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PHOTOVOLTAICS AND THE NATIONAL PARK SERVICE: AN INSTITUTIONAL ANALYSIS

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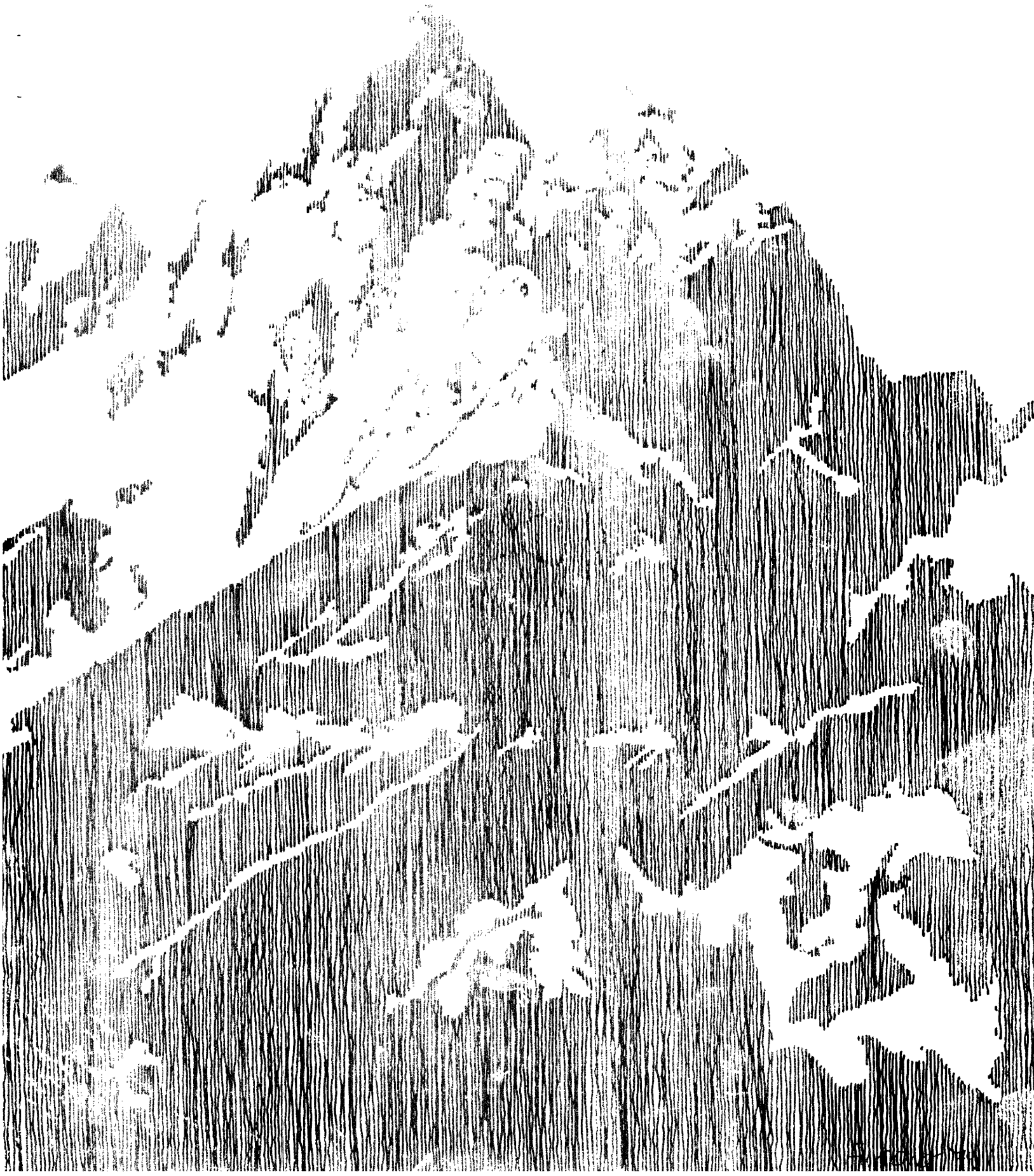

ABSTRACT

This paper is one of a series resulting from institutional analysis of photovoltaic (PV) acceptance. The case reported here involves the acceptance of PV by the National Park Service. As part of the Department of the Interior, the NPS is an agency exemplifying the federal non-defense sector. A modified organizational set model which concentrates on exchanges between and among organizational set elements, was used in this study. Though initially the inquiry from the Department of Energy to NPS to do a PV field test at a NPS site was considered the perturbation prompter, preliminary exploration showed an earlier perturbation--the need for energy conservation. The differentiations which followed on this perturbation provided an envelope within which PV was subsequently considered and accepted. This envelope made an otherwise incomprehensible innovation more comprehensible by its association with an ongoing routine of acceptance of energy conservation initiatives. The critical role of the NPS's Denver Service Center as an innovation mediator is described. The DSC serves such a function routinely for the NPS, a reality which greatly enhances the likelihood of acceptance of innovations disseminated through this institutional entity.

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CONTENTS

This paper is one of a series resulting from institutional analysis of photovoltaics (PV) acceptance. These studies are undertaken with sponsorship of the US Department of Energy (DOE) as part of its Photovoltaic Program. In addition to institutional questions, DOE is interested in economic, marketing, and technological issues, and is sponsoring a series of studies and field tests on these topics. Institutional analysis studies have typically been undertaken related to particular PV field tests, though in some cases studies have focused on comparable technologies and institutional forces influencing their acceptance.

This paper reports the results of institutional analysis related to the acceptance of PV in the non-defense federal sector, specifically by the National Park Service. The study was undertaken in connection with a field test of PV providing full power at the National Bridges National Monument site in the Four Corners area of Utah. Turn on date for the field test is estimated for late summer, 1979, with a power rating of 100 kw peak. The field test is being conducted by MIT's Lincoln Laboratory (LL) in collaboration with the National Park Service (NPS).

In reporting the institutional analysis undertaken in connection with this field test, this paper first briefly presents the theory and method of institutional analysis, then describes sequentially the application of that method to the NPS field test. The paper concludes with findings pertinent to DOE's concern with facilitation of PV acceptance.

Theory

An "institution" is defined as a discernible entity that carries or is the repository for social meaning. (For a detailed discussion of these theories, see Nutt-Powell, et al., 1978.) Institutions are characterized by function (finance, regulation, research, and so on); activity (marketing, analyzing, legislating, enforcing and so on); and role (vendor, linking-pin, translator, and so on). There are six types of institutional entities: formal and informal organizations (the US Department of Commerce; a pick-up softball team); members (a GE executive); persons (Joseph Jones); collectivities, whether known or unknown to members (the Taxpayers Revolt); and social orders (the importance of good design). Institutional entities combine and interact to form an institutional arena. Within that arena, exchanges occur between and among institutional entities; institutions are stability seeking and routine establishing. Exchanges between and among institutions, which occur over time, combine to create a resource configuration. Institutional analysis is the study of how and in what forms social meaning is created, transmitted, maintained, and/or changed. The particular structure of a given institutional arena is simultaneously stable and changing, but it is identifiable. Information in exchanges is the key source of data for institutional analysis.

Innovation (such as the introduction of PV into the Nebraska agricultural sector) is a deliberate and substantive alteration in the institutional arena. Once again, information is vital, for it is the currency of innovation; it is of two types: (1) Technical -- What do you trust?; and (2) Personal -- Whom do you trust? Exchanges within the institutional arena exhibit one or both types of information. Because

institutions are stability seeking, and routine establishing, they are considered to be "risk averse." Innovation creates the condition for risk by disrupting social meaning. Rather than attempting to maximize benefits (which would support rapid acceptance of innovation), the institutional arena tends to minimize risks (which leads to resistance to the quick adoption of innovation). Institutions are more likely to accept an innovation (i.e., institutionalize it) if their information about that innovation is personal rather than technical, since such exchanges are more likely to link to routine, stable meaning, thus creating some confidence that risk has been minimized.

Method

There are seven steps in conducting an institutional analysis:

(1) Identify the sector (i.e., economic, geographic) to be studied, determine study objectives.

(2) Prepare a preliminary sector exploration -- an overview that could be applied to any location-specific sector

(3) Construct an hypothesized institutional arena

(4) Identify the "perturbation prompter"

(5) Devise the specific research design

(6) Monitor perturbations

(7) Analyze the institutional arena.

It is important and sometimes confusing to remember that the researcher him/herself is an institutional entity, engaged in exchange within the institutional arena. When performing an institutional analysis of innovation, it is also important to handle well the "gnat on the elephant" problem. That is, it is necessary to have an innovation which is sufficiently significant to cause perturbations that will be taken

seriously within the institutional arena. However, the innovation and its perturbations may well "poison the well," that is prompt institutional exchanges that would be characteristic only of such experiments. Thus some innovations are less suitable than others for research and demonstration-based institutional analysis. The selection of perturbation prompters must be guided by the recognition that such prompting must come via an already accepted (institutionalized) credible means if it is to be perceived as worthwhile, but it must not be so unique that it reflects only the experiment itself.

INSTITUTIONAL ANALYSIS OF PV ACCEPTANCE BY THE NATIONAL PARK SERVICE

Sector Identification and Study Objectives

DOE's basic mission is providing for the energy needs of the nation. Solar energy, as a renewable resource, is an integral part of DOE's program to achieve its objectives. Many of the applications of solar energy must respond to market constraints, hence the necessity for economic and marketing studies. However, applications in government uses are not constrained by the same market conditions. Presumably policy directives from appropriate executive and/or legislative sources could prompt use of solar as opposed to other energy resources by government entities. This study is directed toward determining the accuracy of this presumption.

DOE's status as a federal agency determined a focus on the federal (as opposed to regional, state, local or special authority) government level. At the federal level a distinction can be made between defense and non-defense agencies. This distinction has important ramifications in the making and implementation of policy. It also has implications for the process of institutional analysis, if for no other reason than the pragmatic limitations which security clearance places on an analyst's access to data. Thus the federal non-defense sector was chosen for study. The National Park Service (NPS) was selected as the agency for specific study as consequence of the interagency agreement it was concluding with DOE which would lead to the installation of a PV system at Natural Bridges National Monument in Utah. Thus the particular study focus was on the various institutional factors which influenced the decision of NPS to adopt PV.

Preliminary Sector Exploration

A preliminary sector exploration involves two activities: (1) the preparation of an overview of the sector, defining in an aggregate sense characteristic functions and activities of the sector; and (2) location-specific background investigation to identify for the particular arena being considered the institutional structures. This background information serves as the basis for the creation of an institutional arena for the immediate study.

A detailed preliminary sector exploration of the National Park Service is reported in Siczewicz and Nutt-Powell (1979). The primary mission of the NPS is to make federally-owned land available to the public in a manner which enhances the use and enjoyment of natural and historic resources. NPS has nearly 300 operating units, the most familiar of which are national parks, monuments and historic sites. The NPS has a typical hierarchical organizational structure, beginning with the operating units, which are organized by regions, each of which reports to a central administrative unit in Washington, DC. That unit in turn has a reporting responsibility to the Department of Interior's Assistant Secretary for Fish and Wildlife and Parks. In addition to this "line" reporting structure, the NPS has two "staff" units identified as service centers. These units, the larger of which is in Denver, provide a variety of technical and support services to the operating units, as well as carrying out special tasks for the central administration. Because the basic question for this study is the acceptance of a new technology, the preliminary sector exploration reviewed the procurements process. NPS procurements contributing to program activities are governed by the Interior Procurement Regulations (IPR), which in turn are

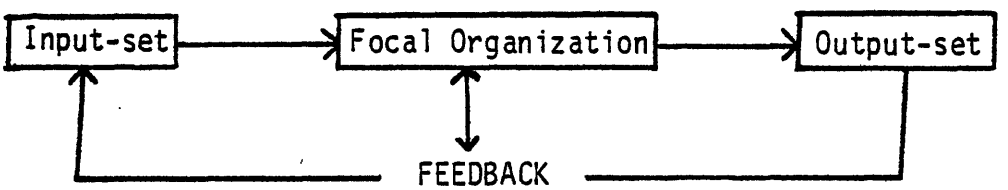
substantially based on the Federal Procurement Regulations (FPR). One regulation limits procurements to proven technologies, which constitutes a formal barrier to innovation acceptance.

Hypothesized Institutional Arena

Unlike the study of agricultural applications undertaken as part of this project, the federal non-defense sector does not lend itself to geographic boundings. (See Nutt-Powell et al., forthcoming.) Resource and information flows tend to be organized and manifest by particular organizational objectives (and interorganizational constraints) rather than physical location. Thus in devising an hypothesized institutional arena for governmental sectors, a model is needed which can capture the information flows and resource allocations of agencies and account for organizational and interorganizational behavior. After some consideration a modification of the "organizational set" model of interorganizational relations was developed for use in this study. (Evans, 1973). This model concentrates on exchanges between organizational set elements.

The organizational set model is an open systems approach using input, output and process elements, and feedback effects. Analysis occurs at three levels: (1) the subsystems of an organization; (2) the organizational system; (3) the suprasystem. The relevant analytic level for purposes of this study is the suprasystem, which is studied by examining the network of interactions of an organization (designated the "focal" organization) with the organizations in its environment. These organizations can be divided into two categories: input and output. The set of input organizations provides resources to the focal organization, while the set of output organizations receives goods and/or services

generated by the focal organizations. Feedback effects flow from the output-set to both focal organization and input-set; and from focal organization to input-set. Thus,

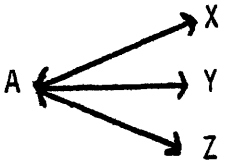


The focal organization may be at any level of aggregation. For example, in the federal non-defense sector it could be a department (Department of the Interior), an agency (National Park Service), and office (Rocky Mountain Region), or a service point (Estes Park). Depending on the question under study, analysis may stress only the input-set, or the output-set, or the feedback effects. At least three dimensions of the input and output-sets can be examined: (1) size; (2) diversity, in terms of apparent missions; (3) interaction patterns. This last dimension is known as the network configuration. Four types of network configuraton are postulated:

(1) the dyad

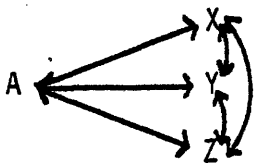
focal organization interacts with an individual organization or class of organizations in the input- or output-set

(2) the wheel



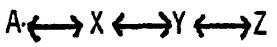
focal organization interacts with more than one organization of a particular type; no interactions among members of the set

(3) the all-channel



all members of the set interact with all others and with the focal organization

(4) the chain



a series of interdependent organizations with only the first having direct interaction with the focal organization

Variations and combinations of these four basic configurations are possible. The network configurations will have consequences for the nature of interactions between and/or among the focal organization set members, creating behaviors characterized by conflict, bargaining, cooptation, amalgamation, domination, and so on. In addition the network configuration will have impacts in the internal processes of the focal organization. Since interactions occur through individuals (however much the tendency to personify organizations), it is also important to recognize the characteristics of the interacting individuals (including numbers), preparation for the interaction (formal education, experience), position in the organization and reference group.

This organizational set approach allows for the development of an institutional arena based on input → throughout (transformation) →

output model. To determine whether an organization is the input- or output-set the analyst adopts the perspective of the focal organization, and asks whether the organization being considered provides resources or improves the provision of resources to the focal organization, or receives resources and/or services from the focal organization. To assist in the determination, the purposes of the focal organization must be identified, so that a judgment can be made as to whether the organization being considered contributes to or benefits from focal organization purpose realization. Complicating this decision is feedback from the output-set to the focal organization and input-set. In some cases the provision of information to the focal organization may cause an organization to be placed among the input-set, while in other cases it will be termed "feedback" (or, a reaction to outputs of the focal organization) from a member of the output set.

For this study, the National Park Service Region is used as the focal organization. The purposes of a NPS Region are to provide resources to individual parks, as well as to provide resources to the entire NPS system. Placing the NPS region into the model yields the following representation:

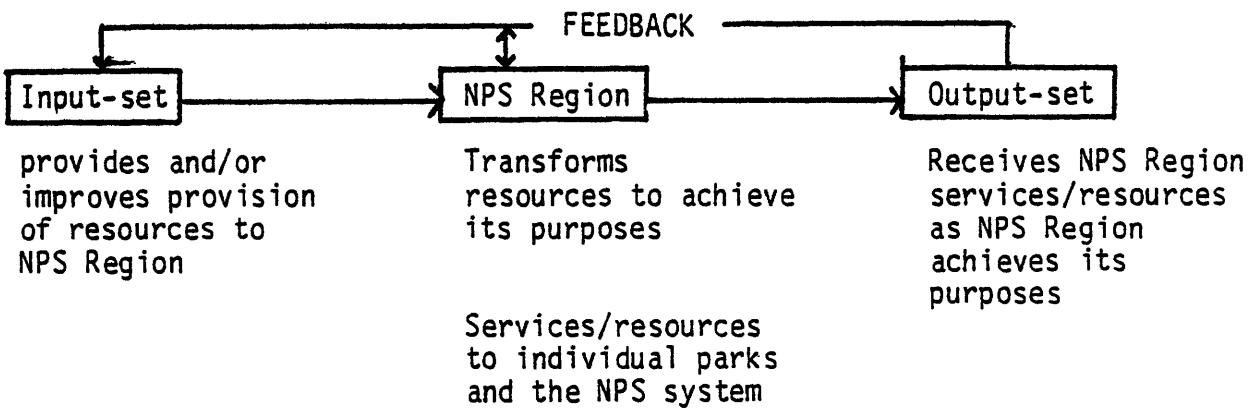


Table 1 presents the hypothesized institutional arena of the NPS Region (the focal organization of the federal non-defense sector under study) organized by function, activity, institutional entity, and typical actions. Table 2 presents the same hypothesized institutional arena organized into input- and output- organizational sets, noting the functions performed by these institutional entities. These two tables were devised based on data gathered through a literature search in June, 1978, supplemented by interviews with NPS staff in July and August, 1978. (A more detailed discussion of The National Park Service, describing in detail each of the institutional entities presented here, is found in Siczewicz and Nutt-Powell, 1979).

TABLE 1 Hypothesized Institutional Arena, Federal Non-Defense Sector, National Park Service

Function	Activity	Institutional Entity	Typical Actions
RESEARCH	Analyze	National Park Service, DC Office	Studies
	Analyze Report	Denver Service Center	Studies on request; EIS
	Analyze Inform	National Park Service Region NPS-Unit	 Studies Studies
		NPS contractors	Studies
		University	Studies
POLITICAL	Adjudicate Analyze Endorse Supply	Congress (elected; staff)	Authorize and study
	Analyze Control	President Agencies	Policy
	Analyze Assist Control Adjudicate	DOI- Administration	Policy Congressional Relations
	Advocate	DOI- other branches	Exploit and/or conserve resources
	Inform Endorse Promulgate Advocate	Interest groups	Use, lobby
	Advocate	State and local government	React to actions of NPS

TABLE 1 (continued)

Function	Activity	Institutional Entity	Typical Actions
PRODUCTION	Control	President	Executive order
	Legislate	Congress	Authorize and appropriate
	Supply	NPS-Region	Request and allocate
	Assist	Denver Service Center	Design; contract; oversee
	Supply	Forest Service	Land transfer
	Inform	Ranger	Initiate request
	Make	NPS unit builders/contractors	Changes Build
	Control	Procurement regulations OFPP; SBA; OMB	Constrain
	Supply Make Control	GSA	Build and buy
FINANCIAL	Finance Analyze	Congress (CBO; CBCs)	Appropriate Study, monitor
	Analyze Control	President (OMB)	Budget apportion
	Analyze Control	DOI -- Adm	Budget; apportion
	Control	Region	Prioritize
	Report	NPS Unit	Request
	Analyze Investigate	GAP	Evaluate
	Finance	Users	Pay

TABLE 1 (continued)

Function	Activity	Institutional Entity	Typical Actions
SERVICE	Supply Control	NPS Unit	Resource availability conservation
	Advocate Assist	DOI-Adm	External relations; PR
	Assist	NPS-DC office	Administration
	Assist.	NPS-Denver Service Center	Technical assistance
	Market	Concessionaries	Selling
SOCIALIZATION	Advocate	DOI branches Forest Service	conserve; exploit
	Educate Advocate Inform	Interest groups	Value advocacy; awareness
	Educate	Park Practice Program Park Ranger Assn NESA NEED	Awareness

TABLE 2 Hypothesized Institutional Arena, Federal Non-Defense Sector, with National Park Service Region as Focal Organization

Input-Set	Output-Set
Department of the Interior - Administration (Service, Political)	NPS unit (Service, Finance, Production, Research)
National Park Service -- DC Office (Political, Service, Research)	Concessionaries (Service)
National Park Service -- Denver Service Center (Service, Production, Research)	Government Accounting Office (Finance)
Congress (Finance, Production, Political)	Users (Finance)
President (and OMB): (Finance, Production, Political)	Ranger (Production)
Procurement regulations (Production)	Builders/Contractors (Production)
General Services Administration (Production)	Interest Groups (Political, Socialization)
Cabinet Secretaries (Political)	Other agencies (Production, Socialization)
Contract researchers (Research)	State and local government (Political)
University and other non-NPS generated researchers (Research)	Park Practice Program (Socialization)
	Park Ranger Association (Socialization)
	Department of the Interior, other branches (Political, Socialization)
	NESA, NEED (Socialization)
	University and other non NPS-generated researchers (Research)

Perturbation Prompter/Specific Research Design

At the initiation of the study it was thought that the opportunity to test a PV system was the perturbation prompter for the National Park Service, and that DOE, through Lincoln Lab, was the initiating source. Information obtained during the preliminary sector exploration (summer, 1978) indicated that for NPS, PV was being considered as a solution for a problem occasioned by another perturbation, namely the energy crisis. This introduced the possibility that PV use by NPS may not have been simply the adoption of a single innovation by an organization, but the adoption of a stream of innovations as a result of an exogenous shock -- the oil crisis and the changes in policy it brought.

While PV is itself an innovation (necessitating certain adjustments in organizational activity as a consequence of its intrinsic attributes), its introduction into the NPS was not that of an innovation into an undisturbed (or unperturbed) environment. Thus the initial suppositions about the focus of the study were altered. Rather than studying the sequence of events beginning from a perturbation occasioned by DOE and/or LL contact with NPS, the study took as its point of initiation the energy crisis dating from the winter, 1973, and followed the events through the point of acceptance by NPS of PV as a solution for its energy needs.

The innovation under consideration, then, is energy conservation, and the manner in which that concept was differentiated to the point of using a discrete solar energy solution -- namely photovoltaics. The approach in assessing NPS response to this perturbation is case study preparation. A series of five hypotheses was developed concerning the time stages of innovation differentiation and acceptance on the part of NPS:

H_{t1}: Energy conservation need is the innovation.

H_{t2}: Energy conservation in building design is the innovation.

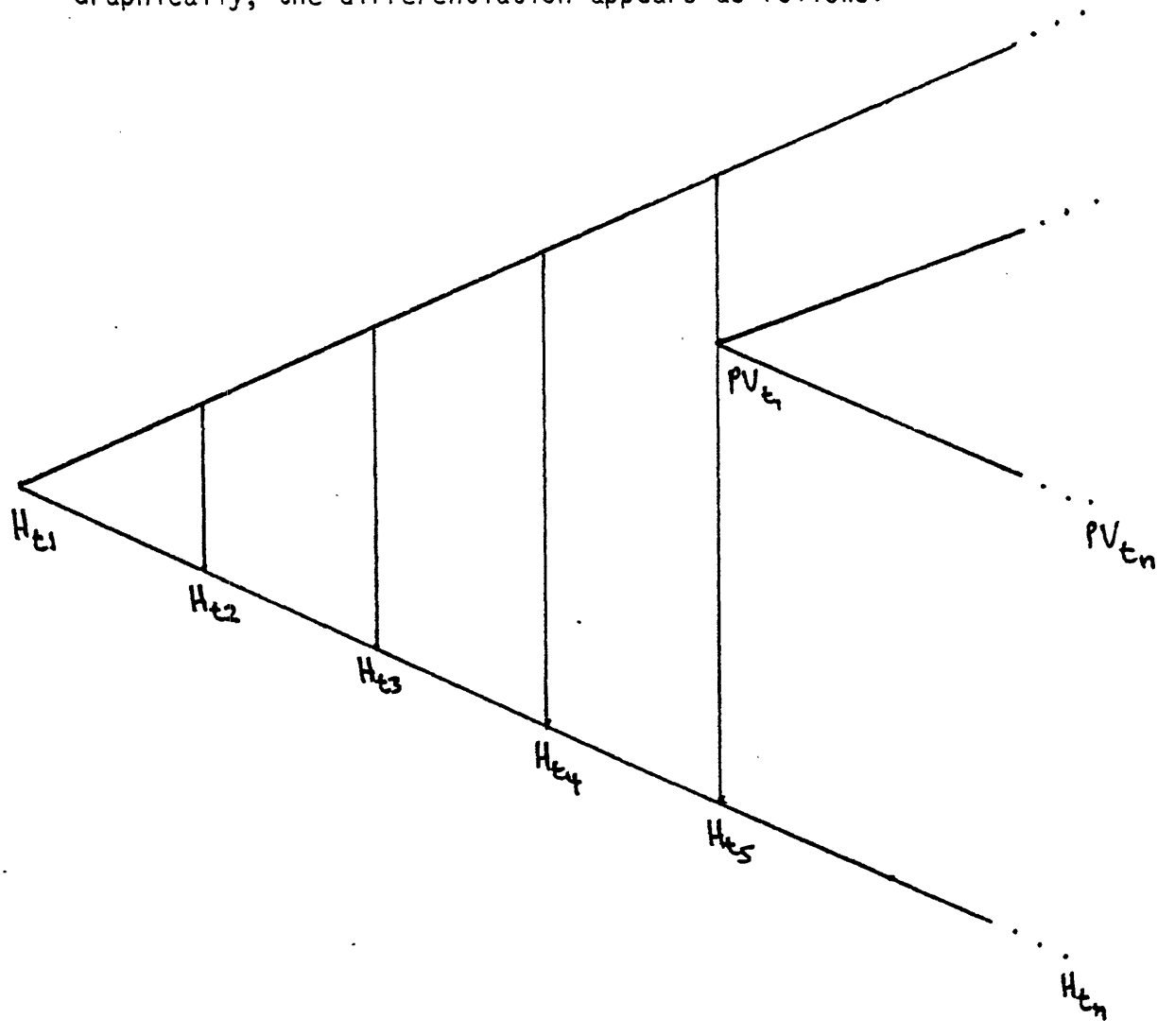
H_{t3}: Energy conservation in building design specifications (materials, building type) is the innovation.

H_{t4}: Energy conservation by use of renewable resources is the innovation.

H_{t5}: Energy conservation using photovoltaics is the innovation.

Each hypothesis suggests increasing differentiation, as something previously incomprehensible (energy conservation) became increasingly comprehensible.

Graphically, the differentiation appears as follows:



Each point in time represents an increasing differentiation of the innovation -- energy conservation. One can also postulate a comparable differentiation process for the innovation -- photovoltaics. This second innovation differentiation process occurs within the process which continues to occur for energy conservation. It is possible to initiate the PV differentiation process because it fits within a more developed (that is to say, comprehensible) innovation differentiation process -- energy conservation. It is this incorporation within the now comprehensible innovation -- energy conservation -- that enables PV (an innovation, as yet technologically unproven) to be accepted by NPS as "proven," a requirement imposed by procurement regulations.

The study focus therefore was directed to determining if the hypothesized sequence of events (differentiation) is accurate, and the extent to which the NPS response to the perturbation prompter (the energy crisis) was handled in a routine way (that is, a routinized procedure for handling "new things") or an innovative way. We are especially lead to this last consideration because of the existence of the Denver Service Center, an entity within the NPS which has as its routine activity the provision of technical assistance for difficult problems (that is, those occasioned by perturbations).

The two roles which might be performed by the Denver Service Center which would facilitate adoption of innovations are:

(1) Searching for an innovative way to solve a problem which has high priority/significant impact;

(2) Awareness of the existence of innovations and finding ways to incorporate them in the mainstream of organizational processes. (Radnor, Feller, and Rogers, 1978).

The study also examined the potential role of NPS's rules, regulations and practices (especially regarding procurement) in the acceptance of innovation. Results of the preliminary sector exploration suggested that procurement regulations were direct formal barriers to innovation. Further the procurement process itself seemed to encourage conservative behavior on the part of bidders on "new" work, which would be manifest in higher cost estimates than those for "routine" work.

The primary data collection mechanism used in the study was personal interviews, focusing on historical recollection of events and actions leading to the NPS decision to use PV. These data were supplemented with an analysis of written documentation (memoranda, meeting minutes, letters, publications, and so on) because this documentation represents a substantial portion of interorganizational exchanges. Primary data collection occurred during January, 1979. A chronological summary of key documents and events is provided in Appendix 1.

Findings

The hypothesized stream of linked innovations based upon energy conservation innovation appears to be valid, although, as one might expect, the historical record shows a more detailed differentiation process than that hypothesized. The stream of innovation differentiation and acceptance as revealed by the record may be summarized as follows:

D_{t1}: Energy Conservation (EC) need is the Innovation (I).

D_{t2}: EC effects is the I.

D_{t3}: EC is institutionalized /formalized is the I.

D_{t4}: Analysis of energy shortage effects is the I.

D_{t5}: Need for EC innovation is the I.

D_{t6}: Analysis of alternative energy sources is the I.

D_{t7}: Analysis of solar energy possibilities is the I.

D_{t8}: Solar thermal heating and cooling is the I.

D_{t9}: Photovoltaics is the I.

D_{t10}: Consideration of design aspects (aesthetics) related to solar energy use is the I.

D_{t11}: Institutionalization of solar energy applications is the I.

D_{t12}: Search for building design/materials which meet EC needs is the I.

Our search of historical records revealed a first specific introduction of the need for energy conservation in May, 1973. An architect had submitted a memorandum on designing for energy conservation to the House Sub-Committee on Conservation and Natural Resources. This sub-committee has oversight responsibilities for the National Park Service. The memo generally argued that the Department of the Interior, and NPS in particular, had a major role to play in energy conservation. The memorandum was transmitted from the sub-committee to the NPS, and in turn to the regions and the Denver Service Center (DSC). The argument here was readily comprehensible to NPS personnel, turning as it did on the conservation responsibilities of the agency.

Thus it is not surprising to find a rapid move to D_{t2}, as evidenced in a memorandum in late June, 1973, from the NPS Director to the administrative units regarding the particular role NPS would have in the energy conservation efforts of the country, and noting in particular the impact this would have on park use and programs. The memorandum pointed out a probable shift in users and their interests, and the needs to begin considering the effects of energy conservation on park use, operations,

educational programs, and park design; it also mentioned a consideration of new technologies. This memorandum anticipated by two days President Nixon's public message on a federal energy reduction program.

In early July, 1973, GSA issued regulations on energy conservation in buildings. These regulations were quickly followed by a memorandum from the NPS Associate Director establishing an energy conservation system, including a reporting procedure and designation of energy conservation coordinators at unit, region and central levels. These actions initiated D_{t3}, the institutionalization/formalization of energy conservation activities. The implementation of this stage provided the basis for a subsequent differentiation, and hence new stage, involving the analysis of energy shortage effects. By December park superintendents were submitting memoranda to regions on the effects of energy shortages, evidence of D_{t4}. By this time, also, the OPEC oil embargo was influencing national behaviors. In late December the NPS Acting Director sent a memo to all regions on forming an Energy Conservation Action Group.

In the six months which had elapsed from the NPS Director's June 27 memo on energy conservation, additional stages of differentiation had occurred. The oil embargo confirmed the conclusions of D_{t5} on the need for energy conservation innovations, and D_{t6}, which focused on an analysis of alternative energy sources. (Though neither have written records, both were reported in personal interviews with NPS staff.) Thus in January, 1974, a NPS notice seeking organizations to study NPS sites for possible solar technology use appeared in the Commerce Business Daily. Congressional support for this initiative was also evidenced in a February memorandum from a House oversight sub-committee staffer to the NPS on projects which might qualify for application of solar energy

techniques. The emphasis on solar energy possibilities was further reinforced in an early March memorandum from the NPS Associate Director on solar policy and solar energy applications. By April the solar energy efforts had further differentiated to an emphasis on solar thermal (D_{t8}), as evidenced in a memo on R&D projects of the Denver Service Center-NPS, noting two projects where the DSC was working with leading solar consultants to develop, with NPS funds, prototype systems at two locations.

Evidence of innovation acceptance (that is, the fruition of D_{t3}) is found in NPS's speedy NPS approval of a request from the DOI Office of Management Operations to give presentations about the department's Energy Conservation Program during the Regional Superintendent's conference. By now this topic was a routine for the NPS. Energy conservation was also routine for DOI, as it issued a departmental manual on the program in June, 1974, requested information on energy saving strategies and actions of agencies, and in July issued standardized forms for quarterly energy conservation reports.

In August, 1974, Howard Haiges was named energy coordinator of the DSC. This both culminated the acceptance of energy conservation, and initiated a new round of differentiation. Haiges began a systematic effort of finding possible projects and sources of funding for various new energy initiatives, notably in solar. In November, 1974, an inquiry was directed to HUD, with copies to NASA and NSF, expressing interest in participating in demonstration projects. This paralleled the congressional push for solar legislation, which resulted in the Solar Heating and Cooling Demonstration Act, signed in September, 1974.

Interestingly, there was no evidence of further differentiation in 1975. This is attributed to two primary causes. First, NPS was consolidating the very rapid advances in innovation acceptance of 1973 and 1974. Indeed the stages of differentiation identified occurred in a 16-month period, beginning with the architect's memo to the House sub-committee in May, 1973. Second, the passage of the Solar Heating and Cooling Demonstration Act meant that an hiatus would occur, allowing necessary administrative structures for implementation to be created. Indeed the legislative process of creating the statute had seen five different committees claim jurisdiction; its implementation involved three different agencies (HUD, ERDA, NASA). With the administrative responsibility for new solar efforts now assigned to a different agency, NPS had to wait for others to take next steps.

In September, 1976, a memorandum of understanding was signed between ERDA and DOI on solar applications and sites. NASA's Marshall Space Flight Center, which was taking a lead for ERDA in implementation of various solar thermal applications, was dealing directly with Haiges and the DSC, as evidenced in a memo in late September. This formalized solar innovation network served as the mechanism to move to the next differentiation stage, D_{t9}. In October, 1976, a memorandum was sent from MIT's Lincoln Laboratory to NPS-DSC on Lincoln Lab's photovoltaics field tests and applications program. Lincoln Lab had been directed to the DSC by the NPS Chief Scientist, a central administration position which had been created during D_{t3}. Haiges in turn communicated this information to all DSC unit managers. Meanwhile the process for use of solar thermal continued, as memoranda on possible solar sites came to DSC, and in turn were culled, and sent on to NASA-Marshall. The first of

the NPS-initiated solar uses, the Lovell Visitor Center at Bighorn Canyon, became operational during the fall.

In early 1977 the first indications of D_{t10}, the consideration of design aspects (especially aesthetics) related to solar energy appear, as DOI's Assistant Secretary for FWP is frustrated in efforts to put major solar projects into the District of Columbia. In mid-1977 NASA begins installation of heavily instrumented solar thermal systems at four locations. In August the Mount Rushmore Visitor Center becomes operational. In November the first signs of D_{t11} appear, with NPS reprogramming its funds to cover higher costs for the Yosemite application, which originally were to have been covered by NASA.

By December the differentiation process for PV (D_{t9}) was well advanced, with a draft interagency agreement between NPS and MIT-Lincoln Lab (on behalf of DOI and DOE) on a field test at Natural Bridges National Monument. This was further confirmed in July, 1978, with reprogramming of NPS funds for the project.

The final differentiation stage which we found (D_{t12}), a search for new building designs/materials for energy conservation needs, appears in June, 1978, with an inquiry from DSC to DOE on appropriate energy technologies. It is advanced in November, 1978, with an exploration of the utility of mound underground shelters.

Conclusions

The National Park Service path to acceptance of photovoltaics is indeed much as hypothesized. An initial "grand innovation", in this case energy conservation, proceeds through stages of differentiation. Each stage builds on the routines established in prior stages; these routines provide a structure of comprehensibility which enable the ready incorporation of subsequent innovations and/or innovation differentiations.

In the context of the organizational set model discussed earlier in this paper, the NPS region was identified as the focal organization. The primary components of the input set were the country's energy situation (notably the oil embargo), the House oversight sub-committee, major executive agencies (notably GSA), DOI/NPS central administration and, especially, the Denver Service Center. The primary output components were the park units, which provided feedback to the input units, especially on the various programmatic initiatives in energy conservation.

Interestingly, as the innovation became more differentiated the DSC, as a routine support unit focused on interpreting new things, played an increasingly critical role. Indeed the DSC manifest qualities of both of the innovation adoption facilitation roles it could have followed, namely innovation searching, and innovation incorporation. As a staff agency the DCS took a high priority problem--energy conservation innovation need--and sought out an innovative solution--solar energy, both thermal and PV. Under Haiges' direction, means of incorporating the innovation into NPS routine activities were also devised.

What is especially interesting here is how the NPS was able to find a routine way to incorporate these innovations. The DSC is established specifically to assist NPS units in dealing with things they cannot routinely handle. Thus when a need for a major effort in energy conservation--and then new energy technologies--arose which NPS units were unequipped to handle the DSC was available as an existing (read routine) mechanism to handle the unfamiliar. Thus the NPS did not have to create an innovative response mechanism to accompany the energy conservation as innovation need.

That is not to say the acceptance of the innovation, and its subsequent differentiations, proceeded without difficulty. The most evident area is in procurement where vendor fears about new technologies resulted in bids considerably higher than estimated (1.5 to 3 factors higher), and fewer bidders. The combination of detailed public scrutiny common under FPR and vendor unfamiliarity with the work (despite NPS assertions that it was "routine") provide a significant barrier. This may mean that such situations call for negotiated contracts, selecting from an "innovative bidders" list.

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APPENDIX 1

Chronological Record of Events and Documents Relating to NPS Acceptance of Photovoltaics

1973

May 1: Memo from Leo Daly, AIA, to the Hose Sub-Committee on Conservation and Natural Resources, re: Design Aspects of Energy Conservation. Copy sent to NPS and out to regions and Denver Service Center.

June 27: Memo from Director (NPS), re: conservation of energy and its effects on park use, day-to-day operations, environmental education, design, new technologies.

June 29: President Nixon initiated the "Federal Energy Reduction Program" in his Energy Statement to the public:

- pledged that federal government would achieve a 7% energy use reduction over the succeeding 12 months,
- Office of Energy Conservation (which later became part of the Federal Energy Office) was delegated responsibility for managing and coordinating the effort.

June-December Staff reviews of possible innovations, alternative energy sources.

July 11 In order to comply with Nixon's government-wide Energy Conservation Program, the GSA established more stringent regulations, re: energy conservation in buildings (temperature, lights, etc.)

July 20 Memo from NPS Associate Director to staff

(1) established park conservation coordinators and energy conservation plans -- plans flow from park conservation coordinators to regional conservation coordinators to the NPS conservation coordinator.

(2) energy consumption reports from parks to regions to NPS

November 27: GSA bulletin FPMR D-101

- identified measures to conserve energy in public buildings during summer and winter.

December: Memos from park superintendents to their employees about energy conservation.

Memos from park superintendents to region about effects of energy shortages.

December 27: Acting Director of NPS sends out memo to all regions about forming an Energy Conservation Action Group to be coordinated by NPS Associate Director for Park System Management in response to:

December 27: Federal Energy "Czar" William Simon indicates that a stand-by rationing system might go into effect.

1974

January 3: In the Commerce Business Daily, NPS sought organizations to study NPS sites for possible NPS use for solar technologies.

January 16: Memo by Walker (NPS Director) indicating ways that NPS would be affected by gas shortage.

January: Federal Management Circular 74-1: Energy Savings Program.

February 7: Memo to NPS Staffer from House Subcommittee Staffer re: FY75 construction program; those projects which might qualify for application of solar energy techniques were indicated.

February 15: GSA Federal Property Regulations, re: energy conservation in buildings.

March 6: Memo from Associate Director (NPS) of Park System Management to Director (NPS), re: (1) solar policy - use of it should move ahead; (2) memo should be sent to regions indicating solar energy should be considered for all new structures and reconstruction.

March 18: Memo from Norton (Regional Administrator, GSA) to Regional Director (NPS) about sharing energy conservation ideas.

April 19: Memo "R&D Projects of the DSC-NPS" indicates that DSC is engaged in projects for the solar heating and cooling of park facilities.

- DSC is working with leading consultants to develop prototype systems:
  - Big Horn Canyon
  - Pecos National Monument

May 8: From Ciotti (Office of Management Operations-DOI) to NPS suggesting that OMO give presentations about Energy Conservation Program during the Regional Superintendent's conference if NPS approval given.

June 12: Departmental Manual Release 1649 (DOI) established a formal energy conservation program within DOI.

June 27: OMO within DOI requested information relative to strategies and actions taken to save energy within DOI.

July 20: Standardized forms adopted by DOI for the Quarterly Energy Conservation Reports.

July 22: Memo from Associate Director for Park System Management to the Regions requesting the compilation of "Energy Conservation Briefs" about unusual conservation methods in the parks.

August: Memo A98-DSC-PR named Howard Haiges as energy coordinator for DSC-NPS.

September: Solar Heating and Cooling Program signed by President

October: Memo from DC to NPS Administration indicating the NPS energy conservation policy.

November 3: Letter from DSC sent to HUD expressing interest in receiving funding assistance form demo projects in housing and information so that NPS could keep abreast of solar energy technology; - copies sent to NSF and NASA.

1975: No evidence

1976

September 15: Memo of understanding sites, applications between ERDA and DOI re: solar.

September 21: Memo from Gunner NASA - (Marshall Space Flight Center) to Haiges discussing possible sites for solar thermal.

September: Lovell Visitor Center (Bighorn Canyon) became operational.

October 12: Memo from Ross Peatfield (MIT Lincoln Lab) to Hannenberger (NPS, Denver) and Haiges explaining the nature of the MIT-Lincoln Lab program.

November: Memos about possible solar sites

November 9: List of possible solar thermal sites sent to Gunner, NASA.

November 10: Memo from Haiges to all DSC unit managers explaining the MIT-Lincoln Laboratory program

1977

Early 1977: Herbst, Assistant Secretary for FWP, wanted to expand use of clean energy. However, major projects couldn't get passed. NPS finds it difficult to do projects in DC., because of Fine Arts Commission's impact on any modifications to structures.

February: Carlsbad & Yosemite chosen as sites for solar thermal. (NASA)

Mid 1977: NASA project put in heavily instrumented solar thermal systems in four places - installed "free."

July 20: Executive Order 12003 on Energy Policy and Conservation.

August: Mount Rushmore Visitor Center became operational - NASA-funded.

November 18: $53,000 was programmed for Yosemite, but low bid was $91,900; initially it was thought that it would cost NPS nothing, but then costs rose to $35,000 to $53,000 to $91,900 - NPS.

December 2: Draft Interagency Agreement between NPS and MIT-Lincoln Lab (DOI and DOE).

December 14-15: Orientation trip to Natural Bridges National Monument by NPS and MIT-Lincoln Lab.

1978

June 2: Letter from DSC to DOE - San Francisco, re: Appropriate Energy Technology which might be employed at various NPS sites.

July: $32,000 reprogrammed for NBNM solar energy project.

August: Energy Conservation & Management Program Plans for DOI, NPS, and NPS-regions.

- Each Region had to submit a list of Energy Conservation demonstrations
- solar applications are popular to submit.

November 1: Staff Directive 78-1-: use of metering of resource consumption in buildings.

- Mound underground shelters explored.