33

Analysis of Energy Service Industry

By

Ichiro Soma

B.E., Mechanical Engineering
Waseda University, 1989

Submitted to the Department of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE
in Civil and Environmental Engineering
at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

May 1994

Signature of author____________________
Department of Civil and Environmental Engineering
May 6, 1994

Certified by____________________
Fred Moavenzadeh
Thesis Supervisor
Director, Henry L. Pierce Laboratory
George Macomber Professor of Construction Management

Accepted by____________________
Joseph M. Sussman, Chairman
Departmental Committee on Graduate Studies

ANALYSIS OF ENERGY SERVICE INDUSTRY

by

ICHIRO SOMA

Submitted to the Department of Civil and Environmental Engineering on May 6, 1994 in Partial Fulfillment of the Requirements for the Degree of Master of Science in Civil and Environmental Engineering

ABSTRACT

The purpose of this thesis is to clarify the potential ways Heating Ventilating and Air Conditioning (HVAC) engineering firms may contribute to formulating solutions to the global warming problem. The energy service industry is an industry that makes contributions toward solutions to this problem. While it plays a critical role in increasing the end use efficiency of electricity, it is also an emerging market which is attractive to engineering firms and contractors. This thesis analyzes the energy service industry in order to clarify the attractiveness of this market to the engineering firms and contractors, and the options when entering this market.

The first part of this thesis summarizes the global warming problem: its theory and possible damages. It poses the question of why increasing end use energy efficiency is the least cost option, especially for the United States where energy prices are low and current efficiency is also low.

The second part first discusses the demand-side management programs implemented by the electric utilities, which are the major revenue source for the energy service companies (ESCOs). The future directions of these programs are explained. The following section reviews the method of performance contracting which enabled the marketing of energy efficiency, and the two key equipment technology used by the ESCOs. In the final section, an industrial analysis of the energy service industry is done, and the options for the engineering firms and large contractors seeking to enter this market are shown.

The case study of EUA Cogenex shows an example aggressive strategy for entering this market.

Thesis Supervisor: Fred Moavenzadeh

Title: Director, Henry L. Pierce Laboratory

George Macomber Professor of Construction Management

Acknowledgements

First of all, thanks to Professor Fred Moavenzadeh for generously supporting me during my studies here at MIT. I was not able to fulfill my interdepartmental interest without his program. Special thanks to Charlie Helliwell for providing his time to give me precious advice to my thesis.

Thanks to all the members of MIT society whom I had chance to meet.

Finally, thanks to Kajima Corporation for the scholarship. I must also thank all the corporate members who had supported me on realizing this study at MIT.

Contents

Exhibits

Chapter 1: Introduction

1.1. Aggressive Strategy for Engineering Firms Under the Influence of Global Warming

The goal of this thesis is to clarify the potential roles of Heating Ventilating and Air Conditioning (HVAC) engineering firms in contributing to solutions of the global warming problem. Since 1985, when the evidence of ozone depletion was first discovered in the Antarctic, this global environmental problem has risen to become a high priority. For a private company, even regional regulation causes critical changes to the business environment. What will be the consequences of global changes? This thesis discusses and investigates the results of recent studies by economists, natural scientists, and engineers, and seeks to identify opportunities for the HVAC engineering firms to participate in the solution.

The latter half of this thesis will be devoted to the analysis of energy service companies (ESCOs). These companies are part of the energy efficiency industry. ESCOs are contractors that engage in increasing end use efficiency of non-residential buildings. Their work is a model for how engineering firms can contribute to reduce the global warming problem and continue to make a profit.

The favorable growth of ESCOs in the last decade is not irrelevant to the recent series of global environmental problems such as acid rain and global warming. If it were not for the utilities demand-side management programs and support of government policies, they could not have grown smoothly.

This is particularly true in the U.S., where energy prices are about half of all other industrialized countries.

Another factor which has supported the implementation of marketing energy efficiency was the use of performance contracting. This contracting method has allowed ESCOs to give incentives to the end users to increase their energy efficiency. It is also a risk taking business which depends on the technical capability of the firm. This risk, however, is not high at all when compared to other industries. In other industries such as electronic manufacturing, one risk or another is taken in making decision about the next product to develop; investment timing of the new manufacturing equipment, pricing, and product portfolio decision making are a few of these risks. For manufacturing firms, this risk can not be avoided simply by possessing enough technical capability. If an engineering firms wants to grow, under current stagnation of new construction market, avoidable high risk with high return should be its direction. Unlike manufacturing, if an engineering firm possesses sufficient technological expertise, high risk can be overcome. The main issue is to narrow down uncertainty associated with the energy efficiency business. From this perspective, HVAC engineering firms can be more competitive by aggressively demonstrating their technological expertise.

ESCOs' target is also different from the traditional one. Their vast opportunity lies in the renovation of buildings. In the past, there were few opportunities left for the engineers once the building was built. Therefore, the volume of new construction controlled their prosperity to a great extent. Engineering firms can smooth the cyclical nature of their business by aggressively participating in this retrofit market.

Ever since the first air conditioning unit was introduced by Carrier, the basic role of engineers has not changed. Although there have been innumerable innovations in HVAC equipment and system design, the general procedure is still to wait for customers to build new buildings or invest in a renovation project. Therefore, the basic role of marketing is to capture such clients effectively. However, I believe that marketing should become more aggressive in engineering firms. Furthermore, I believe that aggressive marketing will be increasingly critical to the service of performance contracting. The potential customers of performance contracting are widely spread out compared to new construction. Therefore, a traditional marketing approach is not sufficient to pioneer these customers.

This thesis will clarify the question of what engineering firms should do with this market by analyzing the group of energy service companies.

In this thesis, the term *HVAC engineering firms* refers to firms concentrating on heating, ventilating and air-conditioning (HVAC) designs and energy consultation. It also applies to any architectural firms possessing a department with an equal function. Specifically, the ultimate goal of this thesis is to seek opportunities for large scale general contractors in Japan, to enter the energy services sector of the efficiency industry. Such large-scale general contractors (Kajima, Shimizu, Taisei, Obayashi, Takenaka) offer both design and construction. Mechanical and Electrical departments (HVAC engineering) of these giants have another merit in entering this market: they will be able to decouple their revenue source with the major architectural work, therefore, gaining more independence and profitability. Independent source of revenues for the department will consequently result in the increased competitiveness of general contractors.

1.2. Overview of Chapters

In Chapter 2, scientific evidence of the global warming problem is summarized. Second, the economic impact of the problem is discussed. Third, the relative weight of energy as a cause of the problem is analyzed. Finally, possible improvements which can be made in the non-residential buildings sector are discussed.

Chapter 3 analyzes energy service companies (ESCOs). These companies have been growing constantly by taking advantage of demand-side management (DSM) programs. Although the growth statistics for the entire industry were not available, considering the fact that all DSM performance contracting jobs are done by ESCOs, their growth of sales should correlate with the growth in DSM bidding. By analyzing the energy service companies and their performance contracts, strategies for engineering firms to take advantage of the energy service industry are explored.

Chapter 4 is devoted to a case study of the company, to show how it has exploited the market or how it can exploit the market.

Chapter 5 draws conclusions and recommendation for the future research.

Chapter 2: Surrounding Social Environment

2.1. Global Warming

2.1.1. Global Environmental Problem

Two major issues of global environmental problems affect the participants of HVAC-related industries, both directly and indirectly. Stratospheric ozone depletion has affected the industry directly. Chlorofluorocarbons (CFCs) responsible for the depletion are used as refrigerants in various series of refrigeration units and air conditioning units throughout the world. Global warming affects the industry indirectly because of increased demand for efficient energy use.

The effect of global warming on the industry will be discussed in this thesis. The recent discussion of scientists and economists will be analyzed to see the direction of the future. Then the thesis will go into the main issue. How can we use this effect on the industry as an advantage? Ozone depletion problem will be excluded from this discussion, because the future of CFCs is rather clear compared to the global warming problem.

2.1.2. Theory of Global Warming

The earth has an average surface temperature of 15°C, which enables human beings to survive. This is the result of the 'natural' green house effect maintained by water vapor (0.2% of atmospheric volume) and carbon dioxide (0.03% of atmospheric volume). These substances define the heat transmission via radiation among sun, the earth's surface and space. If there were no greenhouse effect, the temperature of the surface of the earth would be close to -18°C, which can be calculated from the radiative equilibrium. (Absorbed solar energy equals emitted terrestrial energy.) The green house effect originates in the difference in the wavelength of radiation that reaches the earth and that which is reflected from the earth into space. Since the sun's radiation approaching earth is a shortwave radiation of 0.2 to 4.0 micrometers [μm], only 100 out of 340[w/m^2] coming in will be subjected to reflection; the remaining 240[w/m^2] are absorbed by the earth's surface. On the other hand, radiation from the earth's surface is in infrared longwave bands (4 to 100[μm]), therefore, 180 out of 420[w/m^2] will be reflected by the clouds and aerosols, return to the surface and warm the earth's average surface temperature to 15°C.

It is this greenhouse effect that enables earth to harness the species. The current concern is that, since the industrial revolution, we are increasing the concentration of carbon dioxide and other greenhouse gases at an accelerating rate. The major source is carbon dioxide emitted by burning fossil fuels. The other sources are methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbons (CFCs). Methane is emitted from the bacteria activities in rice paddies and organic-rich landfills, the rearing of cattle and other domestic ruminants, biomass burning, coal mining, and natural gas leakage. Nitrous oxide is emitted from fertilizer production, and CFCs from air conditioning units.

Compared to preindustrial concentrations, carbon dioxide has increased by 25 percent and methane has more than doubled. Apparently our economic activities have risen to the point where the entire earth's system is being changed. The contribution of these trace gases to the greenhouse effect in the past, through the radiative forcing, was two-thirds for carbon dioxide, 15% for methane, 24% for CFCs, and 6% for nitrous oxide, respectively.[1]

Another fact worthy of notice is that although the above increase in carbon dioxide concentration alone is able to change the radiative forcing, it only amounts to a fraction of carbon dioxide existing in the environment. The annual emissions of carbon dioxide is 6 to 7 [GtC].[2] This is less than one percent of the stock carbon contained in the atmosphere which is 750[GtC].[3] This small additional carbon dioxide is triggering the global warming.

There is a close correlation between this concentration increase and the rise of earth's average surface temperature.[4] But the relation between the cause and consequence is ambiguous. The most relied on theory is as follows.

> "Very long (Milankoitch) cycles in the earth's position (orbital eccentricity varies on a 100,000-year cycle, the obliquity of axis tilt over 41,000 years, and precession of the equinoxes over 23,000 and 19,000 years) are the most likely initial cause of temperature change. Poorly understood mechanisms such as changes in 'ocean circulation and marine production for CO_2... and fluxes of emission from natural wetlands for CH_4' then cause a rise (fall) in greenhouse gases in response to the initial rise (fall) in temperature."[5]

Although there is more to be revealed concerning the global warming theory, the validity of the data showing the increase of earth's temperature in the past

---

[1]Intergovernmental Panel on Climate Change. *Scientific Assessment of Climate Change: Report Prepared for IPCC by Working Group I.* (New York: World Meteorological Organization and United Nations Environment Programme. 1990) ix, 59-64.

[2]5.4 ± 0.5[GtC] from fossil fuel burning and 1.6 ± 1[GtC] from deforestation.

[3]Intergovernmental Panel on Climate Change. *Scientific Assessment of Climate Change: Report Prepared for IPCC by Working Group I.* (New York: World Meteorological Organization and United Nations Environment Programme. 1990) 14.

[4]Carbon Dioxide Information Analysis Center. *Trends '91.* (Oak Ridge, TN: Carbon Dioxide Information Analysis Center (Hansen and Lebedeff data series)) Figure.

[5]Cline, William R. *The Economics of Global Warming.* (Washington, DC: Institute for International Economics. 1992) 27.

century has gained major consensus. IPCC had concluded in a 1990 report that there has been a real, but irregular, increase of global surface temperature since the late nineteenth century amounting to 0.45°C ± 0.15°C.

The scientific majority view on prospective global warming is based primarily on simulations by general circulation models (GCM). GCM is based on feedback modeling of following; 1) liquid to vapor, 2) solid-to-liquid and vapor, 3) vapor-to liquid and solid: cloud feedback, and 4) ocean-atmosphere coupling. These impacts amount to $\Delta T(CO_2 \text{ alone}) \cong 1.2°C$, $\Delta T(CO_2 + \text{water vapor}) \cong 1.8$-2.5°C, $\Delta T(\text{above + snow and ice}) \cong 2$-4°C, $\Delta T(\text{above + clouds}) \cong 1.5$-5.5°C.[6] Although this model is thought to be most effective, there are questions that it is not sufficient to account for the current increase of the earth's temperature.

2.1.3. Simulated Damage of Global Warming

What would happen in the case of an equivalent doubling of carbon dioxide?[7] This scenario has been simulated as follows.[8] If the current trend of global warming is sustained, the equivalent doubling of carbon dioxide will occur in the early 2030s. The value ranges cited are simulated ranges of general circulation models (GCMs). According to the Intergovernmental Panel on Climate Change (IPCC) report, the temperature change will be +1.5 to 4.5°C. These numbers have been adjusted to current global warming trends. The sea level will rise from 0 to 80 [cm] , assuming that there are only small changes

---

[6] Hartman, Dennis L. "Modeling Climate Change." *Global Climate and Ecosystem Change.* Ed. G. McDonald et al. (N.p.: Plenum Press, 1989) 97-140.

[7] "Equivalent doubling" means that the preindustrial value of carbon dioxide, equivalent to 280 ppm, is doubled to 560 ppm. It includes all other trace gases responsible for a radiative effect which are converted into an equivalent volume of carbon dioxide.

[8] Schneider, Stephen H. "Global Climate Change." *The Energy Environment Connection.* Ed. Jack M. Hollander. (Washington, D.C.: Island Press. 1992) 78.

in the Greenland and West Antarctic ice sheets in the early twenty-first century. But eventually, a rise of several meters of sea level will occur, according to the equilibrium. The model demonstrates that other major changes will occur in precipitation and evaporation. The precipitation change will be +7 to +15%, and the evapotranspiration change will be +5 to 10%. Regional distributions will have a much wider range. For example, the regional temperature change would be -3 to 10°C. For regional climate changes, different techniques are being developed by P. H. Gleick to evaluate the small-scale hydrological effects of large-scale climatic changes. GCM cannot predict regional effects since a typical model divides the earth's surface into 1,920 mesh. Each mesh has a size of 4.5° of latitude and 7.5° of longitude, which is too large for accurate regional predictions.

The damage done to the U.S. economy from this climate change is predicted in Appendix 2-3., based on the simulation results. Total damage is estimated to be 61.6 billion excluding several unestimated numbers, in the case of CO_2 doubling. This is approximately 1.1 percent of the U.S. GDP. The important fact is that while it will be possible for humans to recover from most of these damages, that done to the natural ecosystem such as the loss of its variety of species and the loss of biodiversity will be irreversible.

2.1.4. Options for Dealing With Global Warming

Despite the fact that there is a variety of circumstantial evidence to support the global warming theory as explained in the preceding section, there is no positive explanation. Several options can be considered in dealing with global warming, taking into account the uncertainty of the phenomenon and its effect on the earth's system.

The first option is to make a purely passive response to global warming. The second option is to actively reduce its speed. This can be done through reduced energy consumption, reduced emissions per unit of energy consumption or GNP, removing greenhouse gases from atmosphere, and selective emissions reduction in a cost effective manner. The third option is to offset climatic effects. This can be done through climatic engineering. The plan will be to paint roads and roofs white and/or put particles into the stratosphere to decrease the reception of radiative heat from the sun. The last option is simply to adapt to the warmer climate: to prepare according to what might happen.[9]

Among the options, it seems optimal to take an option which will benefit the society even if global warming and its effects do not occur as simulated. Many people call this a 'no regret policy.'

2.1.5. Realistic Mitigation Options

From the past movements in the international politics and opinion of the majority of scientists and economists, only the least cost strategy (no regret policy) are predicted to be taken by most of the countries. Only chance for majority of the countries to approve of drastic options is when scientific evidence of accelerated global warming has been discovered or the past temperature fluctuation in the earth history is explained clearly without opposition. Unfortunately, this is not likely to happen. Compared to ozone depletion problem, global warming is a product of far more complex system of earth's system.

---

[9]Nordhaus, William D. "The Economics of the Greenhouse Effect." *MIT Workshop on Energy and Environmental Modeling and Policy Analysis.* (June 1989): Table 2.

Nordhaus has proposed the necessity of abatement cost function curve for determining the realistic mitigation options in 1989. He insisted on taking a careful step towards the uncertain global warming problem. Since that period, various studies have been done on various mitigation options. Many other economists and researchers created the abatement cost curve. To scientifically determine the reasonable investments on this global warming problem. In his 1989 paper he proposes the least-cost actions which will benefit the society even if nothing severe happens. Many agee with this policy decision. For example, one of the most authoritative institution in the U.S., the National Academy of Sciences released a report in April 1991 suggesting low-cost action the U.S. could take right away to blunt the potential for global warming. These "no regrets" strategies, such as increased energy efficiency and development of renewable energy substitutes for fossil fuels, would be beneficial to society even if fears of a runaway greenhouse effect prove to be unfounded. On the other hand, in September 1991, the Academy issued a report by a different panel of experts, suggesting that adapting to global warming may be more economical than preventing it.

Most focused and suggested least cost strategy (no regrets policy) is to increase the energy efficiency. Rubin et al. presented that "variety of energy efficiency and other measures that are now available could reduce U.S. emissions of greenhouse gases by roughly 10 to 40% of current levels at relatively low cost, perhaps at a net cost savings."[10]

---

[10]Rubin, Edward S., Cooper, Richard N., Frosch, Robert A., Lee, Thomas H., Marland, Gregg, Rosenfeld, Arthur H., and Stine, Deborah D. "Realistic Mitigation Options for Global Warming." *Science* 10 (July, 1992): 148.

2.1.6. Expert Opinion[11]

Each researcher's opinion seems to differ according to his or her academic background. While many natural scientists urgently appeal for the mitigation of global warming, economists tend to take a calm stance. The following quote reveals a part of their different understanding of the common problem.

> "I must tell you that I marvel that economists are willing to make quantitative estimates of economic consequences of climate change where the only measures available are estimates of global surface average increases in temperature. As [one] who has spent his career worrying about the vagaries of the dynamics of the atmosphere, I marvel that they can translate a single global number, an extremely poor surrogate for a description of the climatic conditions, into quantitative estimates of impacts of global economic conditions."
> -anonymous scientist who declined to submit his guesses on global warming effects to Nordhaus.

Natural scientists focus on such issues as the loss of bio-diversity in the tropical region. With their knowledge, they are able to analyze the long-term effects which will result. On the other hand, economists tend to be indifferent to these effects, as long as human economic prosperity is maintained. While natural scientists tend to be pessimistic, knowing of the complexity of earth's system, economists tend to be optimistic because they believe in the adaptability of human beings to the surrounding environment.

Another noticeable fact was that in general both the natural scientists and the economists agreed that the impact will be greater for the low-income, developing countries. Most of these countries are positioned within 30 degrees latitude of the equator, and they contain 52 percent of the world's population. But these countries only produce 16 percent of the world's output and their

---

[11]Nordhaus, William D. "Expert Opinion on Climate Change." *American Scientist.* Vol.82 (Jan./Feb. 1994): 45-51.

economies are deeply connected to the ecosystem. They are dependent on natural resources and worse, they have mortgaged their natural resources to pay the interest accumulating from their debt.

2.2. Energy Efficient Economy: A Macro View

2.2.1. Introduction

From the above analysis of global warming problems, it seems inevitable that governmental regulations will gear society towards more energy efficient economy. This particularly applies to the U.S. As discussed in the section on realistic mitigation options, because of cheap oil prices/taxes, the U.S. economy has large opportunity in increasing their energy efficiency at the end use. Increasing energy efficiency is the lowest cost option with lowest risk for the government. The driving power of politics comes from societal expectation. Ever since ozone depletion was actually discovered in the Antarctic, general interest in various global environmental problems have increased interest. The theoretical discussion of increasing energy efficiency of end users to benefit the economy is discussed in the following section. Another favorable side-effect of increased energy efficient economy, the increase of economic competitiveness of the country/industry through higher energy intensity will also be discussed.

2.2.2. Theoretical Limitations on Energy Efficiency

To describe the opportunities of increasing energy efficiency, the notion of second law energy efficiency will be introduced in this section. There are two concepts for computing energy efficiency. The one which is more generally used is classified as the first law efficiency. The second law efficiency considers the 'quality' of energy usage. The first law of efficiency is defined as

$$\eta = \frac{Q}{F}$$

where as F is the energy provided to the system, and Q is the gained useful energy.

The second law of efficiency is defined as

$$\eta = \frac{W}{F}$$

where W is the theoretical minimum energy required if ideal Carnot's cycle (S. Carnot, 1796-1832) is used for calculating energy efficiency. F is the energy input required for the specific system. Ideal Carnot's cycle efficiency η_c is obtained from

$$\eta_c = 1 - \frac{T_2}{T_1}$$

where T_2 is the low temperature heat source, and T_1 is the high temperature heat source. The efficiency of Carnot's cycle is defined by both heat sources. Here the Carnot's cycle is used for comparison. Carnot's cycle has the highest efficiency among those cycle's that work between high and low energy source.

By using the measure of second law efficiency based on thermodynamics, evaluation of currently used technologies can be discussed. Exhibit 2.1.shows the second-law efficiency of appliances used in residential/commercial space heating, transportation and industry sectors. For example, furnaces have first law efficiency of 60 percent meaning that 60 percent of energy fuel embodied is converted into useful energy to warm up the room. But as can be seen the furnace has only 5 percent of second law efficiency. It means that even if 100 percent first law efficiency is attained, this system has an 8.3 percent second law efficiency. Therefore, the method is inefficient when considering the quality of energy. This is just an example. Low cost of energy has given disincentives to both the suppliers and end users to consider the quality of energy used. Most of the energy used for human comfort such as space heating, cooling, hot water supply is low quality. It is very inefficient to use energy intensive depletable resources directly for these low quality of energy usage. Technically speaking, electricity should not be used to directly heat or cool water. It is optimal decision for gasolines to be used for the transportation such as cars, while it is not preferable for the use of heating water by the boiler. In a sense it is ironic that automobiles uses the oil most efficiently. The quality of energy matches the use and it also takes advantages of high volumetric energy density of the substance. Gasoline has the highest volumetric energy density of 34.5 [MJ/Liter] compared to other substitute being considered as an energy source for the next generation of cars. This high density of oil is one of the barriers to brake for electric cars. Cogeneration system is one exception which has high second law efficiency while using oil as an energy source to produce hot water or steam. Its combined cycle utilizes wasted heat by generating electricity. The main purpose of this system is to generate electricity and hot water simultaneously to increase the second law efficiency. Another example of efficient use of energy which is working on commercial base is the use of unused energy. It will be discussed in the next section. As burning of fossil fuels receive constraints from the global warming, this second law efficiency should be increasingly considered.

Exhibit 2.1. Second-law Efficiencies for Typical Energy Consuming Activities

Sector	Second-law Efficiency (Percent)
1. Residential Commercial:	
Space heating:	
Furnace	5
Electric resistive	2.5
Air conditioning	4.5
Water heating	
Gas	3
Electric	1.5
Refrigeration	4
2. Transportation: Automobile	12
3. Industry:	
Electric-power generation	35
Process-steam production	28
Steel production	23
Aluminum production	13

Source: Ross, Marc H., Williams, Robert H. *Our Energy: Regaining Control.* New York: McGraw-hill, 1981. 96

2.2.3. A Case on High Second-law Energy Efficiency

Based on this notion of energy efficiency, there are already two commercially based projects under operation in Japan. The Hakozaki plant in the Tokyo metropolitan area uses river water as a heat source, and the Makuhari plant which locates in newly developed Makuhari area uses sewage treatment water as a heat source. They are both utilized for district heating and cooling to provide hot and cool water. The coefficient of performance (COP) for the Hakozaki plant is 4.9 for cooling, 3.8 for heating, and 6.0 for simultaneously heating and cooling of the water.[12] The second law efficiency for this plant would be 34 percent, 47 percent, and 75 percent, respectively. These numbers show that at least in terms of the output from the plant, it is comparable to the second law efficiency of a thermal power plant. Such potential energy

[12]Yoshida, Hajime, Maekawa, Tetsuya. "Some Experiences of Utilization of Urban Waste Energy by means of Electric-driven Heat Pumps." *Heating, Air-Condtioning and Sanitary Engineering.* Vol.66, No.6: 421

embodied in river water and sewage is called Unused Energy, for which there are various sources. (Exhibit 2.2.)
In this context, unused energy does not refer to natural energy such as solar power, wind and tides. It involves relatively low temperature waste heat resources within the urban environment.

The idea of the system is to pump the energy from low energy resource and to concentrate it into higher energy. Similar to a solar collector, that a mirror collects the sunlight into one point with several hundred celsius degrees. With the development of a higher efficiency heat pump (which is proceeding under Ministry of International Trade and Industry of Japan (MITI) funded project), the efficiency numbers will be further increased. Rivers are an ideal heat resource; in summer water is cooler than air, while in winter it is warmer, therefore it is a good resource to gain both energy for air conditioning and a hot water supply. The difficulties are that gaining energy from low energy resources requires a highly efficient system and to make it more cost effective, and that the system must be close to the mass energy demands to reduce the loss from the pipeline while transporting the heat.

By making use of this environmentally clean new energy resource, engineers are trying to deal with the higher demands for electricity in the 21st century without increasing the carbon emission and air pollutants.

Exhibit 2.2. Various Types of Unused Energy Source

Energy Source	Form	Temp. range(Celcius)
Sea, River	warm water	5 to 20
Subway	air	10 to 30
Sewage treatment plant	warm water	15 to 25
Waste Incinerator	warm water	15 to 30
	steam	110 to 150
Thermal plant	warm water	10 to 150
	steam	110 to 150

Source: Society of Heating, Air-Conditioning and Sanitary Engineers of Japan, SHASE Journal

2.2.4. Motivation and Force

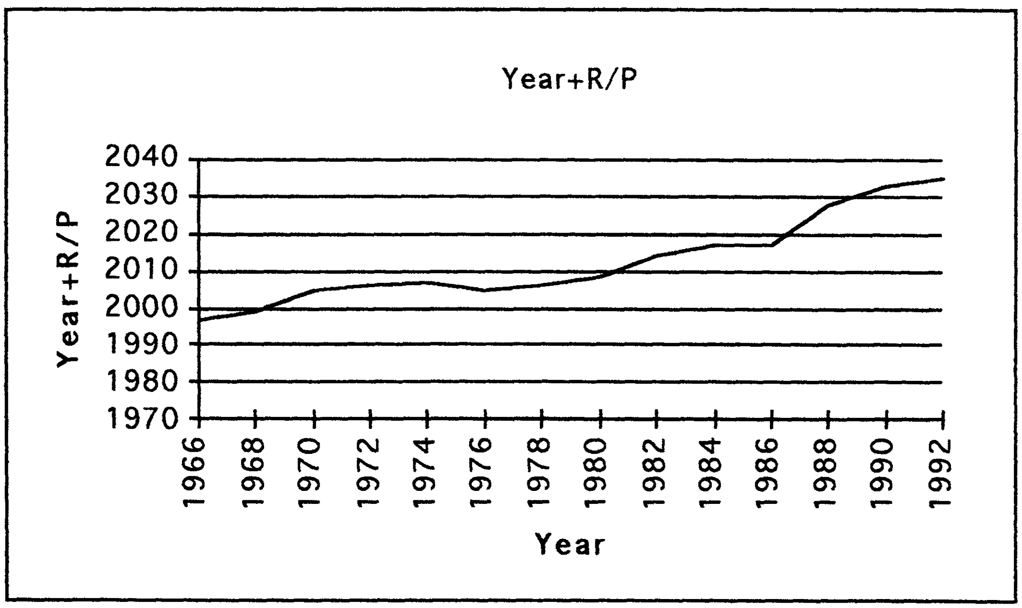
First of all, limits on our depletable energy source such as oil, gas, coal, and uranium is not the priority reason for promoting energy efficient economy. In 1973, oil embargo forced everyone to re-think about limited energy sources we have, and that oil supply from O.P.E.C. countries is not stable. Since then, countries have diversified their energy sources and increased the efficiency. Oil reserves has been growing due to the newly found oil wells in the middle east. In 1973, oil was estimated to dry up in 34 years which is 2007. As it appears in the Exhibit 2.3., R/P ratio[13] is increasing. At least oil will remain for current generation of people. Even if oil is to dry up, there are enough other resources to substitute (Exhibit 2.4.). Considering the time of oil dry up, it can easily be projected that efficient technology will be developed by the time to make other resources useful as oil. Even with current technology, it is possible to gain more oils from inferior wells and oil shale that are not counted as the oil reserve in the statistics. Most of these technologies such as polymer injection to the wells to recover residual oil, were developed after the 1973 oil

[13]Reserves/Production (R/P) ratio: If the reserves remaining at the end of any year are divided by the production in that year, the result is the length of time that those remaining reserves would last if production were to continue at the current level.

crisis. It is cost effective if the oil price is near 30 dollars. This price range was sustained from 1973 to middle of 1980s (in current dollar). So the oil prices will go up in the future, but it should be available many years after 2040.

Therefore present problem is not the limits of energy sources. The problem is its usage and effect to the environment which is now highlighted as global warming problem as explained earlier in the chapter. Fossil fuels such as oil and coal generates carbon dioxide as a result of combustion process. The only possible solution is to this is to capture the carbon dioxide, or to reduce its emissions. Currently technology to capture carbon dioxide is not commercially viable. In addition, there is enough space available for increasing energy use efficiency without reducing our quality of life.

Exhibit 2.3. R/P Ratios



Source: BP Statistical Review of World Energy, June 1993

Exhibit 2.4. Reserves/Production (R/P) ratio:

Kind:	Oil
Reserve:	1006.8 thousand million barrels
Production 1992:	64920 thousand barrels/day
R/P:	43.1 Yrs
Kind:	Natural gas
Reserve:	138.3 trillion m^3
Production 1992:	1838.7million tonnes oil equivalent
R/P:	64.8 Yrs
Kind:	Coal
Reserve:	1039182 million tonnes
Production 1992:	2170.9 million tones oil equivalent
R/P:	232 Yrs

Source: BP Statistical Review of World Energy, June 1993

Understanding the above circumstances clearly, the U.S. will at some point receive the most pressure from the international community. U.S. emits the most carbon dioxide per capita, and has the lowest energy intensity. U.S. emission of carbon dioxide is roughly a quarter of the greenhouse gas emitted by all human activities, which is approximately 6000 [Mt/year] CO_2 equivalent. (Exhibit 2.5.) The only emission performance calculations that favors the U.S. is world emissions per GNP which is not likely to be used as common indicator for future carbon dioxide emissions trading market. It is because this calculation disadvantages the developing countries including former Soviet Union. This indicator simply divides the world into the developing countries and industrialized countries. Furthermore, U.S. is the only country without any targets for carbon dioxide stabilization among industrialized nations. (Appendix 2-4.) As explained earlier, increasing end use efficiency is the least cost option for the U.S.

Exhibit 2.5. Emission of CO_2 by Country (1988 estimate)

	CO_2 emission(million Tons)		Per capita CO_2 emission(tons)	
		Ratio(%)		Japan=1
U.S.	1426	24.2	5.79	1.57
Japan	276	4.7	2.25	1
U.S.S.R.(Former)	1102	18.7	3.86	1.72
China	570	9.7	0.52	0.23
West Germany (Former)	200	3.4	3.25	1.44

Source: The White Paper on the Environment, Environment Agency of Japan

Another factor is that the U.S. energy intensity is the lowest among industrialized countries. (Exhibit 2.6.) There are many gains the country can obtain through increasing the energy intensity. First, primary use of energy will be reduced. This will give flexibility to their energy supply policy by diversifying the energy source which will also increase the energy security. Second, through the process of increasing energy intensity, productivity should rise for energy intensive manufacturers. This will boost the economic competitiveness of the companies. (Specially when they go abroad.) Third is a near future target. It is wise to increase the whole economies' energy intensity for the future generation. Although there are no possible energy source crisis in a decade or so, they are depletable and the price will inevitably go up in the long term. It will be the best investment if benefits of future generation were put into the numbers.

Exhibit 2.6. Per Capita Energy Consumption(1989)
(Unit: ton of petroleum equivalent)

	U.S.	Japan	Germany	U.K.	France
Energy consumption	3.29	7.81	4.38	3.69	3.90
Petroleum consumption	1.90	3.18	1.75	1.42	1.60

Source: OECD Energy Balances

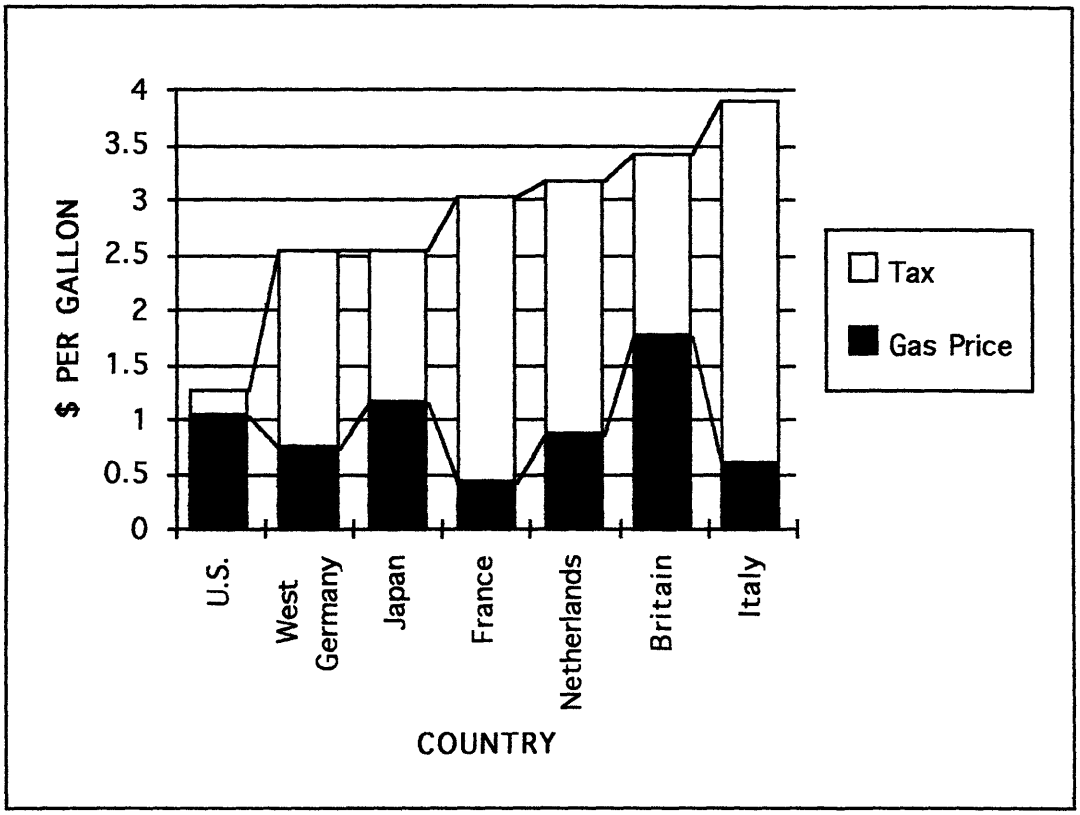
2.2.5. Barriers

In the previous section, feasibility and motivation for the increased efficiency of electricity use by the end user market segment has been presented. Here, the factors that work as barriers and hinder the participants interested in this common goal are discussed.

2.2.5.1. Low price of oil

Low price of oil is particularly an obstacle in the U.S. for improving efficiency of electricity use. The U.S. not only has the lowest oil price among G7 (Group of seven) but the price is half of most countries. (Exhibit 2.7.) From the point of improving the use of energy, this low price hinders most of the projects. It makes many research projects and investments in such technology infeasible.

Exhibit 2.7. Average Gasoline Prices And Taxes Around The World (1989)



Source: International Energy Administration; United Nations Secretariat

From the macro view, it will reduce the speed of developing renewable energy sources. For example, geo-thermal energy projects are suffering from decreased funds from the government and the industry. Statistically, in the 1980s, U.S. Department of Energy reduced their real spending on efficiency research development, and demonstration (RD&D) by 71 percent, and in fiscal year 1989, a further 50 percent in RD&D and 96 percent in the state and local programs that deliver information to citizens.[14] Although this thesis will not discuss political issues, the reduced budget can not be explained without connection to the change of Carter administration(1976-1980) to Reagan(1980-1988), and to Bush administration(1988-1992). Reduced budget on efficiency

[14] Lovins, Amory B. End-use/Least-cost Investment Strategies. (Old Snowmass, CO: Rocky Mountain Institute, N.p.) 4.

will not effect the present status of energy use, but in the long run, it will slow down the spread of technology responsible for increasing efficiency. Therefore, the business opportunities in the future are being sacrificed.

2.2.5.2. Market Imperfections

Market mechanisms seem to be not working well in the arena of increasing the efficient electric use. If the market is working, it is supposed to allocate goods and services more effectively than other systems of rationing, particularly planning in one form or another. This is not working with energy efficient appliances. The problem is that each individual seems to have a different discount rate correlating to their income. (Exhibit 2.8.) This implicit discount rate affects the customers purchasing decision. The implicit discount rate and the fact that energy efficient appliances take several years to recover higher purchase costs, create synergism for making decisions against energy efficient appliances. If better information was available and understandable to all of the people, this would not happen. But since customers are making decisions based on implicit discount rate, energy efficient appliances must be better than the theoretical economic calculations that shows their competitiveness against standard models. These appliances have higher efficiency for higher initial cost compared to standard models with the same function. Although, if the additional up-front capital cost of such equipment was considered with the savings it brings from the electricity cost, its cost is competitive without any doubt.

Exhibit 2.8. Individual discount rates;
Hausman's estimate of the discount rate implicit in consumer purchases of room air conditioners in the US., by income class.

Income Class	Implicit Discount Rate
up to $6000	89
$6000 to $10000	39
$10000 to $15000	27
$15000 to $25000	17
$25000 to $35000	8.9
$35000 to $50000	5.1

Source: J.R. Hausman, "Individual Discount Rates and the Purchase of Utilization of Energy-Using Durables," *The Bell Journal of Economics,* Vol.10(Spring), 1979. 33-54.

2.2.5.3. Matching Societal Benefit and Individual Benefit

The above example demonstrates one of the obstacles that prevents the implementation of end use energy efficiency, although it has a net benefit to users. In the above case, scarcity of capital relative to income is woven into the higher implicit discount rate. Another factor is the lack of information about such appliances/systems. Specific quality assurance, in this case energy saving potential, is necessary to assure the customers.

The solution to these problems are the key to the success in marketing efficiency. The utilities are realizing this through demand-side management programs, and energy service companies (ESCOs) are implementing this through performance contracting. Both methods will be discussed in detail in the next chapter.

One subject which has no solution at this point is the rented buildings. Neither owners nor the tenant has incentive to increase energy efficiency. Owner or developer who built the building is not sufficiently interested in the electricity running cost of the building, since it will be payed by the tenants.

On the other hand, in many cases, the tenant's have interest in decreasing their energy bills, but have obstacles to overcome. First, they do not want to pay the up front cost for changing equipment. Second, they are reluctant to change the owners equipment for them. A new method is definitely necessary to resolve this area. The solution might be provided through the utilities or as government funding in the future.

Japan is one of few countries which continues to put government effort into increasing energy efficiency.[15] Electronic durable goods has been achieving internationally higher standard of energy efficiency, the standard which was set by Ministry of International Trade and Industry of Japan. Many other appliances with longer payback period are supported by the government. For example, solar panel units receive 50 percent subsidy from the government. For larger purposes, the government is aggressively supporting the use of unused energy as part of infrastructure. Unused energy was explained in the section 2.3.3.

2.2.5.4. Fragmentation of The Building Industry

Arthur H. Rosenfeld lists the fragmentation of the building industry as one of the barriers to improving energy efficiency[16]. He says that in spite of the fact that energy cost in commercial buildings can easily reach 30 percent of their operating budget, lack of coordination between the architects/designers, the building engineers and subcontractors, and the operations and maintenance staffs of large commercial buildings often results in a failure to

---

[15]Rosenfeld, Arthur H., Ward, Ellen. "Energy Use in Buildings." *The Energy Environment Connection.* Ed. Jack M. Hollander. (Washington, D.C.: Island Press. 1992) 224.
[16]Rosenfeld, Arthur H., Ward, Ellen. "Energy Use in Buildings." *The Energy Environment Connection.* Ed. Jack M. Hollander. (Washington, D.C.: Island Press. 1992) 235.

capture potential energy efficiency savings. (Clear-cut remedial efforts such as replacing won-out HVAC and lighting systems with more energy-efficient technology can alone cut a building's energy bills by 30 percent.)

This fact was reconfirmed through extensive interviews with the engineers working for the utilities, ESCOs, and engineering firms. I believe this is due to the education system of the architects in the U.S. Most of the architectural department do not have researchers concentrating on HVAC systems therefore, do not possess educational opportunities for the architects. On the other hand, the majority of the HVAC engineers have majored in architecture in Japan. Most of them acquire sufficient knowledge about environmental control systems at an early stage. However the appearance of energy service companies are expected to fix this defect through their service which is called performance contracting. ESCOs can not eliminate this defect, but can fix it in a cost effective matter.

2.2.6. Energy Efficiency As Opportunity

Especially in the United States, implementation of energy efficiency was always a potential market. However, cheap oil prices did not give customers enough incentives. DSM is an effective solution. It helps create a market with a new market mechanism. Even if savings are too small to give incentives to individual customers, aggregated savings will be considerable for the utilities. Using compact fluorescent lamps might save only a small fraction of electricity bills; but if done nationally, the savings will be 10 percent of the total electricity consumed in the U.S. Another point is that the utilities have the trust of the community which is not always the case with commercial firms in the U.S. This eliminates customer concern and worry about the credibility of such a program. This trust is due to the fair practice of Public Utility Commissions and their basic function to serve the public interest.

2.2.7. U.S. and Japan: Efficiency vs. Longevity

There are considerable difference between U.S. and Japanese consumers. They have different attitudes towards new energy efficient products and the efficient use of electricity as a whole. Generally lives of durable goods are shorter in Japan. It is not because of quality or product life, but because of life-style. Although this could seem very bad from one perspective, it has a large merit. Since everyone buys a new car and TVs every 5 years, most equipment in the home is replaced by energy efficient new models. It had been done without the real sacrifice of customers superficially.

2.3. Derivative Effects on Engineering Firms

2.3.1. Introduction

In the previous section, it was explained that increased electricity end-use efficiency is the least cost option to implement with respect to the global warming problem. In this section, the potential of increasing end-use efficiency is described from theoretical aspects; and, the problems of implementation have been examined from societal aspects. Specific energy savings in the building sector are discussed to show the promising growth of energy efficient industry.

2.3.2. Energy Use in Non-residential Buildings

Total energy consumption in the United States was 82.36 quadrillion BTUs (quads[17]) in the year 1992. 36 percent (29.56 quads) was first used to create electricity and the rest (fossil fuels) were consumed by end-use sectors.[18] (Appendix 2-6.) Before reaching the end-users, approximately 66 percent of total energy input is lost in the electricity generation as a result of conversion, approximately 5 percent is lost in plant use and 9 percent is lost in transmission and distribution.[19] As a result, 9.40 quad was consumed by end users. (Appendix 2-7.) This is the size of the target market of energy service companies. Market size depends on how much of the total electricity consumed can be saved. Roughly speaking, each percent saved will account for 1.7 billion dollars.[20]

Although this thesis only focuses on the energy used to operate buildings, the impact will be greater if the entire built environment[21] is taken into account. Calculations done by Croxton Collaborative, Architects show that 54 percent of total energy use is consumed in this built environment for the base year 1982. This calculation takes into account embodied energy in the buildings built, from energy used to mine the minerals, to manufacture the materials, to transport completed products to the construction site, etc. Therefore, it is important for building professionals to realize their responsibility to the

---

[17]Refer to Appendix 2-1. for the conversion table.
[18]Energy Information Administration. *Annual Energy Review 1992.* Washington D.C.: Energy Information Administration, (June 1993) 3.
[19]Ibid. 236.
[20]Approximate electricity cost in the U.S. which is $0.06/kWh was used for calculation.
[21]The built environment includes not only all buildings—residential, commercial, and industrial—but also infrastructure (roads, bridges, parking lots, etc.).

environment. Looking from a different perspective, these professionals have an opportunity to contribute.[22]

How much of this consumed electricity can be saved without lowering the quality of life? Studies done by EPRI and Rocky Mountain Institute's Lovins show how cost effectively savings can be accomplished. While, these studies show the opportunities, the EPRI study shows conservative estimates and Lovins' study shows ideal limits. According to Lovins, over 50 percent of electricity can be saved through the use of energy efficient lighting, energy efficient motors and retrofitting the HVAC systems with the price below 3 cents/kWh. He insists that lighting retrofit which represents nearly 20 percent of the number, can be cost effective without accounting for the electricity savings. It is because these efficient lamps have longer life, saving the installation labor and the replacement costs. The conservative EPRI research also shows that 20 percent of electricity can be saved by applying efficient technology to commercial lighting, cooling, refrigeration, and industrial motor drives.

The studies shows that there are large savings potential by retrofitting lights, motor systems and HVAC systems. In addition the cost of implementation is below 3 cents/kWh for these technologies.[23]

2.3.3. Size of Building Retrofit Market for ESCOs

Different data shows how energy consumed in office buildings has changed through the past (Exhibit 2.9.). This exhibit shows that buildings built in 1991

---

[22]National Audubon Society, Croxton Collaborative. *Audubon House: Building the Environmentally Responsible, Energy-Efficient Office.* (New York: John Wiley & Sons, 1994) 25-27.
[23]Fickett, Arnold P., Gellings, Clark W., Lovins, Amory B. "Efficient Use of Electricity." *Scientific American.* (September, 1990): 72.

are three times more energy efficient than ones built in 1975. This is a good example of how regulation can lead the builders to promote energy efficiency. Furthermore, it shows that most office buildings built before 1978 have obsolete HVAC systems together with lighting systems. Therefore, these buildings are the potential market for the energy service companies. In the U.S. according to a 1989 survey, 79 percent of the existing buildings were built before 1980 (Exhibit 2.10.). It is a reasonable assumption that most of these buildings have no better energy intensity than those built after 1980. For most of the building owners, there were almost no incentives for retrofitting their building systems with high efficiency equipment.

Exhibit 2.9. Progress in Reducing Annual Energy Use And Costs
(Per Square Foot of Office Space) in 1985

	Electricity		Natural Gas	
	kWh	Cost	kBtu	Cost
1975 typical office tower	30	$2.25	170	$3.40
1978 California Building Standard	20	$1.50	10	$0.50
1991 California Building Standard	10	$0.75	5	$0.25

Source: Rosenfeld, Arthur H., Ward, Ellen. "Energy Use in Buildings." *The Energy Environment Connection.* Ed. Jack M. Hollander. Washington, D.C.: Island Press. 1992: 229.

Exhibit 2.10. Net Energy Consumption and Expenditures in Commercial Buildings by Year Constructed

Year Constructed	Total Consumption of Major Energy Sources (trillion Btu)	Total Foorspace (million sq.ft.)	Gross Energy Intensity (thousand Btu/ sq.ft.)	Gross Energy Intensity per Operating Hour (Btu/(sq.ftxhr)	The Share of Electricity in Total Energy Consumption (percent)
1945 or Before	1.00	13,997	71.6	20.2	31
1946-1959	0.99	10,511	94.0	25.8	38
1960-1969	1.27	12,167	104.8	25.0	46
1970-1979	1.34	13,329	100.7	24.0	54
1980-1989	1.18	13,179	89.6	21.1	65

Source: Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-871A through F of the 1989 Commercial Buildings Energy Consumption Survey, Tables 11 and B18

2.3.4. Conclusion

In this section, specific energy saving potential at cost effective level was clarified. Although, the opportunities are widespread, a variety of barriers which have prevented energy savings from happening must be overcome. The next chapter will discuss how ESCOs are marketing this energy efficiency business through performance contracting (shared savings contracting) and how it has become attractive from a business perspective.

2.4. Conclusion

In this chapter, the global warming problem was summarized. Next, the most likely mitigation option to be implemented by the U.S. government (or any other non-environmental issue inclined countries) was explored. The most likely option, to increase the end use energy efficiency, is the most cost effective way to reduce carbon emission. Moreover this option will consequently benefit the society even if effects of global warming turns out to be less severe than simulated by the global circulation models. Furthermore, theoretically, according to second energy efficiency measures which takes in account entropy (quality of energy), our use of energy is far from ideal with respect to the use of depletable resources such as oil. Although there are enough opportunities to increase energy efficiency, various institutional and psychology behavior barriers worked against efficiency. Looking into the building sector, an EPRI study showed that 700 billion kWh can be saved for the cost of only 4 cents/kWh. This seems feasible where average electricity in the U.S. is 6 cents/kWh. The annual savings will be 14 billion dollars. For reference, electricity price in the U.S. ranges from 1.78 cents/kWh in

Wyoming (Pacific Corp.) to 16.35 cents/kWh in New York (Long Island Lighting).[24]

[24]DOE form EIA-826 and Energy Users News survey

Chapter 3:

Working Out Countermeasures For The Industry

3.1. Introduction

3.1.1. What are Energy Service Companies?

This chapter will be devoted to the analysis of Energy Service Companies. The role of utility demand-side management programs with regard to ESCOs will also be discussed, since their existence determines the growth of this group of companies (energy service industry)[25] to a certain extent.

An Energy Service Company is defined as "a firm which provides energy management services including an engineering evaluation of the building, financing and installation of energy-saving equipment and procedures; and which provides an agreed upon comfort level for a fee usually guaranteed not to exceed the building's avoided energy costs."[26]

The service offered by energy service companies (ESCOs) can be thought of as energy management. It comprises technical and financial methods. Major technical methods are 1) installing energy efficient ballasts, 2) replacement of lighting fixtures from incandescent to fluorescent lamps, 3) installing inverter (variable frequency) control of compressors, 4) installing variable speed pumping, 5) installing variable speed fans and 6) fitting the system according to recent heating and cooling demands. The main financial method

[25]There is no particular word for describing the industry of ESCOs. For convenience, energy service industry will be used in this thesis to represent ESCOs.

[26]Hansen, Shirley J. *Performance Contracting For Energy And Environmental Systems.* (Lilburn, GA: The Fairmont Press. 1993) 279.

is a shared savings agreement, which was originally offered by EUA Cogenex. This agreement supports the client's internal budgeting process. Since Cogenex provides project management and financing using their own capital, clients can avoid the high capital cost associated with most system renovations. For Cogenex, the agreement gave them stable income once invested capital is recovered through annual energy savings. The fact is that these technical and financial methods can be implemented by manufacturers, financing firms and architectural and engineering (AE) firms. Each area can be called energy management services, but the key is to accomplish it with a systematic approach, both from the technical and financial aspects.

Only by this approach can a company offer enough merit and incentives to the potential clients. It is a way to break the barriers in developing a market which offers energy efficiency. As one engineer of Cogenex said in an interview, "It's a win-win situation. Clients save money through energy conservation without additional supporting staff nor large budgeting, and we also get the profits from the shared savings."[27] Lacking either side of the method decreases the ability of the service to convince and capture customers. Exhibit 3.1. shows the list of Energy Management Services.[28]

There is also a revised and evolving approach which utilizes demand-side management (DSM) programs. Clients receive rebates from the utility for using specified technology, such as high efficiency motors. Some DSM programs support performance contracting on project base, in other cases utilities offer a request for proposal for a project which targets a megawatt range savings within their entire supplying area. The use of DSM enables

---

[27]Blazon, David T.(Project Engineer, EUA Cogenex Corporation). *Interview.*
[28]Service offered by ESCOs.

utilities to keep total demand within their existing power plant generating capability, thus reducing the annual growth of electricity use, avoiding or putting off new investment.

Exhibit 3.1. Energy Management

Lighting
- Converting from incandescent to fluorescent
- Installing energy-efficient ballasts
- Using motion-sensor controls
- Implementing daylighting controls
- Installing speculor reflectors
- Converting and upgrading of HID systems

Motors
- Downsizing motors that are too big for the job
- Using variable-speed drives on pumps, VAV fans, etc.
- Making premium-efficiency motor modifications

Systems
- Installing cogeneration systems
- Designing energy-management systems
- Using water-conservation techniques
- Providing free cooling systems
- Reducing process energy
- Improving refrigeration efficiency

Finance Programs
- Guaranteed/shared savings programs
- lease-purchase arrangements
- Demand-Side Management utility payments

Source: EUA Cogenex

3.1.2. Market Environment and Potential Growth

There are several factors accounting for the growth of the emerging energy service companies' market. One factor is the combination of regulations and societal expectations for energy efficient buildings which was discussed in Chapter 2. Other issues include the ozone depletion problem. CFC phase-out triggers the necessity of reconsidering existing systems. Substitutes for CFC, such as HCFC123, in existing chillers will result in generating less cooling than required by engineer's specification. Consequently, owners of old buildings must think about replacing the existing building system with a new, less energy consuming system. Related motivations exist for tenants in the building. Electricity represents a large part of the variable cost of a commercial lease.

Another factor is technological advancement in building systems. Increasing efficiency of individual heating, ventilating and air-conditioning (HVAC) equipment and the continuing transition to energy conservation building systems makes existing old systems obsolete. Over the past decade, energy efficiency has increased considerably.

A final factor is that continued growth of the market may attract government support and funding. Even a loan with modest interest rate will shoulder ESCOs financial risks to great extent.

Success and growth of the overall market will rely on persuasion and providing customers with sufficient information to implement a project. Some current approaches to marketing are described in the following sections.

3.1.3. Overview of Energy Service Industry

At the roots of the energy service industry are engineering firms that began to specialize in energy-efficiency in the early 1970's. Performance based-contracting, the main service that energy service companies (ESCOs) offer, was established around 1980, which is the main characteristics of the . This innovative financing technique began in Europe as "chauffage": a shared-savings concept.

There were many entrants to this industry in the past. Two major representative groups represent a large part of this industry, these are the large HVAC building control systems companies and the independent power production companies (IPPs). The large HVAC building control system companies became participants of this industry and started offering vendor-financing which proliferated around 1984. This type of financing focus on enhancing the sales of their products, and it was similar to a lease/purchase agreement. They now offer wide range of performance contracts, and do not limit their customers to purchase their own line of products. Their objective in this industry has gradually switched from selling their products to basic energy services.

IPPs were born as a result of the federal Public Utilities Regulatory Policy Act (PURPA) passed in 1979, which established a legal foundation for independent power production. These companies became major players by exploiting innovative power generation technologies. They are now in transition, moving from marketing supply-side management to demand-side management.

The market range for energy services in the U.S. for the next decade is estimated to be from $18 billion to $26.7 billion annually. On 1990, ESCOs and IPPs contracted $9.1 billion from utilities for independent power, cogeneration, and alternative energy financing transactions, and this number does not even include ESCOs typical private financing projects.

3.2. Demand-Side Management

3.2.1. Introduction to Demand-Side Management

An understanding of the utility industry is crucial for an analysis of the energy management services industry. There are no general statistics that shows the contribution of DSM projects to the total revenues of ESCOs, however, most ESCOs appear to rely heavily on DSM. For example, EUA Cogenex, which is one of the major ESCOs, raise more than half of its revenue from DSM.

Here, the term the utility industry or the utilities refer to the utilities responsible for generating and selling electricity. Without Demand-Side Management (DSM) or utility support as a mediator to the end users, the industry will lose a fundamental condition that allows business to function smoothly. After reviewing the background of the utility industry and conditions that affect it, performance/shared savings contracting is discussed. Performance contracting is the most successful DSM program in saving electricity which targets industrial and commercial end users. This contract is the main and dominant types of business of energy service companies (ESCOs).

Demand-side management focuses on activities which involve actions on the demand side of the electric meter, and are either directly caused or indirectly stimulated by the utility. These activities include those commonly called load management, strategic conservation, electrification, strategic growth or deliberately increased market share.

3.2.2. Demand-Side Management Mechanism

How can the electric utilities gain profit from reducing their electricity sales? Traditional regulation of utilities discouraged the practice of treating energy-efficiency programs as resources that substitute for some amount of generating capacity. It is largely because of the policy which ruled the utilities. "each kWh a utility sells... adds to earnings [and] each kWh saved or replaced with an energy efficiency measure... reduces utility profits"[29] This

---

[29]Moskovitz, David. "Will Least-Cost Planning Work Without Significant Regulatory Reform?" *Presented to NARUC Least-Cost Planning Conference.* (Aspen, CO: Np. April 12, 1988)

generates a conflict between utility shareholders and the utility customers. The least-cost planning concept which currently prevails has changed this notion. It gives even consideration to DSM and supply-side resource additions. The emergence of new cost recovery mechanisms for DSM expenditures helped the utilities compensate for their program costs and for the net amount of revenue lost due to DSM impacts.[30] Performance contracting incentives go further. They provide profit opportunities for utilities that deliver effective DSM programs, while ensuring the utility shareholders the return from the project.

Some conditions which lead to least-cost planning are: 1) difficulties associated with the siting, construction, fuel supply and transmission of new generation sources, 2) the substantial incremental fixed costs associated with construction of new generating facilities and 3) environmental concerns associated with electrical capacity additions, including air emissions and water quality.

The idea of the DSM program is also important from a societal point of view. Providing electricity is an essential public service. Therefore, while fulfilling the shareholders interest, the regulatory commissions have a responsibility to consider the total benefit to SOCIETY. The primary goals of DSM programs has undergone a transition through the years. From a national and global point of view, it is necessary to increase end-use energy efficiency considering the global warming and continuing competitiveness within the capitalist economy frame work. The idea of shared saving contracts between customers and energy management companies basically stand on the same idea. In many cases, the key to implementing energy efficiency is to decouple the conditions

[30]Gellings, Clark W., Chamberlin, John H., *Demand-Side Management: Concepts and Methods.* (Lilburn, GA: The Fairmont Press, 1993) 429-431.

and to re-integrate so each participant will benefit according to individual interests. The society as a whole will gain through this procedure.

In many cases, there is a lack of trust between the sellers and consumers. By having utility companies to oversee the project, clients without any knowledge of energy management can implement projects without anxiety and a feeling of taking great risk. The utility can provide the firms and individuals with assurance since utilities are strictly regulated by public commissions.

3.2.3. History of Utility Regulation

The control of the utilities, which has evolved gradually in the U.S., was always intended to serve the best interests of the end users. Nearly half of all electricity generated was under the control of three massive holding companies until 1935. In that year the Public Utilities Holding Company Act(PUHCA) was enacted. The purpose of this legislation was to break up some powerful trusts and to regulate the holding companies that then controlled almost all of the electricity and gas networks throughout the U.S. Though the intent was to weaken those companies, the PUHCA contained barriers against new entrants. It basically prevented them from constructing and operating electric generating facilities.[31] The problems created by this limitation became evident in the 1970s, and new legislation was necessary to modify the controls. With the 1970s oil crisis, legislators felt compelled to reduce dependence on imported oil. Increased efficient use of primary energy source suddenly became of interest to the state agency responsible for supplying energy. A new technology then, called cogeneration attracted many people in

[31]Standard and Poor's Industry Surveys

this area. The system was able to increase efficiency considerably, but changes in legislation were necessary. Massachusetts, for example, undertook a feasibility study of cogeneration. The cogeneration system is a system in which hot water and electricity is generated simultaneously. If used appropriately, 70-80 percent of primary energy is converted into useful energy, whereas a thermal plant converts only 35 percent. But, as recommended in the final report of the Governor's commission on cogeneration[32], "tax incentives, grid connection, ordered sales wheeling, reasonable rates, and exemption from both the Public Utilities Holding Company Act and state utility regulation"[33] were absolutely necessary to give enough incentives for the non-utility companies to install the cogeneration system. Among the conditions, connection to a utility power grid was the most critical factor, since that connection always determines the cost effectiveness of the system. During 1978 most of these essential conditions for the non-utility companies to install the cogeneration system were realized under President Carter's administration as the Public Utility Regulatory Policies Act of 1978 (PURPA). Under Title II of this law, the Federal Energy Regulatory Commission (FERC) encouraged the development of small non-utility-generating projects, and these were exempted from PUHCA's restrictive regulations. The new legislation opened opportunities for these small projects, by allowing them the connections to the power grid to sell their excess electricity. As a result, they were able to get return on investment of 20 to 30 percent range. In general, there is an expectation for the number to be in this range for businesses investing in unfamiliar activities which do not

[32]The Commonwealth of Massachusetts Michael S. Dukakis, Governor. *Cogeneration: Its Benefits to New England.* (October, 1978) xiv
[33]The Commonwealth of Massachusetts Michael S. Dukakis, Governor. *Cogeneration: Its Benefits to New England.* (October, 1978) xv.

increase production of their products.[34] As a result of this relaxation of restrictions, according to the North American Electric Reliability Council, independent producers accounted for an estimated 6.2% of total US. electricity generation in 1993. Finally, the current issue is the Clean Air Act. This legislation is indirectly forcing the use of demand-side management programs.

3.2.4. Most Recent Regulation: The Clean Air Act Amendments and The State Energy Efficiency Programs Improvement Act

The legislation which passed Congress recently which have the greatest impact on the utility companies include the Clean Air Act Amendments (CAAA) and the State Energy Efficiency Programs Improvement Act of 1990 (PL101-440). The Clean Air Act Amendments were enacted in 1990.(See Appendix 3-3.) During the past two decades, the utilities cut sulfur dioxide emissions by about 20 percent, which is equivalent to 8 million tons of pollutants, despite an 85% increase in the use of coal as fuel. Still, to comply with the acid rain provisions of the CAAA, utilities must make additional reductions for Phase I by January 1, 1995 by switching fuels, installing flue-gas desulfurization systems (scrubbers), and emission allowance trading. For Phase II, due in 2000, further reductions must be accomplished through the above methods, and, in addition clean coal technologies, DSM, and increased use of renewable energy sources. The final goal of the Clean Air Act is to cut the sulfur dioxide emissions by a total of 10 million tons per year, to no more than 8.95 million tons annually by 2010. The State Energy Efficiency Programs Improvement Act of 1990 reauthorizes funding for state and local energy assistance

[34]The Commonwealth of Massachusetts Michael S. Dukakis, Governor. *Cogeneration: Its Benefits to New England.* (October, 1978) 78.

programs. It also requires a 10 percent improvement in energy efficiency by the year 2000.

These laws have several effects on DSM programs. The CAAA provides additional incentive for the utilities to further their DSM programs by introducing the concept of marketable emission credits. The initial intention of this concept is to motivate pollution-producing facilities to control their pollutants beyond the requirements. At the same time, it rewards those utilities that have low emissions plants. For DSM programs, it gives additional impetus to the utilities for implementing the programs. By reducing demand, they are able to earn additional emission allowances. Those allowances can be sold or saved for future use.

Another law which enabled DSM programs to be more attractive is the State Energy Efficiency Programs Improvement Act . This act makes it possible for the state to subsidize DSM programs. This subsidy resolves the conflict of interest between the shareholders of the utilities and the end users. The shareholders are satisfied that the reduced energy sales are compensated by subsidy, and the users benefit from the avoided project costs of new power plants through increased efficiency of energy use by DSM programs. Therefore, DSM program users and/or ESCOs can realize increased return on investment resulting from the increased energy efficiency.

3.2.5. Direction and Goals of Public Utility Commission

The New York State Energy Plan of 1992 can be used as a model for other states. It had four proposed goals: 1) Economic Competitiveness, 2) Environmental Quality, 3) Energy Security and 4) Public Health and Safety. Although the dominance of each goal might change over time and from state to state, all are important. The major interests concerning energy supply these days are increased cost of building new power plants (approximately one billion dollars per one gigawatt plant), obtaining necessary environmental approvals, the desire for a higher quality environment, diversity of energy sources, a sustainable economy, increased energy intensity and higher productivity for a competitive economy. All of these factors support one basic idea: increased energy efficiency. Renewable energy is important now and will ultimately be a necessity, but most of these technologies—such as wind and solar—are not economically competitive at this moment, although their competitive use can be seen on the horizon. Private market mechanisms have failed in terms of energy efficiency because of low oil prices in the U.S. which fluctuates little over 10 dollars per barrel. The solution that DSM provides is that a public utility can take the initiative to decouple the revenues from the sales of electricity. By doing so, they can function as an overseer for the end users. The DSM mechanism works for the utilities, the shareholders, and the end users. Many utilities have realized the merit of DSM programs and have increased their DSM activities within the last five years. With no other method close at hand, DSM programs occupy an important position within the utilities. At this point, many professionals project that the DSM programs will continue to increase at a high rate until at least 2010. Thus the business environment for the ESCOs seems to be very promising at this point.

3.2.6. Demand-Side Management Potential

The growing possibilities of the DSM market can be identified from projected numbers in some of the state's energy plans. For example, for the State of New York, implementation number targets for DSM are described as follows in its NEW YORK STATE ENERGY PLAN.

"The American Council for an Energy Efficient Economy and State Energy Office(SEO), and independent studies of achievable electric energy savings potential by New York's electric utilities tend to confirm that the 1989 State Energy Plan(SEP) demand-side management reduction targets of 8-10 percent in 2000 and 15 percent in 2008, if economically justified, appear reasonable."[35]

While primary energy consumption savings potential from the utility DSM was 4.6[TBtu] in 1990, their projections for 2000 and 2010 are 181.2 and 318.2, respectively. The number projected far exceeds the achievable contribution from renewable and indigenous energy resources which is in the range of 103.6 to 228.1[TBtu]. With the encouragement of federal legislation and appropriate guiding, the market can grow rapidly.

3.2.7. The International Market of Demand-Side Management

Internationally, the utilities tend to follow two major trends. One is Integrated Resource Planning(IRP) and the other is deregulation. The former stance is taken in the U.S. where utilities are vertically-integrated, making strict regulations necessary to protect end-user consumers, and to provide them with incentives to save energy. Here the public utility commission, relatively independent of political or market influences, regulates the utility according to the rate payers' best interests. The United Kingdom approach represents the latter when a complete restructuring of the electric system was started five years ago. The United Kingdom privatized and disaggregated the utility systems with separate generation, transmission and distribution companies. The purpose of this restructuring was to introduce competition into the industry in order to achieve economic efficiency in rates. While this

[35]New York State Energy Plan VolumeII: Plan Report. (February, 1992) 26.

mechanism works effectively in optimally reducing the rates, it is difficult to implement an energy policy which truly seeks to benefit society in the way DSM programs do. This mechanism leaves ESCOs no market; the distribution companies will have no incentives to reduce the sale of electricity which produces their revenues. Following the United Kingdom system are Norway, Chile, Argentina, Australia and New Zealand, while Poland has taken a mixed approach. Although ESCOs will have virtually no opportunity in other countries which adopted the United Kingdom approach, many countries do offer them other opportunities.[36] For example, the International Energy Services Company (INTESCO) already has a subsidy in the Czech Republic and in India. If a specific country does not take the U.K. approach which prevents ESCOs from capturing a market, the feasibility of its business depends on macro factors. The macro factors to be considered are political stability, corporate tax rates, availability of skilled labor, cost of labor and materials, currency convertibility, devaluation risk, capital repatriation, tariffs on equipment and services, and the ease of capital formation[37]. Success depends on access to the capital of the country. Therefore, alliances in the domestic market hold the critical key to success.

3.2.8. Demand-Side Management Programs

Due to small incentives such as low price of oil to the end-users, most of the energy conservation programs are lead by electric utilities. More than 500 DSM programs are sponsored. Four hundred of them are targeted to commercial and industrial (C&I) sectors (1989). Total expenditures on DSM

---

[36]Wolcott, David R. "Stockhom Conference Focuses on Conflict Between Integrated Resource Planning and Deregulation." *Energy Efficiency Journal.*.Volume1, No.6: 11.

[37]Lyons, Chester L. "International Markets-A Tremendous Opportunity for the ESCO Industry." *Energy Efficiency Journal.* Volume 1, No.5: 6-7,14

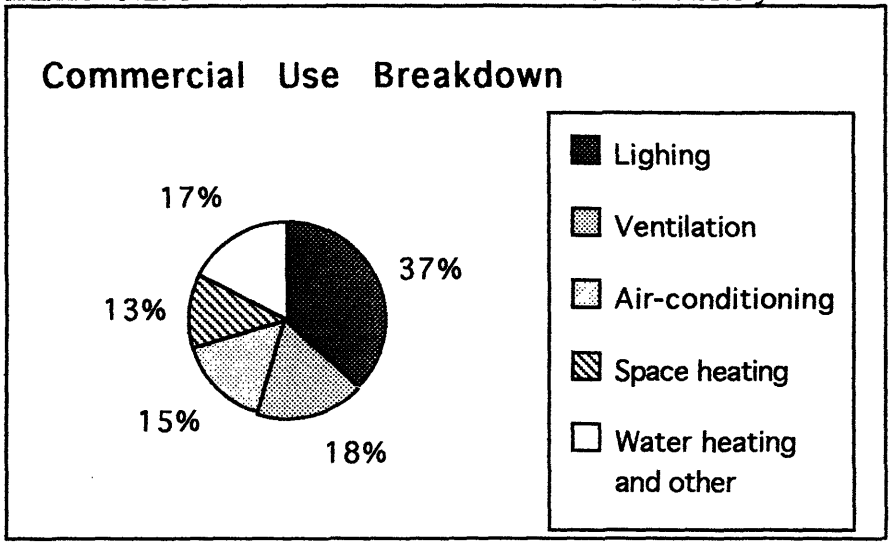
programs exceed $1.2 billion annually (1990). Geographically they are dominant on the West Coast, and in the northeastern and north central United States.[38]

Utility DSM are classified into two major categories, residential and C&I programs. Here the focus will be on C&I programs. Residential programs do not pay off for ESCOs and engineering consultants because of low volume of individual electricity consumption.

The C&I sector is of high priority not only to the utilities but also to a nation. It appears clearly on the statistics. As described previously, the commercial and industrial sectors account for approximately 28% and 34% respectively of US. electricity sales. In the C&I sectors, a limited number of medium and large sized customers use most of the energy. Nationwide, approximately 37% of commercial electricity use goes to lighting, 18% to ventilation, 15% to air-conditioning, 13% to space heating, and 17% to water heating and other miscellaneous uses. (Exhibit 3.2.)

[38]Nadel, Steven. "Electric Utility Conservation Programs: A Review of the Lessons Taught by a Decade of Program Experience." *State of the Art of Energy Efficiency: Future Directions.* ED. Edward Vine.(N.p.: American Council for an Energy-Efficient Economy, 1991) 61-104.

Exhibit 3.2. Breakdown of Commercial Use Electricity



Source: BNL 1987

All of the DSM programs are basically for existing buildings. Their intent is to retrofit outdated ineffective equipment, or sub-optimally designed HVAC systems. For most of the utilities, basic programs consists of 1) Audit, 2) Rebate, 3) Loan and 4) Performance Contracting. Summary and basic information on these programs is as follows:[39]

Audit programs:

- Combination of a non engineering audit(without detailed engineering assessments) and limited marketing and post audit follow-up efforts.
- Participation rates: typically 1% per year with some exception
- Effectiveness and cost: 28% reduction on use, $.02/kWh cost per kWh saved

Rebate programs:

- The most common type of financial incentive programs. Common subjects of rebate are energy efficient lighting, air conditioning and motors.
- Participation rates 4%.(cumulative)
- Effectiveness and cost: rebates are equal to 2050% of the cost of a measure

Loan Programs:

- Offered by a few utilities but rebates are preferred

[39]Nadel, Steven. "Electric Utility Conservation Programs: A Review of the Lessons Taught by a Decade of Program Experience." *State of the Art of Energy Efficiency: Future Directions.* ED. Edward Vine.(N.p.: American Council for an Energy-Efficient Economy, 1991) 61-104.

Performance Contracting Programs:

- Generally done by ESCOs. ESCOs provide the customer a energy conservation package which includes technical consultation, financing, and project management. They will receive payments from the utility for each kWh or kW saved.
- Participation rates: from less than 1% to as high as 15%
- Effectiveness and cost: average of $.033/kWh (Boston Edison's ENCORE program, 1988)
- ESCOs are interested in customers with peak demands of 500KW or more.

New Construction (Technical assistance programs):

- Effectiveness and cost: $.034/kWh assuming a 20year average measure life(Tennessee Valley Authority's C&I New Construction Program, 1990)

New Construction (Rebate programs):

- Effectiveness and cost: $.01/kWh saved, including free riders (Southern California Edison's Energy Excellence program, Wisconsin Electric's Smart Money, 1989)

Among all of these programs, Performance Contracting and New Construction Programs are the possible areas where ESCOs and Engineering firms can participate. First, opportunities in New Construction Program are discussed and then opportunities in Performance Contracting.

From a general perspective, New Construction programs are most effective. Because it does the right thing in the beginning, the "costs per kW saved can be as much as 80% lower when measures are incorporated into new construction instead of being retrofit."[40] Most of the programs offered in this category focuses on two major issues. One is to provide technical assistance to the designers of the mechanical and electrical systems. The other is to provide incentives for the builders to use high-efficiency lighting fixtures, motors, and cooling systems. While these two aspects seem different, they both in fact originates from one cause: the indifference or relatively low interest of developers/owners of the new building to the energy consumption of the

---

[40] New England Electric System and Conservation Law Foundation of New England. *Power by Design: A New Approach to Investing in Energy Efficiency.* (Westborough, MA: New England Electric System. 1989)

building. As mentioned in the energy efficiency section, this results from simple ignorance to complicated conflicts of interest, such as no-incentives to the building owner since the lessee pays the utility costs. For new construction, ESCOs will perform as design/build contractor with technical expertise in energy efficient building systems. Customers can rely on the accuracy of life cycle costs associated with the project, since the utility is involved in the energy saving calculations.

The performance contract program is where participating ESCOs and engineering firms have great merit and strength. Almost all of the performance contracting work is done by ESCOs. Performance contracting has several attractive characteristics for clients. It works like a turn-key project in construction, therefore clients do not need knowledgeable personnel within the organization, in addition, the guarantee of utilities overseeing ESCOs eliminates most risk. ESCOs retain the responsibility for the energy saving calculations which they have proposed. For the utilities, the use of ESCOs cost more than other programs, because they must directly or indirectly cover the ESCO's overhead cost. However, their use is effective since ESCOs have the capabilities to incorporate advance technologies and to offer systematic approach on optimizing the HVAC systems. The utilities have expertise in implementing individual equipment, and ESCOs have strength in constructing the optimal system.

Technologies adopted by utility demand-side management programs are described in the EPRI research. The 1992 survey completed by EPRI shows the participation rate of utility demand-side management programs according to the applied technology. (Exhibit 3.3. and Exhibit 3.4.) The leading equipment technologies applied in the commercial sector was lighting and HVAC.

Lighting and motor/drives were dominant in the industrial sector.

Exhibit 3.3. Commercial Participation in Utility Demand-Side Management Programs
(1992 EPRI data; total 734,000 participants)

Technology	% Participants	# Participants
HVAC	12.1	88,713
Audit/Bldg. Envelope	15.4	113,092
Efficient appliances	5.1	37,092
Load Control	9.8	71,545
Lighting	32.7	240,255
Special Rates	11.4	83,970
Thermal Storage	0.2	1,429
Motors/Drives	1.3	9,650
Standby Generation	0.03	279
Misc./ Informational	7.6	55,849

Source: EPRI

Exhibit 3.4. Industrial Participation in Utility Demand-Side Management Programs
(1992 EPRI data; total 145,000 participants)

Technology	% Participants	# Participants
HVAC	2.1	3,094
Audit/Bldg. Envelope	9.8	14,147
Efficient appliances	8.6	12,408
Load Control	2.3	3,273
Lighting	17.4	25,210
Special Rates	44.6	64,688
Thermal Storage	0.2	243
Motors/Drives	10	14,516
Standby Generation	0.2	219
Misc./ Informational	7.8	11,349

Source: EPRI

3.3. Performance Contracting

3.3.1. Definition

In this section, performance contracting which has become a power marketing tool for selling energy efficiency to the building owners, is discussed. Performance contracting is defined by the following key attributes:[41]

- A complete energy service, including marketing, designing, building, financing, and maintenance of the energy management technology
- Financing, especially shared savings contracts, where customers pay for energy services from a percentage of actual energy savings for negotiated term.
- Payment based on measured results.
- Most of the technical, financial, and maintenance risk is held by the performance contractor.

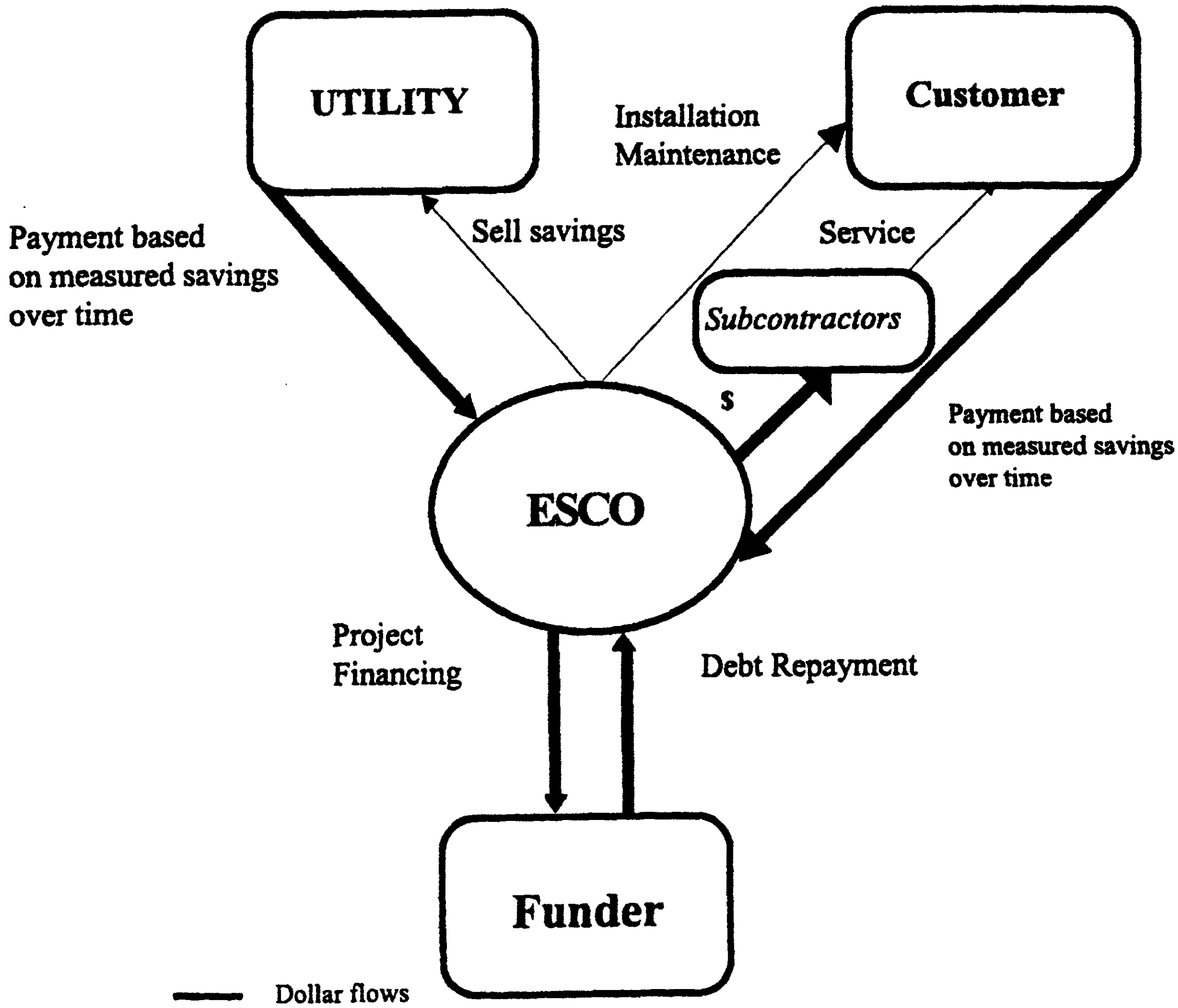
Currently all performance contracts offered by the utilities are served by energy services companies (ESCOs) but not all ESCOs are utility performance contractors. Some focus on the private market which does not involve utilities. In either case, an ESCO installs energy efficient equipment, and receives payment based on customer's savings. ESCO also offers maintenance service as part of the monitoring they conduct to assure the energy savings is as projected. If the utility is involved, ESCO is eligible for the payment from the utilities based on reduced kilowatts. Project financing is a part of the

[41]Lyons, Chester R., Limaye, Dilip R. "Performance Contracting." *DSM Quarterly*. (Spring. 1992): 20

package: all initial costs required for installing equipment and consultation fees with financing costs are paid for through the energy cost savings. (Exhibit 3.5., Exhibit 3.6.) Customers are free to finance themselves for the equipment.

Various contracts have been developed as a performance contract. However, most contracts have been made to revise or supplement the shared savings contract. Therefore, the shared savings contract is used as a representative method of performance contracting in this thesis.

Exhibit 3.5. Performance-Based Conservation Program with Utility Involvement

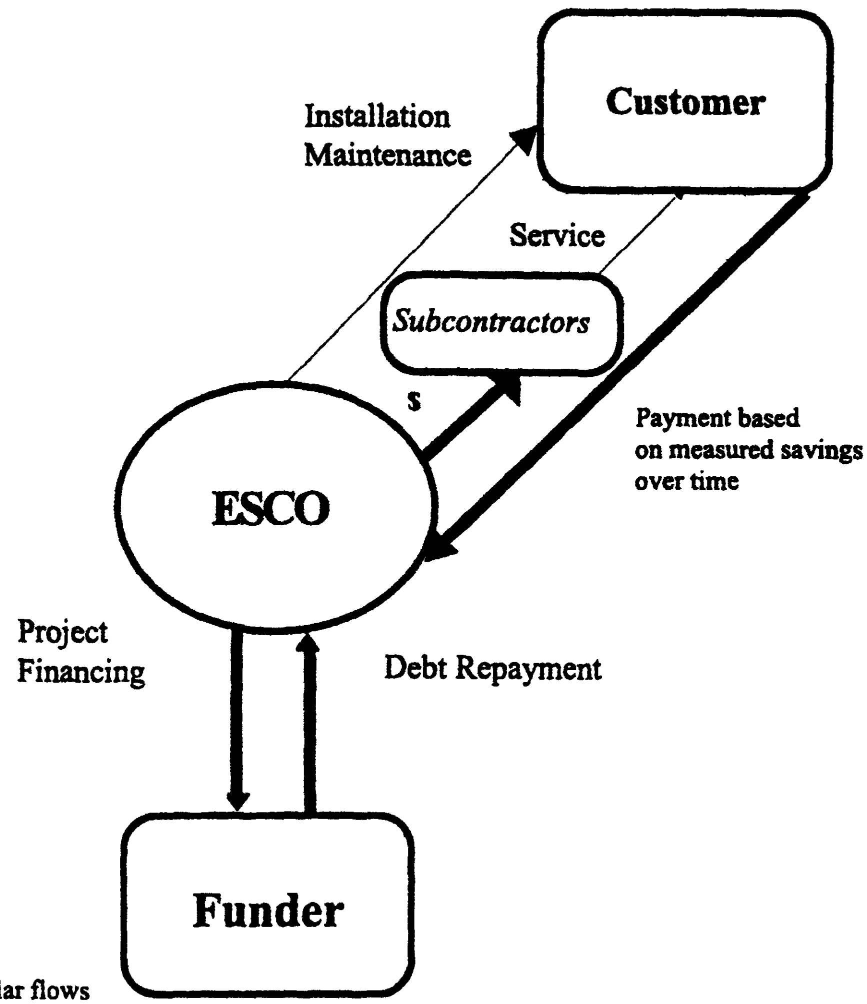


Project Financing = Installation Costs plus working capital for growth

Revenue from utility & customer - maintenance cost and debt repayment = ESCO profit

Source: National Association of Energy Service Companies

Exhibit 3.6. Performance-Based Conservation Program without Utility Involvement



Dollar flows

Project Financing = Installation Costs plus working capital for growth

Revenue from customer - maintenance cost and debt repayment = ESCO profit

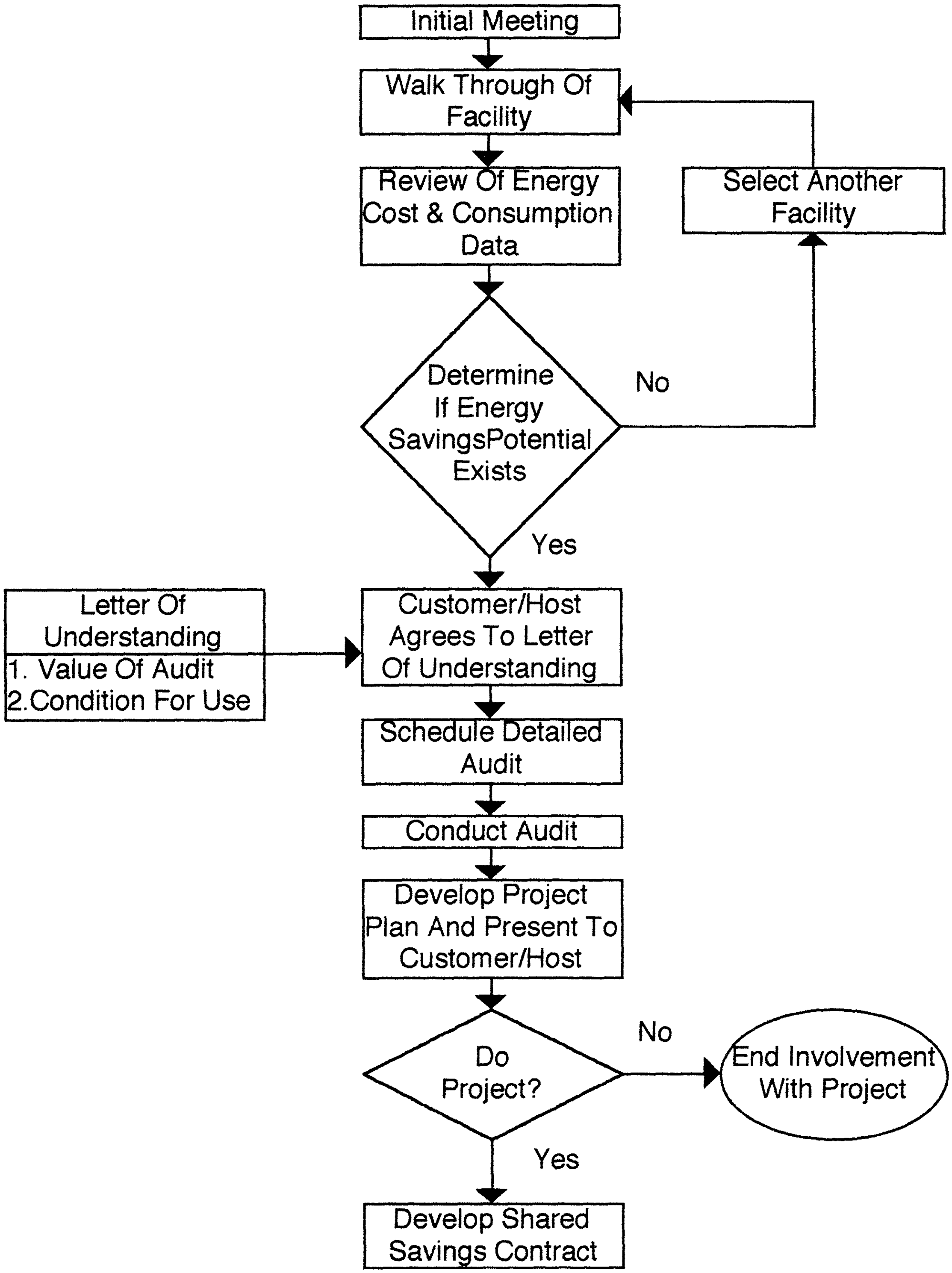
Source: National Association of Energy Service Companies

3.3.2. Implementation of Shared Savings

The typical sales and implementation process for a performance based project is presented in Exhibit.3.7. and Exhibit.3.7.[42] The first stage of implementation shows the necessary steps to complete before developing a shared savings contract. During this stage, there are two critical aspects which must be carefully implemented. One is a technical factor: to make thorough review of energy cost and consumption data of the facility for the past three or more years. These data become the base for calculating the savings which will be shared. Unexpected trends in energy use after the execution will shake the calculation of ESCOs expected revenue. Another critical aspect is related to negotiation. It is important to inform the responsible representative of the customer (a building owner or manager) completely about the shared savings concept and to have confirmation that the person in charge is willing to make a contract before entering the contracting process. The former is important because few people (including numbers of the legal profession) are aware of this contract, and more time is required for the customers internal process to get a consent. This also affects the latter. The latter is important because the cost associated with performance contracting is high compared to normal contracts: legal work for the shared savings contract and financial work for credit analysis and credit enhancement both require high-cost consultants. The second stage of implementation shows the execution of the shared savings contract. In this stage, the main concern for the ESCO is to make sure that the actual savings are over the projected numbers. If not, reconfiguration of the energy management systems or installing new equipment will be necessary.

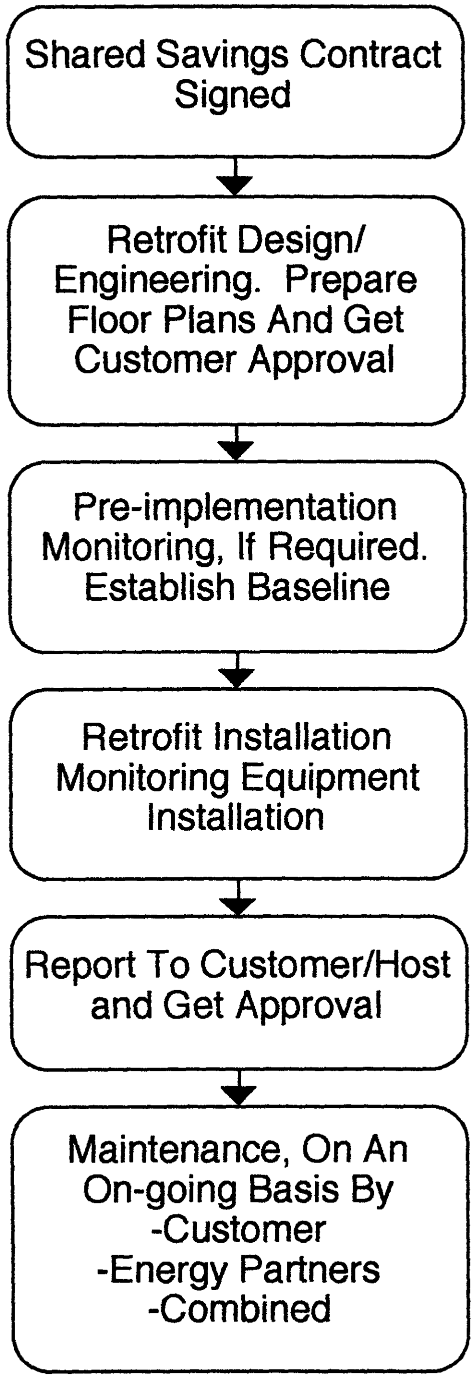
[42] Lyons, Chester R., Limaye, Dilip R. "Performance Contracting." *DSM Quarterly.* (Spring. 1992): 21.

Exhibit.3.7. Implementation of Shared Savings Contract (First Stage)



Source: Lyons, Chester R., Limaye, Dilip R. "Performance Contracting." *DSM Quarterly* Spring. 1992: 21

Exhibit 3.8. Implementation of Shared Savings Contract (Second Stage)



Source: Lyons, Chester R., Limaye, Dilip R. "Performance Contracting." *DSM Quarterly*. Spring. 1992: 22

3.3.3. Project Cost Breakdown

Sample calculations of shared savings project are shown in Exhibit 3.9. As it is in this case, 30 percent savings are not uncommon in many projects. Utility subsidy is offered in most of the states. The form of subsidy is by kilowatts or given as rebates to the equipment such as compact fluorescent lamps or ballasts.

Exhibit 3.9. Shared Savings Project Cost Breakdown

Initial Building Data:
225,000 sq.ft. office building
Energy costs $2.00/sq.ft./yr.
Total energy bill $550,000/yr.
Energy reduction
=1.5 Watt/sq.ft.
=337.5 kW
Utility Subsidy:
=$300/kW or $101,250(337.5kW x $300/kW)

Energy Cost Savings Per Year:
1.5 Watt/sq.ft. equates to 25% dollar cost savings per year
=.25 x $550,000/yr.
=$137,500 savings/yr.

Key Installation Cost Data:
Lighting cost=$900/kW
HVAC retrofit cost=$1,600/kW
Project budget 85% lighting and 15% HVAC

Retrofit project cost=$1,005/kW(weighted average)
Initial Project Cost
=$1,005/kW x 337.5kW
=$339,187

Continuing Costs: maintenance and monitoring
Assume 5% per year of initial costs
=.05 x $339,187
=$16,959/yr.

In PV Terms $16,959/yr. for 7 years (8% discount)
=$88,295

339,187	Initial project cost
50,878	ESCO profit(@15%)
88,295	PV of maintenance and monitoring
478,360	Lifetime project cost in PV terms
101,250	Utility subsidy(21%)
337,110	"Customer" share(79%)

Percentage of the savings required for a Performance Contractor to recover its cost plus a profit:
Assume: 12% interest on fully amortized debt, and ESCO makes nothing on the financing.
Given: N=7
i=12
PV of project cost=$478,360
The annual payment needed by the Performance Contractor is $104,817
$104,817/$137,500 (annual dollar savings)=76%

For reference, the simple pay for project was:
$478,360 (Total cost)/$137,500 (Annual energy savings)=3.5 years

Igonored:
Increases/decreases in energy cost;
Tax impacts of interest deduction on debt.

Source: Lyons, Chester R., Limaye, Dilip R. "Performance Contracting." DSM Quarterly. Spring. 1992: 23

3.3.4. Customer's Point of View

The customer takes almost no risk in the shared savings contract. The main concentration in the negotiation process is to check on the item where ESCOs have the opportunity to make a profit. The possible subject items are 1) mark-up on equipment and materials, 2) mark-up on labor, 3)maintenance contractors and fees, and 4) financing.[43] The best and most reasonable way to

[43]Ibid. 22.

avoid as much of these mark-ups as possible is to choose the ESCO with high credibility. Many ESCOs have built up good records through the past years.

3.3.5. Problems Associated with Shared Savings Contracts

There are two major concerns within the industry. One is the uniformity of the capital source. The primary source remains the high cost of bank interest. ESCOs need to gain access to lower institutional capital. Another is the method of maintaining the credibility of the industry participants. To avoid entrance of low credibility firms, some kind of third-party consulting services for ESCO evaluation is necessary. Such service will also help customers' judgment in the selection process and eliminate the confusion about the credibility of the company.

3.4. Present Equipment Technology

3.4.1. Introduction

There are two key energy efficient technologies that ESCOs use to lower the electricity cost in a building. One is high efficiency motors and the other is high efficiency lighting fixtures. These products have achieved noticeable improvement recently, and as a result, provided better opportunities for ESCOs due to their cost effectiveness. Of all the electricity consumed in the commercial sector, 37 percent is used for lighting and 43 percent is used for motors in various HVAC systems and components.

3.4.2. High Efficiency Motors

Motors have many applications. They are used in fans, blowers, boiler feedpumps, compressors, air-conditioners, and other appliances. In the U.S., motors consume 57 percent of all electricity supplied to the nation. Motors account for 37 percent of electricity used in the residential sector, 43 percent in the commercial sector, and 78 percent in the industrial sector.[44]

This volume of electricity consumption by motors are what makes the large savings possible. Small savings per motor aggregates to a noticeable amount, because of the dominance of electricity consumption by motors. Another reason which gives the incentives to investment in motors is its relative low cost compared to the running cost. Since most of the costs associated with motors are the running cost, small increase in efficiency such as five percent, justifies the investment in new motors. (Exhibit 3.10.)

---

[44]Nadel, Steve et al. *Energy Efficient Motor Systems: A Handbook on Technology, Program and Policy Opportunities.* (Washington, D.C.: American Council for an Energy-Efficent Economy. 1991)

Energy savings are possible because of a motor's high electricity consumption, and because of partial load operations in oversized installations.

Motors are classified into two categories, depending on the characteristics of the supplied current. In DC motors, a constant direction magnetic field is generated by direct current. Synchronous and inductive motors usually use alternating current (AC) to generate a magnetic field. The AC drives can either use a three-phase or one-phase alternating current, the latter mostly for small-scale applications. Synchronous motors typically use three-phase AC. The speed of AC drives is strongly dependent on the frequency of the power supply, and without additional control requirements, can only be varied in small ranges. DC drives can be controlled easily by adjusting the supplying current or voltage. Thus, DC motors are usually used where precise speed control and torque are required. AC synchronous motors are used for large installations where their higher efficiency (up to 95%) and availability for power factor corrections compensate for their higher costs. AC induction motors are used where robustness, reliability and low costs are most important.

There are several key issues regarding the energy efficiency of a motor system. First, is that initial cost of a motor itself is low compared to the running cost. Therefore, a small difference in efficiency makes a large difference in cost, if other factors remain constant. In an example case, the higher initial cost of a high efficiency motor can be paid back in 11 months. (Exhibit 3.10.) Because of the fact that running cost far exceeds the initial cost, and because new motors have longer life expectancy, the retrofitting of motors is feasible. Second, the efficiency of the whole motor system is what matters. The efficiency of the drive train and the appliance which the motor serves are also important. For example, a motor-pump system with a combination of a standard efficiency motor (efficiency 90%), standard pump (77%), throttle (66%), and standard pipe (69%) will have a total efficiency of 32 percent. A system with every possible energy efficient components, such as adjustable-speed drive (95%), efficient motor (96%), most efficient pump (88%), and low-friction pipe (90%) will have a total output of 72 percent.[45] This comparison highlights the importance of each individual component's energy efficiency. This calculation, however, does not affect the payback period calculation; therefore the cost effectiveness of the energy efficient motors does not change.

Although there is no information on the potential savings which can be achieved through retrofitting motors, a similar analysis was done in Germany. Exhibit 3.11. shows the energy saving potential in Germany, of switching standard motors to more efficient ones. The study concludes that motors consuming 46.8% of total electricity can be influenced by retrofitting. This would involve 10% of small-scale motors and 25% of 3-phase AC motors.

[45]Fickett, Arnold P., Gellings, Clark W., Lovins, Amory B. "Efficient Use of Electricity." *Scientific American.* (September, 1990): 71.

Exhibit 3.10. Life-Cycle Cost Comparison for 5-Hp Motor

	Conventional Motor	High-Efficiency Motor	
Efficiency at full load	84%	89.50%	
Power output	3730W	3730W	
Power input	4.440kW	4.168kW	
kWh per year (12h/day, 5day/wk, 52wk/yr.)	13853	13004	
Annual kWh differential	-	-	849kWh
20-yr kWh differential	-	-	16980kWh
Annual energy cost at $.07 per kilowatt-hour	$970	$910	
Initial motor cost	$310	$380	
Motor life	10yr	20yr	
Motor amortization cost	$22	$8	
Total annual cost	$992	$918	
Motor cost pay-back period	-	-	11 months
20-yr life-cycle energy cost (8% capital cost, 3% annual price escalation)	$15167	$14229	
Total 20-yr life-cycle cost	$15510	$14354	

Source: published manufacturer's data

Exhibit 3.11. Breakdown of Electricity Consumption for Motive Power and Possible Efficiency Improvements

<table>
<tr><td colspan="4">100% electricity consumption</td></tr>
<tr><td colspan="3">69% for motive power</td><td>31% for process heat, lighting and others</td></tr>
<tr><td colspan="2">37% for
3-phase AC motors</td><td rowspan="3">32% for DC motors
1-phase AC motors
small-scale motors

32% of total</td><td rowspan="5"></td></tr>
<tr><td colspan="2">all 3-phase motors</td></tr>
<tr><td>for 60% electronic control exists, or is not recommended

22.2% of total</td><td>for 40% electronic control possible

14.8% of total</td></tr>
<tr><td>motors already optimized</td><td colspan="2">Motors which can be influenced
46.8% of total electricity used for motive power</td></tr>
<tr><td></td><td>electronic control
saving: 25%</td><td>correct size, high efficient motors
saving: 10%</td></tr>
</table>

Source: Fichtner Beratende Ingenieure, The Potential for Energy Savings in the Application of Electrical Energy —Study for the Commission of the European Communities, Directorate General for Energy, Stuttgart, June 1988.

3.4.3. High Efficiency Lighting Fixtures

Lighting efficiency can be improved in various ways. (See Exhibit 3.12. for energy saving potential of the various technologies discussed in this section.) For example, in the residential sector, compact fluorescent lamps (CFL) are now being introduced. The CFL can save up to 75 percent of electricity use compared to traditional incandescent lamps, which are predominant in the residential sector. (Exhibit 3.13.) CFLs are also rapidly gaining acceptance for the lighting of commercial interiors, for replacement of existing incandescent fixtures, and in dedicated fixtures in new construction.[46] A CFL has the ballast

[46]Simonovitch, Michael et al. "Thermal Performance Characteristics of Compact Fluorescent Fixtures." *Proceedings of the 1990 HVAC & Building Systems Congress.* LBL-28791 (Seattle, WA: N.p. October 7-12, 1990): 1.

built into the fixture and has a Edison base; therefore, they can be fitted into existing sockets for use. These CFLs are being promoted aggressively through the utility rebate programs.

In the non-residential sector, fluorescent lighting systems are predominant. Efficiency of these systems can be increased through better lighting system design and by controlling the system to adjust to the actual usage.

The former approach is being accomplished through the improvement of thermal characteristics of the system or ballasts. Much research is underway for both areas. Thermal management is important because the overheating inside the light fixtures reduces lumen output and hence lighting fixture efficiency by 15 to 20 percent.[47] For now, the electronic ballast is spreading rapidly in the market due to its cost effectiveness.

Controlling methods include dimming of the system, use of natural light and the use of occupation sensors. Dimming is intended to adjust the indoor lighting levels of perimeter areas according to the level of light coming in from the windows. Occupation sensors are used to detect the presence of people, and to switch off the lights automatically when the room is vacant.

---

[47]Siminovitch, M. J., Rubinstein, F. M., Packer, M., "Thermally Efficient Compact Fluorescent Fixture Systems." *Proceedings of the IEA/ENEL Conference on Advanced Technologies for Electric Demand-Side Management.* LBL-30180 (Sorrento, Italy, April 2-5, 1991): 1,2,9.

Exhibit 3.12. Energy Savings Potential and Simple Payback of Typical Energy-efficient Lighting Technologies

Technology	Energy Savings Potential (%)	Unit Cost ($)	Simple Payback (Yrs)
Compact fluorescent lamps	60-75	5-10	0.5-1.5
Screw-in compact fluorescent units	60-75	15-25	1.0-2.5
High efficiency fluorescent lamps	15-20	3-10	0.1-1.3
High efficiency magnetic ballasts	10	7-12	1.4-2.8
Electronic ballasts	20-25	20-40	0.5-3.0
Optical reflectors	30-50	10-50	0.5-3.0
Lighting Controls	25-50	20-120 & up	0.5-2.5
Occupancy Sensors	30-50	60 & up	0.5-3.0
Parabolic Fixtures	5-25	50-150	0.1-3.0

Source: Geller, H. S. *Commercial Building Equipment Efficiency: A State-of-the-Art Review.* Washington, D.C.: American Council for an Energy-Efficient Economy. 1988.

Exhibit 3.13. Economics of New Energy Efficient Lighting Technologies

Costs and benefits	High-frequency ballasts vs. core-coil ballasts	Compact fluorescent lamps vs. incandescents
1. Unit cost premium		
a. Wholesale	$8	$5
b. Retail	($12)	($10)
2. Characteristics		
a. % energy saved	33%	75%
b. Useful life	10yr	3yr
c. Simple payback time (SPT)	2yr	1yr
3. Unit lifetime savings		
a. Gross energy	1330kWh	440kWh
b. Gross $	$100	$33
c. Net $ [3b-1a]	$92	$28
d. Gross equivalent gallons	100	40
e. Miles in 25-mpg car	2500	1000
4. Savings (1985-1990)		
a. 1990 sales	3 M	20 M
b. Sales 1985 through 1990	8 M	50 M
c. Cum. net savings [4b x 3c]	$750 B	$1.4 B
5. Savings at saturation		
a. U.S. units	600 M	750 M
b. U.S. annual sales	60 M	250 M
c. Annual energy savings [5b x 3a]	80 BkWh	110 BkWh
d. Annual net $ savings [5b x 3c]	$5.5 B	$7 B
e. Equivalent power plants	16 "plants"	22 "plants"
f. Equivalent offshore platforms	45 "platforms"	60 "platforms"
g. Annual CO2 savings	55 Mt	80 Mt
6. Project benefits		
a. Advance in commercialization	5yr	5yr
b. Net project savings [6a x 5d]	$27.5 B	$35 B
7. Cost to DOE for R&D	$3 M	$0
8. Benefits/R&D cost [6b/7]	9000:1	

Source: Rosenfeld, Arthur H., Ward, Ellen. "Energy Use in Buildings." *The Energy Environment Connection.* Ed. Jack M. Hollander. Washington, D.C.: Island Press. 1992: 245.

The most frequently implemented efficiency enhancing method for lighting systems involves the ballast component. Electronic ballasts now have one-third of the U.S. market, mostly due to the standards established in California and New York.[48]

Ballast is an essential component of a fluorescent lighting system. Its functions are as follows: "Ballasts, by means of inductance, capacitance, and/or resistance limit the current of fluorescent lamps to the required value for proper operation and also to provide the starting voltage and current."[49] "Ballasts consume power and transform the electrical characteristic of the power supply to match those required by lamps they are designed to operate."[50] The standard core and coil type ballasts consume typically about 10% to 20% of the total input energy.[51] New electronic/high frequency ballasts save 33 % of energy compared to the traditional core-coil ballasts. (Exhibit 3.13.)

Core and Coil Ballasts:

The standard core and coil ballast uses a combination of inductive and capacitive networks to accomplish the current control. Inductors are normally constructed of laminated iron cores, with aluminum wires wound over the core.

---

[48]International Energy Agency. *Electricity End-Use Efficiency.* (Paris, France: Organisation for Economic Co-operation and Development, 1989) 71.
[49]Advance Transformer Company. "The ABC's of Electronic Ballasts." (Advance Transformer Company. Rosemont, IL: 1989)
[50]Singh, Harmohindar, Mallik, Arup K., Kapur, Arjon. "Industrial Lighting Practice and Potential." *Strategic Planning and Energy Management.* (Summer 1989): 26.
[51]Turner, Wayne C., Ram, Thiagarajan. "Electronic Ballasts." *Energy Engineering.* Vol.90, No.1. (1993): 7

The energy efficient core and coil ballast has been improved by changing some of the materials used. The inductors are made of copper wire coils. The core is larger and it uses higher quality steel. As a result, resistance losses are reduced, and less energy is lost as heat.

The disadvantages of the core and coil ballasts are:

"-The core and coil ballasts have a limited frequency range which reduces the efficacy of lamps.

-The lamps operated by a core and coil ballast produce fewer lumens because of the resistance created by the core and coil of the electromagnetic ballast. This creates power loss which is converted into heat energy. The lost power, called "ballast losses," cannot be used to produce light from the lamp.

-Because of the heavy weight of the metal, they are difficult to handle, and install and result in higher shipping costs."[52]

Production of standard efficiency units ceased on December 31, 1987 per the National Appliance Energy Conservation Act of 1987, and amendments of 1988.

Electronic Ballasts:

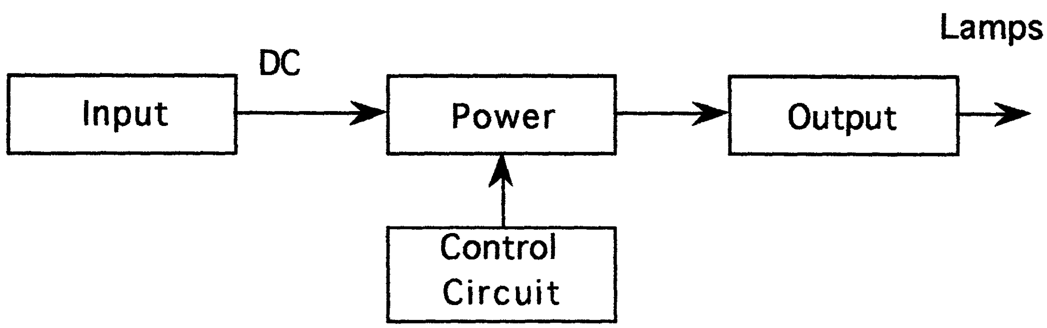
Development of electronic ballasts began with research at Lawrence Berkeley Laboratory in the late 1970s. It was sponsored by the Department of Energy. Electronic ballasts consist of an input circuit, a power switch, an output circuit, and a control circuit.(Exhibit 3.14.) The input circuit converts AC power into DC power. The power switch, which is controlled by the control circuit, connects the output circuit to the DC supply for a portion of each

---

[52]Turner, Wayne C., Ram, Thiagarajan. "Electronic Ballasts." *Energy Engineering*. Vol.90, No.1. (1993): 7

switching cycle to create the AC pulse train. Thus, it functions as an inverter providing the high-frequency AC used to power the lamp. Since this higher frequency is more than the rate of recombination of the ionized gas, it eliminates light or ion decay during each cycle. Therefore, input power is transferred to the lamp more efficiently.

Exhibit 3.14. Block Diagram of a Basic Ballast



Source: Turner, Wayne C., Ram, Thiagarajan. "Electronic Ballasts." *Energy Engineering*. Vol.90, No.1. 1993: 8

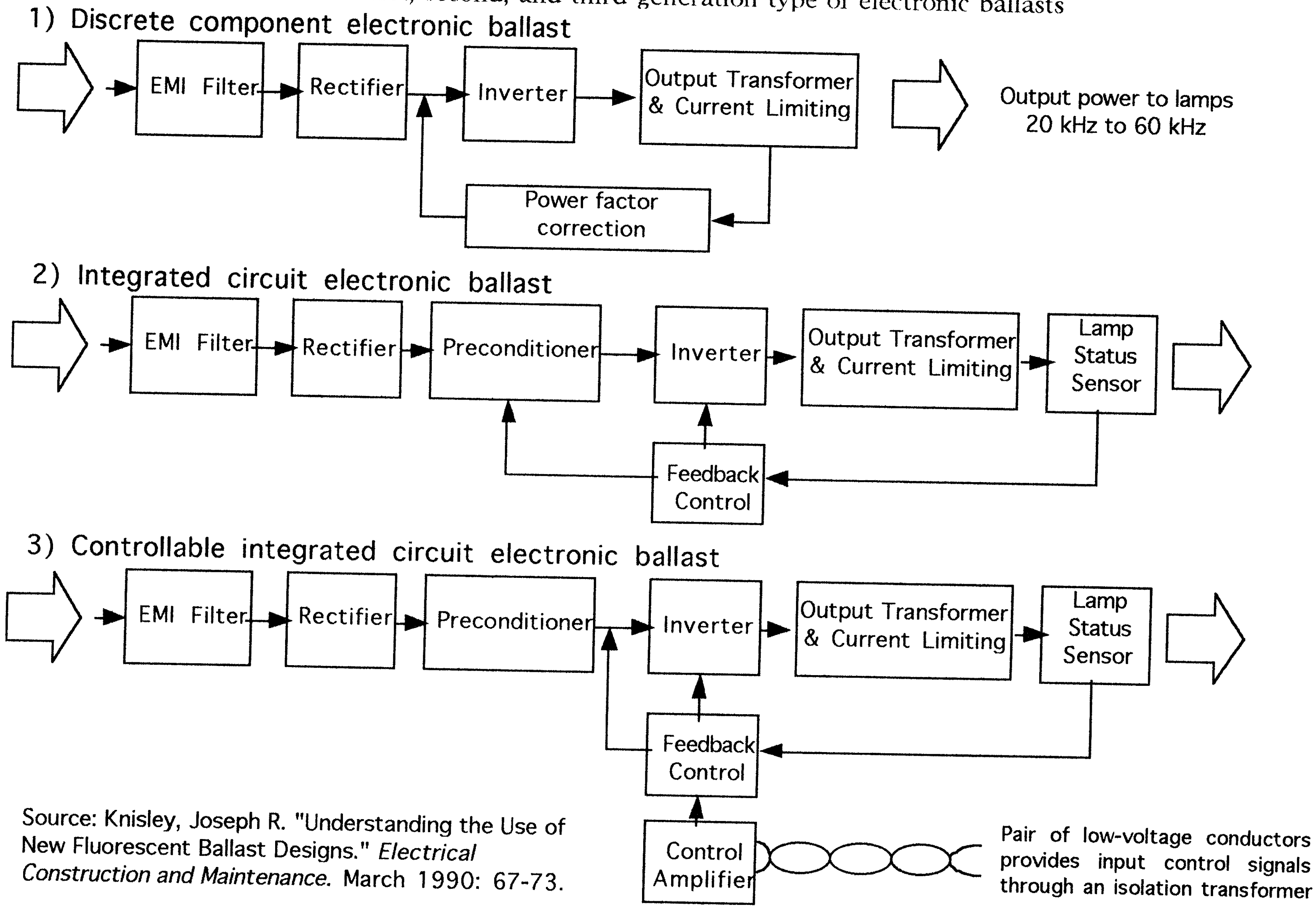
"Electronic ballasts can be divided into two basic types: those constructed with discrete electronic components (first generation design) and those constructed with specialized integrated circuit chips (second and third generation types)."[53] (See Exhibit 3.15.) The second generation ballasts has preconditioning and feedback control in addition to components of the first generation. This feedback control senses the wattage requirements of the lamps being served, therefore, a user can update a lighting system with a new type of lamp without changing the ballast. The third generation ballast adds a control amplifier. This amplifier enables various controls to be added to the lighting system. Examples of added controls are a manual dimming control, an automatic occupancy detector, an automatic photocell dimming unit, and a central building control system. The use of integrated circuits (ICs) in the

[53]Ranson, H. E. "Energy Saving Ballasts." *PG&E Technical services Information Center*. Application Note No.08-59-84.

ballast system enabled complex control of the lighting system, which would otherwise require an expensive controlling system.

Apart from the technical advantages, electronic ballast technology has changed the image of fluorescent lighting fixtures held by the general public. As a result of operation at higher frequencies, the annoying perceptible stroboscopic flicker of the first fluorescent lamps is eliminated. Although these fixtures have always been energy efficient in comparison with incandescent lamps, a major drawbacks included the buzzing sound of the ballasts, flicker, and the sense of artificial light. Technological innovation has overcome the first two. While there are no remaining obstacles for the usage of fluorescent lamps in offices, the artificialness (partial spectrum) of the light is still a barrier to increasing residential use.

Exhibit 3.15. Functions of first, second, and third generation type of electronic ballasts



Source: Knisley, Joseph R. "Understanding the Use of New Fluorescent Ballast Designs." *Electrical Construction and Maintenance.* March 1990: 67-73.

The payback period for replacing a first generation fluorescent lighting system with electronic ballast and typical F032T8 type lamps is as follows.[54] (Exhibit 3.16.) The payback period is computed as the smallest value of n that satisfies the equation;

$$\sum_{n=0}^{n_p} F_n >= 0$$

where n_p is the payback period.

Exhibit 3.16. Economic Analysis of Energy Efficient Lighting Fixtures

Data
Number of Fixtures in the Building (NOF)
Hours of Operation (HOP)
Coincident Cooling Hours (CCH)
Coincident Heating Hours (CHH)
Electrical Consumption Cost (ECC)
Electrical Demand Cost (EDC)
Natural Gas Cost (NGC)
Cooling System Coefficient of Performance (COP)
Heating System Efficiency (LCI)
Labor Cost of Installation (LCI)

Existing Fixture Data
Number of Lamps per Fixture (NLE)
Numbers of Ballasts per Fixture (NBE)
Total Number of Lampps (TLE)
Total Number of Ballasts (TBE)
Lamp Type
INput Watts per Fixture (IWFE)
Lamp Cost (LCE)
Lamp Life (LLE)
Ballast Type
Ballast Cost (BCE)
Ballast Life (BLE)

[54]Turner, Wayne C., Ram, Thiagarajan. "Electronic Ballasts." *Energy Engineering.* Vol.90, No.1. (1993): 12-15.

Proposed Fixture Data
Number of Lamps per Fixture (NLP)
Numbers of Ballasts per Fixture (NBP)
Total Number of Lamps (TLP)
Total Number of Ballasts (TBP)
Lamp Type
INput Watts per Fixture (IWFP)
Lamp Cost (LCP)
Lamp Life (LLP)
Ballast Type
Ballast Cost (BCP)
Ballast Life (BLP)

Analysis
Lighting Load Reduction(LLR)
=NOF(IWFE-IWFP)(conversion factor)
Air Conditioning Load Reduction (ACLR)
=(1/COP)(LLR)
Lighting Energy Savings (LES)
=(LLR)(HOP)
Air Conditioning Electricity Savings (AES)
=(LLR)(CCH)/(COP)
Additional Heating Gas Consumption (AHC)
=(LLR)(CHH)(conversion factor)(conversion factor)/(HSE)
Total kWh Savings (KWHS)
=LES + AES
Electricity Dollar Savings (EDS)
=(LLR)(EDC) + (ACLR)(EDC) + (KWHS)(ECC)
Additional Gas Cost (AGC)
=(AHC)(NGC)
Lamp Replacement Savings (LRC)
=NOF{[(NLE)(LCE)(HOP/LLE)] - [(NLP)(LCP)(HOP/LLP)]}
Total Annual Dollar Savings (TADS)
Implementation Cost (IC)
=(TLP)(LCP) + (TBP)(BCP) + (NOF)(LCI)
Simple Payback
=(IC)/(TADS)

Source: Turner, Wayne C., Ram, Thiagarajan. "Electronic Ballasts." *Energy Engineering.* Vol.90, No.1. 1993:12-15

Various lamps, ballasts, and lighting controls are now being developed. Most programs are supported by the U.S. Department of Energy and based at the Lawrence Berkeley Laboratory.[55] Exhibit 3.17. shows some future expected advancements in increasing the efficacy of fluorescent lamps.

---

[55]Morse, Frederick H. *Efficient use of electricity in the Swedish commercial building sector.* (Stockholm, Sweden: Swedish Council for Building Research. 1990): 50.

Exhibit 3.17. Options for Increasing the Efficacy of Fluorescent Lamps

Technology	Total Efficacy (Lumens/Watt)	Actual or Potential Year of Market Entry
Standard lamp	75	-
High-frequency operation	90	1980
Narrow-band phosphors	100	1983
Istopically enriched	110	1988
Magnetically loaded	120	1990
Surface wave lamp	160	1995
Two-photon phosphors	230	1995

Note: The lighting efficacy values assume that the measures are applied in combination and in sequence.

Source: Lawrence Berkeley Laboratory. *FY 1986 Annual Report: Windows and Lighting Program.* LBL-22156. Berkeley, CA: Lawrence Berkeley Laboratory.

3.5. Market Attractiveness to HVAC Engineering Consulting Firms

3.5.1. Introduction

In this section, a structural analysis of the energy service industry is made following Michael E. Porter's framework.[56] As defined earlier, the energy service industry is part of the energy-efficiency industry. This industry is growing and its participants are from various industries. At this moment there are no appropriate specific statistics published by the U.S. Department of Commerce. The industry analyzed here is the arena where companies that are called energy service companies (ESCOs) are active.

3.5.2. The Intensity of Rivalry

Participants in the energy service industry have various backgrounds and connections to other sectors. They can be classified into several strategic groups. The first group are utility subsidiaries that are organized by the utilities who realized the growth of the DSM market. The second group is building control manufacturers that participate in the market directly. The third group is an engineering-oriented group which is evolving in the market. The fourth group consists of companies specifically organized to participate in this market. ESCOs behave according to their group. It can also be said that all but the last group have certain strengths in the energy saving technical approach.

Another interesting point is that the second group has an additional and different purpose for participating in this market. Through this service, they are attempting to penetrate the capital-poor, opportunity-rich markets in

---

[56]Porter, Michael. E. *Competitive Strategy*. (New York, N.Y.: The Free Press, 1980)

developing countries. Performance contracting exempts the customers from paying high initial cost, therefore, making it easier to buy building control systems. Honeywell is implementing this strategy.

The industry is currently highly concentrated. As the market continues to grow, the number of participants will increase, leading to a lower concentration in the future. For the new entrants, technical capability is not a critical barrier to entering the industry. At this time, however, as the industry is maturing, increased competitiveness will require specific expertise. This is by no means to say that technical expertise is not essential. To the contrary it is crucial, however, recruiting engineering professionals from engineering firms is not difficult. Many engineering firms have had to cut their work forces after the boom of the 1980s. Therefore, current economic conditions support recruiting. Although there are problems to be solved, most factors, favor the participants. The diversity of the competitors seems to be working to portion out the projects.

The most critical factor necessary for continuous growth within the industry is access to capital. Other factors relate to the directions of future government energy policy. Tax systems and policy changes dramatically change potential profitability. Therefore, companies associated with the energy business must be sensitive to possible changes.

3.5.3. The Bargaining Power of Suppliers

Suppliers to the industry are the manufacturers of the energy efficient equipment that is installed by energy service companies. Strategic equipment at the moment include energy efficient lighting fixtures and motors. Building control systems that integrate the entire system are also critical to the ESCOs.

Some suppliers such as manufacturers of building control systems strategically participate in this market. Honeywell and Johnson Controls are representative of these companies. (Appendix 3-4.) Other suppliers include engineering firms in the role of energy consultants, and mechanical and electrical contractors. They have less bargaining power over the ESCOs. This is because the main market for them that is new construction, is stagnating. Attractiveness and necessity of additional jobs offered by the ESCOs to them, reduces their bargaining power.

3.5.3.1. Energy-Efficient Lighting Fixture Industry

Industry Outlook

The energy-efficient lighting industry consists of ballast, controls and lamp manufacturers, reflectors and luminaire designers and manufacturers, and lighting designers and management companies.[57] Major players in this segment are lamp manufacturers and ballast manufacturers. Major manufacturers of efficient lamps are GE, GTE/Sylvania, OSRAM/Siemens, Panasonic, and Philips. Major manufacturers of the ballast are Advance, EBT, MagneTek, Motorola, OSRAM, and Valmont (Sold by GE).

A common influence on these companies is the stimulation they recieved through utility programs and Federal programs such as the Environmental Protection Agency's (EPA) Green Lights Program. The interactions of these programs promoted dramatic growth in this industry. Rapid growth since 1990 (see Exhibit 3.18.) has restructured the industry, and increased competition. There were consolidations, new entrants, and some who decide to exit the

---

[57]International Institute for Energy Conservation. *Seizing the Moment: Global Opportunities for the U.S. Energy-Efficiency Industry*. (Washington, D.C.: IIEC. 1992) 52.

industry. This market growth attracted outsiders such as the electronic giant Motorola which entered the market in 1991. On the other hand, GE decided to leave this segment of the market. The industry is polarized into component manufacturing and distribution, thus making switching cost low for buyers.

Exhibit 3.18. U.S. Domestic Standard Fluorescent Electronic Ballast Shipments

	Units in 1,000		
Year	U.S. Only	Imports	U.S. & Imports
1982	50	0	50
1984	350	0	350
1986	350	50	400
1988	800	250	1050
1990	1250	1200	2450
1992	5650	3250	8900
1994	14650	5850	20500

Notes:
1. Table does not include shipments to foreign countries, however this number is relatively small.
2. Table does not include U.S.-made electronic ballasts used in compact fluorescent/quad lamps
3. Data rounded to the nearest 50,000 units
4. Data for 1990 through 1994 are estimates

Source: U.S. Bureau of Commerce; Arthur D. Little estimates

Analysis

Pros for the ESCOs are that 1) the concentration of the suppliers is lower and fragmented, 2) there is some differentiation but not enough to create high switching costs, and 3) they do not pose a credible threat of forward integration. Cons are that what ESCOs buy are only part of many major manufacturers' product lines and that the suppliers' products are an important input to the ESCOs' business. This weakness will become severe if restructuring of supplier side industry continues in the direction of concentration. In any case, suppliers do not have the option of reducing the quality of the products. For the ESCOs, quality that realizes energy efficiency and longevity (lower life cycle costs) of the product, defines their shared savings and profits. Since ESCOs are the only effective distribution media (limited to retrofit) which links the manufacturers with non-residential building consumers, it is in their best interest to develop a mutually beneficial relationship. Manufacturers have a constraint that requires them to think about the cost effectiveness of their product to the customers.

At this moment the largest factor that influences one company's relative superiority over another is the supply/demand imbalance for the product (compact fluorescent lamps and electronic ballasts). Recent explosion in the utility use of DSM created an erratic demand and order lead times from two to six months are not an unusual situation for electronic ballasts. It was forecasted that this would be resolved by 1993.[58] Since the price of the product directly connects to the investment payback period, there are virtual limits for an increase in price. It is to the benefit of suppliers to avoid increases in price and not interfere with expected market growth.

Another factor to consider is the relative importance of ESCOs to the suppliers. As explained earlier, ESCOs have a relative superiority over manufacturers when considering the limited non-residential building market segment. For lamp manufacturers, since sales of another energy efficient lighting, compact fluorescent lamps (CFLs), which target the residential market segment are growing simultaneously, they have the option of choosing the relative importance of buyers (ESCOs and residential sector). Furthermore, the sales of CFLs are done directly with the consumers via the utility rebate program. Therefore a higher margin is expected for the lamp manufacturers. The reason is that the utilities have a priority interest in saving electricity and not

58Ibid. 61.

gaining profit from distribution of CFLs. The above condition might weaken the ESCOs buyer power.

Finally, under the above conditions, the ESCOs should internally try to lower the raw cost of the products by buying in volume. The consideration should be taken to do the purchase on corporate wide project bases instead of an individual project base. Therefore, the larger ESCOs will have higher profitability in the future if they utilize their scale merit to the maximum.

3.5.3.2. Electric Motor Manufacturers

Industry Outlook

The electric motor industry supplies the ESCOs with highly efficient motors and electronically controlled adjustable speed drives (ASDs). These products are still a small part of the manufacturer's product lineup. Motors are classified into three categories, 1) fractional horsepower motors with size under 1 horsepower, 2) integral horsepower motors larger than 1 horsepower, and 3) direct-current motors that operate in low energy powered applications.

The U.S. motor industry is highly fragmented with approximately 340 companies as of 1988. Major U.S. capital manufacturers are A.O. Smith, General Electric, GMC's Delco Products, Emerson Electric, Reliance Electric, and MagneTek. Foreign manufacturers with market shares in the U.S. are ASEA Brown Boveri, Seimens Automation, Toshiba/Houston International, and Mitsubishi Electric.[59] Among the foreign participants, Japan was the leading country exporting to the U.S. market in 1989.[60]

---

[59]Ibid. 113-114.
[60]Ibid. 115.

According to an engineer from a Mexican motor manufacturer exporting to the U.S. The U.S. industry has a competitive advantage only on the basis of quality and superior energy performance Most companies have an excess manufacturing capacity due to the stagnation of demand in their major markets. The industry has experienced little growth in the past years.[61] Their major market is durable consumer goods where their motors are used by original equipment manufacturers (OEMs). Their major market has stagnated because in 1988 residential construction was at its lowest since 1946. In addition commercial buildings where they supply large motors for elevators, HVAC systems, and pumps, were excessively built in the mid-1980s.

Analysis

ESCOs have superior buying power over the motor industry. The motor industry is fragmented, and they face competition with large manufacturers from other countries. Although the supplier's product is a key component for the ESCOs, this fragmentation and severe competition, combined with the non-specialized characteristics of the product, will prevent them from taking control of the price.

Furthermore this new energy efficient motor market will be attractive to most manufacturers who do not want to miss the chance to increase or sustain their market share. Market potential for the industry is as follows. Motors consume 57 percent of the electricity generated. Two hundred thousand motors larger than 125 horsepower currently in use consume 587 TWh per year (21 percent of total electricity) which, if highly efficient motors available in the market were used, can save 9-23 percent of the usage. These are the targets of DSM

---

[61]U.S. Department of Commerce. U.S. Industrial Outlook 1990. (Washington, D.C.: U.S. Department of Commerce. January 1990).

programs such as motor rebate programs and through performance contracting with the ESCOs. At this moment, market saturation of energy efficient motors are 20 percent of current national sales, and represent only 3 percent of the total stock of motors over 1hp.[62]

Distribution is another weakness of the manufacturers. They currently have no effective distribution route other than through utility rebate programs and ESCOs. This is because end-users, architects, HVAC engineers, and OEMs generally select motors based on initial cost, reliability, and durability. In a sense this is a reflection of consumer attitudes toward the product which was discussed in the first chapter. As a result of the above conditions, ESCOs will be able to secure a stable supply into the near future.

3.5.3.3. Building Control System Manufacturers

Building control system manufacturers, such giants as Johnson Controls and Honeywell, are both the old participants of the industry as well as influential suppliers to the energy service companies. Their industry is further concentrated than this energy service industry; therefore, ESCOs have less control of the supplies from them.

3.5.4. The Bargaining Power of Buyers

At this point, there are more potential customers than all the ESCOs can manage. Together with the fact that customers basically has nothing to lose, they are likely to keep the price structure stable. As this industry turns out to be more promising to others, entrants are expected to increase. As the relative

[62]International Institute for Energy Conservation. *Seizing the Moment: Global Opportunities for the U.S. Energy-Efficiency Industry*. (Washington, D.C.: IIEC. 1992) 115.

concentration of the energy service industry rises, customers are able to choose among more qualified ESCOs. The customers have nothing to lose from a performance contract; therefore, their selection will remain to be the qualification of the ESCOs.

If this market remains to grow, some qualification institution such as in bonds maybe necessary to give sufficient information to customers.

3.5.5. The Threat of New Entrants

Possible new entrants are 1) product vendors: air-conditioning, controls, 2) engineering firms, 3) mechanical and electrical contractors and 4) other specialty contractors. Among the possible companies, the most powerful candidates have already entered the market. A major threat might be the entrants from the construction sector. Their project management skills are applicable, and as a coordinator they only need to form an alliance with an engineering firm. For example, Beacon Construction has formed a subsidiary targeting this market.

3.5.6. The Availability of Substitutes

The continuous supply relies on the supply of new construction with ineffective building environmental systems. If designs of the building systems were done appropriately, inefficient building will decrease. This will function as a substitute in the long run. In other words, if there were enough incentives (such as government subsidy for efficient equipment of higher energy price) to have an energy efficient system in the building at the time of construction, there will likely be less opportunity to enhance the business.

3.6. Opportunities for Engineering Firms

3.6.1. Entry in to the Market

For the engineering firms, there are two ways to take advantage of this market: an aggressive strategy and a passive strategy. An aggressive strategy is to realize an alliance relationship with a company capable of raising capital. The example alliance will be the utilities or equipment manufacturers. The sample case is discussed in the EUA Cogenex case in the last chapter. A problem that may be overlooked is the difference of attitudes between professional consultants and contractors. If this conflict can be resolved in a positive way, such a company will be a most competitive company.

A passive strategy is to limit their involvement only to consulting as they are doing right now. This might be the right answer in retrospect. When we look at other industries, the future trend lies in strategic outsourcing. This is particularly the case when professionals of different segments are necessary to combine a team. ESCOs are a team of financing managers, engineering professionals, and project managers. Although, it is not happening at this moment, outsourcing or virtual corporation seems to be the ideal future organization style for this industry. Engineering firms can take their part without professional moral conflict when that stage arrives in the future.

There is still another opportunity which might be available in the future, one case of which can be found in Japan—the extensive involvement of government in the energy policy. In Japan, most of the end-use efficiency programs are subsidized by the government. For example, recently, the Ministry of Construction announced that they will fully support for the construction of 'unused energy' plants. The Ministry of International Trade and Industry (MITI) subsidizes half of the price for solar panels. They are also promoting a project to develop higher coefficient of performance heat pumps with the industry. If such government funds can be provided at a low interest rate or at least a rate competitive with what the ESCOs take to pay for the required fund, it will dramatically enhance the energy efficiency resulting in net benefit to the society.

3.6.2. Size of Building Retrofit Market

"Renovation" is thought as one of the key/cogent business market in the next decade among mechanical and electrical engineers (of engineering firms/divisions) in the building construction industry. Renovation consists of architectural element which is interior-renovation, and engineering element which is the renovation of mechanical and electrical systems inside the building. Among the engineering element lies the new emerging market called energy management services. Energy efficiency of the building has always been a concern to the engineers in this market, but until now there were no organizations focusing systematically and specifically in this area.

The motivation for marketing renovation market is the stagnation of new building construction. The market has not grown since 1985.(Appendix 3-1.) This raises the priority of renovation relatively. While new construction growth seems to become mature, many modern non-residential buildings are facing the era of renovating building systems.(Appendix 3-2.) The Building Owners and Managers Association states that there are about 1.3 million nonresidential buildings in the United States, and about 75% of this number are more than 10 years old. This suggests that significant energy savings can be realized in just slightly less than 1 million nonresidential buildings.

3.6.3. Risk Averseness of The Firms

To capture the emerging market of energy management services, consulting firms have to not only break through a large psychological barrier that consumers have concerning the implementation of high energy efficiency, but also high initial cost investments. According to J. R. Hausman, individual discount rates differ amazingly according to their income.[63] This can also be applied to the corporate clients. With their budget constraints, they are many times not able to allocate the budget even if they understand the merits. Performance contracting, which is currently provided by energy services companies, is a key to a breakthrough of corporate minds.

3.6.4. Opportunities and Possibilities for Large Scale AEC Firms in Japan

As the following case clearly shows, financing is a critical key for entering and succeeding in this market. Many clients understand the effect of the savings. The problem is that their internal annual budgeting constraints do not allow them to allocate the large initial cost of the project even though return on investment is high. One way to break through this barrier is to offer a complete project package as Cogenex is doing. This package is similar to the turnkey project concept in construction contracting. Another way, such as cooperating with investing firms, is worthy of exploration. A mix of finance and engineering services has the potential to open up a vast new market.

---

[63]Hausman, J. R. "Individual Discount Rates and the Purchase of Utilization of Energy-Using Durables," *The Bell Journal of Economics,* Vol.10(Spring, 1979): 33-54.

Looking to the market within Japan, large general contractors seem to have the qualifications. The barrier for them in creating this market might be the risk averseness among their organizations. This is a result of the continuous growth of the Japanese market from World War II to the mid 1980s. Large AE firms must change their notions in this new era after the "Bubble economy." One method is to be aggressive in taking risks through careful management. Another is to rethink the business scope and extend their services. Energy management service relates to both of these. Typically for large scale AE firms/general contractors, the latter will be their particular strength in enhancing the information network to capture potential clients and new projects.

Service related to a building can be simply charted as shown in Exhibit 3.19. Three major consultants in the architectural engineering industry are architects, structural engineers and mechanical & electrical engineers. Linkage of structural engineers is basically concluded once a building is completed. The remainder of the consultants will be required occasionally during the life span of a building. Architects will be required for major and minor interior changes according to the transition of the tenant. Mechanical and electrical engineers will be required to maintain the required criteria of the functions such as increasing indoor air quality and comfort in correspondence with enhanced computer use. By offering energy management services, AE firms can further extend their relationships to the life span of the building.

From a totally different perspective, the energy management service can be aggressively used to decrease the cyclical nature of this industry. A decreased number of projects with decreased interest rates in the depression period will strengthen the incentive to do the service. Human resources can be allocated efficiently and the project will internally have less risk. This approach is effective without devoting total aggressiveness into this field in a period of depression such as the one Japan is now experiencing.

As mentioned in the introduction, the priority of renovation work is increasing every year. Therefore, with all the surrounding business environment of the industry which is discussed in this paper, I believe this is one area in which AE divisions can effectively extend their specialties and services.

Exhibit 3.19. Life-cycle of Building

Stage	Function	Consultant
MARKETING	FEASIBILITY STUDY	Marketing
PLANNING	DESIGN	Architect Structural Mechanical & Electrical Landscape
EXECUTION	CM	Construction manager
OPERATION	MAINTENANCE SECURITY FACILITY MANAGEMENT REAL ESTATE *ENERGY MANAGEMENT* INTERIOR FURNISHINGS	Maintenance Security operator Facility manager Real estate agency *Energy analyst* Interior Coordinator
RENOVATION		
DESTRUCTION		

Chapter 4: CASE STUDY

4.1. Contractor: EUA Cogenex

4.1.1. History and background

EUA Cogenex Corporation is one of the nation's leading energy service companies. Their headquarters is located in Lowell, Massachusetts. Its major business area is the Northeast, but their past clients are spread through more than 32 states. They also work internationally. EUA Cogenex provides the customers with guaranteed/shared savings agreements, lease-purchase arrangements and DSM utility payments. The customer benefits through the saved electricity cost and the lack of up-front capital outlay. Through DSM, the utility company can avoid the cost of developing a new power plant, which is becoming increasingly constrained through recent regulations established in response to global warming resulting from increased carbon dioxide emissions.

EUA Cogenex was organized in 1983 by Joseph S. Fitzpatrick, who is presently responsible for the day-to-day management, planning and development functions of the company. Before founding EUA Cogenex he was the Commonwealth of Massachusetts' first Secretary of Energy under Governor Edward King. EUA Cogenex was started as Citizens Heat and Power Corporation and bought by Eastern Utilities Associates in 1986 to become their subsidiary. Eastern Utilities Associates is a relatively small public utility holding company with operating electric companies in Rhode Island and Massachusetts. (Exhibit 4.1.)

EUA Cogenex is one of the energy service companies (ESCOs) which offers energy management services. Their current revenue sources are demand-side management bidding, energy management services, and cogeneration. In 1992 revenue shares for each area were 51%, 29% and 21%, respectively. Pre-tax income for each area was 115%, 42%, and -57%, respectively.(Exhibit 4.2.) EUA Cogenex has grown consistently since 1988. They have overcome the recession which affected many major corporations. Exhibit 4.3. shows the growth of the company and its projections. They project future growth to be above 20 percent in revenues.

Exhibit 4.1. EUA Utility Companies

Blackstone Valley Electric Company
Eastern Edison Company
Newport Electric Corporation
Montaup Electric Company
EUA Cogenex Corporation
EUA Ocean State Corporation
EUA Energy Investment Corp.
EUA Service Corporation

Exhibit 4.2. EUA Cogenex: Revenue Source
(data for 1992 in $1,000,000)

Source	Revenue		Project Assets		Pre-Tax Income	
EMS	$12.60	28.51%	$34.00	29.54%	$2.00	41.67%
DSM	$22.50	50.90%	$44.70	38.84%	$5.50	114.58%
COGEN	$9.10	20.59%	$36.40	31.62%	($2.70)	-56.25%
Total	$44.20	100.00%	$115.10	100.00%	$4.80	100.00%

Source: EUA

Exhibit 4.3. EUA Cogenex: Financial Data (in millions of dollars)

	Historical			Projection		
	1988	1990	1992	1993	1995	1997
Revenues	3.9	18.7	28.3	47.1	54.7	67.7
Total Assets	19.4	75.4	147.4	180.5	232.5	257.8
Total Capitalization	1.5	51	94.4	136.2	199.8	230.6
Capital Expenditures and Other Investments	10.3	27.8	50	43.6	43.5	38.5
Number of Employees	20	45	150 *			

*Includes 65 EUA Nova employees

Source: Eastern Utilities' brochure to the stockholders

4.1.2. Business Environment of EUA Cogenex

If the market for energy management services (EMS) continues to grow as in the company's forecast, rivals with strong capital backing such as other utilities, manufactures of energy efficient products, and finance companies are expected to enter this market. Competitors in the EMS market and Utility DSM Programs are listed in Exhibit 4.4. In the EMS market at present, however, not many companies are offering systematic consultation besides Cogenex. This industry is still highly concentrated and the potential market is vast. Other major companies are focusing on selling their own energy efficient products in their area. This clearly gives Cogenex a lead in differentiation.

Exhibit 4.4. Competition

EMS market: manufacturers and distributors of energy efficiency equipment

- Andover Controls Corp.
- Barber Colman, Inc.
- Control Solution, Inc.
- Honeywell Inc.
- Johnson Controls Inc.
- Landis & Gyr AG
- Nova Controls Corporation

Utility DSM Programs: Energy Services Companies (ESCO)

- CES/WAY International Inc.
- Energy Investment Inc.
- Enersave Inc.
- HEC Inc.
- Kenetech Corp.
- Metal Optics Inc.
- Proven Alternatives Inc.
- Sycom Enterprise Inc.
- Sylvania Lighting Services Corp.

Surprisingly, even with their considerable growth, EUA Cogenex's major projects were repeat business, referrals from existing customers, vendors and suppliers, and the formation of strategic partnerships. They are now intending to strengthen their sales force through the human resources of newly acquired EUA Nova.

The most uncertainty they have concerning their future growth is in the realm of government regulation. Cogenex is controlled under the jurisdiction of the Securities and Exchange Commission (SEC) ruled by the Public Utility Holding Company Act of 1935. The SEC required certain restrictions as to the approval of the acquisition of EUA Cogenex by Eastern Utilities Associates. The limitation was that EUA Cogenex's revenue source within the New England area (later the State of New York was added.) was not to exceed the revenues from outside this base area. This condition might become an obstacle to their growth in the future, although their current revenues within the area is approximately 60 percent of the total revenues, as of 1992.

4.1.3. Shared Savings Agreements

The main service that EUA Cogenex offers is performance contracts, such as shared saving contracts. They make contracts directly or through the DSM programs offered by the utilities. In the latter case, they qualify for an additional rebate from the utilities if the target reduction is accomplished.

Some examples of technological service they offer are as follows. One of the customers of energy management services was Rowes Wharf (Boston, MA). This building is 15-story, with area of 665,000 sq.ft, and is a mixed-use development complex. A plate and frame heat exchanger and lighting conservation measures were installed by Cogenex. The reduced cooling load for the chillers will reduce their operation time, extending the life of the equipment. At Massachusetts Institute of Technology (Cambridge, MA), Cogenex has done analysis and installation of energy conservation measures, including lighting, motors and HVAC equipment. For the DSM programs, in the past they have worked for Boston Edison Company, Commonwealth Electric Company, and Massachusetts Electric Company. Contracted megawatt reduction ranged from 3 to 10 megawatts.

In either case, both through the utility or direct approach, Cogenex and the clients agree upon a prescribed base year and a set of savings calculations to determine Cogenex's allocation of savings and associated revenues. They generally price contracts so that they provide for the repayment of Cogenex's investment within 4 to 5 years. Due to the nature of this contract, failure of initial analysis will lead to decreased revenues, therefore risk management plays a critical role. Along with technical analysis, financial evaluation of the customers is essential. It is a minimal requirement to check the financial condition of the customers. The shared savings contract takes a variable number of years for the payback according to each customers. Therefore, it is important for Cogenex to check the financial credibility of the customers to assure their payback from the savings. As this service continues to grow, the insuring of these projects should also be considered more carefully.

In the case where the EPA Green Lights Project was implemented at Massachusetts Institute of Technology, kWh savings were $52,465 and cost base addition was $194,161. This made the simple payback period 3.7 years on average. Savings accomplished by installing energy efficient lighting fixtures were calculated at a cost of $0.07 per kWh. Cost base addition includes raw construction cost with PCB disposal, budget construction management at 5% and EUA margin at 21% on the total project cost. For the client, this contract is very attractive. It requires no up-front cost for them and no additional administrative personnel to take control of the project. Furthermore, once the project expense is recovered, the savings will increase. A MIT administrator noted that because of internal annual budget constraints, it was difficult to accomplish the retrofit project with their own funding, although everyone understood the potential savings.

As described previously, this service differentiates Cogenex from other companies. Going under Eastern Utilities enabled them to access the capital. To continue winning in this market they must continue their efforts to assure additional financing at favorable rates.

One problem to be associated with shared savings contracts is the legal issue, which is left ambiguous. As mentioned by Bryant in the Energy Users News;

"Fixture ownership is left ambiguous in most shared savings arrangements, a situation that could prove problematic in the event of military base closures or natural disasters such as Hurricane Andrew."

4.1.4. Corporate Strategy

4.1.4.1. Securing Access to the Capital

Acquisition of EUA Cogenex was part of EUA's strategy to diversify into energy related areas which focus on DSM. For EUA Cogenex, this acquisition enabled them to gain access to the capital they need for offering performance contracts. In performance contracting, the company must always have a good supply of capital to continue their growth.

While they were under Citizen Energy Group as Citizens Heat and Power Company (CHPC), they had difficulties in raising necessary capital in order to make shared savings agreements. When the company was organized in 1983, banks were not eager to lend for intangible services. (This is still true to some extent at this point.) Therefore, alliance with a company possessing large capital was absolutely necessary for them.

4.1.4.2. Vertical Integration

Vertical integration through acquisition of New England Sun Control (named EUA Nova after acquisition), which manufactures lighting fixtures specially designed to conserve energy, was accomplished on December 1992. It was done to ensure the supply of the fixture which is a backbone of the energy management services strategy. Through this acquisition, Cogenex was able to establish direct access to the cutting edge technology, and a stable supplier of the strategic energy efficient lighting fixture.

It must be noted that only part of the demand will be fulfilled by the former NESC. This is for their mutual benefit. For EUA Cogenex, maintaining connection with the rest of the lighting fixture market will be necessary to keep EUA Nova competitive in the lighting industry. EUA Nova will always have an incentive to keep their product costs near the market price. Another reason is to avoid Nova becoming an obstruction to accessing a broader range of clients. On the other hand this same reasoning applies to Nova. Having access to a wider market will give them better opportunity to absorb information on changing buyer needs. The information will be valuable for precise analysis of future product research design and development.

4.1.5. Conclusion

This case is a good example of aggressive strategies to take for engineering firms. They have taken every opportunity to become a company which is able to offer performance contracting. They have also taken a further step to vertically integrate one of their strategic suppliers. This shows a new possibility for aggressive engineering firms.

Chapter 5: Thesis Conclusion

5.1. Conclusion

The goal of this thesis was to clarify the potential ways HVAC engineering firms may contribute to solutions for the global warming problem. Through the analysis, the energy service, what ESCOs are performing was analyzed to be attractive enough for the engineering firms to take the step of entering this market.

The analysis of the global warming problem showed that the least cost option is the most probable direction for the U.S. policy to take, if the politicians appreciate the studies of economists and scientists. The least cost option is to limit the flow of cash input to the area where people will enjoy the benefit of the investment even in the case that global warming does not turn out to be as hazardous to humans as expected. It is a so-called 'no regret policy.' Among the least cost options, increasing the end use efficiency of the electricity is the best. Reduced electricity use will result in less carbon dioxide emitted from the power stations. Furthermore, it contributes to reducing sulfur dioxide emissions which become the cause of acid rain. Even a modest estimate shows that approximately 20 percent of electricity consumed can be saved at a cost below 3 cents per kilowatt hour. This number shows that if energy cost is below 3 cents per kilowatt hour, the investment will result in net profit. The average electricity price in the U.S. is now approximately 6 cents per kilowatt hour. This means that if proper methods were available for introducing the importance of increasing energy efficiency, the activity would itself promote it on the business base.

ESCOs are the group of companies that are actually selling efficiency. Major suppliers of their projects are the electric utilities. They offer the projects through demand-side management programs. According to projections done by the State of New York, this supply of work is expected to continue for at least a decade. The public utility commission and the federal policy which influences the utilities' decision making are also for demand-side management programs.

Control over suppliers and the characteristics of performance contracting give ESCOs many advantages in business. Their largest obstacle is a lack of information on this new performance contracting method. Another problem is the capital source.

Several options were presented for the engineering firms to enter this market. The most aggressive scenario was to take the similar path of EUA Cogenex which was presented in the case study. The engineering firms will need a capital source, and will need to switch to a form of a contractor.

The ultimate goal was to seek opportunities for genera contractors in Japan to do similar business. From the analysis of ESCOs' key technology, it can be concluded that there are small opportunities left inside Japan for these technologies. With the exception of some motor technologies, they are already widely implemented. However, performance contracting can be used to implement other advance technologies in the market. They also have the opportunity in Asia, and other countries where Japanese corporations have gained ground.

5.2. Areas for Additional Research

Opportunities overseas are promising. The form of ESCOs is unique, and there are not many companies yet offering such services in other countries. Large international contractors such as Bechtel have already organized a subsidiary to enter the market. Feasibility studies of entering the international market will be valuable for large ESCOs and international contractors seeking the chance to enter this market.

Appendices

Appendix 2-1. Conversion Tables

1 Quad Equivalent of Energy Resources

Natural Resources	1 Quad Equivalent
Crude Oil	170 x 10^6 lbs
Bituminous Coal	40x10^6 short tons
Natural Gas	10^12 cubic feet
Uranium-235	17 short tons
Wood (air-dry)	6.25 x 10^7 ton

1 Quad Equivalent of Energy Units

1 Quad =10^15 BTU
=1.055 x 10^9 GJ
=2.52 x 10^17 calorie
=2.93 x 10^11 kWh

Appendix 2-2. International Agreements on Complex Environmental Issues

1976 Barcelona Convention for the Protection of the Mediterranean Sea Aginst Pollution

1985 Vienna Convention and 1987 Montreal Protocol on Substances that Deplete the Ozone Layer

1988 Sofia Protocol on Long-Range Transboundary Air Pollution by Nitrogen Oxides

1989 Basel Convention on Transboundary Movements of Hazardous Wastes

1992 Conference on Environment and Development (UN CED)
Framework Convention on Climate Change
Rio de Janeiro, Brazil

Appendix 2-3. Estimates of Annual Damage from Global Warming to the U.S. Economy at 1990 Scale
(billions of 1990 dollars)

	2 x CO_2 (2.5°C)	Very-long-term warming (10°C)
Agriculture	17.5	95
Forest loss	3.3	7
Species loss	4.0 + DS	16.0 + D'S
Sea-level rise		
Construction of dikes, levees	1.2	35
Wetland loss	4.1	
Drylands loss	1.7	
Electricity Requirements	11.2	64.1
Nonelectric heating	-1.3	-4
Human amenity	Xa	Ya
Human life	5.8	33
Human morbidity	Xm	Ym
Migration	0.5	2.8
Hurricanes	0.8	6.4
Construction	± Xc	± Yc
Leisure Activities	1.7	4
Water supply	7	56
Urban infrastructure	0.1	0.6
Air pollution		
Tropospheric ozone	3.5	19.8
Other	Xo	Yo
Total	61.6 +Xa+Xm+Xo+ DS± Xc	335.7 +Ya+Ym+Yo+D'S ± Yc

Note: Xa, Xm, Xo, DS, +-Xc, Ya, Ym, Yo, D'S, Yc are unestimated.

Source: Cline, William R. The Economics of Global Warming. Washington, DC: Institute for International Economics. 1992. 131.

Appendix 2-4. Country Policy Positions on Greenhouse Warming as of mid-1991

Country	Carbon dioxide stabilization		
	At level of:	By:	Comment
European Community	1990	2000	Tax equivalent to $10 per barrel of oil pending, to be levied half on carbon content, half on energy
Belgium	1990 minus 5%	2000	
Denmark	1988 minus 20%	2005	
France	See comment	2000	Ceiling of 2.0 metric tons per capita. Currently 1.8 metric tons.
Germany	1987 minus 25%	2005	Cutback of 25% to 30% from 1987 expected for unified Germany.
Itlay	1990 minus 20%	2005	
Netherlands	1989-90 minus 3-5%	2000	
United Kingdom	1990	2005	Cut contingent on action by other countries. Measures to cut methane are planned.
Finland			EFTA members have agreed in principle to EC target.
Norway	1989	2000	Goal is preliminary. Depend on research and results of international negotiations.
Sweden			EFTA members have agreed in principle to EC target.
Switzerland	1990	2000	Parliamentary approval pending.
United States	None		Cutback of CFCs was expected to leave total greenhouse gas emissions by 2000 at 1990 levels.
Japan	1990	2000	Stabilization of CO2 emissions per capita.
Canada	1990	2000	
Australia	1988 minus 20%	2005	
New Zealand	1990 minus 20%	2000	
Soviet Union	None		
China	None		
Brazil	None		Measures in process to arrest deforestation.

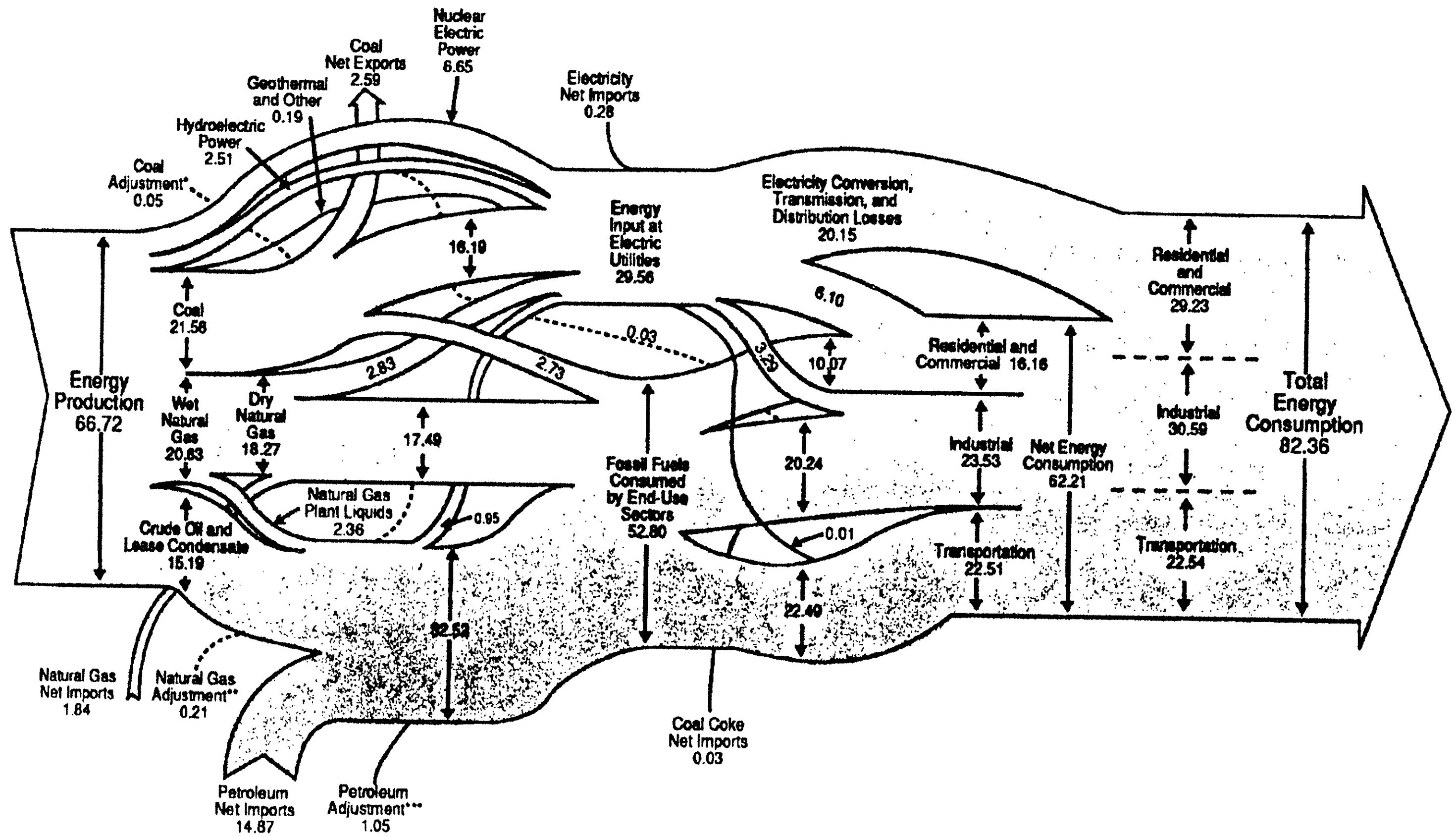
Source: Schmidt, Karen. *Industrial Countries' Responses to Global Climate Change.* Washington: Environmental and Energy Study Institute 1991.

Appendix 2-5. The Top 10 Carbon-emitting Countries

	Carbon dioxide emissions (millions of tons of carbon-equivalent)			Economic Indicators		Emissions performance				
	Fossil fuels	Land use change	Total emission	1989 population (thousands)	1989 GNP per capita	Share of world emissions (%) A	Share of world population (%) B	Share of World GNP (%) C	A/B	A/C
United States	1,222	5	1,227	248,800	20,690	0.18	4.78	25.74	3.67	0.68
Soviet Union	1,034	0	1,034	282,830	7,545	0.15	5.43	10.67	2.72	1.38
European Community	786	0	786	342,489	13,294	0.11	6.58	22.77	1.71	0.49
China	596	0	596	1,113,900	1,153	0.09	21.40	6.42	0.40	1.33
Brazil	54	390	444	147,300	4,409	0.06	2.83	3.25	2.24	1.95
India	155	118	273	832,500	980	0.04	15.99	4.08	0.24	0.96
Japan	248	0	248	123,100	15,710	0.04	2.36	9.67	1.50	0.37
Indonesia	35	185	220	178,200	1,468	0.03	3.42	1.31	0.92	2.40
Myanmar (Burma)	1	126	127	40,000	984	0.02	0.77	0.20	2.36	9.22
Poland	129	0	129	37,900	4,980	0.02	0.73	0.94	2.53	1.95
World	5,700	1,600	7,000	5,206,100		1.00	100.00	100.00	1.00	1.00

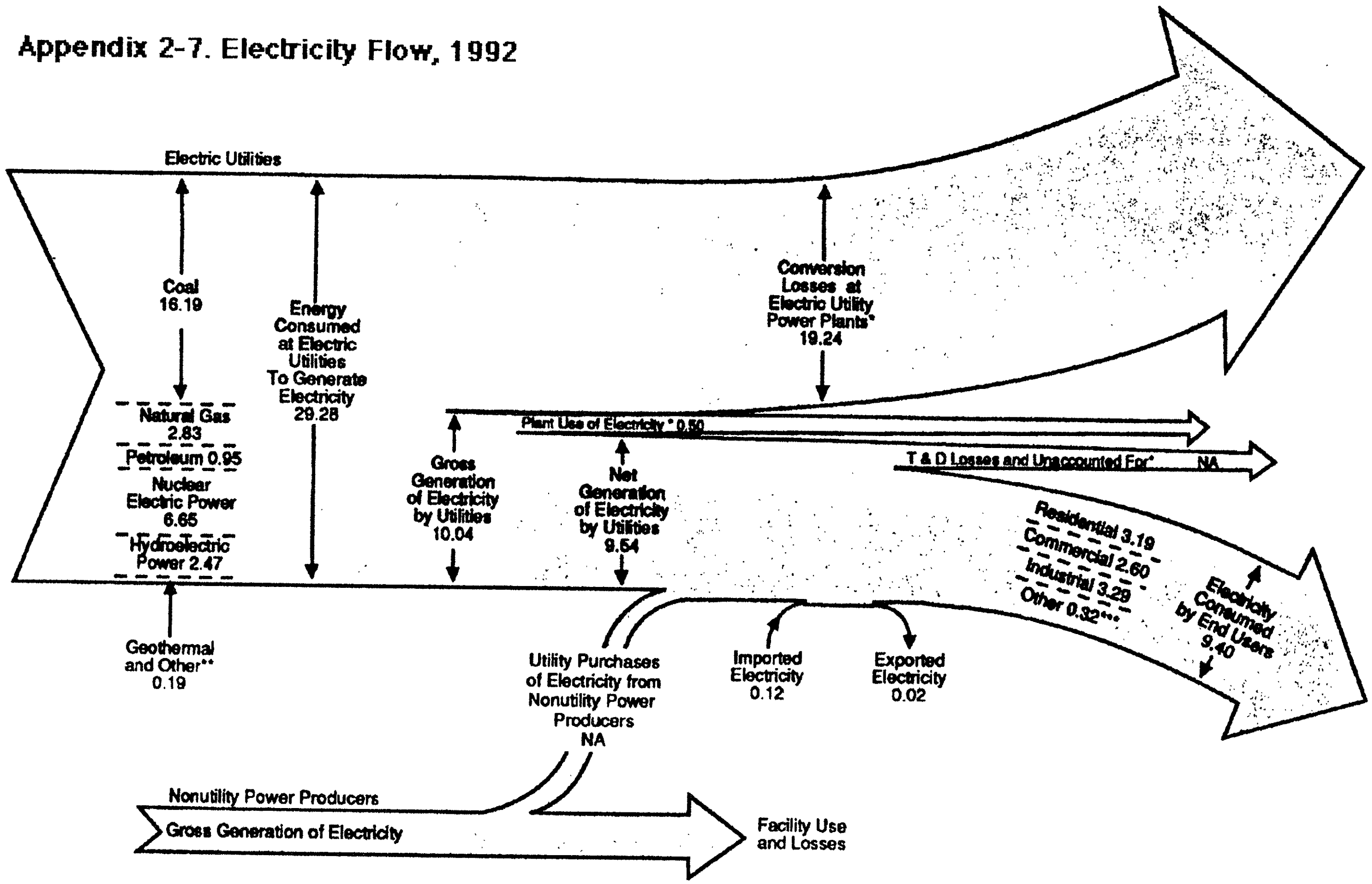
Source: Compiled from Cline, William R. *The Economics of Global Warming*. Washington, DC: Institute for International Economics. 1992. Table 8.1.

Appendix 2-6. Total Energy Flow, 1992



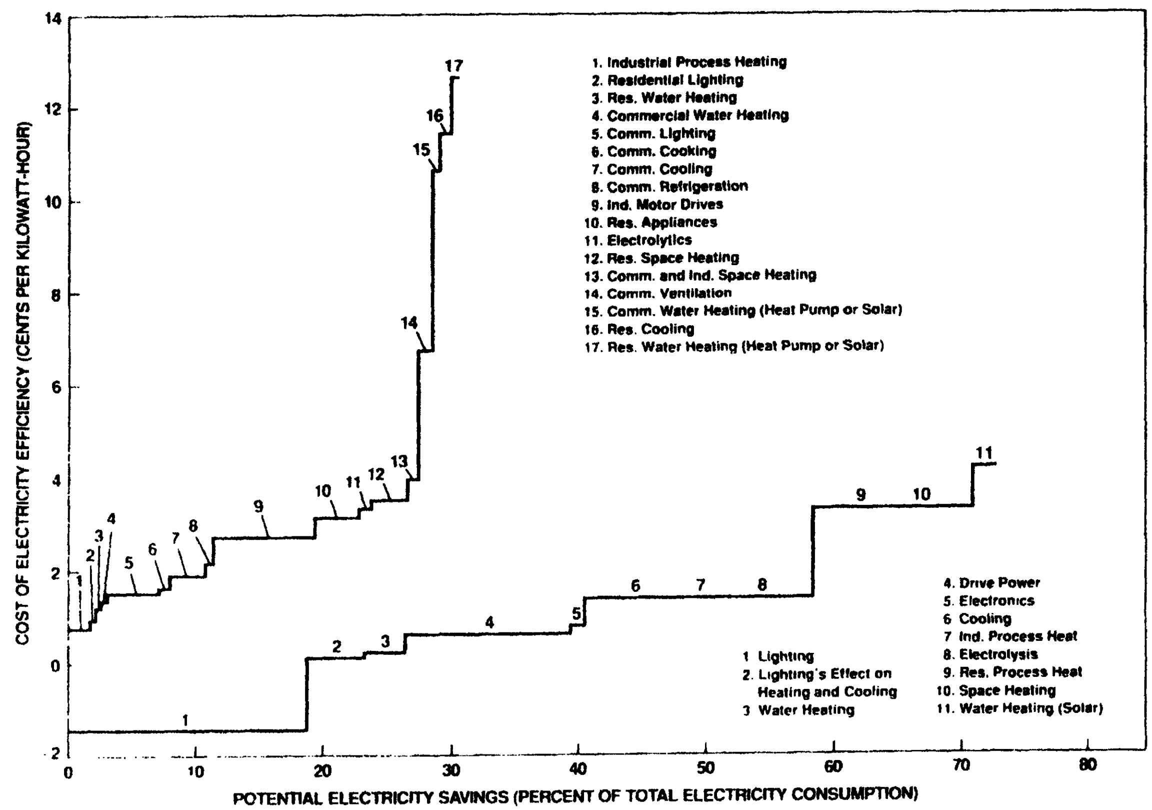
Source: Energy Information Administration

Appendix 2-7. Electricity Flow, 1992



Source: Energy Information Administration

Appendix 2-8. Potential Electricity Savings



Fickett, Arnold P. et al. "Efficient Use of Electricity". Scientific American. September 1990: 72.

Appendix 3-1. Value of New Construction Put in Place: 1964 to 1991

No. 1204. Value of New Construction Put in Place: 1964 to 1991

[**In millions of dollars.** Represents value of construction put in place during year; differs from building permit and construction contract data in timing and coverage. Includes installed cost of normal building service equipment and selected types of industrial production equipment (largely site fabricated). Excludes cost of shipbuilding, land, and most types of machinery and equipment. For methodology, see Appendix III. See also *Historical Statistics, Colonial Times to 1970*, series N 1-29 and N 66-69]

YEAR	CURRENT DOLLARS					CONSTANT (1987) DOLLARS				
	Total	Private			Public	Total	Private			Public
		Total	Residential buildings	Nonresidential buildings			Total	Residential buildings	Nonresidential buildings	
1964	72,124	51,921	30,526	14,412	20,203	294,569	211,627	124,768	60,892	82,942
1970	100,727	72,819	35,863	23,008	27,908	309,244	225,168	114,138	71,796	84,077
1971	117,311	87,612	48,514	24,204	29,699	337,451	254,502	145,554	69,621	82,949
1972	133,318	103,286	60,693	26,568	30,030	360,780	281,593	170,190	71,490	79,187
1973	146,826	114,477	65,085	30,683	32,348	364,938	285,937	166,249	76,259	79,001
1974	147,476	109,344	55,967	32,195	38,132	319,362	242,274	130,126	70,029	77,089
1975	145,623	102,330	51,581	28,397	43,293	290,137	208,991	109,920	58,990	81,147
1976	165,441	121,462	68,273	27,936	43,979	315,865	235,338	136,685	55,617	80,527
1977	193,126	150,044	92,004	30,871	43,083	340,833	266,393	165,926	57,134	74,440
1978	230,178	180,032	109,838	39,135	50,146	362,862	285,880	174,695	65,343	76,982
1979	259,839	203,194	116,444	51,732	56,646	364,554	288,789	165,116	77,359	75,766
1980	259,746	196,100	100,381	58,290	63,646	328,435	252,645	128,926	78,972	75,790
1981	271,950	207,259	99,241	68,450	64,691	320,950	247,427	118,343	85,091	73,523
1982	260,594	197,531	84,676	73,953	63,064	297,759	226,510	97,595	87,505	71,249
1983	294,945	231,494	125,521	70,438	63,450	332,625	261,398	143,108	80,888	71,227
1984	348,817	278,600	153,849	87,493	70,217	382,435	306,152	170,732	96,664	76,284
1985	377,366	299,543	158,474	103,455	77,823	401,967	321,706	172,338	111,262	80,260
1986	407,693	323,100	187,148	98,674	84,593	421,367	335,709	195,377	102,596	85,658
1987	419,264	328,636	194,656	100,933	90,628	419,250	328,535	194,622	100,877	90,715
1988	432,223	337,441	198,101	106,994	94,782	415,004	324,332	190,292	103,037	90,673
1989	443,721	345,417	196,551	113,988	98,305	409,775	318,653	181,321	105,711	91,122
1990	446,434	337,777	182,856	117,971	108,657	402,770	304,057	164,887	106,369	98,714
1991	404,892	295,736	160,961	96,763	109,156	363,204	265,345	145,162	86,934	97,859

Source: U.S. Bureau of the Census, *Current Construction Reports*, series C30, and press release, CB-91-14

Appendix 3-2. Commercial Buildings—Number and Square Footage of Floorspace, by Type of Building and Characteristic: 1989

No. 1240. Commercial Buildings—Number and Square Footage of Floorspace, by Type of Building and Characteristic: 1989

[For composition of regions, see table 25]

BUILDING CHARACTERISTICS	All buildings [1]	Assembly	Education	Food sales	Food service	Health care	Lodging	Mercantile/services	Offices	Public order and safety	Warehouse
NUMBER (1,000)											
All buildings	**4,528**	**615**	**284**	**102**	**241**	**80**	**140**	**1,278**	**679**	**50**	**618**
Region:											
Northeast	783	96	38	(S)	54	12	21	259	108	(S)	95
Midwest	1,046	134	54	(S)	59	21	24	303	139	(S)	177
South	1,847	275	108	45	87	30	50	523	275	(S)	243
West	851	109	84	(S)	41	17	44	193	157	(S)	104
Year constructed:											
1900 or before	172	53	(S)	(S)	(S)	(S)	(S)	43	27	(S)	(S)
1901 to 1920	242	41	14	(S)	(S)	(S)	(S)	61	36	(S)	27
1921 to 1945	680	125	32	(S)	34	(S)	17	194	85	(S)	67
1946 to 1960	868	138	87	(S)	38	15	18	254	109	(S)	113
1961 to 1970	821	82	65	(S)	35	24	36	227	129	(S)	107
1970 to 1979	884	97	52	(S)	57	10	32	227	128	(S)	137
1980 to 1983	317	32	10	(S)	(S)	(S)	9	78	62	(S)	50
1984 to 1986	329	31	14	(S)	(S)	(S)	10	78	71	(S)	74
1987 to 1989	215	17	9	(S)	(S)	(S)	(S)	67	39	(S)	35
Government owned	577	87	192	(S)	13	9	14	33	70	39	65
Nongovernment owned	3,951	528	92	99	228	71	126	1,246	609	(S)	553
FLOORSPACE (mil. sq. ft.)											
All buildings	**63,184**	**6,838**	**8,148**	**7,921**	**1,167**	**2,054**	**3,476**	**12,365**	**11,802**	**616**	**9,253**
Region:											
Northeast	13,569	1,507	1,888	(S)	284	378	549	2,647	2,703	(S)	1,811
Midwest	15,955	1,408	2,221	(S)	339	912	982	3,059	2,281	(S)	2,639
South	22,040	2,750	2,404	278	370	472	1,215	4,778	3,817	(S)	3,422
West	11,620	1,174	1,634	(S)	173	292	730	1,882	3,001	(S)	1,381
Year constructed:											
1900 or before	1,654	386	(S)	(S)	(S)	(S)	(S)	428	289	(S)	(S)
1901 to 1920	4,245	492	435	(S)	(S)	(S)	(S)	514	552	(S)	348
1921 to 1945	8,098	926	1,244	(S)	147	(S)	442	1,322	1,166	(S)	1,448
1946 to 1960	10,511	1,470	2,267	(S)	152	371	358	1,694	1,849	(S)	1,279
1961 to 1970	12,167	1,249	2,201	(S)	282	355	1,042	2,458	1,736	(S)	1,702
1971 to 1973	13,329	1,410	1,391	(S)	268	586	578	3,464	2,425	(S)	2,178
1980 to 1983	4,274	373	155	(S)	(S)	(S)	216	873	1,174	(S)	650
1984 to 1986	5,670	293	158	(S)	(S)	(S)	510	896	1,860	(S)	1,003
Government owned	14,342	1,394	6,312	(S)	109	495	622	399	2,353	575	597
Nongovernment owned	48,842	5,443	1,835	787	1,058	1,559	2,854	11,966	9,449	(S)	8,656

S Figure does not meet publication standards [1] Includes parking garages, vacant, and other commercial buildings, not shown separately.

Source: U.S. Energy Information Administration, *Commercial Building Characteristics, 1989*

Appendix 3-3. Clean Act Amendments of 1990 (PL 101-549)

Title I	— Attainment and maintenance of air quality standards
Title II	— Motor vehicles and fuels
Title III	— Toxic air pollution
Title IV	— Acid rain control
Title V	— Permits
Title VI	— Stratospheric ozone protection
Title VII	— Enforcement
Title VIII	— Miscellaneous
Title IX	— Clean air research
Title X	— Disadvantaged business concerns
Title XI	— Employment transtion assistance

Appendix 3-4. 1993 ESCO Bidders List

Corporation	Project Size Upper Limit ($ in million)	Year Incorporated
CES/WAY International, Inc.	50	1918
Central Hudson Enterprises Corp.	10	1962
Citizens Conservation Corp.	50	1981
Co-Energy Group		1983
EUA Cogenex Corporation	10	1983
Energy Masters Corporation	20	1975
Energy Performance Services, Inc.	25	1992
Enersave, Inc.	10	1989
HEC, Inc.	none	1982
Heatac Systems & Energy Services	none	1986
Honeywell Inc.	none	1886
Johnson Controls, Inc.	none	1885
KENETECH Energy Management, Inc.	20	1985
Landis & GYR Powers, Inc.	none	1891
Northeast Energy Services, Inc. (NORESCO)	none	1981
Onsite Energy (EUA/Onsite, L.P.)	10	1982
Proven Alternatives, Inc.	none	1991
Public Service Conservatio Resources Corp. (PSCRC)	none	1992
Sycom Enterprises	none	1986
Viron Corporation	none	1974

Source: National Association of Energy Service Companies

Bibliography

Advance Transformer Company. *The ABC's of Electronic Ballasts.* Rosemont, IL: Advance Transformer Company, 1989.

Bates, Robin W. "The Impact of Economic Policy on Energy and the Environment in Developing Countries." *Annual Review of Energy and the Environment.* Ed. Robert H. Socolow. Palo Alto, CA: N.p.,1993. 479-506.

Blazon, David T.(Project Engineer, EUA Cogenex Corporation). *Interview.*

Bryant, Frank. "Lighting Retrofit at DOE Bldg. May Serve As Shared Savings Prototype." *Energy Users News.* August 1993.

Cline, William R. *The Economics of Global Warming.* Washington, DC: Institute for International Economics. 1992.

Cropper, Maureen L. Portney, Paul R. Discounting Human Lives. *Resources.* Summer 1992, no108

"Eastern Utilities Associates#(EUA-NYSE)." Research. Smith Barney. 15 April, 1993

Energy Information Administration. *Annual Energy Review 1992.* Washington D.C.: Energy Information Administration, June 1993.

Energy Information Administration. *Commercial Buildings Energy Consumption and Expenditures 1989.* Washington, D.C.: U.S. Department of Energy. DOE/EIA-0318(89). 1992

"EUA Cogenex Corporation." *Offering Circular.* Salomon Brothers Inc. 1 October, 1993

Fickett, Arnold P., Gellings, Clark W., Lovins, Amory B. "Efficient Use of Electricity." *Scientific American.* September, 1990. 65-74

Geller, H. S. *Commercial Building Equipment Efficiency: A State-of-the-Art Review.* Washington, D.C.: American Council for an Energy-Efficient Economy. 1988

Gellings, Clark W., Chamberlin, John H., *Demand-Side Management: Concepts and Methods.* Lilburn, GA: The Fairmont Press, 1993

Hansen, Shirley J. *Performance Contracting For Energy And Environmental Systems.* Lilburn, GA: The Fairmont Press. 1993.

Hartman, Dennis L. "Modeling Climate Change." *Global Climate and Ecosystem Change.* Ed. G. McDonald et al. N.p.: Plenum Press, 1989

Harvey, Robert G., etal. "DSM Contracting-All That Glitters Is Not Gold." As the Energy Markets Expand. *Proc. of the Fourth International Syposium on*

Distribution Automation and Demand-Side Management, Orlando, FL, 17-20 January 1994. 453-459

Hausman, J. R. "Individual Discount Rates and the Purchase of Utilization of Energy-Using Durables," *The Bell Journal of Economiscs*, Vol.10(Spring), 33-54, 1979

Intergovernmental Panel on Climate Change. *Scientific Assessment of Climate Change: Report Prepared for IPCC by Working Group I.* New York: World Meteorological Organization and United Nations Environment Programme. 1990.

International Energy Agency. *Electricity End-Use Efficiency.* Paris, France: Organisation for Economic Co-operation and Development, 1989.

International Institute for Energy Conservation. *Seizing the Moment: Global Opportunities for the U.S. Energy-Efficiency Industry.* Washington, D.C.: IIEC. 1992.

Johonson, Robert. E. *The Economics of Building.* New York, N.Y.: John Wiley&Sons, 1990

Kotler, Philip. *Marketing Professional Services.* Englewood Cliffs, N.J.: Prentice-hall, Inc., 1984

Lawrence Berkeley Laboratory. *FY 1986 Annual Report Windows and Lighting Program.* LBL-22156. Berkeley, CA: Lawrence Berkeley Laboratory.

Lovins, Amory B. End-use/Least-cost Investment Strategies. Old Snowmass, CO: Rocky Mountain Institute, N.p.

Lyons, Chester L. "International Markets-A Tremendous Opportunity for the ESCO Industry." *Energy Efficiency Journal.* Volume 1, No.5. 6-7,14

Lyons, Chester R., Limaye, Dilip R. "Performance Contracting." *DSM Quarterly* Spring. 1992: 20-27

Morse, Frederick H. *Efficient use of electricity in the Swedish commercial building sector.* Stockholm, Sweden: Swedish Council for Building Research. 1990.

Nadel, Steve et al. *Energy Efficient Motor Systems: A Handbook on Technology, Program and Policy Opportunities.* Washington, D.C.: American Council for an Energy-Efficent Economy. 1991.

Nadel, Steven. "Electric Utility Conservation Programs: A Review of the Lessons Taught by a Decade of Program Experience." *State of the Art of Energy Efficiency: Future Directions.* ED. Edward Vine.: American Council for an Energy-Efficient Economy, 1991. 61-104.

Nordhaus, William D. "Expert Opinion on Climate Change." *American Scientist.* Vol.82 Jan./Feb. 1994. 45-51.

Nordhaus, William D. "The Economics of the Greenhouse Effect." *Proceedings of the MIT Workshop on Energy and Environmental Modeling and Policy Analysis.* June 1989.

O'Callaghhan, Paul. *Energy Management.* London, U.K.: McGraw-hill, 1993

Palmer, Kathleen(Marketing Assistant, EUA Cogenex Corporation). *Interview.*

Porter, Michael. E. *Competitive Advantage.* New York, N.Y.: The Free Press, 1985.

Porter, Michael. E. *Competitive Strategy.* New York, N.Y.: The Free Press, 1980.

Ranson, H. E. "Energy Saving Ballasts." PG&E Technical Services Information Center, Application Note No. 08-59-84.

Rose, David. J. *Learning about Energy.* New York, N.Y.: Plenum, 1986

Rosenfeld, Arthur H., Ward, Ellen. "Energy Use in Buildings." *The Energy Environment Connection.* Ed. Jack M. Hollander. Washington, D.C.: Island Press. 1992: 223-257..

Ross, Marc H., Williams, Robert H. *Our Energy: Regaining Control.* New York: McGraw-hill, 1981.

Rubin, Edward S., Cooper, Richard N., Frosch, Robert A., Lee, Thomas H., Marland, Gregg, Rosenfeld, Arthur H., and Stine, Deborah D. "Realistic Mitigation Options for Global Warming." *Science* 10 July.1992: 148,149,261-266.

Schneider, Stephen H. "Global Climate Change." *The Energy Environment Connection.* Ed. Jack M. Hollander. Washington, D.C.: Island Press. 1992.

Siminovitch, M. J., Rubinstein, F. M., Packer, M., "Thermally Efficient Compact Fluorescent Fixture Systems." *Proceedings of the IEA/ENEL Conference on Advanced Technologies for Electric Demand-Side Management.* LBL-30180, Sorrento, Italy, April 2-5, 1991: 1-10

Simonovitch, Michael et al. "Thermal Performance Characteristics of Compact Fluorescent Fixtures." *Proceedings of the 1990 HVAC & Building Systems Congress.* LBL-28791, Seattle, WA: N.p. October 7-12, 1990: 1-13

Singh, Harmohindar, Mallik, Arup K., Kapur, Arjon. "Industrial Lighting Practice and Potential." *Strategic Planning and Energy Management.* Summer 1989: 26-37

Stein, Benjamin, Reynolds, John S. *Mechanical and Electrical Equipment for Buildings.* New York: John Wiley & Sons, 1992. 847

Tester, Wood, and Ferrari editors. *Energy and the Environment in the 21st Century.* Cambridge, MA.: The MIT Press, 1991.

The White Paper on the Environment, Environment Agency of Japan

Turner, Wayne C., Ram, Thiagarajan. "Electronic Ballasts." *Energy Engineering.* Vol.90, No.1. 1993: 6-19

U.S. Congress, Office of Technology Assessment, *Building Energy Efficiency,* OTA-E-518(Washington, DC: U.S. Government Printing Office, May 1992

U.S. Department of Commerce. *U.S. Industrial Outlook 1990.* Washington, D.C.: U.S. Department of Commerce. January 1990.

Wolcott, David R. "Stockhom Conference Focuses on Conflict Between Integrated Resource Planning and Deregulation." *Energy Efficiency Journal.*.Volume1, No.6. 10-13

Yoshida, Hajime, Maekawa, Tetsuya. "Some Experiences of Utilization of Urban Waste Energy by means of Electric-driven Heat Pumps." *Heating, Air-Condtioning and Sanitary Engineering.* Vol.66, No.6. 419-424