, since it has the underlying assumptions that rational concerns that can be assessed objectively are always at the root of stakeholder positions. This assumption of rationality may not hold most of the time, but is necessary when coupling stakeholder inputs to a more or less objective systems analysis. Also, many stakeholders may use fake concerns to mask their real concerns. For example if stakeholders feel that aesthetics may not be considered as important by the decision-makers as much as environmental impact, they may express concern over environmental impact while the only thing they care about is aesthetics.

*6.5.3 Converting the contextual information into a system representation*

Using the CLIOS notation, cell phone towers and skyscrapers are external drivers (beyond the boundary of the current system), and the wind farm is a policy level (we can decide whether or not to allow it), and bird deaths (both total and as a result of the wind farm) are performance measures. The acceptable thresholds can then be discussed during the performance metric refinement with stakeholder. Figure 6.6 shows the representation of this statement.

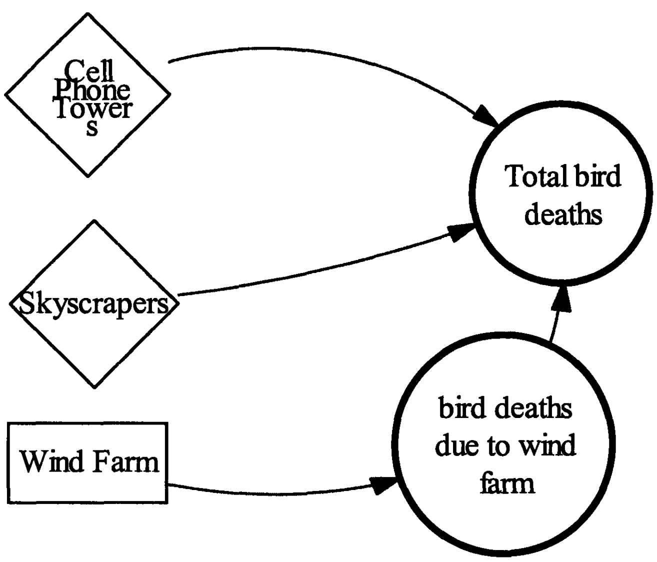


**Figure 6.6 – Causal Loop Representation of the Stakeholder Statement**

### 6.6 System Representation, Evaluation, and Policy Design Stage (CLIOS Steps 1-9)

The system representation, evaluation and policy design stage of the SAM-PD process essentially consists of system and goal definition, system component and linkage representation and characterization, and design, evaluation and selection of alternatives. As such it corresponds to the steps 1-9 of the CLIOS process. In this section, we will look at the details of this stage while mapping the SAM-PD process on the CLIOS process.

#### *6.6.1 Problem Refinement/System Definition (CLIOS Step 1)*

In this step, problems with the system have to be clearly described and a summary of issues and system goals is prepared. The first step of the joint fact finding process is to determine the scope of the problem to be studied. The scope determines where the system boundaries are and what issues/areas need to be addressed. The boundaries can be both in terms of geographical area covered, as well as the components of the system that are considered. In the engineering systems literature, the scoping of a system is foten callled a system representation.

Traditional environmental impact assessments mainly focus on risk-assessment in defining the scope, but it is possible for the stakeholders to take into account benefits resulting from alternatives as part of the scope of the analysis as well. A good example is the case of the proposed offshore wind farm in Nantucket Sound, where many potential benefits of clean energy for Massachusetts and the United States could be used alongside the potential risks in the scope of the scientific analysis.

Also possible is to take into consideration non-risk related issues such as aesthetics arguments and social effects of projects, where a pure scientific analysis may not be necessary, but where options to address these concerns and reduce their potential impact on stakeholders would require expert knowledge. As an example, the impact of erecting wind turbines in Nantucket Sound on tourism in the region, or real estate prices could be assessed to some extent using similar projects in other regions that have been allowed. Whether or not such considerations are taken into consideration in the scope of the problem is up to the group of stakeholders, but if the actual concerns of NIMBY (not in my backyard) advocates is not addressed in some form, it may be expressed in terms of emphasis on uncertainty in the science, which may lengthen the scientific analysis process, or make it more difficult to reach an agreement in the negotiations phase.

The important thing to note is that the scope will be heavily affected by who is present at the table in the collaborative process. While decision-makers are by required by law to define a minimal scope for the problem, scientists have to make sure that the scope is sufficient or possible to evaluate, while other stakeholders will try to address their own concerns in the scope (NRC, 1996). Usually, different stakeholders highlight the parts of the system that are directly of interest to them, or those which if analyzed would favor their positions. This is essentially a value-based judgment, and can result in conflict. The challenge for the facilitator is then to reframe or redefine the issues in terms of interests, which are usually negotiable, rather than positions, values, or needs, which usually are not. This is called "interest-based" framing, and is an approach proposed by Fisher et. al (1991). They argue that by focusing on the interest rather than on positions, there is a higher possibility of a robust agreement, since it may be possible to find a solution, which satisfies both parties' interests. Once the underlying interests are identified, they will be discussed in the group. The opposing sides will be more motivated to take those interests into account if they feel that their interests are also being taken into consideration. The aim of discussions is to find possible solutions that satisfy the interests of as many stakeholders as possible (Fisher et. al 1991).

The problem identification and goals summary should capture the concerns and needs of policymakers, managers and stakeholders and how the system is or is not responding to them. The initial problem definition by the convener group is thus refined to reflect stakeholder perspectives on the issue.

Much of this information will be available through the input elicitation activities in the stakeholder conflict assessment stage.

The stakeholder survey should include the following questions for individual stakeholder organizations, to serve as the basis for the system representation, evaluation and policy design stage of the SAM-PD process:

- What is the stockholder's view of the system boundary/the scope of the project?
- What part of the system/project are they interested in?
- What is their organizational interests/mandate regarding the system and how does it impact their position on the project/system management strategies? Does their organization favor a pre-defined position, or a pre-defined set of strategies? If so, how does that position serve their interest?
- How does the system affect them at the present and how do they think it will impact them in the future? (Stakeholders with Influence, Other Stakeholders)
- What are the most important issues they see with the project/system? What do they think could be done to address these issues?
- What are the institutional relations that govern the system (Decision-makers)
- What information do they possess on the project/system? What information do they believe is necessary, but missing? What capacity do they have for further information gathering? What are the resources they have at their disposal to contribute to the management of the system/evaluation of the project?
- What is the approximate timeline in which the decision has to be made? Is the timeline flexible or fixed? Can the decision be staged? (Decision-makers)
- How would they want to participate in the decision-making process? Would they like to be present at all stages, or be kept informed of all the stages, or would they like to provide feedback once the recommendations are opened up for public comments? What do they think of a joint fact finding process as an alternative for the decision-making process?
- How is the internal decision-making mechanism for the organization? Who is person with the authority to negotiate in a potential joint fact finding process?
- Who are the other stakeholders that should participate in the decision-making process? Also, who if not involved could undermine the quality, legitimacy or outcome of the joint fact finding process?

For each project/system, questions specific to the system should be substituted whenever appropriate. The neutral then synthesizes the interviews into a value assessment report that can be used by the different stakeholders to understand the scope of values, interests and knowledge that other stakeholders hold.

The answers to the questions in the previous step, along with the initial categorization of stakeholders should provide a basis for the selection of participants for the collaborative process.

*6.7.2 Initial System Representation (CLIOS Steps 2-5)*

Before stakeholders come together for the collaborative systems representation, we propose that an initial systems representation is constructed based on stakeholder inputs. In our view, this provides many advantages over starting the systems representation from scratch with the stakeholders present. We referred to these advantages in Chapter 5, but for the sake of convenience, we will briefly review them here:

1) Providing stakeholders with a sense of common accomplishment right from the start
2) Providing stakeholders with an initial holistic perspective on the problem
3) Focusing the discussion from early on, and facilitating convergence
4) Effective utilization of stakeholder times and avoiding early frustration

It often happens that participants overlook issues, which are important to others, but are not important to them. Particularly, when stakes are high, the number of issues that people think are part of the problem in dispute tends to increase. However, if the most important issues are not identified, it will be impossible to develop solutions to the conflict that will successfully resolve it (CRC, 1999).

There are basically two main issues that have to be addressed at the representation-level:

1) Have all the important issues been identified?
2) Should every issue that any stakeholder considers as important be part of the analysis?

In addressing the first question, it is important to have a diverse enough set of stakeholders at the table, such that a comprehensive coverage of issues is explored. The role of scientists in this stage is crucial, since many of the issues that have to be considered in the analysis may be salient and not so obvious. On the other hand having all the issues that are discussed in the analysis may make it impossible to analyze the system in time or at all, which is a point that the second question raises. While it is imperative to be as inclusive as possible, there is no easy way out of this. Essentially, the inclusion of issues should result from an overall agreement by the group that the issue is important enough to be considered. The facilitator's role in making sure that the group considers each issue carefully, is essential in keeping the process from alienating those stakeholders whose proposed issues may not be taken into consideration as part of the scientific analysis. An important consideration is how to capture the relationships between the different issues in the system, and how the links among the different components can be represented

Figure 6.7 is an outline of the steps leading from stakeholder input elicitation to system representation.

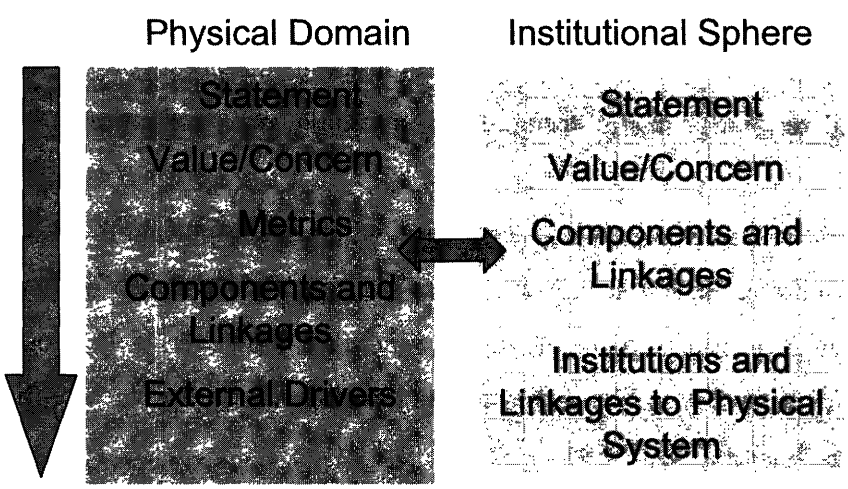


**Figure 6.7 Converting Stakeholder Inputs into System Representations**

We generally start with the values/concerns (performance measures) and work our way back to external drivers step by step. In this way we are constructing a representation that has outputs that are important for stakeholders to consider in the decision-making process. The basic methodology used for the systems representation is the one outlined in the CLIOS process, as described in Chapter 2.

In order to illustrate how this is done, we consider the Transportation/Air Pollution example shown in Table 6.2 and Figure 6.4.

**Table 6.2 Illustrative Example: Transportation/Air Pollution System**

Step 1) Extracting Contextual Knowledge from Stakeholders

Statement A: "We are really concerned with the congestion in the city, we believe that it is adversely impacting the productivity of the city. I believe the problem is that we don't have sufficient highway infrastructure. The government should build more highways"

Statement B: "Congestion definitely impacts air pollution in our city. The problem is the number of cars that are on the streets. People don't take public transportation anymore, because we don't have adequate public transportation."

Step 2) Extracting values/concerns from statements

Statement A) Value/Performance Measure: Productive time loss
Stated Driver: Congestion
Stated secondary driver: Infrastructure Availability
Statement B) Stated Value/Performance Measure: Air Pollution (health+smog)
Stated Driver: Congestion
Stated secondary driver: Public transportation availability

Step 3) Determining system performance metrics

| Values/Drivers | Metric |
|---|---|
| Air Pollution | CO,CO2, NOx, NMHC emissions (tonnes/year) PM10 concentration, Ozone concentration (ppm)<br><br>pre-mature deaths due to pollution (people/year) |

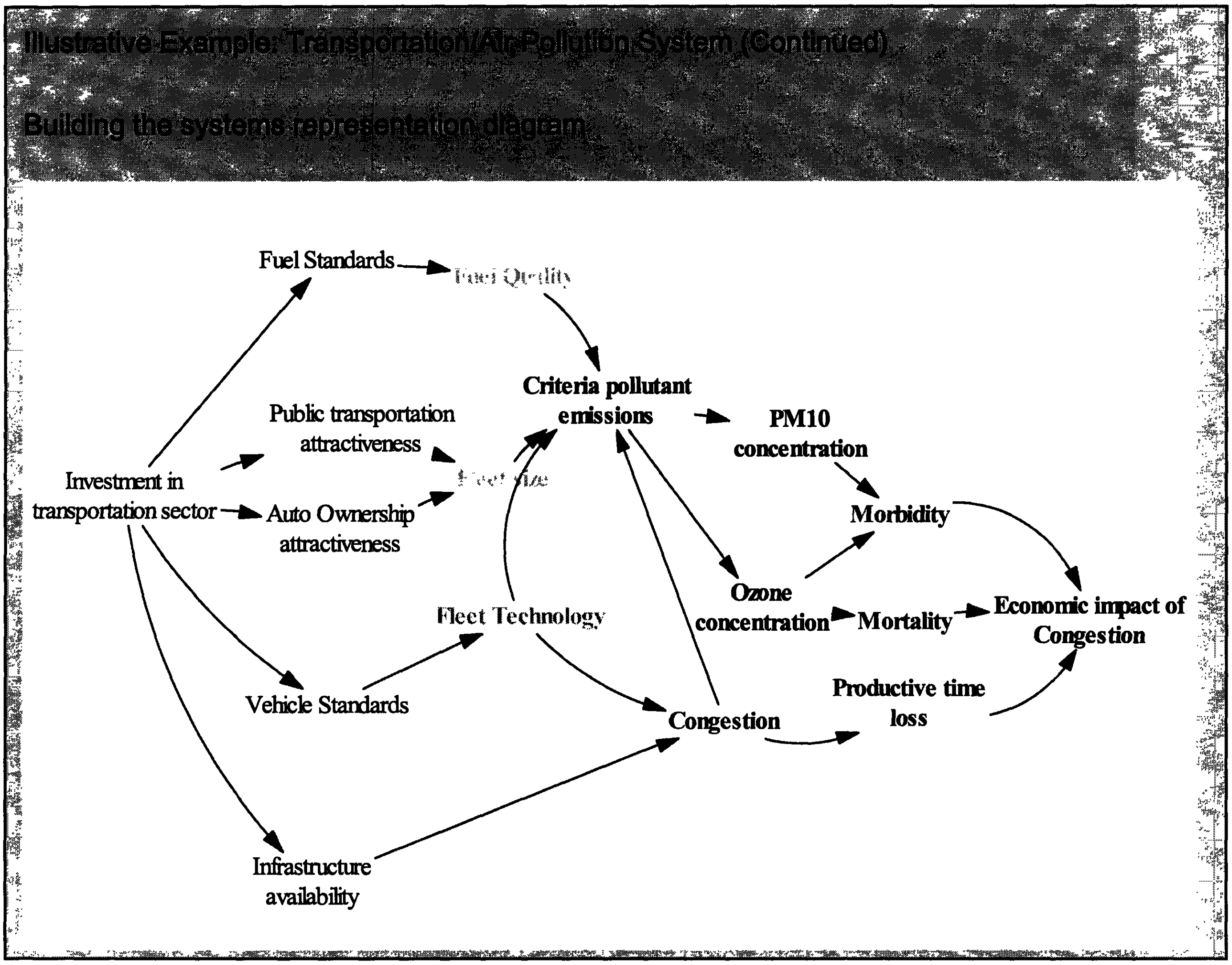


**Figure 6.4 Building the systems representation diagram based on stakeholder statements**

At the initial representation stage, we assume that all stakeholder concerns should be included in the system representation. It is up to the stakeholders to negotiate what parts of the system can or should be quantified (modeled) later on when they review the representation.

### *6.7.3 Stakeholder-assisted representation*

Once the initial representation is created, participants chosen by the neutral for the collaborative process can review and refine it, by adding new components and links or agree to remove unnecessary components and links from the representation.

*Ground Rules:* The rules by which the representation is modified by stakeholders are established on the first stakeholder meeting with the help of the neutral. The ground rules of the most important means of stakeholder process management. The rules can consist of a minimum number of participants agreeing before a component or link is added, or could be designed to limit the number of components each participants can add in any given session or for any given subsystem to ensure that the components and links with the highest priority are chosen.

*Integrating Preferences and Values into the Representation:* Generally, given the extensive number of components and linkages that can be generated, it is necessary to differentiate the most important parts of the representation for the evaluation stage. At this stage, components and links are characterized as discussed in the CLIOS representation stage steps. A modeler (system analyst) can help implement the changes in the representation software, that can be projected at all times on a screen visible to participants.

*Identifying interactions between actors and physical system:* Once a commonly agreed representation emerges, it is time to look at what organizations and institutions have control, influence, knowledge on different parts of the system. This is an important part of the preparation for the working group formation. Here the concepts of Class 2 links or "Projections" in the CLIOS process can be applied (See Chapter 2).

### *6.7.3 Evaluation/Quantification of the Representation (CLIOS Steps 6-9)*

An important part of the evaluation step is to identify what information is required to assess the system both in its current state, as well as the potential impacts of the new project or proposed management strategies.

In this stage the following questions have to be answered by the group using the cumulative knowledge of the participants: What data is needed to describe the current status of the system? How much of this information is available? If some data exist, are they sufficient to make an informed assessment of the decision? If not, what type of data is required to make such an assessment? What are the uncertainty levels and what levels of uncertainty are acceptable for such an assessment? How can further baseline data be acquired, and what resources are available within the group to obtain additional information that will help an assessment of the system that is acceptable by the stakeholders? (Rebori, 2000)

The presence of representative stakeholders, decision-makers and scientists can provide a clear picture of who in the group has information, expertise or resources that could be used to assess the system. This is one of the strengths of the joint fact-finding process compared to traditional processes, where funding and information is limited to that of the decision-making entity.

*Strategy/Alternative Generation*: The generation of alternatives is usually done in brain-storming process carried out by the facilitator. Brainstorming is a collaborative technique for generating new and innovative ideas and solutions to a problem. A facilitator initiates brainstorming by asking the parties to suggest ideas for solving the problems identified in the scoping process. Judgment about the merits of the proposed solutions/strategies is withheld until later. The facilitator usually lists the ideas in a way that is visible to the participants, helping them keep track of what has been said, and to build on earlier suggestions. This often results in creative solutions to problems that no one person or one side would have been likely to develop on their own (CRC, 1999).

Once all the ideas are out there, the facilitator helps the group to narrow down the alternatives to a manageable size, by grouping related proposals together, and making the alternatives consistent in terms of level of detail and underlying assumptions. The participants develop and implement a joint strategy for answering the key policy questions, based upon jointly agreed methodologies. Here, participants do not have to reach agreement on the methodologies for every issue. Their primary goal is to clearly separate the issues upon which they can agree from those which are still subject to debate. Points of mutual agreement can then help as a basis for continuing the analysis of disputed issues (CRC, 1999). As in all other stages, the role of the facilitator is crucial in the success of the process. This process may take several sessions, depending on the difficulty of reaching an agreement on issues.

*Working Group Formation and Fact-Finding*: Once the alternatives to be explored are agreed on by the group, working groups need to be established to explore the system, both in terms of the baseline status and in terms of analyzing the potential impact of strategies or alternatives on the system. While for smaller problems two to three working groups may be sufficient, in a complex technical system more working groups may be required. Working groups should be sufficiently diverse to incorporate different stakeholder interests, so that no working group is considered representative of a particular stakeholder view. While it is impossible to explore all the issues with the full group, it is important that the full group be still engaged in some form in the joint fact finding process.

Questions that will shape the working group structure by which to assess impacts are: What additional data will be needed to assess the impact of the new project or proposed strategies? If new data are necessary, who will collect the data? Who pays for data collection? How will outside experts be selected? What methodologies should be applied? Who will manage the data gathering and coordination? What kind of information repository will be necessary? Will the collected information become public knowledge or kept confidential until agreements are reached? What are the time frames for collection, analysis and reporting? And finally, who will own the data once collected? (Rebori, 2000)

Basically, a fact-finding committee is formed from expert members of each of the conflict parties, in addition to independent experts hired by the stakeholder group and decision-makers who have some knowledge about the issues being explored. Experts may have to be paid through the convener or through the pooled resources provided by the stakeholder group. The working groups have the task of working out the important facts and eliciting relevant knowledge from the literature, as well as other commonly agreed sources. This kind of collaborative approach will result in a level of interaction that would not likely occur under other circumstances, if each of the experts represented their respective interests, thus shifting away from "adversarial science". (Schultz, 2000). If there is expertise missing in the ranks of the participants for a particular area, the group can invite outside experts that it commonly agrees on to form working groups on that issue.

With the shared information sources and expertise, factual knowledge on the system, in the form of technical literature, agency findings and consultant expertise is very likely available to some extent for the system in question. The problem then becomes agreeing on the information as relevant for decision-making. An important challenge is that in high-stake, highly uncertain science-intensive conflicts, the facts in dispute are focused on the most uncertain areas.

There may be general agreement on the majority of the facts, but the process can stop when it comes to facts in dispute, that are difficult to quantify or establish within an acceptable uncertainty range. That alone may result in a stalling of the process. Therefore, it is imperative to have the working groups focus on producing a new document synthesized from available literature that reflects not just where consensus was achieved but also where factual issues remain in disagreement or where there is irreducible uncertainty. This kind of bottom-up approach, in addition to giving the group a definite goal, allows the group to focus their efforts on the facts instead of on positions allowing for invention or consideration of new solutions in the process (Schultz, 2000).

*Communicating Results to the Group:* In terms of communication of results, it is important that the working groups report to the full group on a regular basis, so that the group as a whole can provide feedback on whether or not to proceed with further studies and exploration of issues. Effective factual communication is important, since this allows non-experts to offer possibly fresh insights, forcing experts to examine a set of problems in a new way. Additionally, this can lead to better understanding of the system as a whole by the stakeholders, which may further help them understand other points of view on the system. (Schultz 2000).

After several intervals of fact-finding and reporting, once the results of the different working groups are deemed sufficient for decision-making purposes, the facilitator and the working groups draft a combined document summarizing and synthesizing the findings. The final document is then presented to the stakeholders for evaluation of the different alternatives. Often, the document is accompanied by a variety of scientific and technical computer models that can assess the impact of different strategies/alternatives on the system.

*Transparency of Process to the Public At Large*: It is imperative for all the information and transcripts from the meetings to be available to the public. This can be done by establishing a stakeholder process website, where progress in every session is reflected in an accessible format to those not directly participating. The website should also allow the public to provide comments and feedback on the process. The neutral should provide participants with copies of feedback given by the public at the beginning of each session, to ensure that participants can use the feedback in refining the discussions. The balance of where to draw the line is delicate and needs to be explored, as integrating the feedbacks can slow down the process immensely.

*Level of Quantification/Evaluation:* It can be argued that there exists a level of quantification, which accompanied by a qualitative analysis and cautions on uncertainties can provide a better understanding of the strengths of linkages to the stakeholder and is therefore an essential step of the analysis. On the one hand John Sterman argues for the importance of quantitative models for a group understanding of the problem at hand. While a qualitative model can potentially increase a group's information processing capacity, he points out that it is dangerous to draw conclusions on the dynamics of a system that are solely based on diagrams, a position which can hardly be refuted, given the wide range of evidence (Sterman, 2000). On the other hand, advocates of the use of qualitative modeling have argued that in a number of cases quantification may either decrease the model's relevance for an audience or can even be dangerously misleading as well.

However it is clear that selecting between different strategies requires some form of quantification, given that there are always trade-offs involved. Policies are then designed jointly with stakeholders based on their qualitative and quantitative insight gained by the model they helped create. In addition to technical and economic feasibility, social feasibility of options is brainstormed with stakeholders present. Using the jointly developed model, negotiations can then be carried out to reach agreement on a set of policies.

## 6.8 Consensus-seeking Negotiation (CLIOS Steps 7-9)

### *6.8.1 Facilitated negotiation on alternatives and consensus-based (or overwhelming majority) agreement.*

Once the working groups have submitted the final report, and before actual evaluation by the full group takes place, it is important to agree on objective criteria by which to analyze alternatives. Objective criteria refer to factors that are used to evaluate a decision or possible outcome. Objective criteria will help move the group from joint fact-finding mode to a decision-making mode. People usually support objective criteria during a collaborative process because criteria are not tied to specific positions. (Rebori 2000). However, the objective criteria would probably be based on the important performance metrics that the stakeholders have specified in the previous steps. Objective criteria can be categorized into three broad categories (Godschalk, 1994):

*1) Technical criteria:* To test different strategies/alternatives, the group can establish criteria such as levels and coverage of service, performance standards, resource requirements, or degree of impact of the project. As an example, in the case of a new offshore wind power project, the criteria can be the amount of electricity produced, the amount of green house gas emissions prevented, cost of electricity produced, the number of potential bird fatalities, number and severity of navigational problems, number of fish affected, whale population changes in the area, etc.

*2) Social and community criteria*: These can measure the societal and economic impacts of the strategies/project. In the case of offshore wind power, this could be net employment change, change in real estate prices, change in tourism revenue, changes in fisheries income, etc.

*3) Value-based criteria:* These are the trickiest set of criteria that are hardest to quantify. They can incorporate some NIMBY values, as well as other sociopolitical values that are hard to quantify. While it may be difficult to compare different strategies/alternatives on the basis of these criteria directly, it is important to take them into consideration, and find ways to capture them in terms of negotiable items. In the case of offshore wind power, these could include the number of visible wind turbines on the horizon, the height of the turbines as seen from the shore, the number of lights that can be seen from the shore (all an effort to capture the aesthetics value of an unfettered ocean view). Of course, in many NIMBY arguments, the issue is mostly binary in nature, but it may be possible to address the concerns of some of the groups by addressing some of these issues in terms of objective criteria.

As indicated in the previous section, it is useful to have models, where different assumptions for different packages of alternatives can be evaluated easily, without having to redo the entire joint fact-finding process. Many of the alternatives may be invented after the stakeholders have a better picture of the system as a whole, a result of the final fact-finding document coming together. Unlike other processes, scientists and experts stay on with the full group to assess the impact of the different alternatives/strategies that the group comes up with. For this purpose it is useful to have an integrative model of the entire system, which can predict the impact of one change on the different components of the system simultaneously, thus capturing some of the complex dynamics that a system may exhibit. Using an overall systems framework, and an adequate system representation it is possible to integrate the knowledge created into one coherent model. While some of the alternatives/strategies may not be quantifiable, it is useful to qualitatively see how they would impact the system (Mostashari, 2003).

Using the joint fact-finding document and the models, the group then proceeds to look at the most promising alternatives identified in previous steps under the range of uncertainties, and examines its costs and benefits from the different stakeholder perspectives also exploring any barriers to implementation. It does so based on the objective criteria that were agreed on by the participants. Here however, the main focus of the discussions will be about the uncertainties about the system, which the working groups were not able to reduce to generally acceptable levels. There are two ways to proceed in this stage. One is to devise experiments that may provide more certainty and more knowledge on the issue. The other is to proceed with the given uncertainty range and negotiate *contingent agreement*s, which specify specific actions that would be taken to ameliorate the potential consequences of the problem to risk-levels acceptable to the group as a whole. The former will probably serve as a good delaying tactic for those interested in stalling the project/strategies, as it will be costly and time consuming to do in most cases. The latter is normally undesirable for decision-makers and in case of permit processes would pose additional risk for the developer.

After the stakeholders explore different strategies in the strategy analysis stage, sets of policies can be designed jointly with stakeholders based on their qualitative and quantitative insight gained by the model they helped create. In addition to technical and economic feasibility, social feasibility of options is explored with stakeholders present. Negotiations using the developed model are carried out to reach agreement on a set of policies. Stakeholders can brainstorm on implementation procedures for policies in agreement, focusing on how costs and benefits would be distributed and how responsibilities would be distributed.

As indicated previously, the goal of the consensus-building process is not to have agreements on every single issue, but to agree as a group on a package of strategies/alternatives that are acceptable as a whole. As in all other negotiations, the success or failure of reaching an agreement depends on individual participants' best alternative to a negotiated agreement or BATNA (Fisher, 1991). It is up to the facilitator, and the evolving group dynamics to shape the BATNA's in a way that an agreement seems desirable. Generally, if the process can be sustained for a long time, the time and resource investments, as well as the change in relationships due to collaboration should help in the final process, creating a momentum for reaching a consensus-based agreement.

The list of alternatives is then narrowed down to one package of solutions, which are fine-tuned until all the parties at the table can agree. A helpful strategy is for each participant to propose several possible packages that are acceptable to them. Once all the packages are proposed, the group can work together to develop several variations in an attempt to develop a mutually preferred alternative. In this way, an agreement can be packaged without anyone having to make imbalanced concessions. Given the difference in priorities, it should be possible to find ways to accommodate most participants' interest such that they would be able to reach agreement (ODRC 2000).

The concept of contingent agreements can make it more attractive for some stakeholders to agree with a package. But for such an agreement to succeed, the participants have to develop a basic level of trust. Additionally, contingent agreements have to be documented with great care to ensure that they are not misused by any side, given that they are many times not part of the conventional agreement documents. At the end, if a consensus is not reached, an overwhelming majority can also be sufficient for the agreement as a last resort.

Even if the participants themselves can reach an agreement, there is the additional issue of the stakeholders at large. It is imperative to communicate the analysis and the decisions back to the main body of stakeholders frequently during the process, meaning those that were not directly involved, but had some form of representation in the process. The participants, as the representative stakeholders have to ensure that their constituents understand the reasoning behind the decisions and have access to the analysis performed by the group. This is a difficult task, given that non-participants have not developed the same level of understanding or trust necessary to understand why this is the best possible agreement they can get. If any one of the groups represented in the consensus-building process disagrees at this stage, they will likely refuse to sign the agreement, and the agreement may well fall apart (CRC, 1999). Clearly, the skills of the facilitator can be the key to success. If sufficient alternatives/solutions are generated in the previous steps, the facilitator has a more open hand in highlighting areas of possible agreement.

Using a "Single Text Method" to draft the written agreement is a useful way of getting closure. In this method, the group works on the agreement by moving through a single document together, with the facilitator either assigning preparation of the text to an expert that is not a stakeholder, or through having a small group of stakeholders prepare a draft on behalf of the entire group. The draft would have no legal status until the group reviews and refines the draft to reach agreement on a single final text. Agreement reached on any section of the document is taken as tentative until a final agreement on the entire document is reached. This can help by preventing individual stakeholders for bringing in alternative drafts of agreements, which can derail the process of reaching an agreement (ODRC, 2000).

If an agreement is reached, the group has to decide on an implementation schedule, resource allocations and divide responsibilities among the different participants.

### 6.9 Process Effectiveness and Validity Assessment Through Peer Review

Stakeholder-assisted processes are probably more costly and may take a longer time than traditional engineering systems analysis processes. It is therefore important to evaluate whether they have been more effective in addressing the problems, and whether the representations, model, and recommendations that have resulted from such processes are considered valid from an outside perspective, and whether they can be implemented.

### *6.9.1 Perceived Effectiveness of Process*

Surveys can be used to identify whether a particular stakeholder-assisted modeling and policy design process has been effective in the minds of decision-makers, experts and other stakeholders. Each survey can be crafted to its particular audience (decision-makers, advisory agencies, citizen groups, experts, private sector) within the participant group. The following are examples of questions that could be asked in each survey addressed to different stakeholder categories. The 1-5 effectiveness rating scale allows stakeholders to distinguish between their perceived effectiveness for each criterion. The importance of the criterion in the eyes of the participant filling out the survey allows for proper weighting of the criteria in assessing subjective effectiveness.

We emphasize that the answers to these questionnaires will be subjective, and can only measure the perceptions of the individuals answering them. But on a cumulative basis and over a large number of participants, the weighted scores can reflect the overall perception of the effectiveness of the process, while allowing for distinction of perceived effectiveness in the eyes of particular stakeholder groups.

In particular, expert acceptance of the validity of the recommendations is essential in its credibility to non-participant stakeholders and the community at large. A process that is inclusive but relies on inadequate technical grounds could be perceived as undesirable as an exclusive process with good science/technical analysis. Even if all the participating experts agree on the validity of the process and its recommendations, it is important to have external feedback on its validity as well.

### *6.9.2 External Validity of Process and Recommendations through Peer Review*

After the final recommendations have been drafted, it is useful to have non-participant experts, decision-makers, and the public at large review the process and its recommendations before being officially published as the final agreements. Therefore, similar to a commenting period for environmental impact assessment report, one can present the findings and recommendations as different public hearings, through websites and through active requests for peer review by experts. For that to happen, accessible documentation on the process should be available. There are two types of validity we are concerned with:

1. Process Validity:
   - Was the process valid within the context of the laws, regulations and mandates?
   - Was the process sufficiently inclusive?
   - Were the decision rules acceptable and adequate?
   - Were the points of disagreement and the opinions of the dissenting participants adequately included in the final report?
   - Were the expert working groups formed effectively?
   - Was the process sufficiently transparent?
   - Was the public given sufficient means of contributing to the process while it was in progress?
2. Validity of Expert Analysis and Recommendations
   - Was the systems representation used for the process accurate and valid?
   - Were the methodologies used to evaluate the systems representation valid?
   - Were the assumptions made for the expert analysis valid?
   - Were the different uncertainties adequately addressed?

Once the feedback is received the group reconvenes to decide whether there are grounds to rework parts of the process, or if the objections could be addressed without major changes. The final opinion of a diverse set of stakeholders, experts and decision-makers outside the participating group can then be integrated into the final report that is published.

**Table 6.3 Sample Questionnaire for Perceived Process Effectiveness Assessment**

| **Criteria**<br>**"In your view....** | **Effectiveness of Process (1-5)**<br>**1=Not at all effective**<br>**5=Very effective** | **Importance of Criteria**<br>**1= Not at all important**<br>**5=Very important** |
|---|---|---|
| 1. Did the process help the decision-makers fulfill their mandate or their organizational duties effectively? | | |
| 2. Did the process reduce the cumulative potential conflict of the decision-making process effectively? | | |
| 3. Did the process involve stakeholders in decision-making effectively? | | |
| 4. Did the final recommendations address institutional and technical issues effectively? | | |
| 5. Did the involvement of stakeholders inform decision-making effectively? | | |
| 6. Did the involvement of stakeholders increase resources (funds, expertise and information sources) for decision-making? | | |
| 7. Did the involvement of stakeholders help communicate the rationale of the decision-making process to the public at large effectively? | | |
| 8. Did the involvement of stakeholders help the transparency of the decision-making process and increase public trust in the decision-makers effectively? | | |
| 9. Did the final recommendations reflect the public interest effectively? | | |
| 10. And most importantly, are the final recommendations likely to address the problem at hand effectively? | | |

## 6.10 Implementation and Post-implementation Stage (CLIOS Steps 10-12)

"If policy adoption is courtship, implementation is marriage."[23] All the stakeholder-assisted analysis and strategy design in the world in vain unless it addresses the actual system issues realistically and facilitates the implementation of the engineering systems project.

*6.10.1· Implementation schedule, monitoring and enforcement design*

Once the basics elements of an agreement are agreed to, the design of the implementation phase and monitoring is in order. There is often so much emphasis on reaching the agreement that the implementation phase receives too little attention, a fact that can erase all of the achievements of the collaborative process. Here the implementation schedule, resource commitments by the individual stakeholders within the specified timeframe, and optionally contingent clauses need to be refined and spelled out in a written document. The parties should consider agreements on all issues as binding. Sometimes there is a need for institutional change if the strategies are to be implemented. These changes are more difficult to achieve than strategies for the physical system.

Implementation strategies should reflect the understanding of the realities of both the technological and organizational complexity, the scale of the project, the limited time for implementation, the boundaries of agency mandates and influence over member agencies. Additionally, they should also reflect organizational and technological strategies to deal with potential system failure and maintenance after deployment. If the system performance fails to improve, or if serious problems emerge for a new system that were not anticipated, one should return to the systems representation to assess what parts of the system behaved differently than expected ad what components and linkages were identified or evaluated incorrectly. One could then devise strategies to address the problem from a new perspective. Unfortunately, real life is not so simple since time and money are normally in short supply for re-visiting problems.

[23] Weimer & Vining. 1999. *Policy Analysis: Concepts and Practice.* (3rd edition), Introduction Chapter.

There can be many reasons for failure in implementing a stakeholder-assisted engineering system strategy that is even well designed to address existing concerns. Some of these include:

- Funding uncertainty
- Political uncertainty
- Lack of flexibility in strategy
- Lack of robustness for strategy
- Failure of established measures in new contexts
- Unpredictable human interactions with technology
- Unpredictable environmental impacts of technology

A good implementation strategy is one that addresses all of these potential factors in one way or another. Since it is impossible to predict all the possible ways an engineering system can behave over the long-term, it would be wise for stakeholders to accept responsibility for an *adaptive management* of the engineering system post-implementation.

*6.10.2 Adaptive Management*

Adaptive management can be defined as: "The iterative process of designing and implementing management activities in a manner that allows the scientific basis for management plans to be rigorously tested. The primary objective of adaptive management is to develop a better understanding of the systems being managed and to apply that knowledge in a way that allows the manager to continue to learn and develop better management practices"[24]. While it is extensively used in the context of environmental systems, it is a concept that is crucial to the management of any large-scale engineering system with emergent behavior.

As discussed in Chapter 4, C.E. Holling first used the term "adaptive management" in his Adaptive Environmental Management book in 1978. Adaptive management is based on adaptive process control theory, emphasizing learning control devices. Essentially,

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[24] Source: Wildlife Crossing Engineering and Biological Glossary, http://www.wildlifecrossings.info/glossary.htm

adaptive management improves its strategies based on gradual feedback though time, fine-tuning the process in a way that increases experience-based learning (McLain and Lee, 1996). For complex systems with emergent behavior, adaptive management is the only way to ensure the sustainability of a system over long periods of time.

The SAM-PD process enables adaptive management of engineering systems, by creating a systems model that can later be refined when the behavior of the system does not conform to the existing model of the system. In this way, the systems model is refined over time, helping not only the management of that system, but adding to our knowledge of how similar systems should be managed. The existence of a systems model enables stakeholder groups to go back and improve their understanding of the systems behavior and propose new solutions that address the emergent problems based on newly gained insight. For instance, a systems model of an offshore wind energy facility in Nantucket Sound could serve as the basis of a systems representation for offshore wind energy facilities anywhere in the globe. Any new insights into the systems representation can then be quickly implemented in the systems model, enabling other similar systems managing groups to act quickly to avoid similar problems. This is the power of a *jointly* created diagrammatic representation of a system, and counts as one of the most important advantages of the SAM-PD process.

### 6.11 Chapter Summary

In this chapter we proposed the idea of a Stakeholder-Assisted Modeling and Policy Design Process (SAM-PD), and described its approach to involving stakeholders in engineering systems analysis, design and management. We looked at how the five-stage SAM-PD process would map on the CLIOS process proposed by Dodder et al., and explored its different steps parallel to that process.

Most of the ideas in this chapter were theoretical and relatively abstract. In the next chapters we will explore SAM-PD in action, when we look at the actual case of the Cape Wind Offshore Energy project, where actual stakeholders were called on to participate in a SAM-PD process. With the Cape Wind project still ongoing as of the time this dissertation is being written, the case study concludes at the end of the systems representation stage.

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# ➲Chapter 7

## The Cape Wind Offshore Wind Energy Project

*"You cannot NIMBY anywhere, any time, and expect to have electricity everywhere, all the time"*

-- Norris McDonald[25]

*"The ocean and bays that surround us are perhaps our town's most important and defining natural resource and it is these unspoiled waters that are the very essence of Cape Cod. We are a community of people drawn to the sea as sightseers, swimmers, sailors, fishermen or beachcombers. We are thankful for, and jealously seek to protect, the open space of the ocean around us. There is no other part of our community that offers more sweeping vistas, wildlife diversity and a place of refuge from the steady march of development."* - Barnstable Land Trust

The Cape Wind project, a proposal to build the first offshore wind energy facility in the United States, has become one of the most controversial large-scale engineering projects in recent American history. The controversy over the uncertain long-term environmental, economic and social impacts of the project has polarized the Cape and Islands region of Massachusetts, and has captured regional and national headlines. The case is a good example of a complex large-scale integrated open-system, with a technological system interacting with a social system and an ecosystem under large amounts of uncertainty. As such, it will serve as an illustrative actual case study for this dissertation. In this chapter, we will present an introduction to the case, its main issues and its historical background. The application of the SAM-PD process to this case study will be discussed in Chapter 8.

[25] Comment at Cape Wind DEIS Hearing, December 2004 in Cambridge, MA. Norris McDonald is a Founder and president of the African American Environmentalist Association.

## 7.1 Project Timeline

In November 2001, Cape Wind Associates proposed to build a 420 MW offshore wind farm in a 24-square-mile area on Horseshoe Shoal in Nantucket Sound. The project is to be located beyond the three-mile limit of state waters in federal waters on the outer continental shelf (OCS). Under Section 10 of the Rivers and Harbors Act, the U.S. Army Corps of Engineers is the federal agency that is mandated to regulate all structures and work in navigable waters of the United States. The first application filed by Cape Wind Associates in November 2001 called for the installation of a single scientific-data tower. that was approved by the Corps in August 2002. Upon approval of the data tower permit, project opponents in federal court sued the U.S. Army Corps of Engineers over its jurisdiction on the project. The federal court threw out the suit in September 2003. The opponents have appealed the decision. The U.S. Army Corps of Engineers determined in 2002 that an Environmental Impact Statement (EIS) was necessary according to the National Environmental Protection Act (NEPA). Scoping meetings were held in 2002, where the public was given the chance to comment on the scope of the EIS. The draft environmental impact statement (DEIS) was released by the Army Corps of Engineers in November 2004. The DEIS has been challenged by the opponents of the project, as well as by the U.S. Environmental Protection Agency. Three public hearings were held in various locations, again giving the public the opportunity to comment on the content of the DEIS. As of March 2004, the Army Corps is in the process of compiling public comments and releasing the Final Environmental Impact Statement. It is expected that the decision will be announced by the end of 2005 or early 2006. The initial permitting agency timeline had planned for the decision to be made by July 2003. The delay is an indication of the degree of controversy that has surrounded the project. Figure 7.1 shows the initial timeline proposed by the Army Corps of Engineers.

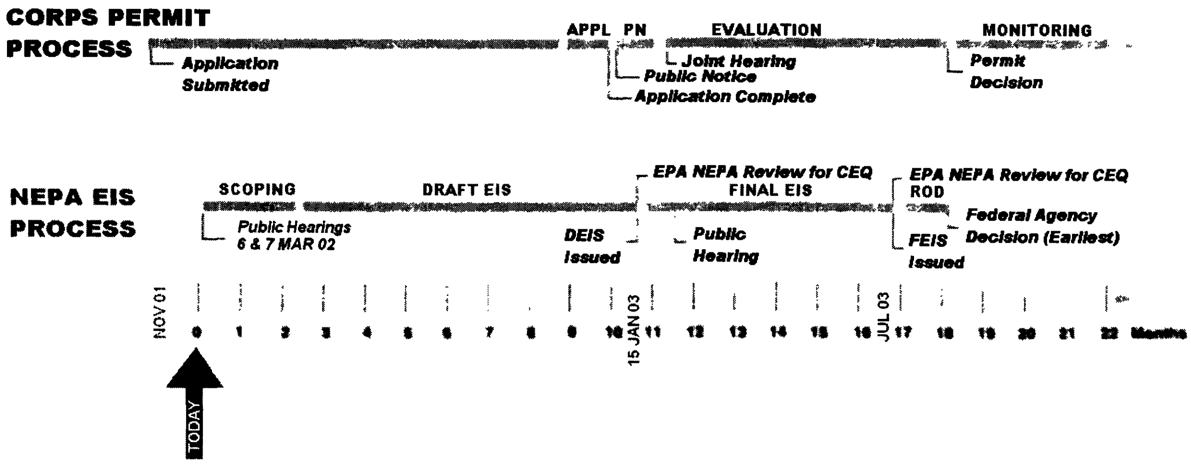


**Figure 7.1. Initial Timeline of the Cape Wind Permitting Process (Source: U.S. Army Corps of Engineers)**

## 7.2 Legal Context for Offshore Wind Energy Development in Massachusetts

At the federal level, there have been efforts at encouraging renewable energy production. Among these, in the Energy Policy Act of 1992, a Production Tax Credit (PTC) was made available to entities that engaged in new renewable energy production through solar, biomass, wood chip, geothermal, and wind electric power production. Additionally, at the state level, there are currently two laws encouraging renewable energy production. These are the Massachusetts Renewable Portfolio Standard (RPS) and the Massachusetts Renewable Energy Trust Fund (RETF) that are intended to promote the renewable energy portfolio of the State. The RPS required that in 2003, 1% of energy provided to consumers come from renewable energy sources. This will increase annually by 0.5%, requiring Massachusetts to produce at least 5% of its energy from renewable sources by the end of 2010 (Watson, 2003).

However, with regards to the usage of federal or state waters for wind energy facilities there are no clear laws, giving rise to controversy on how to regulate private use of public resources. While the Minerals Management Service (MMS) as part of the U.S. Department of Interior has been in charge of assigning leases to offshore Oil and Gas facilities, they have currently no mandate to manage such leases for offshore wind energy facilities such as the Cape Wind proposal.

### 7.3 Project Overview

The proposed wind farm would have 130 turbines, down from an initially proposed 170 turbines. Each wind power generating structure would generate up to 3.2 megawatts of electricity and would stand up to 260 feet above the water surface. The power will be transmitted to shore via a submarine cable system consisting of two 115kV lines to a landfall site in Yarmouth, Massachusetts. The submarine cable system interconnects with an underground overland cable system, where it will interconnect with an existing NSTAR 115kV electric transmission line for distribution[26]. With the exception of two transmission cables and a portion of a proposed "wind wake buffer zone," the project will be located beyond the three mile limit of state waters in federal waters on the outer continental shelf (OCS). Figure 7.2 shows the geographical location of the proposed site for the offshore wind facility and the proposed alternatives.
Depending on wind conditions, the project is projected to produce about 75% of the electricity of the Cape Cod and the Islands on average. In strong winds, the developer estimates that it will cover the entire consumption[27].

According to the U.S. Army Corps of Engineers, the electric support platform is 100 x 200 feet, and pile-supported. There are Heliport and docking structures for access. Four transformers with 10,000 gals dielectric transformer oil with 100% containment capacity for leakage will be installed. In addition two emergency diesel generators, and a 1000 gal diesel fuel storage tank will be mounted in a detention basin (Adams, 2005[28]).

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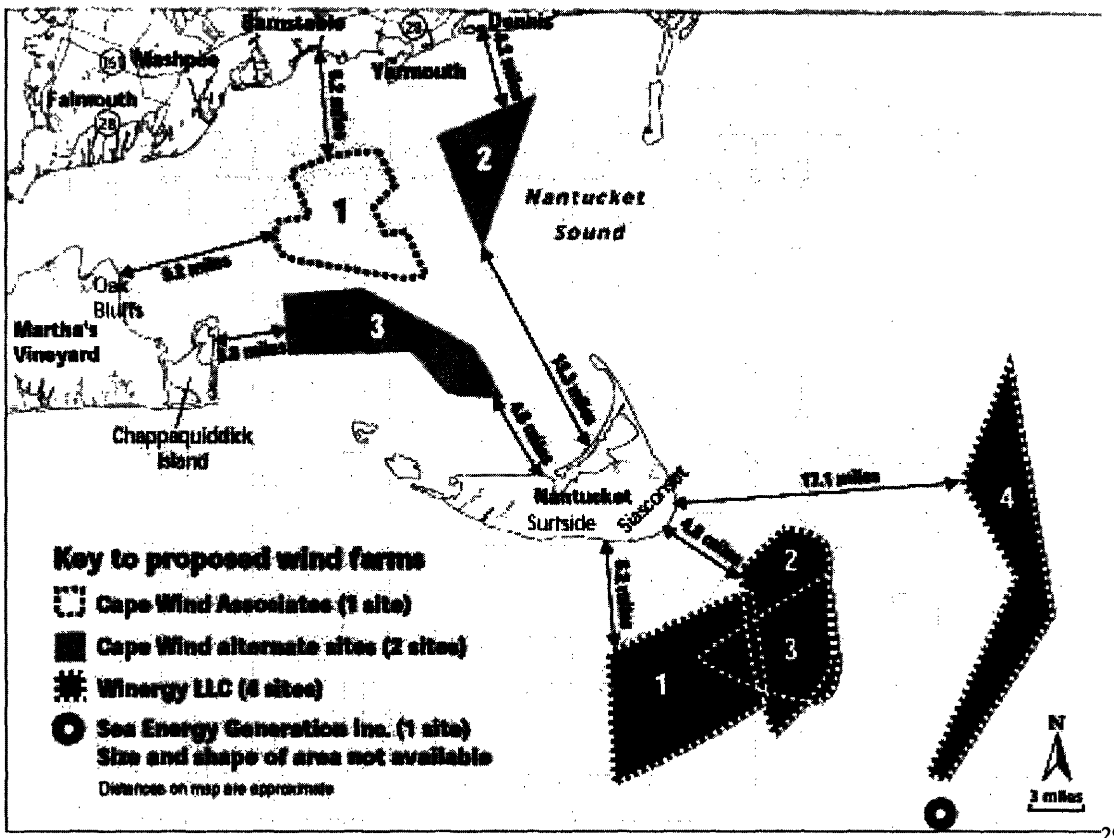
[26] Department of the Army; Corps of Engineers, "Intent to Prepare A Draft Environmental Impact Statement (DEIS) for Proposed Cape Wind Energy Project, Nantucket Sound and Yarmouth, Massachusetts, Application for Corps Section 10/404 Individual Permit", November 2001.
[27] Cape Wind Associates Website www.capewind.com
[28] Adams, Karen (Permit Manager), "Massachusetts Technology Collaborative Public Meeting Briefing", January 8, 2005, U.S. Army Corps of Engineers




Sources: Cape Wind Associates, Sea Energy Generation Inc. and Winergy LLC JAMES WARREN/Cape Cod Times[29]

**Figure 7.2. Geographical location of the proposed Cape Wind project offshore Cape Cod Massachusetts (and alternatives) Source: James Warren, Cape Cod Times**

### 7.4 The Environmental Impact Assessment Process

Based on the NEPA process, Cape Wind was asked to compile an environmental impact statement (EIS) as part of its application. The Army Corps of Engineers determined the scope of the EIS in conjunction with Cape Wind, inputs from federal and state agencies as well as public scoping comment periods. Tables 7.1-7.3 show the details of the scope of the report that was requested by the Army Corps of Engineers.

[29] James Warren, Cape Cod Times Website http://www.capecodtimes.com , Last Accessed October 19, 2004

**Table 7.1 Avian and Marine Habitat Impact, and Impact on Fisheries Scope of the EIS** (Based on the U.S. Army Corps of Engineers EIS Scope Document)

| Category | Issues to be Studied | Methodology to be Used |
|---|---|---|
| Avian Impacts | Current use of the final alternative sites by birds as baseline data<br>- Species, number, type of use, and spatial and temporal patterns of use<br>- Issues to be addressed include: (1) bird migration, (2) bird flight during storms, foul weather, and/or fog conditions, (3) food availability, (4) predation, and (5) benthic habitat and benthic food sources<br>- Information derived from other studies, providing a three-year baseline data set<br>- Endangered Species impact on Piping Plover, and Roseate Tern | - Existing, published and unpublished research results, especially research that describes long-term patterns in use<br>- New field studies undertaken for this EIR/EIS. Data on use throughout the year, especially through November for migratory species, and under a range of conditions. Methods: Remote sensing through radar and direct observations through aerial reconnaissance and boat-based surveys.<br>– Data gathered through radar to be validated with direct observations.<br>- Known impacts to birds from former or current Wind Turbine Generators (WTGs) and other tall, lighted structures (such as communications towers) |
| Marine Habitat Impact | - Vibration, sound, shading, wave disturbance, alterations to currents and circulation, water quality, scouring, sediment transport, shoreline erosion (landfall) and structural habitat alteration.<br>*- Northern right whale, humpback whale, fin whale, harbor seal and grey seal, loggerhead sea turtle, Kemp's Ridley sea turtle and leatherback sea turtle* | - Assessment of: 1) species type, life stage, and abundance; based upon existing, publicly available information, 2) potential changes to habitat types and sizes; and 3) the potential for turbines as fish aggregating structures. The study should assess potential indirect impacts to fish, mammals, and turtles that may result from changes in water movement, sediment transport, and shoreline erosion. |
| Fisheries Impact | - Assessment of potential impacts on specific fishing techniques and gear types used by commercial and recreational fishermen.<br>- Multiple-use conflict The potential for indirect impacts such as changes in fishing techniques, gear type and patterns will need to be included. | - Review of existing literature and databases to identify and evaluate commercial and recreational fish data and abundance data in Nantucket Sound.<br>- Data to be reviewed should include: National Marine Fisheries Service(NMFS) Commercial Data, NMFS Recreational Data, Massachusetts Division of Marine Fisheries Commercial Data, Massachusetts Division of Marine Fisheries Trawl Survey Data and supplemented with intercept surveys. |

**Table 7.2 Other Ecosystem and Physical System Impact Scope of the EIS** (Based on the U.S. Army Corps of Engineers EIS Scope Document)

| Category | Issues to be Studied | Methodology to be Used |
|---|---|---|
| Benthic Impact | - Sufficient information to compare between alternative marine sites and to provide a general characterization of the benthic habitat of the final sites.<br>- Data on the Benthic Macroinvertebrate Community | Assessment and additional data collection as described in the Benthic Sampling and Analysis Protocol (April 18, 2002) supplemented by the ESS letter of May 10, 2002. |
| Interactions between benthos, marine and avian food cycles | - Interconnections between the benthic, fisheries and avian resources.<br>- Predator-prey interactions data | - Noise and vibration Impacts on fish and mammal habitats and migration.<br>- Assessment of the magnitude and frequency of underwater noise and vibrations, and the potential for adversely affecting fish and mammal habitats and migration<br>- Assessment of fish and mammal tolerance to noise and vibrations, with particular emphasis on noise and vibration thresholds that may exist for each of the species. |
| Aviation | - Lighting requirements, and radar interference and radio frequency interference<br>- Lighting scheme will need to minimize impacts to birds while also providing for safe aviation. | - FAA Analysis |
| Communication | - Possible impacts to telecommunication systems - Microwave transmission<br>- Impact on installation of the wind turbine generators between Martha's Vineyard, Nantucket, and the mainland on existing transmission paths.<br>- Impact on boater communications devices | N/A |
| Navigation | - Commercial and recreational navigation impacts need to be addressed specifically for construction, operation and maintenance and decommissioning. - Cable installation activities to be included.<br>- National security issues | - U.S. Coast Guard Risk Analysis |
| Socioeconomic Impact | - Possible impacts on electricity rates and reliability in New England<br>- Explanation of any public funding and any applicable tax credits<br>- Impact on local economy including affects to employment, tourism, boating and fishing, coastal property values and local tax revenues and other fiscal impact to local governments<br>- Environmental justice issues<br>- Educational and tourism impact | |
| Electric and magnetic fields (EMF) | - Data on potential human health impacts of exposure to 60Hz EMF and potential impact from EMF produced from wind turbine generators and their associated cables, and the transmission cable | - Identify populations that could be exposed to 60 Hz EMF greater than 85mG, including human, fish, marine mammals, and benthic organisms |
| Air and Water Pollution Impact | - Compliance with the requirements of the Clean Air Act for construction and operation phases.<br>- Potential for impact on the climate of the region<br>- Potential for spills of contaminants into water | - Emergency response plans to mitigate impacts.<br>- Construction protocol. |

**Table 7.3 Social Impact Scope of the EIS (Based on the U.S. Army Corps of Engineers EIS Scope Document)**

| Category | Issues to be Studied | Methodology to be Used |
|---|---|---|
| Aesthetic and Landscape/Visual-Assessment | - Visual impacts to any National Register-eligible site in proximity to any of the final alternatives | |
| Archeological Impact | - Any impact on historic districts, buildings, sites or objects, local character and culture, tradition, and heritage will be included<br>- Archeological surveys for final site | - Survey based on previous archaeological and geological investigations,<br>- Magnetometer and high resolution side scan sonar surveys will be needed sufficient to provide electronic data which can be analyzed to assess the potential for any artifacts, such as shipwrecks, followed up by diver reconnaissance where needed.<br>- If resources are found which are eligible for listing on the Register of Historic Places, ways to avoid, then minimize, impacts to cultural resources will be considered and discussed. If avoidance is not an option, a Memorandum of Agreement may be required to mitigate potential impacts. |
| Safety Issues | Safety considerations will include public and employee safety through construction, operation and decommissioning. | - Design standards for the structures will be explained. List of preparers will include the names and qualifications of persons who were primarily responsible for preparing the EIS and agency personnel who wrote basic components of the EIS or significant background papers must be identified. The EIS should also list the technical editors who reviewed or edited the statements. Cooperating Agencies and their role in the EIS will be listed. |
| Public Involvement | - List the dates, locations and nature of all public notices, scoping meetings and hearings. The scoping meeting transcripts and summary of comments report to be provided as an appendix. | |

*Alternative sites:* The U.S. Army Corps of Engineers has listed five alternative sites (the proposed site included) that will be assessed in the Environmental Impact Statement. These are presented in Table 7.4.

Five screening criteria are used to evaluate those alternatives: availability of renewable energy (i.e. wind power classification) ISO New England grid connection availability (connection point, transmission/distribution lines, efficiency/capacity) available land or water area engineering constraints (constructability, geotechnical conditions, water depths); and legal/regulatory constraints (i.e. endangered species, shipping channels, etc.).

**Table 7.4 Alternative Sites for the Cape Wind Project**

| Alternatives | Locations |
|---|---|
| Shallow water alternatives | 1. Horseshoe Shoal (preferred site)<br>2. Tuckernuck Shoal (off Nantucket Island) |
| Onshore alternative | 3. Massachusetts Military Reservation on Cape Cod. |
| Combined Alternative | 4. New Bedford Harbor and Horseshoe Shoal could be combined, each with smaller sites could be combined to achieve the same purpose. |
| Deep water alternative | 5. Area south of Tuckernuck Island |

## 7.5 Public Reaction to Cape Wind

Like any other large-scale engineering system, the Cape Wind project gave rise to different reactions from various groups in the community and in the Commonwealth of Massachusetts. An opinion poll[30] done by the Cape Cod Times (openly siding with opponents) indicated a nearly even split between opponents and proponents of the project Among the opponents, "Aesthetics" was the number one reason cited for their opposition. Other reasons included environmental concerns, poor location, wildlife conservation and fishing, as well as objections to private usage of public land for profit. In the following paragraphs, we will be looking at the positions of different groups of stakeholders and decision-makers.

### *7.5.1 Project Opponents*

Shortly after the developer filed an application for a data tower in Nantucket Sound, a well-organized and well-financed opposition group called the Alliance to Protect Nantucket Sound was formed and voiced its opposition. The Alliance based its opposition on aesthetics as well as concerns with fisheries, tourism, migrating birds, marine mammals and the lack of need for the Cape Wind proposal. Supported by conservation groups such as the Humane Society and the Barnstable Land Trust, the alliance filed a lawsuit against

[30] A total of 588 interviews with residents of Barnstable, Nantucket and Dukes County were conducted between February 12-22, 2004 with a margin of error of +/- 4%. The survey was conducted by the Institute for Regional Development at Bridgewater State College and was sponsored by WCAI-WNAN and the Cape Cod Times. See http://www.wgbh.org/cainan/article?item_id=1481753 for more information.

the jurisdiction against the U.S. Army Corps of Engineer's authority to issue a permit for the data tower (Watson, 2003). The lawsuit and its appeal were dismissed, with the U.S. Court of Appeals ruling in February 2005 that the Corps had indeed jurisdiction over the project[31]. Still, it is expected that the Alliance will indeed file a lawsuit on the basis of an inadequate environmental impact statement, should the Corps approve Cape Wind's application.

The Alliance has organized many other local and state organizations in opposition to the Cape Wind project. Table 7.5 shows groups that have expressed "concerns" for the Cape Wind project, as reflected in the Allicance to Protect Nantucket Sound website.

**Table 7.5 Groups with "Concerns" for the Cape Wind Organization (Source: Alliance to Protect Nantucket Sound)**

| Actor Groups | Organizations/Entities/Individuals |
|---|---|
| Political Figures | Governor Mitt Romney, MA Attorney General Thomas Reilly, Senator Edward M. Kennedy, Senator Robert O'Leary, Congressman William Delahunt, State Representative Demetrius Atsalis, State Representative Eric Turkington |
| Towns & Local Business Organizations | Town of Barnstable, Town of Chilmark, Town of Edgartown, Town of Mashpee, Town of Nantucket, Town of Yarmouth, Barnstable County Assembly of Delegates, Cape Cod Chamber of Commerce, Falmouth Chamber of Commerce, Hyannis Area Chamber of Commerce, Martha's Vineyard Chamber of Commerce, Nantucket Chamber of Commerce, Chatham Chamber of Commerce, Harwich Chamber of Commerce, Nantucket Online, Yarmouth Area Chamber of Commerce |
| Preservation Groups | Barnstable Land Trust, Humane Society of the United States, International Wildlife Coalition, Massachusetts Society for the Prevention of Cruelty to Animals, Ocean Conservancy, Pegasus Foundation, Three Bays Preservation, Wampanoag Tribal Council, Save Popponessett Bay |
| Fishermen's Associations | Massachusetts Fishermen's Partnership, Massachusetts Commercial Fishermen's Association, Massachusetts Marine Trades Association, Cape Cod Marine Trades Association, Edgartown Charter Fishing Association, Edgartown Shellfish Organization |
| Other Groups (Navigation, Aviation, Boating, Real Estate, etc.) | Cape & Islands Harbormasters Association, Hy-Line Cruises, Steamship Authority, Barnstable Municipal Airport Commission, Island Airlines, Nantucket Airport Commission, Martha's Vineyard Airport , Marstons Mills Airport, National Air traffic Controller's Union, Cape TRACON, Cape Cod & Islands Association of Realtors |

[31] Electric Utility Week, February 21, 2005, SECTION: ENVIRONMENT; Pg. 9, "U.S. court affirms Army Corps' jurisdiction over Cape Wind, a big win for developers"

*7.5.2 Project Proponents*

The project also has its share of proponents, both in Cape Cod as well as in Massachusetts and the U.S. Table 7.6 shows the supporters of the project as reflected in the Cape Wind (developer) website. Table 7.7 shows groups that see offshore wind power as beneficial, but support a NEPA process to identify environmental and social impact.

**Table 7.6 Supporters of the Project (Source: Caewind.org)**

| Actor Groups | Organizations/Entities/Individuals |
|---|---|
| Local Citizens Groups | Clean Power Now, Vineyarders for Clean Power, Islanders for Wind Power (Nantucket) |
| Environmental Organizations | Greenpeace USA, The Coalition for Buzzards Bay, Green Decade Coalition, Buzzards Bay Action Committee, Northeast Sustainable Energy Association, Clean Water Action, Clean Air-Cool Planet, Massachusetts Climate Action Network, Boston Climate Action Network, Religious Witness For the Earth, African American Environmentalist Association, Thompson Island Outward Bound Education Center, Toxics Action Center, Sustainable South Shore, Envirocitizen, Cape & Islands Self Reliance |
| Health Organizations | American Lung Association - Massachusetts & Maine Chapters, Cape Clean Air, Healthlink, Pilgrim Watch, Citizens Action Network |
| Business, and Labor Organizations | Cape Cod Area League of Women Voters, American Wind Energy Association, American Coucil on Renewable Energy, Seafarers International Union, Maritime Trades Council,<br>New England Regional Council of Carpenters, International Brotherhood of Electrical Workers Local 103, International Association of Bridge, Structural, and Ornamental Iron Workers<br>Industrial Division of the Communications Workers of America Local 201, Cape Cod Internet Council, Coalition for Environmentally Responsible Economies, Mass Energy Consumers Alliance, Competitive Power Coalition of New England, Inc. |
| Towns | Town of Truro, Town of Lenox, Town of Westport |
| Political Figures | George D. Bryant (Provincetown Representative), Barnstable County Assembly of Delegates, Donald L. Carcieri - Rhode Island Governor, Daniel E. Bosley, Chair MA House Committee on Government Regulations, Michael W. Morrissey, Chair - MA Senate Committee on Government Regulations, John J. Binienda, Chair - MA House Committee on Energy, Susan C. Fargo, Chair - MA Senate Committee on Energy,<br><br>Massachusetts State Representatives (Paul Demakis, Matthew Patrick, Robert Koczera, Frank Smizik, Doug Peterson, James Eldridge, Paul Donato, Patricia Jehlen) |

**Table 7.7 Environmental Groups that support the ongoing environmental impact review process through the National Environmental Policy Act (NEPA) and the Massachusetts Environmental Policy Act (MEPA) (Source: Capewind.org)**

| **Organizations Supporting Permitting Process** |
|---|
| Conservation Law Foundation |
| MASSPIRG |
| Union of Concerned Scientists |
| American Rivers |
| Friends of the Earth |
| Cape & Islands Renewable Energy Collaborative |
| Natural Resources Defense Council |
| World Wildlife Fund |
| People's Power and Light |

## 7.6 Stakeholder Involvement in the Cape Wind Project

### *7.6.1 Scoping Hearings*

In March 2002 the Army Corps of Engineers held two EIS scoping meetings, in Boston and in Yarmouth, Massachusetts. The Corps invited Federal, State and local agencies, affected Indian tribes, interested private and public organizations, and individuals to attend the scoping meetings. Stakeholders were also allowed to submiut written comments by mail or email to the New England District of the U.S. Army Corps of Engineers. Seventy three stakeholders submitted oral testimony at these two hearings. Another one hundred and twenty written testimonials were submitted by regular mail and email.

In addition to the formal hearings, there were informal gatherings convened by the Massachusetts Environmental Policy Act Office, the Cape Cod Commission, the Martha's Vineyard Commission, and the Nantucket Planning and Economic Development Commission (Watson, 2004).

*7.6.2 Massachusetts Technology Collaborative Stakeholder Process*

The Massachusetts Technology Collaborative (MTC) is a state agency that administers the commonwealth's Renewable Energy Trust Fund. The MTC initiated a stakeholder process from October 2002 to March 2003. The goal of the MTC process was "(1) to achieve a better shared understanding of the Cape Wind project's potential benefits and environmental impacts; (2) to shed light on the regulatory process and policy drivers behind the project; (3) to develop a mutual understanding among the conflicting positions of project proponents and opponents; (4) to provide data and information to reveal any areas of factual or philosophical agreement among the stakeholders; and (5) to help prepare all parties to review the material to be presented in the EIS and participate effectively in the regulatory process"(Watson, 2003).

The existence of the MTC stakeholder process made Cape Wind attractive as an actual case study for SAM-PD. The MTC stakeholder process was not part of the formal permitting process, but allowed stakeholders and decision-makers to improve their understanding of the contentious issues surrounding the Cape Wind project. For this case study, the MTC Stakeholder process served as a part of the stakeholder conflict assessment and joint fact-finding steps that form the basis of the SAM-PD process.

Greg Watson, a facilitator with the MTC has looked at the lessons learned from the MTC stakeholder process. He notes:

> "While technical concerns and potential impacts of a single wind farm proposal can be analyzed thoroughly through the NEPA process, even some supporters of the Cape Wind project are troubled by the implications of moving forward absent the kind of publicly vetted structure and compensation environmental advocates have always rightfully demanded for other kinds of energy development projects on public lands. The situation will become more complex as the review begins for other pending offshore projects, including some that are speculative in nature and raise additional concerns. Until a system is established, offshore wind farm developers face tremendous procedural and economic uncertainty." (Watson, 2003)

### *7.6.3 Draft Environmental Impact Statement (DEIS) Hearings*

Four public hearings were held in December 2004 in Oak Bluffs, West Yarmouth, Nantucket and Cambridge, MA. A short narrative on the Cambridge meeting was presented at the beginning of this dissertation. In the meetings in West Yarmouth and Nantucket most of the comments were against the Cape Wind project, while in the Cambridge meeting supporters outweighed opponents by three to one. For the case study, meeting transcripts of the meetings were used to explore stakeholder inputs for the SAM-PD process.

## 7.7 Major Sources of Dispute in the DEIS

### *7.7.1 Usefulness: Demand for Electricity*

According to the opponents, ISO NE planning documents show that in 2006 the Southeastern Massachusetts region (including Cape Cod and known as "SEMA") will have 3,350 MW of supply and a projected peak demand of just 2,180 MW (APNS, 2003).

### *7.7.2 Birds Colliding with Towers*

The Massachusetts Audubon Society is calling for a three-year study to explore seasonal variations in bird migration and area usage. The U.S. Fish & Wildlife calls the developers' proposal 'not sufficient,' and recommends at least a three-year study for birds alone. The MA Dept. of Marine Fisheries has expressed "serious concerns centering on the potential risks to migratory birds." (APNS, 2003)

Proponents on the other hand point to the many cases in Europe where bird fatalities are minimal. In the case of in-land wind turbines on Mount Valso, Vermont, a small-scale turbine farm, no bird had been reported killed within a year of its operation (Grady, 2003)

### *7.7.3 Impact on Fisheries*

The Mass. Division of Marine Fisheries anticipates "direct negative impacts to fisheries resources and habitat..." (APNS,2003). Many fishermen's associations have expressed concern over potential impact on their revenues and commercial fishing populations and believe the DEIS was not sufficiently rigorous in addressing the issue.

*7.7.4 Impact on Marine Mammals*

Opponents such as the Humane Society indicate that the EIS has neglected the impact of construction noise and operating vibrations on marine mammals, particularly the North Atlantic right whale and other whale species.

*7.7.5 Tourism*

Disagreements exist on potential impacts on tourism in the region. The impact of tourism is very important to the region, since more than 21% of the jobs on Cape Cod were in tourism-related industries.

*7.7.6. Lease*

Many residents are concerned with the private use of public land (or waters) in the case of the Cape Wind project, and would like the company to pay royalties as part of a lease. While Cape Wind has essentially agreed to a lease agreement if required by Congress, it contends that the feasibility of offshore wind energy facilities would be decreased by such lease payments.

*7.7.7. Local and Regional Economic Impact*

In April 2003, Cape Wind released an economic impact report that said the project would create 600 to 1,000 jobs in Massachusetts. During the construction phase, Cape Wind estimated an economic contribution to Massachusetts of $85-million to $137-million annually. They also estimated between $6 and $10 million in increased personal and business tax increases for the state budget. On the other hand, the Alliance published a report in 2003, which stated that without tax credits, the cost of wind energy would be $85/MWh, or twice as high as the $42/MWh for gas-fired plants.[32]

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[32] Electric Utility Week April 28, 2003, "Cape Wind offshore project gets boost from report claiming benefits to economy"

### *7.7.8 Aesthetics*

Of course, a major disagreement also exists on the visual impact of the wind farm. while both proponents and opponents agree that the wind farm would be visible from the shore at certain times, they do not agree on the degree of the impact and its characterization. Cape Wind will be painting the turbines such that they blend in with the color of the horizon, but there will be still impact during the night and even during the day. While proponents consider the sight to be beautiful, opponents believe it will destroy the character of Nantucket Sound. There is a consensus among proponents that all the other objections by the opponents stem from a basic aesthetic consideration rather than environmental concern.

## 7.8 Current Status of the Project

As of April 2005, the Cape wind project is awaiting Federal and State permit decisions. The State has issued a conditional approval for the project, and it is expected that the U.S. Army Corps of Engineers will also issue a conditional permit approval in late 2005 or early 2006. If so, Cape wind could start construction in 2006 and start operation in 2007. It is expected however that the Massachusetts government and the opposition will then file lawsuits based on EIS inadequacies to drag on the process. There is an extensive cost of capital for the developer with each year of delay in the project (estimated at $10-12 million), which was supposed to be up and running by early 2004 if the decision-making process had been less controversial.

## 7.9 Chapter Summary

In this chapter we introduced the Cape Wind project and its technical, environmental and social aspects. We looked at the legal context of the case, and the permitting process taking place under the jurisdiction of the U.S. Army Corps of Engineers. Furthermore, we analyzed public positions regarding the Cape Wind projects and identified major sources of conflict among stakeholders. In the next chapter, we will present the application of the SAM-PD process as an alternative (yet complementary) approach to making decisions for the Cape Wind project, and explore its merits and drawbacks.

## Chapter References

**APNS (2003)** "Technical Concerns", Alliance to Protect Nantucket Sound, 2003 http://www.saveoursound.org/workings/technical.shtml (Last accessed March 22, 2005)

**Grady, M., (2003)** "Reaping the Wind In A Brand New Age", *Journal of the Conservation Law Foundation*, Volume IX, No. 2 Spring 2003

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# ➲Chapter 8

## Stakeholder-Assisted System Representation of Cape Wind

In this chapter we will explore the Stakeholder-Assisted Modeling and Policy Design Process, as applied to the actual case study of the Cape Wind Offshore Wind Energy Project. The case study is an effort at validating the research hypothesis of this dissertation (revisited below), and will therefore focus heavily on the systems representation aspect of the process, rather than negotiation and implementation issues which are very much ongoing.

### 8.1 Applying the SAM-PD Process to the Cape Wind Project

As introduced in the first chapter of this dissertation, our hypothesis is that stakeholder-assisted systems representation for an engineering system can produce a *superior* representation than traditional expert-based representations. We defined the criteria for a *superior* representation as follows:

- Inclusion of a plurality of views
- Usefulness of representation as a thought expander for stakeholders
- Usefulness of representation for suggesting strategic alternatives for improved long-term management of the system
- Capturing effects that expert-only representation couldn't capture.
- Completeness of representation (taking into consideration technical, social, political and economic considerations)

Here, "traditional expert-based" refers to a systems representation that is mainly created by experts at the request of a decision-making entity (e.g. permitting agency) as part of the technical analysis of an engineering system. As with the case of the Cape Wind project, even traditional processes make use of stakeholder inputs in a limited fashion and are therefore not entirely limited to expert analysis. Thus, the main difference between a stakeholder-assisted and an expert-based systems representation is the centrality of stakeholder involvement, the degree of involvement and the timing of the involvement.

The Cape Wind project serves as a useful case study to explore the validity of this hypothesis, partly because an expert-based permitting process has been ongoing for more than three years. As described in the previous chapter, the characteristics of the case make it a good example of a engineering system with uncertain social and environmental impact and prone to extensive controversy and stakeholder conflict. This makes the case attractive as a SAM-PD application.

Furthermore, and importantly for this research the scope of the environmental impact assessment requested by the U.S. Army Corps of Engineers can serve as the expert-based representation that can then be compared to a stakeholder-assisted representation based on the criteria and measures described in Chapter 1.

In applying the SAM-PD process to the Cape Wind case study, we emphasize that the actual decision-making process is a traditional permitting process. Still, at this stage of the Cape Wind process, the usefulness of a new collaborative process cannot be ruled out. The Commonwaelth of Massachusetts is still fighting to take charge of the permitting process, and if they are successful, the process may need to start from the beginning.

## 8.2 Problem Identification and Process Preparation

### *8.2.1 Initial Problem Identification/Project Proposal*

In November 2001, Cape Wind Associates filed an application for an offshore wind facility in Nantucket Sound. As indicated by the application, the aim of the project was to provide 420 MW of renewable energy to Cape Cod, Massachusetts, as part of the state plan to produce 5% of its energy from renewable sources by 2010. The U.S. Army Corps of Engineers, as the permitting agency has the mandate to approve the project if it judges that potential benefits of the project will outweigh its potential social and environmental cost, as determined through the NEPA process.

***Problem Identification and Process Preparation***

- Initial Problem Identification/Project Proposal
- Stakeholder Participation Level Assessment
- Choice of Convening Group
- Choice of Neutral

***Stakeholder Conflict Assessment***

- Stakeholder Identification
- Stakeholder Value Assessment
- Choice of Process Participants
- Choice of Facilitator

**System Representation, Modeling and Policy Design**

- Problem Refinement/System Definition
- System Representation
- Quantification/Evaluation of Representation
- Alternative Generation

***Model-Based Consensus Seeking Negotiations***

- Facilitated Stakeholder Negotiation on Alternatives and Consensus-based (or overwhelming majority) agreement.
- Process Effectiveness and Validity Assessment

***Implementation and Post-implementation***

- Implementation schedule, monitoring and enforcement design
- Adaptive Management

**Figure 8.1 Stakeholder-Assisted Modeling and Policy Design (SAM-PD) Process Diagram**

*8.2.2. Stakeholder Participation Assessment*

Using the PLP heuristic proposed in Chapter 6, one could get a sense of the level of stakeholder participation necessary for the project. Given its characteristics, the Cape Wind project would require the highest level of participation, which is stakeholder participation in decision-making. While this may not be practical, it is imperative that stakeholders are involved in as much as possible in system representation, assessing risks, and making recommendations. Therefore, it makes sense to use the SAM-PD process to structure the NEPA analysis.

**Table 8.1 Participation Level Point (PLP) Heuristic for Cape Wind**

The Cape Wind Project:

- Has contentious jurisdictional issues
- Affects a wide range of stakeholders
- Has stirred considerable controversy
- Has potentially controversial cost distribution impacts on stakeholders
- Depends on Federal Tax credits and Carbon Trading for part of Funding
- Involves significant scientific uncertainties in environmental impact
- Has a strong environmental justice component
- Is under the permit jurisdiction of the Army Corps of Engineers, which has been criticized for the way of handling the permit process
- Has vocal opponents who have threatened the developer with lawsuits
- Involves a variety of scientific and technical agencies (governmental, private sector, academic) who have significant expertise to offer if engaged
- Involves uncertain long-term effects that could be best mitigated through adaptive management.
- Has strong obstructionist potentials due to polarized environment.

According to the heuristic, these characteristics put the Cape Wind project within the "Public Participation in Final Decision" category of Arnstein, which is the highest category of participation.

### 8.2.3 *Choice of Convening Group*

The convening group has to include organizations that have mandates, authority and resources to ensure the success and effectiveness of the collaborative process and the power to potentially enforce its agreements. Therefore, the main permitting agency has to be part of the convener group. Possible additional organizations that may be helpful as conveners can be determined by assessing stakeholder preferences. Suitable candidate organizations for co-convening the process include the Massachusetts Technology Collaborative and the Massachusetts Environmental Protection Act office. Several stakeholder groups have expressed a desire for the State House and Senate to be involved in managing the process. Table 6.2 shows an ideal convening group, with sufficient authority for the collaborative process to succeed. Such a convening group would reduce the incentive of the Commonwealth of Massachusetts to litigate against the jurisdiction of the U.S. Army Corps, and would ensure that State concerns are directly taken into consideration. It would also provide the U.S. Environmental Protection Agency (EPA) and the U.S. Department of the Interior (DOI) with an incentive to invest in generating science through their experts. A U.S. DOI involvement would also allow for lease issues to be integrated as part of the permitting process.

**Table 8.2 Proposed Convening Group for Cape Wind (Based on Stakeholder Inputs)**

- Federal
  - U.S. Army Corps of Engineers
  - U.S. Environmental Protection Agency
  - U.S. Department of Interior
- Commonwealth of Massachusetts
  - Massachusetts Environmental Protection Act Office
  - Joint Massachusetts Senate-House Appointed Representative Committee
  - Massachusetts Technology Collaborative
  - Energy Facilities Siting Board

*8.2.4 Choice of Neutral*

Selecting the neutral is the task of the convening group in its initial sessions. The neutral (and her/his group) can be a professional mediator, community elders (no obvious choice for the Cape Wind project), or national figures trusted by all sides of the issue. Given the controversy of the case, an outside mediator with a track record of neutrality in high-profile cases may be a good choice. While not necessarily a choice for this particular case, former President Jimmy Carter has played this role for other cases of conflict.

For the practical purpose of this case study, we played the role of the self-appointed neutral in stakeholder conflict assessment. With MIT not having taken sides either way, stakeholders seemed to accept our neutrality throughout the process. The initial involvement in the Cape Wind project came about in a graduate class on joint-fact finding for science-intensive disputes taught by Prof. Lawrence E. Susskind and Dr. Herman Karl. Cape Wind stakeholders were invited to MIT, and introduced to the concept of joint fact-finding. Additionally, stakeholders were given the opportunity to express their positions and interests with regards to the Cape Wind project. At the end of the semester, stakeholders took part in a role-play on an offshore wind energy decision-making process, where they negotiated possible agreements within a consensus seeking process. Later on, the USGS agreed to create the MIT-USGS Science Impact Collaborative (MUSIC)[33], which became the contact point of MIT's joint fact-finding research with the community. While the purpose of the class was mostly educational, the interactions created a basic trust in MUSIC as a more or less objective organization.

In a real collaborative process the selection of the neutral would come from the convening group.

[33] See the MIT-USGS Science Impact Collaborative Website at http://web.mit.edu/dusp/epg/music/

### 8.3 Stakeholder Conflict Assessment

8.3.1 Stakeholder Identification

As we discussed in Chapter 7, the MTC Stakeholder process for the Cape Wind project identified many of the key stakeholder organizations and provided an opportunity for stakeholders to express their interests and concerns. We used the process transcripts as a starting point for our stakeholder conflict assessment. In addition to the stakeholders identified in the MTC Stakeholder process, we also used the U.S. Army Corps of Engineers hearing transcripts to identify further stakeholders and their positions. Tables 8.3-8.5 identify key decision-making stakeholder entities in the Cape Wind project with their respective SPK (stake, power and knowledge) characteristics. Figure 8.2 shows the key stakeholders of the Cape Wind project that we identified in the four major categories. While we did not have access to all of them, we contacted 44 organizations from a total of 62 identified organizations during the Stakeholder Value Assessment stage.

*8.3.2 Stakeholder Value Assessment (Direct)*

From April-November 2004 more than 44 key stakeholder organizations in the Cape Wind controversy were asked to fill out a survey on their perspectives in offshore wind siting criteria and other important considerations. From this sample, 27 organizations (61%) filled out the survey. Five organizations responded that they would not comfortable providing any feedback, because of their involvement in the permitting process or lack of substantial insight about the project and despite multiple attempts, 13 organizations did not respond at all. The purpose of the survey was to elicit issues, linkages and values stakeholders considered important in the decision-making process. The results were used in conjunction with scoping hearing statements, MTC stakeholder process inputs, and stakeholder public statements to help a better system representation. The invitation letter and the questionnaire are presented in Appendix A. Table 8.6 shows the participating organizations.

**Table 8.3 Federal Stakeholders in the Cape Wind Project**

| Stakeholder Organization/Entity | Stake/Power/Knowledge |
|---|---|
| U.S. Army Corps of Engineers | Current Lead Permitting Agency with Federal Jurisdiction over Cape Wind. Expertise in navigational safety |
| U.S. Environmental Protection Agency | Mandated with the Clean Water Act and the Clean Air Act. Expertise in air and water pollution. |
| U.S. Fish and Wildlife Service (DOI) | Mandated with the Endangered Species Act and the Migratory Birds Treaty Act, expertise on migratory birds, marine ecosystem |
| National Marines and Fisheries Service (DOI) | Mandated with the Marine Mammals Protection Act. Expertise in fisheries, marine ecosystem and marine mammals |
| National Park Service (DOI) | Mandated with impact on Historic Places and National Parks |
| U.S. Coast Guard | Mandated with Navigational Safety, Marine Search and Rescue Operations and National Security |
| Federal Aviation Administration | Mandated with Air and Navigation Safety |
| U.S. Department of Energy | Mandated with the National Energy Act. Expertise in renewable energy and energy economics |
| Federal Energy Regulatory Commission | Regulates and oversees energy industries in the economic and environmental interest of the public |
| U.S. Geological Survey (DOI) | Expertise in Marine Geology |
| Minerals Management Service (DOI) | Mandated with lease management for public resources. Expertise in offshore leases for oil and gas. |
| U.S. Department of Commerce | Expertise on local, regional and national economic impact of project |
| U.S. Legislative Branch (Congress and Senate) | Jurisdiction over new legislation with regards to National Energy policy or Ocean Usage under Federal Jurisdiction |
| U.S. Federal Courts and Courts of Appeal | Jurisdiction over lawsuits filed on the Federal level with regards to the Cape Wind project. |

**Table 8.4 Commonwealth of Massachusetts Stakeholders in the Cape Wind Project**

| Stakeholder Organization | Stake/Power/Knowledge |
|---|---|
| Massachusetts Environmental Policy Act Office | State Permitting Agency supervising the State Environmental Impact Report, with expertise on environmental impact analysis of new projects |
| MA Department of Environmental Protection | 402 Water Certification, Waterway licensing, Air Pollution Impact |
| MA Energy Facilities Siting Board | Approval of new power generation processes |
| MA Division of Marine Fisheries | Fisheries Management for areas under State jurisdiction, expertise in marine mammals and organisms |
| MA Coastal Zone Management Office | Mandated with Coastal Zone Management for the Commonwealth of Massachusetts |
| MA Division of Fisheries and Wildlife | Equivalent to the USFWS. Mandated with State protected and endangered species acts. Expertise in fisheries, marine ecosystems and migratory birds |
| MA Board of Underground Archeology | Mandated with protection of underground heritage sites, historical shipwrecks |
| MA Historic Commission | Concerned with Visual Impact to Historic Areas |
| Massachusetts Technology Collaborative | Charged with the State's Renewable Energy Fund. Interested in promotion of renewable energy in Massachusetts. |

**Table 8.5 Local and Regional Government Stakeholders in the Cape Wind Project**

| Stakeholder Organization | Stake/Power/Knowledge |
|---|---|
| Cape Cod Commission | Regional planning and regulatory agency supervising a regional land use policy plan for all of Cape Cod |
| Towns of Barnstable | Town directly affected by Cape Wind project |
| Town of Yarmouth | Town directly affected by Cape Wind project |


**Figure 8.2 Key Stakeholder Organizations identified in the Stakeholder Value Assessment Stage**

In the following paragraphs, we will present some of the results of the stakeholder survey.

*A) General Perceptions of Offshore Wind Energy Development*

In the first question of the survey, stakeholders were asked to state their general perception of offshore wind energy development in the U.S. indepentent of a specific site. 42% of respondents stated having a very positive view of offshore wind energy development, with an additional 15% expressing a positive view. 19% of respondents expressed a conditionally positive view of offshore wind development, while 11% of respondents expressed skepticism. The remaining respondents (13%) chose not to comment on this question. Furthermore, respondents were given the chance to elaborate

**Table 8.6. Stakeholder organizations participating in the MIT stakeholder survey**

| ***Organization*** |
|---|
| Alliance to Protect Nantucket Sound |
| Cape & Islands Renewable Energy Collaborative (CIREC) |
| Cape & Islands Self-Reliance |
| Cape Clean Air |
| Cape Cod Chamber of Commerce |
| Cape Cod Technology Council |
| Cape Light Compact |
| Cape Wind Associates |
| Clean Power Now |
| Conservation Law Foundation |
| International Wildlife Coalition |
| MA Attorney General's Office |
| MA Board of Underwater Archaeological Resources |
| MA Division of Marine Fisheries |
| MA Natural Heritage & Endangered Species Program |
| Martha's Vineyard Commission |
| Mashpee Board of Selectmen |
| Massachusetts Audobon Society |
| Nantucket Planning & Economic Development Commission |
| Northeast Sustainable Energy Association |
| Pegasus Foundation |
| The Humane Society of the United States |
| Three Bays Preservation |
| Town of Yarmouth |
| U.S. Department of Energy |
| U.S. Geological Survey |
| Woods Hole Oceanographic Institute |

on their positions. While not everyone responded, the following comments were made for elaboration on their responses.

*Very Positive and positive:* Those with "very positive" or "positive" perceptions of offshore wind energy in general, emphasized the importance of private sector development of renewable energy in realizing the transition from a fossil fuel economy. The current project was identified as a critical element of this transition towards clean and renewable energies (in contrast to other, renewable but polluting energy sources). Proponents stated that the many benefits of the project, versus the few drawbacks, make it a compelling choice.

*Conditionally positive:* Some undecided respondents emphasized the importance of the choice of location, the lack of proper regulations for offshore wind on the continental shelf as the rationale for their position. Others stated that the advantages of clean power should be weighed against the drawbacks of potential environmental impacts, and that they would be cautious in promoting one or the other position for this purpose.

*Skeptical:* Those "skeptical" of offshore wind energy stated concerns on the effect of the project on tourism, environmental concerns and aesthetics as reasons for their opposition to the project. Other concerns included the choice of the site, the appropriate use of public trust land, cost/benefit analysis, and the lack of appropriate protocols for assessing and mitigating negative impacts, public participation in siting and mitigation plans in the case of problems. Lack of appropriate Federal regulations in dealing with offshore wind energy development was also stressed. One respondent also mentioned that offshore wind development will not withstand a rigorous cost benefit analysis. Another view expressed was the preference for land-based wind farms to offshore wind farms.

*B) Position on the Cape Wind Proposal*

Respondents were asked to state the position of their organization on the Cape Wind Proposal. The purpose of this question was for ensuring that the sample was representative of the different perspectives on the issue, and does not represent the composition of views of all stakeholders in the project. The choices given were opponent, proponent, undecided, neutral and no comment. In the respondent sample, 24% identified themselves as proponents, 20% as opponents, 32% as undecided, 12% as neutral and 8% did not comment on their position. One respondent with a "no comment" answer objected to the formulation of a position question, indicating that it was improper in the context of this project to summarize positions with a multiple-choice question.

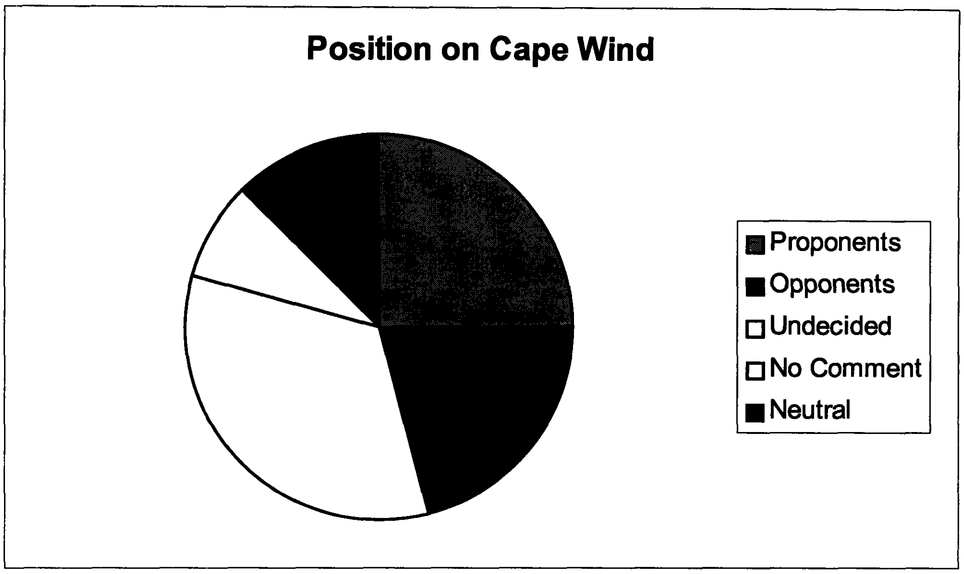



**Figure 8.3 Stakeholder Positions on the Cape Wind Offshore Windfarm Proposal**

*C) Siting Criteria for Offshore Wind Projects:* Stakeholders were asked to consider the process of determining the site for an offshore wind energy project and provide four major criteria they think are the most important to consider in siting offshore wind energy facilities. Table 8.7 shows the criteria listed by stakeholders based on their stated position on Cape Wind.

*D) Benefits of Offshore Wind Farms:* Stakeholders were asked to identify up to three benefits of offshore wind energy regardless of the site. Table 8.8 shows the benefits identified by the stakeholders.

*E) Stakeholder Concerns with Offshore Wind Power*

Stakeholders were also asked to identify up to three concerns they may have with offshore wind energy regardless of the site. Table 8.9 shows the concerns listed by the stakeholders.

**Table 8.7. Stakeholder Siting Criteria based on stated position on Cape Wind**

| Position | Criteria for Siting |
|---|---|
| Proponents | Wind resource availability (2)<br>Commercial feasibility<br>Community acceptance<br>Economic externalities<br>Environmental impacts (2)<br>Local economic benefits<br>Nearby shoreline sparsely inhabited<br>Physical feasibility<br>Proximity to area of electric demand<br>Proximity to power transmission grid (4)<br>Proximity to facilities for construction<br>Shallow water (less than 50 feet)<br>Wave heights |
| Undecided/No Comment/Neutral | Adequate consideration of alternative sites<br>Aesthetic considerations (2)<br>Commercial feasibility<br>Collaborative process (2)<br>Local economic benefit (5)<br>Local Economic impacts (4)<br>Minimal impact on currents/habitats/ecosystems (6)<br>Mitigation of adverse local impacts<br>Multiple Resource Use Conflict<br>Noise impact (construction and operation)<br>Proximity to Migratory Paths for Birds<br>Proximity to Migratory Paths for Marine life<br>Proximity to power transmission grid (2)<br>Ratio of local benefits to impacts<br>Ratio of power generation to impacts<br>Shallow water less than 50 feet<br>Technical Feasibility and Adequate Wind Regime (3)<br>Wave heights<br>Adequate environmental impact information |
| Opponents | Aesthetic considerations (3)<br>Alternative Sites Review (2)<br>Criteria defined by Federal, State, local agencies and public<br>Collaborative siting<br>Cost-benefit analysis (4)<br>Decommissioning bonds of outmoded facilities<br>Environmental impact (5)<br>Federal and/or state offshore development regulatory program in place(3)<br>Impact on Navigation, Aviation (4)<br>Multiple Resource Use Conflict (3)<br>Noise impact (construct. +operation) (3)<br>Proximity to area of electric demand<br>Proximity to Migratory Paths for Birds<br>Proximity to Migratory Paths for Marine life<br>Potential cumulative impacts of facility over lifetime<br>Sufficient Study times |

**Table 8.8. Stakeholder Perceptions of Offshore Wind-power benefits.**

| Position | Benefits of Offshore Wind |
|---|---|
| Proponents | Reduced reliance on imported fossil fuel energy<br>Greater diversification of region's energy portfolio<br>Reduced pollutant emissions<br>New jobs<br>New economic sector introduced to region<br>More stable energy prices<br>Long term economic benefit to host community<br>Health benefits of reduced emissions<br>Cheaper local electric bills<br>Hydrogen generation<br>Implement renewable energy production on large scale<br>Reduction of greenhouse gases |
| Undecided/No Comment | Clean power<br>More stable energy prices<br>Economic development within host communities<br>Reduction of reliance on non-renewable energy<br>Reduction of greenhouse gases<br>Monetary benefits to users<br>Reduction of reliance on foreign oil<br>Creation of hi tech jobs<br>Potential reduction in habitat degradation caused by fossil fuel-based energy production<br>Potential reduction in human health risk |
| Opponents | Lessening fossil fuel dependence<br>Decreasing air contaminants<br>Furthering public awareness of alternate energy sources<br>Renewable energy<br>More diverse energy portfolio<br>Energy source with minimal air pollution<br>Potential economic benefits (currently overstated)<br>None |

**Table 8.9. Stakeholder Concerns with Offshore Wind-power**

| Position | Concerns with Offshore Wind |
|---|---|
| Proponents | Fossil fuel energy facing greater competition*<br>Tradeoff with a project like this with open vista<br>Many concerns based on fear will dissipate after construction<br>Visual Aesthetics (to some people)<br>Potential danger for airplanes, boats if not engineered properly<br>Navigation<br>Boating<br>Potential environmental impacts (ocean ecosystem, mainly)<br>Private use of and profit from public lands<br>Public rejection of Wind Farms |
| Undecided/No Comment | Minimal control for local communities bearing adverse impacts<br>Questions about ability of host communities to maximize benefits<br>Protection of aesthetics (QoL amenity)<br>Protection of competing uses (recreation, fishing, etc.)<br>Large commitment of a public resource and closure to other use<br>Aesthetics<br>Environmental impacts (more needs to be known)<br>Choice of Location<br>Contractor ability to get a performance bond<br>Exit plan to remove old tired turbines<br>Issues of Lease<br>Potential siting near major migratory routes, harming wildlife<br>Anchoring with rip rap introduces artificial reefs (and consequently non-native fauna) and disrupts coastal processes (creating areas of scour and drift) and thus may adversely impact habitat suitability with repercussions for food webs<br>Project sites often chosen on basis of wind availability rather than doing prior site screening to determine risk averse sites<br>Inadequate study times for impacts<br>Creation of offshore wind power does not necessarily lead to taking other energy sources offline. Overall consumption reduction is key.<br><br>The before and after: construction disturbance (via noise, currents, removal/altering of habitat), and responsibility for the removal of turbines when out of service<br><br>Appropriation of public land for corporate use (and no current system to regulate/charge for use)<br><br>There are no guidelines or regulations in place in the US specific for wind energy plants |
| Opponents | Proper licensing<br>Proper environmental review<br>Federal, state and local review<br>Opens door to other forms of offshore development<br>Can endanger valuable offshore resources<br>Cost/benefit analysis doesn't support it from public perspective<br>Choice of Location<br>Environmental and Economic Impacts<br>Decommissioning of out of date facilities |

F) Stakeholder Proposals for Dealing with Aesthetics: Concerning the impact of wind-farms on the aesthetics of the region in question, stakeholders were asked to suggest potential objective ways to allow taking aesthetics into consideration in the decision-making process. Table 8.10 shows stakeholder suggestion on aesthetics based on their position on the Cape Wind Project.

**Table 8.10. Stakeholder suggestions for dealing with Aesthetics Impact**

| Position | Suggestions for Aesthetic Considerations |
|---|---|
| Proponents | "Should be one of very many factors that public agencies evaluate in determining the public interest. " "Analyze sales prices of homes with a wind-farm view, to see if they appreciated less, equal or more than equivalent homes on the coast without a wind-farm view." "No objective way to take aesthetics into consideration. (You could set a price for aesthetics by auctioning off sites (development vs. preservation.)" "All ocean views are beautiful. None more or less than any other. Placement in federal waters three miles or more offshore are in the interest of the public good and far enough away that should not be objectionable to the view of reasonable individuals. Would you pit wealthy homeowners vs. working class homeowners view sheds as more or less deserving? What about environmental justice? Should I be compensated by a power plant a mile away who's 500 foot stack I see from my window?" "I find that these turbines are beautiful, unlike the aging power infrastructure along side our roads that we are so accustomed to that we no longer see it. So, I guess more education on the tradeoffs is needed." "There's no easy answer to that." |
| Undecided/No Comment | Projects may only be granted approval to proceed w/ conditions, with aesthetics one required element in mitigation and developers/opponents working together to minimize adverse effects Visualization conducted by objective third party. Trips to see existing facilities, sponsored by objective third party. Move project out of view of the mainland. |
| Opponents | "Although expense is an issue, siting should be [done as far] away from shore view as possible" "Mapping of resource areas to show locations of higher and lower impact, with input from affected communities." "Measure the real visual impacts, lights at night, construction and repair equipment," "Arguing about aesthetics is not easy to defend, as it is typically seen as being in the interests of the wealthy waterfront property owners, not the public as a whole. I believe aesthetics should included, but not a priority of this issue. Rather, the outright appropriation of public lands for private use, the lack of siting review ...and a paucity of regulations regarding offshore wind development are of primary concern |

*G) Need for Further Information For Decision-Making on Offshore Wind*: Stakeholders were asked to identify areas where more information would be needed for decision-making on offshore wind-energy development. Table 8.11 shows the needs identified by stakeholders based on their position on the Cape Wind Survey.

**Table 8.11. Identified Information Needs for Decision-making[34]**

| **Position** | **Additional Information Needed** |
|---|---|
| Proponents | Analysis of additional potential of offshore wind in case of generous U.S. government support.<br>Economic benefit analysis of electricity production helping the understanding of true economic benefits, effect technology development and labor.<br>Factual information on the enormous benefits of offshore wind power, health benefits from retiring of fossil plants |
| Undecided/No Comment | Better processes for managing such projects, learning from more successful projects such as the LIPA[35] project.<br>Assessing whether contractor is financially capable of building a $700mil project, and can produce a performance bond<br>Determining areas where wind is optimum and then super-impose wildlife high use areas such that wind plants are not being proposed for potentially fragile habitat and/or important wildlife use areas<br>Need to clarify jurisdictional issues regarding permitting and "ownership." |
| Opponents | A pilot government project with a sunset clause to establish independent guidelines<br>True long term costs and real impacts.<br>Longer-term studies of bird movement through and residence in the area, as well as all alternate sites<br>Better understanding of the effect of wind farm construction on currents/ecosystem.<br>Better understanding of impact of noise on marine mammals. |

[34] It seems this question was poorly phrased. Many stakeholders found this question vague and were unable to provide answers.

[35] Long Island Power Authority (LIPA) Wind Energy Initiative http://www.lipower.org/cei/wind.html

*H) Selected Stakeholder Comments on the Cape Wind Permitting Process:*

Stakeholder were also given the opportunity to comment on different aspects of the offshore energy controversy. Some stakeholders also focused their responses on the current permitting process and the MTC stakeholder process. Comments in this section are reproduced regardless of positions or identity of stakeholders.

- "Incentive programs for decreasing fossil fuel usage by the US including, but not limited to: tax credits to citizens that purchase fuel efficient cars, lights, solar panels, etc are needed"
- "We need to bring on line a large amount of renewable power in the very near future, and off-shore is where the wind is."
- "There is a need to revamp the Federal permitting process specifically for off-shore wind projects so that the public feel that they are invested in the process."
- "The controversy over Cape Wind might have been avoided had the developer considered the likely controversies/questions prior to putting forward a formal proposal, and chosen a more risk averse site. For example the Long Island Light and Power Authority has largely avoided this problem with their wind plant development because there was a pre-proposal site selection process that was intended to minimize abutter concerns and choose sites that were not important habitat for birds. While there are obviously SOME concerns with any project, the LIPA project avoided the controversy largely by having done their homework PRIOR to choosing a site for development. As testament to this, no conservation group has objected and there have been no serious concerns raised by US Fish and Wildlife or the NY state wildlife department--whereas Cape Wind has been dogged by questions and concerns raised by both the Commonwealth of Mass Division of Fish and Wildlife and the USFWS; both of which have made research recommendations regarding avian habitat use that Cape Wind has neglected to address. I am concerned that their mishandling of this situation will either impede developments in better areas or will allow other developers to believe that they need not address these important concerns prior to finalizing a site proposal."

- "The choice of locations is critical. For Example, the US Corps of Eng would split up the Cape Wind project in 3 parts. 2 parts in water in different locations and the 3rd on land on the Mass Military Reservation. (MMR) For example, The site Horseshoe Shoals is difficult. The US Army Corps of Eng suggests cutting it up in three pieces one third of which is on land (MMR). The Fed needs to create the proper regulations for sea based wind. What Fed Dept or State Dept should be in charge? Royalties to be paid to the approporate state."
- "Factors such as federal system to give away public trust land, cost/benefit analysis, protocols for assessing and mitigating negative impacts, public participation in siting and response plans in the case of problems must be in place before permitting begins."

*I) Comments on the MTC Process*

- "I believe the selection process of the MTC technical advisory system was geared too much toward "undecided" members. Rather, it should have broken off separate working groups to address various specific issues such as aesthetics, economics, and wildlife/habitat concerns, respectively. These working groups could have included folks who may have already formed opinions about the project, but could have provided some very helpful expertise to the review process."

*8.3.3 Stakeholder Value Assessment (Indirect)*

*Newspapers and Websites:* In many cases it is difficult to reach all the key stakeholders for commenting. There are some indirect ways for considering the views of stakeholders about the system. In the case of Cape Wind we used more than 60 newspaper articles, 47 press releases, and stakeholder websites for information on their values, positions, interests and concerns. An example of one newspaper article used in value assessment is shown in Table 8.12. Most organized stakeholder groups in the U.S. and other developed countries also have some of their views presented on their websites (See Table 8.13). These are usually far more comprehensive than those that can be found in newspaper articles, but similar to newspaper articles, websites only represent the voice of those already vocal.

**Table 8.12 Stakeholder Value Assessment Through Newspaper Articles on Cape Wind**

Excerpts from The Boston Globe, October 17, 2004, Sunday THIRD EDITION

"Report On Possible Risks From Wind Farm Fuels Ire", by By Beth Daley

*"... The potential for **bird deaths** promises to become a major question surrounding the wind farm..in an area heavily traveled by **sea ducks, migratory birds**, and some endangered species...federal wildlife authorities have complained that two widely disparate numbers suggest that there is **not enough data** to know **how many birds fly through the area**, let alone how many will be killed by the turbines..one figure used in a version of the report, compiled by **aerial and boat surveys**, counts 210 individual birds over about 180 hours of observation that fly in the zone the turbine blades will sweep. Another figure, based on two months of radar data, shows that 127,697 birds or bats flew through the same area, some of which may have been counted multiple times... "there is no data for 10 months of the year with the radar survey, and it's clear the other information is **unreliable**," said Vernon Lang, assistant supervisor of the New England Field Office of the US Fish and Wildlife Service...He says the lack of fundamental data means "we only get a glimpse of what is happening. We need more information."... [Cape Wind says that] the two different bird counts are not designed to be compared, but rather to help Army Corps officials make an informed decision about bird **behavior, habitat, and potential harm** in the area where the wind farm would be built. He said the radar study was taken during **fall and spring migratory months in 2002**, giving a snapshot of the busiest times of the year for birds in Nantucket Sound.*

*Supporters of the project say that any bird deaths would be minimal **compared** with the millions of birds that die each year colliding with **skyscrapers and cellphone towers**. Opponents, meanwhile, have said any bird deaths are unacceptable."*

The bolded terms contain stakeholder views on performance metrics for the system, views on data issues and measurement methods, reliability and uncertainty of baseline information, metrics for determining good system performance, and views on acceptable risk.

**Table 8.13 Selected Stakeholder Websites for Cape Wind Project**

| Stakeholder Group | Role | URL (Webpage Addresses) |
|---|---|---|
| U.S. Army Corps of Engineers | Decision-makers | http://www.nae.usace.army.mil/projects/ma/ccwf/windfarm.htm |
| Cape Wind Associate | Developer | http://www.capewind.org/index.htm |
| Alliance to Protect Nantucket Sound | Primary opponents of Cape Wind | http://www.saveoursound.org/ |
| Clean Power Now | Grassroots citizens group for the Cape Wind project | http://www.cleanpowernow.org/ |
| Windstop.org | Grassroots citizens group against the Cape Wind project | http://www.windstop.org |

*Formal and informal hearing transcripts:* In many cases, formal or informal hearings are held at different stages of decision-making. Transcripts of these hearings, when available, can shed further light on stakeholder views on the system. EIS scoping meetings were held March 2002 and DEIS comment meetings were held in December 2004. We used transcripts from these meetings to further inform the assessment of stakeholder values and concerns. Table 8.14 shows the components and linkages identified by stakeholders as important. The numbers in parenthesis shows number of stakeholders identifying each of these issues in their comments

**Table 8.14 Stakeholder Comments in Public Hearings**

Extracted from the Stakeholder Comment Summary Transcript from the New England District through April 24, 2002 as part of Section 10 Permit Application Draft Environmental Impact Statement Cape Wind Associates, LLC Prepared for: US Army Corps of Engineers File No. 200102913

| **Category of Comment** | **Issue/Linkage/Component** |
|---|---|
| Project Goal And Justification | Power available to NE (5)<br>Location (5)<br>Scale (5)<br>Magnitude (5)<br>Energy Demand Assessment (21) |
| Analysis of Alternatives | Technical Feasibility (62)<br>Economic Feasibility (62)<br>Comparison with other sources (62)<br>Comparison with On-Shore (62)<br>Location (62)<br>Size/Scale (62)<br>Power Demand Assessment. (62)<br>Collaborative Assessment (1)<br>Clarity of Assumptions in Analysis (62) |
| Permitting Process | Transparency of Process (10)<br>Need to Refine NEPA Process for Offshore Wind Energy (10)<br>Inclusion of Fishermen in planning (55)<br>Inclusion of State Agencies in Planning (55) |
| Jurisdiction And Authority | Use of Federal and State Resources for Profit (26)<br>No existing regulations for permitting wind farms (26)<br>Compensation of Federal Government (2) |

## Table 8.14 Stakeholder Comments in Public Hearings (Continued)

Extracted from the Stakeholder Comment Summary Transcript from the New England District through April 24, 2002 as part of Section 10 Permit Application Draft Environmental Impact Statement Cape Wind Associates, LLC Prepared for: US Army Corps of Engineers File No. 200102913

| Category of Comment | Issue/Linkage/Component |
|---|---|
| Energy Source | Renewable Energy Capacity (52)<br>Energy Efficiency (52)<br>Energy Costs (52)<br>Impact on Air Pollution (52) |
| Fuel Diversity | Diverse Energy portfolio (28)<br>Dependence on Foreign Oil (28)<br>National Security (8)<br>Local independence in Energy (10) |
| Economic Analysis | Total Cost Assessment (6)<br>Value of Savings (6)<br>Market Value of Wind Power (6)<br>Cost relative other sources (6) |
| Wind Technology | Impact of emerging technology on feasibility of alternatives (16)<br>Assessment of European Experience (24)<br>Credibility and reliability as a Power Source (24) |
| Electricity Rate Change | Impact on Electricity rates in NE (17)<br>Reliability issues for wind and other fuels (17)<br>Price volatility of fossil fuels (17)<br>Potential supply limitations (17) |
| Fiscal Impacts | Potential sale of power to grid (17)<br>Share of renewable energy in Cape (17)<br>Fiscal impacts on towns (17)<br>Subsidies (17) |
| Environmental Tradeoffs | Air Pollution Benefits (11)<br>Avoided Impacts (11)<br>Assessment of emission reduction (9)<br>Amount of fossil fuel saved (4)<br>Impact on Fuel Consumption (6)<br>Impact on Recreational Fish (34)<br>Impact on Commercial Fish (34)<br>Vibrations (34)<br>Sound (34)<br>Sediment Transport (34)<br>Creation of unique habitats under towers (10)<br>Avian Collision (27)<br>Proximity to migration paths (27)<br>Loss of habitat (27)<br>Loss of marine feedstock (27)<br>Bird nesting on structures (27) |

**Table 8.14 Stakeholder Comments in Public Hearings (Continued)**

Extracted from the Stakeholder Comment Summary Transcript from the New England District through April 24, 2002 as part of Section 10 Permit Application Draft Environmental Impact Statement Cape Wind Associates, LLC Prepared for: US Army Corps of Engineers File No. 200102913

| **Category of Comment** | **Issue/Linkage/Component** |
|---|---|
| Socioeconomic Impact | Regional Economic Impact (5)<br>Negative Visual Impact (41)<br>Value of Natural Resources in Area (5)<br>Characterization and referenced judgment of visual impact (78)<br>Impact on Real Estate Prices (8)<br>Impact on local tax revenue (8)<br>Impact on Recreation (47)<br>Impact on Tourism (47)<br>Impact on Fishing (47)<br>Impacts on Fishing (55)<br>Safety in case of adverse weather (55)<br>Identification of existing archeological sites (3)<br>Oversight by Mass Historical Soc. (3)<br>Educational Opportunities (7)<br>Positive Impact on Tourism (7)<br>Number of local jobs created (13)<br>Duration of Jobs (13)<br>Impact on long-term sustainability (13) |
| Health and Safety Impact | Impact on Human Health (4)<br>Impact to Local Air Quality (4)<br>Impact on Aviation (9)<br>Landfall impacts on residential areas (10)<br>Landfall Impacts on Wetlands (10) |
| Construction and Removal Operations | Construction protocols<br>Waste Management during construction (2)<br>Mitigation measures during construction (2)<br>Installation, Maintenance, And Removal Protocols (5)<br>Tower and Cable Maintenance Schedule (12)<br>Contingency Strategy in case of project failure (21) |

## 8.4 Problem Refinement and System Definition

Based on the information gathered in the stakeholder value assessment stage, the Cape Wind project has the following characteristics:

- System Goal: Providing renewable wind energy for Cape and Islands through installation of a wind farm offshore.
- Geographical scale: The area in question includes Nantucket Sound and adjacent land and sea areas (Cape and Islands). However the general impacts and consequences of the project extend to the region and the nation.
- Temporal Scale: The project was proposed in 2001 and its anticipated lifetime is at least 25 years from the time of installation (currently 2006 or 2007). Project lifetime could be expanded if turbines, cables and foundations are replaced and/or well-maintained.
- Institutional issues:
  - Large-scale disputes among stakeholders in locality and on a nation-wide basis.
  - Likely to serve as precedent of offshore wind development in the U.S.
  - Lack of existing regulations specifically for offshore wind energy development and ambiguous jurisdictional issues.

## 8.5 Initial Stakeholder-Assisted Representation

With the stakeholder inputs in the value assessment stage, we created an initial systems representation that would serve as a basis for the stakeholder-assisted representation process.

### *8.5.1 Identifying Major Subsystems*

Using the CLIOS process approach, the systems representation is developed in a top-down approach, with information being categorized in major subsystems. This can be done using the summary that was prepared in stakeholder value assessment stage. Subsystems can be developed using their functions, or by their technologies. Based on stakeholder inputs, the following subsystems can be initially determined: Energy Subsystem, Socioeconomic Impact Subsystem, Environmental Subsystem, and Navigation, Aviation and Safety Subsystem.


**Figure 8.4 High-Level CLIOS Systems Representation of the Cape Wind Project. The Sphere around the physical systems is the institutional sphere with the major actor groups identified. Here the concept of nested complexity is shown by the complex physical system embedded in institutional complexity.**

*8.5.2 Populating the physical subsystems:*

Based on the stakeholder identification and consultation step, the physical domain can be populated with their major components. Figures 8.5-8.8 show the populated subsystem diagrams for Cape Wind.

Energy Subsystem

The Energy subsystem in the Cape Wind CLIOS consists of four major layers: Energy Production, Energy Demand and Distribution, Energy Economics and Wind Farm Characteristics. The dashed arrows show the linkages of the proposed wind farm with the existing layers. Given that the wind farm is currently not in existence, these links do not yet exist.

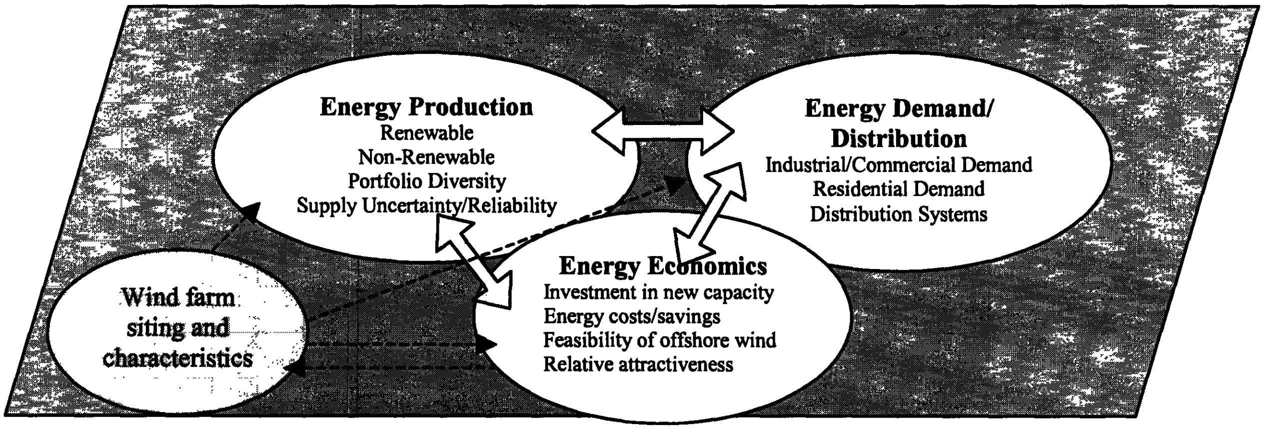



**Figure 8.5 The Cape Wind Energy Subsystem at the Component Group Level**

Socioeconomic Subsystem

The Socioeconomic subsystem in the Cape Wind CLIOS consists of four major layers: Local and Regional Economic Impact, National Impact, Social Impact, Wind Farm Characteristics.

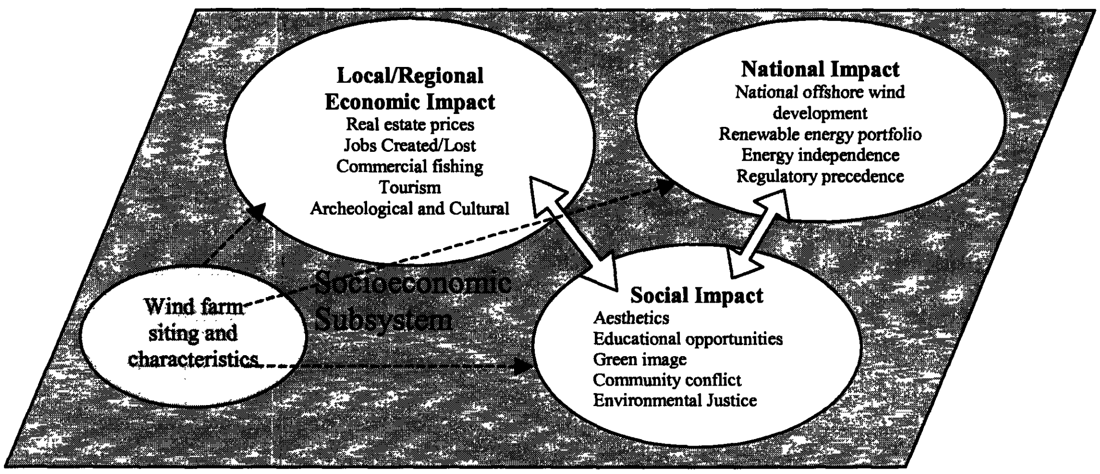



**Figure 8.6 The Cape Wind Socioeconomic Impact Subsystem at the Component Group Level**

Environmental Subsystem

The Environmental subsystem in the Cape Wind CLIOS consists of four major layers: Marine life impacts, avian impacts, air pollution impact and wind farm characteristics.

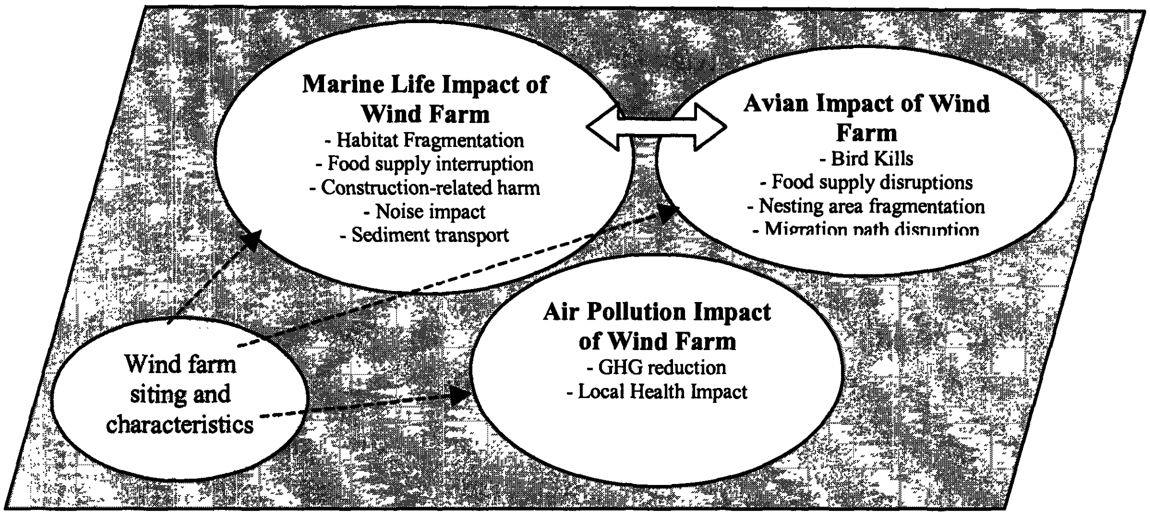



**Figure 8.7 The Cape Wind Environmental Impact Subsystem at the Component Group Level**

Navigation, Aviation and Safety Subsystem

The Navigation, Aviation and Safety subsystem in the Cape Wind CLIOS consists of four major layers: Navigation Impacts, Aviation Impacts, Construction Impacts and wind farm characteristics.

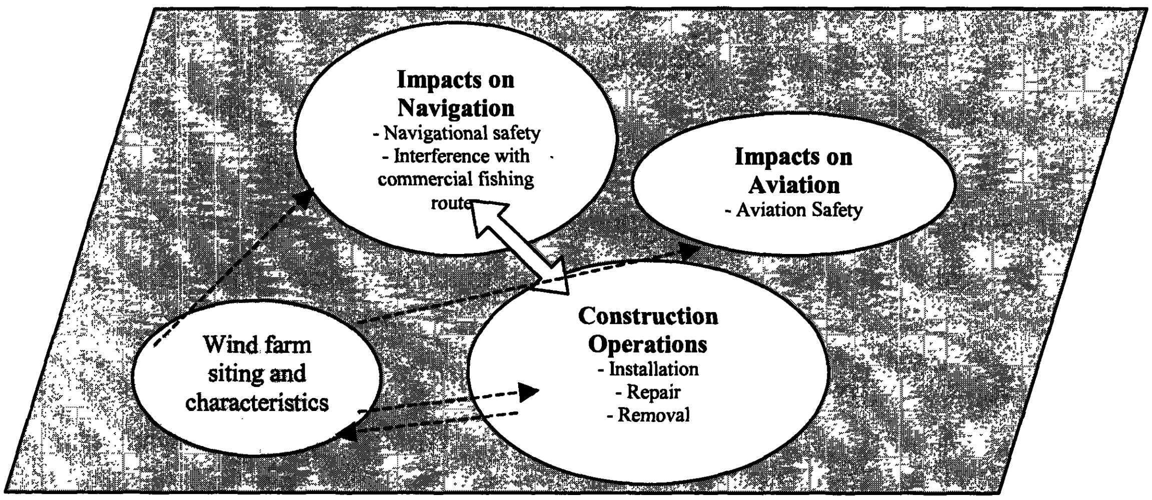



**Figure 8.8 The Cape Wind Navigation, Aviation and Safety Subsystem at the Component Group Level**

*8.5.3 Describing Linkages and Components in the Physical System*

*A) Energy subsystem*

The energy subsystem consists of electricity production, electricity consumption and distribution, energy economics and wind farm characteristics layers. The components and interconnections in each layer can be analyzed based on stakeholder inputs.

A.1) Wind Farm Characteristics:

*Components and Linkages:* The central component of the wind farm characteristics layer is the location of the wind farm. The location determines the distance to the high-voltage electricity grid, proximity to port facilities and water depth. The technical feasibility of the site depends on these three components. The location also determines the average wind speed that can be expected throughout the year. In addition, the location determines the distance to the nearest residential areas and historical sites, which impacts the visibility of the wind plant from the shores by Cape Cod residents and visitors to historical areas. The visibility of the wind farm is also determined by turbine height, the number of turbines, climate conditions, light reflection during the day (depends on turbine coloring) and the number of red lights on each turbine during the night. The wind farm power generation capacity depends on maximum individual turbine capacity, the average wind speed, the number of turbines, and the total operating time of the plant in any given year. The maximum turbine generation capacity depends on available wind technology and can change over time as better turbines become available. In summary, we can show the individual components and interconnections for Wind Farm Generation Capacity and Visibility of Wind Farm in a causal tree form as illustrated in Figure 8.9 and 8.10.

*Characterizing the Components and Links:* Figure 8.11 shows the completed representation for the wind farm characteristics layer. The location of the wind farm, the number of turbines, and their height, maximum generation capacity and coloring are an open choice. As such they are considered *policy levers*. As discussed in Chapter 2, in CLIOS representation, we show policy levers with rectangles.

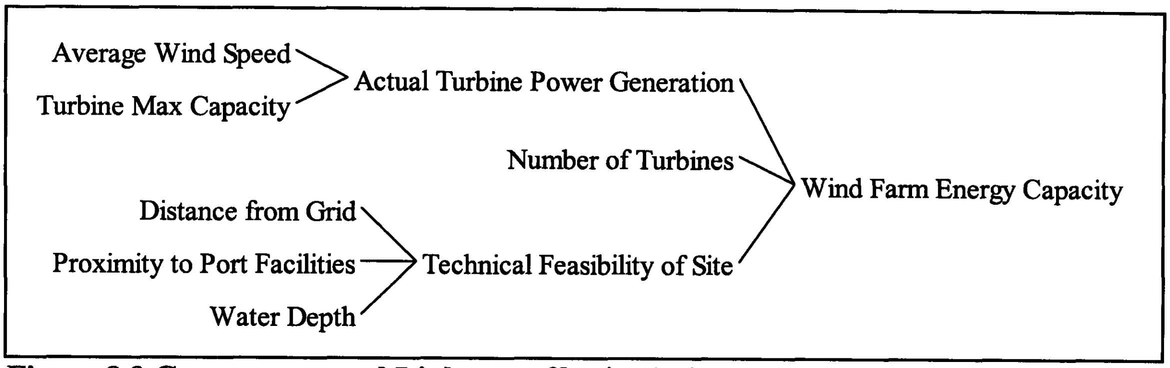



**Figure 8.9 Components and Linkages affecting Wind Farm Energy Capacity**

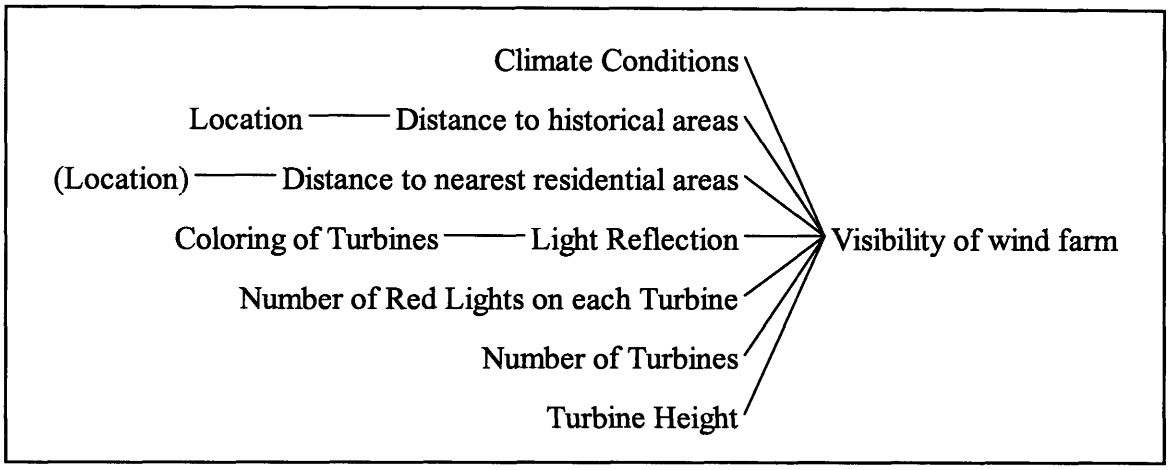
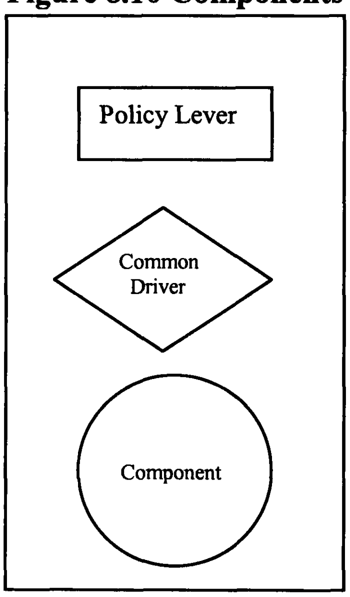
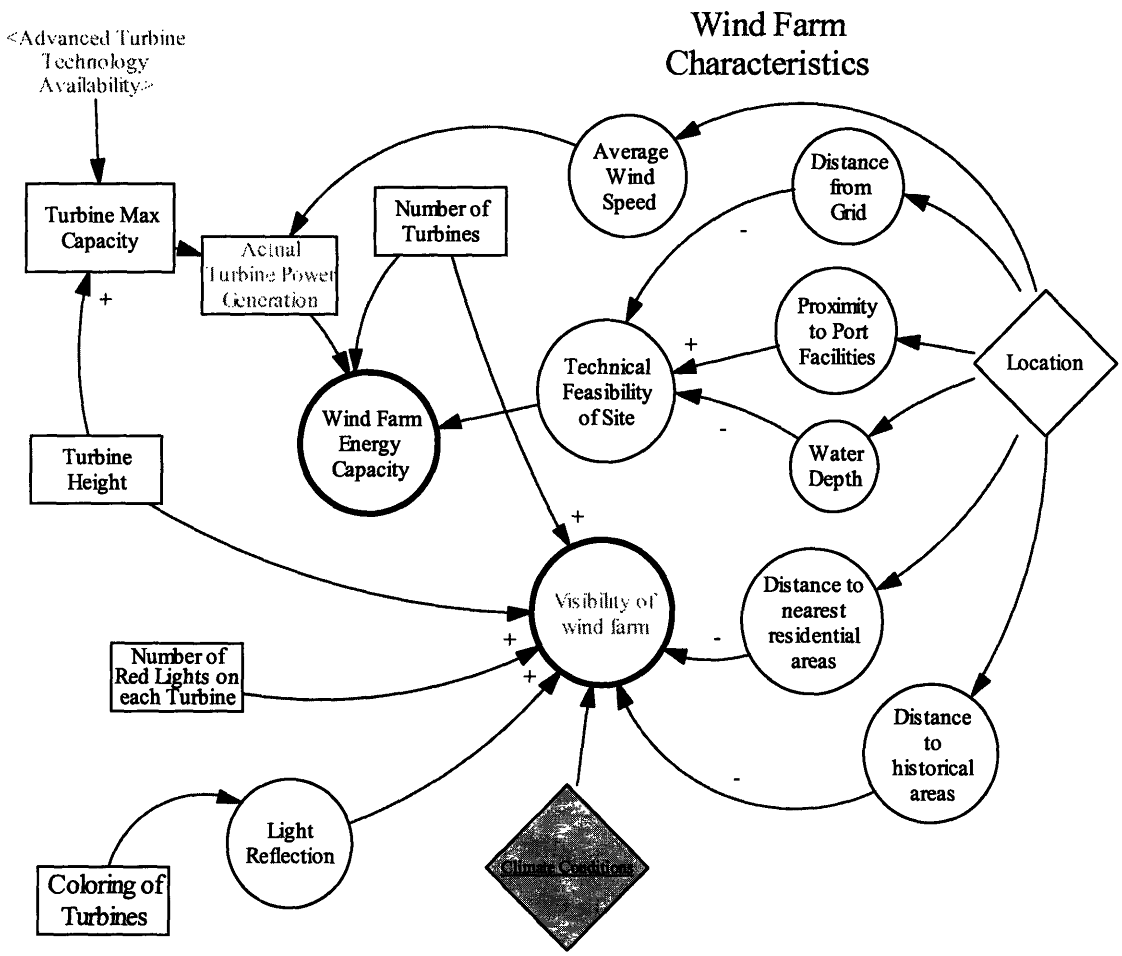



**Figure 8.10 Components and Linkages affecting Visibility of Wind Farm**




Since location and climate conditions are common drivers between different layers and even different subsystems, they are shown as diamonds. Shades indicate that the driver is external to the system, meaning that it is beyond the boundary of the system. The double (darker) boundaries indicate that a component is considered to be a performance metric. That is, the stakeholders have indicated that the performance of the system depends on how these components fare with regards to the different strategies and alternatives available. In this layer, wind farm energy generation capacity and visibility are the two performance metrics. Components used in the same subsystem but in different layers are shown with "< > " boundaries.

The representation is accompanied by a table that highlights major uncertainties in the layer, sources of disagreement (often on the same uncertainties), and methodologies/tools that can be used to evaluate the layer.



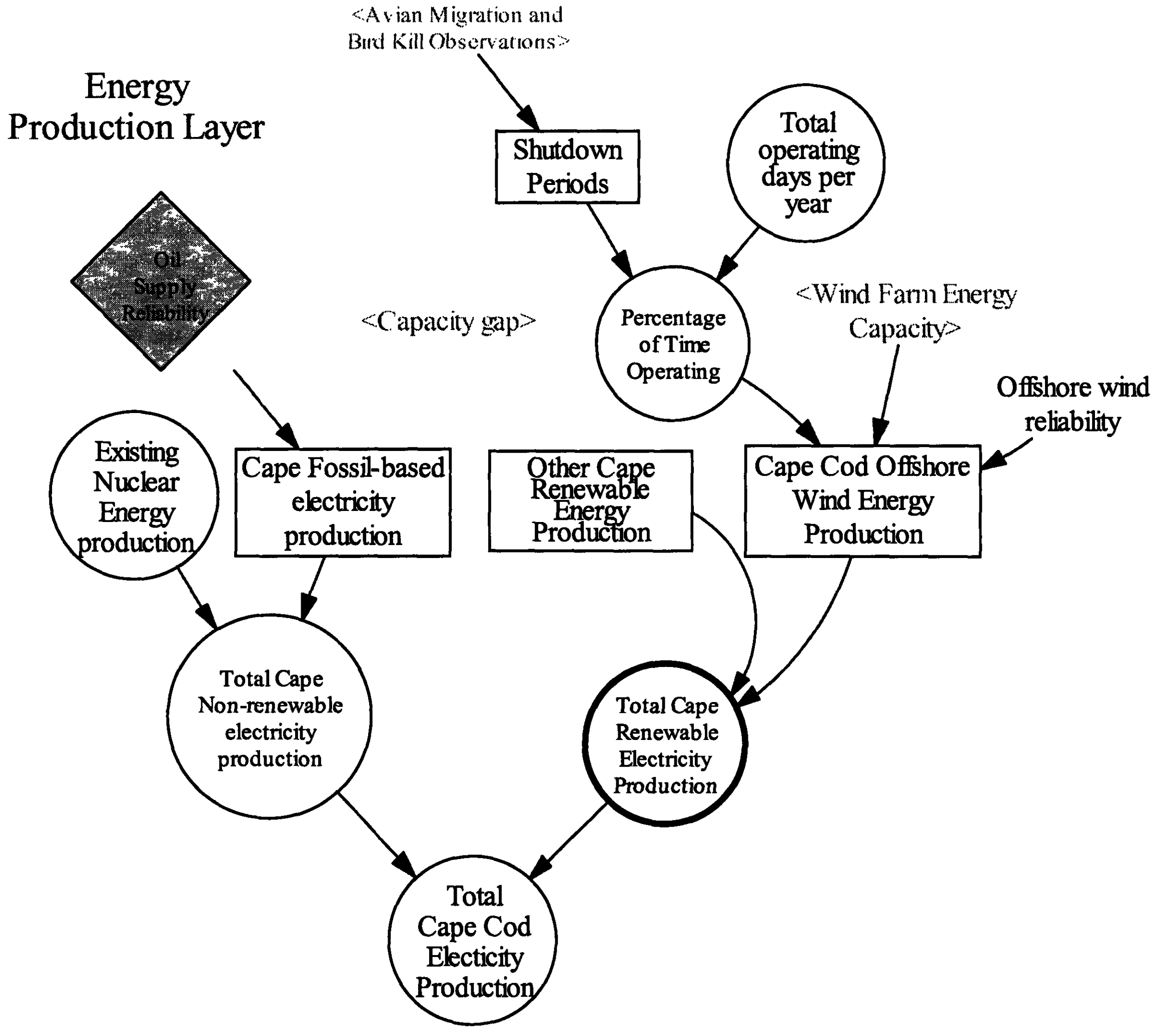

| | |
|---|---|
| **Major Uncertainties** (H=High M=Medium L=Low) | - Visibility of Wind Farm (M-H) |
| **Sources of Disagreement** | - Visibility of Wind Farm (Strong)<br>- Actual Turbine Power Generation (Weak) |
| **Quantitative Tools/Models** | - Visibility Simulations from different areas on shore<br>- Electricity Generation Model under Varying Wind Conditions |
| **Qualitative Tools/Frameworks** | - Aesthetics assessment through simulations for residents<br>- Visitor opinion surveys for historical areas and national parks |

**Figure 8.11 Systems Representation of the Wind Farm Characteristics Layer**

A.2) Energy Production

*Components and Linkages*: The electricity production for the Cape and Islands comes from a variety of sources, including existing nuclear energy facilities, gas- and oil fired plants, coal-fired plants and renewable sources of which the offshore wind energy farm would become one. Oil supply reliability and price fluctuations can impact fossil-based production. The renewable energy production capacity of Cape Cod would depend on sources such as solar energy, on-shore wind energy, the proposed wind farm and biomass. The total contribution of the wind farm depends on the total operating hours of the wind farm and average wind speeds. If the wind farm is shut down during high migration season for some time, the total production capacity can decrease, but this could reduce the environmental impact dramatically. We will look at this link further in the environmental subsystem.

*Characterizing Components and Links:* Figure 8.12 shows the completed systems representation of the Energy Production layer. We can determine how to produce the necessary energy when there is a capacity gap (more demand than production). For instance we can decide whether to invest more in fossil-based energy production or renewable energy. As such these components are *policy levers*. Here we are concerned with the total amount of renewable energy produced, since the overall goal is for the state to produce as much as 5% of the energy from renewable sources by 2010 (see Chapter 7). Therefore, total renewable energy production is a performance metric and shown with a thicker border.




| | |
|---|---|
| **Major Uncertainties** (H=High M=Medium L=Low) | - Cape Cod Offshore Wind Production (M)<br>- Wind Energy Reliability (M)<br>- Effect of oil supply reliability on fossil-based electricity production (M) |
| **Sources of Disagreement** | - Cape Cod Offshore Wind Production<br>- Other Cape Renewable Energy Production |
| **Quantitative Tools/Models** | - Sensitivity analyses for oil supply fluctuations (volume and price)<br>- Wind Energy Electricity Production Models |

**Figure 8.12 Systems Representation of the Energy Production Layer**

A.3) Energy Consumption

*Components and Linkages*: An increase in the Cape Cod population and economic growth, along with an increase in per capita consumption in electricity will lead to an increase in residential, business and industrial electricity demand in the Cape and the Islands. If the total electricity demand of the region increases beyond the combined renewable and non-renewable electricity production shown in Section A.2, there will be a capacity gap that has to be overcome either by building additional fossil-based power plants, increasing renewable energy capacity in the region, or importing electricity from outside the region from the national grid. Figure 8.13 shows these relationships individually.

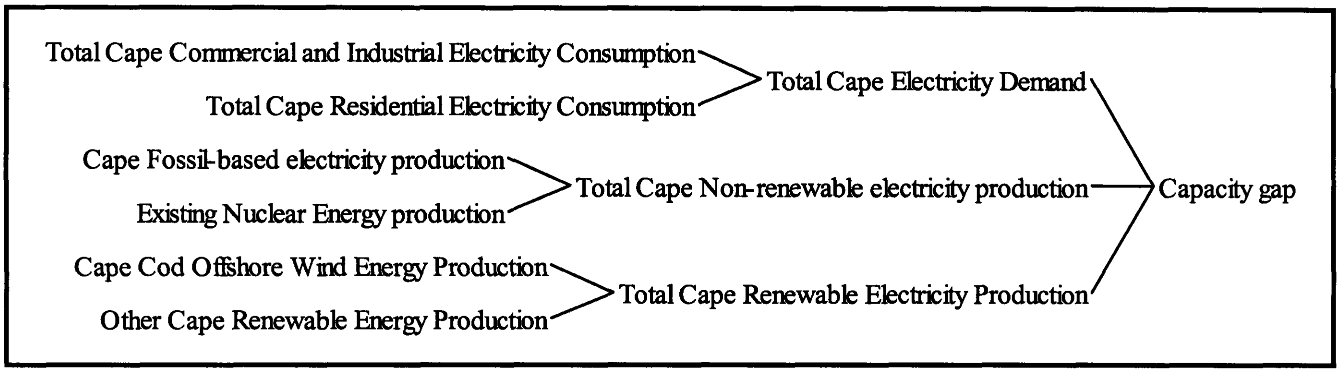
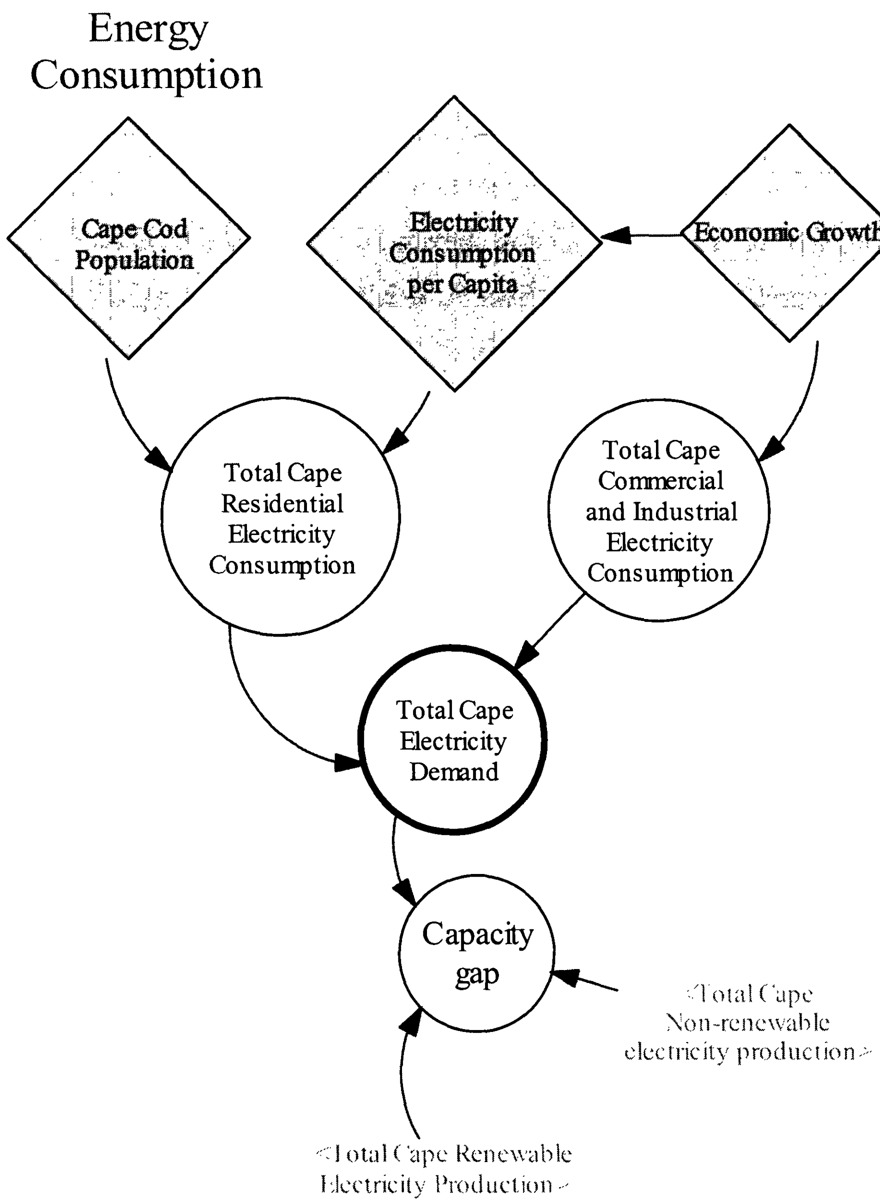



**Figure 8.13 Factors affecting Power Generation Capacity Gap**

*Characterizing Components and Links*: Population, economic growth, and per capita electricity consumption are external drivers (shown with shaded diamond). Stakeholders have identified total Cape Cod electricity demand as a performance metric. Figure 8.14 shows the completed systems representation for the Energy Consumption layer.




| | |
|---|---|
| **Major Uncertainties** (H=High M=Medium L=Low) | - Energy Demand Assessment (L) |
| **Sources of Disagreement** | - Cape Cod Long-term Electricity Demand (Weak) |
| **Quantitative Tools/Models** | - Energy demand modeling |

**Figure 8.14 Systems Representation of the Energy Consumption Layer**

A.4) Energy Economics

*Components and Linkages*: The sum of total annual costs of capital and operation for Cape Wind in addition to the transmission cost make up the basic costs for Cape Wind. However, should we consider additional mitigation and research funds such as environmental research funds for post-construction, federal lease payments, impact mitigation funds and removal and upgrade funds, the cost of electricity produced would be higher. How much each of these funds should be, or whether they should at all exist is a matter of negotiation among stakeholders. Figure 8.15 basically shows the impact of different factors on the cost per kWh of electricity.

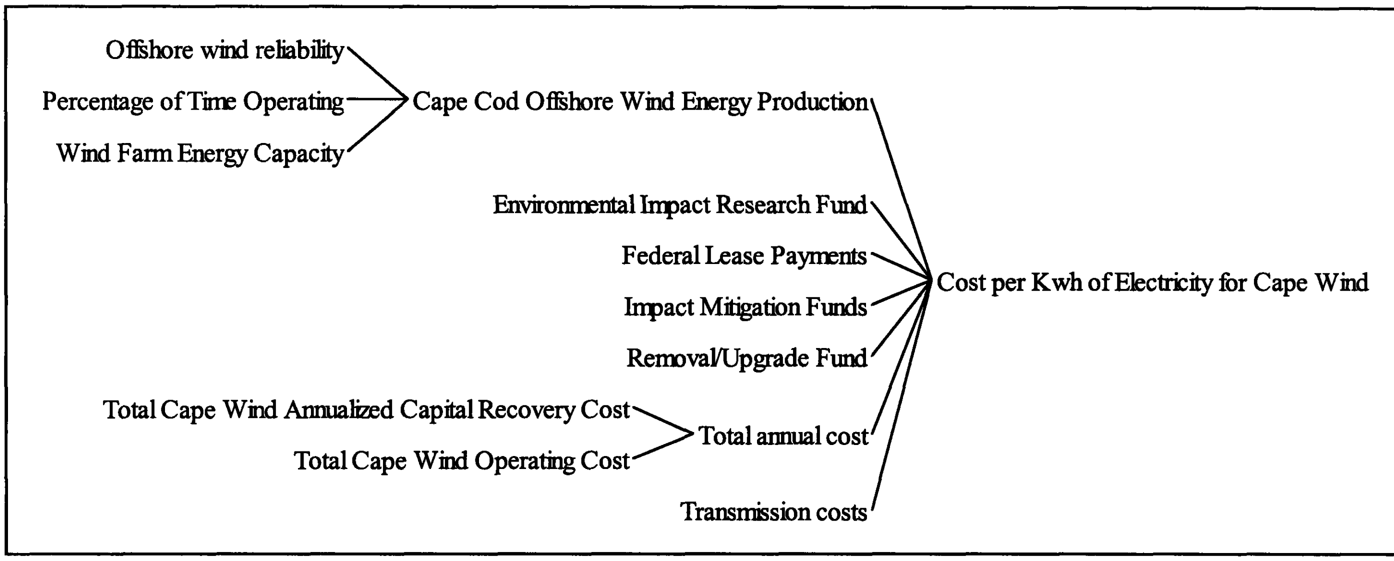
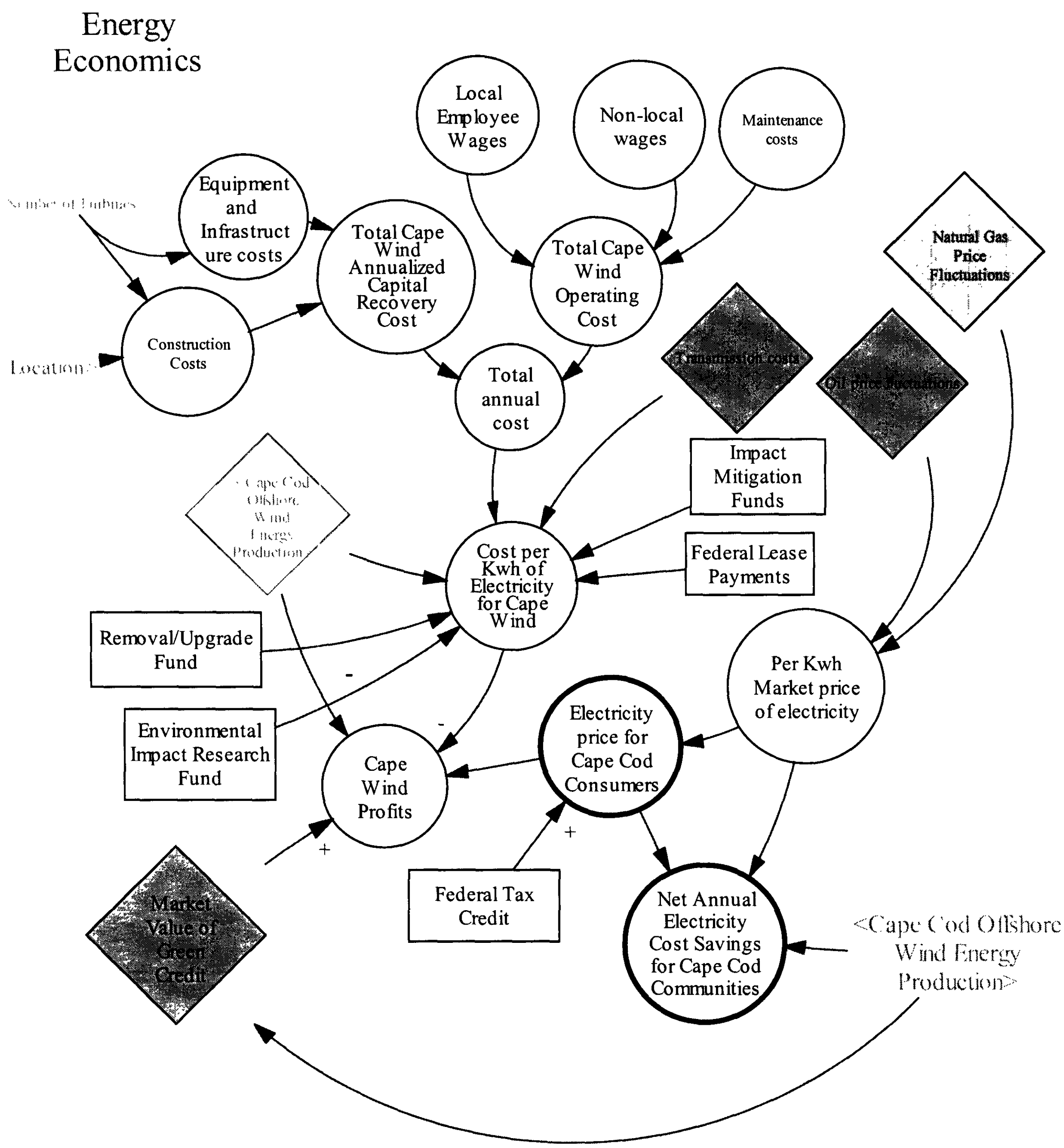



**Figure 8.15 Components making up the kWh electricity cost for Cape Wind**

*Characterization of components and links:* Figure 8.16 shows the comprehensive systems representation for the energy economics layer based on the intermediate step of Figure 8.15. Here grid transmission costs, oil and natural gas fluctuations and market value of green credit have been taken as external common drivers (shown with shaded diamonds). Impact mitigation funds, environmental research funds, federal lease payments, removal/upgrade funds, and federal tax credits are taken as policy levers (shown in rectangles). Electricity rates for Cape Cod residents and Net Annual Savings for Cape Cod Residents are considered performance metrics in this layer.

This ends our representation of the energy subsystem. We then proceed to the environment subsystem of the Cape Wind system.




| *Major Uncertainties*<br><br>(H=High M=Medium L=Low) | - Oil and Gas price fluctuations (H)<br>- Value of Green Credit (M) |
|---|---|
| **Sources of Disagreement** | - Net Annual Savings for Cape Cod Residents (Strong) |
| **Quantitative Tools/Models** | - Energy cost models with cross fuel-source elasticity |

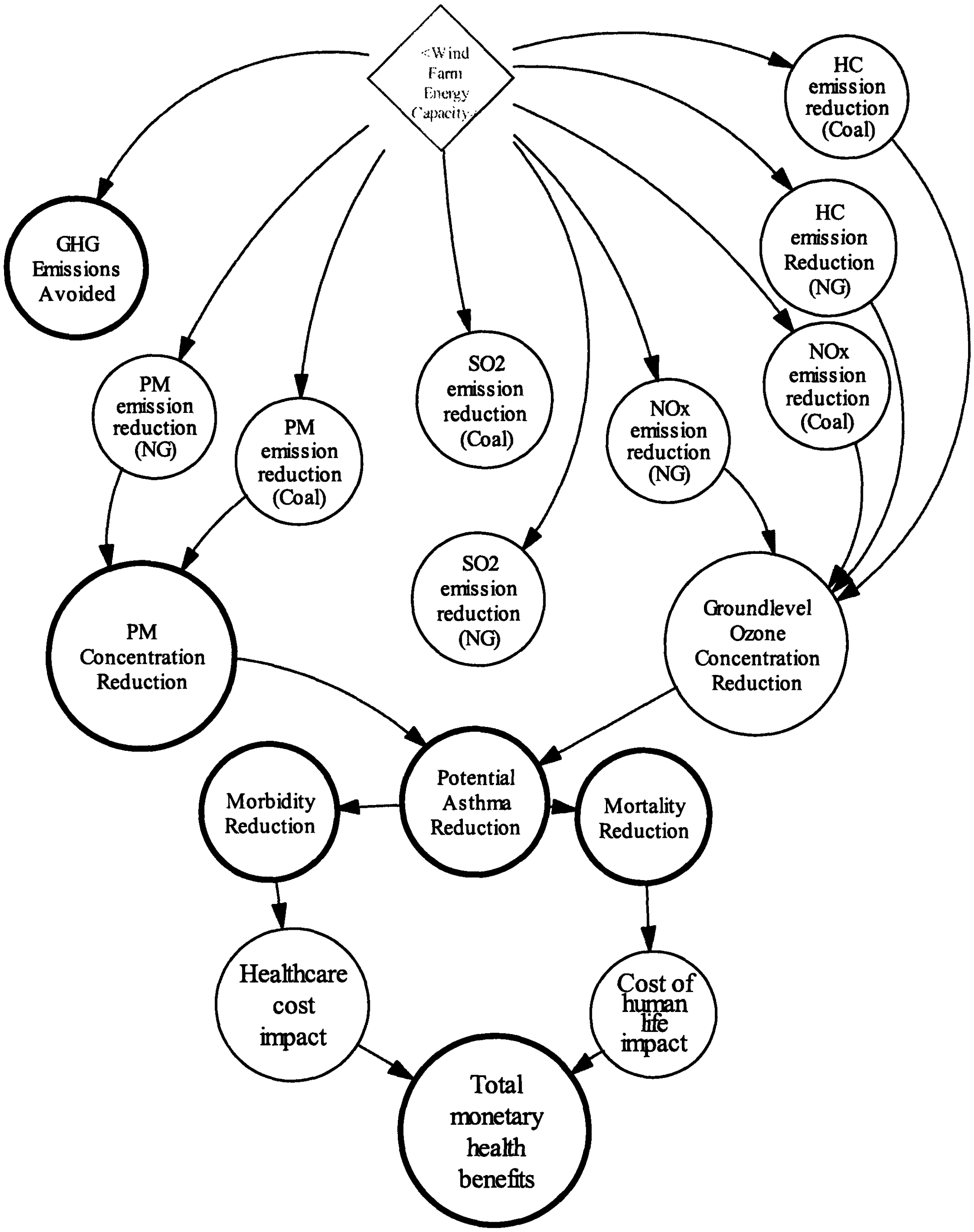
**Figure 8.16 Systems Representation of the Energy Economy Layer**

*B) Environment Subsystem*

The environmental impact subsystem includes layers for air pollution impact, marine and avian impacts and endangered species impact.

B.1) Air Pollution Impact

*Components and Linkages:* Since the wind farm itself has no air pollution impacts during operation, in this context air pollution impacts are in terms of avoided emissions. Assuming that the generation capacity of the wind farm could substitute for coal or gas-fired power plants, we would have a reduction (compared to same power generation by fossil-based plants) of Green House Gases (primarily CO2), Particulate Matter (PM), SO2 and Hydrocarbons. The avoided emissions vary based on whether a gas-fired plant or a coal-fired plant is substituted. In addition to general climate change benefits, there are direct health benefits in the form of reduced asthmas and other respiratory problems. The reductions can result in lower morbidity (cases of illness), or mortality (deaths). The reductions translate into reduced productivity loss and human life loss, as well as reduced health care costs for the region. Figure 8.17 shows the completed systems representation of the air pollution impact layer.




| | |
|---|---|
| **Major Uncertainties (H=High M=Medium L=Low)** | - Fossil-based plant substitution potential (M)<br>- Tangible Health Impact Benefits (L)<br>- Impact on Global Climate Change (L) |
| **Sources of Disagreement** | - Fossil-based plant substitution potential (Medium-Strong) |
| **Quantitative Tools/Models** | - Atmospheric Chemistry Models<br>- Health Impact Models |

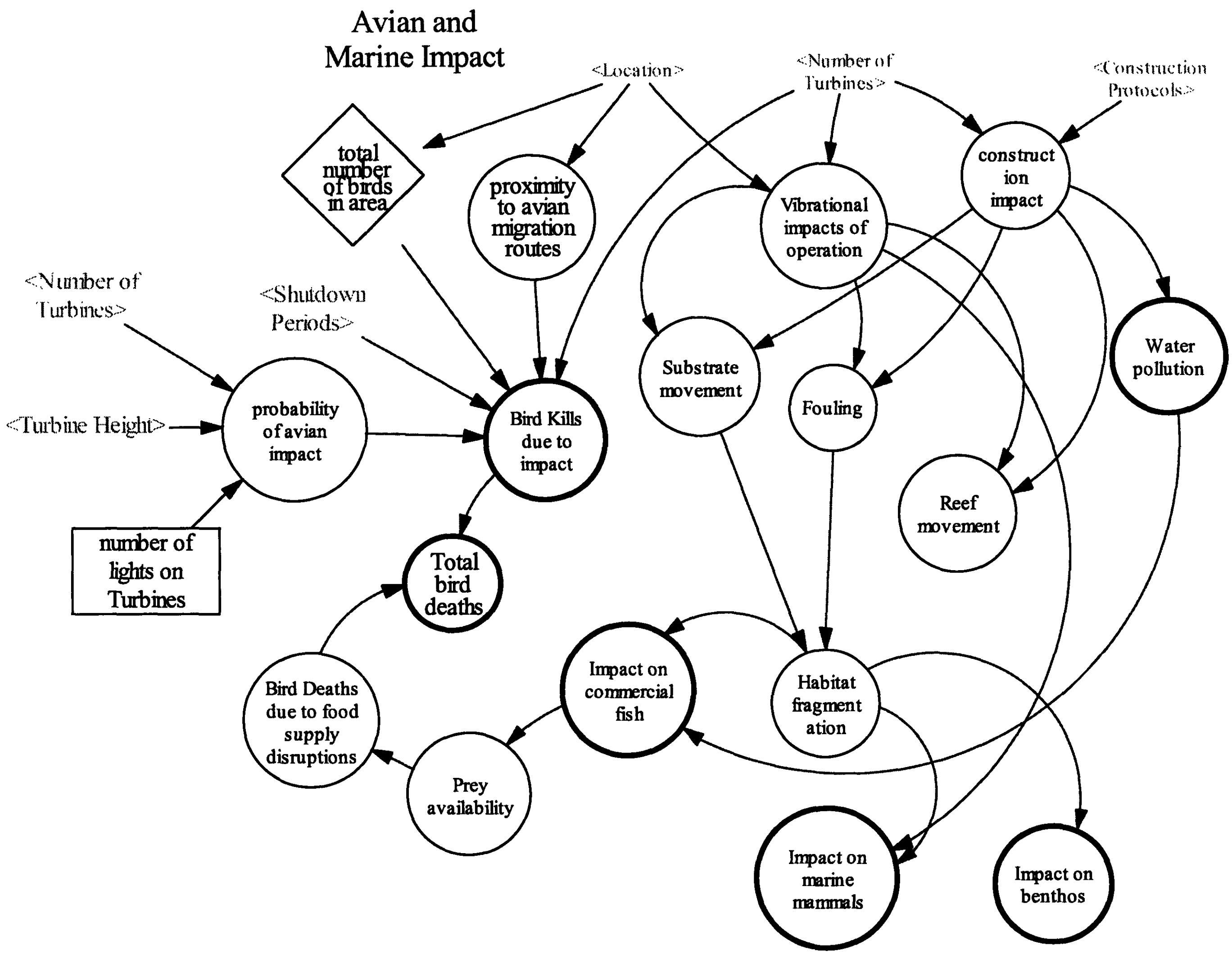
**Figure 8.17 Systems Representation of the Air Pollution Impact Layer**

B.2) Avian and Marine Impact

*Components and Links:* The location determines proximity to avian migration routes and avian seasonal residences. Locations that have a higher number of resident birds in the area can have a higher likelihood of bird kills through collision with the wind turbines. In addition, turbine height and the number of lights on the turbines can potentially contribute to bird kills. Shutdown periods during peak migration season can reduce the risk of migratory bird kills significantly, and can serve as a strategy to reduce the environmental impact of the wind farm.

The number of turbines also impacts the potential of bird kills and impacts on marine life. During operations, the vibrations of the turbines may result in substrate movement and fouling, as well as extensive habitat fragmentation. This can in the longer term affect benthos (seabed organisms), commercial fish stocks, marine mammals and prey availability for birds. The potential disruption of the food supply for birds can result in deaths unrelated to collision with the towers. In addition to the operation, there is the potential of construction noise impacts on marine mammals. Construction protocols can address many of these issues by designing ways to reduce noise and habitat destruction during construction of seabed foundations and installation of the turbines. The existence of a oil tank on the electric transformer platform introduces the risk of water pollution through oil leak. Double-hulled containers can help address this problem.

*Component and Link Characterization:* Figure 8.18 shows the systems representation of the marine and avian impact layer. Bird kills through collision and total bird deaths due to combined collision/food disruption, impact on marine mammals, impact on benthos and impact on commercial fish are considered performance metrics in this layer. Number of lights on the turbines is a policy lever, and the number of birds in seasonal residence in the area is an external driver.




| | |
|---|---|
| **Major Uncertainties (H=High M=Medium L=Low)** | - Impact on Commercial Fish (H)<br>- Impact on Marine Mammals (H)<br>- Impact on Benthos (H)<br>- Total Bird Deaths (H)<br>- Water pollution Impact (L) |
| **Sources of Disagreement** | - Total Bird Deaths (Strong) |
| **Quantitative Tools/Models** | - Baseline models (Distribution, abundance, habitat use)<br>- Predator-prey models<br>- Predictive models (Distribution, abundance, habitat use)<br>- Geomorphic change Models<br>- Sea dynamic models<br>- Ecological Indicator Models<br>- Lighting and Noise impact models |

**Figure 8.18 Systems Representation of the Marine and Avian Impact Layer**

B.3) Protected/Endangered Species

*Components and Links:* Proximity to migration routes affects potential impacts on Birds under the Migration Birds Treaty Act, as well as sea ducks and roseate terns (all on protected/endangered species in the state/federal lists). Construction noise can impact marine mammals such as North Atlantic Right Whale and other whale species as well as gray seals. Habitat fragmentation can also impact green sea turtles, loggerhead turtles, and leatherback turtles. Figure 8.19 shows these relationships.

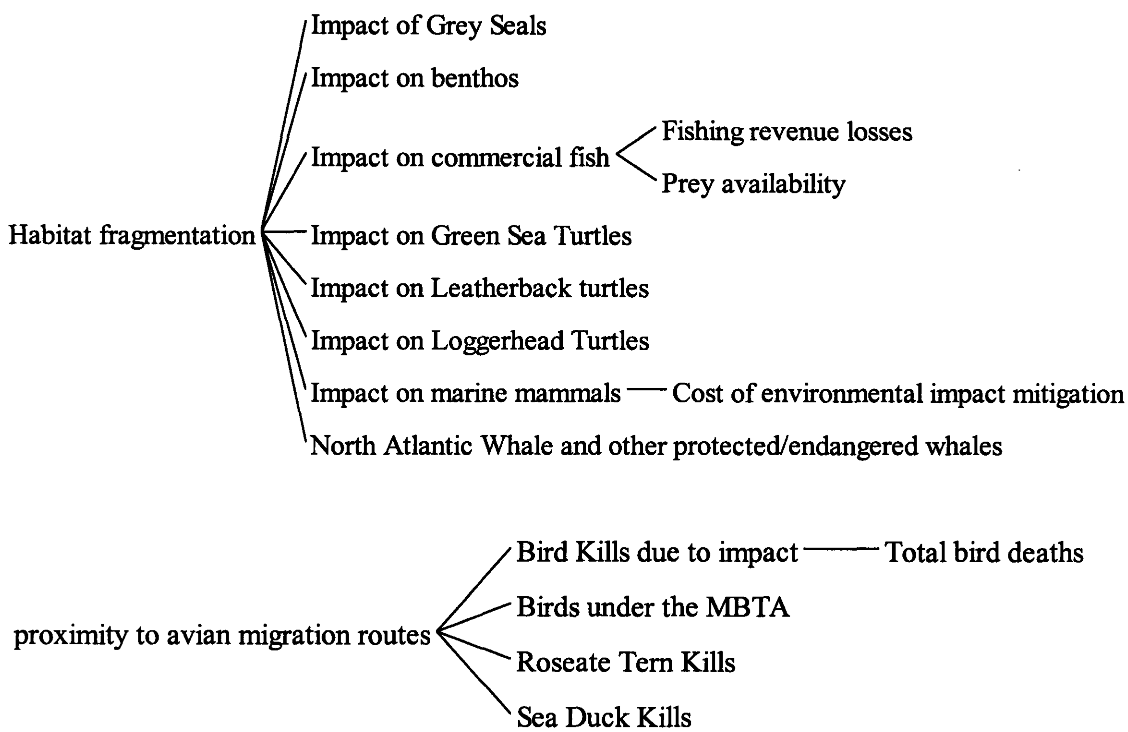
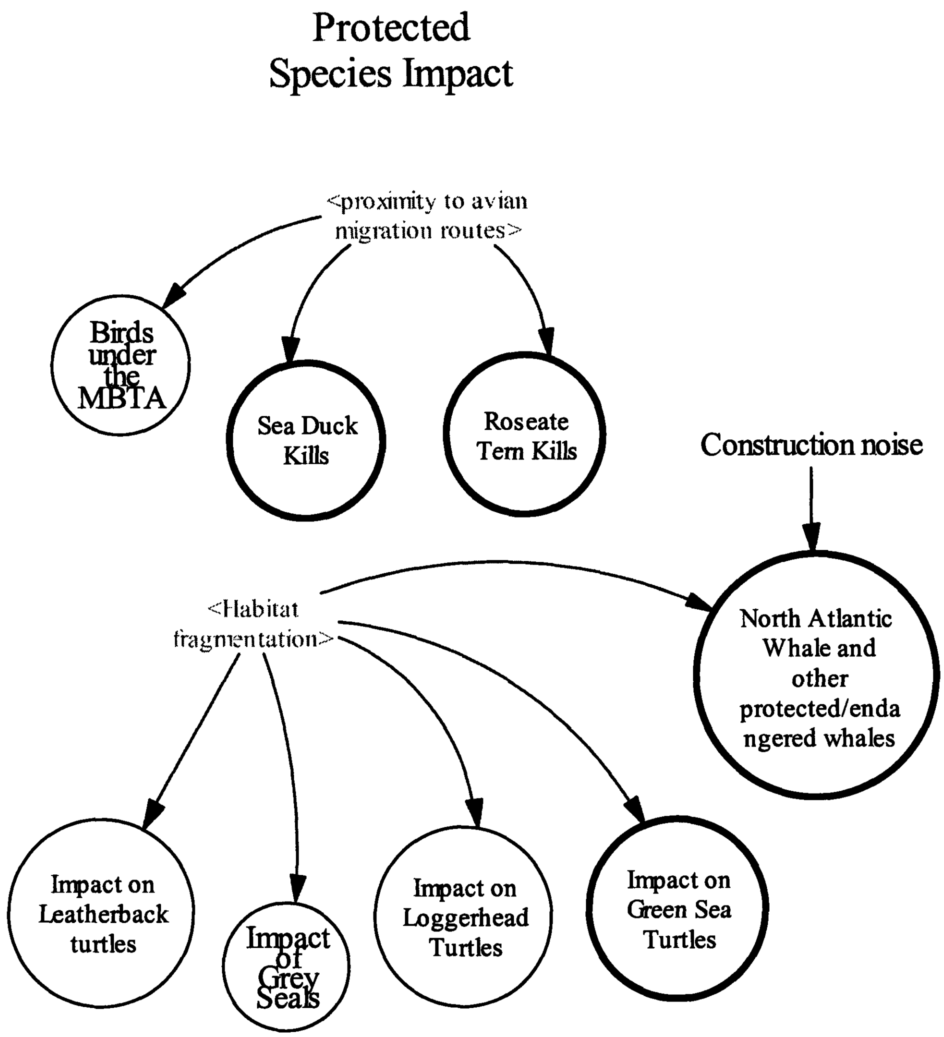



**Figure 8.19 The Impact of Habitat Fragmentation and Proximity to Avian Migration Routes and Seasonal Residences.**

*Characterization of Components and Links:* Figure 8.20 shows the systems representation of the endangered species layer. Impacts on sea ducks, roseate terns, green sea turtles and North Atlantic right whales are particularly important to stakeholders and can be considered performance metrics.




| | |
|---|---|
| **Major Uncertainties (H=High M=Medium L=Low)** | - Impact on Endangered turtle species (M)<br>- Impact on Whales (H)<br>- Impact on Roseate Terns (H)<br>- Impact on Birds under MBTA (H) |
| **Sources of Disagreement** | - Impact on Endangered/Protected Bird Species (Strong) |
| **Quantitative Tools/Models** | - Baseline models (Distribution, abundance, habitat use)<br>- Predictive models (Distribution, abundance, habitat use)<br>- Geomorphic change Models<br>- Sea dynamic models<br>- Ecological Indicator Models<br>- Lighting and Noise impact models<br>- Radar Observations and Species Specific Observations |

**Figure 8.20 Systems Representation of Endangered/Protected Species Impact Layer**

B.4) Post-Construction Monitoring

*Components and Linkages*: Stakeholders also emphasized the importance of post-construction and operation monitoring of the environmental impacts of the project. These could be funded by an environmental impact research fund, discussed in the energy economics layer. The observed impacts could then result in changes in the way the project is managed. Changes could include longer shutdown periods, removal of high-impact turbines, changes in the coloring and lights or changes in the number of turbines operating. Figure 8.21 shows the systems representation of the post-construction monitoring. In the next section, we will look at the socioeconomic impact subsystem.

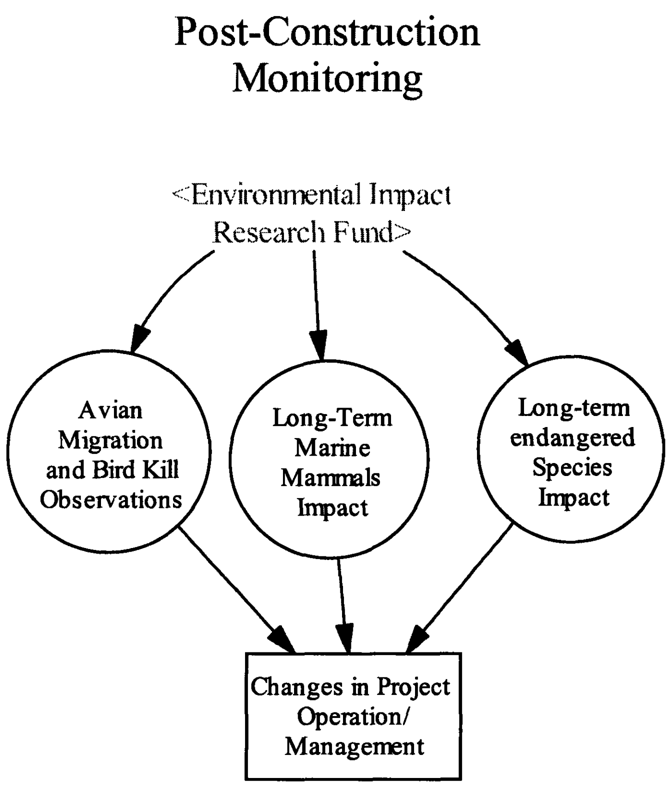



**Figure 8.21 Systems Representation of Post-Construction Monitoring Layer**

*C) Socioeconomic Impact*

C.1) Local and Regional Economic Impact

*Components and Links*: The local economic benefits of the project can be summarized in Figure 8.22. The local costs can be summarized in Figure 8.23. The net local economic benefit is determined by subtracting the local economic costs from the benefits.

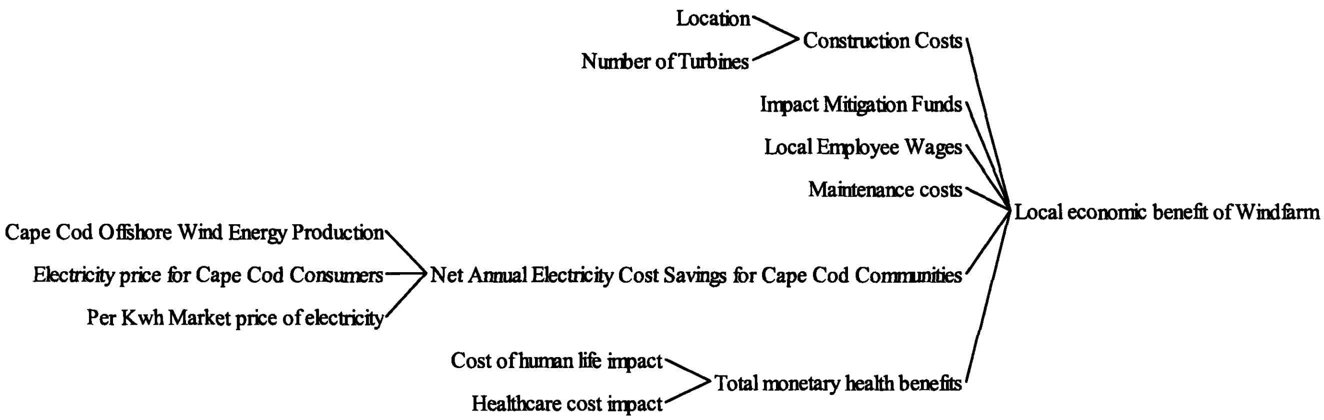



**Figure 8.22 Local Economic Benefits of the Wind Energy Project**

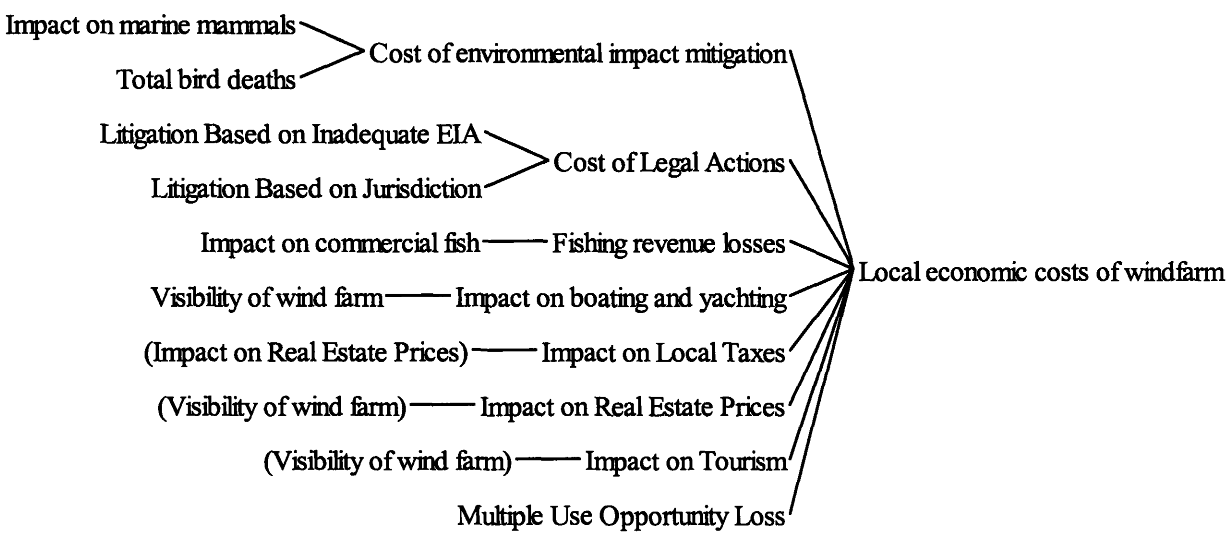
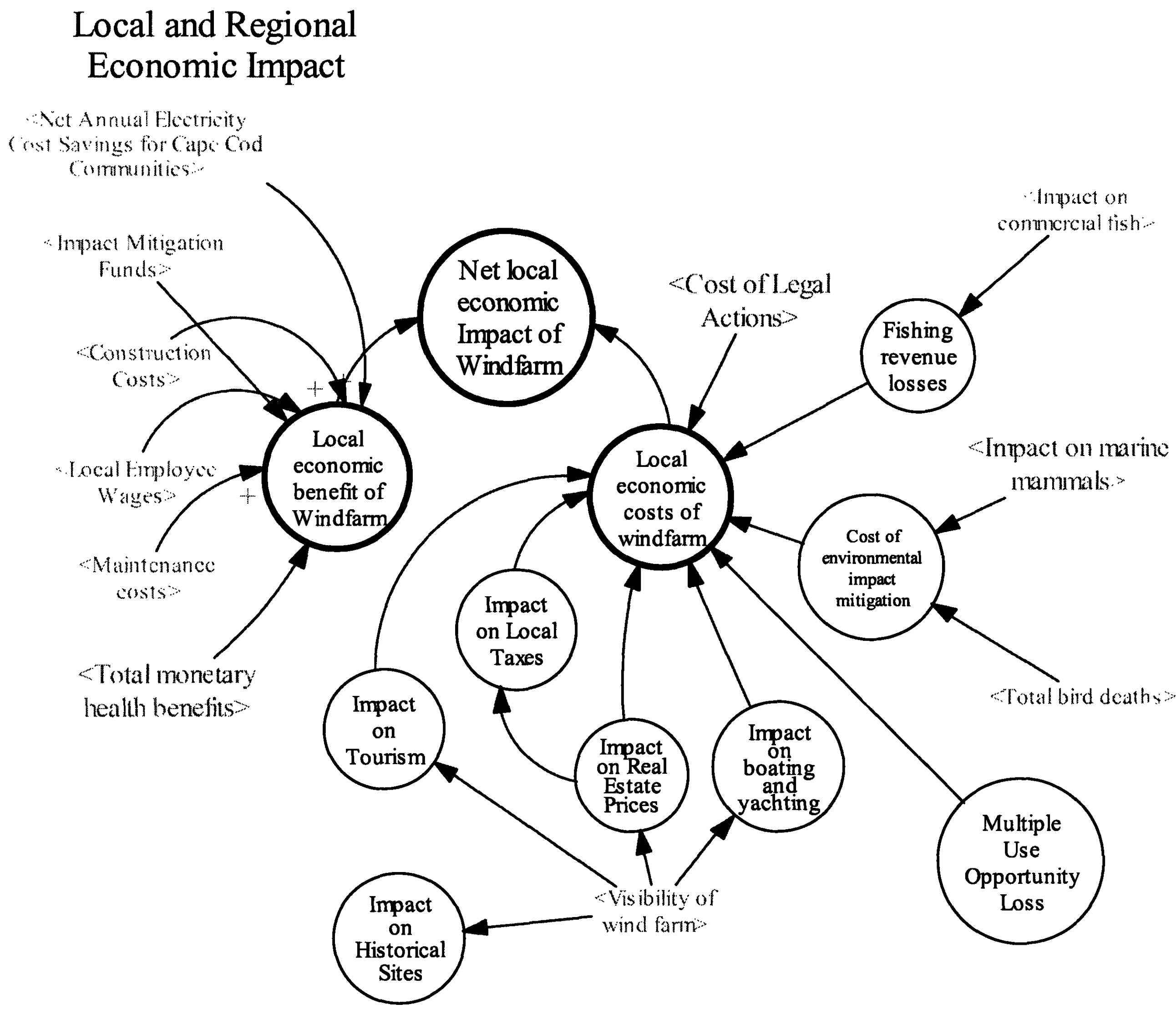



**Figure 8.23 Local Economic Costs of the Wind Energy Project**

*Characterizing Components and Links:* Figure 8.24 is the comprehensive systems representation for local and regional economic impact of the project.

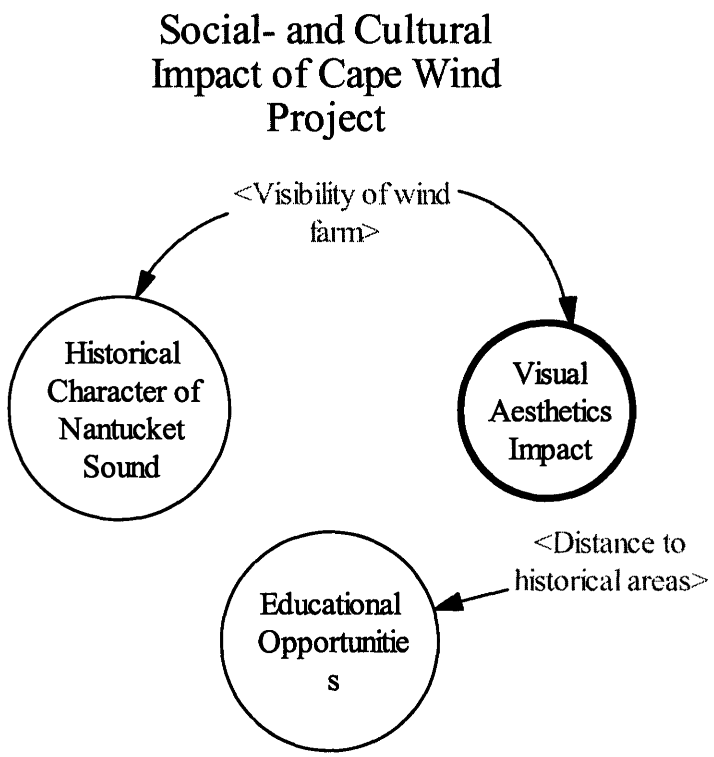



| | |
|---|---|
| **Major Uncertainties (H=High M=Medium L=Low)** | - Fishing Revenue Loss (H)<br>- Impact on Real Estate Prices (M)<br>- Total Monetary Health Benefits (H)<br>- Cost of Legal Action (M) |
| **Sources of Disagreement** | - Monetary Health Benefits (Medium)<br>- Impact on Real Estate Prices (M)<br>- Impact of Fishing Revenues (M-H) |
| **Quantitative Tools/Models** | - Regional Economic Impact Models<br>- Regression Models for Real Estate Value Impact Assessment<br>- Third-party Tourist Surveys |

**Figure 8.24 Systems Representation of Local/Regional Economic Impact Layer**

C.2) Social and Cultural Impact

*Components and Links:* Stakeholders have expressed concern with the impact of wind farm visibility on the historical character of the Nantucket Sound and the open vista of Nantucket Sound. On the other hand, some stakeholders see a potential opportunity for educational opportunities on renewable energy for area schools. Figure 8.25 shows the representations of social and cultural impacts of the project.




| | |
|---|---|
| **Major Uncertainties (H=High M=Medium L=Low)** | - Visibility of Wind Farm (M) |
| **Sources of Disagreement** | - Impact on Historical Character of Nantucket Sound (Weak)<br>- Impact on Aesthetics (Strong) |
| **Quantitative Tools/Models** | - Third-party Visual Simulations and Third-Party opinion Surveys |

**Figure 8.25 Systems Representation of Social and Cultural Impact Layer**

C.3) Stakeholder Process

*Components and Links:* Stakeholders commented on the importance of the decision-making process and its impacts on the validity of the final decision. Stakeholders indicated that stakeholders needed to have a more active role in the decision-making. Some stakeholders indicated that State agencies should be more actively involved. This would result in a more credible EIS. Stakeholders believed that community acceptance and support was crucial to the success of the project. Involving stakeholders may reduce conflict and the probability of litigation, this may reduce the costs of project implementation delay and potential litigation costs. Together, these make up the cost of conflict, which tie into the local economic costs of the wind project. Other stakeholders have expressed doubt that stakeholder involvement will actually help in reducing the conflict, as it takes only one unhappy stakeholder to file a lawsuit. The cost of stakeholder involvement and time constraints in decision-making are seen as arguments that weaken the attractiveness of stakeholder involvement. Figure 8.26 shows the systems representation of the stakeholder process layer. The major uncertainties seem to lie in assessing the value of the stakeholder process. The qualitative and speculative nature of this layer makes it only useful as a contextual consideration for most stakeholders.

C.4) Long-term impacts of the Project

*Components and Links:* Most stakeholders agreed that the Cape Wind project had a precedent setting nature with extensive consequences that went beyond the current project. Stakeholders agreed that an approval of the permit would spur new offshore wind energy developments and that its defeat would have serious consequences for future similar developments. An approval would potentially lead to more renewable energy for the Cape and Islands, as well as the United States as a whole. On the one hand, this can have positive long-term impacts on emission reduction, job creation and health benefits. On the other hand, more wind farms would also mean increased cumulative impact, which may not be linear. For instance, were the entire Eastern seashore be covered with wind farms, it would make it impossible for birds and marine mammals to find suitable habitats at all. Again this layer is rather speculative and can be used as context. Figure 8.27 shows the long-term impacts of the project beyond the current process.

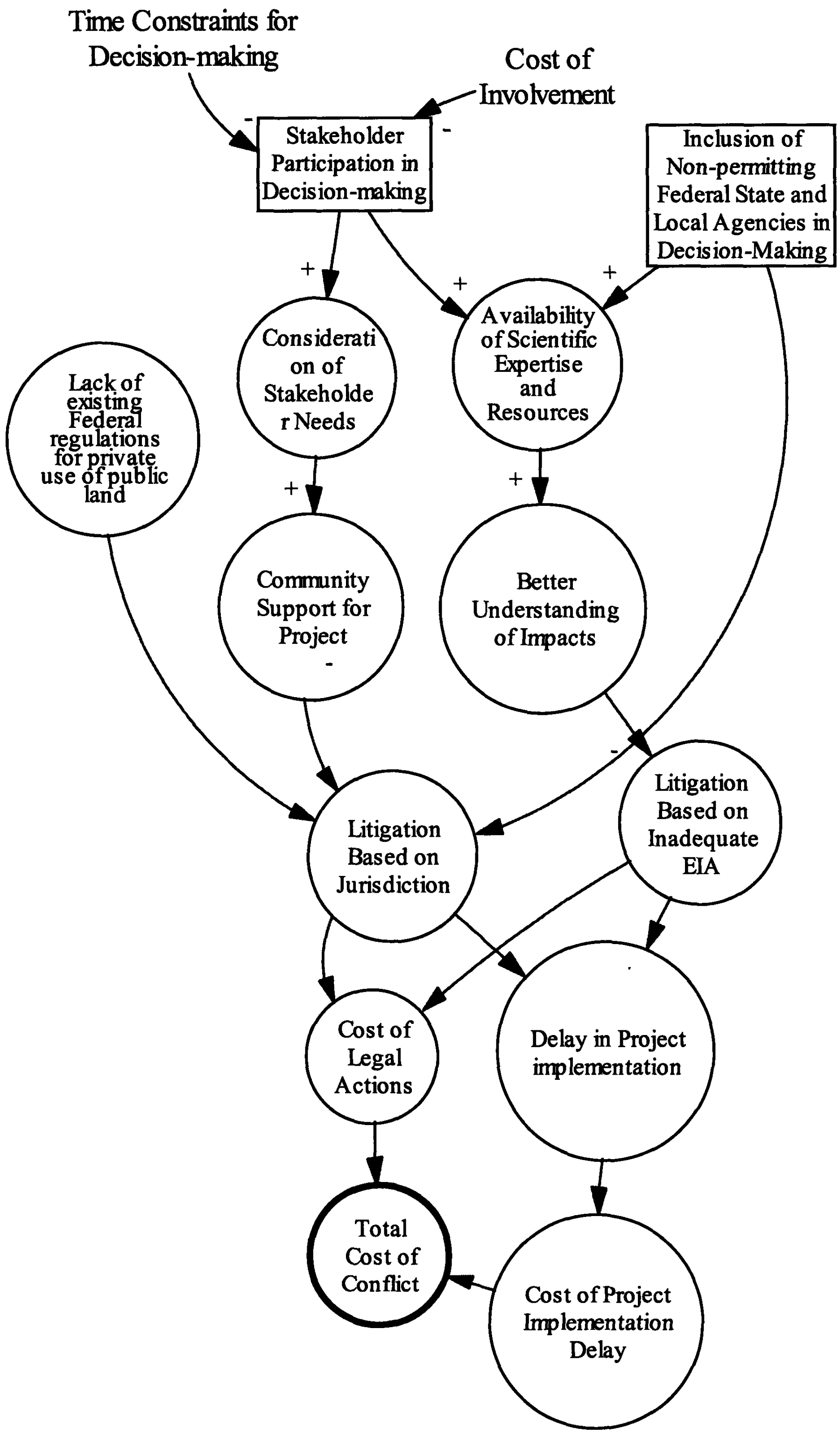



**Figure 8.26 Systems Representation of the Stakeholder Process Layer**

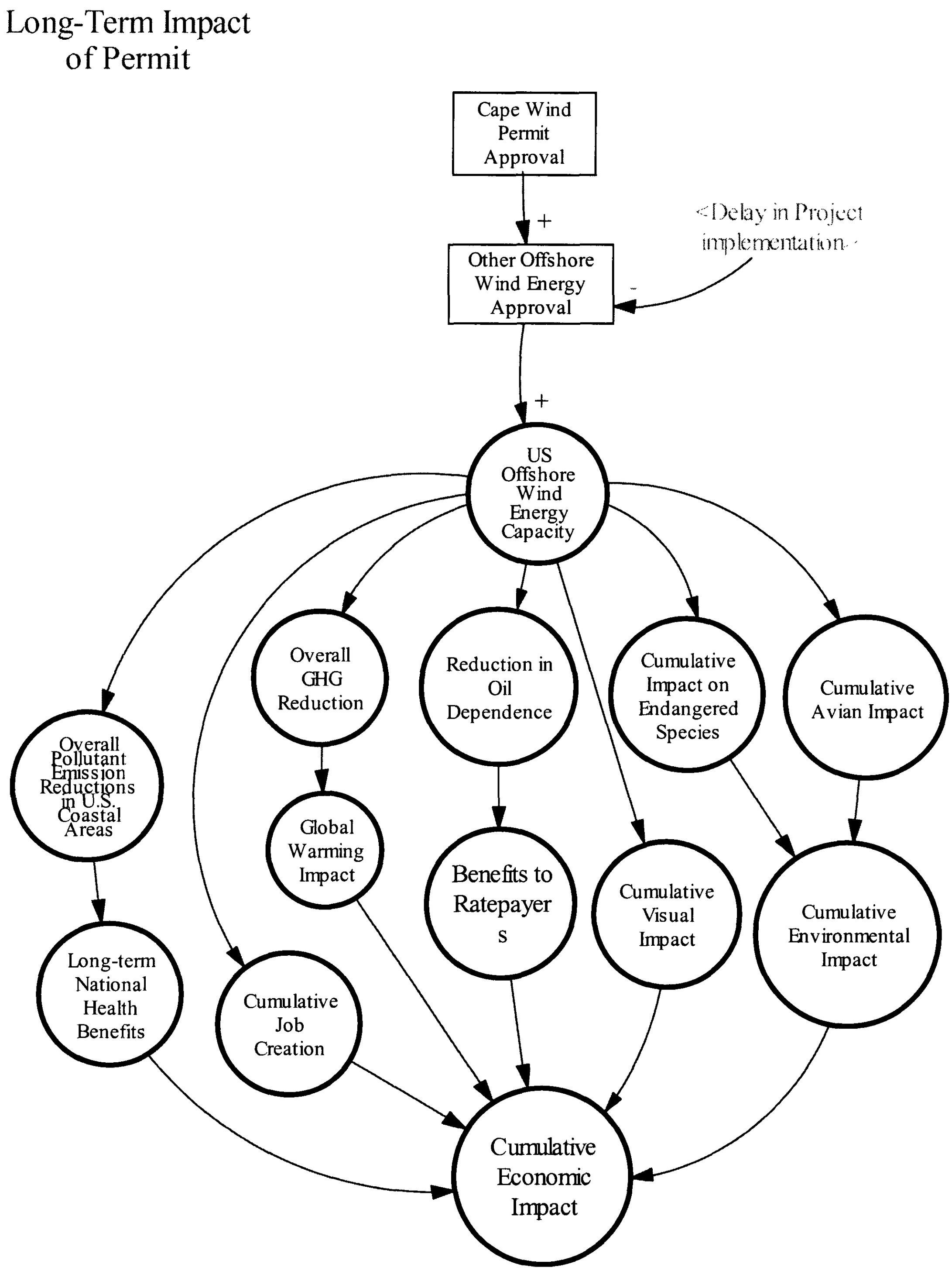



**Figure 8.27 Systems Representation of Long-Term Impacts of Project**

This completes the representation of the socioeconomic subsystem. In the next section we will look at the Navigation, Aviation and Safety Subsystem.

*D) Navigation, Aviation, Safety*

D.1) Navigation and Aviation and Safety

*Components and Linkages:* The location of the project determines proximity to navigation routes, impacting the probability of vessel collisions with the wind turbines in adverse weather conditions. Additional factors include the number of turbines, their structural safety and construction protocols for restraining cable design as well as turbine maintenance. Factors affecting the risk of airplane collision with the wind turbines are the number of turbines, the number of lights on turbines, turbine height, proximity to aviation routes, and climate conditions. Figure 8.28 shows the navigation and aviation layer.

D.2) Safety, Construction and Maintenance

*Components and Linkages:* Turbine repair operations depend on the funds allocated to repair and maintenance, as well as the maintenance schedule. The potential of upgrading the turbines with more advanced technologies depends on the availability of funds for upgrade and replacement of turbines. The development of advanced wind technology on the other hand depends on the market for wind energy in the U.S., which in turn is highly dependent on the permit of the project, as discussed in the long-term impact layer. A better turbine technology means higher power generation capacity at lower environmental impact. Also important for stakeholders is the availability of removal funds to ensure the turbines are adequately removed at the end of the lifetime of the wind farm.

With the last subsystem represented, the initial system representation for the Cape Wind system is complete. In the next section, we will look at the stakeholder refinement and validation of the system representation.

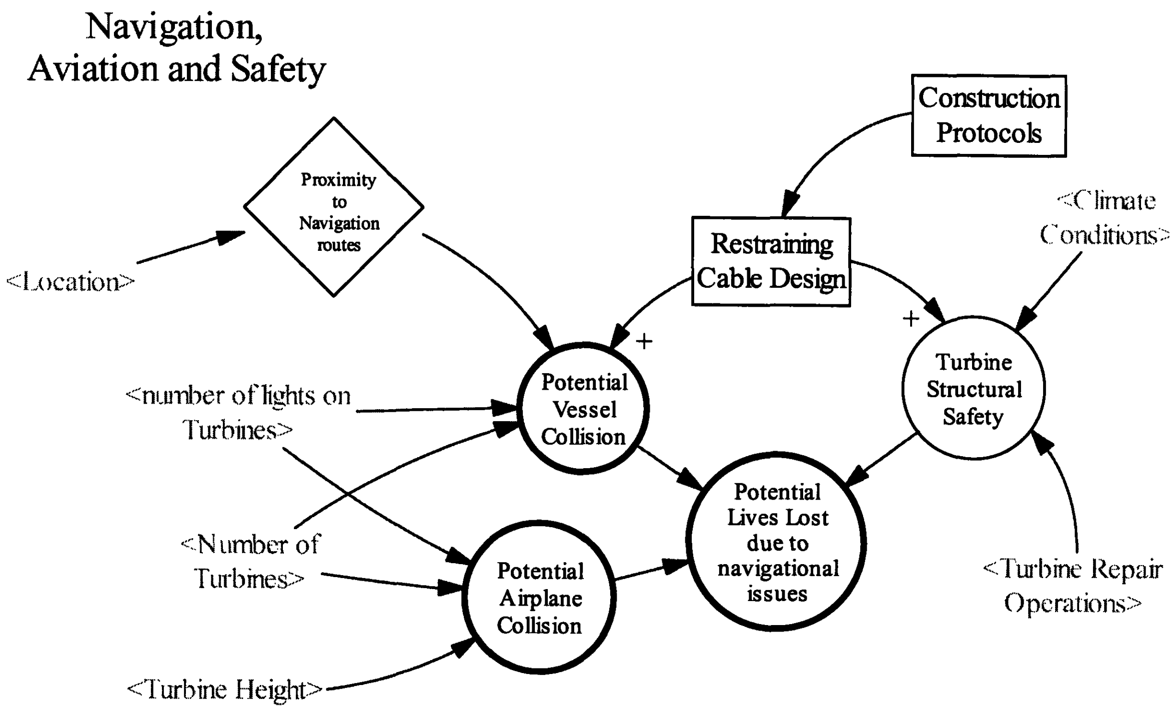



**Figure 8.28 Systems Representation of Navigation and Aviation Layer**

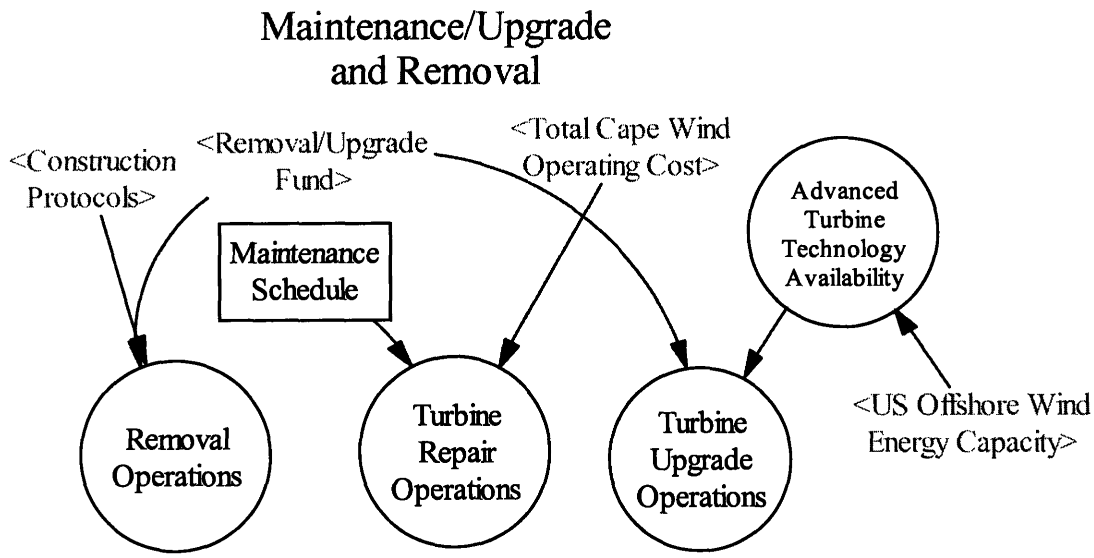



**Figure 8.29 Systems Representation of the Safety, Construction and Maintenance Layer**

## 8.6 Stakeholder-Refined Systems Representation

### *8.6.1 Workshop Invitation and Process Preparation*

Once an initial systems representation based on stakeholder inputs was developed, the representation was put on the project website[36]. This was done both in the form of a PowerPoint presentation, as well as the actual VenSim model file (with the option to download the software for free). Additionally, the survey results were provided in report format to stakeholders. Figures 8.30 and 8.31 show snapshots of the website.

Stakeholders were then invited to attend a collaborative systems representation workshop at MIT. Efforts for finding a neutral venue on the Cape itself had failed in the weeks prior

[36] A complete website for the Cape Wind Case Study was created to facilitate communication with stakeholders. In addition to the online survey, many stakeholders have provided feedback through the website. The entire process was made transparent for those stakeholders not participating directly in the process. The website can be accessed at: http://web.mit.edu/amostash/www/Capewind

to the workshop. Most organizations considered the Cape Wind project as a "political hot potato", and did not wish to be co-conveners of the workshop.

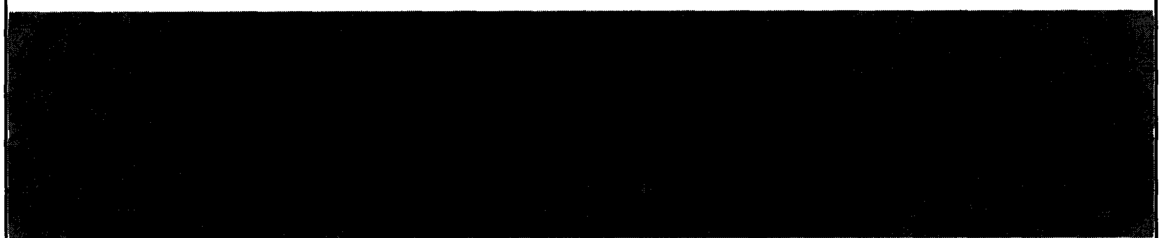
More than 60 stakeholder organizations for the Cape Wind Project were invited to attend, and 18 stakeholders, mainly from Cape Cod, agreed to attend the meeting at the MIT Strata Center, a 4-hour round-trip journey on a rainy Saturday afternoon (April 2, 2005). Stakeholders who could not attend were given the opportunity to comment via the website or through email. The presentation for the workshop was made available one week before, for the public to be informed of its content. Five stakeholders who were unable to attend the workshop provided feedback on the systems representation via the website. The invitation letter is also available in Appendix B.

A press release was circulated among local media outlets, explaining the goal of the workshop (See Figure 8.32). MIT Tech Talk featured the workshop in its March 30, 2005 issue.

**Massachusetts Institute of Technology**

Stakeholder-Assisted Modeling and Policy Design Process (SAM-PD)

# Cape Wind Off-Shore Wind Energy Project



**Stakeholder-Assisted Representation Research at MIT**

- At MIT we are looking at ways stakeholders can be more proactively engaged in the representation and scoping of large-scale engineering projects, such as the Cape Wind project. It is our view that the active involvement of stakeholders can help in making more informed decisions that take into account stakeholder needs and knowledge, and go a long way in avoiding costly conflict in the community.

**Phase I –MIT Stakeholder Survey on the Cape Wind Project**

- In the first phase of this research, we have contacted more than 50 stakeholder organizations in the Cape Wind project with a balanced representation of opponents, proponents, undecided and neutral stakeholder, to understand their views on the project and its scope. Download the MIT Stakeholder Survey Report

**Phase II- Collaborative Stakeholder Process**

In the second phase of our study, we are inviting feedback from stakeholders on the representation created in phase I, to refine it further and make sure stakeholder concerns are adequately covered. Based on that representation, we will then look at the different alternatives and get stakeholder inputs on a potential collaborative approach to the project. Stakeholder feedback can be provided in stakeholder meetings we will be setting up at MIT, or through email and phone

**Figure 8.30 Snapshot of Cape Wind Case Study Website**

# Collaborative Process Workshop for Offshore Wind Energy Siting

MIT-USGS Science Impact Collaborative

Saturday April 2, 2005
2:00-6:00 p.m.
MIT Stata Center, Room 32-124
32 Vassar Street
Cambridge, MA 02139
Campus Map
RSVP by March 28, 2005 to
capewind@mit.

- **Workshop Details (PDF)**
- **Press Release (March 19, 2005)**
- **Presentation (PowerPoint)**
- **Stakeholder-Assisted Systems Representation (Vensim Model)***
- **Free Vensim PLE Software Download**
- **MIT Cape Wind Phase I Stakeholder Survey Results**

***Steps for Accessing the Systems Representation**

(The systems representation is presented in the Presentation. Follow these steps only if you wish to edit/modify the representation)

1. Download Vensim PLE for free
2. Install on your computer.
3. Download the Systems Representation and save in the same directory as Vensim PLE
4. Run Vensim PLE
5. Go to File> Open Model > Cape Wind

**Figure 8.31 – Snapshot of the Cape Wind Case Study Website (Workshop Announcement)**

NEWSPAD™
BETA

**MIT Research Group Explores Stakeholder Involvement in Siting Offshore Wind Energy Projects**

**The MIT-USGS Science Impact Collaborative (MUSIC) looks at the potential role of joint fact finding as a way to bring together federal and state government permitting agencies, federal, state and local advisory agencies, citizen groups, developer, labor unions, environmental groups, consultants and academic experts in decision-making for offshore wind energy projects.**

**Cambridge, MA (PRWEB) March 19, 2005 -- The MIT-USGS Science Impact Collaborative (MUSIC) is sponsoring a stakeholder process on offshore wind energy projects at MIT on April 2nd, 2005. Stakeholders in the Cape Wind offshore wind energy proposal have been invited to MIT, to discuss lessons from the ongoing permitting process for the Cape Wind proposal, and look at ways to improve the decision-making process. The stakeholder meeting, to be held in the world renowned MIT Stata Center, will shed light on how to design a siting process for offshore wind energy that takes into account stakeholder concerns and local knowledge, while avoiding competing scientific studies that can undermine the process. "Most stakeholders involved in environmental disputes have different levels of scientific understanding, and trust among stakeholders can erode if each group brings its own scientific resources to support its position, leading to dueling or competing studies and experts. Perceptions of unequal distribution of scientific resources can undermine the collaborative spirit and lead to a breakdown of the process, or worse yet, litigation." according to Dr. Herman Karl, the Co-Director of the MUSIC program. The MIT-USGS Science Impact Collaborative has developed an effective framework called joint fact finding (JFF) to address conflict in complex science-intensive decisions. The purpose of a JFF process is to handle complex scientific and technical questions. JFF helps participants agree on the information they need to collect and how gaps or disagreements among technical sources will be handled. JFF allows stakeholders to build a shared understanding of technical and scientific issues and their implications for policy. They can also help resolve disputes about scientific and technical methods, data, findings and interpretations. The Cape Wind Project is a proposal to build 130 wind turbines off Cape Cod, in Nantucket Sound. The permit process is administered by the U.S. Army Corps of Engineers. With its technical and social complexity, and high degrees of controversy and conflict, the Cape Wind project has become an important case study in the MIT research. The case study was initiated at MIT in 2003 during graduate seminars on joint fact-finding at MIT, where different stakeholders were invited to express their views on the permitting process. In 2004, Ali Mostashari, a Ph.D. candidate at MIT, initiated a research project on stakeholder-assisted modeling and policy design for the Cape Wind project, as the basis of a joint-fact finding process in offshore wind energy siting. As part of this project, more than 44 representative stakeholder organizations were contacted to fill out a survey on their views of the important aspects of the process. Participants in the survey included opponents, proponents, undecided and neutral stakeholders as well as those not taking any positions on the project. Based on the responses to the survey, comments in six public hearings, comments in the Massachusetts Technology Collaborative stakeholder process, stakeholder news releases and interviews, the group was able to construct a system representation that highlighted the most important concerns and issues dealing with offshore wind projects, as perceived by a broad range of stakeholders. "Pubic hearings are just not sufficient to address the complex issues of projects such as Cape Wind. There needs to be a direct stakeholder dialogue, which can bring all sides of the issue together to work out the issues in a collaborative manner. We have seen how conflict can prolong the permitting process, without improving its substance" says Mostashari. "The goal of the April 2nd workshop is to learn from stakeholders in the current permit process how it can be improved for future offshore wind projects, as well as similar issues such as siting of LNG facilities"**

**Figure 8.32 Press Release for the Collaborative Process Workshop at MIT**

Volume 49 – Number 22
Wednesday – March 30, 2005

TechTalk

SERVING THE MIT COMMUNITY

**Cape Wind Project meeting**

The Cape Wind Project, with its controversial environmental, economic and aesthetic impact on Nantucket Sound and Cape Cod, has been an important case study for participants in MUSIC and proponents of joint fact-finding since 2003. After the issuing of the draft environmental impact statement (DEIS) in November 2004, the permitting agency has yet to announce any decision on the project. The delay is widely seen as politically motivated.

On April 2, MUSIC will host stakeholders in the Cape Wind offshore wind energy proposal to discuss the permitting process and possible ways of resolving some of the scientific issues in dispute. MUSIC interns have prepared a web page (http://scienceimpact.mit.edu) to portray how citizens might use joint fact-finding.

Ali Mostashari, a doctoral candidate in engineering systems, has organized the April 2 meeting. In 2004, as part of his dissertation research project on policy design in the Cape Wind Project, Mostashari convinced more than 44 representative stakeholder organizations to summarize their views of the offshore wind energy siting and permitting process.

"Pubic hearings are just not sufficient to address the complex projects such as Cape Wind. We have seen how conflict can prolong the permitting process, without improving its substance. The goal of the April 2nd workshop is to learn from stakeholders in the current permit process how it can be improved for future offshore wind projects, as well as similar issues such as siting of LNG facilities," Mostashari said.

**Figure 8.33 MIT Tech Talk Article on Stakeholder Workshop**

*8.6.2 Participating stakeholder organizations*

Stakeholders who participated in the workshop or provided feedback on the representation are listed in Table 8.17.

**Table 8.17 Participating and Contributing Stakeholders in MIT Stakeholder Workshop**

| Actor Group | Organization | Position of Representative |
|---|---|---|
| **U.S. Federal Agencies** | U.S. Fish and Wildlife Service | Regional Director |
| | U.S. Fish and Wildlife Service | National Energy Coordinator |
| | U.S. Geological Survey | Senior Scientist |
| **State and Regional Agencies** | Massachusetts Division of Marine Fisheries | Cape Wind Project Contact |
| | Massachusetts Office of Environmental Protection | Wind Energy Coordinator |
| | Cape Light Compact (Regional Consumer Utility Protection Agency) | Cape Wind Project Contact |
| **Local Groups** | Alliance to Protect Nantucket Sound | Communications Director |
| | Clean Power Now | President |
| | Cape Clean Air | President |
| | Wind, Energy and Ecology Information Services | President |
| **Developer** | Cape Wind Associates | Communications Director |
| **National Groups** | The Humane Society of the U.S. | Field Director for Marine Life |
| **Academia** | MIT Ocean Engineering Department | Professor |
| | MIT Ocean Engineering Department | Graduate Student |
| | MIT Edgerton Center | Lecturer and Students |
| | MIT Engineering Systems Division | Professor |
| | MIT Department of Urban Studies and Planning | Graduate Students |
| | University of Massachusetts-Amherst Department of Environmental, Earth and Ocean Sciences | Professor |

*8.6.3 Workshop Materials*

Stakeholders were given a folder that included the an introduction to joint fact finding and systems representation, a SAM-PD process diagram (Figure 8.1), the press release, information about the MIT-USGS Science Impact Collaborative and the initial systems representation. Table 8.18 shows the summary of arguments presented to stakeholders in the presentation and the handouts.

**Table 8.18 Summary of arguments presented to stakeholders during Introduction**

| | |
|---|---|
| Goal of Workshop | • Use stakeholders' experience with Cape Wind process to collaboratively design a systems representation as a basis for collaborative decision-making processes for offshore wind energy projects. |
| Problems with Current Permitting Process | • Public hearings do not address stakeholder needs adequately<br>• "Everyone is entitled to their own opinions, but not their own facts". Is that so?<br>• Uncertainties in scientific information result in adversarial science, with experts providing different and often conflicting information.<br>• Stakeholders spend funds for competing research<br>• Information production for EIS is often perceived as biased by marginalized stakeholders<br>• Transparency is a major problem<br>• Major cost of conflict, litigation, divisions in community<br>• Decisions are often made in courts, taking them out of the hands of stakeholders |
| Introduction to Joint Fact Finding | • Joint fact-finding (JFF) is a collaborative process, where federal, state and local decision-makers, citizen groups, private sector, experts and scientists (in general stakeholders) jointly review a project and negotiate a decision in a consensus seeking process.<br>• Stakeholders focus on underlying interests rather than positions on particular issues.<br>• Current NEPA process can make use of a JFF to inform its decision-making. Section 101 of NEPA process allows for collaborative decision-making (guidance memos currently circulated in many agencies)<br>• Joint fact-finding is normally convened by the permitting agency<br>• If the stakeholder group comes to an agreement, permitting agency then bases its decision on its recommendations<br>• Stakeholder-Assisted Modeling and Policy Design Process (see process diagram) is a joint fact finding process that uses stakeholder-assisted systems representation as a basis for the collaborative decision-making process<br>• This process can channel conflict into a productive effort for making the best decision. It does NOT eliminate conflict.<br>• It is no silver bullet, and there is no guarantee that it can stop litigation, but it is definitely more probable to succeed in reducing conflict than the traditional process |

*8.6.4 Workshop Structure*

The workshop was divided into five parts. In the first part, participants were introduced to the idea of joint fact-finding and collaborative systems representation. In the second part, stakeholders were asked to form four breakout groups to collaboratively refine the systems representation for the energy, environment, socioeconomic and navigation, aviation and safety subsystems. In the third part, stakeholder breakout groups were asked to identify 4-5 major uncertainties in their subsystems that needed to be addressed. In the fourth part of the workshop, stakeholders were asked to identify ideal working groups, whose joint findings would be considered credible by all sides. In the final part, stakeholder breakout groups reported back to the entire group with their recommendations on the system representation, uncertainties and working groups. Breakout groups were formed in a way to include a balance of opponents, proponents, undecided and neutral stakeholders. In order to shift the discussion away from the usual discourse, stakeholders were asked to think in terms of a generic offshore wind energy systems representation, rather than the Cape Wind case.

*8.6.5 Ground Rules for Collaborative Representation*

MIT students were assigned to each breakout group as consensus recorders. Modifications and suggestions were only reported as group recommendations when all 4-5-breakout members came to consensus to have it included. Each group was given a large poster-size systems representation that could be modified and written on. All modifications and suggestions however were recorded separately, regardless of whether agreement was reached. Stakeholders were asked to prioritize between three-five modifications and up to five uncertainties per subsystem. They were given a total of 90 minutes for the three tasks (representation, uncertainty identification, working group proposal). Figures 8.34-8.36 show pictures of the MIT Stata Center workshop and the participating stakeholders.

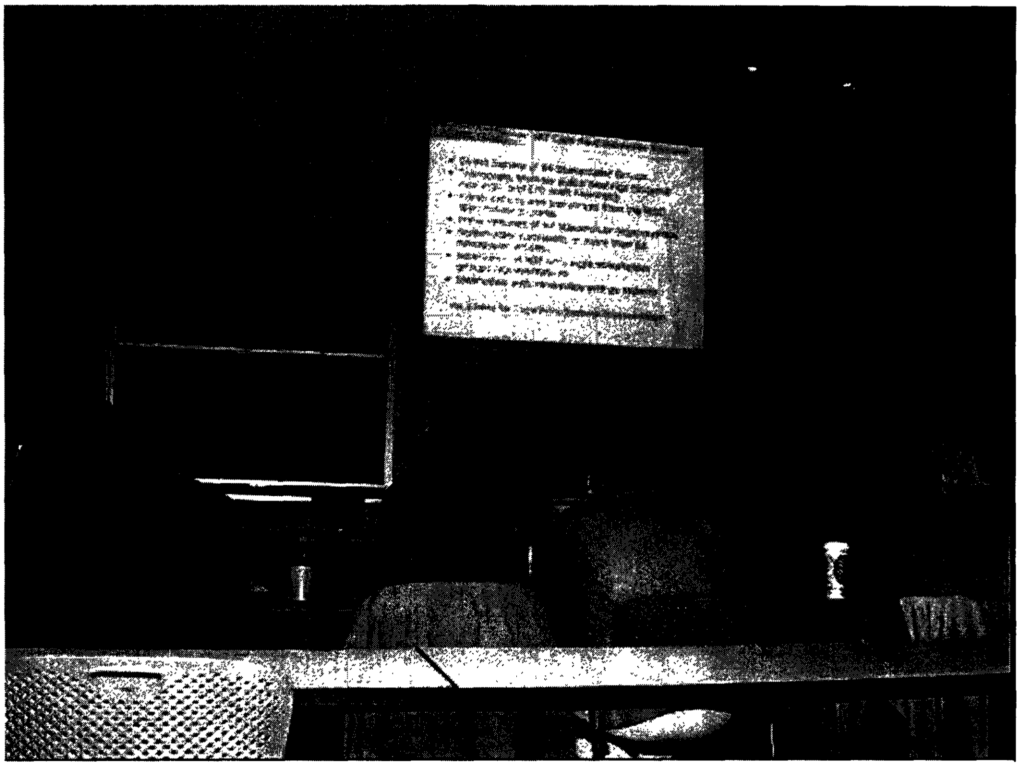


**Figure 8.34 Initial Introduction on Joint Fact Finding and Systems Representation**

**Figure 8.35 Stakeholders Working on the Energy Subsystem Representation**

**Figure 8.36 The Socioeconomic Impact Group**

## 8.7 Workshop Dynamics and Results

In this section we will look at the attitudes, dynamics and behavior of the stakeholders during the introduction, collaborative systems representation, collaborative uncertainty identification and collaborative working group formation.

### *8.7.1 Stakeholder Responses to the Introduction to Joint Fact Finding and Systems Representation*

In general, while an emphasis was made repeatedly that the workshop goal was to go beyond the Cape Wind project, and to think whether a joint fact finding project could be applied in for a new offshore wind project, stakeholders kept coming back to their positions on Cape Wind, or ask questions that were mostly implicit statements about their opponents. General statements in the introduction (paraphrased) are shown in Table 8.19.

**Table 8.19 Comments During the Introduction to Joint Fact Finding**

| **Comment Focus** | **Questions/Comments** | **Responses Given by Facilitator/Organizers** |
|---|---|---|
| Science, Facts and Uncertainty | 1- Why is adversarial science considered undesirable? With adversarial science one can get to the bottom of the facts and prove the facts of a process.<br>2- There is no uncertainty in the fact that many windfarms in Europe haven't had a single bird kill in the past five years. When people don't accept this, how can this process help? | 1-Adversarial science does not refer to differing scientific views, but to the competing investments in science that can serve as a weapon in a public dispute. Shared scientific resources and inclusive working groups will allow scientists representing different stakeholders to examine underlying assumption and methodologies used.<br>2- How "historical facts" are interpreted to apply to the current context is a subjective matter. Joint fact-finding allows for a joint clarification of implicit subjective assumptions in making use of knowledge. |
| Stakeholder Rationality | 3- This process assumes that all stakeholders are rational; we KNOW that there are people here who don't care about the truth or facts. | 3- Universal rationality is not a basic assumption. However, there is the assumption that people have underlying interests that determine their positions. If those interests can be considered, positions can often change based on a commonly developed understanding. |
| Process Improvement | - How would this process guarantee that political actors wouldn't independently play their politics, regardless of what a group of stakeholders decide?<br>- Who pays for the increased scope of issues that have to be studied?<br>- Stakeholder involvement is difficult when there is a limitation of resources and time constraints in decision-making.<br>- Overwhelming majority decisions are not useful, since it will still leave someone marginalized who can litigate.<br>- This process will take too long. It is the best way for the opponents to stall the project. | - There is no guarantee. What this process accomplishes is to provide a common basis for decision-making among stakeholders. This does not necessarily guarantee success, but it provides an improvement over the dominance of adversarial positions.<br>- Not all of the representation needs to be included in the scope of the study. That's up to the stakeholder group to negotiate. Who pays is also not pre-determined. Many stakeholder organizations may have resources that could help in this regard.<br>- Resources and time are often wasted in trying to create a litigation-proof EIS, in litigation processes, and in the politicization of the decision-making process. Joint fact-finding may take longer to complete on the front end, but may save substantial time for the overall process. For example, the Cape Wind project is now around 2.5-3 years behind schedule. During this time many of the longer contentious studies would have been completed. |
| Systems Representation | - There are issues that a representation cannot capture. For instance how do you capture the fact that the jurisdiction of the project is problematic, and that we lack an effective Ocean policy? | - Actually these can be captured by a systems representation, as they have been to some extent in the Stakeholder Process layers and the long-term impact layers of the systems representation. Not all parts of the systems representation will be quantified into a model, but the effect of institutional issues can be discussed and evaluated qualitatively. |

*Tensions in the Session:* During the questions asked by one of the proponents, who went into one of the details of the Cape Wind project, opponents started to argue on the validity of the question. We intervened, by emphasizing that the Cape Wind project was not the emphasis of the session. The intervention however may have made stakeholders feel that they did not get a chance to speak their mind. Tensions remained in the audience until the break, after which the collaborative systems representation was to start. After the introductions were over, stakeholders were offered refreshments and a chance for informal conversations for 15 minutes. There was extensive mingling, and by the end of the break much of the tension seemed to have reduced in intensity.

### *8.7.2 Stakeholder Responses to the Systems Representation Breakout Session*

Stakeholders were allowed to self-select into subsystem breakout groups of interest, with some limitations that would ensure balance in the groups. Each group was given a spot in the large room to discuss their respective subsystems representations. Conflict was minimal in the breakout groups, and limited to grunts when consensus was not reached for particular issues a participant was putting forward. Table 8.20 shows the representation changes made by groups through consensus decision-making. The atmosphere of the groups was mostly friendly, with the exception of one group (Socioeconomic impact), where it remained cordial throughout. At the end of the first task, most breakout group members seemed to be smiling and having a good time.

### *8.7.3 Stakeholder Responses to Uncertainties in the System*

Stakeholders stayed in the same breakout groups, and continued working collaboratively on the most important uncertainties in their subsystems, through consensus. Table 8.21 shows the uncertainties they identified as important.

### *8.7.4 Stakeholder Identification Of Ideal Working Groups*

Again, staying in the same breakout groups, stakeholders identified working group compositions for their subsystems that would make the technical analysis credible for stakeholders. The focus was a generic offshore wind energy project. Table 8.22 shows the working group formations proposed by stakeholders.

**Table 8.20 Consensus Modifications/Additions to the System Representation by Stakeholders. The refined systems representations are presented in Appendix C.**

| Breakout Group | Layer | Suggested Modification/Addition |
|---|---|---|
| Energy | Windfarm Characteristics | Wave heights (location)<br>Sea Bed conditions |
| | Energy production | long-term ten-twenty years contracts for power |
| | Energy Economics: | Electricity cost stability<br>Financing costs |
| Environmental Impact | Avian and Marine Impacts | - Seasonal residences more important than proximity to migration routes<br>- Construction noise impact (on marine mammals) and commercial/recreational fish species<br>- Construction impact on benthos. Impact on Benthos has direct impact on prey availability and habitat use |
| | Protected Species Impact | - Seasonal residence<br>- Impact on foraging resources<br>- Proximity to migration route of whales |
| | Air Pollution Impact | - Number of oil barges and related risks<br>- Intake and discharge of water used by plants for cooling impacting volume and chemicals<br>- Reduction in temperature variations<br>- Less polluted marine and coastal areas |
| Navigation, Aviation and Safety | Navigation | - Proximity to Fishing areas<br>- Flight patterns should also be included<br>- Size of exclusionary zone<br>- Turbines as aid to navigation<br>- Climate conditions effect everything<br>- Risk to Search and Rescue Operations |
| | Construction and Maintenance | - Time of the year restrictions limiting maintenance schedule<br>- Hazmat Management<br>- Size of the overall system impacting maintenance costs |
| Socioeconomic Impact | Local and Regional Economic Impact | - Municipal tax revenue for infrastructure > local economic benefit<br>- Revenue recycling > local economic benefit<br>- Transmission system infrastructure impacts local economic costs<br>- Transmission system improvements may increase electricity reliability<br>- Source of needed funds limits stakeholder participation<br>- Effect of timing (urgency) limits stakeholder participation<br>- Existence/Lack of regulations for Ocean policy can undermine all positive influences |

**Table 8.21 Consensus Major Uncertainty Identification by Stakeholders**

| Breakout Group | Suggested Uncertainties |
|---|---|
| Energy | • Fluctuations in fossil fuel prices<br>• Cost of renewable energy certificates<br>• Litigation costs<br>• Disaster or terrorism risk |
| Environment | • How long it would take for power plants to cease operation and power independence to be realized<br>• Delay in air pollution environmental benefits<br>• Comprehensive characterization of resources and habitat use for all endangered and protected species<br>• Modeling the differential avian collision impact<br>• Electromagnetic effects |
| Navigation | • Human error<br>• Weather<br>• Potential future changes to size of exclusionary zone<br>• Potential future changes in regulatory structure |
| Socioeconomic Impact | • Public Acceptance<br>• Monetary Health Benefits<br>• National Energy policy<br>• Cost and benefit distribution<br>• External Safety threats (terrorism etc.) |

**Table 8.22 Consensus Ideal Working Group Identification by Stakeholders**

| Breakout Group | Suggested Working Group Composition |
|---|---|
| **Energy** | • U.S. DOE<br>• Energy Facility Siting Board<br>• UMASS Renewable Energy Lab<br>• MIT LFEE<br>• ISO Grid Manager<br>• Electric Power Research Institute<br>• American Wind Energy Association<br>• Consultants and Experts on Both Sides |
| **Environment** | • All Federal and State Resource Agencies<br>• University Centers<br>• Local and National NGO representatives<br>• Academic Research Scientists<br>• Outreach and Communication Teams |
| **Navigation** | • NOAA<br>• Department of Homeland Security<br>• U.S. Coast Guard<br>• State Coastal Zone Management<br>• U.S. Navy<br>• Shipping Line Representatives |
| **Socioeconomic Impact** | • Chambers of Commerce<br>• Private consultants on all sides<br>• MTC (or equivalent)<br>• State Economic Development Office<br>• State Energy Office<br>• Academia<br>• Congress and State Legislature<br>• Fishermen Associations |

*8.7.5 Reporting Back to the Group*

The consensus recorders within each group brought back the results of their consensus decision-making with regards to the systems representation, uncertainty identification, and working group formation. The results were then presented to the group at large, which had an opportunity to comment. At the end of the session, stakeholders were asked to fill out a feedback survey on their experience with the workshop, and the potentials of joint fact-finding and the system representation. In the following section, we will look at the results of the feedback survey.

## 8.8 Exploring the Hypothesis Through Stakeholder Feedback Survey

The survey served as one of the principal ways to explore the validity of the hypothesis of this dissertation. Therefore, the questions were mainly designed to elicit the views of the diverse stakeholder group (including government, private sector, experts and citizen groups) on the criteria of a *superior* presentation.

### *8.8.1 Inclusion of a plurality of views*

The system representation was the result of inputs of tens of stakeholder groups and was therefore by definition inclusive of a plurality of views. We asked stakeholders however whether the systems representation adequately addressed the key concerns and interests for an offshore wind energy project such as Cape Wind. 67% of respondents said they thought the systems representation adequately reflected stakeholder concerns. 25% believed it did not, and 8% believed it would with further refinement.

Here is a summary of comments from people who thought the systems representation was either totally inadequate, or needed further refinement.

- Added dimension afforded by seeking to understand the certainty sought by stakeholders would help better refine studies and actions needed to address uncertainties.

- Not yet, but getting there.

- Too light on supportive environmental benefits, benefits to organized labor, and more clear energy benefits.

- The survey was comprehensive, but the meeting was not representative, because there were too few people. Also, some knowledge gets lost when converted to representation.

- I'd like to see more consideration of how this process would change if driven by government, not private sector

### *8.8.2 Usefulness of representation as a thought expander for stakeholders*

Stakeholders were also asked whether they felt that their understanding of the offshore wind energy system had improved working with the systems representation. 83% said it had improved their understanding. 8% said that it had helped a little, and another 8% believed it hadn't helped at all. Comments by those whose understanding of the system had only slightly improved or not at all, said that they had not had a chance to look at the entire systems representation in much detail, or that the issues had been discussed ad nauseum and were known by everyone.

### *8.8.3 Usefulness of representation for suggesting strategic alternatives for improved long-term management of the system*

Stakeholders were also asked whether they thought the systems representation would allow for more decision-options to be considered than the current permitting process allows. 67% believed it would, 25% believed it may depending on how it is used, and 8% believed that it would not. Stakeholders were also asked whether the representation would form a better basis for scoping offshore wind energy projects than the current permitting process. 83% said that the representation was a better basis for scoping, 8% said that it may be depending on how it is used, and 8% said that it wasn't. Comments by those who were unsure or thought the representation would not support better scoping and/or options are as follows:

- I think it is good to understand relationships of various considerations, but this leaves out personal preferences/values that drive decisions.

- Still needs development

*8.8.4 Completeness of representation (taking into consideration technical, social, political and economic considerations)*

Stakeholders were asked whether the representation was sufficiently comprehensive in capturing economic, social, political and technical considerations. 75% believed it was sufficiently comprehensive, 17% thought it was not, and 8% said they didn't know. Those who didn't think it was comprehensive enough, had the following comments:

- Needs more refinement, abbreviated language in boxes leads to ambiguity in depicting total impact. The folks who put this together did not know the terms of references well enough to create correct short hands and draw all the boxes and arrows.
- It's better now, but it still needs work
- Focus should not be on comprehensiveness but should be how to decouple values/opinions from analysis

## 8.9 Additional Feedback from the Stakeholder Survey

In addition to issues relating to the hypothesis of this dissertation, we asked stakeholders other questions on the Stakeholder-Assisted Modeling and Policy Design (SAM-PD) process as a whole.

*8.9.1 Working group formation and science development through joint fact-finding*

Stakeholders were asked whether they thought working group selection by stakeholders in a joint fact-finding context would help reduce conflict and increase the credibility of the analysis. 92% thought it would. 8% were unsure.

*8.9.2 Superiority over Current Permitting Process*

Stakeholders were asked whether they thought the proposed process, based on a commonly agreed systems representation was an improvement over the current permitting process. 83% thought it was, and 17% said they were unsure. Comments of one of the stakeholders who were unsure:

- Maybe, only if legislative changes are made to allow the process to impact decision-making.

*8.9.3 Transparency*

We asked stakeholder whether they thought the SAM-PD process would be more transparent than the current permitting process. 75% said they thought it was more transparent, while 25% said they were either unsure, that it may have the potential or that it would depend on particular permitting processes.

*8.9.4 Drawbacks of the SAM-PD process*

Stakeholders were asked to comment on their perceived drawbacks of the SAM-PD process and potential obstacles. Those providing feedback had the following to say:

- Needs to provide a separation of values/opinions from fact-finding/science.
- I don't know that they are drawbacks, so much as areas in need of development. The process needs to be refined and tried on other cases as well.
- Commercially viable sites are very limited. This model would be more effective if there were many options for sites among which one could choose.
- Do it <u>before</u> a project is proposed to eliminate sites likely to generate most controversy and choose ones with least adverse impact.
- Needs to be institutionalized by permitting agency
- If it is too narrowly focused it could lead to flawed conclusions
- There needs to be buy-in by the project proponent

*8.9.5 Other stakeholder comments on the SAM-PD process*

- "It's a new way for looking at an old problem"
- "Well of course this a better process, the traditional requirement for notice and comment make no provisions for stakeholders interacting."
- "A rather refreshing look at collaborative, community based decision-making."

## 8.10 Comparing the Refined Stakeholder-Assisted Representation with the U.S. Army Corps of Engineers Scoping Document

In addition to the stakeholder views, we compared the stakeholder-assisted representation with the scope of the environmental impact assessment used by the Army Corps of Engineers as the basis for decision-making. The scope of the EIS, determines the system boundaries, the components and interconnections that have to be evaluated for the final decision. There is a major difference between the systems representation and the scope of the EIS: The scope of the EIS is essentially a subjectively narrowed down systems representation in which the permitting agency has determined what needs to be evaluated. In a SAM-PD process what remains in the scope is one that stakeholders decide on collaboratively, and within a joint fact-finding context.

Tables 8.23-8.25, reproduced from Chapter 7, show the scope of the EIS. They include components and linkages that need to be addressed for decision-making, and as such can be considered a systems representation in non-diagrammatic format.

### *8.10.1 Inclusion of a plurality of views*

Having considered all the sources used in eliciting stakeholder input, we can trace the stakeholder-assisted representation back to inputs by more than 70 stakeholder groups and more than 130 individual stakeholders ranging from Federal, State and local government organizations, to environmental groups, experts, local citizen groups and individual Cape Cod residents. The scope of the environmental impact assessment was finalized using the feedback from seven Federal government agencies, two state agencies and one regional agency. As such, the stakeholder-assisted representation contains the views of more diverse views, and is more inclusive of a plurality of views.

**Table 8.23 Avian and Marine Habitat Impact, and Impact on Fisheries Scope of the EIS** (Based on the U.S. Army Corps of Engineers EIS Scope Document)

| Category | Issues to be Studied | Methodology to be Used |
|---|---|---|
| Avian Impacts | Current use of the final alternative sites by birds as baseline data<br>- Species, number, type of use, and spatial and temporal patterns of use<br>- Issues to be addressed include: (1) bird migration, (2) bird flight during storms, foul weather, and/or fog conditions, (3) food availability, (4) predation, and (5) benthic habitat and benthic food sources<br>- Information derived from other studies, providing a three-year baseline data set<br>- Endangered Species impact on Piping Plover, and Roseate Tern | - Existing, published and unpublished research results, especially research that describes long-term patterns in use<br>- New field studies undertaken for this EIR/EIS. Data on use throughout the year, especially through November for migratory species, and under a range of conditions. Methods: Remote sensing through radar and direct observations through aerial reconnaissance and boat-based surveys.<br>– Data gathered through radar to be validated with direct observations.<br>- Known impacts to birds from former or current Wind Turbine Generators (WTGs) and other tall, lighted structures (such as communications towers) |
| Marine Habitat Impact | - Vibration, sound, shading, wave disturbance, alterations to currents and circulation, water quality, scouring, sediment transport, shoreline erosion (landfall) and structural habitat alteration.<br>*- Northern right whale, humpback whale, fin whale, harbor seal and grey seal, loggerhead sea turtle, Kemp's Ridley sea turtle and leatherback sea turtle* | - Assessment of: 1) species type, life stage, and abundance; based upon existing, publicly available information, 2) potential changes to habitat types and sizes; and 3) the potential for turbines as fish aggregating structures. The study should assess potential indirect impacts to fish, mammals, and turtles that may result from changes in water movement, sediment transport, and shoreline erosion. |
| Fisheries Impact | - Assessment of potential impacts on specific fishing techniques and gear types used by commercial and recreational fishermen.<br>- Multiple-use conflict The potential for indirect impacts such as changes in fishing techniques, gear type and patterns will need to be included. | - Review of existing literature and databases to identify and evaluate commercial and recreational fish data and abundance data in Nantucket Sound.<br>- Data to be reviewed should include: National Marine Fisheries Service(NMFS) Commercial Data, NMFS Recreational Data, Massachusetts Division of Marine Fisheries Commercial Data, Massachusetts Division of Marine Fisheries Trawl Survey Data and supplemented with intercept surveys. |

**Table 8.24 Other Ecosystem and Physical System Impact Scope of the EIS** (Based on the U.S. Army Corps of Engineers EIS Scope Document)

| Category | Issues to be Studied | Methodology to be Used |
|---|---|---|
| Benthic Impact | - Sufficient information to compare between alternative marine sites and to provide a general characterization of the benthic habitat of the final sites.<br>- Data on the Benthic Macroinvertebrate Community | Assessment and additional data collection as described in the Benthic Sampling and Analysis Protocol (April 18, 2002) supplemented by the ESS letter of May 10, 2002. |
| Interactions between benthos, marine and avian food cycles | - Interconnections between the benthic, fisheries and avian resources.<br>- Predator-prey interactions data | - Noise and vibration Impacts on fish and mammal habitats and migration.<br>- Assessment of the magnitude and frequency of underwater noise and vibrations, and the potential for adversely affecting fish and mammal habitats and migration<br>- Assessment of fish and mammal tolerance to noise and vibrations, with particular emphasis on noise and vibration thresholds that may exist for each of the species. |
| Aviation | - Lighting requirements, and radar interference and radio frequency interference<br>- Lighting scheme will need to minimize impacts to birds while also providing for safe aviation. | - FAA Analysis |
| Communication | - Possible impacts to telecommunication systems - Microwave transmission<br>- Impact on installation of the wind turbine generators between Martha's Vineyard, Nantucket, and the mainland on existing transmission paths.<br>- Impact on boater communications devices | N/A |
| Navigation | - Commercial and recreational navigation impacts need to be addressed specifically for construction, operation and maintenance and decommissioning. - Cable installation activities to be included.<br>- National security issues | - U.S. Coast Guard Risk Analysis |
| Socioeconomic Impact | - Possible impacts on electricity rates and reliability in New England<br>- Explanation of any public funding and any applicable tax credits<br>- Impact on local economy including affects to employment, tourism, boating and fishing, coastal property values and local tax revenues and other fiscal impact to local governments<br>- Environmental justice issues<br>- Educational and tourism impact | |
| Electric and magnetic fields (EMF) | - Data on potential human health impacts of exposure to 60Hz EMF and potential impact from EMF produced from wind turbine generators and their associated cables, and the transmission cable | - Identify populations that could be exposed to 60 Hz EMF greater than 85mG, including human, fish, marine mammals, and benthic organisms |
| Air and Water Pollution Impact | - Compliance with the requirements of the Clean Air Act for construction and operation phases.<br>- Potential for impact on the climate of the region<br>- Potential for spills of contaminants into water | - Emergency response plans to mitigate impacts.<br>- Construction protocol. |

**Table 8.25 Social Impact Scope of the EIS (Based on the U.S. Army Corps of Engineers EIS Scope Document)**

| Category | Issues to be Studied | Methodology to be Used |
|---|---|---|
| Aesthetic and Landscape/Visual-Assessment | - Visual impacts to any National Register-eligible site in proximity to any of the final alternatives | |
| Archeological Impact | - Any impact on historic districts, buildings, sites or objects, local character and culture, tradition, and heritage will be included<br>- Archeological surveys for final site | - Survey based on previous archaeological and geological investigations,<br>- Magnetometer and high resolution side scan sonar surveys will be needed sufficient to provide electronic data which can be analyzed to assess the potential for any artifacts, such as shipwrecks, followed up by diver reconnaissance where needed.<br>- If resources are found which are eligible for listing on the Register of Historic Places, ways to avoid, then minimize, impacts to cultural resources will be considered and discussed. If avoidance is not an option, a Memorandum of Agreement may be required to mitigate potential impacts. |
| Safety Issues | Safety considerations will include public and employee safety through construction, operation and decommissioning. | - Design standards for the structures will be explained. List of preparers will include the names and qualifications of persons who were primarily responsible for preparing the EIS and agency personnel who wrote basic components of the EIS or significant background papers must be identified. The EIS should also list the technical editors who reviewed or edited the statements. Cooperating Agencies and their role in the EIS will be listed. |
| Public Involvement | - List the dates, locations and nature of all public notices, scoping meetings and hearings. The scoping meeting transcripts and summary of comments report to be provided as an appendix. | |

### *8.10.3 Capturing effects that expert-only representation couldn't capture*

A fundamental difference between the stakeholder-assisted systems representation and the EIS scope is in the scope of decisions each are designed to support. While the scope of EIS is aimed at producing the knowledge necessary to decide whether or not the permitting agency should approve or deny the permit application for a particular location, or approve it with minor conditions, the stakeholder-assisted systems representation is designed such that it can provide a comparison between different alternatives for the long-term management of the system over its entire lifetime. This extends beyond construction, and impacts the design and management of the system based on its emerging behavior.

*Energy Subsystem:*

The EIS only looks at the impact of the proposed wind energy plant on local electricity rates and lacks a comprehensive energy subsystem. This is not surprising, since the permitting decision is not focused on the overall impact of the proposed plant on the regional energy issues. The stakeholder-assisted systems representation looks in detail at energy consumption, energy production, energy economics and wind farm characteristics in a comprehensive and holistic manner. The differences arise in the definition of the problem and the system boundaries. The stakeholder-assisted systems representation enables the exploration of the following questions, which cannot be answered with the EIS scope:

1. How much energy demand will there be in the coming years in the Cape and the Islands?
2. How much available energy will there be if no new plants are built?
3. How would investments in different energy capacities impact energy supply?
4. What does it take for 5% of the energy supply in Cape and the Islands to come from renewable sources by 2010?
5. What are the impacts of the different tax incentives, green credits, environmental research funds, mitigation funds, capital interest and fossil-fuel price fluctuations on the rate of electricity in the region?
6. What effect would different leasing policies have on energy economics for the offshore wind energy?
7. How competitive would offshore wind energy be given a range of different oil and gas prices?
8. What is the impact of direct distribution to towns versus grid distribution on electricity costs?
9. What combination of design parameters would make the project economically feasible?

10. What is the impact of moving the project from the proposed place to another one in terms of economic and technical feasibility?

*Environmental Impact Subsystem*

The environmental impact subsystem of the EIS is rather comprehensive and comparable to the stakeholder-assisted systems representation in terms of the components and linkages it is exploring. Differences are minor, and revolve around different emphases on which endangered bird species were to be studied. The EIS lacks sea ducks as a component, while the stakeholder-assisted representation lacks piping plovers. What is missing from the scope of the EIS is a comprehensive approach to the global impacts of GHG reduction, and the impact of air pollution emission reduction potentials on public health in the region.

*Socioeconomic Impact*

In terms of socioeconomic impact, the two representations are comparable. The main difference is the existence of long-term impact layer in the stakeholder-assisted representation, which looks at the project as a precedent setting case.

*Navigation, Aviation and Safety Impacts*

The two representations are again quite similar in terms of navigation and aviation impacts. In addition to the issues covered in the EIS, the stakeholder-assisted representation considers challenges to search and rescue helicopter operations, and the potential for upgrading turbines with more advanced technologies (flexible turbine designs).

*Public involvement*

The stakeholder process layer of the stakeholder-assisted system representation is far more comprehensive than its EIS counterpart, capturing the effect of conflict and potential delays in project implementation in the overall cost of the wind energy proposal and tying participation and conflict resolution back into project economics.

*8.10.2 Usefulness of representation for suggesting strategic alternatives for improved long-term management of the system*

The stakeholder-assisted systems representation allows decision-makers to explore a variety of decision options in addition to the Yes/No decisions on a particular location. Table 8.26 shows the Yes/No alternatives, along with four additional packages that could help address many of the uncertainties of the project, even within the current location.

**Table 8.26 Sample alternative packages that can be identified based on stakeholder-assisted system representation**

| Package/ | 1 | 2 | 3 (Yes option) | 4 | 5 | No build |
|---|---|---|---|---|---|---|
| Number of Turbines 2006 | 80 | 130 | 130 | 130 | 80 | |
| Number of Turbines 2010 if impacts as anticipated | 130 | 130 | 130 | 130 | 130 | |
| Continuous Monitoring | Yes | Yes | No | Yes | Yes | |
| Mitigation Insurance Fund | No | Yes | No | Yes | Yes | |
| Environmental Research Fund | Yes | Yes | No | Yes | Yes | |
| Lease Payment | Yes | Yes | Yes | No | Yes | |
| Shutdown during peak migration season | Yes | Yes | No | Yes | Yes | |
| Potential Removal of Particular Turbines with Disproportionate Higher Impact | No | Yes | No | Yes | Yes | |
| Return of Mitigation Insurance Fund to Developer if Impacts equal or less than Anticipated | No | Yes | No | Yes | Yes | |
| Favorable support to expand Windfarm further if impacts less than anticipated | No | No | No | No | Yes | |
| Developer required to upgrade with better technology every 10 years | No | No | No | Yes | Yes | |

The packages in Table 8.26 are just a few samples of packages that such a system representation could produce. Many more can be created using different combinations of the policy levers.

The main difference with the traditional permitting process is thus the possibility of *contingent* agreements. Contingent agreements allow for a project approval contingent upon future actions given particular circumstances.

*8.10.5 Completeness of representation (taking into consideration technical, social, political and economic considerations)*

As indicated earlier, the stakeholder-assisted representation addresses most of the issues addressed in the EIS, while also addressing other crucial issues that stakeholders view as part of the problem definition. As the stakeholder input in section 8.9 indicated, the existence of the extensive regional energy subsystem, the long-term impact layer, the stakeholder process layer and the post-construction monitoring layer allows for much more accuracy in addressing the issue at hand.

**8.12 Chapter Summary**

In this chapter we applied the SAM-PD process to the Cape Wind Offshore Wind Energy project. Specifically, we engaged stakeholders in the system representation, uncertainty identification and working group formation within a joint fact-finding context. We then compared the resulting system representation to the scope of the environmental impact assessment process and found that the stakeholder-assisted representation was more comprehensive, provided more decision-making options, captured effects that the scope could not capture, and included a plurality of views. Stakeholder survey results during a SAM-PD workshop also confirmed these observations. In the next chapter, we will look at the lessons learned from the Cape Wind case study, including refinements needed in the SAM-PD process based on the actual application of the process.

# ➲Chapter 9
## Learning from the Cape Wind Case Study

*Everything has been said before, but since nobody listens we have to keep going back and beginning all over again.*

*--Andre Gide, Le traite du Narcisse, 1891*

The Cape Wind case study outlined in the previous chapters provides interesting insights into some of the merits and drawbacks of collaborative systems representation, and provides an opportunity to refine the SAM-PD process. In this chapter we will reflect on these observations as they apply to different aspects of collaborative processes. To what extent these observations may apply to other collaborative processes is for the reader to decide.

### 9.1 SAM-PD Process Preparation

Process preparation is one of the most crucial elements for the success of any collaborative process. While every effort was made to overcome shortcomings with advanced planning and persistence, there were many obstacles, which did not allow for the SAM-PD process to be applied seamlessly. The main obstacles revolved around the fact that in order for a SAM-PD process to succeed, it has to be convened by an entity that is a formal part of the decision-making process. For the Cape Wind case study, there was not an entry point into the formal decision-making process for the research team. Additional issues included timing, critical stakeholder involvement, and insufficient face-to-face access to stakeholders.

*9.1.1 Importance of Involving the Decision-makers as Conveners*

The Cape Wind case study emphasized the importance of having actual decision-makers as process conveners. One of the main disadvantages experienced throughout the case study, was that we lacked the authority of a convener-appointed neutral. We indicated earlier that neutrals and facilitators have to be appointed by conveners and the stakeholder group respectively. A self-appointed neutral can only count on the interest and enthusiasm of stakeholders, and the high degree of controversy in a project to motivate stakeholders to take part in a collaborative process. In the case of Cape Wind, the name of MIT worked well in attracting stakeholders. This was due to a couple of factors. For some stakeholder groups, MIT presented the potential of a heavyweight ally or opponent for their cause. For other stakeholder groups, MIT's scientific and technical credibility seemed to ensure its support of renewable energy development[37]. Others thought that a stakeholder process would be a good way to delay the project, by undermining the validity of the current NEPA process. Still, we had to rely on extensive indirect stakeholder inputs (such as public hearings, press releases and newspaper articles) for many crucial stakeholders, who did not take part in our survey or participate in the stakeholder-assisted representation workshop. For most stakeholders, it took repeated requests to have them respond to the value assessment survey.

This would have been different, if SAM-PD had been used by the permitting agency (U.S. Army Corps of Engineers) or the Massachusetts Technology Collaborative (MTC). Recently after participating in the Cape Wind workshop on April 2, 2005, the Cape and Islands Renewable Energy Collaborative (CIREC) started a coordinated community energy planning for Cape and the Islands, and opted to use a SAM-PD process for collaboratively identifying policies at the household, town and regional level that would lead to a fossil-free Cape Cod by 2025. With the MTC and CIREC spearheading the project, many of the stakeholders we did not have access to have filled out the stakeholder value assessment survey and are participating in the collaborative process.

[37] When sending out emails, my signature read "Martin Fellow for Sustainability". On two occasions Cape Wind proponents responding to my emails assumed in their responses that I was a supporter of the wind project. This however did not seem to create any problems with the opponents of the project, since they saw my research as a tool to delay the project and declare the NEPA process bankrupt.

When the permitting agency is part of a convening group for a stakeholder process, there is a much higher perceived chance of the recommendations and agreements affecting the actual decision. This increases the attractiveness of the process for stakeholders, and gives it more legitimacy and formality.

### *9.1.2 "Right" Timing for SAM-PD Process*

An important research question that needs to be addressed empirically in the literature is the issue of timing of a collaborative process. The SAM-PD process is designed with the implicit assumption that stakeholders would be involved just after the initial problem definition stage of a decision-making process. Essentially this constitutes the earliest that a collaborative process can be initiated, since issues have to be at least initially defined and stakeholder groups have to be formed and ready to participate. Yet, as we move forward in the decision-making process we face tradeoffs. On the one hand all the crucial stakeholder groups will be easier to identify so that no key stakeholder groups emerge later in the process. Also a little emerging controversy is healthy since it helps keep stakeholder interested and engaged in the process. On the other hand, collaborative processes take time, and decision-making time windows are limited. Also, if stakeholders are already polarized to the extent that a collaborative process cannot build an initial trust among them, it may be too late for the process.

In the Cape Wind case study, the ideal timing for a SAM-PD process seems to have been as a part of the MTC stakeholder process in late 2002, when the issues were still being explored and the EIS scope had not been finalized. Unfortunately, we had not yet started with our case study at that time. However, it is important to note that other types of collaborative processes may be applied in later stages of a decision-making process. Because of the centrality of a stakeholder-assisted systems representation in SAM-PD, its application is more or less limited to earlier stages of the decision-making process.

*9.1.3 Critical Stakeholder Involvement*

While many of the crucial stakeholders took part in the Cape Wind case study, an important set of stakeholder groups were not motivated to participate. These included the various fishermen associations, the U.S. Army Corps of Engineers and the State Environmental Protection Act Office. The former did not respond to repeated emails and calls, and the latter excused themselves since they were involved in the decision-making process and did not wish to give the impression that this was a parallel process to the actual permitting process. This again demonstrates the need for an entry point into the actual permitting process, and the lack of legitimacy for a parallel process.

Additionally, who represented a contacted organization can also have an impact on the dynamics of the process. We observed that the higher ranking members of an organization had a more open hand in collaborating, since they were less concerned with how their statements may be seen as representing their organizations.

*9.1.4 Necessity of Extensive Face-to-face Interviews in the Value Assessment Stage*

While we elicited inputs from more than 190 stakeholder groups and individuals through online surveys, public hearing statements, press releases, newspaper articles, nothing seemed more effective than personal contact. Those stakeholders with whom we interacted on a more personal level, and face-to-face were more likely to participate enthusiastically in the process, or suggest other stakeholders. Face-to-face interactions allowed stakeholders to build more trust, and become more interested on a more personal level in the collaborative process. Therefore, while online surveys can make the inputs more structured and more useful for systems representation purposes, they fail to build trust by themselves[38]. In the Cape Wind case study, the personal touch was a result of personal interviews with a few stakeholder groups, attending public hearings, personally handing out over 300 research pamphlets to stakeholders, and chatting informally about the process.

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[38] One of the stakeholders told me informally that my Middle Eastern name may have had a hard time convincing people in less urban areas of Cape Cod to participate. He then hastily added:" But if they had seen you, they would have liked you a lot. You talk and sound very American to me" ☺.

### 9.2 Collaborative Process Dynamics

The face-to-face portion of the collaborative process in the Cape Wind case study, that is the stakeholder workshop was rather brief, and did not allow for observing many interesting phenomenon that would shed light on its dynamics. Still, the importance of the role of the facilitator emerged as an important considerations in a SAM-PD process. Aside from the skills and expertise of a professional facilitator, it is important for the system model gatekeeper (or modeler) to be a different person than the facilitator. Early in the collaborative process, some stakeholders made efforts at derailing the process by going back to detailed positions at a time when the larger picture was being discussed. In these instances it is imperative to have a facilitator other than the modeler, who can channel the discussions back to the initial process structure. It is important that the facilitator have the skill to avoid the domination of the discussions by the more aggressive stakeholders.

In the case of Cape Wind, the modeler played the role of the facilitator for the first part of the workshop, and various MIT students were briefed on how to facilitate in the breakout sessions and appointed to different groups. In the first part of the workshop, where the idea of collaborative processes and an overview of the system representation were presented, two stakeholder groups got into verbal disagreement. The modeler had to cut both of them short abruptly, and emphasize that they could continue the discussion if it pertained to a particular breakout session later on. This did not sit well with the stakeholders who felt they had not been heard.

While breakout facilitators were given instructions and ground rules on how to manage the groups and record agreements and disagreements, their lack of experience led to more aggressive stakeholders in the group to be more dominant in the discussions. The ground rule of consensus-only modifications and suggestions helped in limiting the impact of this dynamic, but one could argue that with more experienced facilitation the breakout dynamic may have been more tractable. Also important was the necessity of contextual knowledge for each breakout group facilitator. We later established with the stakeholders, that what had been recorded in one of the breakout groups (Environment) was not what the breakout group had in mind. The facilitator of the breakout group was unfamiliar with some of the technical terms and therefore recorded a few of the ideas incorrectly.

### 9.3 System Representation as a Basis for Collaborative Process

While the basic structure of collaborative processes is similar, the use of a system representation can change some of the dynamics of the process.

#### *9.3.1 System Representation as a Knowledge Organization Tool*

What the majority of stakeholders agreed with, was that a system representation can be a good way to structure dialogue about a problem. Many stakeholders had experiences with past collaborative processes where extensive laundry lists were created, but never put into context. For most stakeholders it was refreshing to see how their views fit into the larger picture of the offshore wind energy system and interacted with other components. One stakeholder commented that it was not unlike putting together a puzzle or doing the New York Times Crossword Puzzles.

Most stakeholders found the term "system representation" to be misleading. They preferred the term model. Many said they would not distinguish between a qualitative model and a quantitative one, because a qualitative model could later on be quantified or mostly quantified. While it may make sense to distinguish between the two in academic settings, for practical purposes it is better to refer to the systems representation as a systems model[39].

#### *9.3.2 System Representation as a Trust-Building Tool*

The Cape Wind project has a history of bitter community relations. Many of the people invited to the workshop resented one another. Most had never talked to each other directly or held a constructive dialog. Given the nature of the system representation, where the emphasis is mainly on problem definition, rather than risk assessment, cost distribution and decision-making, this stage created an opportunity for stakeholders to interact without the

[39] Most stakeholders didn't even like the term "conceptual model", since that didn't seem adequate for the systems representation. The dominant preference was to call it "system model".

concern of having to compromise on anything. The stakes in a system representation are perceived as rather low, and the stage is far enough from the final decision-making stage that it allows stakeholders to be flexible.

With the time limitations announced, the teams started to work on modifying the systems representation. While it was initially awkward for people to interact, the feeling of creating a common product gradually led to interesting rivalries among different breakout groups. Consisting of stakeholders with differing views on Cape Wind, the teams came to consider their subsystem as a common product. Many of the teams would try to finish one section ahead of time, asking how the other teams were doing in terms of time, and whether any other group had come to an agreement on the representation. What started out as a skeptic group of people with personal reservations gradually gave way to a sense of enthusiasm.

This seems to suggest that if used from earlier stages of the collaborative process, a system representation can serve as a way for people to work together in different ways than they are used to, accelerating the trust-building phase that is of crucial importance of collaborative processes.

### *9.3.3 Ease of Interaction with a Systems Representation*

The concept of a system representation was intuitive to most stakeholders. It took stakeholders very little time to familiarize themselves with creating systems representations. Some stakeholders had problems in understanding the concept of polarities, or the signs on the directional arrows. In a system representation a positive arrow going from one component to another means that an increase in the effect of the first component will lead to an increase in the effect of the target component. In other words, it is an issue of directionality of change rather than a positive or negative influence. While this had been described to stakeholder during the presentations, some stakeholders in found this to be non-intuitive. While polarities are crucial to understanding the dynamics of a system, it may be better to introduce them at later stages, when stakeholders are comfortable with the basic concepts of systems representation.

### *9.3.4 Importance of Policy Levers*

Stakeholders particularly liked the concept of "policy levers". As described in Chapter 2 policy levers are components of the system that can be "tweaked" to affect the system as a whole. For most stakeholders the rationale behind a system representation only became clear when they understood that there are components in the systems that are decision variables. Most stakeholders felt more in control of the system representation after this point was explained to them. Any time they started to look at the subsystem, most teams started with looking at the policy levers and working their way through the representation. Stakeholders commented that the existence of so many policy levers would mean a wider range of decisions that could be made.

### 9.3.5 System Representation as a Working Team Formation Tool

The ability of stakeholders to look at different parts of the system as a whole rather than at individual issues in a laundry list provides an opportunity to assign different working groups to evaluate different parts of the system. In the workshop, stakeholders initially defined ideal working groups that could be assigned to various aspects of offshore wind energy projects. Many had suggestions on how to lump different linkages into one working group, due to the similarity of expertise and resources needed. Overall stakeholders found that having a systems representation would allow them to make sure that all the important aspects of the problem were covered and could be assigned to different working groups.

### *9.3.6 Systems Representation and Uncertainty*

Prioritizing uncertainty was one of the first more controversial issues in groups. Stakeholders realized that uncertain areas were more prone to be included in the evaluation and assessment stage. Opponents therefore emphasized uncertainties that were hard to reduce (environmental), while proponents focused on uncertainties of regulation, market, terrorism etc. The prioritized list shown in Table 8.21 essentially was a compromise between the different stakeholders. The system representation allowed stakeholder to see how those uncertainties would impact the system as a whole, rather than a particular component. This allowed discussions in the breakout groups on whether an uncertainty however large would have an important impact on the system. The idea of color-coding uncertain links was met with mixed reactions. Proponents did not like red as the color for large uncertainties and believed such a color-coding could give the perception that the project is flawed. Opponents were rather fond of the idea. In hindsight, showing uncertainty in the system representation has to be rethought and refined.

### *9.3.7 Need for Quantification*

Nearly all stakeholders assumed that the current system representation would have to be quantified in order to be useful. Parts of the representation dealing with institutional issues could be left as contextual and qualitative considerations, but stakeholders seemed to see one of the advantages of the system representation in the *VenSim* environment to be the possibility of quantification. What seemed attractive to stakeholders was the ability to look at dozens of alternative strategies and potentially compare their impacts across the different performance metrics identified. For this reason, stakeholders see the system representation and its subsequent quantification as a promising tool throughout the decision-making process.

## 9.4 Compatibility of SAM-PD with Current Permitting Process

Most stakeholders were vague on how a SAM-PD process may fit into the current permitting process. Some had initially assumed that the idea was to have system representations to capture ideas during the public hearings. Others saw this process as a promising parallel process that would produce recommendations that the permitting agency could then use as one additional criterion for its decisions. The general impression was that without serious changes to the current NEPA process such a process would have limited value. On the other hand stakeholders agreed that it would be necessary to show the merits of such a process in action before any steps would be taken to make it part of the NEPA process.

In the case of Cape Wind, most stakeholders thought that this process came in too late in the process. They would have preferred to see such a process in late 2002 instead of now. The developer was skeptical about any role of collaborative processes in the current permitting process for the Cape Wind project, and had therefore requested that the workshop focus on post-Cape Wind offshore wind energy projects.

Peyser (2004)[40], an MIT graduate student working with MIT-USGS Science Impact Collaborative (MUSIC), has looked at the potential of incorporating collaborative processes into the current NEPA process for offshore wind. She argues that section 101 of the National Environmental Protection Act, which focuses on "productive harmony" between man and nature can be interpreted as an imperative for collaborative processes.

Essentially, collaborative processes could enter at any stage of the NEPA process in different forms. However, a system-representation centered collaborative process is more suited to the initial stages of the decision-making process and can currently serve as a parallel process with actual NEPA processes, providing consensus-based recommendations, which the permitting agencies would most probably consider an important basis for their decisions.

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[40] Peyser Jennifer, "Joint Fact Finding for Public Involvement in Wind-Permitting Decisions: Beyond NEPA", MUSIC Website, http://web.mit.edu/dusp/epg/music/pdf/peyser_000.pdf (last accessed April 15, 2005)

## 9.5 Additional Insights From the Cape Coordinate Community Energy Planning Process

As mentioned briefly, the Cape and Islands Renewable Energy Collaborative (CIREC) and the Massachusetts Technology Collaborative (MTC) opted to use the SAM-PD process as the basis of a new coordinated community planning process for the future of energy in the Cape and the Islands. The stakeholder groups invited to the coordinated community planning process included many of the same stakeholder organizations as for Cape Wind. In addition, it included stakeholders that the Cape Wind case study did not have access to. Similar to Cape Wind case study, a system representation was created based on a stakeholder value assessment survey. A professionally facilitated collaborative system representation session was held on Cape Cod.

With the SAM-PD process used right from the beginning of the process, the system representation was quickly embraced as a way to organize the knowledge needed to design and evaluate strategies that could allow the Cape to aggressively move in the direction of energy independence and fossil-free energy supplies. Again, stakeholders who had not participated in the Cape wind workshop became enthusiastic about using a system representation and helped refine the representation. Furthermore stakeholders unanimously asked to continue the process to its completion. Due to the ongoing nature of the process, it was not possible to use the case study as part of this dissertation. The initial system representation however can be viewed in Appendix D.

Again the observation was made that after an initial resistance towards the idea of a collaborative process, participants (which included decision-makers, fossil-fuel and renewable energy providers, journalists, energy economists, environmental groups, and town representatives) became engaged and enjoyed the process.

## 9.6 Chapter Summary

In this chapter we looked at what was learned from the application from SAM-PD to the Cape Wind case study, and how the process had to refined and marketed in order to be most effective. Overall most stakeholders, who initially had doubts whether collaborative process would work, eventually embraced the concept of a system representation as a central piece of a collaborative process. It seems that had the process been initiated together with the MTC stakeholder workshop, it could have had an actual impact on the actual decision-making process.

The case study showed what changes to the SAM-PD process could make it more attractive for stakeholders. It also highlighted the importance of having professional facilitation and decision-maker support in the process. The case study also revealed that the SAM-PD process can expand the decision-space of a problem by providing many policy levers which can be used to modify the system in a way that goes beyond a yes/no decision in a permitting process.

In addition to permitting processes, SAM-PD can be applied to strategic management of engineering systems. In the next chapter, we will look at how a SAM-PD process might have been applied to Transportation Air Quality Strategies in Mexico City.

# ➲Chapter 10

## The Mexico City Transportation/Air Pollution System

*There is a 50% chance that the temperature rise in the 21st century will be above 2.5 degrees Celsius, a change that is considered to be very serious indeed with potentially very nasty consequences. Let us assume your physician tells you that you need to take a certain medicine that does not taste good and that might make you drowsy for several days. He also tells you that there is a 50 % chance that you don't really need the medicine - you might heal without it. On the other hand, he tells you that if you don't take the medicine you might get really sick. What would you do? (I myself would take the medicine, but admittedly, this is a matter of choice).*

*-- Prof. Mario Molina on Global Climate Change*[41]

### 10.1 Applying SAM-PD to the Mexico City Transportation/Air Pollution System

The Mexico City Project at MIT[42] was the brainchild of Mario Molina, Chemistry Nobel Laureate in 1995. It was one of the most ambitious efforts at an integrated assessment of air pollution impact on a metropolitan level. From 1999-2004, the Mexico City Project provided many qualitative and quantitative-based recommendations for emissions reduction from mobile sources in the Mexico City Metropolitan Area. However most of these recommendations have not had much success in implementation. While there are many possible explanations for the slowness in implementation, a perceived lack of ownership in the decision-making process by crucial stakeholders could be considered an important factor.

In this chapter, we will look at how such a complex project could have improved its impact on the air pollution problem in Mexico City by integrating stakeholder involvement in the structuring of its knowledge generation right from the beginning. Particularly, given the

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41 At a press conference at the Harvard Center Health and the Global Environment addressing global climate change on June 11, 2001. http://www.med.harvard.edu/chge/kerry.html

42 See the Mexico City Website at http://eaps.mit.edu/megacities/

importance of the transportation system in the air pollution problem, we will focus on the potential ways the SAM-PD process could have helped in developing recommendations that would have an improved chance of implementation. Unfortunately, due to funding limitations and the termination of the Mexico City Project at MIT, there was no possibility of getting the necessary actual data to construct a full-scale system representation and involving actual stakeholders in the process. However, the analysis illustrates how SAM-PD could also be used for strategic management of existing engineering systems.

### 10.2 Background on the Mexico City Transportation/Air Pollution System

The Mexico City Metropolitan Area (MCMA) with a population of nearly 20 million people is the second most populated metropolitan area in the world after Tokyo. It is a vital part of the Mexican economy, hosting more than 37000 industries and contributing to more than 30% of the national GDP (Gobierno DF 2001). The urban transportation system in the MCMA is by necessity a large system, composed of 3.5 million vehicles within different transportation modes serving passenger- and freight transportation, with a large impact on the city's everyday activities and long-term development. In the past decade, there has been a sharp increase in transportation demand, using aging infrastructure with limited capacity. Congestion and longer trip times have followed, contributing to a more severe problem of air pollution. The interactions between people, technology, social, economic and political issues within the system are difficult to predict, making it a good example of an engineering system (Mostashari, 2003).

Currently, Mexico City is the fourth most polluted city in the world (being the most polluted city just a decade ago). Despite two decades of effort by the local and federal governments, improvements in air quality have had mixed success at best. Continued population growth, and limited enforcement of existing environmental protection regulations have contributed to the limited impact of governmental policies for pollution mitigation. On the one hand, significant improvements were achieved in some of the critical parameters for air quality. Examples were the dramatic reductions in lead concentration and in emissions of CO. Sulfur dioxide pollution has also been reduced in sufficient amounts to achieve healthy levels in the MCMA (World Bank, 2000). On the other hand, according to the World Health Organization, the average level of particulate matter in the city exceeds international standards by a factor of two. And in 1999, ozone levels exceeded international standards for 212 days during the year. Air pollution-induced mortality was estimated to be 4,520 people annually in 1999. Infant mortality due to high particulate matter concentrations is 1.8% higher in the MCMA than in the rest of Mexico (EHP 1998). In addition, atmospheric oxygen levels are 23 percent lower than normal, due to the area's high elevation, which results in less efficient fuel combustion and higher pollutant emissions. The air pollution situation is exacerbated by the fact that the entire area is surrounded by various mountain ranges that function as a natural barrier, trapping gases and particulate matter (CAM 2001).

The transportation sector is a major source of air pollution in the Mexico City region, accounting for nearly all CO, more than 75% of its NOx, 35% of NMHC, 24% of SO2, and 41% of PM10 (CAM 2001). There have been many attempts to reduce this effect by modernizing the transportation fleet, use of alternative fuels, inspection and maintenance and setting stricter emission standards. However many of the policies have resulted in unintended consequences not foreseen at the time they were drafted. For instance, the "Hoy No Circula" program designed to limit auto use on specific days actually resulted in increased auto ownership in the MCMA (Molina and Molina 2002). In addition, with the looming economic and political uncertainties and upheavals in Mexico in the past five years, the air pollution problem has slipped in the public awareness and lost its momentum on the priority list of decision-makers.

### 10.3 The Mexico City Project and the Impact of Its Recommendations

The Integrated Program on Urban, Regional and Global Air Pollution, funded by the Mexican government and the World Bank, was initiated in 1999 at MIT to pursue air pollution impact on megacities in a coordinated and interdisciplinary manner. The program used Mexico City as its principal case study. Much of the extensive initial research has been published in "Air Quality in the Mexico Megacity" book[43] and more extensive studies will be published in a subsequent book in 2005.

At its height, the Mexico City project employed nearly a hundred researchers at MIT, Harvard University, the Autonomous University of Mexico and the Monterrey Institute of Technology, working on various aspects of air pollution ranging from bottom-up emission models for transportation, energy sector, industry, commercial sector, residential consumption, and the informal sector, to health effects, atmospheric chemistry, and stakeholder involvement. It held a total of seven workshops together with decision-makers in Mexico City, Mexico and Cambridge, MA to assess progress and exchange information and ideas.

Generally, there are many issues that limit the use of technical recommendations and scientific findings in actual decision-making processes. These include inadequate communication of uncertainties to stakeholders, inadequate communication of technical rationale, inadequate consideration of social and institutional feasibility, inadequate stakeholder involvement in the decision-making process and poor coordination among technical teams working on various aspects of an engineering system. In the following paragraphs we will look at these and other factors in more detail.

### *10.3.1 Inadequate stakeholder understanding of uncertainty inherent in scientific analysis*

While it is obvious for scientists that scientific analysis has inherent uncertainties, it is harder for non-expert stakeholders to accept that scientists often can't make definite statements. While scientists are trained to think in an uncertain world, stakeholders want assurances that a recommendation will *definitely* solve the problem in question. This becomes more and more of an issue when the stakes in a problem are high, and when decisions impact many stakeholders. In the Mexico City project, this was seen in the reactions of the participating Mexican decision-makers. Many were surprised that the MIT

[43] Molina M., Molina L.T. (Eds). "Air Quality in the Mexico Megacity: An integrated assessment", Kluwer Academic Publishers, 2002.

team of domain experts was not able to produce solutions that would give a crystal clear picture of the air pollution. When uncertainties were highlighted in the presentation of research results, the visiting decision-makers were often slightly dismayed and sometimes impatient.

Salter (1988) identifies four types of uncertainty that are encountered in what she calls "mandated" science, that is, science used in policy making. They include:

a) Uncertainty due to underdeveloped state of knowledge: This type of uncertainty that will be resolved in time through the normal progress of disciplines. In the case of Mexico City, this includes everything we didn't know 10 years ago about the atmospheric chemistry of Mexico City, which we know now.

b) Uncertainty from input data: The second type of uncertainty results from unavailability and inadequate access to information, although there is an expectation of certainty on the part of decision-makers. In the Mexico City context, this can include input data, such as emissions data, travel origin-destination data or any other data that should be available, somewhere or measurable in some form, but may not be available in sufficiently reliable form to researchers, creating uncertainty in the validity of the outputs.

c) Uncertainty in the causal relationship between system components: This type of uncertainty involves the limits inherent in certain kinds of research and research methodologies. Given that "all models are wrong, some are useful", there is an accepted level of uncertainty in scientific methodology that may be obscure to non-experts. A good example in the Mexico City project is the vehicle fleet turnover and demand analysis models.

d) Uncertainty in dealing with increasing complexity: This type of uncertainty refers to the seemingly limitless complexity that can be discovered through scientific research, and the inability to produce final and comprehensive conclusions through open-ended inquiry. This is due in part to the complexity of the "real world" and interdisciplinary nature of technically intensive policy problems. In other words, the scientific issues involved in policy cannot be kept isolated in a laboratory where they remain uncontaminated by other variables. A good example of this type of complexity is the possible effects of emissions outside the Mexico City Metropolitan Area, or the effectiveness of emission reduction measures in the long run.

*10.3.2 Lack of effective communication of the rationale for recommendations to stakeholders (lack of transparency)*

The scientific/technical analysis used to arrive at the recommendations is often so complex, that non-experts (or sometimes even experts outside the domain) cannot understand the rationale behind the recommendations. Oftentimes scientists do not have the time or the inclination to come up with ways to educate the public or even the decision-makers on how their analysis comes up with the recommendations, making the science a "magical black box" that abides by the motto "take it or leave it". Many of the Mexico City project models were so complex that colleagues from other groups would have a hard time understanding the underlying assumptions, let alone the public.

*10.3.3 Inadequate consideration institutional and social feasibility of recommendations when framing strategies*

Questions of equity or justice often arise over the allocation of resources or the distribution of economic and social costs of technical recommendations. Many of the recommendations that the scientific community comes up with however, only consider societal feasibility only as an afterthought (if at all), not as one of the major considerations. Once recommendations are drafted, scientists and experts often leave issues of social and institutional feasibility to decision-makers. Given that the process is not always iterative, decision-makers are often stuck with recommendations that may not be socially or institutionally feasible at all. Thus, they turn away from science and make their decisions based on institutional interests, trying to give the appearance that the science has been used as a basis. This can also lead to many scientific recommendations becoming ineffective in the actual policy-making process. The actual framing of the question, the format of the output, and the consideration of social and institutional issues should be integrated into the initial scientific analysis process as important considerations.

*10.3.4 Lack of recommendations for actual implementation plans*

While in the Mexico City project efforts were made in to think through the implementation stage, the lack of adequate stakeholder involvement also separated the recommendations from actual implementation strategies. This is often not the case, given that recommendations require actual implementation plans that have to be drawn up by people who are familiar with the scientific analysis, and be brainstormed with those in charge of implementing them. This normally requires interdisciplinary trained experts, with good technical and scientific grounding, as well as extensive knowledge of the policy process, who can serve as an interface between experts and society. Additionally, the inclusion of stakeholder can allow for pooling available resources for implementation such as money and human resources, so the strategies can be designed more realistically. This highlights the importance of engaging stakeholders and decision-makers early on, so that sound and practical implementation schedules can be drawn up.

*10.3.5 Lack of sufficient interaction with stakeholders and decision-makers*

In the Mexico City project, the scientific/technical analysis was in for practical purposes separated from the stakeholder involvement process. Most stakeholders, decision-maker and expert interactions happened once or at most twice a year in the Mexico City workshops. The level of interaction, particularly in the first four workshops was limited to an audience listening to lectures. Only in later workshops did interactive games and interactive breakout groups become a major part of the workshop. However, in the rest of the year even different expert groups within the project did not interact extensively.

*10.3.6 Lack of sufficient interactions among different research programs*

Even more surprising than the lack of stakeholder engagement, is the limited cooperation among academic research centers. In many cases there are parallel academic efforts that address many of the same issues in different ways. This can result in the emergence of "competing scientific knowledge", where the decision-makers and stakeholders have to decide which one is "good science". Pooling resources among scientific knowledge producers and working together to solve a common problem could prevent this. The issue of pooled resources becomes very important in terms of available information for analysis, given that shared information can reduce many uncertainties that arise from unavailability of data. Unfortunately, most of the time this becomes an issue with financing research projects and competing grants for similar research, undermining effective cooperation. The Mexico City project had the option of working with the World Bank, and World Resource Institute's EMBARQ program, who were also focusing on the same issues, but coordination was not achieved during the project.

*10.3.7 Lack of prioritization of broad-based, multi-benefit recommendations*

Basically, the problem in policy decisions is one of allocation of resources. In addition to the environment, there are issues of economic development, employment, safety, education, non-environmental related healthcare, technological innovation and trade among others. Implementations of expensive policies that seem to undermine economic development is not what decision-makers are fond of. Often an effort has to be made to limit analysis to strategies that have benefits across multiple public policy objectives.

In other words, integrated assessment may often not be as integrated as it should be. When formulating strategies for emission reduction, attention has to be paid to strategies that have other benefits as well. This is particularly important for *selling* the recommendations to the decision-makers in times of economic difficulties, when environmental measures take the backseat.

## 10.4 Stakeholder Involvement in the Mexico City Project

### *10.4.1 Rationale For Involving Stakeholders*

Many of the obstacles in the impact of science in decision-making identified in section 10.3 can be addressed by involving stakeholders. The engagement of key stakeholders in the Mexico City air quality program design can have the following advantages:

- Improved representation of the system in question and improved framing of the problems.
- Pooled information and data sources and to reduce data uncertainty
- Task allocations to minimize parallel efforts and make best use of resources
- Diverse perspectives that can help consider social and institutional feasibility at the same level as scientific and technical feasibility
- Inclusion of potential "champions" or supporters of specific recommendations in the process
- Collective agreement on and understanding of inherent uncertainties and acceptable levels of uncertainty for decision-making purposes
- The inclusion of stakeholders and decision-makers with resources to implement policies in the process, and the resulting buy-in of the recommendations. However, there are also downsides, which have been discussed earlier in this research

### *10.4.2. Stakeholder Conflict Assessment for Mexico City*

Recognizing the value of stakeholder involvement, the Mexico City project started a collaborative process in late 2003, to involve decision-makers and other crucial stakeholders more pro-actively in the project. Prof. Lawrence E. Susskind and his doctoral students, Christina Rosan, Rebecca Dodder and Dong Young Kim initiated a stakeholder conflict assessment for the Mexico City project. They identified more than 50 stakeholders and conducted face-to-face interviews with many of them. The goal of the stakeholder conflict assessment was to:"

- Produce an understanding of the range of stakeholders' views on the adequacy of the existing institutional arrangements to deal with environmental, transportation, and land-use management in the MCMA.

- Provide an understanding of the range of stakeholder views about the likely benefits and costs associated with implementing stricter environmental regulations in the MCMA to reduce air pollution.
- Assess whether or not direct negotiations among the relevant stakeholders and regulators will have a good chance of leading to a constructive resolution of metropolitan and environmental management issues in the MCMA " (Susskind, 2004)[44]

The results of the interviews are currently being compiled and are not available for analysis. Unfortunately, the subsequent stages of the collaborative process were cut short by a lack of funding and the termination of the Mexico City project at MIT. Fortunately the Mexico City project will continue on a more limited basis at the University of California-San Diego and the Mario Molina Center for Energy and Environment.

An essential challenge with the timing of the stakeholder process was that it came after the technical experts in the Mexico City project had completed its studies and reports. This step, if taken at the beginning of the project in 1999, could have resulted in a far more successful set of recommendations that would have a higher chance of implementation in today's political climate in Mexico. Additionally, the lack of funding made the continuation of the process rather difficult. More importantly, the process started too close to the Mexican elections, at a time when intermediate- or long-term commitments are rarely embraced by decision-makers. We will discuss this further in section

In the following section, we look at how a SAM-PD process could hypothetically have been applied to the transportation/air pollution system. In reality, SAM-PD would have been adapted to evolve based on the above-mentioned stakeholder conflict assessment stage.

[44] Susskind, L. et. al. "Recommendations On Institutional Reform", project proposal to the Program for Urban, Regional and Global Air Pollution, 2004.

## 10.5 Using SAM-PD for the Mexico City Transportation/Air Pollution System

In this section, we will go through the SAM-PD process steps to illustrate how it would be applied to the Mexico City transportation/air quality system.

### *10.5.1 Initial problem definition*

The air pollution problem in Mexico City has been identified as one of the most pressing environmental issues in Mexico. The transportation sector contributes to more than 70% of the pollutant emissions. The problem has been addressed in different ways in the last three decades by federal and metropolitan agencies.

### *10.5.2 Determining the convening organizations and the neutral*

A variety of Federal, state and metropolitan institutions in Mexico are concerned with this issue, but a reasonable strategy is having a federal agency like the SEMARNAT (the Federal environmental protection agency) as the prime convener and metropolitan commissions such CAM (Metropolitan Environmental Commission) and COMTREAVI (Metropolitan Transportation Commission) as co-conveners could ensure support on all levels of Federal, state and local governments for the process. The location where collaborative meetings take place have to be on grounds which the stakeholders will consider as neutral. It also needs to have audiovisual facilities required for the process, be accessible to all and a large enough location to hold everyone comfortably. It also needs to be available for as long as the group needs to meet, which can be for several months, or even years (Burgess, 1996).

Given that neither CAM, nor COMETRAVI have an allocated space for this purpose, SEMARNAT could provide the location as the main convener.

Consensus building processes can be expensive, as they involve a lot of people over a long period of time, using multiple facilitators, analysts and other neutrals and often outside technical experts. For the purpose of this process funding could come from SEMARNAT and further funding may be requested from the Global Environmental Fund, to ensure continuity of the process.

Usually, the convening group has to determine the neutral. Given Prof. Molina's reputation in Mexico, the Mexico City project could have served as the neutral.

### *10.5.3 Stakeholder Identification*

In the case of the MCMA transportation/air pollution problem the following initial list of stakeholders should be considered:

**A) Government Agencies**

Federal (National) Government and National Oil Company

**SEMARNAT (Secretaría del Medio Ambiente y Recursos Naturales***)*

SEMARNAT is the national environmental protection agency. Its purpose is to "create a national environmental protection policy reversing the tendencies of ecological deterioration and establishing the bases for a sustainable development in the country". Regarding air pollution, it is mostly concerned with enforcement of emission standards for point sources. Its agenda for transportation related air pollution is limited to funding for air pollution research and the conversion of governmental vehicles to low emission vehicles. However, SEMARNAT can also allocate funds to state and local environmental agencies for their air quality programs.

**SCT (Secretaría de Comunicaciones y Transportes)**

SCT is the equivalent of the U.S. Department of Transportation. As a federal agency, it is responsible for setting vehicle standards at the national level, as well as federal public transportation subsidies. It can also provide funding for state or local projects dealing with transportation infrastructure development.

**Hacienda (Federal treasury)**

Hacienda is the Federal Treasury and is in charge of collecting taxes and monitoring the state of the economy. It is also one of the most powerful agencies in the Federal government whose support or opposition in any program can directly affect the outcome.

Willingness to implement strategies: Hacienda is an important player in any fuel tax increases, since this will have an impact on inflation and consumer price index changes. Given that gasoline taxes already make up 60% of its price, the Hacienda is likely to resist substantial fuel tax hikes.

**PEMEX (PEtroleus MEXicanos)**

PEMEX is the state-owned oil company. Although not a regulatory agency, it is an important actor in air quality programs, due to its control over fuel quality and provision. PEMEX has responsibility for oil and gas drilling, refining, and transport within Mexico. Because Mexico is a large net oil exporter, PEMEX serves as a major profit center for the Mexican government, generating a sizeable fraction (up to 30%) of total revenues for the national government. It is therefore one of the most powerful stakeholders in Mexican politics. At the same time, because it is state-owned, it is subject to political control. PEMEX can therefore be forced to make investments for environmental or other purposes more easily than could private companies. The national government therefore faces a balance in running PEMEX between maximizing its profitability and meeting other social objectives such as employment and providing fuel to the public at low prices (Zuckerman 2001).

PEMEX is an important stakeholder in the retrofitting strategies, since emission control technologies such as three-way catalysts and PM/NOx filters are sensitive to fuel quality. For the most effective catalysts and filters to be installed, sulfur levels should be lower than 30 ppm for gasoline and 50 ppm for Diesel. This imposes additional costs on PEMEX, which it can only partially recover by increasing fuel prices. PEMEX would also oppose additional fuel taxes, since this will affect their market, without benefiting the company. Currently PEMEX has plans to introduce low-sulfur gasoline in 2008 and low-sulfur diesel in 2010, which is far later than anticipated in the analyzed strategies (PEMEX 2002).

State Governments

*Federal District (DF) Agencies*

**SETRAVI (Secretaría de Transportes y Vialidad de la ciudad de México)**

SETRAVI is the Federal District's transportation agency. It supervises the inspection and maintenance program within the DF. It is responsible for issuing permits to colectivos and taxis and supervises the Metro and the trolleybuses. It also supervises vehicle replacement or scrappage programs.

**SMA (Secretaria del Medio Ambiente)**

SMA is the Federal District's environmental agency. It supervises the "No driving day" (Hoy No Circula) program, and maintains an emissions inventory of the MCMA together with INE and CAM. It is also responsible for funding research programs aimed at reducing air pollution in the MCMA.

*State of Mexico Agencies*

**SCT-EM (Secretaría de Comunicaciones y Transportes del Esatdo de Mexico)**

SCT-EM is the State of Mexico's transportation department. It essentially parallels SETRAVI's activities in the State of Mexico. The standards set by SCT-EM for vehicle emission standards are less stringent than the standards set by SETRAVI in the DF, resulting in ineffectiveness for the inspection and maintenance program (Molina and Molina, 2002).

**SE-EM (Secretaria de Ecologia)**

SE is the State of Mexico's environmental agency, and parallels the DF's SMA. Its main activities are not in the area of air pollution, but it is the only regulatory agency in charge of the environment in the State of Mexico and is therefore an important player in any metropolitan-wide air quality program.

Metropolitan Agencies

Given the diverse set of jurisdictions in the MCMA, metropolitan agencies were established to coordinate air quality programs across different agencies in the DF, the EM and the federal government. There are two main metropolitan agencies involved in transportation-related air quality efforts: CAM and COMETRAVI.

**CAM (Comision Ambiental Metropolitana)**

CAM was created in 1996 to coordinate between national and state governments on metropolitan-wide environmental programs. CAM has among its members several national government agencies, including SEMARNAT, the ministries of Commerce and Industry, Health, and Energy and Mining. It also includes major non-regulatory stakeholders, such as PEMEX. The key players, however, are drawn from the state governments. The president of CAM rotates every two years between the EM governor and the DF mayor, and the technical secretary rotates between the states' environmental ministers (Zuckerman 2001). CAM is essentially the major force behind any air quality program in the MCMA, and is the agency responsible for designing and implementing the PROAIRE. It has currently succeeded in negotiating federal assistance for substitution of older taxis with conventional new vehicles such as the Nissan Sentra.

**COMETRAVI**

COMTRAVI is similar to the CAM in that it has responsibility for ensuring that the DF, EM, and national government work together. In this case it is on issues related to transportation in the MCMA. Its most visible contribution has been the initiation of the "No driving day" (Hoy No Circula) program, which is considered a mixed success (Makler 2000). COMETRAVI has traditionally focused on transportation Supply/Demand management and the inspection and maintenance program (Makler 2000). It is hoped that by CAM and COMETRAVI serving as co-conveners, they could be rejuvenated again.

<u>Private Sector Stakeholders</u>

**Automobile Manufacturers**

The automotive industry in Mexico is one of the most important industries (the oil industry is the most important). Mexico is currently the ninth largest Automobile exporter in the world. This gives the automobile manufacturers a strong lobbying power. The companies manufacturing in Mexico are: Volkswagen, Ford, Renault, BMW, Honda, Volvo, General Motors, Daimler Chrysler, Nissan and Mercedes Benz. These companies will be important players in any air quality program dealing with vehicle technology or vehicle scrappage. Among these players, General Motors and Honda are the only two with commercially-available hybrid vehicle models. Toyota Mexico on the other hand has a dealership which imports vehicles from its manufacturing plants abroad. A more detailed discussion of the Mexican Auto sector and its interests in air quality programs can be found in Aoki (2002). Among the different car manufacturers, Toyota is the only one aggressively marketing its hybrid vehicles to the Mexican government. Toyota has loaned ten of its "Prius" hybrid vehicles to SEMARNAT for one year. The Ministry is utilizing the cars to facilitate its multiple activities within Mexico City. The performance of the vehicles will be evaluated by Toyota and Ministry participants on a monthly basis in order to learn how hybrid technology adapts to Mexican driving conditions and what can be done to improve it.(EV World, July 2003). Toyota intends to sell 300,000 hybrid vehicles a year by 2005, with 15% of that market intended for Mexico (ENN 2002). Toyota Mexico does not have a production plant in Mexico at the moment, and acts only as an import and distribution company.

**Freight companies**

Freight-oriented companies (both shippers and carriers) are also a strong political force in Mexico. They seek low transportation costs, and would generally object to any fuel tax increases (especially on diesel) or filter retrofitting regulations, which would impose higher costs on their fleets or cargo, unless they are compensated. A more detailed discussion on the freight sector, and its organizational structure can be found in Bracamontes (2003).

Fleet Owners and Operators

**Taxi fleet owners and operators**

In 2002, there were 104,694 legal and 22,000 illegal taxis (pirates) in Mexico City, creating the largest fleet of taxis in the world (IPN 2002). The taxis are driven by the owners as well as operators leasing the vehicles. Taxi owners normally drive their vehicle for one shift (approximately 5-10 hours) and lease their vehicle out for a second shift. They will be directly affected by any regulations on vehicle age, retrofitting and scrappage, and would generally oppose having to make any new investments in vehicles, unless they are compensated in some form. Taxi operators (drivers) can be owners or operators of taxis. If they lease the vehicle, the only issue of concern would be the daily lease and the total cost of fuel that they have to pay for themselves.

**Colectivo fleet owners and operators**

There are approximately 32,000 colectivos in the MCMA. Colectivo owners are concerned with any changes in the public transportation structure that will affect their economic investments. They often own more than one vehicle and lease the additional vehicles out to operators. Any requirements for retrofitting or scrappage will directly affect their profits. While by sectoral nature they are independent, they have formed associations which protect their interests. Colectivo Associations are associations formed by colectivo owners and concession holders which deal with issues like fares, route operator assignments and territorial disputes between the operators (COMTRAVI 1999). Colectivo Operators can be vehicle owners or concession holders. If they don't own the vehicle they are mostly concerned with the daily price of leasing the vehicle rather than overall cost (COMETRAVI 1999).

**Bus fleet owners and operators**

In 1985, the RUTA-100 bus company serving all of the MCMA was dismantled due to financial difficulties, and the routes were concessioned to private bus companies. Eleven companies assumed the commitment to maintain the routes of the existing 24 RUTA-100 operating divisions, introducing 2,900 buses and servicing 165 routes over a 10 year period with a renewal option. Three of these companies were taken over by former Ruta-100 managers and drivers (GEF 2000). The most important bus operator in the Federal District is RTP, which operates under the supervision of SETRAVI. It essentially took over most routes of Ruta-100 within the Federal District, and is transporting an average of 900,000 passengers per day (Dodder 2002). In addition to RTP there are four more companies serving the DF, serving only 60% of the initial Ruta 100 routes (Schaeffer 2000). The bus companies have little or no coordination in most cases, and serve overlapping routes.

**Expert Organizations:** Academic institutions such as MIT, Harvard, BU, UNAM, ITESM, and environmental research centers such as the World Resource Institute can provide much of the needed technical expertise for this system.

**Other Key Stakeholders:** Environmental NGOs (Greenpeace, Iniciativa GEMINGO etc.), Media representatives (Reforma and others), CNIE, ITAM, Consejo Nacional de Industriales Ecologistas, CONCAMIN and others are also important stakeholders that could increase the legitimacy of the process among the public.

*10.5.4 Participation Level Assessment*

Table 10.1 shows the PLP heuristic (See Chapter 6) for the Mexico City transportation/air pollution system. The characteristics of the system seem to point to a need for extensive involvement at the level of assessing risks and recommending solutions.

**Table 10.1 The PLP Heuristic for the Mexico City Transportation System**

| Step 1: Examine System Characteristics | Yes | No |
|---|---|---|
| Is the system in question spread over multiple jurisdictions? | 1 | |
| Does the problem affect a multitude of heterogeneous stakeholder groups? | 1 | |
| Has the issue already stirred visible controversy? | 1 | |
| Are cost distribution issues important? | 1 | |
| Is all the funding necessary for building/managing the system available to the decision-makers/project developers? | | 1 |
| Is uncertainty in scientific information a source of controversy? | | |
| Are environmental justice issues relevant? | 1 | |
| Is there distrust of the decision-makers' ability to adequately represent stakeholder interests? | 1 | |
| If marginalized in the decision-making process, do stakeholders have the ability to adversely impact the implementation or management of the project/system in a significant way? | 1 | |
| Do some stakeholders have access to useful information/data or financial/human resources they would be likely to share if they were involved? | 1 | |
| Is adaptive management of the system over time imperative? | 1 | |
| Is significant process obstruction by stakeholders likely if they are involved? | -2 | |
| Participation Level Points (PLP) | Sum: 8 | |
| ***Step 2: Determine Level of Participation (Based on a modified Arnstein's Ladder)*** | PLP | |
| ***Public Participation in Assessing Risks and Recommending Solutions*** | 6-8 | |

*10.5.5 Stakeholder Value Assessment*

As with the Cape Wind case, it is possible to design initial surveys that provide basic information for the initial transportation system representation. Tables 10.2 and 10.3 show the survey designed for the Mexico City transportation air pollution system. Unfortunately the survey did not go online, due to political controversies in Mexico, hesitation that it would interfere with the main stakeholder conflict assessment, and the termination of the Mexico City project. Still, a few surveys were filled out by several government agencies in a January 2004 workshop in Mexico City.

**Table 10.2 MIT Transportation/Air Quality Research Questionnaire**

The following questionnaire seeks to identify each organization's perceptions of the transportation system in Mexico City. Information gathered in this survey will support research that aims to improve the level of involvement of stakeholder groups in the Mexico City project.

Please answer as many questions as apply to you or for which you have time. The survey should take only a few minutes to complete. Return completed forms to Jed Horne or Travis Dunn. Thank you very much for your participation.

Your Name:______________________________

Your Organization:__________________________ Contact email: ________________

Problem Definition

- The Transportation team in the MIT Mexico City project seeks to better understand and address both air quality and transportation problems. For best results, should recommendations be aimed at primarily improving transportation planning, air quality, or both?

  (1) Transportation planning □ (better transportation services)
  (2) Air Quality □ (ways to make vehicles less polluting)
  Transportation Planning **and** Air Quality □ (consider both at the same time)
  (3) Other, please explain __________________________

- Consider the transportation system of Mexico City. What part of the system are you and your organization most interested in or most affected by (e.g., highways, light rail, Metro, taxi service, colectivos, economic impact or any other part you are interested in)? Please list no more than 3.
- (1) Over what parts of the transportation system does your organization have authority or legal mandate (if any)?

**Table 10.3 MIT Transportation/Air Quality Research Questionnaire (Continued)**

- Which additional governmental and non-governmental organizations do you think we should consult for our research?

- In your view, what are a few positive and negative aspects of the current transportation system? If no changes to the system are made, what future impacts to you anticipate?

- What 3 issues do you feel are most important with respect to the transportation system? (for instance metropolitan employment, health effects, traffic, air quality, affordable public transportation, etc.)

Information

- What information, data, or unique perspective do you possess on the system that others do not? What further information do you believe is necessary for better understanding of the system but currently missing?

- What capacity does your organization have for further information gathering?

Stakeholder-assisted policy design

- How would you like to participate in the development of recommendations and implementation of solutions to the problems you have identified (please select one):
  - ☐ be present at all stages
  - ☐ be informed at each stage
  - ☐ provide feedback once the recommendations are opened up for public comment
  - ☐ other:______________

In our initial test runs from surveys filled out by stakeholders in the Mexico City workshop n January 2004, decision-makers and experts from the Petróleos Mexicanos (PEMEX), Secretaría del Medio Ambiente (SMA), Secretaría de Transportes y Vialidad de la ciudad de México (SETRAVI), Comision Ambiental Metropolitana (CAM), Secretaría del Medio Ambiente y Recursos Naturales (SEMARNAT), Instituto Nacional de Ecología (INE) and the Universidad Nacional Autónoma de México (UNAM) voiced their desire to participate at all stages of the transportation/ air quality-related policy analysis--representation, modeling, developing and evaluating strategic options, as well as implementation and monitoring. Most of them asked to be present at all stages of the modeling process. Nearly all those surveyed thought that the air quality program for mobile sources should be approached as part of a combined transportation planning/land-use system. Also, many of those surveyed volunteered to provide information on the system, and some offered to collect information on currently unavailable information such as actual in-use emission factors of the Mexico City vehicle fleet.

*10.5.6 Initial System Representation*

Building on results from the survey and expert interviews, it is possible to construct an initial system representation of the system. We have constructed this system representation based on stakeholder statements throughout the seven workshop transcripts, research reports, media articles and interview transcripts[45].

Figure 10.1 shows a potential high-level starting point for the stakeholder-assisted systems representation.

*The Transportation/Air Pollution "Story" in Mexico City:* The "story", or a series of related events and dynamics for the transportation/air pollution system in Mexico City can be described as follows:

The population, economic activity, and GDP/capita (considering distributional impact) create a demand for passenger and freight transportation. For passenger transportation, this demand has to be satisfied either by private auto usage or public transportation. The choice between private auto and public transportation depends on their relative attractiveness. Passengers choosing public transportation are often with middle- and lower income, and passengers with higher income levels choose private autos. Within the public transportation options, passengers choose transportation modes based on travel cost, travel time, and other level of service variables (reliability, safety, accessibility, availability). The mode share in the passenger transportation sector determines the size and composition of the passenger transportation fleet. Freight transportation demand can be satisfied by trains, trucks, or a combination of the two. There is intra-urban freight and inter-urban freight (not shown for brevity in representation), and together they determine the size and composition of the freight fleet providing service to the MCMA.

[45] For workshop transcripts, research reports and interviews see the Mexico City Project Website at http://eaps.mit.edu/megacities/

The impact of transportation sector on the environment depends heavily on the size and composition of the passenger and fleet transportation fleets. Additionally, it is important what type and quality of fuels are being used, how efficient the vehicle technologies are in terms of fuel economy and emission control technologies. Also important is the role of inspection and maintenance in ensuring that emission standards are met and highly polluting vehicles are not allowed on the streets. Total transportation-related emissions can have a strong impact on local health, which in turn can result in morbidity and mortality, thus reducing productivity among the workforce. On the other hand, transportation provides mobility and accessibility for the workforce, thereby increasing the overall productivity of the city, and contributing to job creation and economic growth. Too many vehicles on limited infrastructure can result in congestion, which impacts emissions and productivity negatively. When congestion is high, there is more pressure to build additional infrastructure in the city (such as the Segundo Piso project in the MCMA). However, new infrastructure will increase mobility in the short-run and subsequently the demand for transportation in the long-term.

This system representation is very high-level and has to be developed in more detail to capture social impacts of policies, such as those felt by residents of informal settlements, public transportation providers and the general public whose livelihood is at stake. However, even this limited representation offers an insight into areas where interventions though policy levers are possible. In this representation policy levers include public transportation attractiveness, vehicle technologies, emission control technologies, urban sprawl policies, fuel type and fuel quality, inspection and maintenance, and available infrastructure. The high-level presentation can be expanded into different subsystems where each of the components can be studied with more detail.

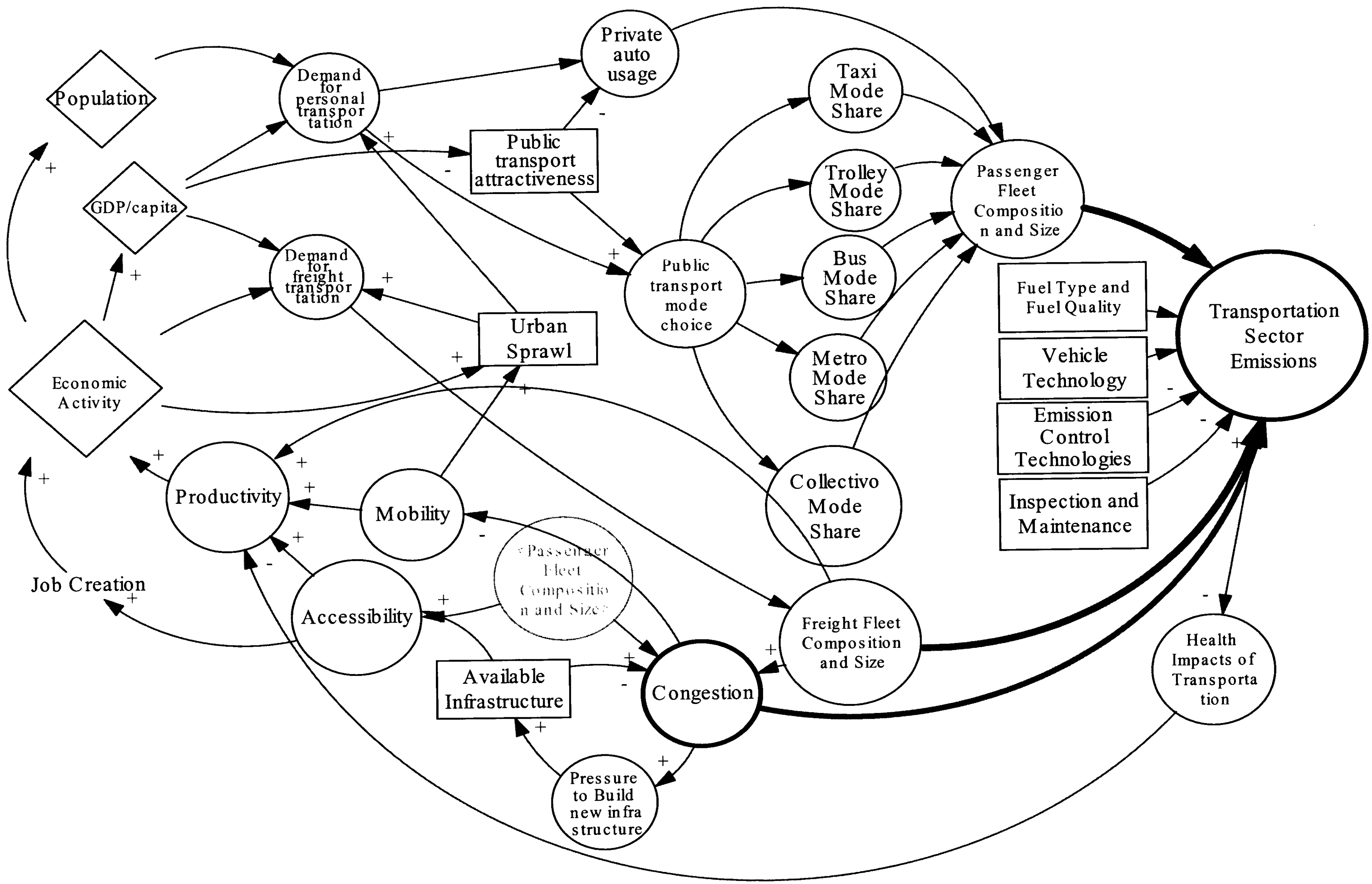


Figure 10.1 High-Level System Representation of the Transportation/Air Pollution System (with insights from Dodder et. al, 2005)

*10.5.7 Stakeholder-Assisted System Representation*

Once an initial system representation is created, stakeholders can help refine the system representation, based on the next steps of the SAM-PD process as described in Chapter 6. Here, stakeholders can expand the representation to include parts of the system that represent the impacts and issues they are interested in. Forming breakout groups that focus on different subsystems and layers can help in structuring the representation in a balanced way that can provide for the inclusion of diverse interests.

Figure 10.2 shows a basic expansion of the freight transportation layer based on interviews with MIT Researchers working on the impact of congestion pricing on freight transportation. The assumption in the expert analysis is that the cost of congestion pricing is negligible when compared to the increases in efficiency, and shifting mode choice from individual truckers to carrier services for most less-than-truckload freight[46]. Therefore, MIT researchers were surprised to see that many freight carrier services in the MCMA are opposed to congestion pricing, since they contend it would increase their costs. Their inclusion in the system representation would probably result in adding components such as the impact of congestion pricing on the profits of carrier companies. To address this issue, all the components that help assess the impact of congestion pricing on carrier companies need to be taken into consideration. The quantitative evaluation of the layer can then shed a light on whether congestion pricing increases or decreases carrier service profitability. Involving stakeholders allows for analyzing the underlying assumptions in a representation. For instance, in the expert representation a basic assumption has been that congestion pricing will affect all carrier services in the same manner. However one could assume that many inefficient carriers would oppose any measures that exposed their inefficiency in competition with more efficient carriers. At this point, and with the status quo, every delay can be justified to their customers though the existence of congestion. Furthermore, while the costs are immediate, the paybacks are quite gradual, and many carrier services may never see the benefits, making their opposition a rational choice.

[46] See Waliszewski, Janine, "Impact of Congestion Pricing on Freight Transportation in Mexico City", Master's Thesis, Center for Transportation and Logistics, June 2005 (Title subject to change).

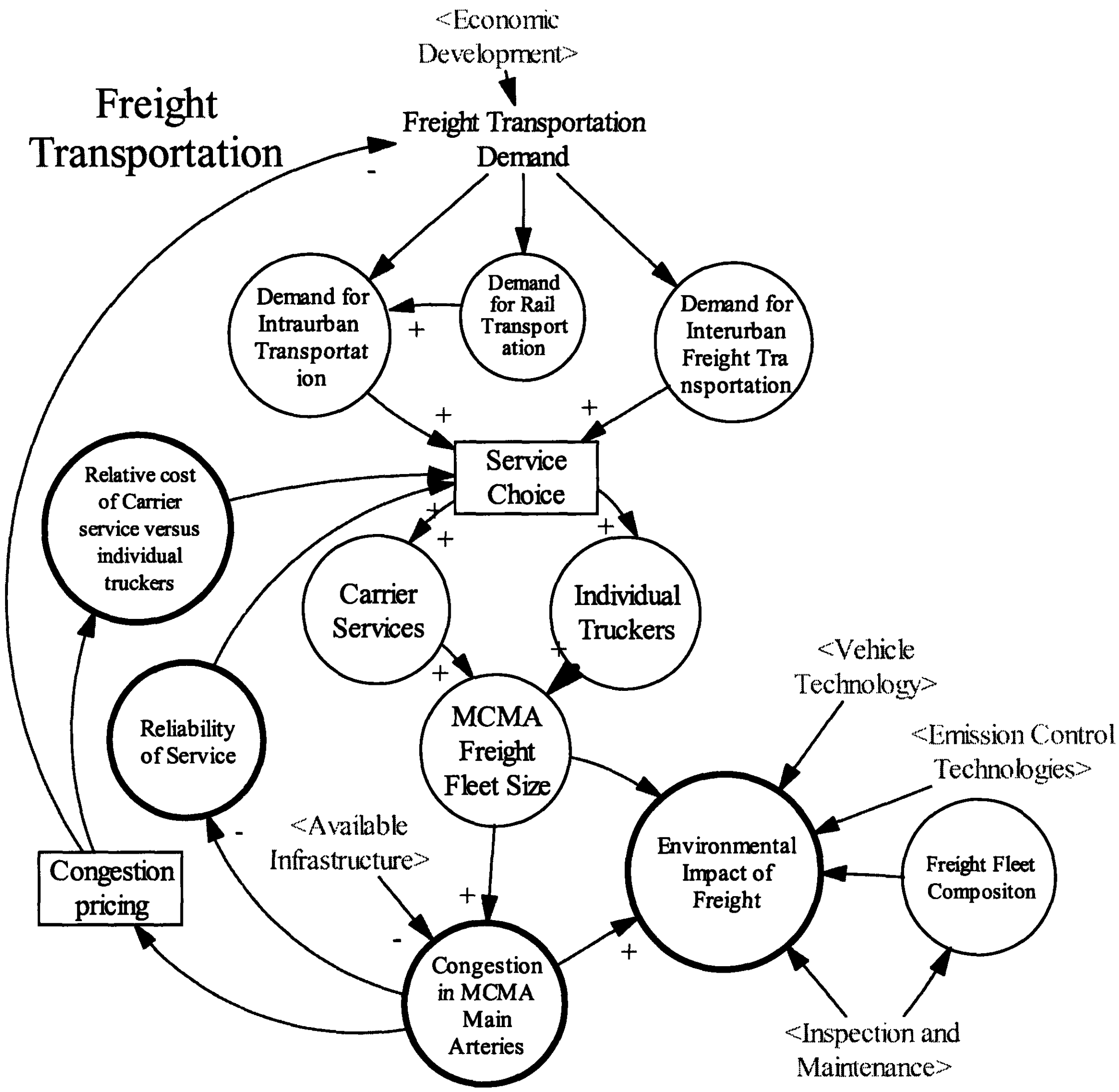


**Figure 10.2 Expert representation of the MCMA freight transportation layer to explore the impact of congestion pricing.**

*10.5.8 Refinement of System Goals and Performance Metrics*

The stakeholder group as whole can then refine system goals and performance metrics such that the outputs of any quantitative model conform to the information needs of stakeholders to make decisions. A performance metric for SEMARNAT may be tonnes of emissions of NOx, while it may be the number of people with asthma for the health department, or operator income for Bus drivers. In order to negotiate on any possible sets of strategies, stakeholders need to know how their respective performance metrics are affected.

*10.5.9 Gaining Insight from the Systems Representation*

Without quantification, one can gain some insight from the system representation. For example, due to the multiplicity of performance metrics on can see that the design of multi-purpose policies could be more useful than concentrating on the environmental aspects alone.

For instance, energy intensity reduction strategies can both benefit the environment and the economy in the long run; higher fuel economy regulations can increase the amount of available gasoline and diesel for export, while benefiting the environment; and finally congestion measures can also help the economy as well as the environment. The government and banks may be ready to finance such strategies, if they believe the economic returns will be worthwhile.

*10.5.10 Constructing a Quantitative Model*

Using different modeling tools such as demand modeling, corridor modeling, fleet turnover modeling, emissions models, economic models and transportation flow models it is possible to quantify the system representation to a certain extent. Some of the components and linkages may have to be evaluated with qualitative tools. The combination of quantitative and qualitative insight can provide an understanding of the system. Expert groups can be formed to work on each of the different subsystems and layers.

### *10.5.11 Strategic Alternatives and Model-Based Negotiation*

Once the current system is evaluated as the base case, the impact of different strategies can be explored. Stakeholders can brainstorm on different alternatives and see their impacts on the various performance metrics through the model. The strategies can also be bundled together and evaluated over different ranges of uncertainty to see how they would perform with regards to the defined metrics. The bundles can then be narrowed down by negotiation among stakeholders to get to acceptable range of packages than can then be refined.

Figure 10.3 shows an illustrative quantitative graphical interface of the jointly-created model, that stakeholders can use to determine the impact of each strategy on their stated values. Here the strategy that is explored is the impact of PM filters on emissions profiles of buses, taking into account cost to different stakeholders.

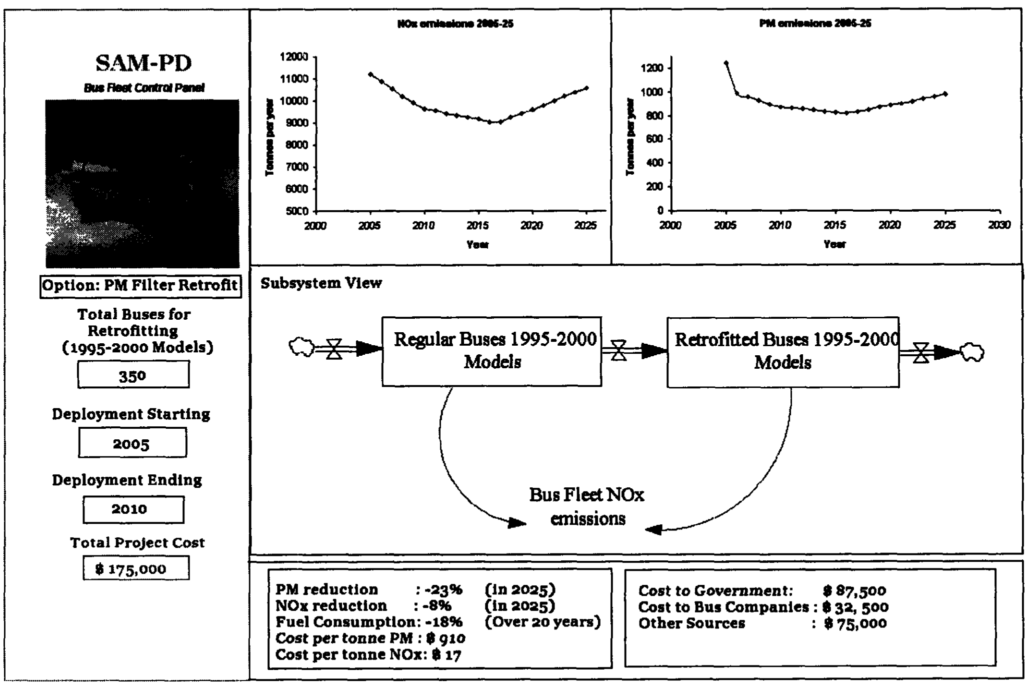


**Figure 10.3 – A sample graphical interface for jointly created model allows stakeholders to assess the impact of the different strategies on their stated performance metrics.**

*10.5.12 Process Effectiveness and Validity Assessment*

Process effectiveness criteria were explored in chapter 6, and can be applied to the process at the end of the negotiation process in the case of agreement.

Additionally, if stakeholders come to an agreement on alternatives packages for the MCMA transportation/air pollution system, the process transcripts and the system models can be sent for peer review to other technical expert groups, to be evaluated on the basis of the stated performance metrics. The feedback of the peer review can then be integrated into the final analysis with stakeholder approval, or be included as additional commentary within the report produced by stakeholders. The aim of the stakeholder process is to have a single text at the end that represent a set of strategies that are effective in addressing the problems of the system and that an overwhelming majority of stakeholders can live with. A public comment period for those who did not participate in the project would allow more stakeholder feedback to be taken into consideration in the final text.

*10.5.13 Implementation and Post-Implementation Strategies*

Implementation strategies for the MCMA Transportation/Air Pollution system should reflect the understanding of the realities of both the technological and organizational complexity, funding limitations, the scale of the project, the limited time for implementation, the boundaries of agency mandates and influence over member agencies. The dedication of the participating stakeholders to implementation is essential to its success. Additionally, they should also reflect organizational and technological strategies to deal with potential system failure and maintenance after deployment. Oftentimes institutional change is a necessary step before the policies can be implemented. Here the convening group of CAM, COMETRAVI and SEMARNAT should ensure that the funding and enforcement commitments are unambiguous and accessible. The system model along with all the process transcripts and presentations should be maintained by the convening group and made available to the public at large through websites, media articles and public outreach campaigns. Funding should also be made available for post-implementation monitoring. It is important to create monitoring mechanisms that can monitor the various performance metrics identified over time to see whether they are up to the expected level. If there are problems with the system, the system representation and the subsequent models need to be revised for emerging issues that were not considered. Often there is no need for the entire group to reconvene for minor system improvements, but stakeholders whose performance metrics are being affected adversely should be consulted. If serious problems arise, the problem may need to be re-defined and the process reconvened.

## 10.6 Obstacles to Collaborative Process for the Mexico City Project and Other Developing Country Systems

The preceding sections depict a hypothetical SAM-PD process. An actual collaborative process was essentially not convened for many practical reasons. Some of the obstacles were mentioned before: Timing of the stakeholder process and lack of funding. But there are many issues that can be cited as important obstacles to a collaborative process in developing country contexts.

While some of these could also be true for developed countries, they are more pronounced in developing countries such as Mexico.

### *10.6.1 Emerging Democratic Institutions*

Mexico emerged from a single-party rule in 2002 after 70 consecutive years. The experience of democracy in Mexico is new and still in flux. For many years decision-makers have been used to exclude stakeholders from decision-making processes, and involving stakeholders in any shape or form is a new concept. Furthermore, mechanisms for stakeholder recourse are still weak. That means that stakeholders cannot take decision-makers to court on the basis of existing laws easily. Given this lack of responsiveness to the public, decision-makers are slow to embrace collaborative processes that would take away their power over a decision they are responsible for. As we emphasized, the authority and political will of convener is crucial to the success of collaborative processes, and this was lacking in the Mexico City context. Similar problems also exist in other developing countries.

### *10.6.2 Weak Civil Society*

In addition to problems within the power structure, civil society itself is not strong in developing countries. The experience of forming unions or citizen groups for advocating their demands is new to the public. Without established representative stakeholder groups, there is often a confusion on who to involve in such processes. Additional problems that contribute to the lack of organized citizenry can include poverty and lack of voice among stakeholders, unequal access to involvement processes for different social classes and cost-implications of participation for stakeholders. In the context of Mexico City this could be considered a serious issue. While there are emerging environmental groups, their representativeness is still limited to the middle class, which does not constitute the majority of citizens living in the MCMA.

### *10.6.3 Political Power Struggles*

In the early years of democratic societies there is a strong power struggle in many developing countries. In the case of Mexico City, the divided jurisdiction of the DF and the EM, which are governed by opposing parties, does not help the cause of a collaborative process. The political battles have resulted in legal cases against the current mayor of Mexico city, making any cooperation between the PAN (national government), the PRI (currently in power in the EM) and the PRD(currently in power in the DF) nearly impossible.

## 10.7 Chapter Summary

In this chapter we looked at how the SAM-PD process could have been applied to the Mexico City transportation/air pollution system. The basic rationale for involving stakeholders in the system representation and modeling of the Mexico City transportation/air pollution system was the evaluative complexity of the project, where different stakeholders emphasize different performance metrics. Stakeholder involvement can produce models that have outputs empowering stakeholders to make decisions. Also, the identification of components and linkages, which Mexico City project experts may not have emphasized in their models, will be important. This can help in better implementation of recommendations resulting from these models and can reduce conflicts that arise when stakeholder interests and needs are neglected. Additionally, a common systems representation can help ensure that different experts working on various parts of the system are working based on common assumptions that are transparent and can be examined openly by stakeholders. SAM-PD can be quite effective in allowing stakeholders create a larger design space by brainstorming about the different ways policy levers can be combined to produce solutions to the air pollution problem, while addressing other important issues. We also discussed obstacles to collaborative processes in Mexico and other developing country contexts. Still, we would argue that a limited collaborative process focusing on a broader inclusion of stakeholders in the knowledge generation in Mexico City starting in 1999 would have improved the acceptance of recommendations, at least on part of the decision-makers in the MCMA.

In the next and final chapter, we will look at the insights of this dissertation, the contributions of this research and future work.

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# ➲Chapter 11

## Conclusion and Future Work

*A conclusion is the place where you get tired of thinking.*

*-- Arthur Bloch*

### 11.1 Summary of Dissertation

In this dissertation we explored early stakeholder involvement in engineering systems decision-making. Particularly, we put forth the hypothesis that the engagement of stakeholders in the problem definition and system representation of engineering systems can result in representations that are superior to expert-centered representations. The main contribution of this dissertation is the Stakeholder-Assisted Modeling and Policy Design (SAM-PD) process, which joins consensus building processes with engineering systems analysis, facilitating engagement of stakeholders in engineering systems design.

Chapter 1 set the context and motivation for this dissertation. It provided basic arguments for stakeholder involvement in engineering systems design and management. It introduced the main hypothesis, the sub-hypotheses and the process by which we could validate them.

Beginning with Chapter 2, we looked at how engineering systems analysis is currently performed and explored different approaches, methodologies and processes that are used for engineering systems decision-making. We looked at the applications and shortcomings of each with regards to engineering systems with wide-ranging social and environmental impact.

In Chapter 3, we explored the role of expert analysis in engineering systems analysis, and demonstrated that the analysis process entails subjective choices that shape its structure and outputs. While the expert(s) often do a superb job in assessing cumulative risk and benefits, he/she usually refrains from addressing the risk-benefit distributions among the stakeholders. Yet the success or failure of an engineering system depends on the informed acceptance of anticipated and emerging risks by stakeholders who will be bearing them.

In Chapter 4 we looked at institutional support for collaborative processes in engineering systems decision-making, the definition of stakeholders, rationale for stakeholder involvement and different levels of participation. We then looked at past efforts in involving stakeholders in engineering systems and discussed their merits and limitations. Finally we looked at the pros and cons of stakeholder involvement in engineering systems decision-making.

Chapter 5 dealt with the concept of system representation, and discussed its importance in the overall engineering system analysis and design process. The chapter made an effort at advancing the current understanding of system representation and its relationship with cognitive and value-based differences. Specifically, it illustrated through two sets of experiments that cognitive biases of system modelers can result in system representations with different components and linkages, and different system boundaries. It also looked at how a narrower system view could inhibit the adequate analysis of a problem that crosses disciplinary system boundaries.

In Chapter 6 we introduced the Stakeholder-Assisted Modeling and Policy Design (SAM-PD) process, which is a fusion of the CLIOS process (from the field of engineering systems) and consensus-building processes (from the field of negotiation and conflict resolution), creating a new process. Elements facilitating the fusion include discourse integration and pragmatic analysis, tools that allow for a more structured interpretation of stakeholder comments and their conversion to system representation components and linkages. In this chapter, we proposed the Participation Level Point (PLP) heuristic as a way to assess what level of participation would be needed for engineering systems. The PLP heuristic links Arnstein's public participation ladder to characteristics of a particular engineering system. Additionally, we propose the Stake, Power, Knowledge (SPK) framework to identify which stakeholders to include at different levels of participation.

Chapters 7 through 9 focused on the Cape Wind Offshore Wind Energy study, the main case study of this dissertation. In Chapter 7 we provided the background for the case, including technical details, controversies and the current permitting process. Chapter 8 focused on the 12-month stakeholder involvement experiment performed on the case study to explore the validity of the dissertation hypothesis. Chapter 9 explored the lessons learned from the case study and looked at to what extent the hypothesis could be validated.

In Chapter 10 we looked at the case of the transportation/air pollution system in the Mexico City Metropolitan Area (MCMA) and explored the potential applications of SAM-PD to the technical analysis of that project. We identified obstacles to using collaborative processes in a developing country context, including legal and jurisdictional issues, as well as other institutional obstacles.

## 11.2 Contributions of this Dissertation

The contributions of this research can be divided into four distinct areas: Literature synthesis, conceptual, methodological and experimental.

### *11.2.1 Literature Synthesis Contributions* (Chapters 2-4)

The literature review chapters of this dissertation, Chapters 2-4 provide a review and analysis of existing literature in the fields of engineering systems, sociology of science and negotiation and conflict resolution, as they relate to the involvement of stakeholders in the analysis of engineering systems. To an engineering systems audience, the dissertation provides some insight into the social science literature of stakeholder involvement. To a social science audience, it portrays the approaches that are used in the technical analysis of engineering system. One could argue that stakeholder involvement in engineering systems decision-making requires knowledge of these previously disparate literature streams.

### *11.2.2 Conceptual Contributions* (Chapter 5)

a) Conceptual Analysis of System Representation

The conceptual developments in Chapter 5 are mainly original contributions that explore the interrelationships of representations, beliefs and value systems. It further analyzed the characteristics of a successful stakeholder-assisted system representation process, distinguishing among direct, indirect and hybrid direct-indirect involvements of stakeholders. Furthermore, the dissertation provides an overview of challenges of involving stakeholders in system representation and proposes ways to overcome them.

b) SPK Framework for Stakeholder Classification

Another minor, but helpful contribution of this dissertation is the Stake/Power/Knowledge (SPK) framework to assess at what level individually identified stakeholders need to be involved in the process in order to improve a decision-making process. Given the limitations on how many stakeholders can physically participate in a collaborative process, it is necessary for the neutral and the convening group to assess at what levels individual stakeholders or their representatives should be involved. The SPK framework provides a rough mental guideline for this process. Stakeholders can be assessed on their stake, power and knowledge (expert or local) on the decision. Stakeholders with high stakes in the collaborative process, even if they lack any power or knowledge can add legitimacy and community acceptance. Stakeholders with high knowledge can add to the scientific/technical /contextual validity of the analysis, while stakeholders with power (that is mandate or resources) can increase the viability of the process. Stakeholder with lower stake, power and knowledge can be involved through feedback systems, information websites, media releases and outreach campaigns.

### *11.2.3 Methodological Contributions* (Chapter 6)

The stakeholder-assisted modeling and policy design (SAM-PD) process shown in Figure 11.1 is the main methodological contribution of this dissertation. By merging a collaborative decision-making process with the CLIOS process, SAM-PD emerges as a new process that modifies the way both processes are carried out separately. In addition SAM-PD has additional elements that are not part of any of its parent processes. These include the PLP heuristic for analyzing the participation level necessity for engineering systems, direct and indirect stakeholder input solicitation methods, the use of discourse integration and pragmatic analysis in converting stakeholder statements to system representation components, and post-process effectiveness analysis. By joining a systems analysis perspective with a collaborative process approach, SAM-PD provides the field of engineering systems with a way to involve stakeholders in engineering systems analysis, while providing the field of negotiation and conflict resolution with a system-centric collaborative process. As such it does not replaces previous systems analysis methodologies, or previous collaborative processes but complements them.

The SAM-PD process features can be summarized as follows

- Assessment of stakeholder participation needs of an engineering systems analysis
- Direct- and indirect tools for stakeholder value and knowledge assessment
- Conversion of stakeholder statements into system representation components
- System representation as a tool for organizing knowledge in an accessible manner and enabling holistic decision-making
- System representation as a basis for stakeholder dialogue and negotiation
- Stakeholder negotiated performance metric (model output) design
- Transparent mapping of uncertainties on linkages and components
- Capturing feedback loops in complex systems
- Simultaneous consideration of technical, environmental, social, and economic aspects of an engineering system
- Working group formation and task delegation facilitation
- Enabling the use of diverse quantitative and qualitative models for evaluation of different parts of the system.
- Preserving process knowledge post-implementation and enabling refinement of system model over time through additional learning about the system
- Created generically applicable system models that can be used for similar systems with minor modifications

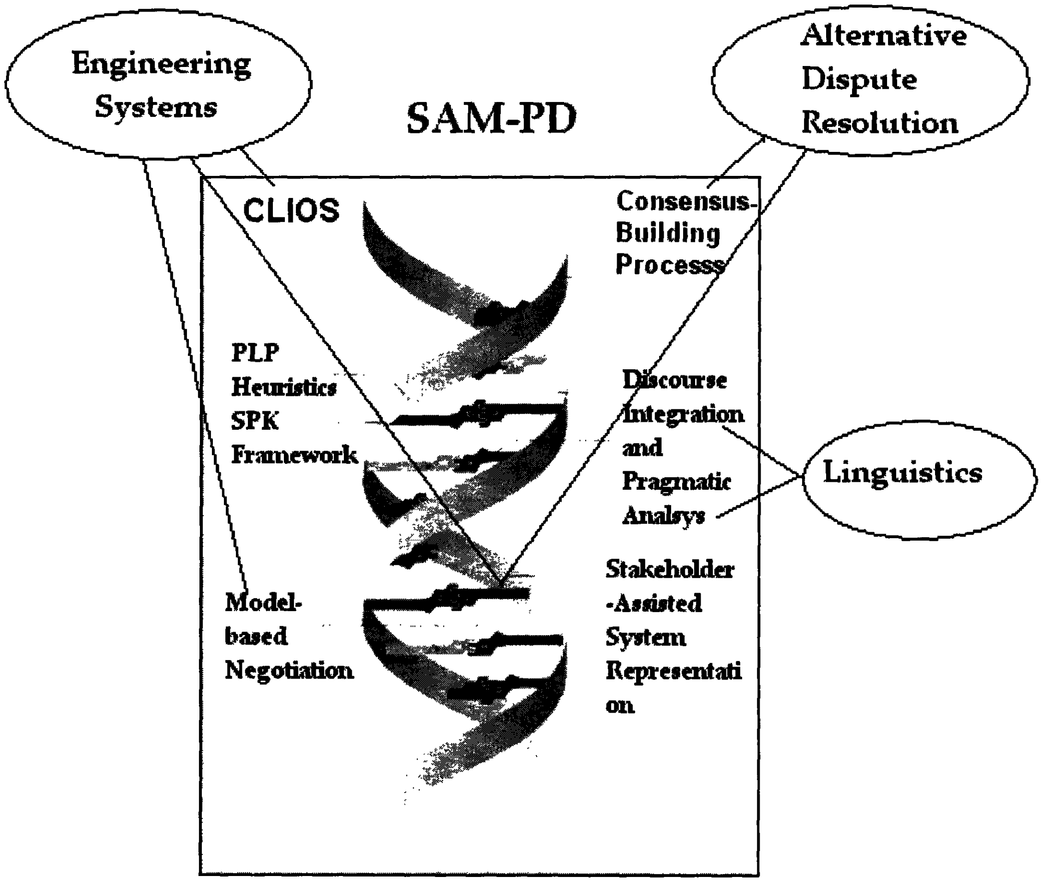


**Figure 11.1 The SAM-PD Process Double Helix**

### *11.2.4 Empirical Contribution*

The empirical contributions of this dissertation are the cognitive system representation bias experiments presented in Chapter 5 and the case studies presented in Chapters 7-10 and in Appendix D of this dissertation.

<u>a) Cognitive Biases in System Representation</u>

The system representation experiments on MIT and Cambridge University students explored two types of biases: 1) System boundary, components and linkage biases and 2) Partial cognition biases related to disciplinary focus. These experiments, while conducted as part of instructional courses and not within totally controlled conditions, are helpful in the context of this dissertation and new in the field of engineering systems. They illustrate that even when controlling for educational levels, technical skills and previous work experience, system representations performed by different groups was subject to the collective mental map of the people present in the representation process. This emphasizes the basic notion of subjectivity in the representation and modeling process for an engineering system.

<u>b) Cape Wind Offshore Wind Energy Project</u>

The Cape Wind offshore wind energy case study presented in Chapters 7-9 is one of the most controversial engineering system projects in recent American history. The case study in this dissertation, performed over a twelve-month period through April 2005, is the first academic study of the Cape Wind engineering system as a whole, with inputs from the actual ongoing process and its stakeholders. It also features one of the first engineering system representation processes that have involved actual stakeholders with a system-centric perspective. Bearing in mind that the Cape Wind process is still ongoing, this case study can serve as a time marker in the literature for future studies on Cape Wind. As of April 15, 2005, more than 600 individuals have visited the SAM-PD website on Cape Wind, and many undergraduate and graduate students have contacted the research team for more information on different aspects of the project. Additionally, the Massachusetts Technology Collaborative (MTC) and the Cape and Islands Renewable Energy Collaborative (CIREC) were motivated based on the Cape Wind case study to use the process for a coordinated community planning for the energy future of Cape Cod. This ongoing process has been described below.

Most importantly, the case study served as a way to apply SAM-PD to a real process, refine it through the actual experience, and explore the validity of the dissertation hypothesis.

c) Mexico City Transportation/Air Pollution Project Case Study

The Mexico City Transportation/Air Pollution case study presented in Chapter 10 focuses on the potential application of SAM-PD to the transportation/air pollution system studied by the MIT Mexico City project. As a hypothetical, "what if" case study, with no direct input from actual stakeholders, the insights it provides are far more limited than the Cape Wind case study. However, the case study features an analysis of some of the reasons the Mexico City project expert analysis failed to positively influence air quality policies in Mexico City. While it is suggested that SAM-PD would have been a useful process for knowledge generation in the transportation/air pollution system study, the chapter features the challenges faced in applying a collaborative process in the context of a developing country case such as the Mexico City Metropolitan Area.

d) Cape and Islands Coordinate Community Planning Project

As noted above, participants in the Cape & Islands Renewable Energy Collaborative (CIREC) have initiated a coordinated community planning process for managing and accelerating the local and regional transition to a sustainable energy future. The process is called "Transitioning from the Energy Present to the Energy Future" and is supported and co-convened by the Massachusetts Technology Collaborative, a quasi-state agency in charge of the renewable energy funding for the Commonwealth of Massachusetts. CIREC and MTC have chosen to pursue the SAM-PD process. Appendix D features descriptions of the project and the initial results from a stakeholder value assessment survey filled out by more than 26 stakeholder organizations, as well as an initial system representation. Modifications suggested to the system representation by stakeholders at an actual collaborative meeting are also presented in Appendix D. The ongoing process is unique, in that it uses SAM-PD right from the problem definition, and is convened by credible organizations in the region. Additionally, the process has a professional facilitator, which helps a more *correct* version of the SAM-PD process to be implemented. Also important was the issue that the SAM-PD process was recognized by independent stakeholder groups as a good way to structure their collaborative process.

The ongoing process will continue throughout Summer 2005 supported by the author and may extend into the Fall. It will constitute the first start-to-finish case study for SAM-PD, which will eventually pass into the model-based consensus-seeking negotiation stage of SAM-PD.

## 11.3 Observations from Dissertation

In the process of writing this dissertation, and through the case studies some observations on stakeholder involvement and system representation emerged as important. A summary of these observations, which often reinforce existing knowledge, but also offer new findings is presented in the next paragraphs. Many of these observations have been discussed in Chapter 9 with illustrative examples.

### *11.3.1 Stakeholder Involvement*

a) Importance of strong convener and compatible legal framework

For any collaborative process to be successful, the convening organizations need to have the power, legitimacy and resources to push the process through and have the ability to enforce its agreements, overcoming social, economic and political obstacles that emerge on the way. If the genuine will and resources for the process do not exist within the convening agencies, there is little chance for the process to succeed, regardless of its design and management. Therefore, unless the organizational mandate of the conveners and the legal framework is compatible with a collaborative process, the benefits of a collaborative process will remain limited.

b) Importance of facilitator

SAM-PD tries to limit obstructionism partially by starting with an initial system representation and insisting on ground rules for the collaborative process. However, thoughtful process design is a necessary but insufficient condition for the success of collaborative process. Like any other collaborative process, the success or failure of the SAM-PD process depends significantly on the skills of the facilitator in managing stakeholder interactions and channeling conflict into productive cooperation on the process. This subjective dependence on the facilitator may be considered a drawback of the process from an engineering perspective, but the importance of "skill" and experience in the success or failure of a project is by no means new to the engineering profession.

c) Choice of stakeholders

For any large-scale engineering project there are often tens of thousands of stakeholders and dozens of major stakeholder groups. Not all of these stakeholders can be involved, and not all are interested in doing so. The theoretical level of participation can range from minimal (in an autocracy) to all-inclusive (in a direct democracy). The actual level of participation will be somewhere in between the two (See Figure 11.2). Additionally, the value of increased stakeholder participation is does not increase uniformly. Intuitively, there will be a place where the incremental value of additional stakeholder involvement will have leveled-off or even decreasing benefits by increasing the cost and complexity of the process to an intractable level. This idea is captured in the hypothetical benefit-participation curve in Figure 11.3.

Therefore, it is imperative that the "right" stakeholders be at the table in a collaborative process. The SPK framework was proposed to guide the thought process of the neutral in mapping key stakeholders. In essence the idea behind the SPK framework is that the stakeholder group that participates in the collaborative process must add value to the process, by increasing its collective enforcement power, legitimacy, resources, knowledge or expertise. The negotiation and conflict resolution literature has many resources on key stakeholder identification that were briefly discussed in Chapter 4. However, this is a crucial area where there is much potential for more empirical research.

In addition to which stakeholder entities should be involved, the choice of the particular individual representing his/her organization or a group of stakeholder makes a difference in the process dynamics. Usually, higher-ranking members of an organization have a more open hand in collaborating, since they are confident that their statements may be seen as representing their organizations, and have an easier task convincing their own organization of a decision in the collaborative process.

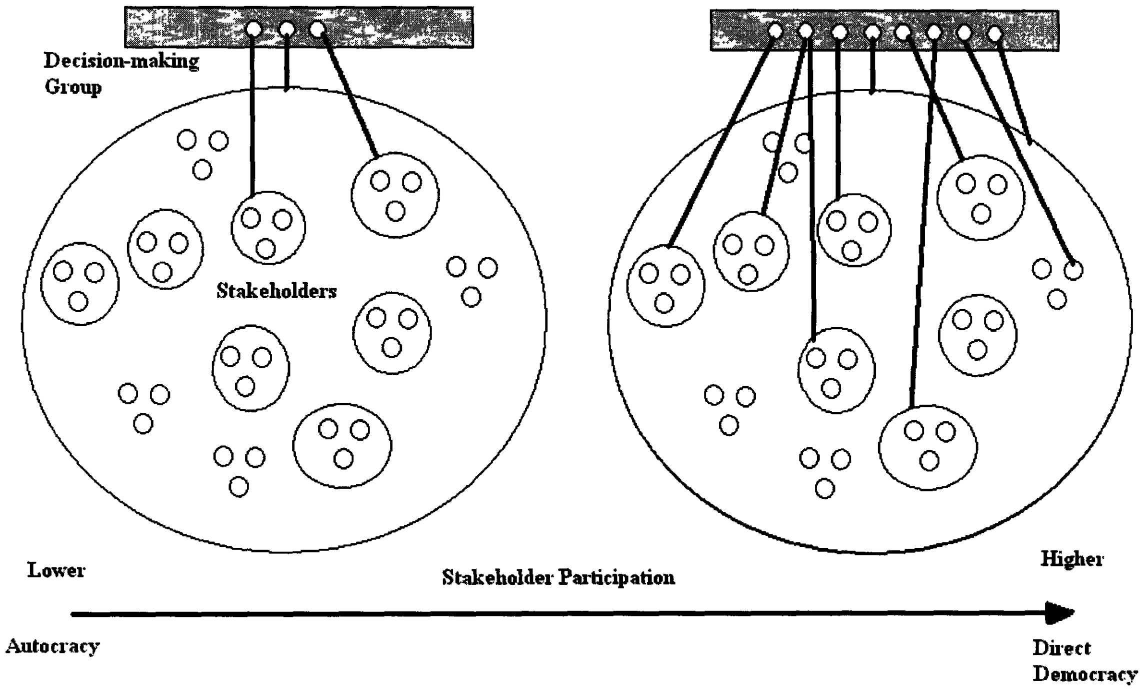


**Figure 11.2 Increasing stakeholder participation in decision-making**

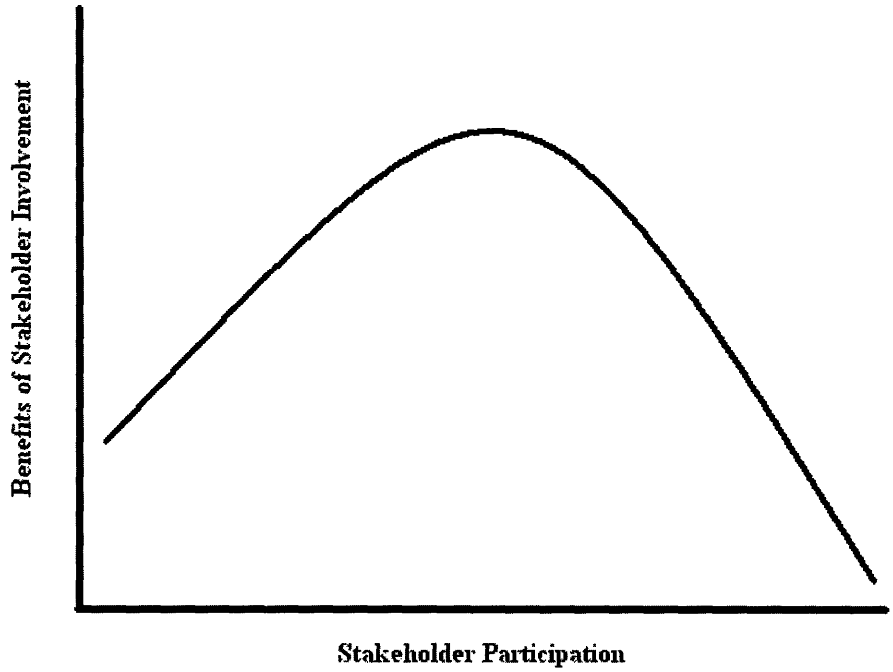


**Figure 11.3 Incremental Benefit of Stakeholder Participation**

*d) Lifecycle Cost of a Collaborative Engineering System Decision-making Process*

One of the main obstacles cited for using collaborative processes for decision-making is the extra cost associated with involving stakeholders. One could argue however, that the initial higher cost and increased process time occur in the early stages of the process, can save time and cost of conflict and delays that occur for expert-based processes, and make it less costly to deal with emergent adverse behaviors of a system. As an illustrative example, one could consider the Super 7 highway in Connecticut, where the expert process took four months, but the project was delayed for 17 years and was only partially completed due to strong stakeholder resistance. This idea is captured in Figure 11.4.

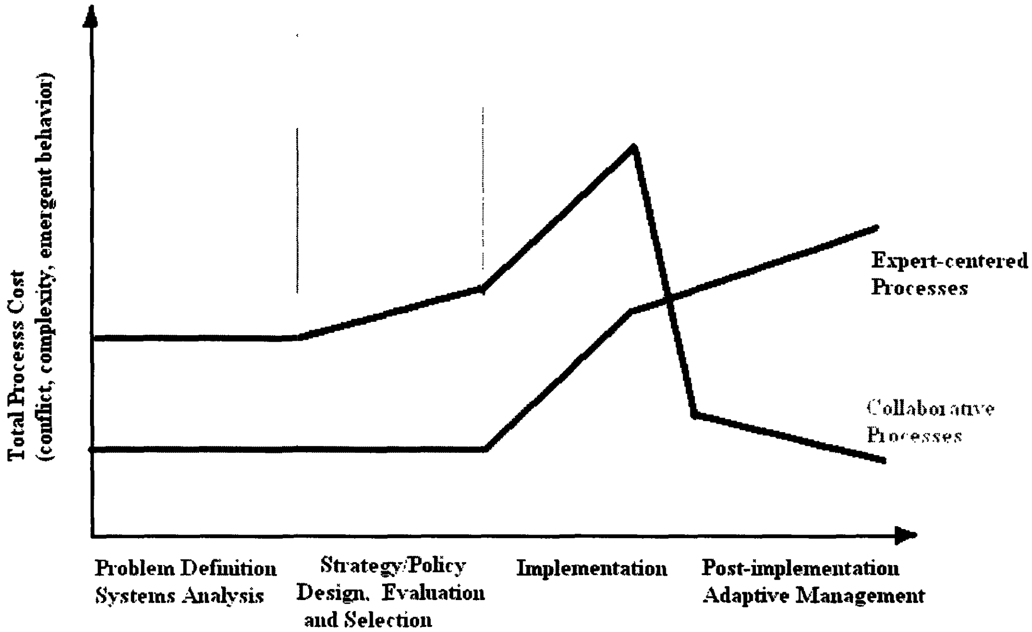


**Figure 11.4 Total Process Cost for Collaborative and Expert-centered Processes**

*11.3.2 System Representation*

*a) System Representation as a Knowledge Mapping Tool*

A system representation can be a good way to structure dialogue about a problem. For most stakeholders seeing how their interests in parts of the system fit into the larger picture results in an improved understanding of the system. Also, a system representation can identify where most of knowledge is concentrated, and in what areas we still lack information.

*b) System Representation as an Integrated Assessment Tool*

Most of this dissertation has focused on how various stakeholders can jointly work on a complex engineering system through a common system representation. However system representations can also serve as an integrated assessment tool for complex systems among a group of experts coming from different disciplines, who focus on different parts of the system. The Mexico City project is a prime example of this necessity. With different expert subgroups each going on their own tangent, with little communication and varying assumptions the final integration of results became a complicated and nearly impossible task. A common system representation can help communication among experts even in cases where public involvement is not present.

*c) System Representation as a Trust-Building Tool*

A system representation can serve as a way for people to work together in different ways than they are used to, accelerating the trust-building phase that is of crucial importance of collaborative processes. This trust is badly needed as a momentum for the rest of the collaborative process, where value conflicts emerge more strongly.

*d) Ease of Interaction with a Systems Representation*

The concept of a system representation that shows issues and their interconnections in a semi-graphical form is intuitive to most stakeholders. Designing more interactive and graphical interfaces can increase the ease with which stakeholders interact with the system analysis. This can include features that allow stakeholders to click on links to see available sets of data and trace the progress of working groups in analyzing the links. There is however the consideration that "technophobic" stakeholders may actually be more at ease with less technical interfaces.

*e) Importance of Policy Levers*

The identification of policy levers, that is areas where stakeholders can influence the system, is very empowering for stakeholders. It both expands their decision space and focuses their attention on what components in the system are actually importance. This can then serve as a way to generate strategic alternatives by different combinations of policy levers. Essentially for $x$ policy levers with $y$ choices each, there are a total of $x^y$ alternatives. This creates much flexibility in the negotiation stage.

*f) System Representation as a Working Team Formation Tool*

The ability of stakeholders to look at different parts of the system as a whole rather than at individual issues in a laundry list provides an opportunity to assign different working groups to evaluate different parts of the system. Stakeholders can form groups that include experts they trust to represent their views, and who can defend their interests in the knowledge generation process. The system representation can then show what parts of the system have been covered by existing groups, and what additional experts may be needed to address other parts of the system stakeholders agree to study.

*g) Systems Representation and Uncertainty*

Prioritizing uncertainty is one of the more controversial issues in groups. Stakeholders realize that uncertain areas are more prone to be included in the evaluation and assessment stage. The prioritized uncertainties are usually a compromise between the different stakeholders. The system representation allows stakeholder to see how those uncertainties would impact the system as a whole, rather than a particular component. This allows discussions in the breakout groups on whether an uncertainty, however large, would have an important impact on the system. Even if no information exists on parts of the system, expert estimates can provide an upper bound for uncertainties.

*h) Quantification and Evaluation of System Representation*

By not specifying a particular model for quantifying or evaluating different relationships in the system representation, SAM-PD allows the integration of many different models into an integrated system model. By linking the different inputs and outputs of various subsystem models, SAM-PD can help evaluate the impact of different alternatives on the overall system. Another insight was that not all of the system representation need or can be quantified. Social and institutional components and interconnections can be evaluated with social science frameworks, and many quantifiable components with a lack of baseline or predictive data may be considered in the decision-making, but not quantified. Still, having these components allow us to monitor and measure them at later times, or understand an emerging impact on the system.

### *11.3.3 Obstacles To Collaborative Processes In Engineering Systems*

One of the pre-requisites for SAM-PD or other collaborative processes is the existence of some institutional support and legal framework compatibility for collaborative processes. While this may be present in varying degrees in the context more developed countries, it can certainly pose a challenge in developing countries with lower institutional capacity and shortage of abundant expertise and resources.

Additional challenges are the potential lack of organized stakeholder groups that are representative of the stakeholders at large. In some situations, special interest groups may be more organized than the less vocal components of the population, leading the collaborative process towards a narrow outcome that may benefit few stakeholders. Additionally, there are cases where stakeholders may not want to participate in a collaborative process, intent on derailing a policy decision regardless of the outcome. Of course these problems can also occur in developed countries, although to a lesser extent.

More challenges can arise when a project is overly politicized making a "wise" decision irrelevant. In such cases it may be impossible to shift the decision-making process from an ideological and political battlefield to a collaborative wisdom-seeking process. The national missile defense system may be a good example of such systems.

## 11.4 Validations of the Hypothesis

The case study used to explore the validation of the hypothesis was the Cape Wind case study. In this section, we will look at the appropriateness of the experimental design, the limitations of the case study, and the extent to which the hypothesis could be validated through the five sub-hypotheses outlined in Chapter 1.

### *11.4.1 Appropriateness of the Experimental Design*

In order to establish whether the experimental design was adequate to validate the hypothesis we will address the following questions:

*1) Is the Cape Wind project a good choice for validating the hypothesis?*

The Cape Wind project is a large-scale, controversial engineering system with wide-ranging social and environmental impact, where thus-far a non-collaborative process has been used for decision-making. The location of the proposed project in Cape Cod provided adequate access to stakeholders, and language barriers did not exist (as did for the Mexico City project, another alternative process). The use of the Cape Wind project as a case study in a two-semester joint fact-finding course at MIT also provided additional opportunities for face-to-face discussions with stakeholders and access to background materials. Additionally, due to the dissatisfaction of stakeholders with the permitting process, there was an interest among stakeholders to explore alternatives, providing an opportunity for the SAM-PD process to be presented to stakeholders.

*2) Does the choice of the Cape Wind scope of the environmental impact assessment as a basis for an expert-centered system representation offer a valid comparison?*

It could be argued that we have selected the expert-based comparison, that is the scope of the Environmental Impact Statement, such that a superior system representation by stakeholders is inevitable. In other words, are we setting up a paper tiger in choosing the scope of the EIS, which was developed under legal and organizational constraints? We argue the answer is no.

The scope of the EIS consists of system components, linkages and boundaries for what the permitting agency is expecting an evaluation/quantification. As such it is precisely a system representation. Given that the EIS produced based on this scope will serve as the only basis for decision-making for the engineering system, it is valid to compare it with a stakeholder-assisted system representation that seeks to do the same. For that reason, it is the comparison of the two processes leading to a system representation that is the emphasis of this research. Specifically section 101 of the NEPA process encourages collaborative processes, and the NEPA process as a whole allows for conditional approvals of a project that allow different strategic alternatives to be taken into consideration. Therefore, the playing field is more or less even.

*3) Whose representation is it anyway? Is the system representation really the product of stakeholder inputs or could any system expert try to create a better system representation?*
In this case study, the author only acted as a scribe. While cognitive biases are still prone to enter the system representation, the refining session with actual stakeholders dissecting the system representation was used to ensure that the representation was adequate. Every component on the systems representation can be traced back to a particular stakeholder, or a group of stakeholders. Nothing was added by the author to the representation to improve its substantive quality. Additionally, in a complex system such as Cape Wind many fields of expertise such as marine biology, marine geology, avian studies, energy economics, energy systems etc. was needed which the author did not have the expertise to model.

*4) What was the actual experiment for hypothesis validation?*
The Cape Wind case study is the result of an experiment that spanned from September 2003 to April 2005. The period between September 2003 and April 2004 was spent on process preparation, familiarity with the details of the case, informal interviews with stakeholders and collection of background materials on the case. Starting April 2004, the project website was created and an online stakeholder value assessment survey was

developed to assess stakeholder interests and knowledge. The development of a stakeholder-assisted system representation, which was based solely on direct and indirect stakeholder inputs, ensued in September 2004 and took until late November 2004. The initial system representation along with survey results was sent to stakeholder organizations for feedback. The representation was modified, refined and verified by stakeholders in the April stakeholder workshop, which presented the quality control stage of the system representation. Admittedly, more sessions would have produced an even better representation, but even the current system representation was still superior to the expert-centered system representation, as we illustrated in Chapter 8.

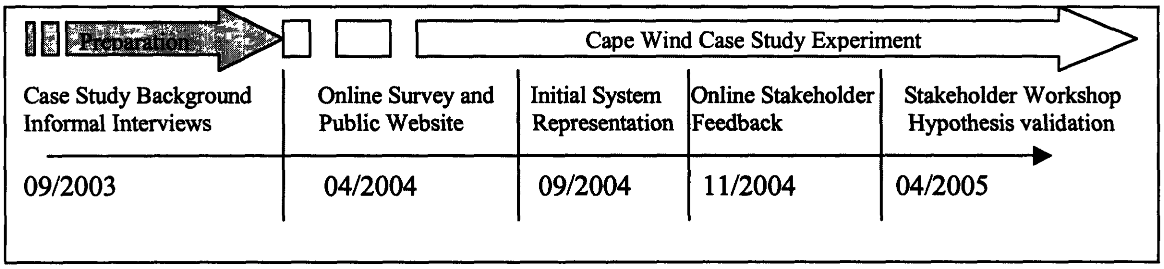


**Figure 11.5 Cape Wind Case Study Timeline**

*5) Was the stakeholder group representative of stakeholders at large?*

The initial system representation created based on direct and indirect stakeholder inputs was comprehensive in its reach. The system representation included direct inputs from 27 key stakeholder organizations, and the indirect inputs of another 43 organizations (totaling 70 organizations) as well as many individual stakeholders, and political figures who provided comments in the public hearings. The workshop participants included the developer and the main opponents, as well as key opponent and proponent organizations, Federal and State agencies, academics for different disciplines related to the different aspects of Cape wind. Much feedback was also received through the website from regional planning agencies, State advisory agencies, regional energy providers and other stakeholders. Still, the process did not benefit from the participation of the Federal permitting agencies and the many fishermen associations, which are considered crucial stakeholders. Overall, the representation was reasonable but not perfect.

### 11.4.2 Hypothesis Validation

In Chapter 8 we explored to what extent the main hypothesis could be validated. In particular, we observed that the system representation was more inclusive of a plurality of views, served as a thought expander for stakeholders, captured some effects that the expert-centered representation could not capture, better took into account social, economic and political feasibility and was more useful in suggesting better alternative strategies for the system. This was explored both through a stakeholder follow-up survey after the workshop, as well as through the detailed comparison of the two system representations. The detailed analysis is given in Chapter 8.

Overall the experiment showed that stakeholder involvement would not undermine the technical quality of a system representation, while taking into consideration additional values that the expert-centered representation did not account for. The experiment also showed that the inclusion of stakeholders expanded the decision-space from a Yes/No decision to more strategic alternatives, and can therefore create more flexibility in making decisions that take stakeholder interests more into consideration. While we anticipate that this would result in better decision-making, given the stage we are at, this would be impossible to verify.

## 11.5 Limitation of the Research

The topic of stakeholder involvement in decision-making for large-scale engineering systems is monumental. As one of my committee members emphasized, to do the immensity of the work justice, a lifetime may not be sufficient. This research had to limit its scope, due to limitations in time and resources. Like any other dissertation, its success would actually be measured by how much new research it sparks, rather than whether it closes the door on a field of study.

The hypothesis of this dissertation focused on the impact of stakeholder participation on engineering systems representation. While the system representation stage defines the problem and determines the performance metrics, it does not by itself address the challenges with dealing with evaluative complexity, or the idea that "good" system performance is matter of subjective judgment. It serves as a basis for the rest of the collaborative SAM-PD process which faces many challenges in having stakeholders come to an agreement on acceptable risks, acceptable uncertainties in knowledge about the system, cost distribution issues and detailed agreements on the implementation of the project. Additionally, issues like adaptive management (described in Chapter 4) for cases such as Cape Wind may take 15 to 20 years, making it impossible to measure the effectiveness of stakeholder involvement on this aspect of engineering systems design and management.

Even within the system representation stage, the limitations of access to stakeholders over extended periods of time necessary to refine system representations, and the lack of formal authority in the process that resulted in reduced access to crucial stakeholders undermined the perfect execution of SAM-PD as it is theoretically presented in this dissertation.

Additionally, this dissertation did not address important issues such as process legitimacy, the required changes in current the legal structure, challenges of integrating local knowledge in system representations, challenges of interdisciplinary research and scientific translingua[47].

## 11.6 Future Work

Here we propose a set of paths that lead from the end of this dissertation to future research areas of interest to engineering systems.

### *11.6.1 System Representation Biases and Mental Maps*

With our increased reliance on models for important and complex decisions it is imperative that we understand the cognitive biases that impact modeling in a more robust fashion. This dissertation presented two data points on cognitive biases in representation, but better experiments with controlled conditions are needed to assess the full extent of biases. Particularly, research experiments that focus on the following would be a valuable contribution to the field of engineering systems:

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[47] Common language for communication among experts of different disciplines and backgrounds.

- Impact of disciplinary background on system representation
- Impact of political and religious views on system representation
- Impact of formal education and actual work experience on system representation
- Impact of exposure to different sources of information on system representation

### *11.6.2 Refinement of SAM-PD Process through Application*

Probably the most important currently outstanding research is to apply the SAM-PD process to an actual case study from the problem definition stage to the implementation stage, as part of the actual decision-making process. The current MTC/CIREC coordinated community energy planning has the potential to be a case study for a completely applied SAM-PD process, which the author will pursue. Other potential applications include hydrogen economy planning, regional transportation planning, urban broadband Internet initiatives and NASA's Human-Lunar Exploration initiative. A complete case study would allow the refinement of the system modeling, strategic alternative generation, model-based negotiation and consensus-seeking implementation of engineering system stages.

### *11.6.3 Interactive System Representation and System Modeling Interfaces*

Also important is research into the use of emerging information technology innovations to make the system representation and system modeling interfaces more accessible while maintaining the transparency of the relationships and assumptions.

For siting applications it may be useful to connect model outputs to a GIS model that could allow stakeholders to use different layers of information for different sites and consider them in their decision-making.

The use of interactive computer simulations and games based on the system models created for energy and transportation systems can help in educating the public at large about the tradeoffs of different decisions that society faces today.

### *11.6.4 Dealing with "obstructionism"*

The SAM-PD process has tried to address some of the issues related to process obstructionism by stakeholders, through careful selection of stakeholders, creating an initial system representation to channel stakeholder dialogue right from the beginning and emphasis on decision rules and effective facilitation. However it is still far from addressing obstructionism as one of the most important obstacles facing collaborative processes. We need to investigate better ways of dealing with obstructionism, while not undermining the collaborative spirit of the process.

## 11.7 A Closing Word

The central idea of this dissertation was that current stakeholder involvement approaches for large-scale engineering systems are inadequate, and that *effective* stakeholder involvement in engineering systems decision-making is essential to the process. The emphasis on *"effective"* refers to the fact that not all stakeholder involvement results in improved representation, design and management of engineering systems.

This dissertation proposed the Stakeholder-Assisted Modeling and Policy Design (SAM-PD) process as an effective collaborative process for engineering systems decision-making that allows stakeholder involvement from the problem definition stage to implementation, and post-implementation management of a project. The SAM-PD process is a synthesis of existing collaborative processes in the negotiation and conflict resolution literature and existing engineering systems analysis processes. Through the application of the process to three actual engineering systems projects, the dissertation showed that stakeholder involvement in engineering systems design and management not only did not undermine the technical quality of the analysis, but added to the quality of the system representation that serves as a basis for the engineering systems analysis and decision-making.

As such it emphasizes the importance of evaluative complexity as a crucial aspect of engineering system and concludes that systems analysis cannot be separated from the decision-making and implementation for engineering systems in their complex social and institutional environment.

The basic implication of this research is that it would be myopic of engineering systems analysts to shift the burden of stakeholder involvement to decision-makers, and keep the analysis a merely expert-centered process. Due to the many subjective choices that have to be made with regards to system boundaries, choice of components, inclusion of linkages, nature of outputs and performance metrics and assumptions about data and relationships, system analysts are in fact not producing the analysis that will help the decision-making process. The best airport designs done with multi-tradeoff analysis and intricate options analysis may lead to nowhere if stakeholders affected by the project do not see their interests reflected in the analysis. The notion is that a good systems analysis is not one that impresses other engineering systems professionals with its complexity, but one that can actually address the problems at hand.

SAM-PD provides an alternative engineering systems analysis process, whereby the combined wisdom of decision-makers, experts, citizen groups and private sector actors determines the design space, system boundaries and model outputs that are useful for decision-making.

Without a change in the way engineering systems analysis is done, many more projects will have the same fate as projects such as the Cape Wind Offshore Wind Energy Project, the Mexico City Airport, the Yucca Mountain nuclear waste repository, and the Connecticut Super 7 highway, which had brilliant technical designs but failed to take into consideration that the aim of building engineering systems is to serve the actual needs of people, not just to create another technical artifact with a high price tag and impressive technology. To emphasize the point, I close with quote from the late MIT Engineering Dean Gordon Brown on what engineering really signifies.

Engineering is not merely knowing and being knowledgeable, like a walking encyclopedia; engineering is not merely analysis; engineering is not merely the possession of the capacity to get elegant solutions to nonexistent engineering problems; engineering is practicing the art of the organized forcing of technological change... Engineers operate at the interface between science and society..."

Dean Gordon Brown, MIT (1962)

# Glossary

**Actors**
Include individuals and formal and informal organizations on the institutional sphere.

**Actor groups**
An initial identification of major actors, grouping them by function or hierarchy, including all stakeholders-individuals or organizations that can effect or be effected in the system.

**Adversarial Approach**
The adversarial approach to a conflict sees the other party or parties as an enemy to be defeated. The adversarial approach typically leads to competitive confrontation strategies.

**Advocacy**
Advocacy is the process of taking and working for a particular side=s interests in a conflict.

**Alternative (Strategic Alternative)**
One of the mutually exclusive courses of action (if one is chosen, the other cannot be chosen) attaining the objectives. A course of action that combines features selected from two alternatives becomes a new alternative. Other terms used interchangeably: Option

**Analysis**
Refers to quantitative or mathematical study (as opposed to qualitative study).

**Backlash**
Backlash is a negative response to an action. When stakeholders in a contested situation are forced to do something against their will, or have a decision imposed on them, they will often resist or try to get back at the person or group who forced them in the first place. This can result in a reversal of an apparently resolved situation, and may even escalate the conflict further.

**BATNA**
BATNA is a term invented by Roger Fisher and William Ury which stands for "best alternative to a negotiated agreement." Any negotiator should determine his or her BATNA before agreeing to any negotiated settlement. If the settlement is as good as or better than one's BATNA, the agreement should be accepted. If the alternative is better, it should be pursued instead of the negotiated settlement. When one party's BATNA is good (or even if they just think it is good), they are unlikely to be willing to enter into negotiations, preferring instead to pursue their alternative option.

**Bounding** – is a conceptual tool used to keep the study focused while acknowledging the critical elements that affect the system and exist beyond the detail of the study. It helps define the context within which the system is operating.

**Checklist** – an outline of the salient characteristics and issues of the system, defined in Step 1. Developing the checklist helps define the scope of the study and stages the issues that the study will address. The checklist reminds the author of critical elements to be sure to include in the study.

**CLIOS Process**
A disciplined, holistic approach to studying complex sociotechnical engineering systems. It uses quantitative and qualitative means to investigate complex, large-scale, integrated, open systems and has twelve basic steps.

**Common Driver**
Components shared across multiple layers of the physical domain.

**Components**
Units that make up a major subsystem. They may be policy levers, common drivers, or basic elements.

**Component Diagram** – are the qualitative representation of the inner workings of a major subsystem. They outline the significant components and their relationships.

**Complexity** - Complexity consists of three types.
*Internal complexity:* The number of components in the system and the network of interconnections between them
*Behavioral complexity*: The type of behavior that emerges due to the manner in which sets of components interact
*Evaluative complexity*: The competing actions of decision makers in the system who have alternate views of "good" system performance. This type of complexity relates the links from the institutional sphere to the physical layer

**Communication Channels**
Communication channels are the means available to communicate with another person or group. They may include direct face-to-face communication, telecommunications (telephone, e-mail, written communications), or indirect communication--through third parties or the media, for example.

**Complex Adaptive System**
A form of system containing many autonomous agents who self-organize in a co-evolutionary way to optimize their separate values.

**Compromise**
A solution to a mutual problem that meets some, but not all, of each of the parties' interests.

**Complexity Science**
The study of the rules governing emergence, the constraints affecting self-organization and general system dynamics in nonlinear adaptive interacting systems

**Complex System**
One not describable by a single rule. Structure exists on many scales whose characteristics are not reducible to only one level of description. Systems that exhibit unexpected features not contained within their specification. Systems with multiple and often rivaling objectives

**Complexity Theory**
The study of how critically interacting components self-organize to form potentially evolving structures exhibiting a hierarchy of emergent system properties.

**Concessions**
Concessions are things one side gives up to try to de-escalate or resolve a conflict. They may simply be points in an argument, a reduction in demands, or a softening of one side's position.

**Conflict Management**
This term refers to the long-term management of intractable conflicts and the people involved in them so that they do not escalate out of control and become violent.

**Conflict Resolution**
This term (along with dispute resolution) usually refers to the process of resolving a dispute or a conflict permanently, by providing each sides' needs, and adequately addressing their interests so that they are satisfied with the outcome.

**Conflicts of Interest**
This term refers to the situation in which a person has a vested interest in the outcome of a decision, but tries to influence the decision making process as if they did not. In other words, they stand to benefit from a decision if it goes a particular way, but they participate in the decision making process as if they were neutral. An example would be an expert from the tobacco industry testifying that tobacco is safe and does not cause cancer. If he argued this on the basis of scientific merits, rather than his connection to the tobacco industry, he could be charged with having a conflict of interest which altered his position on tobacco research.

**Consensus**
Consensus decision-making requires that everyone agrees with a decision; not just a majority as occurs in majority-rule processes. In consensus-based processes, people must work together to develop an agreement that is good enough (though not necessarily perfect) that all of the people at the table are willing to agree to it.

**Constituents/Constituency**
Constituents or one's constituency refers to the people a decision maker represents. The constituents of a governmental leader are the citizens he or she represents in Parliament or other legislative body. The constituents of a negotiator are the people he or she is negotiating for; members of a union, perhaps, or of an interest group or business.

**Credibility**
Credibility refers to whether or not a person or a statement is believed or trusted. Sometimes leaders or expert witnesses are not considered by the public to be credible because they have a personal interest in the outcome of a situation or a conflict which would likely influence their views and/or statements about that situation or conflict.

**Decision making process**
The decision making process is the process that is used to make a decision. It can be an expert process, where the decision is made by one or more "experts" who look at the "facts" and make the decision based on those facts; it can be a political process through which a political representative or body makes the decision based on political considerations, or it might be a judicial process where a judge or a jury makes a decision based on an examination of legal evidence and the law.

**Decision Support Systems (DSS)**
DSS are interactive computer-based systems intended to help decision makers utilize data and models to identify and solve problems and make decisions. According to Turban (1990), a DSS has four major characteristics: DSS incorporate both data and models; they are designed to assist managers in their decision processes in semistructured (or unstructured) tasks; they support, rather than replace, managerial judgment; and their objective is to improve the effectiveness of the decisions, not the efficiency with which decisions are being made (cf., p. 9).

**Descriptive Model Physical**
Conceptual or mathematical models that describe situations as they are or as they actually appear.

**Deterministic Model**
Mathematical models that are constructed for a condition of assumed certainty. The models assume there is only one possible result (which is known) for each alternative course or action.

**Dialogue**
Dialogue is a process for sharing and learning about another group's beliefs, feelings, interests, and/or needs in a non-adversarial, open way, usually with the help of a third party facilitator. Unlike mediation, in which the goal is usually reaching a resolution or settlement of a dispute, the goal of dialogue is usually simply improving interpersonal understanding and trust.

**Disputants**
Disputants are the people, groups, or organizations who are in conflict with each other. They are often also called "parties." (Third parties, however, are not disputants, but rather people who intercede to try to help the disputants resolve the dispute.)

**Dynamics**
The behavior of a system in time. Changes with time are the essence of complexity, a static system is merely a snapshot within an evolutionary continuum, however interesting it may be in its own right.
**Drivers** – in CLIOS, drivers are components going through more than one subsystem layers in the physical domain. There are two types of drivers, including common drivers and exogenous drivers. They are drawn as diamonds in the component diagrams.

**Engineering Systems** – are complex systems, with technology at their core exhibiting internal, behavioral, and evaluative complexity. Furthermore, they are large-scale both in terms of geographic coverage or the extent of their impacts. Engineering systems have a tight coupling of their subsystems and external forces such as social, political, and economic influences affect them.

**Exogenous Drivers**– are forces that affect the system, but which the system may have little ability to affect. As common drivers, they may also link several layers of the physical domain, or unlike common drivers, they may simply be represented as a single component of a layer. They are drawn as shaded diamonds in the component diagrams.

**Expanding** – is the process of breaking a subsystem down into its finer parts. It is used to develop a component diagram.

**External Forces** – are forces that affect the system, but which the system may have little ability to affect.

**Emergent Behavior** – refers to the behavior that emerges, or results, from the interaction of two entities. In complex systems, it is often difficult to predict even when the behavior of the system's parts is predictable.

**Emergence**
System properties that are not evident from those of the parts. A higher level phenomena, that cannot be reduced to that of the simpler constituents and needs new concepts to be introduced. This property is neither simply an aggregate one, nor epiphenomenal, but often exhibits 'downward causation'

**Evaluative Complexity**
The existence of many different stakeholders with different viewpoints about system performance makes it difficult to reach decisions about systems design

**Facilitation**
Facilitation is done by a third party who assists in running consensus-building meetings. The facilitator typically helps the parties set ground rules and agendas, enforces both, and helps the participants keep on track and working toward their mutual goals. While similar to a mediator, a facilitator usually plays a less active role in the deliberations, and often does not see "resolution" as a goal of his or her work, as mediators usually do.

**Fact-based disputes**
Fact-based disputes are disputes about what has occurred or is occurring. Such disputes can be generated from misunderstandings or inaccurate rumors (when someone is accused of doing something they did not actually do). Facts-based disputes can also be generated by differing perceptions or judgements about what has occurred or is now occurring. For example, a dispute over the level of threat caused by the ozone hole or the greenhouse effect is a "facts-based dispute," even though all the scientific facts are not readily discernable or agreed to.

**Framing**
Framing is the process of defining what a problem is about. Just as a frame can be placed around a photograph, including some portions of the picture, but cropping other portions out, people can define some aspects of a problem as important, while they ignore (or are unaware of) other issues that do not concern them.

**Framework** – is a qualitative model of a system that uses description and diagrams to characterize the system and its behavior. The CLIOS diagrams are frameworks.

**Game Theory**
The study of interactions between intelligent agents, concentrating on whether outcomes are zero, positive or negative sum.

**General Systems Theory (GST)**
The interdisciplinary idea that systems of any type and in any field can all be described by a common set of ideas related to the holistic interaction of the components. This nonlinear theory rejects the idea that system descriptions can be reduced to linear properties of disjoint parts.

**Genetic Algorithm (GA)**
The use of evolutionary techniques to diversify, combine and select options in order to improve performance, following the methods of natural selection by coding options as genes.

**Graphical User Interface (GUI)** - A program interface that uses a computer's graphics capabilities to make the program easier to use. Graphical interfaces use a pointing device to select objects, including icons, menus, text boxes, etc. A GUI includes standard formats for representing text and graphics.

**Institutional Sphere**
Made up of organizations and actors that influence the physical domain. It is a complex system in its own right, but its interaction with the physical domain forms the larger CLIOS.

**Impartiality**
This refers to the attitude of the third party. An impartial third party will not prefer one side or one side's position to another side's position, but will approach them both as equally

valid. In principle, this objective can be hard to achieve, although a third party can make an active effort to treat each side the same, even if he or she tends to prefer one party or one party's argument over the other.

**Incompatible interests**
Incompatible interests are things that people want that cannot be simultaneously achieved. If a community has a limited budget to spend on public services, for example, and each of four agencies (the police, the schools, the hospital, and the roads department, for instance) all need a budget increase to even maintain current services, these departments have incompatible interests--not all of their funding requests can be met simultaneously.

**Interests**
Interests are the underlying desires and concerns that motivate people to take a position. While their position is what they say they want, such as "I want to build my house here!", their interests are the reasons why they take that position (because I want a quiet lot with a good view of the city). Often parties' interests are compatible, and hence negotiable, even when their positions seem to be in complete opposition.

**Interest-Based Problem Solving**
Interest-based problem solving defines problems in terms of interests (not positions--see immediately below) and works to reconcile the interests to obtain a mutually-satisfactory solution.

**Interest groups**
Interest groups are advocacy groups--groups of people who join together to work for a common cause. Environmental groups, groups defending human rights, and groups working for social causes are all interest groups.

**Internal Complexity**
Complexity of the system structure that makes it very difficult to change without causing system failure

**Joint Fact-Finding**
Joint fact finding is a process in which two or more disputants work together to clarify disputed facts in a conflict--for example, they might cooperate on a scientific study of environmental impacts of a proposed project.

**Knowledge**
Knowledge refers to what one knows and understands. Knowledge is sometimes categorized as either unstructured, structured, explicit or tacit. What we know we know is explicit knowledge. Knowledge that is unstructured and understood, but not clearly expressed is implicit knowledge. If the knowledge is organized and easy to share then it is called structured knowledge. To convert implicit knowledge into explicit knowledge, it must be extracted and formatted.

**Knowledge Acquisition**
The extraction and formulation of knowledge derived from various sources, especially from experts.

**Knowledge Base**
A collection of facts, rules, and procedures organized into schemas. The assembly of all the information and knowledge of a specific field of interest.

**Knowledge Management (KM)**
KM is the distribution, access and retrieval of unstructured information about "human experiences" between interdependent individuals or among members of a workgroup. Knowledge management involves identifying a group of people who have a need to share knowledge, developing technological support that enables knowledge sharing, and creating a process for transferring and disseminating knowledge.

**Layering**
An organizing tool for layering the subsystems into relatively independent layers, if subsystems become too detailed to analyze.

**Legitimacy**
Legitimacy refers to the perceived fairness of a dispute resolution process. For example, fair elections or litigation based on socially-accepted laws are generally considered legitimate, as are the decisions that result from such processes. On the other hand, elections where voters are harassed or forced to vote a particular way are usually considered illegitimate, as are court decisions handed down by biased courts. Legitimacy of decision making procedures is important, because illegitimate procedures almost always escalate conflicts, making their ultimate resolution more difficult.

**Linear Programming**
A mathematical model for optimal solution of resource allocation problems.

**Links**
General term to describe the connections between the components of the physical domain (defined as class 1), the components of the institutional sphere and the policy domain (defined as class 2), or the components of the institutional sphere (defined as class 3). The class 2 links are also known as "projections."

**Lose-Lose Situations**
Game theory makes a distinction between positive-sum situations (often called "games,") in which everyone can win (also referred to as "win-win"), negative sum games in which all sides lose (also referred to as "lose-lose") and zero-sum games in which one side wins only if another side loses.

**Major Subsystems**
The principal, relatively independent divisions of the physical domain. Identifying major subsystems is the first step toward representing a CLIOS.

**Major Subsystem Diagram**
Macro-level representation of the CLIOS, using major subsystems identified in Step 2.

**Mapping**
Process of 'flattening' the Institutional Sphere into a surface in order to examine its parts. The Institutional Sphere is mapped into a plane for convenience to allow one to consider it.

**Mediation**
Mediation is a method of conflict resolution that is carried out by an intermediary who works with the disputing parties to help them improve their communication and their analysis of the conflict situation, so that the parties can themselves identify and choose an option for resolving the conflict that meets the interests or needs of all of the disputants. Unlike arbitration, where the intermediary listens to the arguments of both sides and makes a decision for the disputants, a mediator will help the disputants design a solution themselves.

**Methodology**
A system of principles, practices, and procedures applied to a specific branch of knowledge

**Model**
Quantitative representation of a system (as opposed to a qualitative one).

**Negotiation**
Negotiation is bargaining--it is the process of discussion and give-and-take between two or more disputants who seek to find a solution to a common problem. Negotiation occurs between people all the time--between parents and children, between husbands and wives, between workers and employers, between nations. It can be relatively cooperative, as it is when both sides seek a solution that is mutually beneficial (commonly called win-win or cooperative bargaining), or it can be confrontational (commonly called win-lose or adversarial) bargaining, when each side seeks to prevail over the other.

**Neutrality**
This term means that a third party is not connected to or had a prior relationship with any of the disputants.

**Non-governmental Organizations (NGOs)**
The term "non-governmental organizations" (NGOs) refers to international organizations that are not associated with any government.

**Physical Domain**
A system in its own right, it interacts with the institutional sphere to form an engineering system. It represents a physical system managed by the institutional sphere.

**Policy Lever** – represent the components in the physical domain that may be directly affected by actors on the institutional sphere. They are drawn as rectangles in the component diagrams.

**Polarization**
Polarization of a conflict occurs as a conflict rises in intensity (that is, escalates). Often as escalation occurs, more and more people get involved, and take strong positions either on one side or the other. "Polarization" refers to this process in which people move toward extreme positions ("poles"), leaving fewer and fewer people "in the middle."

**Positions**
Positions are what people say they want--the superficial demands they make of their opponent. According to Fisher and Ury, who first distinguished between interests and positions, positions are what people have decided upon, while interests are what caused them to decide. Often one side's position will be the opposite of their opponents', although their interests may actually be compatible.

**Positive-Sum Situations (Positive-Sum Games)**
Game theory makes a distinction between positive-sum situations (often called "games,") which everyone can win (also referred to as "win-win"), negative sum games (also referred to as "lose-lose") and zero-sum games in which one side wins only if another side loses.

**Power**
Power is the ability to get what you want, or as conflict theorist Kenneth Boulding put it, to "change the future." This can occur through force (sometimes referred to as "power-over"), through cooperation (referred to as "power-with" or exchange power) or through the power of the integrative system--the system of identity and relationships that holds people together in groups.

**Principled Negotiation**
This approach to negotiation was developed by Fisher and Ury and first presented in their best-selling book, Getting to Yes, in 1981. Basically an integrative negotiation strategy calls for "separating the people from the problem," negotiating on the basis of interests rather than positions, identifying options for mutual gain, and using objective criteria to judge fairness of any proposed settlement.

**Projections**
Links that connect the institutional sphere and the physical domain. The influence may be thought of as going in either direction: from the institutional sphere to the physical domain or vice versa. However, the projection coming from the institutional sphere can only go to the physical domain, projected as a policy lever and this projection cannot bounce directly back to the institutional sphere. For projections coming from the physical domain can come from any components on the layers and go back projecting on the institutional sphere. Projection is important as it forms close loops between the physical domain and institutional sphere, which are key sources for Step 5 to generate insights of the system.

**Ripeness**
A conflict is said to be "ripe" for settlement or negotiation when it has reached a stalemate, or when all of the parties have determined that their alternatives to negotiation will not get them what they want or need. In this case, they are likely to be ready to negotiate a settlement which will attain at least part of their interests--more than they are getting otherwise or stand to get if they pursue their force-based options further.

**Representation**
A way to denote the structure of a system and the direct and indirect relationships between its components, in order to characterize a system and its behavior.

**Strategic Alternatives**
Alternatives for improvement in the physical domain. They are strategic in that they are selected and combined to form robust solutions for system improvement. Furthermore, they are chosen and shaped to maximize feasibility of implementation.

**Stages**
Refer to the three stages in the CLIOS process, which are stages of Representation, Design, Evaluation & Selection, and Implementation.

**Step**
Refers to the twelve steps of the CLIOS process.

**Subsystem Drivers**
Components that impact more than one sub-layer of a subsystem in the physical domain.

**Scale-up Problem**
Most negotiations and other conflict resolution processes occur among a small group of people. In intergroup, inter-organizational, and international conflicts, these negotiators represent a large number of other people, not just themselves. Getting those people--the constituents--to agree to the settlement developed by the negotiators is often a problem, as they have not gone through the same trust-building and understanding-improving process that the negotiators have experienced. We refer to this as the "scale-up problem," as the small group understandings and trust must be "scaled up" to the larger population if peace building is to be effective.

**Stakeholder Conflict Assessment**
Stakeholder Conflict Assessment is the process of determining who else is involved in a conflict and what their interests, needs, and positions are. It also involves the determination of external constraints that affect the situation and any other factors that define the conflict situation beyond one's own view of the conflict.

**Stakeholders**
Stakeholders are people who will be affected by a conflict or the resolution of that conflict. It includes current disputants, and also people who are not currently involved in the

conflict but might become involved because they are likely to be affected by the conflict or its outcome sometime in the future.

**System**
A dynamic entity comprised of interdependent and interacting parts, characterized by inputs, processes and outputs.

**System Dynamics**
The study of how systems actually behave, using models to simulate the assumptions and rules being followed. Often the behavior seen is very different than the behavior people expect.

**Systems Thinking**
The systems approach relates to considering wholes rather than parts, taking all the interactions into account, see also General Systems Theory. It considers processes rather than things to be primary

**Values**
Values are the ideas we have about what is good and what is bad, and how things should be. We have values about family relationships (regarding, for instance, the role of the husband with respect to the wife), about work relationships (regarding, for instance, how employers should treat employees) and about other personal and relationships issues (regarding, for example, how children should behave towards adults, or how people should follow particular religious beliefs).

**World view**
A world view is a person's fundamental image of the world--one=s set of core beliefs about how their social environment is put together. It involves one's fundamental values about what is good and bad; it involves beliefs about who does what and why; it involves assumptions about what causes events and what those events might later cause. World views are closely linked with a person=s sense of identity. People see themselves as part of some groups and not part of others, of having a particular role to play in society, and particular relationships with others. One's image of who one is results from one's fundamental image of the world and one's image of how one relates to other people in it.

# Appendix A - Cape Wind Online Survey Invitation Letter and Survey Questionnaire and Raw Survey Results

## A) Invitation Letter

Dear ------,

For a doctoral research at MIT on stakeholder involvement in decision-making on large-scale systems such as the permit process for the Cape wind project in Nantucket Sound, we have designed a survey that seeks input from all stakeholders that were previously involved in the MTC process.

Filling out the survey should not take more than a few minutes, but it can help develop a set of objective criteria for site selection of future offshore wind projects.
http://web.mit.edu/amostash/www/capewind.htm

The survey is not related to MTC, and you were only contacted because you are considered stakeholders in the Cape Wind project. I am a doctoral candidate at the Technology, Management and Policy at the Massachusetts Institute of Technology (see my background at http://web.mit.edu/amostash/www/resume.htm).The survey relates to my doctoral research on Stakeholder-Assisted Policy Design for Large-Scale Complex Systems with high stake and large amounts of scientific uncertainties, such as the Cape Wind project. The underlying hypothesis of the research is that many adverse effects of conflicts that arise in such projects can be mitigated if stakeholders could be involved in defining the scope jointly.

**Attached**, please find a paper that Prof. Joseph Sussman and I have published on the issue, that uses another controversial project, the Mexico City Transportation/Air Quality system as a case study. It provides a good background on how joint fact-finding can be used for science-intensive disputes. The results of the survey will not be used with identifying information, but the information will help spell out how stakeholders and decision-makers in any offshore wind project would include in a joint fact-finding approach. The use of the information will be purely academic in nature and it will not be used to influence any decisions. The aggregate results (without any identifiers) and the subsequent analysis will then be available within my doctoral dissertation and upcoming conferences. All those who contribute to the survey will be fully acknowledged in the publications.

Background on MIT efforts at Joint Fact-Finding and the Cape Wind Project: In Fall semester 2003 and spring semester 2004, two classes called "Joint fact-finding in Science-intensive policy disputes" have been looking at science-intensive issues in general, and at the Cape wind project in particular. Prof. Larry Susskind and Prof. Herman Karl are closely following the Cape Wind project form a joint fact-finding approach. Many of you were invited to our Fall series to discuss your views on a possible "Joint fact-finding approach" in the process of issuing permits for Cape wind and other offshore wind projects. We would be delighted to have others join us as well.

**B) Follow-up Invitation Letter**

Dear ------,

Early in the Summer you received an email from me on an academic survey at MIT on the proposed Cape Wind Project. The content and format of the survey is described at the bottom of this email. We have received many responses so far from important stakeholders (listed below), and we believe the survey can shed light on stakeholder concerns and help improve the current permitting process for offshore wind projects.

However, we have not yet received your input, which is very valuable to us. Your input is very important to us to achieve a balanced representation of views. None of the views expressed will be linked to your organization in subsequent reports or publications. The survey shouldn't take more than a few minutes to complete, but will give your organization an opportunity to influence the design of better permitting processes. The survey can also be filled out by any other informed person representing your organization.

The survey can be filled out at: http://web.mit.edu/amostash/www/Capewind/survey.htm
If you have any concerns with the questions or the survey in general, or are not inclined to fill it out, we would be more than happy to address them or at least understand your concerns. If you need to talk to me, my phone number is (617) 267-3786. I am reached by email as easily (amostash@mit.edu)

Thanks and Best Regards.

Ali Mostashari
Ph.D. Candidate, MIT

About the Survey

You are contacted because you are considered a stakeholder (citizen group, scientist, federal-, state- and local government agency, professional association) in the proposed Cape Wind project. I am a doctoral candidate at the Technology, Management and Policy program at the Massachusetts Institute of Technology (see my background at http://web.mit.edu/amostash/www/resume.htm).The survey relates to my doctoral research on Stakeholder-Assisted Modeling and Policy Design for Large-Scale Engineering Systems with high stake and large amounts of scientific uncertainties, such as the Cape Wind project. The underlying hypothesis of the research is that many adverse effects of conflicts that arise in such projects can be mitigated if stakeholders could be involved in defining the scope of environmental and socioeconomic assessment of such cases in a collaborative fashion and in dialogue, rather than a polarized atmosphere where stakeholders resolve conflicts through legal action.

The results of the survey will not be used with identifying information, but the information will help spell out what issues stakeholders and decision-makers in any offshore wind project would include in a joint fact-finding approach. Later, we may ask you whether or

not you would be interested in joining other stakeholders in a collaborative process, outlining important aspects of the project on a system-wide scale.
http://web.mit.edu/amostash/www/Capewind/survey.htm

**Background on MIT efforts at Joint Fact-Finding and the Cape Wind Project**
In Fall semester 2003 and spring semester 2004, two classes called "Joint fact-finding in Science-intensive policy disputes" have been looking at science-intensive issues in general, and at the Cape wind project in particular. Prof. Larry Susskind and Prof. Herman Karl are closely following the Cape Wind project form a joint fact-finding approach. Many of you were invited to our Fall series to discuss your views on a possible "Joint fact-finding approach" in the process of issuing permits for Cape wind and other offshore wind projects. We would be delighted to have others join us as well.

**About Stakeholder-Assisted Modeling and Policy Design**
**http://esd.mit.edu/symposium/pdfs/papers/mostashari.pdf**

**To fill out the survey click on the link below**
**http://web.mit.edu/amostash/www/Capewind/survey.htm**

**C) Survey Questionnaire**

## About This Survey

At MIT, we are trying to understand different stakeholders' perceptions on different aspects of the Cape Wind project, and to explore the adequacy of the current permitting process is accommodating stakeholder interests. The premise of our research is that a collaborative stakeholder process that takes into account stakeholder concerns and inputs in the environmental- and social impact assessment from the beginning can help in avoiding costly conflicts from all sides. The case of the Cape Wind proposal is of interest to us, because of the central role of technology and environmental impact in the permitting decision, as well as the diversity of stakeholder views on its potential merits and drawbacks. You can help us by filling out the following survey.

The following questionnaire seeks to identify your organization's perceptions of Offshore Wind in general and the Cape Wind Project in particular. Information gathered in this survey will support research that aims to improve the level of involvement of stakeholder groups in dealing with offshore wind project such as the current project. At a later stage, we may ask you whether you would like to participate in a stakeholder-assisted environmental and social impact assessment process for the proposed Cape Wind Project along with other stakeholders. Of course filling out this survey does not imply your consent in taking part in such a process.

Please Note that:

- Your Participation is voluntary
- You may decline to answer any or all questions
- You may decline further participation, at any time, without adverse consequences
- All information submitted through this survey will be used in anonymous and aggregate form only, and processed with confidentiality.

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Please answer as many questions as apply to you or for which you have time. The survey should take only a few minutes to complete. Thank you very much for your participation.

* Denotes required Field

**Your Name ***

**Your Affiliation/Organization ***

Contact Email Address *

**Problem Definition**

- Regardless of a specific site, how do you feel of development of offshore wind energy in the U.S.?

Very positive

Optional explanation of preference:

**Position:** In the case of Cape Wind, would you consider your organization to be:

Undecided

- Consider the process of determining the site for an offshore wind energy project. Which four criteria do you think are the most important to consider in the order of importance?

1.

2.

3.

4.

- What are the potential main **benefits** of offshore wind energy development? (List three in order of importance)

1.

2.

3.

What are the potential main **concerns** with offshore wind energy development? (List three in order of importance)

1.

2.

3.

One of the important points raised in siting many offshore wind development projects is the impact of wind-farms on the aesthetics of the region in question. While it may or may not be important to you personally, what objective way would you suggest that would allow taking aesthetics into consideration alongside other considerations as a siting criteria ?

**Information**

- What further information do you believe the public should have for better understanding the interactions between the wind farm, the coastal communities and the ecosystem (environmental, economic, etc.)? In other terms, what currently unavailable information would be necessary for decision-making on offshore wind energy projects?

- What capacity does your organization have for further information gathering on the interactions between the wind farm, the coastal communities and the ecosystem (environmental, economic, etc.)?

## Comments

- If you have any additional comments on the current permitting process, offshore energy development or stakeholder participation, please use the box below. Thanks again for your time and contribution!

By clicking on the "submit" button you consent to the usage of the data you provide in this survey, in the manner indicated above. There are no known risks associated with filling out this survey.

Submit | Reset this form

This survey has been developed as part of a dissertation on "Stakeholder-Assisted Modeling and Policy Design Process for Engineering Systems" by Ali Mostashari, Ph.D. Candidate in Technology Management and Policy program at MIT.

Stakeholder Responses to the Online Survey

(Names and Affiliations Omitted for Privacy Purposes)

4. Perception of wind energy
Very positive

All significant and relevant energy initiatives in the US have been undertaken by the private sector, if we relegate renewable energy to coops and government programs it will be only a token, symbolic gesture without making a meaningful contribution to the needed energy transition from fossil fuel and fission to renewables and hydrogen.

5. Position on Cape Wind: Proponents
6. Criteria for siting: depths
wave heights
proximity to area of electric demand, proximity to electric transmissions system
7. Benefits : Reduced reliance on imported fossil fuel energy & greater diversification of region's energy portfolio
reduced pollutant emissions
new jobs, new economic sector introduced to region, more stable energy prices
8. Concerns fossil fuel energy will be concerned with greater competition

always a tradeoff with a project like this with open vista - visual impact

most other concerns are based on fear and will dissipate after construction of project

9. Aesthetics: It should be one of very many factors that public agencies evaluate in determining the public interest.

10. Further info needed:Greater analysis of what additional potential could be realized in offshore wind if US Government provided as generous supports as many European countries do.

11. Information gathering capacity: We are gathering all information being asked of us from government permitting agencies.

4. Perception of wind energy
Very positive

The many benefits, versus the few drawbacks, make it a compelling choice. USA is behind and must catch up as quickly as is feasible.

5. Position on Cape Wind: Proponents
6. Criteria for siting: Not more than 50' deep to water bottom, so towers can be safe and economical
   Close to existing transmission lines
   Nearby shore line can have port facilities necessary for construction and service, and preferable to be relatively uninhabited (at least by NIMBYs)
7. Benefits : Long term economic benefit to electricity users and the US economy and government.
   Health benefits - cleaner air than fossil fuels
   Less reliance on other countries for fuels, such as the middle east.
8. Concerns Visual esthetics (to some people, but others love them) - many who object have not seen them so far.
Could be dangerous for airplanes, boats etc. if not engineered properly

9. Aesthetics: Analyze sales prices of homes with a wind-farm view, to see if they appreciated less, equal or more than equivalent homes on the coast without a wind-farm view.

10. Further info needed: Your study could come out against the disinfomation issued by the "Alliance to Protect Nantucket Sound" and "Windstop" organizations..... case after case has shown that their strategy has been (and continues to be) to put our known untruths, hold them out in the public's eye for month(s), and only after forced to retreat by lawsuits or pressure from newspapers, so they admit their "mistake".

11. Information gathering capacity: We do what we can, but are a volunteer grassroots organization, NOW OVER 2,000 MEMBERS. The relatively little time (compared to staffed organizations)we have is mainly devoted to educating the Cape Cod area public at this time.

4. Perception of wind energy
Very positive

Critical element in transition to sustainable energy economy

5. Position on Cape Wind: Undecided
6. Criteria for siting: commercial feasibility
   potential for local public benefit
   ability to mitigate local adverse impacts
7. Benefits : clean power
   ability for local communities to stabilize electricity prices
   economic development within host communities
8. Concerns minimal control for local communities who might bear adverse impacts

questions about ability of host communities to maximize benefits
protection of aesthetics (QoL amenity) and other competing uses (recreation, fishing, etc.)

9. Aesthetics: Projects may only be granted approval to proceed w/ conditions, with aesthetics one required element in mitigation and developers/opponents working together to minimize adverse effects

10. Further info needed:Nantucket Sound project environment is adversarial; LIPA project environment less so. LIPA model a better one!

11. Information gathering capacity: CIREC is attempting to jumpstart a regional "fact finding" and "visioning" approach to energy supply and use planning; our obstacle is funding. I'm hoping to get word within the next couple days about a key grant; will keep you posted, as I believe this is an area which you and colleagues should track closely.

4. Perception of wind energy
Positive

The organization supports the project, but has not taken a position publically.

5. Position on Cape Wind: Proponents
6. Criteria for siting:
Physical feasability
financial feasibility
   economic externalities
   economic benefits
7. Benefits : cheaper electric bills (locally)
   regional economic development
   hydrogen generation
8. Concerns aesthetics

navigation

boating

9. Aesthetics: There is no objective way to take aesthetics into consideration. (You could set a price for aesthetics by auctioning off sites (development vs. preservation.) We do it all the time with land on Cape Cod.

10. Further info needed:Wind energy is the most technologically intensive AND the most labor intensive form of electricity generation. An economic benefits analysis of generating electricity by incurring costs domestically (technology and labor), opposed to incuring costs overseas (oil) would help understand the true benefits.

11. Information gathering capacity: We had been gathering information (through Committee) on wind energy generation on Cape Cod prior to this proposal. We are consistantly monitoring this project and disseminating information to members.
12. Comments In the first question: The word private will skew the response. All energy generation in the US is private. Try the same question with the word public and then again with out either and check the results.

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4. Perception of wind energy
Conditionally positive

The Board of Selectmen in Yarmouth voted in opposition to the application of Cape Wind based on a number of criteria including, but not limited to, effect on tourism, environmental concerns and esthetics.

5. Position on Cape Wind: Opponent
6. Criteria for siting: Requiring a substantial review of all effects both good and bad
   Allowing a reasonable time line to complete studies
   A decommisioning bond for the removal of outmoded facilities
7. Benefits : Lessening fossil fuel dependence
   Decreasing air contaminents
   Furthering public awareness of alternate energy scources
8. Concerns Proper licensing

Proper environmental review

Federal, state and local reveiw

9. Aesthetics: Although expense is an issue, siting should be away from shore view as possible

10. Further info needed:A pilot government project with a sunset clause to establish independent guidelines

11. Information gathering capacity: As a representative of the town my role was limited to trying to convey the intent of the Board of Selectmen. My impression is that the town

would be very limited in gathering information independtly. Tough fiscal times in towns across the Commonwealth
12. Comments

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4. Perception of wind energy
Very positive

5. Position on Cape Wind: No Comment
6. Criteria for siting: Sea floor less than 50 feet deep to ecomonmize on turbine structure
Sea floor with sand or garvel to economize on cost for monopoles
Proximity to high voltage distribution interconnection
7. Benefits : Health benefits from offsetting fossil fuel emissions
Reduction of oil for electrical generation, independence, sustainablity issue
Improvement in air qualtiy and offset of CO2 from fossil plants
8. Concerns I see little concern with the most benign source of power.
9. Aesthetics: All ocean views are beautiful. None more or less than any other. Placement in federal waters three miles or more offshore are in the interest of the public good and far enough away that should not be objectional to the view of reasonable individuals. Would you pit wealthy homeowners vs. working class homeowners viewsheds as more or less deserving? What about environmental justice? Should I be compensted by a power plant a mile away who's 500 foot stack I see from my window?

10. Further info needed:Factual information on the enormous benefits of offshore wind power, health benefits from backoff of fossil plants (saving 15 premature deaths every year), reduction of imported oil from OPEC and unstable conntries, risk reduction of barge and tanker oil spills, leveling of cost of delivered power (the wind is free and forever), seeking a sustainable source of power in view of Hubbert's peak of oil production, as well as for natural gas, employment from manufacturing wind turbines in the Untied Sates, and the impact on reducing greenhouse gas (CO2).

11. Information gathering capacity: As information director, I seek factual substantiated data and facts to counter misinformation, exaggerations, and outright deception by richly funded opposition groups. We hold public presentations, run news ads to help inform and educate the public on the highly complex issues.
12. Comments Please feel free to call me (508) 833-1271 anytime or correspond by e-mail. I appreciate your interest.

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4. Perception of wind energy

Very positive

5. Position on Cape Wind: Undecided
6. Criteria for siting: Overall benefit to energy users
Conflicts with public use of ocean resources
  Environmental impact and economic impacts
  Aesthetic considerations
7. Benefits : Reduction of reliance on non-renewable energy
  Reduction of greenhouse gases
  monetary benefits to users
8. Concerns Large commitment of a public resource which forecloses use by others.

Degree of benefit specifically to areas most affected by a specific project

Aesthetics / Environmental impacts (more needs to be known)

9. Aesthetics: Visualization conducted by objective third party. Trips to see existing facilities, sponsored by objective third party.

10. Further info needed:Nothing comes to mind.

11. Information gathering capacity: Not much. We are a small agency with limited financial and staff resources. Our counterpart on the Cape is better equipped.
12. Comments There is a need to revamp the Federal permitting process specifically for off-shore wind projects so that the public feel that they are invested in the process.

4. Perception of wind energy

Very positive

We need to bring on line a large amount of renewable power in the very near future, and off-shore is where the wind is.
We conditionally support the Cape Wind Project.

5. Position on Cape Wind: Proponents
6. Criteria for siting: environmental impacts
 wind resource
 distance from the grid

7. Benefits : being able to buy the power through the Cape Light Compact
 beginning the trend able to implement large scale renewables in N.E.
 reduction of greenhouse gases
8. Concerns

9. Aesthetics: I find that these turbines are beautiful, unlike the aging power infrastructure along side our roads that we are so accustomed to that we no longer see it. So, I guess more education on the tradeoffs is needed.

10. Further info needed:Not sure what "system" you are refering to here. But if you are refering to the stakeholders process, I feel that the public was not given the opportunity to understand all of the factual information that was gathered during the process. A cd just doesn't cut it!

11. Information gathering capacity:
12. Comments

4. Perception of wind energy
Positive

The choice of locations is critical. For Example, the US Corps of Eng would split up the Cape Wind project in 3 parts. 2 parts in water in different locations and the 3rd on land on the Mass Military Reservation. (MMR)
For example, The site Horseshoe Shoals is difficult. The US Army Corps of Eng suggests cutting it up in three pieces one third of which is on land (MMR).
The Fed needs to create the proper regulations for sea based wind.
What Fed Dept or State Dept should be incharge?
Royaltes to be paid to the approporate state.
5. Position on Cape Wind: Undecided
6. Criteria for siting: Shallow Water
Away from significant winds
Out of the view of the main land

7. Benefits : Start a process of ending the USA's dependence on foreign oil like that of your country..
It's clean
It can create good hi tech jobs
8. Concerns

Location: Horseshoe Shoals may be the wrong place.
The contractor needs to prove he can get a performance bond
Establish an exit plan to remove old tired turbines

9. Aesthetics: Move first project out of view of the mainland.

10. Further info needed: Further info needed:That the contractor is financially responsible to build a $700mil project, i.e. can produce a performance bond

11. Information gathering capacity:
12. Comments

4. Perception of wind energy
Conditionally positive

Factors such as federal system to give away public trust land, cost/benefit analysis, protocols for assessing and mitigating negative impacts, public participation in siting and response plans in the case of problems must be in place before permitting begins.

5. Position on Cape Wind: Opponent
6. Criteria for siting: federal and/or state offshore development regulatory program in place PRIOR to processing applications
evaluation of potential sites and idenfication of areas of higher or lower preference based on a set of publicly defiend criteria
environmental sensitivity of the site as determined by independent parties with input from federal, state, local agencies and the public
other user conflicts including fishing, recreational boating, commercial navigation (sea and air), and enjoyment of an undisturbed horizon by redidents and visitors
7. Benefits : renewable energy

8. Concerns opens door to other forms of offshore development

can endanger valuable offshore resources

cost/benefit analysis doesn't support it from public perspective

9. Aesthetics: Mapping of resource areas to show locations of higher and lower impact, with input from affected communities.

10. Further info needed:not clear what 'system' you mean

11. Information gathering capacity: we are conducting independent analyses of alternatives which will contribute to the discussion of other viable approaches to the cape wind proposal
12. Comments

4. Perception of wind energy
Positive

I believe that this can be an important source of cleaner energy but it is important that projects be sited in areas with least risk to the marine ecosystem.
5. Position on Cape Wind: Undecided
6. Criteria for siting: Minimal risk to endangered or fragile marine species or birds
Minimal risk to fragile marine ecosystems
Not in a major migratory route for marine mammals or large numbers of birds
Close to area where power will be of greatest benefit
7. Benefits : May reduce habitat degradation caused by fossil fuel energy sources
May reduce risk to human health caused by burning fossil fuels
Provides greater energy self-sufficiency for US
8. Concerns If sited in or near major migratory routes or seasonal high use areas may kill wildlife or displace migration to detriment of animals

Anchoring with rip rap introduces artificial reefs (and consequently non-native fauna) and disrupts coastal processes (creating areas of scour and drift) and thus may adversely impact habitat suitability with repercussions for food webs

Project sites are being chosen on basis of wind availability rather than doing prior site screening to determine risk averse sites and this results in controversy over potential impacts which can only be resolved with multi-year intensive study

9. Aesthetics: My organization is generally unconcerned with this. Our concern is with potential adverse impacts on wildlife.

10. Further info needed:I am not sure what you mean by "the system" but I believe that if we are to have offshore wind power it is important to take a step back and look at areas where wind is optimum and then super-impose wildlife high use areas such that wind plants are not being proposed for potentially fragile habitat and/or important wildlife use areas; and(2)there is a need to clarify jurisdictional issues regarding permitting and "ownership."

11. Information gathering capacity: We are familiar with wildlife biologists for most marine species and have suggested that there should be a forum for sharing GIS data bases and other sources of information on habitat use in order to assist in identifying areas that are more risk averse (and thus prone to fewer conflicts). We are happy to help sponsor such an effort. I myself have a background in marine mammal research, and am appointed to a number of federal scientific review groups, such that I am familiar with major migratory corridors, important feeding and foraging habitat, and nursery areas.
12. Comments The controversy over Cape Wind might have been avoided had the developer considered the likely controversies/questions prior to putting forward a formal proposal, and chosen a more risk averse site. For example the Long Island Light and Power Authority has largely avoided this problem with their wind plant development because there was a pre-proposal site selection process that was intended to minimize abutter concerns and choose sites that were not important habitat for birds. While there are obviously SOME concerns with any project, the LIPA project avoided the controversy

largely by having done their homework PRIOR to choosing a site for development. As testiment to this, no conservation group has objected and there have been no serious concerns raised by US Fish and Wildlife or the NY state wildlife department--whereas Cape Wind has been dogged by questions and concerns raised by both the Commonwealth of Mass Division of Fish and Wildlife and the USFWS; both!
of which have made research recommendations regarding avian habitat use that Cape Wind has neglected to address. I am concerned that their mishandling of this situation will either impede developments in better areas or will allow other developers to believe that they need not address these important concerns prior to finalizing a site proposal.

4. Perception of wind energy
Skeptical

On land.

5. Position on Cape Wind: Opponent
6. Criteria for siting: Environmental impacts
Public safety
True cost to ratepayers
Impact on tourism
7. Benefits : None

8. Concerns Location

Impacts

Decomissioning

9. Aesthetics: Measure the real visual impacts, lights at night, construction and repair equipment, things like that.

10. Further info needed:True long term costs and real impacts.

11. Information gathering capacity: Polling of members.
12. Comments

4. Perception of wind energy

Conditionally positive

Siting is a very important issue, as large offshore development should be looked at carefully, regardless of the end result.

(Per the next question: I cannot speak on behalf of my institutions, as they are both quite large and exhibit varied opinions overall. I personally am opposed to the current siting of Cape Wind.)

5. Position on Cape Wind: No Comment
6. Criteria for siting: proximity to critical habitat for marine mammals
proximity to migration tracks and feeding area for birds, particularly endangered/threatened species
potential disturbance of currents/existing habitat and functioning ecosystem
creation of noise (construction and operation) and its impact on surrounding wildlife
7. Benefits : increased proportion of renewable energy compared to nonrenewable sources
energy source with minimal air pollution
potential economic benefits (though I think these are currently overstated)
8. Concerns False sense of well-being leading to the lack of reducing energy consumption. Creation of offshore wind power does not necessarily lead to taking other energy sources offline. We first need to reduce overall energy consumption, accompanied by increased dependence on renewable energy sources (preferably ones that don't damage existing productive habitats---large development projects are still large development projects, even if for renewable energy.)

The before and after: construction disturbance (via noise, currents, removal/altering of habitat), and responsibility for the removal of turbines when out of service
appropriation of public land for corporate use (and no current system to regulate/charge for use)

9. Aesthetics: I believe aesthetics has overtaken the very real arguments to be made against the construction of the current plan as it is proposed. Essentially, arguing about aesthetics is not easy to defend, as it is typically seen as being in the interests of the wealthy waterfront property owners, not the public as a whole. I believe aesthetics should included, but not a priority of this issue. Rather, the outright appropriation of public lands for private use, the lack of siting review (Army Corp with questionable history of review is not reviewing all the alternate sites--only considering whether or not to accept the one proposed site), and a paucity of regulations regarding offshore wind development are of primary concern.

10. Further info needed:Longer-term studies of bird movement through and residence in the area, as well as all alternate sites (per the suggestion of Mass Audubon). Better understanding of the effect of wind farm construction on currents/ecosystem. Better understanding of impact of noise on marine mammals.

11. Information gathering capacity: I believe the physical oceanography department of WHOI could be instrumental in better understanding currents and how that could affect the geology/ecology of the area. Marine mammals and sound can also be addressed by very competent members of the WHOI biology dept.
12. Comments I believe the selection process of the MTC technical advisory system was geared too much toward "undecided" members. Rather, it should have broken off separate working groups to address various specific issues such as aesthetics, economics, and wildlife/habitat concerns, respectively. These working groups could have included folks who may have already formed opinions about the project, but could have provided some very helpful expertise to the review process.

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4. Perception of wind energy
Conditionally positive

Regulating, siting, and permitting protocols, specifically dealing with alternative energy plants on the continental shelf, need to be developed first.

5. Position on Cape Wind: Undecided
6. Criteria for siting: Ecosystem impacts including habitat fragmentation, impacts on wildlife -particularly endangered/protected species
Most power generation with the least environmental impact
The benifits/impacts to the local community

7. Benefits : Continued improvement in alternative energy technology may be a result

8. Concerns There are no guidelines or regulations in place in the US specific for wind energy plants

9. Aesthetics: Our major concerns do not include aesthetics.

10. Further info needed:Of what system??

11. Information gathering capacity: Gathering information in regard to what? Wind energy in general or Cape Wind specifically??
12. Comments Incentive programs for decreasing fossil fuel usage by the US including, but not limited to: tax credits to citizens that purchase fuel efficient cars, lights, solar panels, etc

4. Perception of wind energy

Very positive

5. Position on Cape Wind: Proponents
6. Criteria for siting: Available wind resource
Minimal environmental impact
Community acceptance
Transmission issues
7. Benefits : More renewables in energy mix means less CO2 --> slows global warming
Clean energy - better air quality, human health benefits (no other harmful emissions)
Locally produced power means lower dependence on foreign oil
8. Concerns Potential environmental impacts (ocean ecosystem, mainly)

Private use of and profit from public lands

Public rejection of it

9. Aesthetics: Don't understand question - taking aesthetics into consideration in what? In deciding where offshore wind farms should be sited? There's no easy answer to that.

10. Further info needed:Further information for whom? Are you asking what information I need about the Cape Wind project or what information people in general need for offshore wind projects?

11. Information gathering capacity: n/a
12. Comments I wish some of these questions were a bit more precise.

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4. Perception of wind energy
Conditionally positive

5. Position on Cape Wind: Undecided
6. Criteria for siting: Presence and functions and values of existing marine habitat and resources
Use of these areas by other species (birds, mammals, etc.)
Potential direct impacts of construction and operation
Potential cumulative impacts of facility (alteration of habitat, water flow, sediment transport)
7. Benefits : For the proponent - no cost to acquire/use the land
For the consumer - yet to be determined
For the public at large - yet to be determined
8. Concerns The current regulatory process was not designed to handle this type/size of project

Insufficient resource data

Insufficient data on potential negative impacts

9. Aesthetics: I'm not sure that aesthetics can be integrated. People either like it or they don't.

10. Further info needed:Improved site-specific resource and habitat data.
Comprehensive evaluation of potential impacts to habitat, resources, exsiting uses of the area.
Third-party independent evaluation of potential benefits to the consumer and the environment

11. Information gathering capacity: The Division of Marine Fisheries is directly responsible for management of the Commonwealth's marine resources and habitat (including Nantucket Sound) and maintain the only long-term databases for coastal waters. We have the ability to do a lot more, but that ability is directly related to (and limited by) our funding and staffing levels.
12. Comments Greater presentation of data regarding the various aspects of these projects by independent parties would be of great value. Nearly everything to date has been done by parties either for or against the Cape Wind project.

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4. Perception of wind energy
Very positive

I think it is an opportunity to learn much about the emerging technology, first hand.

5. Position on Cape Wind: Neutral (Government Agency)
6. Criteria for siting: good wind regime,
sound environmental information and review concerning proposed site
proximity to population centers, in the near term
access to the grid
7. Benefits : Reduced use of fossil fuels
distributed generation enhancement for the region
educational experience for the public
8. Concerns Viewshed

Real estate values

How it will benefit those who have to live with it

9. Aesthetics: I think that anyone familiar with the habits of the sailing class knows that polution already exists out there. The fishing interests seem more concerned about privacy out there. I think that if we could have cameras on each of the towers, we would greatly

improive our knowledge of what actually goes on out there. The increased traffic to and from these towers for maintenance would also provide important information not previously available on these huge expanses of ocean.

10. Further info needed:I think that a better link has to be made between the resident and the project. What benefits will he/she derive from the project? Obviously, a small fraction of coastal residents are year round residents, and the majority may be on bottled water, or concerned about other pollutants, asthma rates, cancer rates, etc. Health has to be better addressed.

11. Information gathering capacity: We monitor the projects, and speak with people on both sides of the issue, and we identify technical assistance for our sister agencies so they can better understand the technology, and real issues, in order to carry out their respective functions to the best of their abilities for the public.
12. Comments I think that we will probably need to start identifying those areas where we will not allow development, and why. That process would educate the public, as well as the reviewing authorities. I think that we need to balance our need for a diverse and clean energy supply with our environmental-visual-issues. I don't think the public is aware of the seriousness of the situation regarding fossil energy. To have a few people with a multimillion dollar view to be able to nearly derail a project is outrageous. But it is happening everywhere where there is a view and private access to that view, whether it be a mountain ridge line or an expanse of open water. We need to find a better way to allow for off-shore wind development to continue in a manner that is most protective of all of our rights.

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4. Perception of wind energy
Very positive

Vital part of rational energy system.

5. Position on Cape Wind: No Comment
6. Criteria for siting: Technical feasibility
Lack of collateral negative impacts
Community support
Economic development potential
7. Benefits : Reduction in emissions from electricity sector
Reduction in fuel imports
Introduction of power with stable non-fuel dependent price into system
8. Concerns Aesthetics

Avian

Conflicts/impacts with marine flora and fauna

9. Aesthetics: Good visual simulations clearly presented can address many concerns - as well as de-commissioning funds to assure it will be a temporary impact in the long run

10. Further info needed:Clear explanation of how the regional electricity system works

11. Information gathering capacity: Not enough
12. Comments

NOTE: This message was sent using a WWW form. The address skaplan@clf.org was typed manually, and may easily be incorrect.

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4. Perception of wind energy
Skeptical

Will not withstand a rigourous cost benefit analysis.

5. Position on Cape Wind: Opponent
6. Criteria for siting: There is no credible fundamental Federal siting process presentley in place

7. Benefits : None that have been objectivley analysed

8. Concerns Navigation Fishing Boating Tourism Avian Benthic Nursery Flying

No tax revenue No lease Revenue No decommissioning considered

Public land taking Location has no benifit to N E grid

9. Aesthetics: This area should be a Marine Santuary or a Marine Protected Area. An organization like C L F is decididley hypocritical on this issue.

10. Further info needed:Citizens need to fully understand the practical effect of this massive power plant as a part of a deregulated six STATE GRID.

11. Information gathering capacity: We have 1400 members and 3000 affiliate members.
12. Comments We believe that this industrialization of an important natural resource handsomely benefits the developer but does absolutley nothing for prices, carbon fuel consumption, nor cleaner air if you truly look at the practical affect of the real output.

4. Perception of wind energy

No Comment

It is premature to answer this question until there is a comprehensive regulatory structure to guide development of this form of energy.

5. Position on Cape Wind: Neutral (Government Agency)
6. Criteria for siting: comprehensive federal and state review process
proper site review process and procedures
adequate consideration of alternative sites
clear understanding of costs and benefits to ratepayers
7. Benefits : possible inclusion as an additional generating resource in the electric grid
help to reduce dependence on fossil fuels
help to develop future renewable resources
8. Concerns lack of planning for sites

lack of criteria for development

lack of oversight once developed over owners

9. Aesthetics:

10. Further info needed:We need to have a much better understanding of the impact of ocean industrialization in general and at this specific site. Many agencies have called for years of research on this impact of this type of large scale development. All of this date should be available prior to any ocean development.

11. Information gathering capacity:
12. Comments The current permitting process is fatally flawed in that it is actually not a permitting process for off-shore wind development, but rather a process adapted by the Army Corp but used in reality to determine the impact of a structure on navigation. Ocean siting of industrial projects is an issue that is much broader than navigation or the specific site, therefore, the stakeholder process, while interesting and informative, will do little to aid this process.

4. Perception of wind energy

Skeptical

Regulations need to be defined to ensure Towns, States, and Federal Gov can regulate and oversee the permitting process

5. Position on Cape Wind: Opponent
6. Criteria for siting: impact on sensitive environmental areas
Navigation
recreation, economic impacts
cost benefits
7. Benefits : don't know of any that can't be accomplished on land under strong regulatory guide lines

8. Concerns pollution

maintenance and up keep

no truly governing regulations to ensure the safety to all areas

9. Aesthetics: limited number of towers
out of site from shore line
outside of normal recreation areas

10. Further info needed:dialog and cooperation between the developer and the cities/towns, state and local populas, along with the federal government. Cape Wind has done nothing to foster relations with the local communities and towns of Cape Cod or listened to our concerns

11. Information gathering capacity: legal, and interaction with our neighboing communities and the chamber of Commerce
12. Comments The Army Corps of Engineers is not the proper agency to be permitting offshore wind farms. This is a unique area of explotation with no true regulatory oversight.

# Appendix B Offshore Wind Energy Stakeholder-Assisted System Representation Invitation and Assessment Survey

MIT Collaborative Process for Offshore Wind Energy
Saturday April 2, 2005
2:00-6:00 p.m.
MIT Stata Center, Room 32-124
32 Vassar Street
Cambridge, MA 02139

**Dear Cape Wind Stakeholders,**

We would like to invite you to MIT to attend a single-session collaborative process on offshore wind energy development. The proposed date is Saturday April 2, 2005 from 2:00 p.m.-6:00 p.m. a, MA. An RSVP is required for attendance by March 28$^{th}$.

**About the Collaborative Process**

The goal of the collaborative process is to foster a more interactive dialogue among stakeholders (this includes decision-makers, citizen groups, private sector and experts) with different viewpoints on the issue, based on a stakeholder-assisted systems representation of the Cape Wind project that used inputs from many of you to capture the important issues that need to be addressed in a decision-making process. Unlike public hearings, the collaborative process is not geared towards reaffirming stakeholder positions. In essence, we would like to explore whether and how engaging stakeholders in a collaborative decision-making process would help make wiser decisions for offshore wind energy development, while reducing conflict among stakeholders. There is no guarantee that this will succeed, since the process can be only as good as the dedication of stakeholders to dialogue. Still, our past experience with similar cases shows that stakeholders leave such processes with a better understanding of the diverse aspects of a decision, and with a positive experience of sharing their views with other stakeholders in an atmosphere that is devoid of conflict.

**About the Systems Representation**

A systems representation is a conceptual tool to capture the different aspects of a complex system that includes technical, economic, social and regulatory aspects. The process will be based on previous groundwork done at MIT on the Cape Wind project, including a stakeholder conflict assessment, and a stakeholder-assisted conceptual modeling of the Cape Wind project. In the first phase of this research, we contacted more than 44 stakeholder organizations for the Cape Wind project with a balanced representation of opponents, proponents, undecided and neutral stakeholder, to understand their views on the project and its scope. We then built a system representation based on the survey and comments in 6 public hearings, as well as comments in the MTC stakeholder process.

**Program Structure**

The current structure of the program is as follows:

| | |
|---|---|
| **1:45 p.m. -2:00 p.m.** | Registration and Sign-in |
| **2:00 p.m.-2:30 p.m.** | Introduction to Joint Fact-Finding and the role of systems representations. Discussion of ground rules. Short Q&A |
| **2:30 p.m.-3:45 p.m.** | Interactive presentation of the MIT stakeholder-assisted systems representation of offshore wind projects |
| **3:45 p.m.-4:00 p.m.** | Break- Refreshments will be served |
| **4:00 p.m.-5:30 p.m.** | Facilitated interactive discussion of important decision-factors in offshore wind and strategies for dealing with uncertainties in social and environmental impact. |
| **5:30 p.m.-6:00 p.m.** | Recap of Points of Agreement and Disagreement between Stakeholders (Adjourn at 6:00 p.m.) |
| **6:00 p.m.-7:00 p.m.** | Optional open floor discussions for those interested |

**Notes**

- Participation in the discussions is optional, and is not a prerequisite for your attendance.
- Participants will be asked to respect the views of other participants in the discussion, and be committed to respectful dialogue.
- The discussions will be facilitated (by a neutral?)
- Refreshments will be available throughout the meeting. However participants should make their own arrangements in terms of brunch/lunch before the meeting, as well as dinner afterwards.
- The sessions will be held in MIT's world-renowned Stata Center. Plan to arrive early to explore the $300 million building built by architect Frank Gehry and his team.

**Confirmation of Attendance**

If you decide to attend, please let us know by an email to capewind@mit.edu by 5:00 p.m. Monday March 28, 2005. Please include the following information.

1) Name
2) Affiliation (Organization/Agency)
3) Where will you be driving from? Would you need a ride, or will you be able to offer car-pooling to other participants in your vicinity?

**Invitation of other Stakeholders**

If you so wish, you can also invite other stakeholders to the group. We ask that you limit your invitation to one other individual, so that the balance of the group is not affected significantly.

**Participation Options for Those Unable to Attend**

We realize that MIT is not convenient for many of you, but feel this to be a unique opportunity to have stakeholders interact on neutral ground. For those of you unable to attend the session, the Powerpoint presentation and the Cape Wind offshore wind energy systems representation will be available on our website http://web.mit.edu/amostash/www/Capewind/ by March 28, 2005. Any comments you may have on any of these two documents will be added to the final process document in a separate section. You can provide us with comments by sending emails to capewind@mit.edu

**Location**

Massachusetts Institute of Technology
The Stata Center, Room 32-124 (First Floor)
32 Vassar Street
Cambridge, MA 02139
Campus Map: http://whereis.mit.edu/map-jpg?mapterms=32&mapsearch=go

**Driving Directions**

Once we receive your confirmation, we will send you information regarding car-pooling options, directions and parking.

**Organizing Committee**
Ali Mostashari, Ph.D. Candidate, Technology, Management and Policy, MIT
Prof. Joseph M. Sussman, Professor of Engineering Systems, MIT
Dr. Herman Karl, Co-Director, MIT-USGS Science Impact Collaborative (MUSIC)
Prof. Lawrence Susskind, MIT Professor and Co-Director, MIT-USGS Science Impact Collaborative (MUSIC)
Asher Siebert, MUSIC Affiliate, MIT

**Stakeholder-Assisted Modeling and Policy Design Post-Session Stakeholder Feedback**

Please answer in as much detail as you wish. Your feedback is very valuable for us. Responses will not be linked to individual identities, but we will provide the whole group with a summary of feedbacks once it is compiled.

Name: ______________ Affiliation: ___________________

**1. Do you think this systems representation takes into account key stakeholder concerns and interests in the Cape Wind project adequately?**
Yes ( ) No ( ) Other : ___________________________________
Additional Comments

**2. Looking at the stakeholder-assisted systems representation, do you think your overview and understanding of the different parts and interactions of the system have improved in this session?**
Yes ( ) No ( ) Other : ___________________________________
Additional Comments

**3. If refined further by a group of stakeholders in a collaborative process as discussed in the session, do you think a system representation could be a good basis for determining the scope for an offshore wind energy EIS?**
Yes ( ) No ( ) Other: ___________________________________
Additional Comments

**4. Do you think that forming joint fact-finding expert working groups selected collaboratively by stakeholder groups would help in reducing adversarial and competing science?**
Yes ( ) No ( ) Other: ___________________________________
Additional Comments

**5. Was the Systems representation sufficiently comprehensive in capturing key technical, social, economic and environmental aspects of the Cape Wind system?**
Yes ( ) No ( ) Other: ___________________________________
Additional Comments

**6. In your view, would the interaction of stakeholders on different sides of the issue in a collaborative manner, and based on a commonly designed systems representation be an improvement over the traditional commenting and public hearing process?**
Yes ( ) No ( ) Other: ___________________________________
Additional Comments

**7. Do you believe that based on a systems representation it is possible to form new decision options that would go beyond the current Approval/Refusal decision of the permitting process?**

Yes ( ) No ( ) Other: ___________________________________
Additional Comments

**8. Taking into account the time from problem identification to the final implementation of any offshore wind energy system, how would you compare the time it would take for a joint fact finding process, to that of a traditional NEPA permit process?**

Shorter ( ) Longer ( ) Equal: ( ) Other: ___________________________________

Additional Comments

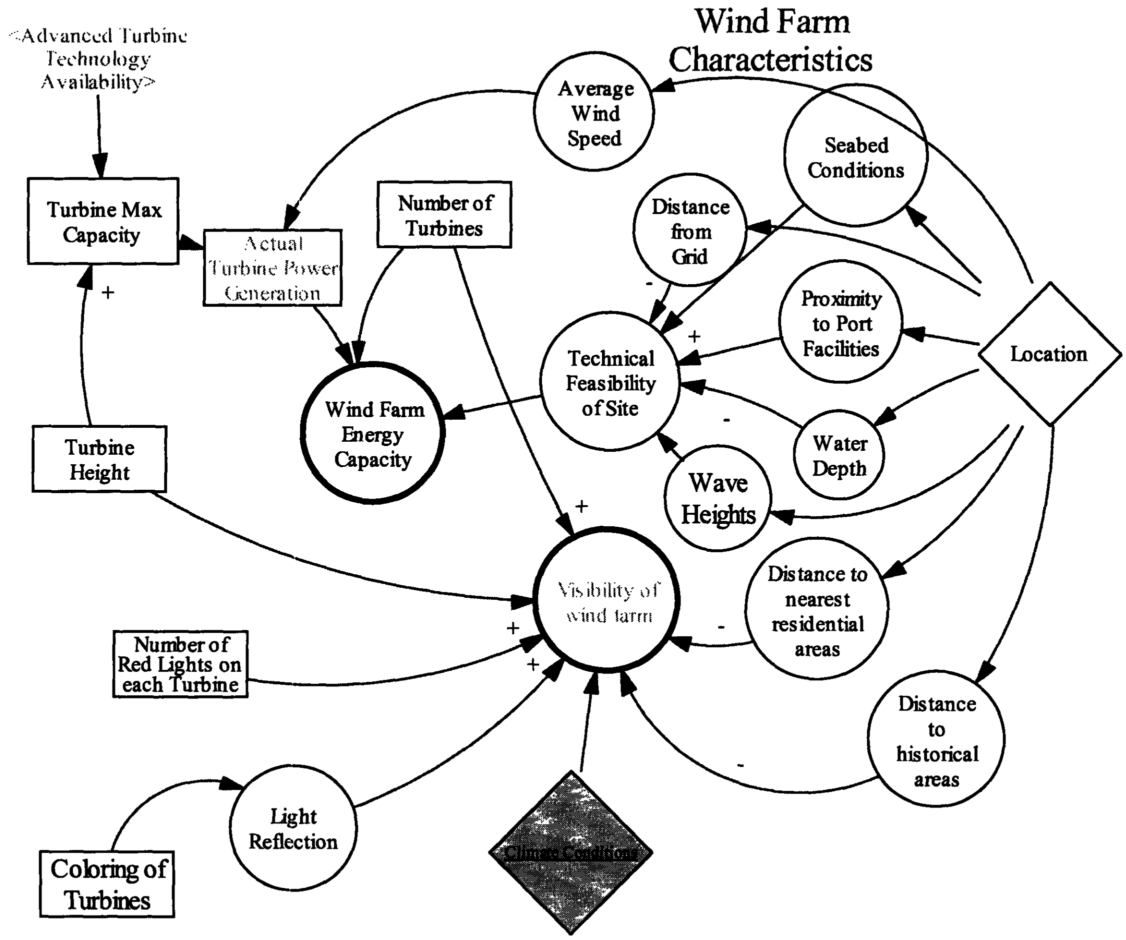
**9. Do you think a joint fact-finding process is more transparent than a traditional permit process?**

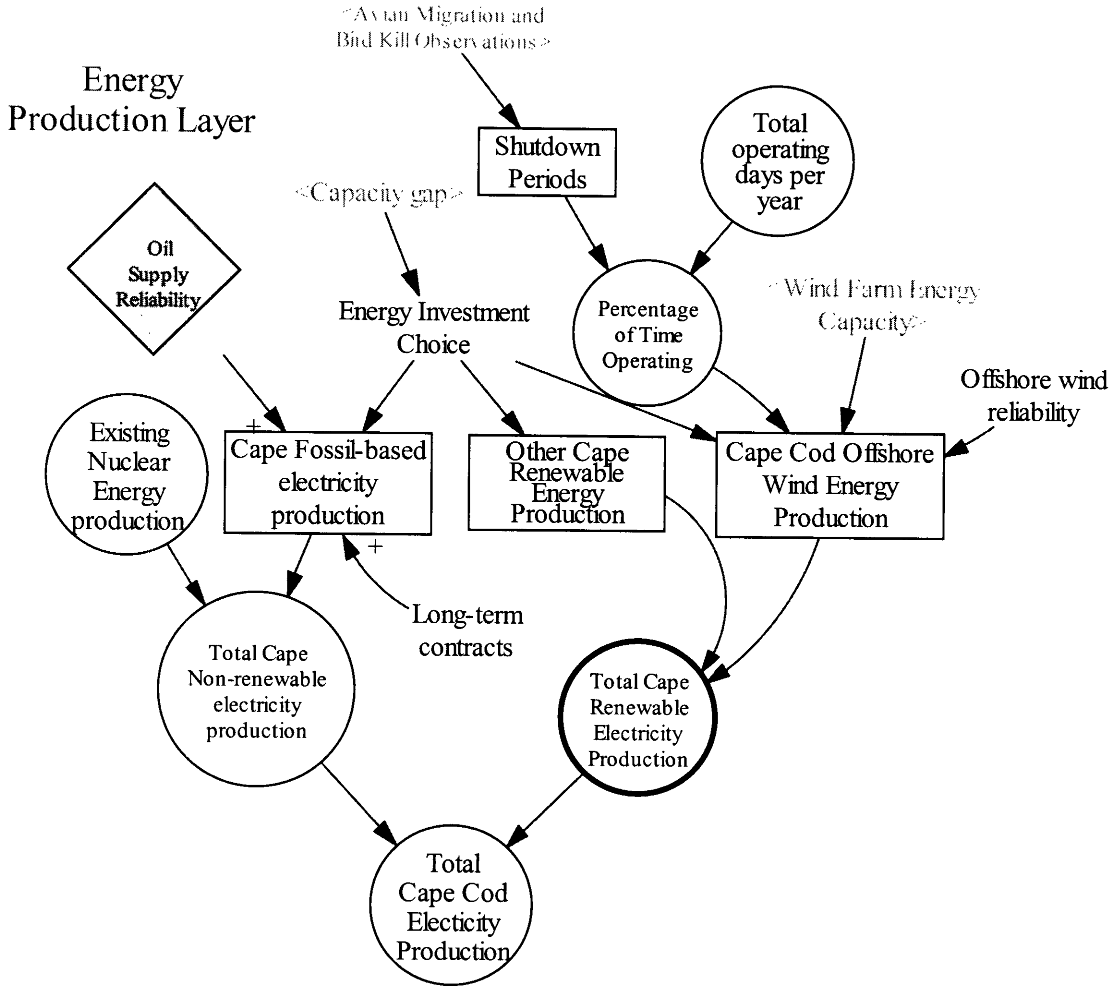
Yes ( ) No ( ) Other: ___________________________________
Additional Comments

**10. And finally, what are some of the drawbacks of a joint fact-finding process that in your mind have to be overcome to make it more relevant to the decision-making for offshore wind?**

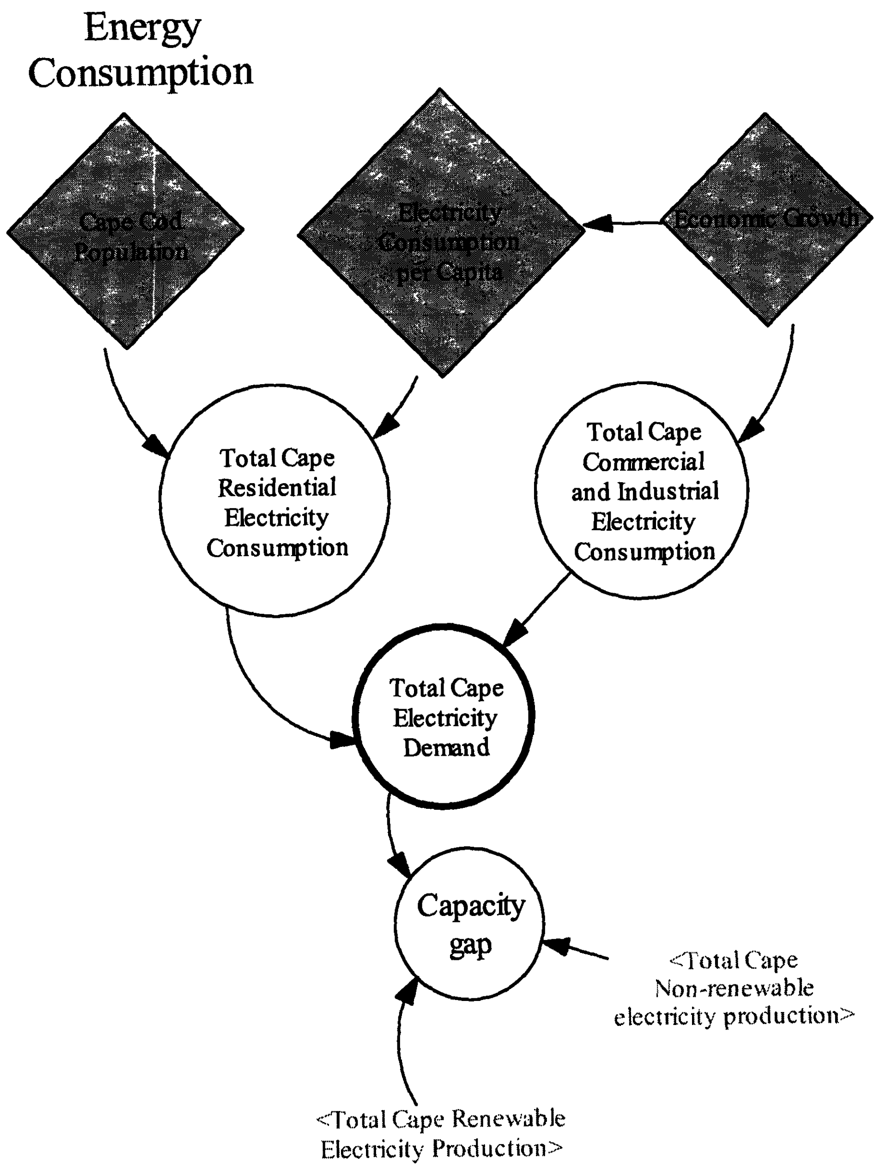
**We thank you for filling out this survey.**

# APPENDIX C Refined System Representations for Cape Wind

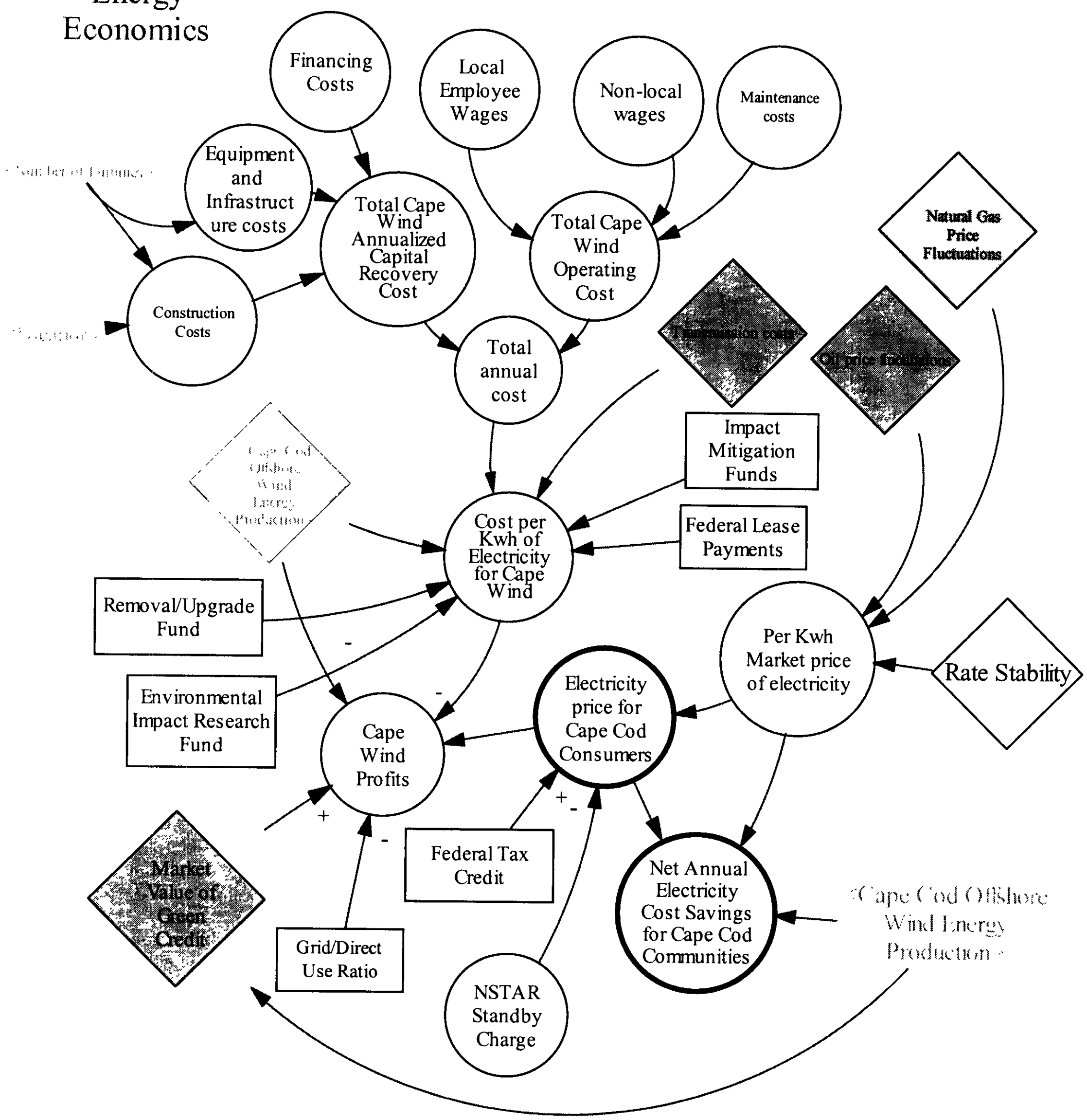




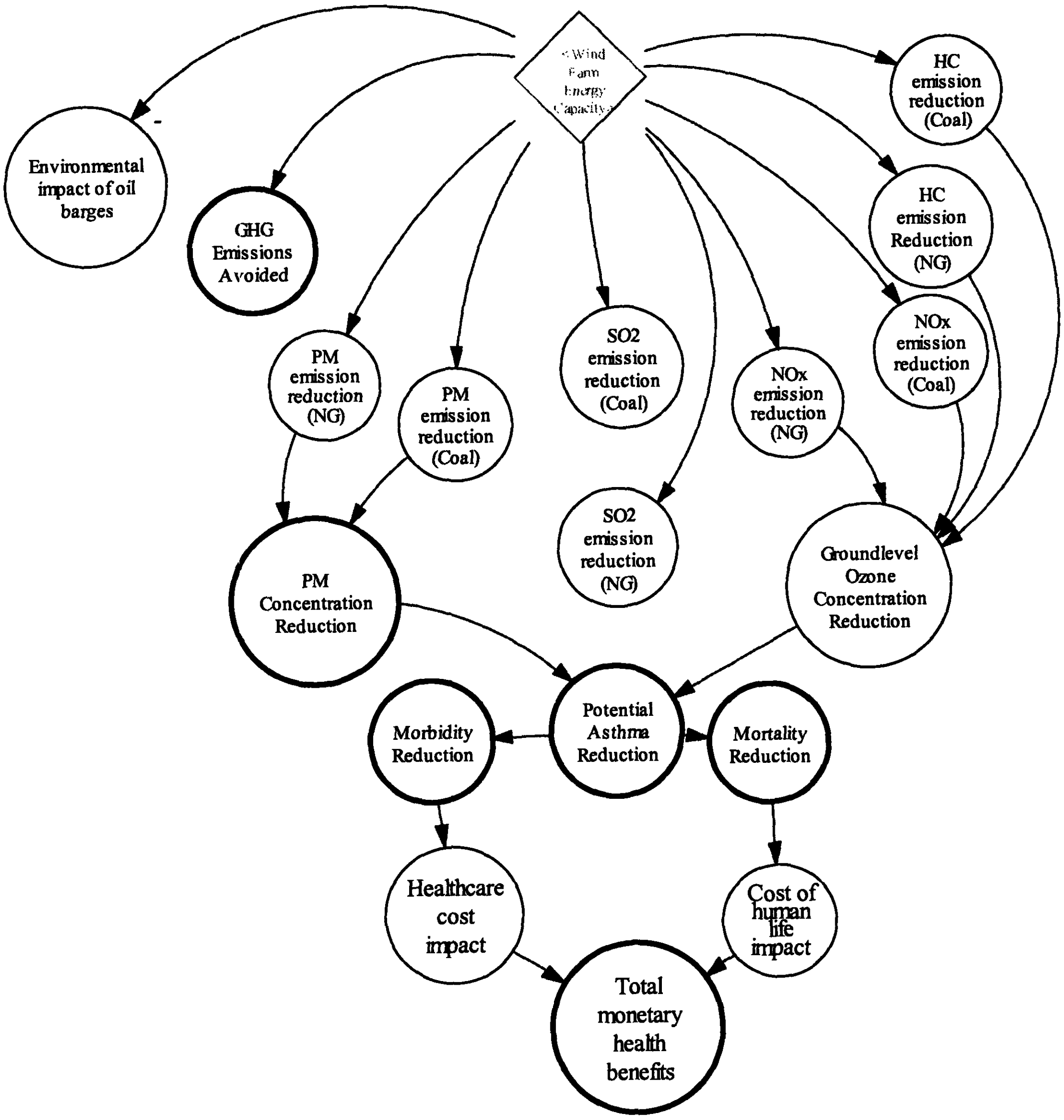
Energy
Production Layer
<Avian Migration and
Bird Kill Observations>
Shutdown
Periods
Total
operating
days per
year
<Capacity gap>
Oil
Supply
Reliability
Energy Investment
Choice
Percentage
of Time
Operating
<Wind Farm Energy
Capacity>
Offshore wind
reliability
Existing
Nuclear
Energy
production
Cape Fossil-based
electricity
production
Other Cape
Renewable
Energy
Production
Cape Cod Offshore
Wind Energy
Production
Long-term
contracts
Total Cape
Non-renewable
electricity
production
Total Cape
Renewable
Electricity
Production
Total
Cape Cod
Electicity
Production

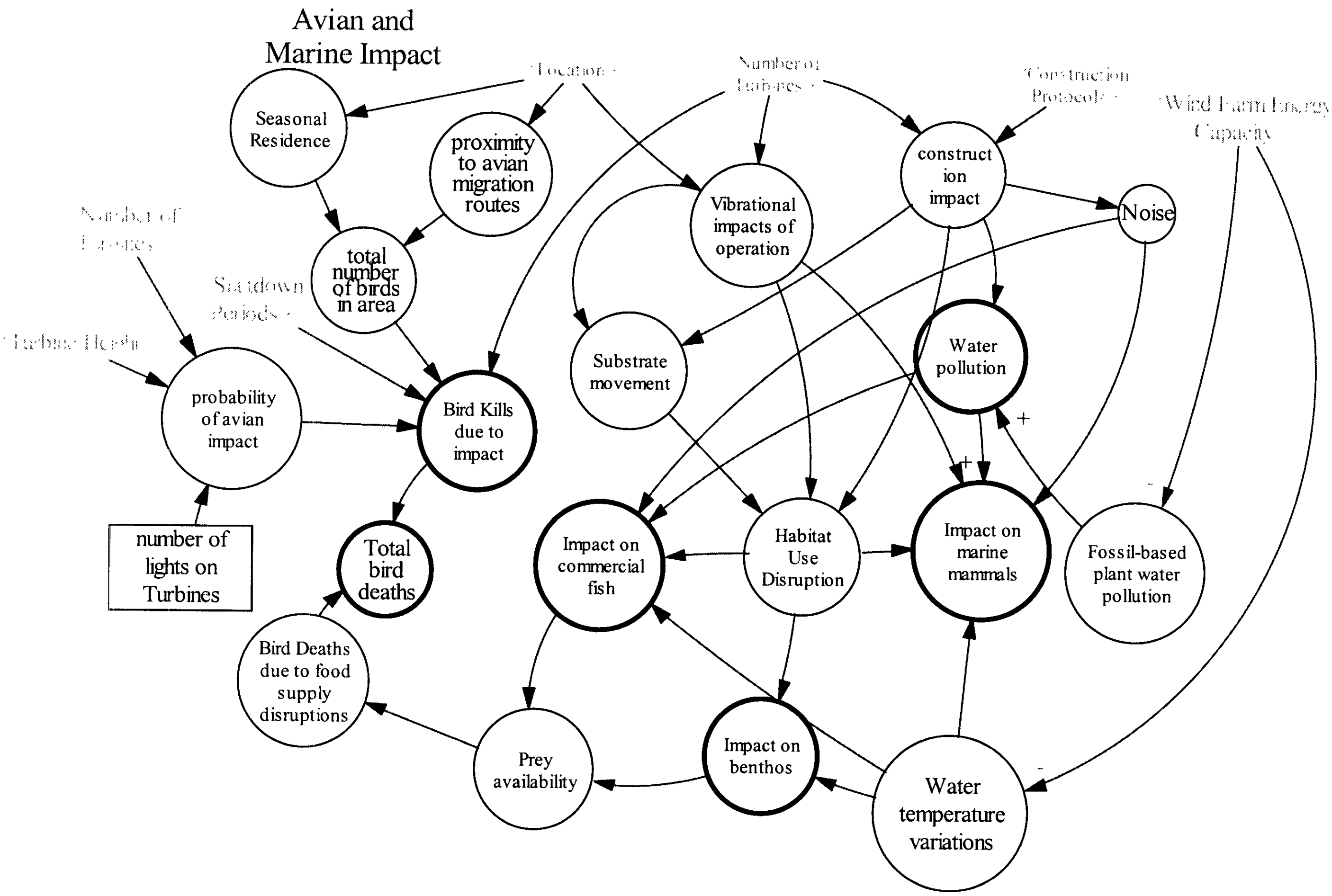

Energy Consumption
Cape Cod Population
Electricity Consumption per Capita
Economic Growth
Total Cape Residential Electricity Consumption
Total Cape Commercial and Industrial Electricity Consumption
Total Cape Electricity Demand
Capacity gap
<Total Cape Non-renewable electricity production>
<Total Cape Renewable Electricity Production>

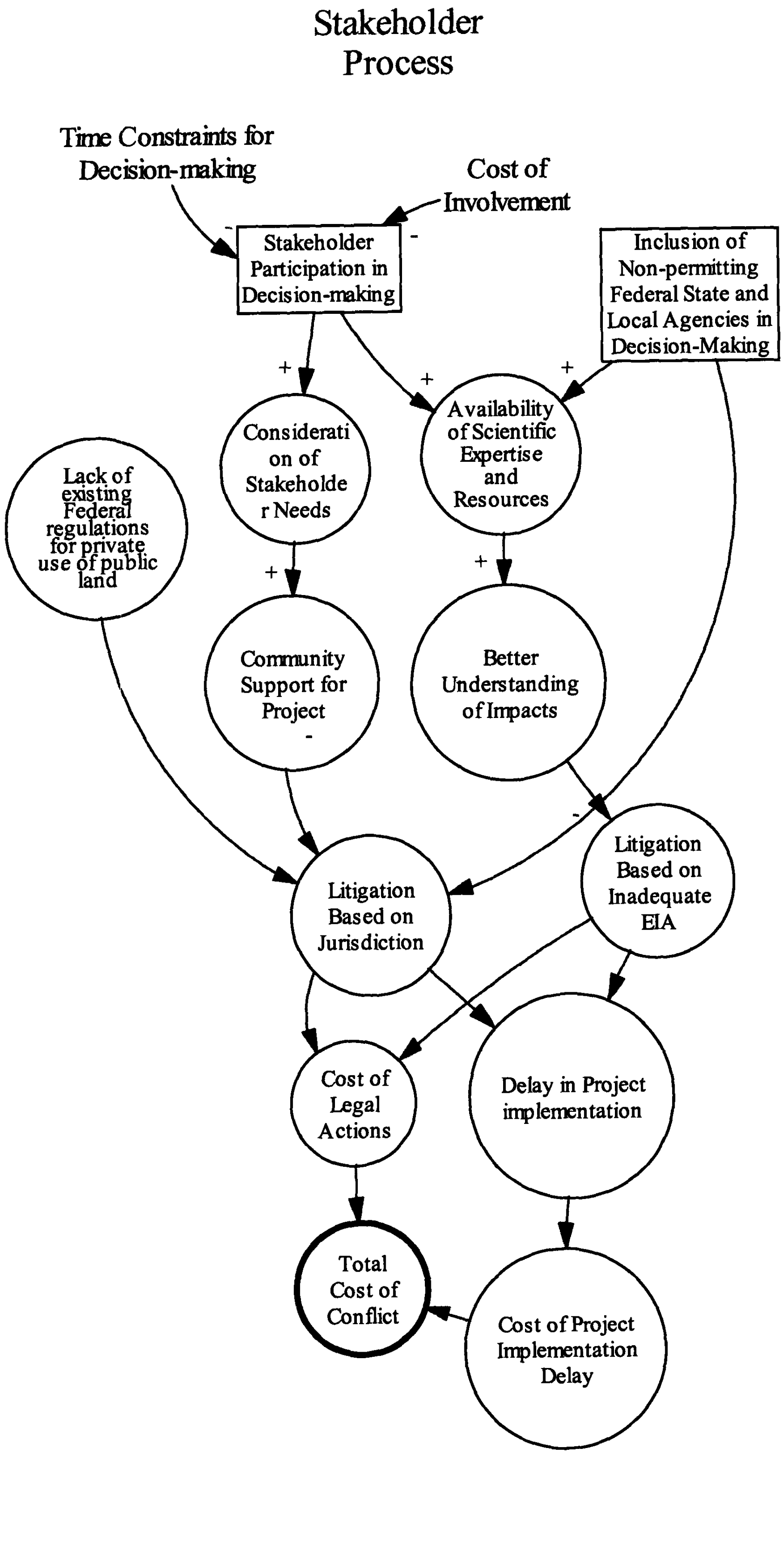
# Energy Economics



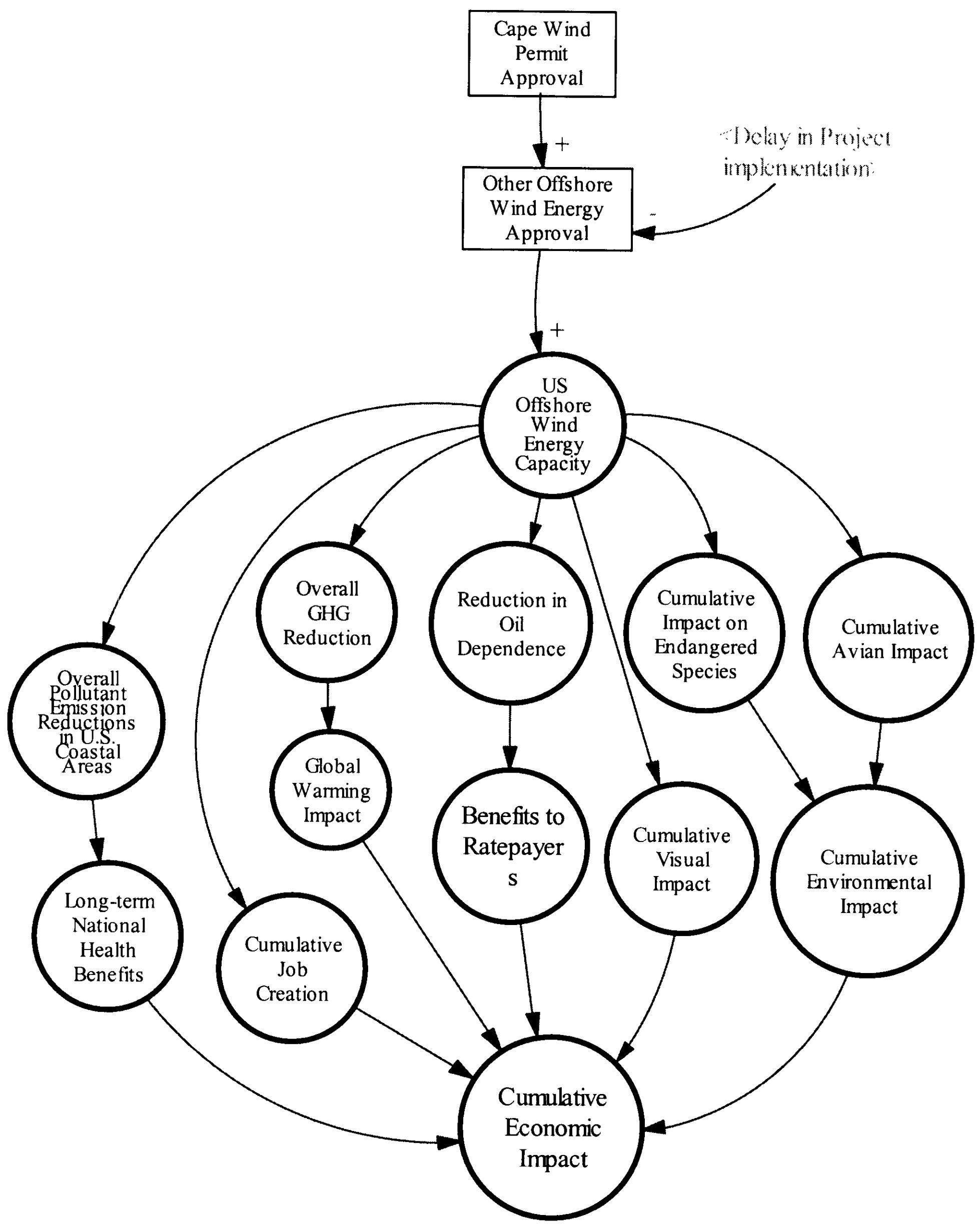
## Air Pollution Impact

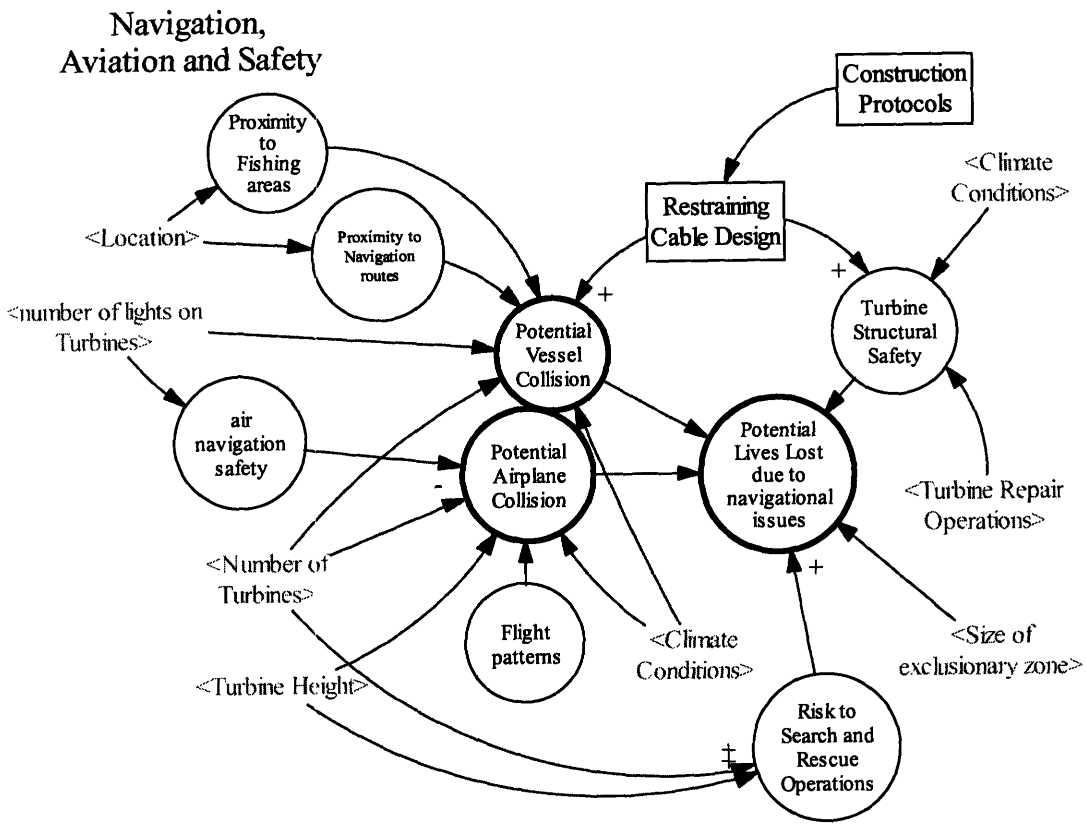



Avian and Marine Impact
Seasonal Residence
proximity to avian migration routes
total number of birds in area
probability of avian impact
Bird Kills due to impact
Total bird deaths
number of lights on Turbines
Bird Deaths due to food supply disruptions
Vibrational impacts of operation
construct ion impact
Noise
Substrate movement
Water pollution
Impact on commercial fish
Habitat Use Disruption
Impact on marine mammals
Fossil-based plant water pollution
Prey availability
Impact on benthos
Water temperature variations
+
+
-
-

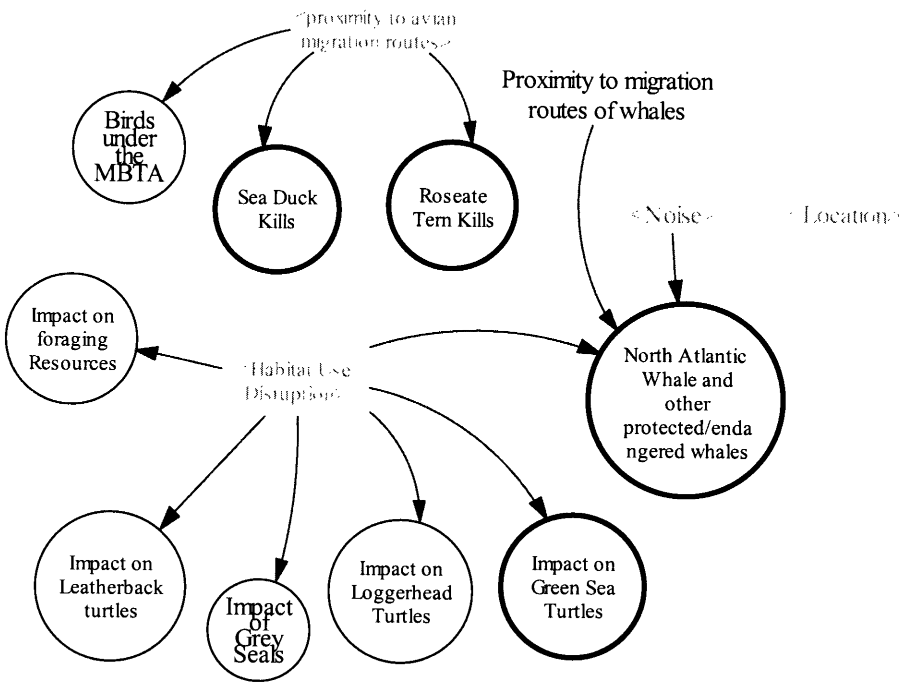

Stakeholder
Process
Time Constraints for
Decision-making
Cost of
Involvement
-
-
Stakeholder
Participation in
Decision-making
Inclusion of
Non-permitting
Federal State and
Local Agencies in
Decision-Making
+
+
+
Consideration of Stakeholder Needs
Availability of Scientific Expertise and Resources
Lack of existing Federal regulations for private use of public land
+
+
Community Support for Project
-
Better Understanding of Impacts
-
Litigation Based on Inadequate EIA
Litigation Based on Jurisdiction
Cost of Legal Actions
Delay in Project implementation
Total Cost of Conflict
Cost of Project Implementation Delay

Long-Term Impact of Permit

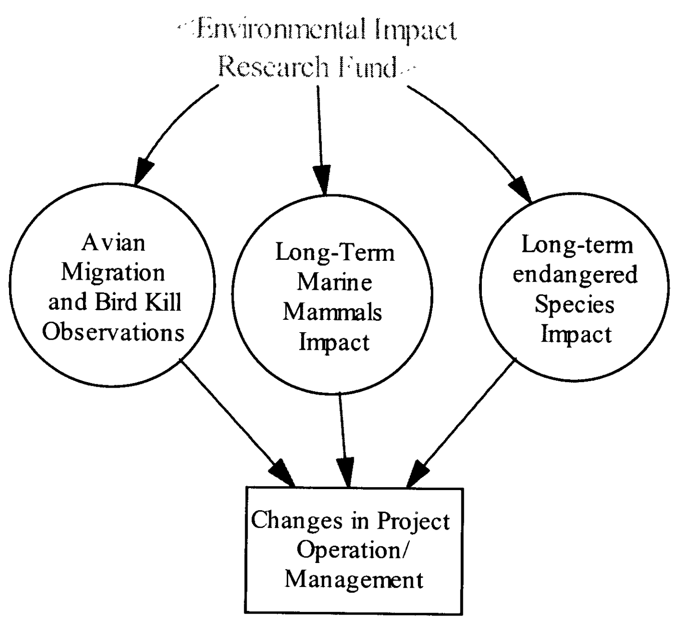



Navigation, Aviation and Safety
Proximity to Fishing areas
Proximity to Navigation routes
<Location>
<number of lights on Turbines>
air navigation safety
Potential Vessel Collision
Potential Airplane Collision
<Number of Turbines>
<Turbine Height>
Flight patterns
<Climate Conditions>
Construction Protocols
Restraining Cable Design
<Climate Conditions>
Turbine Structural Safety
Potential Lives Lost due to navigational issues
<Turbine Repair Operations>
<Size of exclusionary zone>
Risk to Search and Rescue Operations
+
+
-
+
+

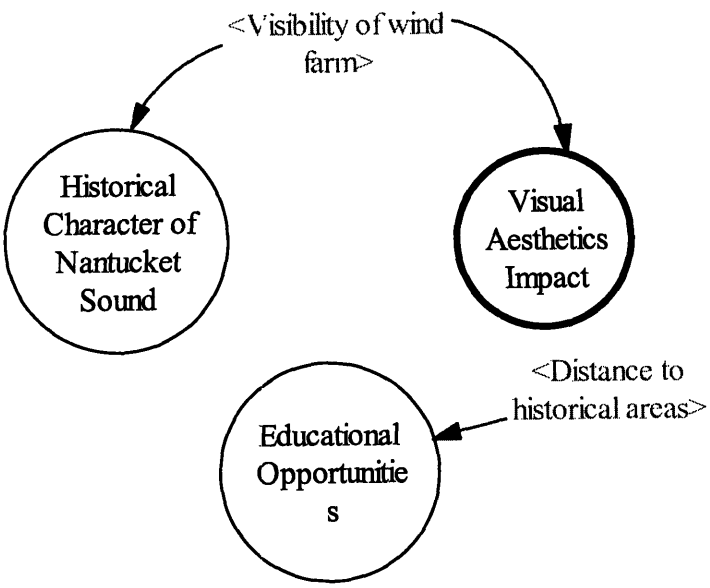
# Protected Species Impact



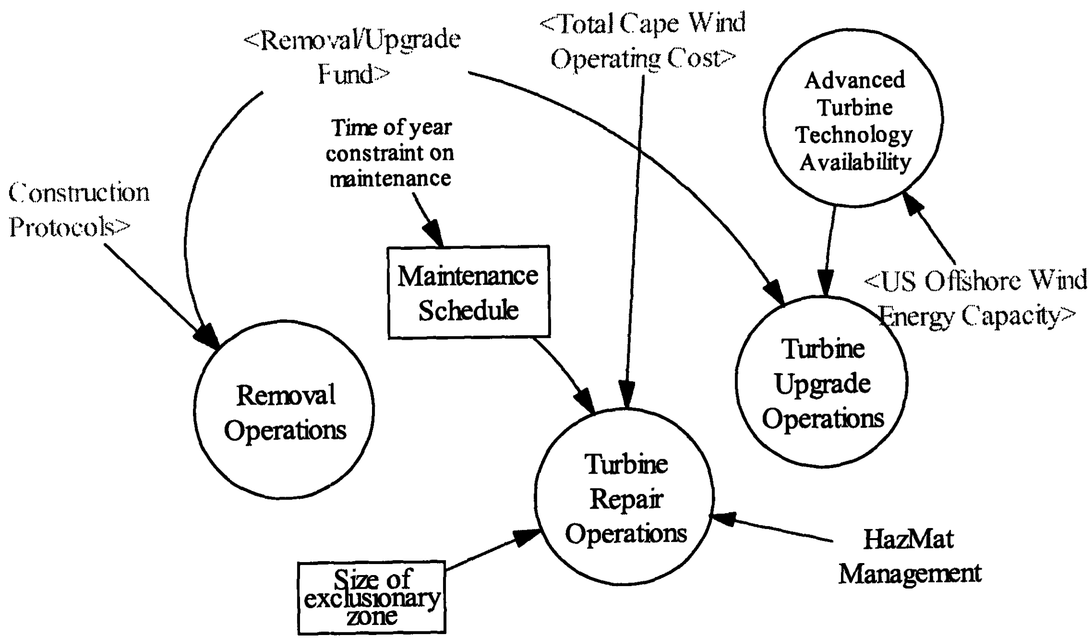

# Post-Construction Monitoring



## Social- and Cultural Impact of Cape Wind Project




## Maintenance/Upgrade and Removal



# Appendix D Cape and Islands Coordinate Community Energy Planning Process System Representation and Survey Results

## Transitioning from the Energy Present to the Energy Future

# Collaborative Community Planning

**Cape and Islands Energy System**
**Stakeholder-Assisted Modeling**

**A Joint Project by the Cape and Islands Renewable Energy Collaborative (CIREC)**

**and the MIT-USGS Science Impact Collaborative (MUSIC)**

**April 2005**

# About the Systems Model and the Online Survey

Participants in the Cape & Islands Renewable Energy Collaborative (CIREC) are initiating coordinated community planning activities geared toward managing and accelerating the local and regional transition to a sustainable energy future.

Community planning activities will engage local and regional stakeholder groups in characterizing the present energy situation, envisioning the energy future, and working together to promote adoption of cleaner and green supply and use options throughout Cape Cod, Martha's Vineyard, and Nantucket.

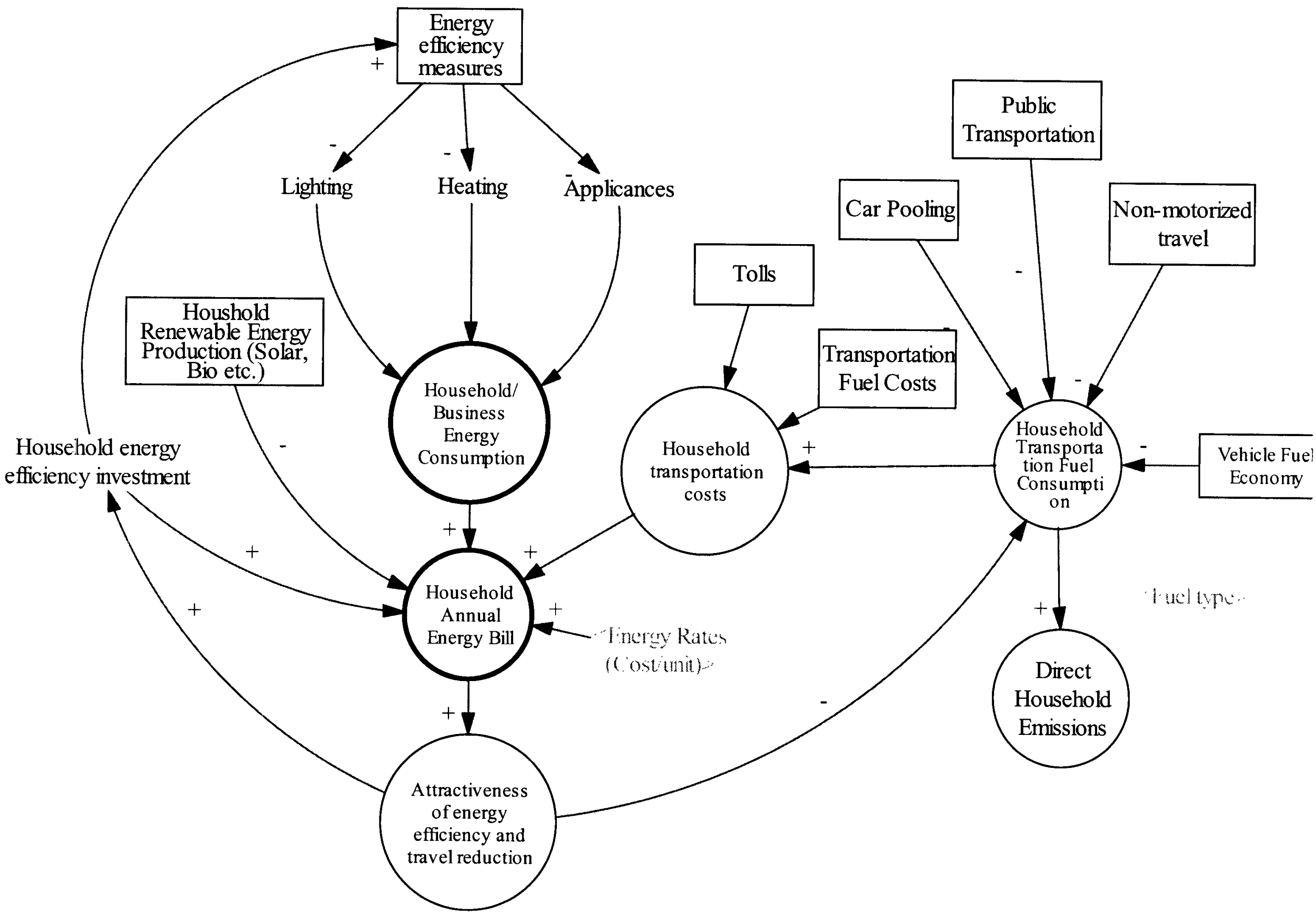
To jumpstart the process, CIREC participants have partnered with representatives from the Massachusetts Institute of Technology-U.S. Geological Survey Science Impact Collaborative (MUSIC) to create an on-line survey. The survey is designed to encourage the public and other stakeholders to weigh in on and prioritize energy-related issues.

The CIREC-MUSIC team has also invited local and regional officials and representatives from environmental and business organizations, state and federal agencies, energy companies, and other key stakeholder groups to attend a mid-April meeting hosted by Waquoit Bay National Estuarine Research Reserve (WBNERR). Stakeholder opinions expressed through the survey and at the meeting will guide the development of both a model of the Cape & Islands energy economy and fact sheets characterizing the "true costs" of the current energy situation.

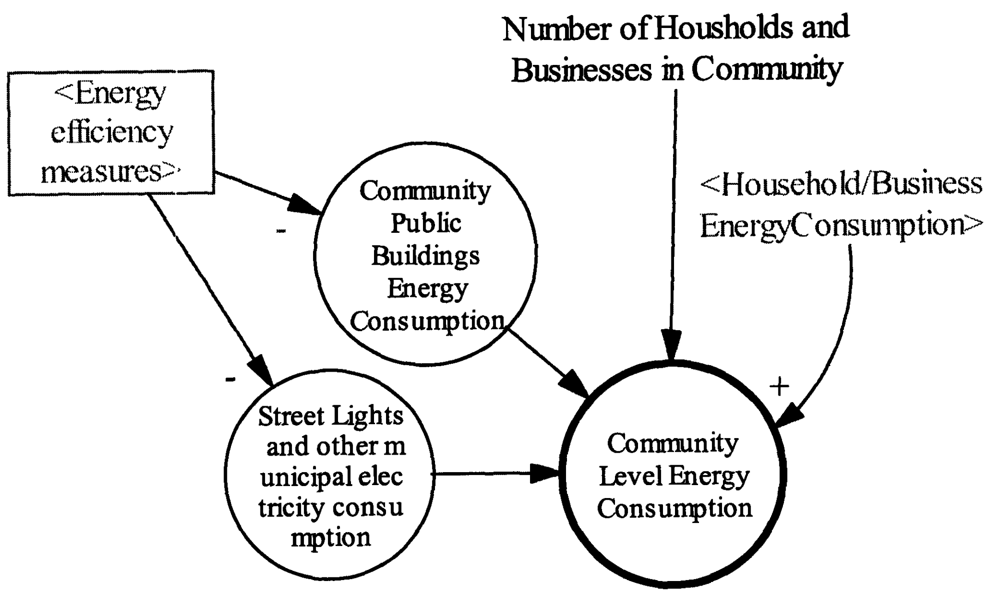
The model, created with support from MUSIC, illustrates how electricity and fuels are supplied to, purchased by, and used by Cape & Islands consumers, and it will identify alternative energy options consistent with the local resource base. It will also show the interconnections among energy systems and diverse economic, environmental, and social issues.

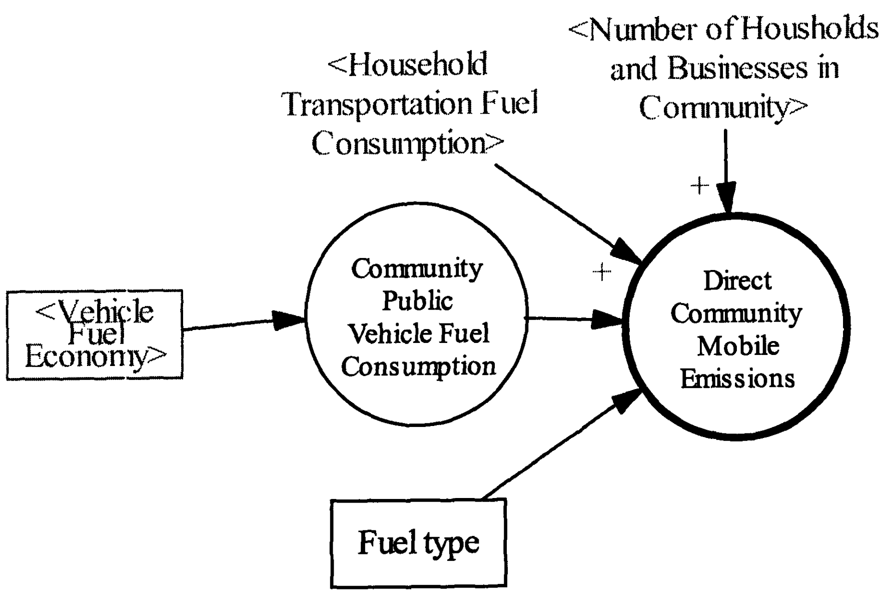
This documents presents the initial Cape and Islands Energy systems model and the results of the online survey. The model will be refined and provided with more detail during the collaborative community sessions.

## Household/Business Energy Consumption

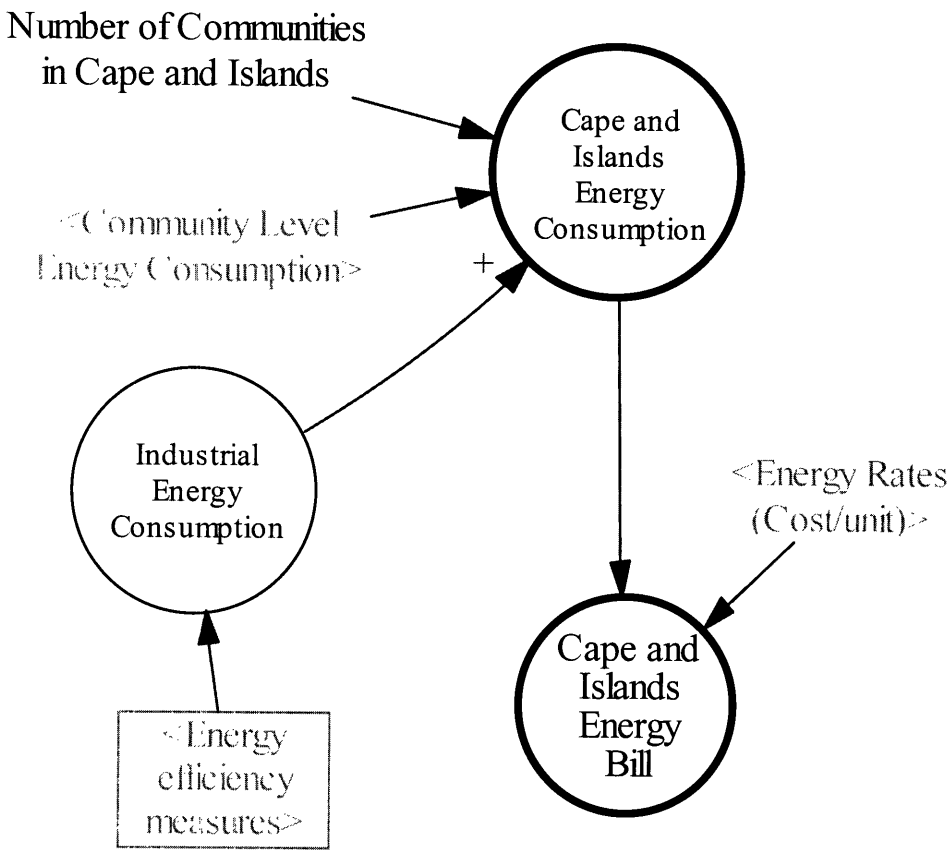


# Community Energy Consumption

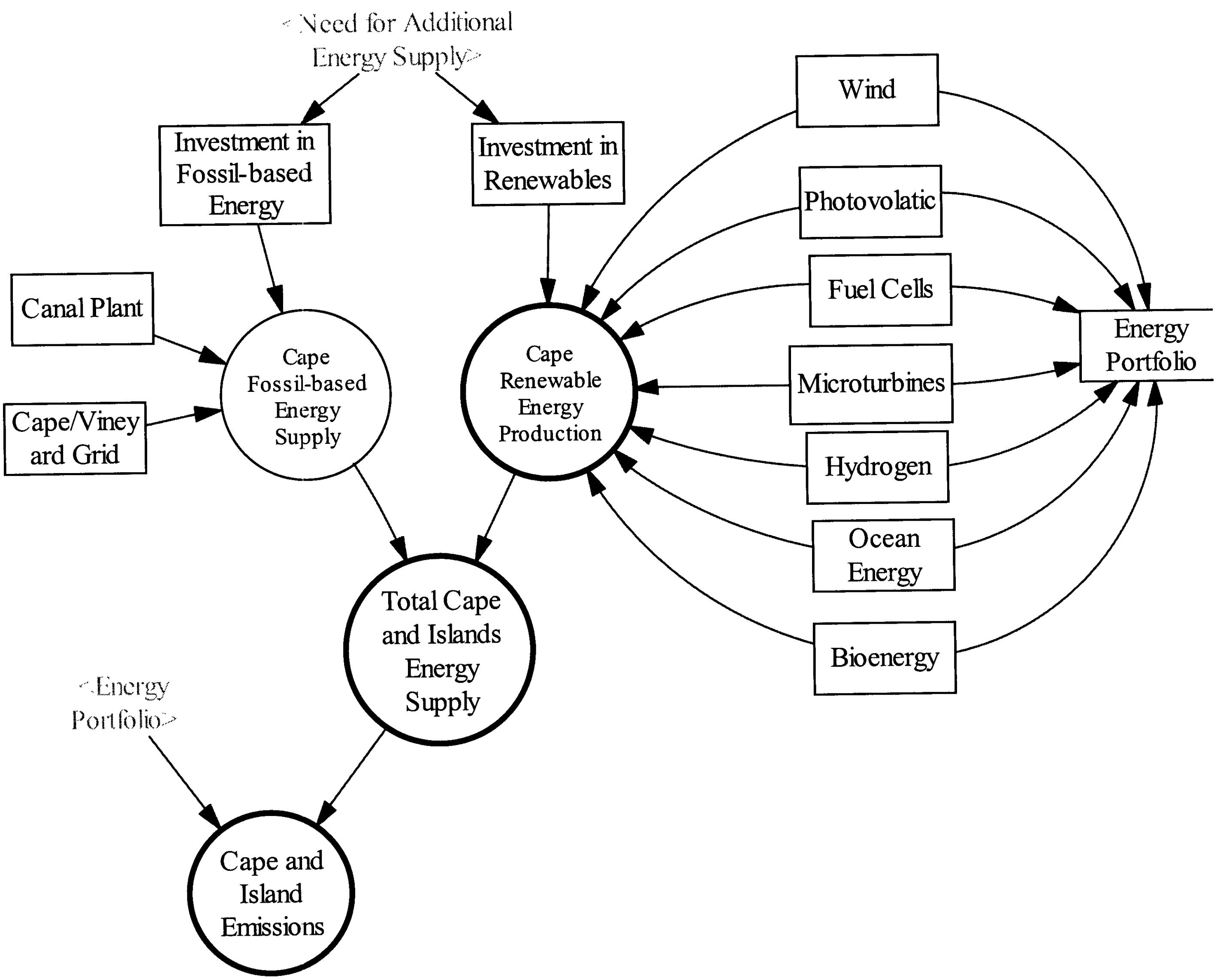


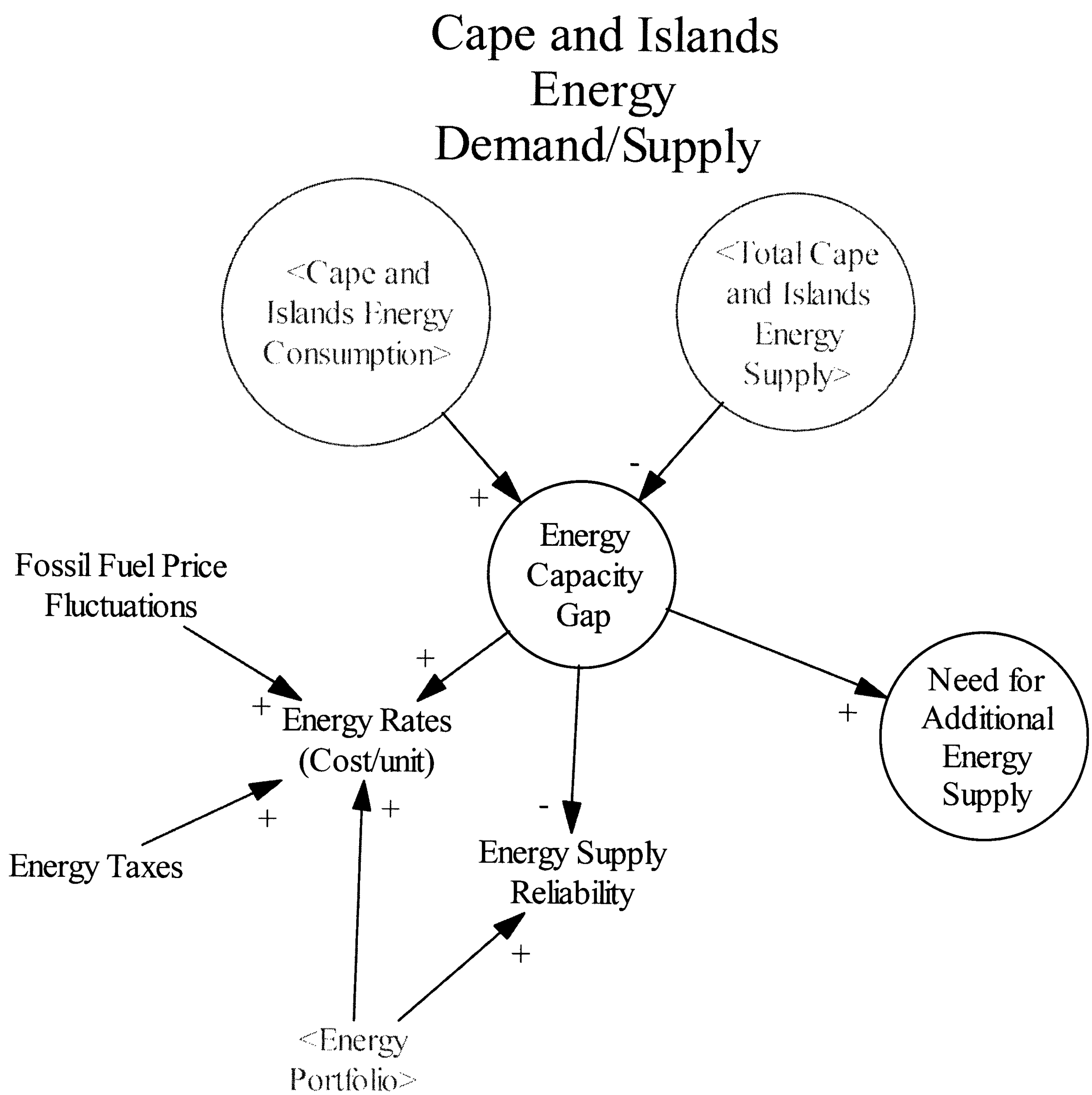



# Cape and Islands Energy Consumption

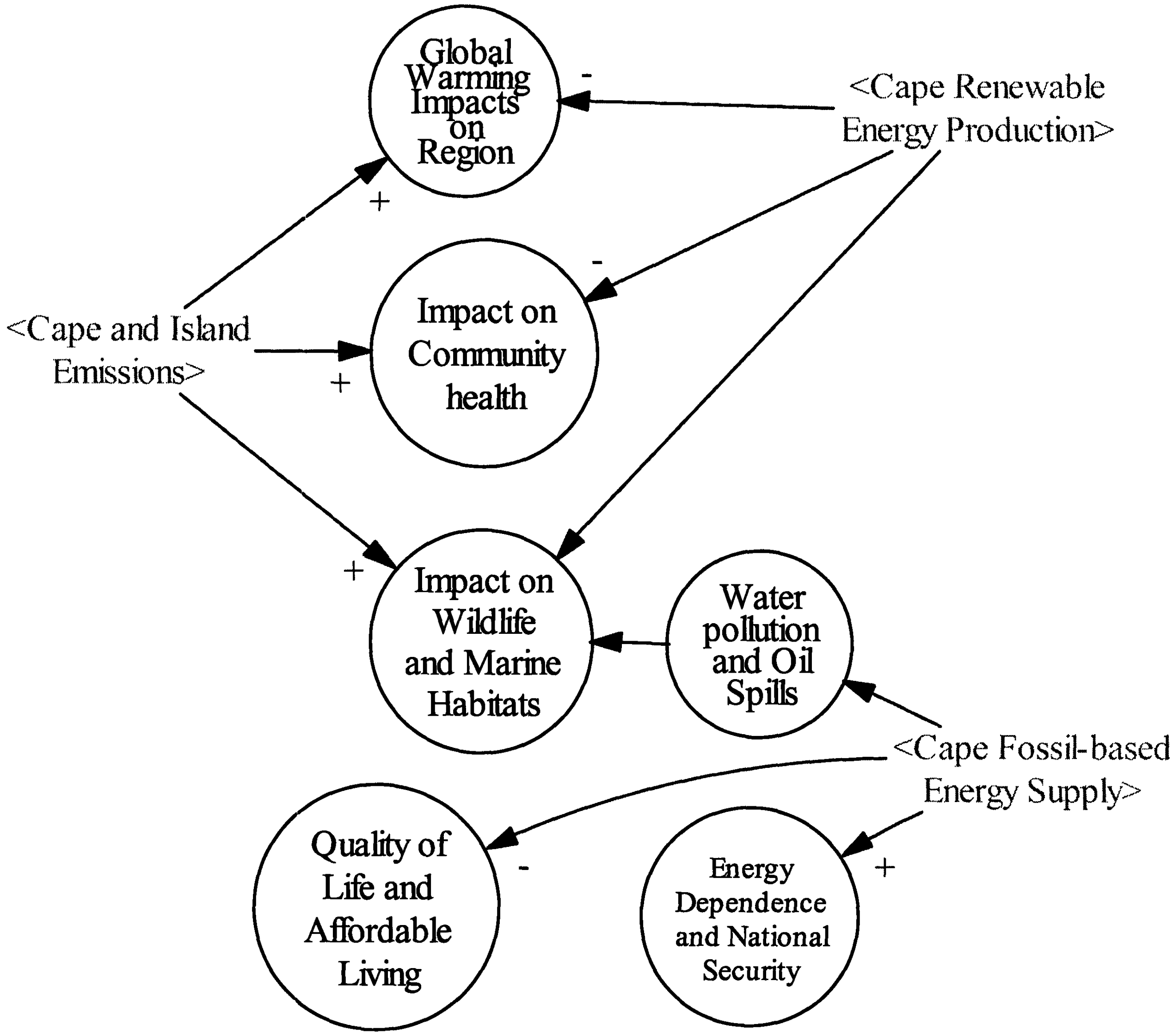


# Cape and Islands Energy Supply




Cape and Islands
Energy
Demand/Supply
<Cape and Islands Energy Consumption>
<Total Cape and Islands Energy Supply>
+
-
Energy Capacity Gap
Fossil Fuel Price Fluctuations
+
+
Energy Rates (Cost/unit)
+
Need for Additional Energy Supply
+
+
-
Energy Taxes
Energy Supply Reliability
+
<Energy Portfolio>

# Social and Environmental Impact



**Transitioning from the Energy Present to the Energy Future**

# Collaborative Community Planning

**Stakeholder Survey Results**

**A Joint Project by the Cape and Islands Renewable Energy Collaborative (CIREC)**

**and the MIT-USGS Science Impact Collaborative (MUSIC)**

***April 2005***

## Present Energy System

*Economic, Environmental, And Social Impacts Of The Present Cape & Islands Energy System*

## At the Household (business) level

- Clearly we need to move toward a cleaner, greener system of power production. Wildlife habitats are degraded and human health is degraded as well. But any alternative source needs to be a responsible source. Some "green" sources such as nuclear power would not be an improvement.
- Complacency among consumers
- Economic: high cost of energy - one of the most expensive regions in the nation, particularly expensive for consumers is home heating.
- Education on cost-effective energy efficiency and renewable energy technologies.
- Expense, health and environment
- Family incomes eroded by increased cost of energy
- High cost of energy for all uses (2)
- High costs of heating and transportation, domination by corporate (off-Cape) interests, health threats, insurance hikes, depression
- Health impacts are big at the household level, with many people in our area affected by our poor air quality. This is an economic, env. and social impact
- Increased cost of living and health issues; degradation of water and air resources-natural
- Increasing cost of home fuel oil, electricity, gasoline
- Need to Build underground utilities to avert power failure and damage
- Rising cost of energy, potential scarcity, health risks
- Rising cost of fossil fuels
- The need for a Cape wide program for land based wind. Not each town going at it independently as is now the case. I want to stress one program, Cape wide. There in no governmental agency at the state, county or local level moving in a Cape wide, one program, direction. This includes MTC.
- The system is in its last stage prior to being replaced by some form of clean energy. But cleaning up the Cape is not enough; the rest of the country has to join in.
- Unstable prices, rising costs, health problems, family members killed in wars for oil and empire building.

*Economic, Environmental, And Social Impacts Of The Present Cape & Islands Energy System*

## At the Community level

- Air quality impact from fossil fuel emissions, particularly from Canal plant, i.e., adverse health.
- Community wind initiatives and municipal solid waste treatment plants adding methane production.
- Damage to tourism through more oil spills on our beaches
- Economic impact on business of rising costs
- Economic impacts of our reliance on imported energy sources is a huge drain on our economy.
- Global warming sea level rise bleeding of environmental life blood for area
- High cost of energy for municipal uses, and the impact of high cost fuel on the economically needy population
- High energy costs are putting pressure on community budgets; air quality, water quality, risks of climate change
- If there was a Cape wide program in operation now would the initial costs be more or less for equipment?? If there was a Cape wide program in operation would the output of clean electrons be more or less?? The answers to these questions are obvious.
- Increasing costs of gasoline adversely impacting tourism; ecosystem degradation; unhealthy air quality
- No comprehensive energy policy, local politicians are not pushing for good energy policy or to integrate renewable energy at a level that can make a difference now.
- Over-reliance on natural gas; future oil spills;
- Pollution of air, groundwater, Nantucket Sound, rising energy and health care costs affecting town and school budgets.
- Poor air quality (and the attendant health risks); harm to individual animals by components of fossil fuel plants (e.g., eiders stuck in holding tanks); occasional devastating oil spills
- Reduce electrical use by substituting fluorescents where ever possible and replacing old appliances with high efficiency models.
- The environmental impacts are mostly seen in terms of water quality issues, ie, oil spills, mercury contamination, and nitrogen loading from atmospheric deposition. Socially, I think our reliance on automobiles to get around on our narrow roads is on of the biggest issues at this level.
- Weird weather, economic stagnation, absurdities regarding public transportation, hindrance on job creation, morale issues

## At the Regional (and/or National) Level

- We need more active programs encouraging conservation and dramatically more efficient and cleaner vehicles--which are the source of considerable air pollution.
- Degradation of human and wildlife habitat (pollution); effects on public health; global warming; alteration of animals' population dynamics; increased oil & natural gas drilling; safety risks associated with LNG platforms
- As one piece in the house of cards, our weakness will contribute to bringing the house down. we have a chance to be leaders and a model, and we have a responsibility to take the risk. we were the place where the mayflower compact was written; a tradition was begun here of self-determination and that precedent compels us to take risks.
- Large Wind Projects, such as Cape wind.
- David W. Cash,Executive Office of Environmental Affairs has just started at the State level. It is very hard for me to think at the Fereral level, when the state is just taking first steps.
- Another 9-11 terrorism attack due to our financing them through foreign oil purchases
- $CO_2$ emissions from power plants & vehicles: impact on global climate change. Nitrification of open water bodies. Dependence on foreign sources of expensive fuel: balance of payments, funding of radical governments and terrorists.
- $CO_2$ Emissions, foreign oil dependence leading to economic vulnerability
- Effects of climate change
- Pollution of our planet, climate change, endless war for oil, crisis in health care costs, huge federal budget defecits, continued corruption of most politicians by energy monopolies.
- Higher costs for goods and services; increased air pollution--unhealthy air quality; energy vulnerability/insecurity; more military conflicts over oil (and possibly natural gas) supplies
- No energy policy. Huge need for focus, development of sustainable, renewable energy technologies
- Biggest threats hear are related to global warming and all of the related problems that come with significant and rapid changes to our climate.
- Regional: Business competitiveness, air quality, water quality, public health, risks of climate change. National: security issues, spending priorities (guns vs. butter problem), climate change

## Long Term Consequences of No Intervention in the Current System

- Air pollution, health problems, high cost of energy, war over limited resources
- Climate change that will impact our natural systems, including food production, which will cause civil war over dwindling resources
- Continuing poor air quality and adverse health impacts. Even though new emission regulations on power plants begin, the purchase of SO2 and NOx allowances under "cap & trade" will leave us in the hot zone since allowances are less costly than cleaner fuel for the same production. Oppressive family expenditures for energy in all forms, a quality of life issue, or even remaining on the Cape.
- Fuel costs will rise and air quality will not improve. But, I must add, that much of our air quality problems arise from plants in the mid-west and from the ever increasing number of cars on the Cape and their associated emissions. Pollution is less of a problem to us in the winter when the number of cars is dramatically lower.
- We will have at least one more major oil spill within the next 25 years. Our air quality will continue to get much worse, with bad air alerts happening more frequently in the summer and smog and haze having more of an impact. I think that within 25 years, probably much sooner than that, we will experience an economic collapse because fossil based energy (except coal) will become much more expensive than it is now, affecting all sectors of the economy and threatening the stability of our current lifestyles and societal structures. People will not be able to afford to vacation here, businesses will not be able to pay high energy costs, and we will have major power shortages during times of peak demands on the hottest days in the summer and the coldest days in the winter. The effects of climate change will become more dramatic over this time, but I think those will be less noticeable than the major changes that will come with economic collapse.
- It must change! If it doesn't the Cape & Islands will become a land of second and third class citizens. There is too much brain power to do otherwise.
- Loss of land area, economic impact for businesses, continued health risks; unsustainable costs for fixed income retirees on Cape Cod.
- Oil on our beaches, loss of tourism dollars. Impoverishment, pollution
- Our natural resources will be severely degraded and the natural appeal of the Cape will vanish. Climate change will take a large toll on our environment.
- Sea level rise, storm severity/frequency, ecosystem change, and aquifer infiltration - will the Cape & Islands still be a desirable place to live and visit?
- Skyrocketing energy costs; increased beach erosion from sea-level rise; more severe storms leading to homeowners inability to get insurance; degradation of ocean ecosystem. Too expensive to live and work in the region
- Water levels may rise a couple 0f feet and storms will increase in size and intensity
- World War Three in the Middle East, irreversible pollution of planet, accidents and terrorist attacks at nuclear power facilities, rising sea levels and more extreme storms - but I am an optimist!

# Promise of Available Renewable Energy Options and Existing Obstacles

## *Bioenergy*

Potential:

- Very Promising (9)
- Promising (11)
- Not promising (4)

Obstacles:

- Need to deal with emission issues from trash to energy. Cost is also an obstacle for many of these
- Not well enough informed on this. I feel doubtful, and the waste stream may subside in several years. Used frying oil , etc. is somewhat helpful for transportation, but really not the answer.
- Digester gas from wastewater treatment facilitates
- Land fills are not big enough on Cape to make feasible,
- We don't have the technology in place now
- Consumer laziness
- Cost and Reliability
- Limited fuel, i.e., wood chips (Indeck) , limited LFG sites, CO2 emissions, can't meet RPS as is. Biofuels somewhat promising but take energy to produce and still have CO2 emissions
- Limited Scope
- These are probably only temporary and will be replaced by more effective systems.
- Cost efficient technology development
- Education, current cost of implementation & use
- Burning anything causes pollution.
- Political Manipulation
- Emissions; supply: certainly there in the short-term, but not sure about its sustainabiity if adopted on a grand scale
- Local production facilites and farm policy
- Need to have municipal, county and other decision makers thinking about energy in a comprehensive fashion
- Not enough resources available, but promising for some smaller scale distributed applications. Obstacles include educating facility managers about these options and having knowledgeable business people who can make economically feasible proposals to them.
- Cost; mindset that many of these things are "wastes" to be managed rather than resources to be harnessed

# Promise of Available Renewable Energy Options and Existing Obstacles

## Fuel Cells, Microturbines, and Other Cogeneration Technologies

Potential:

- Very Promising (8)
- Promising (10)
- Not Promising (3)
- Don't Know (1)
- Infeasible (1)
- Not useful (1)

Obstacles:

- I am less familiar with these, but question is the gain if they rely on fossil fuels for energy generation. And I don't know what "microturbines" are.
- I don't know. I hear different ideas about this. I'm not well enough informed.
- Try to always find ways to use "waste heat" to maximize total thermal efficiency.
- Fuel cells need hydrogen which is not readily available
- It is a long way off here and nationally
- Consumer laziness
- Fuel cells using hydrocarbon reformers still emit as much CO2 as conventional generators.
- Continued production of air pollutants
- Limited Scope
- Only temporary
- Cost efficient technology development
- Cost of implementation, current dependency on natural gas
- Stop using fossil fuel
- Infrastructure implementation
- Lots of different technologies lumped together. Fuel cell technology seems a lot farther off than originally thought; natural gas supplies/cost problematic if used for fuel -- if not would probably have to rely on offshore wind or nuclear for electrolysis
- Cost of producing fuel cells and hydrogen
- I don't see these being very useful unless they are run on biomass
- Cost; limited applicability for current technology; even then, there is a need for education on the value of cogeneration

# Promise of Available Renewable Energy Options and Existing Obstacles
## Hydrogen Energy

Potential :

- Very Promising (5)
- Promising (9)
- Not promising (5)
- Not beneficial/useful (2)
- Infeasible (2)

Obstacles:

- Same concerns with wind energy plants--need appropriate siting
- Difficult to store and distribute
- When produced from renewable energy sources for use as an energy carrier for fuel cells.
- Presently a net loss of energy
- We don't have the technology in place now
- When it's mandatory
- Cost
- Hydrogen for fuel and fuel cells need manufactured hydrogen. No net gain if from hydrocarbons. Only if from pollution free wind, wave, solar, or geothermal sources
- Hydrogen gas stations to make it available
- Limited Scope
- In the future when wind power is put to use 20 miles+ from the shore hydrogen can be produced via electrolysis and stored in compact "pancake" tanks for use in fuel cell vehicles in the future.
- Cost efficient technology development
- Costs of maintenance, no real short term ROI
- Technology still in development
- Negative net energy cost - waste of time/money
- Hydrogen production extremely energy intensive; no infrastructure
- Where would the hydrogen come from?
- Cost of producing hydrogen fuel
- Very inefficient use of the electricity
- Better choice would be plug in hybrid electric vehicles. The production and storage is just too inefficient right now.
- This is long-term solution but technology not available, fuel supply infrastructure not available, vested interests represent obstacles

# Promise of Available Renewable Energy Options and Existing Obstacles

## Ocean Energy: Tidal current, wave, and ocean current technologies

Potential :

- Very Promising (7)
- Promising (12)
- Not Promising (4)

Obstacles:

- Need a design that will not result in injury to marine wildlife
- Technological Challenges
- Needs a not sure category. I am interested in projects in Scandinavia
- Should consider tidal turbines
- Don't know much about them
- Long way off
- As technology improves it will be more promising
- Unreliable, ecological questions
- A future dream, only demo stage now, should be encouraged with federal funds, a long way to go to viable economics, 10 to 20 years?
- Is the technology available?
- Limited Scope
- If the corrosive effects of sea water can be managed, yes.
- Cost efficient technology development
- Costs of implementation, NIMBY
- Technology still in development (2)
- Political manipulation, costs oil to create ocean products
- Technology largely unproven; siting/permitting will be major issue; policy framework doesn't exist
- Environmental concerns; regulatory framework lacking
- The NIMBY factor, but great resource locally
- We have some resources here, particularly wave energy off the eastern coast. Obstacles are ocean management/zoning issues and high capital costs of equipment

# Promise of Available Renewable Energy Options and Existing Obstacles

## Solar Energy

Potential:

- Very Promising (15)
- Promising (7)
- Not promising (2)

Obstacles:

- Consumer laziness
- Cost efficient technology development
- Cost, bad climate for New England
- Costs
- Costs of implementation and maintenance, no real short term ROI
- Education on the benefits of solar thermal needed to accelerate application now; also, there is a need for incentives like those for solar PV; for solar PV, cost is barrier; mechanism needed to offset high capital costs.
- Efficiency/cost
- In the very near future I see much more Solar power generating electricty in homes and factories and feeding back into the grid when surplus is available.
- Interconnections with Nstar problematic
- Limited Scope
- Lots of potential here for including in new construction and retrofits. Obstacles are lack of incentives for solar thermal, a bad image from the past to be overcome, and relatively few trained installers.
- May need price support/tax breaks for consumers
- Need an order of magnitude breakthrough on economics for utility scale generation. Time frame??
- Need more $ for support-cost is still high to get every building to have solar, but we are making progress.
- Needs to increase marketing, and lobby for better tax credits.
- None - we know how to do this, we just need to make the technology available and understood by potential users
- Political Manipulation
- PV is still expensive and there is no focus or incentives on solar thermal, which is much more cost, effective. Very slow and long payback
- Solar thermal should be increased to decrease NG and electricity use.
- Too soon to say. Did not have good luck w/ solar hot water. Maybe battery farms at the equator could ship batteries north & sold, giving equatorial economies an industry, and northern lattitudes winter warmth
- We should have solar pv on EVERY roof!!!

# Promise of Available Renewable Energy Options and Existing Obstacles
## Wind Energy

Potential:
- Very Promising (21)
- Promising (1)
- Not promising (2)

Obstacles:
- They must be sited in locations that minimize potential risk to birds and bats and minimize impacts to fragile species and habitats
- Wildlife impacts; technological challenges of far-offshore locations
- Cape Cod will lead in this.
- Cost-effective today
- Most cost-effective thing we can do today
- But there is a huge need for a central driving force.
- Clean, safe, proven track record
- A mature technology proven world wide. Obstacle: the view!
- No real obstacles
- Minor benefit, wind inconsistency, high maintenance cost offshore
- Obviously the Gold standard
- NIMBY (5)
- The people must have local control of energy developments.
- Political Manipulation
- Siting; lack of consistent regulatory framework both on land and in the ocean
- There are obstacles everywhere!
- Lack of good economic models for financing local projects, lack of technology for going far offshore.
- Uncertainty on tax incentives, siting/permitting barriers

# Visions for Cape and Islands Energy System

- Most homes equipped with solar cells to generate power. More fuel efficient, cleaner cars. Better public transportation system that makes it easier NOT to use cars.
- Affordable, locally produced, renewable energy options for every retail & business consumer
- Community leaders in distributed wind, waste treatment to methane, and waste heat to hydrogen for stationary and transportation applications.
- Initially to meet all load growth with renewables and efficiency. Then to gradually increase that percentage until we are reducing the use of fossil fuels.
- 25% renewable energy would be a great goal by 2010.
- Nantucket Windfarm, community wind, solar PV on most homes and business.
- Hydrogen production from excess electrical generation for fuel cells
- Fossil fuel-free and Energy Independent Cape & Islands (3)
- Nuclear power to satisfy all our energy needs.
- Wind power, both off shore and on shore producing power for domestic and manufacturing consumption during the day and hydrogen production during the down time (late night) hydrogen production for fuel cells for homes and factories.
- To meet the 20 to 25% renewable energy sources that have been achieved in European countries. We have the opportunity to be a leader in off shore wind energy, we must convince the public and our politicians. Everyone driving a hybrid car.
- 65% fossil free co-generation/35% blended biofuels by 2020
- The Cape and Islands Municipal Utility to harness renewable energy that is of, by, for, how, and where the people decide. Goal of total energy self-reliance using clean technologies by 2020.
- Combination of Wind/Ocean/Solar, in order of magnitude. Household solar grid contributions.
- Abundant, cheap, 100% clean energy. That's the ideal (you didn't say it had to be practical). If you're seeking practicality I would offer: a combination of large scale offshore renewable energy sources; widely adopted distributed generation scenarios including individual households and community-scale initiatives, and a decreasing dependence on natural gas and other fossils. Nuclear completely phased out.
- Growing more of our own food, eliminate gas-guzzling vehicles from our roads to reduce pollution and congestion, public transportation in CNG busses!
- Hybrid or biodiesel fueled vehicle mandate, renewable energy sources only sun, wind, biomass
- Net exporter of green electrons. Distributed generation on homes, businesses, and municipalities can probably account for 25-50 percent of our energy demands, and large offshore wind and wave projects can provide electrons for export.
- Leader in U.S. renewables industry
- Sustainable energy economy; net sink of greenhouse emissions

# Information, Incentives And Policies Needed For Energy Efficiency Measure Adoption

- Tax breaks, financial assistance to households with incomes below the Cape median. Progressively higher taxes on cars that are not fuel efficient (e.g., getting less than 30 mpg)
- Rebates/ incentives currently available for some consumers of energy-efficient products for the home are promising. Landlords should be required to pay a portion of heating and electric costs, so that there would be an economic incentive for them to ensure rental properties are adequately insulated and feature energy efficient appliances and light fixtures. We also absolutely need to improve the environmental effects of transportation sources by greatly improving public transit options on Cape Cod, requiring greater efficiency from vehicles (particularly trucks and SUVs) on a federal level, and encouraging manufacturers to increase the availability of hybrid cars. We also need to increase what people pay at the pump and on their utilities to more accurately reflect the costs of their consumption.
- Residential models, municipal models, "tupperware" parties, publicized lotteries for installation of free technology to residences
- Develop new financing techniques for municipal renewable energy projects to lower the integrated life-time costs for renewable energy technologies. Use risk-adjusted discounting in energy decision making.
- Federal and State tax write offs up to 60% of the cost of materials and installation. The $20 billion in annual tax subsidies to Fossil fuels and nukes should be completely switched to efficiency, mass transportation and renewables. We should never forget that the financially viable passenger rail industry was put out of business by government subsidies of the national high way system. Therefore the Federal government would be justified in heavily subsidizing passenger rails now at the expense and via a gasoline/fuel tax.
- The Cape Light Compact(CLC)in 2004 did a great job on Energy Efficiency (EE)programs. However, the CLC had $8 mil to spend in 2004. In 2005 they only have $5 mil. The waite for an EE audit is now beyond 2 months. The CLC could exceed 2004 results but the $$$'s simply ane not there. The CLC is now exploring getting into the wholesale part of the business.
- "People Power" - use your (and other enviro-orgs) power at the ballot box in election, and immediately begin benign informational picketing at the organizations and media which obstruct progress towards energy independence.
- More tax credit (than now) for solar PV. Instead of auto excise tax based on vehicle value, have a carbon tax or credit based on vehicle milage: heavy tax on low milage graduated to deep credits for over 35 to 50 MPG. Tax credit for use of biofuels to level (or reduce) cost comparable to conventional oil/gasoline.
- In general, people tend to act in their own self-interest. That is, they tend to do for themselves first, and for the general good after that. So they will tend to invest time and money in something (e.g., increased energy-efficiency) if it makes economic sense for them individually. And if it helps their community, then that is a bonus.

## Information, Incentives And Policies Needed For Energy Efficiency Measure Adoption (Continued)

- Yes, there are the rare people who, out of a extraordinary sense of obligation, do more for society (e.g., pay more income tax than they owe), but these are the exception. Any long-range plan needs to look beyond the "early adopters" who already "get it", to the "fence-sitters" who need a solid, economic reason to change their existing behavior. Otherwise, (figuratively speaking)you may start out fine but then won't be able to shift into second gear.
- Uncover the barriers that prevent sustainable energy use, and design specific programs to change the identified unsustainable energy use behaviors to sustainable behaviors, ie Doug McKenzie-Mohr
- Cost incentives for efficiency measures.
- Stop supporting fossil fuels with federal money and start passing that money to homes and factories utilizing non-fossil fuel energy sources.
- Creating an awareness of the dangers of doing nothing.
- Require fuel efficiency standards.
- The reassignment of state and federal tax dollars is the only answer I can come up with.
- Tax credits of 50% or more for both residential and commercial installations of renewable energy systems and energy efficiency improvements. Door-to-door outreach is needed to let homeowners and businesspeople know what their options are.
- Tax incentives, government subsidies, community planning and special-interest nonprofit group-cooperative sharing
- Clear and honest information on economic returns and environmental benefits. Policies that would allow homeowners to purchase thier renewable hardware over time ("Pay-As-You-Save", for example - maybe offered by electricity providers).
- Tax incentives for insulation, hi efficiency windows and appliances, discount coupons, etc. Send out info in tax bills, thru schools, bizes/employers "it's about all of us working together"
- Set fossil fuel prices to biomass standard like biodiesel whch is renewable on btu/CO2 comparative basis (biodiesel-CO2 considered nill as CO2 produced equals CO2 absorbed by plants, btus lower than petro diesel but higher than gasoline or natural gas---electricity to cost of wind from Hull turbine a muncipally owned (not for profit) renewable system
- The CLC should do a targeted campaign to building owners who have electric heat first and get them to fuel switch.
- A tariff and credit system should be adopted for automobile purchases based on efficiency. People who buy efficient vehicles should get credits which are paid for by people who buy inefficient vehicles. Local efficiency programs could develop guaranteed savings contracts to pay for initial
costs, people pay back the low interest loan by paying what they should save in utility bills.
- Higher price (reflecting true cost) for fossil-based options (3)

# Information, Incentives And Policies Needed For Increased Clean Energy Adoption

- Tax incentives to individuals to install solar or other energy generating devices (2)
- Higher/progressive taxes on vehicles that pollute. Broad-based and well-marketed public education on advantages of energy conservation and availability of financial assistance.
- I think consumers should pay the true costs of the energy they use, which, as you point out, includes environmental and public health costs. (This is also true for food, especially that which requires excessive transport.)
- Mainly, instruct children in schools. Not only with books, but with active models. It's a long haul.
- Include external costs in evaluating municipal energy options. Have municipalities become energy producers and not just energy consumers.
- Use municipal lands to support energy production. Provide local tax relief for residential and commercial renewable energy systems. Make codes support renewable energy development-- wind and solar friendly.
- Externalities, which have been quantified, should be added to any new generation source's cost benefit analysis. Autos should pay a sales/luxury tax based on their output of emission/passenger mile.
- The Cape, the state and the nation must move much faster toward renewables. Wind is #1 and sun in in 2nd place. The others tag along.
- However, we can't just dump oil. Let us not forget China is the 2nd largest user of oil, behind the USA. China is huge yet a big portion of their nation is without electricity. Incentives? The answer is Federal and State serious tax incentives for big and medium sized business.
- More media information and more disclosure information on utility bills about the "externality" cost of the current fuel or energy. More tax credits for high mileage hybrids and biofuels as noted above. Need consistent federal (not on-again, off-again) production tax credits for renewable energy production. Need federal mandated RPS of 20% by 2020, increasing to 50% at the rate of 1% a year thereafter. (state RPS may be higher than federal if desired by state). Need higher REC values for PV and hydrogen generation from non-polluting (carbon) sources (note, PA has a value of $300 for solar PV RECs).
- Again Nuclear power, once we can get over the 'fear' of this method, all the above problems will be solved.
- Encourage capital investment in off shore wind power.
- Making green energy cost more competitive with traditional sources.

# Information, Incentives And Policies Needed For Increased Clean Energy Adoption (continued)

- The current farm subsidies; production tax credit and blending credits combined with the current rise in the cost of a barrel of oil, if used as intended, can bring down the retail price of blended biofuels in 05-07. The problems is that current producers and distributors are using these incentives to increase their very slim gross margins and shorten the ROI. If folks knew that they could get biodiesel at $1.45 and ethanol at $1.25, I think there would be a huge acceptance for the use of biofuels.
- The other issue slowing the acceptance of biofuels is the engine manufacturers not extending the warranty for the use of biofuels in their products. Business can't afford to take the risk of voiding the warranty of equipment just to use biofuels.
- Quick and dirty resolution would be to have our state government just mandate the use of biofuel-blends across the board, such as CA mandating the ethanol blend. Get the lobby machine tuned up!!
- The renewable energy charges should be LESS that fossil fuel sources, as the overall costs are less. Charging more for renewable energy gives people the false impression that it costs more, but the wind energy from the Town of Hull costs 3.4 cents per kilowatt - less than half of what the Cape rate is! Once again, better outreach and marketing would increase the installation of home- and business-based renewable energy systems. Town ordinances need to be addressed.
- Tax fuel acquired from war. Calculate the cost of not-implementing cape-wind and make that a "wind-free view tax" for the residents/communities that prevent capewind initiatives
- US should participate in international efforts to mitigate climate change by setting and meeting targets for GHG emissions though the widespread adoption of energy efficiency and renewable energy technologies. Level the playing fields for renewables/fossils/nukes one-way or the other (i.e.up or down -- just make it level).
- Make the polluters pay more!
- Create level playing field by reducing direct/indirect subsidies for fossil fuels and internalizing externalities

# Energy Consumption Reduction/ Clean Energy Adoption Strategies

## Household (Business) Level

- Get my teenagers to turn out lights and turn off devices when not in use
- Get support for installing more fuel efficient heating
- Incentives for landlords to provide energy-efficient rental properties
- Decision to utilize of local services (rather than driving elsewhere for a service)
- Find ways to get subsidized or free improvements. Offer my home as a neighborhood model.
- Get more dogs for winter nights.
- Purchase a hybrid vehicle.
- Extra window insulation
- Efficiency, efficiency, efficiency, insulation, insulation insulation
- Passive solar, bike friendly environments
- Energy Efficiency programs, but see above in re reduced funding
- Small wind turbines for a cluster of homes. but NStar has too much veto power
- Join CIRC, CPN and others. Give them money
- Decrease cost, increase reliability of renewable fuels
- Purchase of hybrid vehicle. (Already use compact fluorescent bulbs!)
- Tax incentive for biofuel use. More modern efficent oil or gas furnace.
- Installing energy efficent appliances lights and heating systems, "tightening" up the home to prevent heat leakage
- Hybrid cars (2)
- Improve insulation and reduce drafts with careful caulking
- Replace incandescant lamps with flourescent lamps
- Subscribing to the offer by the Cape light Compact to use green energy
- Biking to work
- Use of Solar Energy
- Co-generation
- Conservation - we have done the Cape Light Compact's energy audit, and lowered out monthly costs by $30.
- Drive high-mileage vehicles.
- Solar cells on houses, contributing to grids in case of excess
- Implement conservative usage tactics: turn off lights, cook together, no TV, shutdown idle computers
- Adopt energy efficient measures that consume less electricity
- Reduced Auto Travel (2)
- Installation of solar panels
- Get the CLC green option on the market and promote it (2)
- Increase the MTC rebate levels for solar and wind so more homeowners can take

# Energy Consumption Reduction/ Clean Energy Adoption Strategies

## Community Level

- Adopt energy efficiency measures in all public buildings
- Again Energy Efficiency programs, but there is a great lack of funding.
- Build wind turbines and biomass digesters
- Cape Light Compact Green Credits
- Car pooling
- Community based solar cells, with grid contributions, paying individuals based on contribution ratios for excess
- Conversion of schools and other buildings to renewable energy (2)
- Credits for hybrid or biodiesel cars and town-vehicle adoption of hybrid vehicles (4)
- Encourage Public transportation (2)
- Get the towns to set good models by requiring green building and strict energy codes
- Greater availability of locally made/ grown/ crafted consumer goods
- Greatly increase conservation programs and small renewable energy systems through door-to-door outreach.
- Have towns buy clean electricity and purchase clean fuels.
- Make stores carry hi efficiency lights ONLY (2)
- Mandate energy efficient future municipal and residential buildings (2)
- More efficiency in municipal buildings, more efficient an fewer vehicles, pv on every roof top, passive solar, super insulated designs for new buildings
- More extensive use of bikes
- Municipal wind turbines (2)
- Off shore wind power (2)
- Planned parenthood to reduce population
- Programs to make natural gardening an elite and highly desirable mode. ie.: less chain saws, power mowers, etc.. Maybe work on the social-taboo angle.
- Reduce municipal vehicles (car pools)
- Require the use of energy efficient lighting of streets and public buildings
- Start a fund like Aspen did that collects the fines for excessive energy consumption
- Start installing wind power for municipal buildings. This will ultimately convince the general population that wind power is not an eyesore but a very attractive power source.
- Support local efforts to install solar or other cleaner means of energy generation to help get the town further "off the grid"
- Support the establishment of municipal utilities that can develop low-cost, 100% clean, renewable energy for the towns, schools, households, and businesses.
- Tax incentives for renewable energy

# Energy Consumption Reduction/ Clean Energy Adoption Strategies

## Cape and the Islands Level

- Mount a public education campaign. Put leaflets on all of the SUVs and miniVans (especially in summer) with info on what that vehicle does to contribute to pollution on the Cape.
- Improved public transit (9)
- Corresponding tolls for vehicles
- Get George Bush out of office.
- Offshore and community wind power development with "reasonable bylaws." (5)
- Massive insulation, air tightening programs for residential buildings.
- More extensive bike trails
- A cape wide centralized program. MTC and/or the CLC have not produced such
- Push on sun, but investigate tide and wave energy
- "People Power" - use your (and other enviro-orgs) power at the ballot box
- Informational picketing at the organizations and media obstructing progress towards energy independence.
- Removing historical review of PV installations and eliminating visual restrictions on wind turbines.
- Produce local energy via "clean and green" methods - tidal, biomass, wind, etc.
- Pass legislation to prohibit diesel smoke from polluting the atmosphere.
- Organize the Cape and Islands Municipal Utility to develop renewable energy throughout the region.
- Car pooling
- Cape Wind, community solar
- Develop indigenous renewable energy resources
- Municipal wind and solar for all public buildings
- Emissions calculations and reduction strategies - larger excise taxes for polluting vehicles
- Hybrid biodiesel electric autos and trucks
- Cape light compact net metering 60 kw home or business renewable electricity
- Set policy that requires the use of renewable energy
- Get all towns and NGOs on board to promote the policy and get buy-in
- Ban regular light bulbs from stores
- More informed decision-making by regional officials
- Climate policy
- Consensus vision of energy future, setting framework for future action

# Actions to Achieve Vision

- Lobby for more support for public transport. Put up a sign by the bridges to remind people of the contribution of cars to pollution.
- Encourage the construction of small-scale, public-owned renewable energy projects through community outreach and the allocation of funds
- Start investigating municipal wind and methane production
- Support legislation in the state house and fight for programs that will subsidize comprehensive efficiency of residential buildings.
- Streamline and encourage offshore wind permitting (as in England and Europe)as well as community wind. Change charter of Cape Light Compact (if needed) to allow direct purchase of wind and PV power.
- Start at home - energy-star lights, use green- energy when given a choice, insulation, hybrid cars, sustainable building methods and materials. Also - don't be shy about it - talk about it with neighbors and friends, encourage them, be a role model, talk to public officials, work to make energy efficiency an "expected" behavior
- Build Nuclear power plants. Wind power can't supply CONTINUOUS energy, therefore it cannot stand alone as a solution.
- Push for the Wind Farm now and then proceed to larger off wind energy further off shore (2)
- State mandate of the use of blended biofuels!!!!!
- All Cape & Island municipalities following federal epact regulations and using 100% biofuels in daily operation of power & backup power generation
- Acceptance by MA DOER for 100% biofuel powered reciprocating engines and turbines as a renewable energy source available for Renewable Energy Credits
- Federal, State, and regional subsidies for implementation of co generation Start reaching out and demanding that policy be set at the regional level
- Expansion of Cape Light Compact and MTC resources to include the subsidies & implementation of 4K-250K co generation power plants
- Regional utility w/renewables
- Public transportation system and incentives, corporate carpools, vanpools etc.
- Call on the Cape Light Compact and our elected officials to provide leadership to move us into the energy future through locally-controlled municipal utilities.
- Generate support and increase awareness. Make it a political issue and get Romney out. Lobby hard. Get involved with progressive organizations which will be active in support. Make Cape Cod a carpool community.
- Educate general public about options and implications of choices made; demand political leadership -- the future of the nation's energy infrastructure is being determined as we speak.
- Adopt a Cape Wide vision that translates into action plans for every sector
- Comprehensive coordinated planning from a Beyond Cape Wind perspective!

# Goals Of Coordinated Community Energy Planning Process

- Make sure that you involve all stakeholders: not just those in "clean energy" groups and town managers (2).
- Address consumption/ production issues together
- Maybe major goals are daunting. Brave little steps will get us there, too. In one word, actually, I would say that purest creativity, not leaning on old solutions, is the way.
- Increased community and private ownership of renewable energy systems.
- Education and public support for efficiency programs, mass transportation, bike trails, passive solar and wind.
- Start with an ad hoc committee with 2 members each from the CLC, EDC and the Assembly of Delegates (Economic Affair Committee), CIREC and one county commissioner (Lance Lambros). Give them $25,000 +/- for an expert (Scott Ridley)and 60 days to produce a county wide Plan.
- Reasonable turbine and PV bylaws to encourage their use. Mandate energy efficient new buildings. Set town goal or establish a town RPS at least comparable to state RPS. (note some US cities do this now, and I believe one MA town did as well). Goal of B20 biofuel for all town Diesel vehicles and oil heating plants (cost issues).
- Promoting public acceptance and the social expectation that each of us will reduce our fossil-fuel energy consumption in whatever ways we can.
- More municipal wind power so that the general population will accept a string of wind turbines along the center and or either side of the Midcape cape; private or public ownership makes little difference-- just get on with it.
- Utilizing on and off shore wind as well as other renewable energy sources
- Education of every elected official representing the Cape & Islands. 2020 date to be only 35% dependant on fossil fuel for the region
- Involving people in every town to become a "green energy activist", and if the people lead, the leaders will have to follow.
- Community awareness of progressive issues and conservation techniques. Increasing collaboration between citizens. Create alliances with progressive political organizations to galvanize support and activism on the issue.
- Communicate so as to create as much synergy as possible; avoid redundancy; avoid unintended "cumulative consequences".
- Conservation is the key
- Regional renewable energy commitment from the top down by all commissions.
- Reduced pollution and increased energy efficiency without economic impacts
- Setting good policy and getting cooperation from many organizations and politicians
- Replace fractious atmosphere with collaborative one; promote comprehensive thinking; gain consensus where possible and identify priorities for future work
- Education about what the problems are and the potential solutions to them, consensus on what should be done, and a plan (with commitments) to move forward

# Additional Comments

- All of the so called Renewable Energy Groups and non-profits need to get together and focus on education and political change in the region. Hire a "consultant" to deliver the message to the State House. If as much energy and resources that are currently associated with the acceptance and non-acceptance of the Wind Farm were harnessed to create a long term solution for this community, it would be done in less than 5 years
- Do not place the wind farm on Horse Shoe Shoal. Let's not forget industrial development during the last two centuries, what it did to our rivers,streams,and bays. We haven't recovered from that yet. This would be a catastrophic mistake building in tidal glacial till. Build it on land...such as Nomans Island,lease the land. On land construction and maintenance would greatly lower the over all costs.
- Don't assume that just because an energy source is "green" (e.g., wind power, hydrogen cells, tidal energy) that it is without environmental costs. These costs must also be considered (e.g., impacts on wildlife habitat or fragile species) and reasonable and independent risk assessments should be done.
- I must say I am very disappointed with MTC for going at it Town by Town rather than the Cape as a whole. That is simply not good management. There is also some disappointment with the CLC, however, they simply don't have the horses with a staff of only eight.
- Increase public ownership of hybrid vehicles for police and other applications. Begin community wind and methane production. Use community produced methane for building and vehicle (CNG) applications
- Make some noise!
- Questions too macro - why not use form to determine what people are doing now?
- The support and roll of the Cape Light Compact needs to be expanded, more visible and well funded.
- This needs an enhancement of the spirit, which generally only arises because of crises.
- Why do the majority of the polls always seem to come up with similar lame excuses for not backing the wind farm. Are the nimbys putting cash in their campaigns? Otherwise intelligent persons surprise me with their responses.
- Wind and solar PV development are paramount. Use excess power to generate hydrogen by electrolysis(instead of sending excess off Cape on the grid.

**Survey Participants (As of April 11, 2005)**

| Name | Affiliation |
|---|---|
| Almy, Jessica | The Human Society of the U.S. |
| Amsler, Megan | Cape & Islands Self-Reliance Corp. |
| Benson, Albert H. | U.S. DOE Northeast Region |
| Brooks, Walter | Cape Cod Today |
| Chris Powicki | Water Energy & Ecology Information Services |
| Conlon, Michael | MASSPIRG |
| Coulson, Mark | N/A |
| Fenlon, Fred J. | Assembly of Delegates, Chair Econ. Affairs Committee |
| Giles, Allan | N/A |
| Kleekamp, Charles | Clean Power Now, Cape Clean Air |
| Mangiafico, Jean | League of Women Voters Cape Cod Area |
| Mullin, Richard F | N/A |
| Patrick, Matt | State Rep. 3rd Barnstable District |
| Richard Lawrence | Cape & Islands Self-Reliance |
| Stead, Cynthia | Resident, Town of Dennis |
| Twombly, Martha | Cape Cod Commission |
| Watson, Greg | MTC |
| Watt, Tana | Cape Cod Commission |
| Weber, Paul | LWV- Wellfleet, MA |
| White, Peter A. | Cape Cod Green Rainbow Party |
| Wright, Tyger | The Wright Company |
| Young, Sharon | The Human Society of the U.S. |

Average Monthly Energy Costs for Participants