Network Infiltration:
Gaining Utility Acceptance of Alternative Energy Systems

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(ABSTRACT)

Our American electric system doggedly follows the central station model developed in the late 1800s. Thomas Hughes says the system gained momentum by adding more alliances with educators, politicians, and other industries until the social network was so intertwined with the technology that deviating from the central station model would be extremely difficult. However, change can occur if a variety of components change, but Hughes does not specify which components. Another network model, actor-network theory, proposes that social relationships (the same ones that maintain system momentum) are actually dynamic relationships that either actively maintain or change the system configuration. But which relationships need to change in order for utilities to accept and interconnect renewable energy with their grid?

This thesis focuses on the social relationships created around renewable technologies and the idea that they can be successfully integrated into the network. In each case, customers, utility executives, institutions, and technology worked together to bring about utility acceptance. Individuals, working within these institutions, can bring about change. In New York City, an urban windmill was installed atop an apartment building. In Sacramento, CA, the municipal utility, SMUD, broke from the system model to become a leader in energy efficiency and renewable energy programs. In Texas, their renewables portfolio standard has become a standard for others to follow.

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Acronyms

AWEA	American Wind Energy Association
Btu	British Thermal Unit
Con Ed	Consolidated Edison
CSA	Community Services Administration
EPAct	Energy Policy Act of 1992
ETF	Energy Task Force
IOU	Investor Owned Utility
IRP	Integrated Resource Plan
kW	kilowatt
kWh	kilowatt-hour
MES	Mature Electric System
PG&E	Pacific Gas and Electric
PSC	Public Service Commission
PTC	Production Tax Credit
PURA	Public Utility Regulatory Act
PURPA	Public Utility Regulatory Power Act
quad	Quadrillion Btus
RPS	Renewables Portfolio Standard
SB7	Senate Bill 7
SMUD	Sacramento Municipal Utility District
TPUC	Texas Public Utility Commission

Chapter 1: Introduction

Gaining utility acceptance of alternative energy systems. It's a daunting task. Recently I presented findings on conceptual designs for an energy center to a major eastern utility. My findings included integration of appropriate renewable technologies given the potential amount of "fuel" and the load characteristics. The company's summer grant program leader had this look on his face like "that was a waste of money." He had no interest in utilizing anything other than the gas turbines for which they had options.

Common sense tells us that as people get older, they become more conservative, less likely to accept change. Established institutions act similarly. Though small changes in the office may occur, the core business does not. The values, the mission, remain the same. We see this in our day-to-day lives, but Thomas Hughes has formalized this physical working of the world in a theoretical framework. Hughes calls it system momentum. As a technology constructs a support institution and establishes relationships with other institutions (i.e. manufacturing, transportation, government, education) it gains momentum and inertia. These characteristics make it difficult, though not impossible, to change the structure of the system.

So why do I want to beat my head against the proverbial brick wall of utility resistance to alternative technologies? Because the wall has chinks. Because utilities can and have integrated renewable energy technologies into their physical generation-transmission-distribution network. Bruno Latour's actor-network theory offers a clue to the location of change. The relationships between different entities[1] (people, institutions, technology, etc.) are dynamic. Since social relationships, according to Hughes, sustain a mature system's momentum, they can also be the locus of change. Therefore, utility acceptance of alternative energy can occur when its relationships with customers and/or other institutions change. In each of the three cases presented in this thesis, a fundamental change in these relationships initiates the utility's integration of alternative energy systems.

[1] Latour would label these entities either "actors" or "nodes" of a spider web-like network. The social and/or physical relationship between nodes represents the links (or network).

1.1 General Areas of Utility Resistance

For five years I worked as a consulting engineer in the energy industry. In those five years I learned that utilities, in general, do not consider renewable technologies for their energy mixes[2] and scowl at you when you do mention them. Utilities also often lump energy conservation expenditures in with public goods funds, and then do not fund the public goods beyond the state requirement. But why are utilities so unwilling to fully integrate renewables and demand-side options into their networks?

First, renewables combine high capital investment with low output. To recover the capital investment, utilities have to either charge a lot for each kWh generated or obtain long-term financing resulting in a lower annualized cost. However, for renewable energy, banks have been steadily shortening the length of loans while keeping the lending rate high. Given the barriers of high capital investment, low output, and poor financing terms, utilities routinely turn to combustion turbine technology firing natural gas. This technology has a low capital investment and can provide exactly the amount of output the utility requires. Even when a utility opts for a more capital-intensive technology, they look to nuclear or coal. Though capital costs on a $/kW scale rival those of wind turbines and photovoltaics, nuclear and coal have high capacity factors. They can deliver a large amount of electricity, or kWhs annually, thus bringing the $/kWh cost way down. Although wind energy has become less capital intensive, in turn lowering the $/kWh cost, most American utilities do not consider it a serious supply option.

The inability to control when and how much electricity a wind turbine or photovoltaic array produces is the second factor. Even in the face of lower prices, utilities still shy away from these technologies because of their intermittent nature. Utilities need to coordinate maintenance outages, transmission congestion, and load across all their resources. Throwing in an unpredictable technology drastically complicates the scheduling process. Transmission pricing schemes also penalize technologies that cannot schedule line capacity in advance. Utilities argue that to ensure reliability of delivery, they must build a back-up facility using combustion turbines. Why build two plants to supply the

[2] Even though Energy Policy Act of 1992 requires an integrated resource plan (“IRP”), which shows that utilities evaluated all options for supplying least-cost energy.

same amount of energy, when one will suffice? Renewable technologies like wind turbines and photovoltaics require a utility to be flexible in its supply needs and align historical wind and insolation[3] data with peak demand periods.

Third, photovoltaics and wind turbines require a lot of land. For example, a 170 MW nominal simple cycle combustion turbine requires 25 acres of land while a 10 MW wind farm would need approximately 500 acres. The wind turbines need to be spaced set distances apart (5 times the rotor diameter perpendicular to the prevailing wind direction and 10 times the rotor diameter parallel to the prevailing wind direction) to optimize the output of downwind turbines (R. Jacobson, personal communication, July 25, 2002). However, the actual utility-related structures on a wind farm that size only take up 25 acres leaving the remaining land available for agricultural use, recreational use, or other uses. Therefore, a utility must have access to significant land resources as well as wind resources to build a utility-scale wind farm. A photovoltaic array requires 1 acre / MW. Though photovoltaics require much less land than wind turbines, combustion turbines only need 0.15 acre / MW.

Fourth, the specter of bad projects in America from the early 80s still haunt utilities (and the banks that finance their projects) today. The combination of state and federal tax credits for development of solar technologies enticed development of numerous wind turbine designs. Unfortunately, most of these designs failed, leaving the U.S. landscape and consciousness littered with broken-down wind turbines, and memories of bankrupt American manufacturers (Righter, 1996, 225). Revocation of incentives also caused most European manufacturers to pull back to their home markets (R. Jacobson, personal communication, March 17, 2003). The specter of failed American wind projects during the 70s and 80s has effectively kept wind power from becoming a major player in the US electric industry (Righter, 1996, 225). Financiers are still unwilling to provide financing terms for the renewable energy industry on par with conventional energy technology financing terms (Brown & Yuen, 1994, 65)[4].

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[3] Amount of sun energy striking a certain area.

[4] Even in 2003, American banks are hesitant to finance wind power. European banks finance most wind projects in America.

1.2 Case Summaries

Despite these four main barriers, some utilities have incorporated alternative energy sources (conservation and renewables) into their generation mix. This thesis examines three such cases: a local effort in 1976 to install an urban windmill in New York City; a city level movement starting in the late 1980s with the closure of Rancho Seco Nuclear Power Plant ("Rancho Seco") in Sacramento, CA, and continuing today with energy efficiency and renewable energy programs; and a state level movement in Texas in the late 90s to get a renewables portfolio standard ("RPS") implemented.

The New York City case demonstrates the first attempt to install an urban windmill and connect it to the grid against the wishes of the incumbent utility, Consolidated Edison Company ("Con Ed") (ETF, May 1977). This case also pits a few residential customers against their utility. The residents of a tenement in the Lower East Side of Manhattan banded together along with the support of other community networks to make Con Ed to reevaluate their interconnection policy. In the New York City case, the Public Service Commission ("PSC") ruled that these few residential customers could connect their urban windmill to the electric grid, and sell excess power to Con Ed (Greenhouse, 1977 May 6, A1 D13). The New York PSC also set up standards by which others could follow suit (Feurstein, 1979, 345-346).

The Sacramento case starts with the first successful voter initiative to shut down a nuclear reactor, in 1989 (Stein, 1989 June 7), and the subsequent energy supply choices that Sacramento Municipal Utility District ("SMUD") made to offset the loss of generation from Rancho Seco. After a succession of general managers in the 80s, SMUD hired S. David Freeman, who had worked at the New York Power Authority, Tennessee Valley Authority, and the Lower Colorado River Authority (SELF, 1996). His history at these places, as well as his views expressed in his 1974 book, *Energy: The New Era*, show a strong commitment to energy conservation and utilization of renewable energy sources. Still in place today, SMUD committed to energy conservation programs and renewable energy technologies like solar photovoltaic arrays and wind turbines, under his guidance (Asmus, 1993).

The Texas case evaluates the culmination of policy efforts that resulted in the most successful renewables portfolio standard ("RPS") process[5]. Although known for oil wells and Enron, Texas has the most aggressive RPS in the country. Texas achieved this status through strengthening the bonds between customers, utilities, and policy-makers. The Texas Public Utility Commission ("TPUC") required utilities to obtain customer input on the integrated resource plan ("IRP") process. Results of this process reflected strong support for renewables and energy efficiency. The state legislature responded to their constituents, first crafting a retail market bill, SB7, then adding an RPS amendment. The amendment clearly outlined the desired growth in renewables, the widespread application, and timeline for TPUC action. Following the RPS guidelines, and their own experiences with customer polling, the TPUC developed the operational rules of the RPS. These rules promoted renewable technology development and penalized utilities and other electricity providers who did not meet compliance goals. Even if a utility did not want to strengthen its ties with the customers by delivering renewable energy, other parts of the Texas electric system would compel compliance.

1.3 Approach

Case study literature within Science and Technology Studies generally falls into two categories: high-level evaluations of several cases or one in-depth case study[6]. Given utilities' widespread reluctance to interconnect and integrate alternative energy supply into their systems, investigating more cases has advantages over focusing on one case. Three cases provide more opportunities to understand the various ways utilities have come to accept alternative energy systems. Examining several successful cases may offer ways to overcome systemic disinterest in alternative systems.

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[5] An RPS is a policy in which specified amounts of energy supply must come from renewable resources. Utilities must have renewable generation in their energy supply portfolio.

[6] Examples of multiple high-level comparisons include Thomas Hughes' *Networks of Power* and George Wise's *New Role Professional Scientists in Industry: Industrial Research at General Electric , 1900-1916* (1980). Examples of in-depth case studies include Bruno Latour's *Aramis: Or the Love of Technology* and *Kettering and the Copper-Cooled Engine* by Stuart W. Leslie.

To uncover the network building in the three cases, I performed an extensive literature search, uncovering primary and secondary texts for each case. Personal communications with key players helped fill in the holes from the texts. The following highlights some of the literature used to construct the stories.

Case 1: NYC Windmill. The literature describing this case study comprises primary texts, newspaper articles, PSC staff reports, and historiographical accounts. The Energy Task Force[7] published *Windmill Power for City People* and *No Heat, No Rent*. The manuals document the ETF's progress towards designing and installing a wind turbine on top of an apartment building in downtown Manhattan. The manuals also document their battle with Con Ed over connecting the urban windmill to the electric grid. The newspaper articles report on the milestones in the battle with Con Ed.

Case II: SMUD. The literature describing this case comprises conference papers, newspaper articles, and SMUD documents discussing the decision to decommission Rancho Seco and develop wind farms, photovoltaic arrays, energy conservation techniques, and a solar rooftop program. Articles from the *LA Times* and *The Energy Report* provide the headlines and basic facts of the story. The SMUD documents show the thinking process behind the company policy and actions as they define their future energy supply. Articles by Peter Asmus, a native Sacramentan and freelance writer, provide context for SMUD's actions.

Case III: Texas. Though Texas' transformation into a leading renewable energy state has been recent, the TPUC and electric industry organizations have already evaluated the program and how it achieved success. According to Ryan Jacobson, a wind energy expert, and these other reports, Texas's RPS leads the nation because of the method used to buy-in the participation of utility executives, a simultaneous green credit program for customers, and an automatic penalty for non-compliance (personal communication, January 22, 2003). Other valuable resources include the TPUC news releases; the state's Public Utility Regulatory Act ("PURA") rules; SB7, the legislature's retail electric market bill; and the legislative history of SB7. Together these documents tell the story of RPS implementation in Texas.

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[7] The task force, a self-help, urban homesteading, group, consisted of five designers and an architect.

The case documents span three decades, numerous political ideologies, and different sized movements. What became apparent in each though, is utility buy-in. Almost all Americans receive electricity from the grid, which means they purchase electricity from a utility. Utilities build the power plants or contract for power from independent power producers. Every action comes back to the utility. Integration of renewable resources requires utility acceptance. The cases became stories of how to engage the support of utilities, a difficult job no matter what the political / historical context or size of the network.

1.4 Chapter Summaries

This thesis uses the three case studies to resolve my two major concerns: 1) how to gain utility acceptance and integration of alternative energy and 2) who or what causes that conversion. I find that the how lies in the social networks that sustain the electric industry. The who or what comprises members of four main groups: customers, utility decision-makers, institution(s), and technology[8]. Individuals within the first three categories build a network of alliances amongst themselves and with alternative energy technologies to convince utilities to interconnect renewable technologies with their electric grid.

Chapter 2 provides a discussion of the theoretical framework used in this thesis, as well as some works that offer practical examples of alliance building. Hughes' system momentum offers a picture of institutional, personal, and technological interaction that is very stable and limited in ability to change. Latour's actor-network offers a much more flexible picture of relationships between institutions, persons, and technology. Whereas Hughes evaluates how those relationships sustain stasis, Latour evaluates the details looking for the dynamic interactions that create change. These two theories offer a way to understand the entrenchment of utilities as well as the dynamic relationships that ultimately bring about change in the cases.

The chapter then presents two additional authors' works. These authors show how reshaping the relationship between the utility and its customers and between the utility and

[8] Institutions can be, but are not limited to, utility regulatory bodies, state legislatures, manufacturers, and research and development organizations.

other institutions can significantly affect the business plan and mission of the utility. In Ruth Schwartz Cowan's discussion of the battle between electric and natural gas refrigerators, she describes the nascent electric industry's alliance building to overcome the established natural gas market. Amory Lovins harkens to this alliance (or relationship) building as the path to follow in order to move from our current physical electric system to a distributed generation system utilizing small-scale, renewable technologies.

Chapter 3 introduces the first case, the urban windmill in New York City. In this case, the most crucial relationship is between the tenant-owners of 519 and the Energy Task Force ("ETF"). Without these two groups working together to achieve affordable low-income housing, odds are the windmill would not have been installed at 519 nor anywhere else. Their good working relationship with institutions such as the Community Services Administration (which funded the projects) facilitated the design and installation process. Good working relationships with licensed engineers and electricians also added legitimacy to the technical design and feasibility of the interconnection with Con Ed's grid. Ultimately the tenant-owners of 519 made two significant changes in their relationship with Con Ed. First, they became active consumers, interacting with Con Ed and prodding them to consider converting their electric grid to accept synchronous interconnection. Second, the tenant-owners moved beyond consumers to producers and sellers of electricity. The 519 example shows how we, at the local level, can become active participants in the electric industry.

Chapter 4 broadens the scale from the home to the community level, investigating SMUD's change from a utility on the verge of bankruptcy to taking a leading role in the integration of renewable energy with its grid. Once again, this story shows the power of dynamic relationships in bringing about utility acceptance of renewable energy. Unlike the tenant-owners of 519, the residents of Sacramento County are customer-owners of their utility, SMUD. As such, they have an inherently stronger relationship with the utility and its decision-makers: the Board and the general manager. The alignment of customer-owner, Board, and general manager desires provided a foundation for integration of alternative energy measures on a utility scale. With the relationships among these three groups working with each other, instead of against, SMUD could commit itself to alternative energy. Building upon this new vision, SMUD strengthened relationships with their own customers through numerous programs, and other institutions such as appliance manufacturers, renewable technology developers, other utilities, and government agencies. The SMUD case shows that change is also possible at the community level and can come from within the utility. Utility executives and customer-owners worked together to re-create a utility that now is a leader in integrating alternative energy systems.

Chapter 5 then brings the focus to the state level. The majority of electric customers in Texas receive electricity from an investor owned utility, like Con Ed in New York. Therefor, they do not benefit from the inherently strong relationship between municipal utilities and those customers. During the implementation of the RPS, government and educational institutions worked together to strengthen the relationship between customer and utility. Customers were invited to become active participants in the future direction of the electric industry in Texas. When customers were given the chance to learn about the pros and cons of different energy supply options, they willingly accepted the opportunity, and a clear majority favored energy conservation and renewable technologies. When people are provided information and the opportunity to disseminate that information, they chose the more environmentally friendly options even with the knowledge that electric rates might increase. Government agencies and customer desires worked together to create change not only in a single utility, but also at utilities across the state. If people can create a voice to be heard by their utility and policy-makers, people can not only create change in their home or community, but at the state level as well.

Chapter 6 then presents the key processes involved in interconnecting renewable energy technologies to the electric system. As Hughes states, "if a component is removed from a system or if its characteristics change, the other artifacts in the system will alter characteristics accordingly" (Hughes, 1987, 51). Although mature systems' momentum limits future choices, the system can still accommodate localized changes. He further opines that mature technological systems are sustained by social systems (i.e. government, education, individuals). Changes in the social relationships can lead to more widespread changes to the electric system. For example, customers can become active participants, infusing the connection between themselves and their utility with strength. The means to spur customers to action varies widely. The three cases each offer different processes: 1) a local group interested in community involvement and self-sufficiency, 2) customer-ownership and a commitment on the utility's part to encourage participation, and 3) a policy requiring informed communication between utility and customer. By awakening the customer node, other keys to successful implementation of renewables become possible.

People sustain a mature system's momentum while also having the capability of redirecting that momentum. Hughes believes that mature systems are more social than technical: "a bureaucracy of managers and white collar employees usually plays an increasingly prominent role in maintaining and expanding the system" (Hughes, 1994, 106). They can change values, and spread along new information to other people. They can build relationships with other social based entities of the mature electric system ("MES") like manufacturers, policy-makers, and utility employees. Information and desires can flow back and forth across the interconnection of nodes. Alliances can form around similar desires or complementary capabilities.

Flexibility is another important key to success. One path to utility acceptance of renewable energy is not going to fit every situation. Just among the three cases in this thesis, several pathways present themselves. Providing options for obtaining renewable energy increases the likelihood that a utility, corporation, government, or individual can find an option that works for their situation. Renewable energy technologies like photovoltaic and wind turbines also exhibit flexibility. They can operate as a stand-alone installation, or together in photovoltaic arrays and wind farms to serve large-scale need.

The wide range of capabilities of people within all non-technical elements of the MES and the flexibility of people and technical elements provides an entryway into the possible ways to gain utility acceptance of alternative energy. These trailblazing cases demonstrate the viability of alternative energy, its compatibility with the MES, and the power of a united customer voice. The MES structure is mature, but the social elements that sustain it can also change it to accept alternative energy systems.

Chapter 2: Two Network Models

As each story unfolds, the language of two network theories will be evident. By using the language of these theories, the role of social relationships in the electric industry will become clearer, highlighting their ability to maintain or change the momentum of the electric system. The two theories are Thomas Hughes' system momentum, and actor-network as used by Bruno Latour.

Thomas Hughes presents and employs the system momentum concept in numerous articles and *Networks of Power: Electrification in Western Society, 1880-1930,* which investigates the early development and growth of the electric industry in the United States, England, and Germany. The American electric network consists mainly of large generation stations connected to individual points of load via transmission lines, distribution lines, and substations. This physical system is commonly referred to as the grid. Any new plant has to interconnect to this physical system, in an area with sufficient transmission capacity to enable delivery of electricity to meet load. However this physical system also maintains relationships with fuel and transportation networks, as well as educational, institutional, technological, and policy networks (among others). All of these physical and social relationships make up the mature electric system, and sustain its momentum[9].

In this thesis, I call will refer to the overarching Mature Electric System as the MES. The MES though is not a uniform network, with nodes (i.e. customers, generators) equally spaced. Nodes cluster within cities or utility service territories. These clusters represent both physical and social sub-networks of the MES. The three cases presented each consist of increasingly larger sub-networks. By looking more closely at these sub-networks, I can better demonstrate the role of social relationships in changing the momentum of the MES. Individuals and the people within a particular institution have

[9] Hughes brings in the engineering term "momentum" to stand for the decisions made by people connected with the electric industry (i.e. utility CEOs, customers, fuel suppliers, educators) that perpetuate the existence of the current configuration: large central generating station delivering electricity to distant customers.

"degrees of freedom not possessed by artifacts" (Hughes, 1987, 54). Individuals and institutions make choices that can either sustain or change the momentum of the MES.

Where system momentum stops in analyzing the potential for change, actor-network theory picks up. While examining the growth and maintenance of technological systems, actor-network also evaluates the processes by which actors[10] within a network of relationships engage one another. The processes studied in Latour's 1987 work, *Science in Action,* define the actor-network theory. Latour posits that a network of actors (both human and non-human) exist around any fact or artifact. The theory explains how actors gain authority and expertise, and how information propagates. Actors draw upon the work of other actors and institutions to strengthen their own position (and to weaken their opponents), and then use this authority to win over the more staid elements. In Latour's actor-network, these social elements that maintain the network configuration can be the same elements that alter the system's shape. Actors essentially use existing relationships and build new relationships to develop a new social network that can challenge the mature system's momentum.

The early electric system in America took several steps to gain the support of individuals and institutions to build up its own network and eventually develop self-sustaining technological momentum[11]. Similar efforts to obtain the support of individual and institutional nodes for alternative technologies and methods will be needed to achieve integration of alternative energy systems with the MES. In *ARAMIS or The Love of Technology* (1996), Latour's creative research account of the death of the experimental public transport system, he presents another important outcome of network building. Technologies that remain an isolated node instead of adapting to a network, fail. Successful implementation of a technology requires adaptation and compromise. It must negotiate between the requirements of the particular circumstance and the requirements of the mature system. For example, two of the cases presented include efforts to aggregate

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[10] Latour's use of the word "actor" reveals his belief that the social relationships of a network actively participate in maintenance of the social network. Although this sets up an understanding of "actor" as active and "node" as passive, I use the terms interchangeably with no such distinction.

[11] See Hughes' article, "The Evolution of Large Technological Systems," in which he discusses the early development of different large systems, including the electric system.

small-scale technologies to mimic the MES' physical structure. This provides many of the benefits of central station technology while virtually eliminating the risk of losing a large block of generation at one time. So not only does it partially replicate the existing generation node configuration, it provides additional benefits to the network. The three cases of this thesis are stories of building and infiltrating networks by enrolling the aid and support of key people, resources, and institutions to gain utility acceptance. In each, people, companies, and organizations worked to establish relationships and build coalitions. The success of each cause depends on these new social networks.

2.1 Implicit Application of the Models

Some accounts of the electric industry imply system momentum or actor-network theory, even though their authors never explicitly mention these theories. The author's are telling a different story or have a different purpose for their writing, but relationship building plays a prominent role in the tale's outcome. Two such examples are Chapter 5 of Ruth Schwartz Cowan's 1983 book, *More Work for Mother,* and Amory Lovins' 1976 article, "Energy Strategy: The Road Not Taken?"

In Chapter 5, Cowan illustrates the battle between electric and natural gas refrigerators during the electric industry's infancy. Electric refrigerators were noisy and contained many moving parts, often in need of repair. The gas versions were quiet and absent moving parts. The natural gas companies had distribution networks that connected households to natural gas supply. With this energy source already in the home, appliances burning natural gas would have had a significant advantage over other technologies. However, electric refrigerators won out over gas even though gas companies already had a foothold in the home. To combat this existing natural gas network, the electric industry willingly courted electric appliance manufacturers and supported electric appliance research and development. The gas industry offered no research or financial support to gas refrigerator developers. With their limited resources, the gas refrigerator developers could not compete with the electric companies' corporate sponsorship. Although technologically superior, gas refrigerators eventually collapsed under the tight knit socioeconomic constructions of the electric industry (Cowan, 1983, 128-143). Her story pursues the answers to how technology adoption occurs in an environment that already supports a competing technology. She examines the broad steps electric companies took to engage the support of manufacturers and customers to create a market and a desire for electric appliances. Her story of the refrigerators mirrors the stories in this thesis. Within each, we will meet actors that use existing institutional networks to bolster their cause and convince utilities to participate in alternative energy system adoption.

Amory Lovins advocates the type of network building conducted by the early electric industry, as illustrated by Cowan, to radically alter the shape of the MES. Utilities should once again align themselves with manufacturers but this time to produce energy efficient products and renewable energy technologies. In his 1976 article, Lovins forecasts energy use and environmental impacts if the MES maintains its momentum and if we make a fundamental shift in energy production and consumption. In the former case, the "hard path," increasing numbers of consumers gobble up increasing amounts of electricity. Instead, Lovins advocates shifting the direction of electric industry development away from centralized generation to small-scale distributed generation. He terms this the "soft path." Although never alluding to system momentum or actor-network theory, Lovins presents concrete steps actors can take to change the MES' momentum. Lovins places the responsibility for increasing efficiency with utilities, end-users, and manufacturers. First, the end-users take responsibility for lowering their electric bill and reliance on fossil and nuclear fuel by reducing heat loss and replacing appliances with more efficient models, as they become available. This, in turn, places a responsibility on the manufacturing sector to develop and market energy efficient appliances. Second, Lovins challenges the utilities to invest their capital in end-user efficiency projects instead of more power plants[12]. Along with increased efficiency, Lovins calls for increased use of renewable energy sources and a decentralized electric infrastructure. If electric utilities could involve themselves in manufacturing, research, and development of electric appliances to expand the electric market, they can do the same to promote energy efficiency and renewable technologies. Lovins calls for nodes throughout the network to convert simultaneously.

[12] Similar to S. David Freeman's conservation power plant idea, as discussed in Chapter 4.

Lovins believes that if enough utilities accept alternative energy systems, then the electric industry will realize fundamental change and follow a new path, just like when we moved from a pre-industrial society to an industrial society. The pre-industrial society had alliances and networks, and a momentum of its own, yet we managed to transform ourselves into an industrial society in short order. We also moved from a natural gas system to a mix of electric and gas. Some of the social mechanisms applied then can be used today.

2.2 Presence of Network Theory in the Cases

The network language of Hughes and Latour pervades the next three chapters. The influence of Hughes and Latour is clear in the focus on social relationships, network building, and network infiltration in the stories. Though the technological components such as combustion turbines, wind turbines, or synchronous inverters must physically interconnect and work together safely, both Hughes and Latour make clear that the possibility for change lies in the social relationships, and these relationships are emphasized throughout the cases.

The three cases in this thesis exemplify the building of social relationships around the concept of alternative energy and the need for these new relationships to compete with the MES' momentum. In no case does the MES welcome the upstart node. Therefore, the node must create alliances with other network nodes to truly permeate the network and realize a shift in the MES. Individuals and individuals within institutions engage each other to convert the utilities that drive the MES. By steadily infiltrating the established system with the new network alliances, the electric system and the way that Americans perceive and relate to electricity will transform.

Chapter 3: Utility Acceptance Through Direct Confrontation

3.1 Introduction

This first case investigates a grassroots movement by the Energy Task Force ("ETF") to place a windmill[13] on top of 519 East 11th street in Manhattan and interconnect the windmill with the electric grid. The ETF and tenant-owners of 519 slowly formed a network of alliances with other networks and nodes like Adopt-A-Building, the Community Services Administration ("CSA"), and local professionals. When the ETF and 519 tenant-owners decided to supply their own electricity for common-use facilities with a windmill, their small network butted heads against Con Ed, a large node of the MES. The 519 network had to work with parts of the existing MES to accomplish its goals. Through its efforts, Con Ed re-evaluated its interconnection policy, modifying it to accept small-scale, renewable generation.

In the mid-1970s, independent interconnections with the MES were in their adolescence. The electric infrastructure was firmly established following Thomas Edison's central station model. According to Hughes, this electric system network maintained a momentum that carried it farther and farther away from alternative energy technologies and small-scale, localized generation. All of the alliances gained through the decades significantly limited the options for further development. For example, "A 1975 George Washington University study found that most utilities prohibit reverse power flows back into the utility grid" (Feurstein, 1979, 345). Not only was reverse power flow uncommon, so was interconnecting an individual generating unit to the incumbent utility's grid. Large industrial and commercial customers might have on-site generation, but not urban residential customers. Interconnection for large customers was handled on a case-by-case basis. No New York state law nor federal law existed, requiring the opportunity for interconnection with the utility grid. In the absence of these types of laws, the 519 network had to force the issue with Con Ed over their perceived right to generate power while remaining interconnected to the grid for the remainder of their electricity needs.

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[13] The technical term is wind generator, but the ETF continually refers to the Jacob's system as a "windmill;" therefore, I sue that term when discussing this case.

Along with fighting institutional practices of the electric industry, the ETF was working in a social consciousness of "energy crisis" and economic downturn. Though most images of the 1973 Arab oil embargo consist of long lines of cars at gas stations, it precipitated a slowing economy with rising fuel costs and interest rates. Between 1968 and 1975, fuel costs in New York City had risen 300 percent, more than double other related cost increases (Christianson, 1979, 82). Con Ed's rates were the highest in the nation at 7.9 ¢/kWh ("Con Eds Rates Highest," 1976). Therefore, the basic mission of the ETF was to show low-income people the link between the energy crisis and local problems (Christianson, 1979, 81). Their first experiment was with the tenant-owners of 519.

3.2 A Fledgling Network is Born

A fire ravaged, derelict building at 519 East 11th St. would be the nexus of a new network that would eventually challenge the Con Ed network and the Hughesian momentum of that system. The building remained gutted until a group of tenants organized themselves into the 519 East 11th St. Housing Development Fund Corporation ("519 Corporation") to take advantage of loan money provided by the City for housing development (Carter & Finch, 1977, 12). With the assistance of Adopt-A-Building, the 519 Corporation bought the building from the Housing & Development Administration for $1,800 (Carter & Finch, 1977, 12). According to the ETF, the Administration was pleased to sell the building to a group interested in rehabilitating it and revitalizing the area through self-help programs (ETF, May 1977, 2). After "lengthy negotiations" the 519 Corporation secured a $177,484 grant from the city in October 1974 to renovate the building (ETF, Sept. 1977, iii) (ETF, May 1977, 2). The "sweat equity" loan had two parts. The first, which acted as collateral, comprised 8 hours/wk/tenant of unpaid labor (ETF, May 1977, 2), valued at $3.00/hr (ETF, Sept. 1977, 3). The loan covered the remaining 32 hours/wk/tenant plus material costs (ETF, May 1977, 2). The relationships with Adopt-A-Building and the Housing and Development Administration, and experience built during the funding process would prove beneficial as the 519 renovation progressed. As an established node, Adopt-A-Building had a network of alliances and a track record of work with the city, which established its credibility. They could lend this authority to fledgling initiatives like 519.

In 1975, as renovation neared completion, Travis Price, an architect with experience building solar homes in Arizona and Rhode Island, entered the scene (Carter & Finch, 1977, 13). He formed the ETF, an "organization devoted to providing designs and technical assistance to low-income, self-help housing groups" (ETF, Sept. 1977, iv). Price foresaw the consequences of fuel prices rising faster than the tenant-owners' earnings, jeopardizing the long-term habitation of 519. So he pursued an energy conservation grant on behalf of the 519 Corporation. Through his "insight and tenacity" and the 519 Corporation's prior experience in getting the housing loan, the 519 Corporation received a $43,000 grant for energy conservation measures and a solar water heating system from the CSA (ETF, Sept. 1977, 4). A federal agency, the CSA provides grants and assistance to those seeking to make energy efficiency improvements to their dwelling. Another grant from the CSA for $17,000 in July 1976, covered cost overruns (iv). With the grant money, the ETF, volunteers, and the tenant-owners purchased and installed storm windows, weather-stripping, insulation, and the solar water heating system.

During the energy efficiency grant discussions, the CSA assigned Miriam Charnow as the 519 Project Manager. In their documentation of the energy efficiency projects, the ETF thanks her for her "strong support, good sense, and patience" (i). The ETF continued this relationship as they planned to install the urban windmill. The existing relationship yielded another sweat equity grant from the CSA. The good rapport established during the weatherization and solar water heater project worked in the ETF's favor when they asked for another grant. Of the original $14,122 requested (ETF, May 1977, 4), the CSA awarded $13,622 (ETF, Sept. 1977, iv), or 96 percent.

3.3 The Network Continues to Grow

Although the weatherization measures reduced the electric load on the air conditioning and heating systems, and the solar hot water heater reduced the electric load from electrically heating the water, the ETF and tenant-owners decided that self-generation of electricity was the next logical step in providing long-term, affordable, low-income housing. Ted Finch, "a biologist and experienced windmiller from his undergraduate days at Hampshire College," joined the ETF (Carter & Finch, 1977, 13). He felt that wind generation would be appropriate for 519 and led the effort to install a wind turbine.

With Finch on board, the 519 network had grown one larger, and would continue to grow and gain steam as it headed towards its confrontation with Con Ed. The tenant-owners, ETF, and a wind energy designer met at 519 to discuss the wind project in the spring of 1976 (ETF, May 1977, 1). The building had separate circuitry and a meter for the common-use facilities: hallway and basement lighting and pumps for the solar water heater. Given this setup, the group felt that meeting the common-use facilities load made more sense than trying to connect to each apartment's individual meter (Carter & Finch, 1977, 13). Coincidentally, Con Ed cut off the electricity that same day due to a payment dispute, which caused the solar collectors to overheat, spewing forth steam (Thomas, 1976 November 13). This occurrence highlighted the need for self-generation to meet the electric load of common-use facilities.

The ETF chose a horizontal axis, three blade, rebuilt, 1920's Jacobs wind generator that could provide 2 kW of capacity at wind speeds of 20 mph. This would slightly exceed the needs of the common-use facilities. According to the ETF, they chose the rebuilt Jacobs[14] for the following reasons:

- Spins in low winds,
- No gears,
- Turns smoothly,
- Easy installation,
- Extracts a good percentage of the available energy in the wind stream,
- Withstands lightning strikes,
- Low $/kW cost, and
- Excellent safety mechanism for high wind situations (ETF, May 1977, 11-12).

Figure 3-1: 519 Windmill[15]

[14] Stopped manufacturing in 1957 (ETF, May 1977, 11).

[15] Picture is from the cover of *Windmill Power for City People*.

Home-sized wind turbines need wind speeds of at least 7-8 mph (Leckie, Masters, Whitehouse, & Young, 1981, 45). The ETF's Jacobs turbine has a cut-in speed of 7 mph (ETF, May 1977, 25). Therefore, the wind over the top of 519 must be blowing at least 7 mph for the turbine to generate electricity. The 519 building experienced average wind speeds between 8-13 mph (Carter & Finch, 1977, 13). Accounting for losses in gearing, generator efficiencies, and rotor efficiencies, wind turbine systems obtain about 35 percent efficiency. However, wind turbines are typically available[16] 99 percent of the year (AWEA, 2002a). Given the average wind speed, the high availability, and access to the Jacobs turbine, the ETF and tenant-owners forged ahead in designing and installing their windmill, and in strengthening and enlarging their network.

Although the ETF contained five engineers and architects, they also needed to bring on board technical assistance from a licensed professional engineer ("PE"), and licensed electricians to augment their own work. Without their assistance, the windmill project would stall. The ETF began the design of the wind turbine system by utilizing such books as *Other Homes and Garbage, Designs for Self-Sufficient Living* by Lim Leckie et. al. and *Simplified Wind Power Systems for Experimenters* by Jack Park (ETF, May 1977, 65). They then enlisted the help of a PE, Robert Silman. He compiled the completed design calculations, reviewed them, signed them, and filed them with the NYC Department of Buildings (ETF, May 1977, 18-19, 39, 48). When it came to installation, the ETF and tenant-owners installed most components through sweat-equity. However, a licensed electrician wired the system and connected the synchronous inverter[17]. These signed and stamped documents and installed wiring became permanent support nodes of the 519 network. As government agencies had requirements that licensed professionals sign off, and in some cases install equipment, enlisting the help of Robert Silman and the electrician became a key hurdle in the installation and operation of the windmill. Even the ETF states, "any viable, economic wind energy venture atop an urban building will require that a good working relationship is established between an engineer and the tenant-installers"

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[16] Able and ready to produce electricity.

[17] A synchronous inverter converts DC power produced by the windmill to AC power that can then be fed into the utility grid. The device synchronizes with the utility's frequency, voltage level, and power output. It allows for sales back to the grid (Lowe, 1999).

(ETF, May 1977, preface). Since a licensed professional must sign the design documents, meeting this requirements goes more smoothly when the PE and building residents can work together. Otherwise, the design may change significantly, possibly increasing costs, or not get approved at all. With this good relationship, the 519 network grew a little larger and a little stronger.

The fledgling 519 network had grown to include the ETF, Adopt-A-Building, the CSA, the work of licensed professionals, and tenant-owners who had transformed into skilled laborers. The network was ready to take on Con Ed and force the utility to deal with synchronous interconnection with the grid.

3.4 Gaining Legitimacy

On November 11, 1976, the ETF and tenant-owners erected the windmill. But the battle still lay ahead of them if they were to actually legally operate the wind turbine in parallel with Con Ed's system. Con Ed's statutes, approved by the New York State PSC, prohibited interconnection between the utility's lines and customer-owned generation (ETF, May 1977, 34). Due to the wind turbine's size[18], the economic disincentive for battery backup, and the intermittent nature of wind, the tenant-owners still needed to receive power from Con Ed within their individual apartments and to meet their needs for the common-use facilities whenever the wind was not blowing. Therefore, on November 12, 1976, the ETF issued a press release (ETF, May 1977, 34). This press just added to the already large amount of negative press Con Ed had received in 1976. A November 13 *New York Times* article said that the windmill would be operational "as soon as a few wires were connected" (Thomas, 1976 November 13). Over the next 5 months, the windmill produced approximately 200 kWh / mo, meeting 110 percent of the common-use facility demand. The extra 10 percent was available for sale to Con Ed, if only they would accept it (Greenhouse, 1977 May 6, D13).

Con Ed initially balked at the idea, according to the ETF. In 1976, Con Ed was the monopoly supplier of electricity to the Lower East Side of Manhattan. The possibility of

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[18] It was sized 1) to meet only the community lighting needs, not electrical demand within each apartment, 2) based on the structural load capacity of the building.

small, distributed generation being interconnected to its transmission and distribution system challenged Con Ed's monopoly status. They neither wanted to accept the energy nor pay for it. First, their statute clearly stated that the ETF requested interconnection was illegal. Second, they were concerned about the effect of power surges on grid stability and line-worker safety (Feurstein, 1979, 345), (Leebaw & Haberman, 1977 May 8), (Greenhouse, 1977 May 6, D13).

What appeared as stalling to the ETF, may actually have been the time needed to evaluate the system, develop safeguards, and then create a tariff. The PSC received a letter from state senator Albert Lewis in which he enclosed a February 1977 article, "Con With the Wind" and expressed concerns that Con Ed may be trampling on his constituency. The article paints Con Ed as a giant utility overly concerned with the very little bit of excess energy from the windmill ("Con," 1977). The PSC's reply to the senator, on March 11, 1977, states "Con Ed has not opposed the installation of windmill generators in New York City and, in fact, has proposed a special rate designed to accept this equipment on its system." Potential problems listed in the article did exist and Con Ed needed time to design specifications for control and safety equipment (Madison, 1977). Once Con Ed could investigate the windmill system and design appropriate safety measures, they could then develop a tariff.

On January 18, 1977, Con Ed submitted amendments to their Service Classification No. 2 – General Small tariff. The proposed amendments included a tenant liability clause and a $7.80/mo capacity charge (Con Ed, 1977). In essence, the clause states, "each customer shall agree in writing to hold the Company [Con Ed] harmless and indemnify it for any damages or injury in any way resulting from the installation or operation of his equipment" (Feurstein, 1979, 346). This clause would have required self-generators to purchase liability insurance, a purchase not required of other electrical equipment owners (Carter & Finch, 1977, 15-16). Con Ed also included a capacity charge instead of a demand charge[19]. Con Ed would then buy any excess energy delivered by the self-

[19] Typically, back-up power customers pay a demand charge based on the maximum monthly demand (MW). In Con Ed's proposed rate schedule, they included a capacity charge instead. So the 519 tenant-owners had to pay a charge based on the amount of capacity they could self-supply instead of an amount tied to the capacity they needed to purchase.

generator at Con Ed's avoided energy cost, not at the avoided peak cost, which more closely reflects the actual generation that the windmill would displace. Self-generators could not be reimbursed for available capacity. The ETF felt that these clauses would become significant barriers to the establishment of any other potential interconnected self-generators (ETF, May 1977, 34). The 519 network had only partially engaged Con Ed's network.

To obtain full engagement, the 519 network sought out the help of a different node on the MES, the PSC. The PSC's responsibilities include overseeing and regulating the electric industry in New York. Incumbent utilities like Con Ed must seek the PSC's permission to increase rates, add a new rate schedule, upgrade transmission and distribution systems, and add generation. Customers brought disputes with their utility before the PSC.

Through attorney John O'Sullivan, the ETF submitted comments to Con Ed's proposed tariff on February 23, 1977 (O'Sullivan, 1977). PSC staff members had already been evaluating the tariff. The next day the staff recommended postponing the effective date to April 7 because 1) their investigation was incomplete, 2) they needed more time to study the issues, and 3) they felt that some provisions would require modification (Newton & Pochman, 1977). After reviewing Con Ed's proposed new rate schedule, the ETF comments, and visiting 519, the PSC staff made their recommendations on April 22, 1977. The PSC ordered the tariff changes on April 26, 1977. Con Ed had to set up an experimental rate for windmill customers, eliminate the indemnification clause, install new backfeed meters, and collect data from the meters to monitor the safety of the interconnection (Greenhouse, 1977 May 6, A1, D13).

The 519 network had successfully engaged the PSC. The PSC's ruling on the 519 / Con Ed dispute gave full legitimacy to the 519 network. Between discussions with Con Ed and the PSC ruling, Con Ed's system altered to accept self-generated, small-scale, renewable energy technologies.

3.5 How a Utility Came to Acceptance

Con Ed was (and still is) a firmly entrenched player in the MES. Their PSC approved statute, prohibited interconnection with self-generators. Following the course of energy development throughout the earlier part of the century, Con Ed had designed a central station system with large generation plants transmitting electricity to all within their protected service territory. They had an electric system infrastructure (i.e. meters, transmission, distribution, large generating stations, fuel delivery) supporting their business practices. To counteract Con Ed's network, the ETF had to build upon the fledgling network created by the initial renovation of 519.

First, the ETF had to enlist the support of the 519 tenant-owners. The urban windmill would have never gotten off the ground without the participation of the tenant-owners. Once the tenant-owners support and willing participation was confirmed, the ETF had to obtain grant money as the low-income tenant-owners of 519 could not afford the cost of designing and installing the windmill. To do so, they had to enroll Miriam Charnow, their CSA liaison from a previous project at 519. The ETF and the tenant-owners had to learn how to design the support structure for the windmill and how to install it. For this, they used a mixture of their own engineering know-how and do-it-yourself books. They had to find a wind turbine that fit the demand requirements of the common-use facilities at 519, while also staying within the structural limitations of the building. They had to enlist the support of licensed professionals to approve calculations, file required documents with the appropriate government agencies, and install some of the components. The grant money helped enlist this support, because it gave the low-income tenant-owners the means to pay for the professional's services. The ETF and tenant-owners engaged the support and aid of John O'Sullivan for legal council. By releasing a statement to the Press, the ETF encouraged the participation of the media in the debate over whether or not self-generators should be allowed to interconnect with their incumbent utility's electric grid. Ultimately the decision for interconnection lay with the PSC, as they had jurisdiction over such matters. By engaging the support of all these other actors, the ETF and 519 tenant-owners had gained legitimacy in the eyes of Con Ed and the PSC, which resulted in gaining the right to self-generate and remain interconnected to the utility grid. In May 1977, the ETF and 519 tenant-owners successfully added this last node to their network, and connected their network to the Con Ed network.

Without being forced by a tenacious group, Con Ed would have continued down the same path for supplying and delivering electricity that they had always followed. In this case, a group of determined and hardworking people built a solid network of alliances to gain legitimacy with respect to the major actors in the MES, particularly Con Ed and the PSC. "We feel that our demonstration has been extremely successful in illustrating wind energy as a form of appropriate technology, and a precedent for working through the array of bureaucratic challenges associated with urban wind energy utilization" (ETF, May 1977, 42).

3.6 Epilogue

After the successful installation of a solar water heater and a windmill at 519 East 11th St., two agencies extended the reach of 519 tenant-owner efforts.

- "The Housing Development Administration of New York City has agreed to give additional mortgage monies for appropriate energy systems in all city funded sweat equity projects" (ETF, Sept. 1977, iv).
- Central Hudson Gas and Electric revised their residential tariff to include demand and metering charges for service to windmill owners who wanted to interconnect (Feurstein, 1979, 346).

Today, visitors to New York City can still catch a glimpse of the windmill. The windmill is a stop along the Green Apple Tour in NYC. The Tour's website proclaims, "View the famous wind turbine & solar panels that helped change the laws about who can supply utility companies with electricity. This urban homestead's meter can run in reverse!" (GMS, 1999). The windmill still stands as a testament to the 519 network's strength in the face of a much larger and more firmly established network of electrical systems.

Chapter 4: Aligning Utility Leaders and Community Alternatives

4.1 Introduction

This second case examines how the leadership and the customer-owners of a utility can switch the direction of utility expansion plans and energy supply. The Sacramento Municipal Utility District ("SMUD"), which started in 1946, was carved out of Pacific Gas & Electric's ("PG&E") territory. The residents of Sacramento County had long fought for a municipal utility as they believed they could serve their own energy needs better and more economically than by remaining customers of PG&E. Municipal utilities receive the unique benefit of tax-exempt bond financing, which offers lower financing rates than an investor owned utility ("IOU"), like PG&E, would receive. As a municipal utility, SMUD's publicly elected Board of Directors chooses the General Manager. Also, as a municipal, the customers are the owners. Therefore, revenues go directly back into the company, not into shareholder pocketbooks.

Aside from its municipal status, the SMUD network has often aligned itself with green and public goods policies. Between 1981 – 1990, SMUD performed energy audits on over 22,000 homes and 70 million ft^2 of commercial and industrial floor space. During 1977 – 1988, 31,000 homes received attic insulation, and 30,000 homes received shade screens between 1983 – 1990. In 1978, SMUD started a voluntary program for pool owners where they switched the clock settings on their pool filter pumps to off-peak hours[20]. These programs reduced peak load by approximately 80 MW. In 1977, SMUD started the Peak Corps Program. Customers volunteered to turn control of their cooling systems over to SMUD so that the utility could directly manage the load during peak demand periods. In 1985, SMUD offered interruptible rate programs to commercial and industrial customers (SMUD, 1992, B-1,B-2).

The SMUD network also interconnected with state policy networks. First, Sacramento is a non-attainment area, which means it exceeds the maximum amount of pollution emissions allowed for that area under the California Clean Air Act. Therefore, any new polluting industry or power plant built in the area must offset their pollution by

[20] Low demand period of the day, typically between 8 pm – 6 am, but does vary based on the location.

cleaning up pollution from another source, at an amount 20 – 200 percent more than its emissions (SMUD & EPSS, 1991, 7). This system results in reduced pollution, not just maintaining the current level. Second, when the state policy networks pass laws, those changes ripple along interconnected networks. In 1972, measure SB277 became law. It required all communities within the state to set minimum energy conservation standards for new residential buildings. The Warren-Alquist Act of 1974 created the State Energy Resources Conservation and Development Commission, which developed residential energy conservation standards (Quigley, 1991, 310). Also according to Quigley, the 1978 Title 24 Standards represented a major departure from earlier conservation law. The law called for the development of both component-based and performance based standards (311). During the late 70s, California passed four laws regarding investment tax credits on energy saving equipment for residential dwellings. The four bills, SB218, AB1558, AB3623, and AB2030 established solar/wind energy system tax credits and a conservation tax credit. This is just a sampling of California regulations dealing with increasing energy efficiency and the use of solar technologies. By the 80s, though, additional laws passed phasing out many of these measures. In 1983, three bills, including SB298 and AB2158, revised and setup a phase-out schedule for the solar and conservation tax credit programs. In 1985, two additional bills significantly reduced the total amount of credit that could be claimed (Quigley, 1991, 294-296). These regulations reflect network elements of the MES with which SMUD interconnected.

Federal level policy nodes could also impact SMUD operations. In 1978 PURPA passed. The Act required utilities to purchase electricity at avoided cost from qualifying facilities. To obtain this status, a facility had to demonstrate a minimum level of renewable fuel use for a unit or the entire facility. This Act also allowed for the entrance of independent power producers, from which the incumbent utilities could purchase power for their dedicated service territory (EIA, 2002a). SMUD would utilize this law to both advantage (meet short-term needs after closing Rancho Seco) and disadvantage (over-dependence during natural gas price spikes) in the 90s to meet power needs. In 1990, amendments to the federal Clean Air Act "significantly increased federal control of air emissions." However, they were no more strict than California's Clean Air Act (SMUD, 1991, 39). Then in 1992, the Energy Policy Act ("EPAct") passed. It required nondiscriminatory open access to all buyers and sellers wishing to rely upon existing transmission paths. This would prevent a transmission and generation owner from pricing transmission access so high that other generators could not supply energy at a competitive price (Smeloff & Asmus, 1997, 91).

The above discussion presents just some of the MES institutional nodes with which SMUD maintained relationships. SMUD's energy choices developed within this relatively static network, designed around a monopoly service provider with large generating stations delivering power to demand locations. Only a limited amount of small-scale, scattered generation existed. Between the momentum of the MES and the growing concern over air and water quality in the 70s, SMUD followed the movement to install nuclear power. The 913 MW Rancho Seco Nuclear Power Plant ("Rancho Seco") came on-line in 1974. At the time SMUD also owned a portion of the Upper American River Project (~650 MW), two geothermal plants (~108 MW), a small solar installation (~2 MW), and a 50 MW natural gas fired plant (Wald, 1989 June 9), (SMUD, 1991, 18).

4.2 An Albatross Threatens to Bring Down the SMUD Network

Rancho Seco, the center of SMUD's energy supply, started as a weak node. During the festivities of commencement day "the plant's steam turbine had malfunctioned, forcing a shutdown before the ceremony began. Although the concealed problem didn't dampen the festivities on its dedication day, it turned out to be an omen of things to come" (Smeloff & Asmus, 1997, 23). Once the plant began generating electricity, plant capacity factors were never stellar[21]. Ironically, its best performance year, 1979, was the same year that its sister plant, Three Mile Island, had a core meltdown. This connection started the first rumblings for closing Rancho Seco (Smeloff & Asmus, 1997, 29-30). Life with Rancho Seco did not get any easier for SMUD or its customer-owners. During the 80s it averaged a 30 percent capacity factor. The industry standard is closer to 60 – 65 percent (Stein, 1988 March 5). Then on December 26, 1985 concerns over another Three Mile Island nearly proved true. During the early morning hours, the integrated control system

[21] Ratio of generation hours to total hours during a given period.

("ICS") failed. The plant went into automatic emergency measures. But years of poor maintenance practices inhibited the valves' and switches' ability to perform properly. Operators scrambled around, frantically trying to find the source of the problem. Meanwhile the core temperature had dropped 180 deg. F. in less than an hour (Nuclear Regulatory Commission ("NRC") regulations limit reactor cooling to 100 deg. F. per hour). Eventually an operator noticed that the circuit breaker switches were halfway off, shutting down the ICS. Four hours later, the "unusual" event was declared over. (Smeloff & Asmus, 1997, 25-27).

Once again, improperly trained workers and neglected maintenance exacerbated a simple problem. Federal inspectors said that SMUD deferred maintenance to keep costs artificially low (Stein, 1988 March 5). This lack of care for Rancho Seco shows that SMUD was never fully committed to the plant; that the node was not sufficiently supported. SMUD was not willing to invest in the necessary annual maintenance and operator training required for smooth plant operation. The plant remained off-line for 27 months, restarting March – April 1988, just a few months before the residents of Sacramento County voted on a referendum to close Ranch Seco for good (Measure B) and another referendum to keep the plant open for a trial period (Measure C).

Skyrocketing rate increases, fist fights among the board members, and high turnover of the GMs characterized SMUD during the 80s (Peyton, 1999 June 6). A disconnect existed between board members, the general manager, and the customer-owners. SMUD was much maligned in the press, regularly on the Nuclear Regulatory Commission's worst plant list, and its bond ratings dropped to a level just above junk. The 1986 Chernobyl accident compounded the issue. After Chernobyl, the local anti-nuclear group, Sacramentans for Safe Energy ("SAFE"), renewed its efforts to close Rancho Seco, and tried to get a ballot initiative on the matter (Smeloff & Asmus, 1997, 30). Mike Remy, a local attorney who had helped draft California's Environmental Quality Act, helped draft the ballot language (30). Using volunteers, SAFE gathered twice the required number of signatures to get an initiative on the ballot (Smeloff & Asmus, 1997, 33), (Stein, 1988 March 11). SAFE pushed for a November 1987 vote. SMUD tried to delay any vote until

November 1988 (Smeloff & Asmus, 1997, 34). The referendum got placed on the June 7, 1988 primary ballot as Measure B.

The Rancho Seco node took another hit from the general manager, Richard Byrne, even while technicians tried to re-start the plant. Byrne, a nuclear power supporter, convened a panel of independent engineers and economists, the QUEST panel (Quality Energy for Sacramento's Tomorrow), to study the Rancho Seco issue. On February 1, 1988, the panel released their results, concluding that the economics of Rancho Seco were not significantly different between remaining open or closing, that perceived risks need to be considered, and that the plant would not be able to meet the industry average reliability factor in the next five years (Stein, 1988 March 11). After a grueling five hour board meeting packed with customer-owners, followed by a closed door session, Byrne recommended closing Rancho Seco and moving in the direction of smaller power plants, energy conservation, and purchasing power through a competitive bidding process (Smeloff & Asmus, 1997, 37). This unexpected shift in the SMUD network took Rancho Seco supporters by surprise since Byrne had been a proponent of the Seabrook plant in New Hampshire while he headed the company there (Stein, 1988 March 5).

However, for those bolstering the Rancho Seco dominated network, a coup was scored when a last minute referendum was added to the ballot. This referendum, Measure C, asked voters to keep Ranch Seco open for a trial run period of 18 months. The referendum also stated that SMUD must try to divest itself of the plant to a nonprofit third party and achieve a 70 percent capacity factor. If the capacity factor dropped below 50 percent for four consecutive months, then the plant would close unless 4 out of 5 Board members voted to keep the plant open. After 18 months, the fate of Rancho Seco would again be in the hands of the voters (Fore, 1988 March 14).

As election day neared, Measure C started to gain momentum against Measure B. Both those trying to keep the existing network intact and those trying to modify it argued economics. The anti-nuclear groups felt they could reach more people through economic arguments than health, safety, and environmental arguments, as SMUD's electric rates were quickly approaching PG&E's rates and some were forecasting bankruptcy for the utility (Stein, 1988 June 5). The proponents argued that millions of dollars had already been spent in fixing and upgrading Rancho Seco, so the plant should be given the chance to recuperate those costs, and prove that it could operate reliably.

On June 7, 1988, approximately 250,000 voters made their voices heard, as shown in Table 4-1. Measure C passed by a 3.2 point margin, or approximately 9000 votes, while Measure B lost by a 1-point margin, or less than 2000 votes. Measure C managed to gain just enough support during its last minute appearance to edge out Measure B, which had been expected to pass. A slight majority gave Rancho Seco just one more chance despite the recommendation of Byrne and the anti-nuclear groups.

Table 4-1
Results of Measures B and C, June 1988

	Yes (percent)	No (percent)
Measure B (close)	49.6	50.4
Measure C (trial period)	51.6	48.4
(Smeloff & Asmus, 1997, 41), (Stein, 1988 June 9)		

4.3 Networkquakes: The Death of a Central Node

The network was still quaking after the vote because the outcome did not strengthen the relationships between actors. Customer-owners almost split on the two Measures. Within a week of the vote, SMUD announced two rate hikes for the next 12 months (Fore, 1988 June 27). This undermined the platform proponents had run on. The Board also fired Byrne, and the plant manager, Carl Andognini, resigned. The Board replaced Byrne with Dave Boggs, who had been the head of Sacramento's regional transit. He had no utility experience, and focused solely on getting SMUD out of the press (Smeloff & Asmus, 1997, 41-42). By November of 1988, the Board had also experienced turnover. Two members did not run for re-election while a third lost at the ballot box (Stein, 1989 June 4). Two opponents of Rancho Seco and one proponent replaced them (Smeloff & Asmus, 1997, 43). The network swapped out nodes: a general manager without energy industry experience replaced one with such experience, and the balance of power in the Board started shifting towards opponents of Rancho Seco.

Due to fuel purchase timing, the Board moved up the do-or-die deadline to 12 months from 18 months. SMUD and the Board did not want to saddle themselves with a bill for fuel they did not need (Smeloff & Asmus, 1997, 43). During the 12-month period, Rancho Seco operated sporadically, resulting in another 44 percent capacity factor performance (Stein, 1989 June 4). Opponents called it a lemon.

By the end of May, though, SMUD had contingency plans for plant shutdown because surveys showed that Measure K, plant closure, would pass (Stein, 1989 June 4). It appeared that opinions were converging. On June 6, 1989, voters in Sacramento closed Rancho Seco. This marked the first time that a public referendum closed a nuclear plant. Although "the vote was not binding . . . a majority of the district's five elected board members had promised to abide by the will of the people" ("Voters Pull Plug," 1989 June 8). Of the almost 210,000 who voted, 53.4 percent voted for closure and 46.6 percent voted to keep the plant operating ("Voters Pull Plug," 1989 June 8). The margin in this election was two times larger than in the previous year's election. A majority voice amongst the customer-owners started to appear. Network connections strengthened around this voice. On Wednesday, June 7, at 10:40 am, Rancho Seco went into hot shutdown[22] (Stein, 1989 June 8).

The death knell of a SMUD system, designed around Rancho Seco, had sounded. SMUD had to decide on how best to replace the 913 MW sporadically provided by Rancho Seco. "Running Rancho Seco had become a measure of SMUD's success as a utility. It was impossible for them to envision a viable municipal utility that did not own most of its own sources of power"[23] (Smeloff & Asmus, 1997, 36). In the 90s, SMUD would have to redefine itself; decide how best to supply power using all options available, and how best to meet its customers' desires.

4.4 Network Metamorphosis: A Utility Embraces Alternative Energy

The removal of the central node of SMUD's MES left the rest of the network in disarray characterized by high turnover of general managers and Board members during

[22] During hot shutdown, electricity production stops but critical mass is retained within the reactor. Once hot shutdown completes, then the plant moves into cold shutdown.

[23] Byrne advocated purchasing power through a competitive bidding process.

the 80s. The emerging customer-owner majority voice offered a new way to reconnect the network. In 1990, the right interconnection of customer, board member, and general manager desires finally emerged. The alignment of these three groups resulted in a company planning policy still followed today.

The first step in this process occurred in January 1990 when Ed Smeloff gained leadership of the Board, running on a platform of energy efficiency and a move towards more 70s-era energy strategies. His fellow anti-Rancho Seco board members took the majority in the Board. Once the Board determined its direction, it moved to fire the current general manager, David Boggs. The second step was finding a general manager with utility experience, instead of appointing yet another political candidate, and a desire for alternative energy supply options. In June 1990, S. David Freeman came to the helm. As a shaper of Carter era energy policy and an advocate of energy conservation, Freeman perfectly mirrored Smeloff's campaign platform. He also brought with him years of industry experience in stopping nuclear projects while in the planning stage, and employing the idea of a conservation power plant instead. With a conservation power plant, the electric service provider enlists the support of its customers in conserving energy, which reduces load demand and eliminates the need for installing or purchasing more energy supplies. The annual expenditures on rebates and research and development equate to the annual loan payment for a traditional power plant. The avoided cost of energy purchases becomes the revenue stream.

The active customer-owners of SMUD were perfect candidates to help Freeman realize the conservation power plant. They had participated in SMUD's energy strategies of the 70s and 80s. They had voted for an anti-nuclear board and an alternative energy proponent for President of the Board. Now those leaders had placed a man of similar beliefs at the helm of SMUD. In coming full circle, the leaders would need the participation of the customer-owners for Freeman's plans to work. This integration of major nodes on the SMUD network both supported it and gave it the strength to work with the MES.

This unified front created a formidable business strategy that emphasized stable rates, conservation, clean air, renewable energy technology, and reestablishing customer-owner faith. To achieve these goals, SMUD had to create a business plan with the input of its customer-owners. “Because Sacramento County residents will pay for these new resources through their electric bills, we believe they should take an active part in this decision-making process” (SMUD et al., 1990). Throughout the 90s, SMUD set up workshops for the community and wrote their reports keeping their community audience in mind. In 1991, SMUD presented three energy scenarios to its customer-owners: minimize rates, maximize rates, and maximize diversity (SMUD et al., 1990). By defining scenarios around renewables and diversity, SMUD redefined the supply nodes of their local network and how that network fit into the larger system.

Freeman also put forth the concept of a conservation power plant. In the short term SMUD would capitalize on PURPA by competitively bidding for power supply contracts. In 1991, competitive bidding was an innovative idea and resulted in low cost supply contracts with other utilities and independent power producers. In the long run, Freeman wanted the utility and its customer-owners to meet future load growth through conservation measures while supplying the remaining load through contracts, co-generation, and renewable resources. For this to work, it required “community understanding and support” (SMUD et al., 1990). Customers had to take advantage of the programs and incentives offered by SMUD – planting shade trees, replacing inefficient equipment with the most energy efficient product (even before the end of its useful life), and moving certain tasks to off-peak hours. Through these efforts, Freeman envisioned an 800 MW Conservation Power Plant by 2000 (Asmus, 1993).

Through customer input and staff analysis, SMUD developed a business plan around the diversity scenario. It met the desires of customers to pursue future resources “that are non-fossil-fired or renewable” (SMUD & EPSS, 1991, 3). It also best met the five non-dollar criteria set by the Board: environmental impact, resource diversity, price risk, reliability, and location (3-4, 7). In a July 1990 Resolution, the Board stated, “it is the policy of this Board to be a leader in achieving cleaner air for the Sacramento region . . . to make Sacramento the clean air capital of the nation by the year 2005” ("Resolution 90-7-14," 1990). Also, “this community has learned from bitter experience at Rancho Seco that ‘putting too many eggs in one basket’ can be a costly mistake” (SMUD, 1991, 6). Therefore the Business Plan set out to achieve the supply breakdown shown in Table 4-2.

Table 4-2
Percentage of Electricity Supply From Various Resources, 1991 & 2000

Resource	**1991**	**2000**
Hydro	41	40
Renewables	4	14
Natural Gas	39	23
Purchases	8	4
Conservation	8	19

Source: (SMUD, 1991, 48)

Conservation, renewables (geothermal, photovoltaic, wind, renewing the license on the Upper American River Project), four local co-generation plants in the late 90s, and purchases were the goals for supplying SMUD’s current and future energy needs. “The foundation of SMUD’s future power program is our commitment to energy efficiency” (SMUD, 1991, 46). They also invested 5 – 6 percent of revenues into energy efficiency programs (SMUD, 1991, 45), more than any other utility (Smeloff & Asmus, 1997, 54). SMUD engaged participants through direct customer appeal, direct mail, mass media, rebates, and loan programs (79).

Furthermore, SMUD developed relationships with other energy entities to foster the development, manufacturing, and availability of energy efficient products and renewable energy technologies. By strengthening relationships with utilities, manufacturers, and government, they strengthened the SMUD network as well as added credibility to developing technologies. Some endeavors included:

- Los Angeles Department of Water & Power & SMUD – developing new kinds of geothermal resources
- SMUD, Southern California Edison, and the Department of Energy – developing advanced solar technology combined with molten salt for energy storage

- PG&E, SMUD, & LUZ Corporation– developing new and more cost effective solar technologies (SMUD, 1991, 38-39)
- Sacramento Alliance for Conservation of Water and Energy Together – promotes conjunctive water and energy conservation
- Golden Carrot program – utilities, government agencies, and environmental groups present a "unified stimulus" to manufacturers to produce appliances that exceed government standards (SMUD, 1992, 14, 62).

Even though a Lovins-like soft-path became the foundation of SMUD's business policy, and most of the community supported SMUD's plans, they did encounter barriers. The *1992 – 2000 Business Plan* highlights the barriers SMUD encountered in the major marketing / program areas for the three customer segments – residential, commercial, and industrial. These barriers consisted of the following:

- Customer misperceptions regarding a renewable or energy efficient technology
- Stimulate market and retailers to carry energy saving items
- Capital intensive
- Long payback period (exceeds three years)
- Inefficient technology not at end of useful life
- Availability of qualified service and maintenance providers
- Speculative nature of construction development: disincentive to spend money on capital intensive items
- No incentive to exceed minimum efficiency standards in building construction
- Budget constraints at public institutions
- Contractors ignore rules.

For example, SMUD's new construction "Rule 15" requires all new construction to be installed with a radio-controlled cycling switch on the air conditioner. Then if a customer joins the Peak Corps Program, no additional work is needed. Rule 15 became effective on January 1, 1990. Only a quarter of the homes built between then and April 1992 had the switch installed "due to lack of cooperation from new home builders and contractors" (79).

Although SMUD did have barriers to implementation, they used their resources and alliances to enroll participants in their conservation and load management programs. They educated consumers on their options. Through strategic alliances SMUD helped fund development of alternative energy technologies they hoped to build in the late 90s. One thing to keep in mind, though, this business plan was developed under the overriding assumption that the MES would stay relatively the same, letting its momentum carry it along. During its forecast period of 10 – 20 years, SMUD did not presume a radical shift in how business would be conducted (i.e. restructuring and customer choice). California's rapid move to restructuring in the late 90s would be a test of the strength of SMUD's local network.

4.5 When the MES Shakes: A Test of SMUD

By 1995, the California energy system started to feel the tremors of change. Reregulation was on the horizon. California's AB1890 called for a competitive market, mandatory rate freezes for IOUs, a competitive transition charge, and mandatory participation by the IOUs (divested of their generation) – all by 1998. The municipal utilities, however, were exempt. Participation was up to the Boards.

At SMUD, Freeman had moved on after three and a half years at the helm, replaced by Jan Schori. Though SMUD wanted to keep its focus on the goals set forth in 1991, Schori was increasingly concerned with staying competitive. PG&E, long the standard by which SMUD compared its success, forecasted deep cuts in rates by reducing expenditures on demand-side management and research and development (6). For the past five years, SMUD had managed to keep rates stable while maintaining high levels of investment in demand side management, capital intensive projects, and the Advanced and Renewable Technologies program. Approximately 200,000 residential customers and 5,000 commercial customers participated in the 20+ programs sponsored by SMUD (4). But "the operating environment has changed dramatically, and this causes SMUD to adapt to new market conditions" (4).

In developing the 1995 IRP, SMUD once again put the call out to its customer-owners, "We are encouraging everyone to participate by placing public notices in local newspapers, conducting a customer survey, and holding a series of workshops" (SMUD, 1995, 2). Analyses showed that if SMUD followed the 1991 resource plan (as modified by the 1993 IRP process), then rates would equal PG&E's projections, eliminating the cost advantage SMUD had over PG&E. SMUD could not risk loosing large customers to competitors as that would increase rates for remaining customers. So SMUD developed and evaluated two scenarios: rate minimization and competitive balance. They chose the competitive balance scenario as the optimum mix of remaining competitive while still providing the public goods funding that had become a defining characteristic of SMUD. They delayed construction of co-gen facilities and Phase II of the Solano wind project because they were not deemed cost competitive and Schori did not want to increase debt. They opted for short-term and spot-market purchases to handle peak summer load. "We believe that the short term capacity market is sufficiently reliable to use as a permanent part of our recommended resource mix" (SMUD, 1995, 10). They backed off from some of the more aggressive demand side management measures such as asking customers to replace less efficient products before the end of their useful lives. They also switched from offering large rebates to offering smaller rebates and SMUD-based financing (18-19). The 1995 Plan did not eliminate programs or funding, but did try to find more economical ways to achieve similar goals. The new SMUD network set in place in the early 90s was held together, but different nodes became more important.

In 1999, though, the network took its biggest test as the utility scrambled to maintain a competitive margin against PG&E's forecasted rates. SMUD felt that their customers wanted retail choice so it opted to participate in the new market. With a general manager focused on cost competitiveness, the 1999 Business Plan paid scant attention to costly energy conservation measures, renewable energy technologies whose capital costs had not decreased as fast as expected, and diversity. For some time, natural gas prices had been low, resulting in a boom of natural gas fired combustion turbines. The majority of purchase contracts were from these operators. By pursing short-term purchase contracts to meet peak load without other alternatives, SMUD lead itself back into the all-eggs-in-one-basket scenario. By decreasing the level of investment in demand-side management alternatives, SMUD opened itself up to natural gas price risk. Between astronomical market price spikes and increases in the price of natural gas during ‘99-‘00, SMUD got burned along with most other utilities in California. In 2001, SMUD instituted its first rate hike in 11 years (SMUD, 2001, 7).

4.6 Alternatives in the Readjusted Network

During the late 90s, SMUD forgot to apply one of the key tenets of the 1991 resource plan – diversity – to its short-term peak supply decisions. With purchase contracts all linked to natural gas, SMUD became subject to natural gas price risk. Maintaining their diverse portfolio would have hedged that risk. Grappling with the new market structure reminded them of the benefits of diversity and managed load. Reports from 2000 on, repeatedly state the core objectives: reliable power, low rates, community involvement, and environmental quality. It has become a mantra. SMUD has renewed its focus on conservation and Advanced and Renewable Technologies programs. But this is now taking place within a system defined by competition. SMUD funds public goods programs at rates higher than those mandated by the state government. They have committed to tie the annual increases in Advanced and Renewable Technologies funding to the consumer price index. Funding for low-income programs will be determined annually based on actual need instead of a fixed amount. They are adding Phase II of the Solano Wind Project. They also started a solar rooftop, net metering program. They are navigating through the possible ways to fund and market all their conservation programs. Through this all, most customer-owners did not switch. They knew the fit was right and their network would hold.

4.7 Conclusion

Similar to the tenant-owners of 519 East 11th St., Sacramentans wanted energy supply decisions in their own hands. They formed SMUD out of PG&E’s territory; contracting for power from PG&E while SMUD developed its own energy supply. With control of Sacramento’s future energy supply in their own hands, the customer-owners sought to build a solid network of relationships between themselves, the Board, the general manager, their energy needs, and possible supply technologies. Two times in its existence the SMUD network relied heavily on one node: Rancho Seco and short-term contracts with natural gas fired generation. The Rancho Seco configuration, which consisted of one single 900 MW block of electricity, brought SMUD to the brink of bankruptcy. It had limited supply options and fractured relationships among its network nodes. The SMUD network reorganized around a diverse energy supply plan that embraced conservation and created room for increasing amounts of renewable energy supply. The second time around, the reshaped network could withstand the beating from natural gas price risk because they had several contracts for smaller amounts of electricity, ultimately giving SMUD more flexibility when confronted with the natural gas price spikes. Although rates increased, the increase was among the lowest of all utilities in California. The solid rapport between customer and utility allowed SMUD to turn its bond ratings around, weather the storm of re-regulation better than most utilities in California, and to maintain its role as a leader in alternative energy systems.

Chapter 5: Uniting Customer Desires with Policy Initiatives

5.1 Introduction

This third case moves to a larger arena – the state. In this case, state policies interweave with Texans' desires for alternative energy supply to bring about utility acceptance. In the wake of EPAct, Texas created the Public Utility Regulatory Act ("PURA"). This legislation, in part, outlined the IRP process specifically requiring customer participation in determining generation expansion plans. This legislation gave customers of IOUs a voice in utility matters, not to the extent of munis, but still a voice. Customers could help direct their future electric supply. Their node became stronger, as did their network link to utilities and regulatory bodies.

The utilities, legislators, and Texas Public Utility Commission ("TPUC") listened to the customers and created policies to reinforce the desires. The interconnection established resulted in a retail market that included full integration of alternative energy systems. This achievement was a culmination of excellent potential for solar technologies, policies requiring utilities to determine customer desires when developing an IRP, and the emergence of Deliberative Polling™ as a means for scientifically determining customer wants. These polls determined an overwhelming desire for energy conservation measures and renewable energy resources.

5.2 Natural Resources

Renewable technologies can only be implemented where they have ready access to "fuel" supply. Wind and sunshine cannot be packaged and shipped across country. Although biomass can be shipped, as a waste material it is cost prohibitive to transport long distances. So for renewables to be an integral part of the MES, they must be applied where they can perform the best. Texas is one such a place.

According to the State Energy Conservation Office, Texas' renewable energy education forum, Texas has the most renewable energy potential of any state with 7.75 quads/yr[24]. Wind, solar, and biomass potential accounts for approximately 4.33 quads/yr

[24] Quadrillion British Thermal Units (Btu)

(SECO, 2002, 1). Over the entire state, Texas has 59,000 square miles (m^2) of class 3 wind (lowest amount needed for utility scale wind turbines), 15,000 m^2 of class 4 wind, and 200 m^2 of class 5 and above winds. A 1995 report by the Environmental Defense Fund and Sustainable Energy for Economic Development advocated development goals for renewables in Texas of 5000 MW of wind, 500 MW of photovoltaic, and 500 MW of biomass by 2005 (AWEA, 1995a).

5.3 MES Momentum

Like SMUD, Texas' electric network is a solid member of the MES. As a statewide network, it has even more rigidity and mass than SMUD. Therefore, the momentum of the electric network in Texas more closely resembles the momentum of the MES. As a major sub-network of the MES, understanding some of the significant movements in the MES will situate Texas' shift in momentum and in status from follower to leader.

In 1995, Texas ranked near the bottom of states' use of renewable resources (AWEA, 1995a). The possible reasons for this ranking are tied to the MES momentum. As the MES adapts to accommodate new growth, it has a limited number of options, according to Hughes. In the 80s, the MES tested wind resources. In the 90s, it tested market restructuring.

The rush to build wind projects in the 80s due to federal and some state policies left devastating fallout. Reputable manufactures had to compete with disreputable companies only interested in benefiting from certain tax credits in place at the time (Righter, 1996, 225). This rush resulted in a littered landscape of failed projects, damaging the reputation of the American wind industry. In the late 80s, the fall in oil prices and the repeal of federal and state renewable energy tax credits put many American wind companies out of business (AWEA, 1995a). The limited number of turbine manufacturers remaining in America would make it more difficult to develop wind projects.

Then in the 90s, the MES began to test market restructuring. No one knew how this permutation would affect the network. In May 1995, the Texas House of

Representatives followed the MES' lead, passing a bill in favor of retail wheeling[25]. Several utilities in Texas lobbied against this bill, calling the measures "out of control." Ultimately, the utilities feared stiff competition from low cost independent power producers (AWEA, 1995b). As integral parts of the MES, the momentum utilities sustained made adjusting to retail wheeling harder than for independent power producers, which came into their own in the 90s. As newer members of the network, located on the fringes, they could adjust to changes in the network structure much more quickly. They could react faster to meet customer desires by adding renewables to their portfolios. These fringe network nodes provided one area for renewables to interconnect with the MES.

The movement in Texas in 1995 towards retail wheeling mirrored the national movement. MES momentum seemed to have found a direction for future development – restructuring. In April 1999, the Clinton administration increased the target level of renewable energy supply to 7.5 percent by 2010 in the proposed national RPS (AWEA, 1999a). A national poll conducted in May 1999 on behalf of the Sustainable Energy Coalition showed strong support for a national RPS, tax incentives for renewables, public benefits funds, and disclosure of energy resource supply on utility bills (AWEA, 1999b).

Another important piece of the MES in which the development of the Texas RPS occurred is the status of federal tax credits. A major production tax credit ("PTC") for solar based renewables, which provided a 1.5 ¢/kWh production credit, would expire on December 31, 2001. To capture this credit, wind power developers rushed to get projects built before the end of 2001. Congress let the tax expire. New projects were tabled until the credit was renewed in March 2002. It only extends through December 31, 2003. Although the price of wind power has been steadily dropping and becoming increasingly cost competitive, the credit virtually guarantees competitive pricing. Supply contracts are under 3 ¢/kWh (Real de Azua, 2001). The inconsistent national policy (and node instability) resulted in boom-bust development cycles (AWEA, 2002b). Without a firm national commitment to the PTC, the Texas electric network must be flexible to starts and stops in the MES momentum.

[25] Same as direct access or customer choice.

5.4 Converting Utility Attitudes Using Customer Input

According to PURA, before a utility can request the TPUC to approve the construction or acquisition of new energy sources, the utility must first scientifically sample the opinions and attitudes of customers once they have been informed of the issues (Office of Public Affairs, 1998). The TPUC requires the utilities to do more than just mail out a survey with the monthly bill. They have to gather responses from a representative and informed group of residential customers. The Deliberative Polling™ process emerged as the means by which many utilities met this TPUC mandate. Developed by Dr. James Fishkin, a professor at the University of Texas at Austin, it "brings a representative sample of people together, provides information from both sides of an issue and then allows them the opportunity to talk about those issues" (Gerrow, 2003). Fishkin believes that information is key to a democratic decision-making process. The results according to Fishkin: "we've been able to show that after people deliberate and focus on an issue their opinions change, and we've been able to show that the opinion change is driven by their becoming more informed" (Gerrow, 2003).

After the eight major utilities[26] in Texas, representing 67 percent of customers, used this technique for their IRP process, the desires of customers across the state became clear. As seen in the previous two cases, the customer voice is an important element in engaging utilities. The majority of sampled customers wanted more energy conservation measures and renewable supply options. Table 5-1 shows the desires of customers before they were educated on the issues for three of the major utilities.

Table 5-1
Customer Opinions on Energy Supply Before Deliberative Polling™

Options	**CP&L**	**WTU**	**SWEPCO**
Efficiency	11%	7%	16%
Fossil Fuel	11%	11%	10%
Renewables	67%	71%	67%
Purchases	18%	10%	3%

(BPA, 2003)

[26] El Paso Electric, Entergy Gulf States, Houston Lighting & Power, Southwestern Public Service, Texas Utilities Electric Co., Central Power & Light, West Texas Utilities, and Southern Electric Power Co.

Customers overwhelmingly supported the idea of renewable energy. Before the town hall meeting, customers were given education packets and asked to read them. During the meeting, customers broke into small groups to work through issues of supply-side options and demand side management. They also questioned a panel of experts to learn different sides of an issue. After the sessions, customers filled out another survey. Table 5-2 presents results for some of the questions.

Table 5-2
Polling Results After Town Meeting

Questions	**First Choice Preference (assuming same cost) (%)**				**How Much Willing to Pay? ($)**	
Utilities	**Renewable**	**Efficiency**	**Fossil**	**Purchase**	**Renewable**	**Efficiency**
TU	56	30	9	-	5.00	1.00
SPS	48	28	20	-	2.00	1.00
EGS	37	50	9	2	1.50	1.00
HLP	58	20	17	3	6.50	3.00
SWEPCO	28	50	13	6	5.00	2.00
WTU	35	31	16	18	5.00	2.00
CPL	16	46	29	8	4.00	2.00
Average	49	31	14	5	5.00	2.00

(Sloan & Taddune, 1999)

On average, Texans strongly preferred renewables and conservation methods for meeting energy needs. The more balanced desire for both methods reflects a greater understanding of the costs associated with renewable energy. With this new understanding, most Texans still supported renewables and showed a willingness to pay extra. Although renewables now shared its early support with energy conservation measures, having these two options favored by the majority of residential customers shows a clear desire for change in the MES: change from large-scale fossil fueled generation, to a greater proportion of energy supply met through alternative systems. According to Mike Sloan of Virtus Energy Research Associates and a key supporter of the RPS, "what the extensive polling effort revealed to the utility management and to policy-makers was the extent of public support for renewable energy, throughout the state and among Texans from all walks of life" (Real de Azua, 2001). State law required utilities to obtain informed and representative customer input. The customers then stepped forward, showing a strong desire for alternative energy systems.

The push for renewables (and energy efficiency) came about after these deliberative polls (Mooney, 2001). This process gave IOU customers their first real opportunity to express their desires to their utilities. In October of 1998, the TPUC adopted a rule allowing electric utilities to offer their customers the choice of non-polluting renewable resources. This rule also supported the 1998 Strategic Plan, *Vision Texas 2000*, which advocated the increased use of renewable resources to meet the state's needs (Kjellstrand, 1998 Oct. 23). Customer opinions formed through balanced information sessions, conducted in front of TPUC members and utility executives, convinced the TPUC and utility executives that the public strongly favored renewables and energy efficiency. The process strengthened the interconnections between customers and regulatory bodies. The scientific process also lent credibility to customer desires.

In a competitive environment, utilities need to meet customer desires in order to retain those customers. As the Texas network's momentum swung towards a competitive environment, the relationship between utilities and customers become increasingly important. The Texas IRP process gave IOU customers a voice they lacked previously; awaking millions of individual nodes within the Texas electric network lit up. The impending switch to a retail market resulted in utilities need to strengthen the connection between the utility node and its customer nodes.

The Texas legislature engaged with these desires. Senator David Cain added the RPS amendment (section 39.904) to SB7, the senate's restructuring bill. The RPS requires every retail electricity provider, municipal utility, and cooperative utility in the state to obtain renewables as a percentage of annual capacity according to the schedule shown in Table 5-3[27].

[27] A muni or coop forgoing participation in the retail market was exempt.

Table 5-3 Deadlines for Percentage of Annual Utility Capacity From Renewables	
Date	**Percentage of Annual Utility Capacity from Renewables**
January 1, 2003	1.65
January 1, 2005	2.15
January 1, 2007	2.75
January 1, 2008	3.00
(AWEA, 1999c)	

Renewable resources allowed under the RPS include wind, solar, geothermal, wave/tidal, biomass and methane landfill gas, and hydro power ("SB7," 1999, 39.904d). Part (a) outlines the deadlines and renewable capacity growth requirements, as shown in Table 5-4. These goals represent the statewide growth goals, and serve as a reference point in determining the success of the RPS.

Table 5-4 Deadlines for Renewable Resource Capacity	
Date	**Total Capacity of Renewables (MW)**
January 1, 2003	1,280 (400 additional)
January 1, 2005	1,730 (450 additional)
January 1, 2007	2,280 (550 additional)
January 1, 2008	2,880 (600 additional)
("SB7," 1999)	

Part (b) calls for a renewable energy credits trading program, which would allow electric providers to purchase credits in lieu of owning renewable capacity or purchasing capacity. Part (c) states that the TPUC will adopt rules for the RPS implementation by January 1, 2000. Parts (e) and (f) state that municipally owned gas distribution systems using landfill gas can obtain credits for those systems.

The 1995 PURA mandate for scientifically gathering customer input, and the subsequent deliberative polling process allowed customers to better understand the issues and options available for electricity supply, and to share their views with the TPUC, legislature, and utility executives. The process created an atmosphere of legitimacy. The Governor signed SB7 into law on June 18, 1999.

As the regulatory node in Texas' network, the TPUC set up the rules by which electric providers would meet the requirements of SB7. In December 1999, the TPUC adopted rules for SB7 covering the following:

- Encourage the construction of renewable energy projects,
- Reduce air pollution from fossil fuel generation,
- Respond to Texan's willingness to pay more for clean energy,
- Increase the renewable energy supply in Texas, and
- Achieve these goals at a modest cost to Texans (Hadley, 1999 Dec. 17).

The specific actions for the RPS are contained within PURA "Chapter 25, Subchapter H, Division 1: Renewable Energy Resources and Use of Natural Gas". In October 1999, the TPUC released a draft version for comment, and the final version became effective on May 15, 2000. Some of the major provisions include the renewable energy credit, transmission provisions, and automatic penalties for non-compliance ("Goal," 2000).

5.5 Policy Ensures Utility Participation

Once the customers presented such a scientifically legitimized and united preference for renewables and energy efficiency, it was up to the policy network segment to enact an RPS that could achieve those goals. According to Randall Swisher[28], success boils down to four key items in the areas of nature, technology, and policy. First, Texas has an excellent wind resource. Second, wind turbine technology is more economical than before. Third, policy-makers need to craft growth inducing renewable energy requirements and fourth, non-discriminatory electricity transmission rules (Real de Azua, 2001). Texas already had 880 MW of renewable resources in the state; therefore, the TPUC had to establish minimum goals that exceeded the amount already available to achieve real growth in the industry. They chose a target of 2,000 additional MWs of capacity by the year 2009, with interim goals according to the schedule shown previously

[28] Executive Director of American Wind Energy Association ("AWEA").

in Table 5-4. The schedule allowed sufficient time for developers to meet the requirements. The requirements were also enacted before the expiration of the federal PTC, allowing developers to take advantage of the tax credit for any projects they could get developed before the end of 2001. More than 10 wind projects, totaling 930 MW were installed by the end of 2001, twice as much capacity as the 2003 requirement (Wiser & Langniss, 2001, 10). In addition, 12 new landfill gas projects (44 MW) and 50 MW in hydro renovations were announced, and 2,650 MW of wind projects requested grid access. Even municipal and cooperative utilities exempt from the 2002 RPS obligation, have contracts for 156 MW of wind energy in place (Wiser & Langniss, 2001, 10).

The TPUC also established flexible and appropriate transmission rules. Some renewable technologies provide intermittent energy that cannot be scheduled. In many states with restructured electric systems, transmission provisions contain severe penalties for not scheduling electric transmissions (AWEA, 2002b, 3). This presents a significant economic disadvantage for solar technologies and slows their development and participation in restructured environments. Given Texas' excellent wind resources, fair and equitable access to transmission was key to ramping up the renewables capacity. In Texas, however, they created special provisions for "as-available" technologies. In establishing transmission rules for the retail market, the TPUC built upon the one stop, standardized, interconnection process they established in 1998. They created a postage stamp rate[29] (initiated in 2002) and a market-based subzonal congestion management scheme, which allocates congested lines fairly among generators (Real de Azua, 2001). Also, as outlined in PURA, all Texas customers bear the cost of grid expansion, not the power plant (Wiser & Langniss, 2001, 15). This eliminates a major cost barrier normally associated with any power plant.

Another key provision is the flexibility of meeting renewable requirements coupled with a stiff penalty for non-compliance. According to Jaime Steve, AWEA's legislative director, "Texas structured its RPS more effectively than other states because they set a

[29] Fixed charge per unit of energy transmitted within a zone, regardless of distance traveled. Zones in Texas are determined at the independent system operator ("ISO") level. The ERCOT ISO covers 85 percent of Texas (EIA, 2002b), (NWCC, 2000).

relatively ambitions, yet achievable, requirement. Then the power providers were set free to decide for themselves how to meet the requirement" (Real de Azua, 2001). Electric providers can build, own, and operate their own renewable resources to meet their requirements or they can purchase renewable energy and the associated renewable energy credits. A renewable energy credit equals 1MWh of renewable energy physically metered and verified in Texas. Electric providers producing renewable energy in excess of their own requirements can sell the excess energy and equivalent credits to providers trying to meet their respective quotas ("Goal," 2000). This flexible process allows for least-cost implementation and easy requirement tracking (Real de Azua, 2001).

Tracking renewable obligations is extremely important in making electric providers accountable. Providers have a year-long compliance period to meet their obligations. They also have a three-month grace period to make up any shortfall. After the grace period, a penalty is automatically charged to the provider in non-compliance. The charge for non-compliance exceeds the estimated compliance costs, making it cheaper to comply (Real de Azua, 2001). Furthermore, eating into the grace period also eats into the next compliance period, potentially making it even harder for an electric provider to meet obligations if it gets behind.

Utilities have two strong incentives to participate in renewable energy production under the terms of the Texas RPS. First, they will do better in a competitive environment if they deliver products their customers want. Second, the utility's bottom line suffers from non-compliance. According to Swisher, "the RPS has provided the extra incentive that utilities need to seriously look at wind and other renewables. Now that they have, it's obvious that they like what they see" (Real de Azua, 2001). Incumbent utilities have signed long-term contracts (10-25 years) for RECs and the associated energy (Wiser & Langniss, 2001, 11). The long-term contracts provide stability for renewable technologies that often do not benefit from long-term policy incentives. Contract lengths of 10 – 25 years have become an anomaly in an era of short-term purchase contracts and short-term financing arrangements. Nowadays, purchasers are typically unwilling to enter into long-term contracts in emerging competitive markets because they do not want to lock in a price when short-term prices might drop. The long-term contracts used in Texas ensure that the electric supplier can meet its renewables obligation while placing risk of non-compliance due to unavailability on the developer.

The TPUC crafted RPS rules that built on the MES, creating a set of relationships between nodes that provided the structure for compliance. This structure aids IOU's ability to meet customer demand. The RPS network's flexibility provides several paths for utilities to achieve compliance and retain customers. The RPS rules also add legitimacy to the state legislature's RPS amendment.

5.6 Confluence of Factors Makes the Texas RPS Work

Similar to the SMUD case, in which major nodes worked towards a common goal, the Texas RPS implementation process reflects a coalescing of node interests. Utilities have embraced renewables and energy conservation because their customers wanted it and because the policy-makers crafted a policy that ensured compliance. Utilities could meet the compliance because of the abundance of renewable resources within the state. The TPUC felt that Texas moved thoughtfully through the restructuring process, opening up the wholesale market in 1995 (SB373), refining the market and calling for a retail market in 1999 with SB7. Texas ensured sufficient generation and transmission capacity to meet future demand, and avoided the price spikes experienced in the California market (TPUC, 2001).

According to the Early Assessment Report to the TPUC, the RPS had strong political support and regulatory commitment. Deliberative Polling™ showed Texan's clear desire for renewables and energy efficiency, which then got the attention and support of legislators, the TPUC, and utility executives. The predictable, long-term purchase obligations drove new development, stability, and economies of scale through mass production. Easy tracking through the renewable energy credit program and automatic enforcement for non-compliance made it more attractive for utilities to participate than to try and dodge participation. And lastly, the RPS allowed for flexibility in meeting the requirements (Wiser & Langniss, 2001, 14-15).

This statewide utility acceptance of renewable energy relied upon the efforts of individuals and institutions throughout Texas. The TPUC crafted IRP requirements that provided customers the opportunity to have their voices heard (akin to the opportunities muni and coop customers have). The Deliberative Polling™ process leant an aura of legitimacy to customer opinion. Utility executives, state legislators, and the TPUC believed in Texans' strong desire for renewables and energy conservation. Initially weak, network connections were strengthened and solidified during the process. Legislators interested in serving their constituents drafted an electric market restructuring bill, including a RPS provision. The TPUC fulfilled its role in the MES by drafting the specific rules for implementing the RPS. The utilities then contracted with developers for capacity and energy from their new projects.

Chapter 6: Conclusion

Our electric system centers on the utility[30]. Large and inflexible, utilities experience difficulties when dealing with intermittent and uncontrollable technologies like wind turbines and photovoltaics. Therefore other MES nodes and social network relationships must be converted to help the utilities adapt. Ultimately, tying into the MES requires an alliance with the utilities. With utility buy-in, new technological nodes like renewables gain legitimacy and stability, firmly connecting to the MES.

Hughes says that mature technological systems have substantial momentum, which limits the system's ability to adapt or assimilate nodes that do not conform to the system's configuration. Though limited, change is not impossible. If an artifact is changed or removed, then other network components and relationships change accordingly (Hughes, 1987, 51). He seems to limit change to the technological elements of the mature system. He then goes on to say that "a system with great technological momentum can be made to change direction if a variety of its components are subjected to the forces of change" (Hughes, 1994, 112). Though one component can cause change in closely related elements of the mature system, widespread change requires a change in numerous network nodes. Hughes does not ever get more specific about the location or catalyst for change. But he also notes that technology shapes and is shaped by society (Hughes, 1994, 102, 112) and that people and social relationships maintain a mature system. This is the real clue to attaining utility acceptance of alternative energy. Utilities are the most stable nodes of the MES, but people run those companies while also being consumers of electricity. Working at the social relationships can create change in the MES.

Actor-network theory's emphasis on the active role of social relationships in maintaining, creating, or adapting social networks provides a lens and a language in which to view the three cases of this thesis. Once a functional technology is developed, it is up to people to implement that technology and interconnect it with the mature system. These two models do not answer directly who or what needs to change. This thesis takes these

[30] Even in states with retail choice, relatively few customers have switched providers, leaving the incumbent utilities with significant obligations to serve.

models just a little further in trying to answer this question. At the root is the answer to gaining utility acceptance of alternative energy systems.

6.1 Who or What needs to Change?

Hughes says that various components of the mature system must change, but does not provide any guideposts. Latour says that the more alliances one can build the bigger the network one can create around an artifact or a belief. He does not say how many alliances are required to overcome an opposing belief. This thesis examined three cases of very different size – apartment building, city/county, and state. Although no definitive critical mass for change was found, each case has four elements in common: customers, utility executives, institution(s), and technology. These four elements are Hughes' "various components." Building an alliance for alternative energy that incorporates some part of each element can lead to utility integration of renewable energy technology, as seen in the previous cases.

At the local level, it appears that change comes from individuals, with some support from institutions. In the 519 windmill case, the major actors are the tenant-owners, the 5-member ETF, the professional engineer, the licensed electrician, Miriam Charnow / CSA, the PSC, and Con Ed. The impetus for utilizing renewable technology started with the individuals and they methodically added in the support of a few institutions that were key to their specific circumstances. Furthermore, the individuals involved can be more flexible, trying various avenues to achieve their goal. For example, if Robert Silman had been uncooperative in performing his professional engineering duties, the ETF and 519 tenant-owners could have searched for a different engineer.

The larger the system, and more integrated with the MES, the more likely change will come through relationships between institutions. The clout of the institution is needed to overcome the momentum of the larger piece of the MES. For example, once SMUD decided to become a leader in renewable energy and energy conservation measures it created relationships with other industries and institutions to support its decision. In Texas, the state legislator and TPUC worked together to create the RPS. These institutions consist of individuals working towards a common goal, and some individuals played key roles in these cases; for example, the senators that pushed for the RPS amendment in Texas and S. David Freeman at SMUD. But the changes more often track along institutional lines as the size of MES conversion increases.

System momentum theory sets up the limited possibilities for change in the MES, but tells us that social actors maintain the system. Actor-network shows how social relationships can be very dynamic, either maintaining the status quo or creating a whole new set of relationships around a new idea or artifact. By looking at the relationships in the three cases, customers, utility executives, institutions, and technology appear to be the four various components that must be enrolled in support of renewable energy to achieve change in the MES. The next step is understanding the processes behind enrolling elements from those four groups. Broadly, the processes fall into alliance building, customer engagement, stability, and flexibility.

6.2 Alliance Building

As discussed above, developing relationships with other individuals and institutions is crucial to gaining support and legitimacy for whatever idea you want to support. Alliances can create legitimacy or lend credibility to alternative theories, to emerging technologies, even to customer voices.

In the first case, association with established entities like the CSA and Adopt-A-Building turned the tenant-owners of 519 into a legitimate group in the eyes of Con Ed. They increased credibility by following procedures to obtain permission for the windmill structure, by having a PE approve the design, and having professionals help with the installation. They were even able to gain the support of the PSC.

In the SMUD case, SMUD used alliances to establish credibility for renewable technologies and energy conservation. Much like the early electric companies building relationships with electric appliance manufacturers, Freeman set forth programs by which SMUD would align with appliance, heating/cooling, and solar water heater manufactures and suppliers to develop more energy efficient products and to offer them in the stores. SMUD also aligned itself with other utilities and developers. They established new goals: to advance research and development into alternative technologies, to make renewables more affordable, and to ensure availability of energy efficient products. SMUD also rebuilt its relationship with its customer-owners. They had to believe in the new utility leadership and be willing to participate in energy conservation and energy production[31] programs. These alliances not only increased the legitimacy of renewable technologies, but also supported SMUD's goal of increased dependence on renewable energy technologies.

In the Texas case, the alliance between policy-makers and constituents established legitimacy for customer voices. The policy network provided the support necessary to find out what electric customers wanted. Under PURA, Texas utilities had to scientifically obtain their customers desires regarding resource plans. Deliberative Polling™ emerged as the tool for conducting the scientific polling. The PURA requirement plumped up once withered links between customers and their IOU. The scientific polling gave customers unbiased information and a forum in which to disseminate that information. Customers could make informed decisions and have those decisions heard by the utility.

Actor-network theory also emphasizes the active role of network relationships. Solid alliances and good working relationships can facilitate action. For example, the ETF and 519 Corporation used the skills learned in negotiation for the building purchase loan and in renovating the gutted structure to obtain loans from the CSA. After successfully designing, purchasing, and installing a solar water heating system, they went back to their CSA project manager, Miriam Charnow, to obtain a second loan to design, purchase, and install a 2kW windmill. Maintaining a good relationship with Charnow smoothed the process for future requests for energy improvement loans. Alliances within SMUD resulted in a clear mission statement – to become a leader in renewable energy and energy conservation. The ideological similarity between Smeloff and Freeman created a solid alliance between SMUD's Board and general manager. Together, these entities could work with an already receptive public to define a business plan that would still shape the utility in a restructured electric market.

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[31] See Osborn, D. E. (2001). *Sustained Orderly Development and Commercialization of Grid-Connected Photovoltaics: SMUD as a Case Example.* Paper presented at the Forum 2001: Solar Energy: The Power to Choose, Washington, D.C. or the SMUD website <http://www.smud.org> for information on SMUD's innovative solar rooftop program.

6.3 Full Engagement of the Customers

Hughes said that redirecting system momentum becomes harder as the system matures, harder, but not impossible. As a technological system matures, the social elements sustain the momentum. But these same elements can adjust their values / beliefs. One of the single largest social elements of the MES is the customer. Millions of customers passively participate every day. The cases presented show what can happen when the customer node awakens, and becomes more than just a physical interconnection point with the electric grid.

Most customers passively participate in the MES. These nodes are weak and the utilities do not work to strengthen the relationship. The 519 tenant-owners were different. By purchasing 519, the renovators could choose how best to manage their electric bills instead of living by the decisions of an absentee landlord. Through their actions they changed their physical interconnection with Con Ed, their billing structure, their monthly bill, their relationship with the utility, and their relationship to electricity.

On a larger scale, the residents of Sacramento desired the same thing: full participation in their electric decisions. Sacramentans wanted to be in charge of their own electricity supply, so they carved out a piece of PG&E's territory, creating the municipal utility, SMUD. Once established, the customer-owners of SMUD had a vested interest in the successful operation of SMUD and in keeping a good, solid reputation for SMUD and their community. Just because the muni structure made them owners did not guarantee their active participation. Though muni customers have inherent pathways for participation, they have to choose to exercise those rights. When the utility's handling of Rancho Seco damaged SMUD's reputation in the press and with investors, the customer-owners responded. They crowded into board meetings, they signed petitions, and they turned out to vote down Rancho Seco and vote in Smeloff as Board president. Once SMUD established energy efficiency programs, the customer-owners opted to participate, to take further control of their energy consumption.

At the state level, the MES encompasses many more customer types. The majority, though, belong to an IOU. Utilities did not ignore their residential customers, but neither did they get the same focus as large industrial and commercial customers. To the IOU, these customers only represented a technological parameter – load. The IRP process gave them a human role as well. With the IRP requirement that utilities determine the desires of residential customers, the relationship between customer and utility strengthened[32].

Gaining allies and strengthening the relationship between millions of customers and their respective utility can lead to fundamental changes in utilities' relationship with renewable technologies. This support network creates stability for any change.

6.4 Creating Stability

Mature systems are inherently stable and will inevitably crush any instability. Therefore it is important that new interconnections or alterations to portions of the MES are themselves stable. The 519 windmill places an almost imperceptible amount of electricity on Con Ed's network, thus allowing it to be safely subsumed into the MES. SMUD, during the 80s, exemplifies the unstable network. Infighting and distrust amongst the nodes threatened the viability of SMUD. By the 90s, the customer-owners, Board, and general manager values were in alignment. These groups of nodes supported each other, while they worked with other actors like manufacturers, to bolster their desire for alternative energy even further. The expiration of the federal PTC shows how unstable policy elements of the MES can create boom-bust cycles in renewable energy development and implementation. At the same time, one of the heralded keys to the RPS' success is its long-term goal. Utilities can safely enter into long-term contracts with renewable energy providers because the obligation to purchase lasts 20 years. Building in long-term goals ensures stability. After 20 years, the new interconnections and relationships may look like permanent members of a reshaped MES.

[32] The SMUD and Texas cases also incorporate the added twist of customer choice. Theoretically, customers should have an even stronger voice in a re-regulated market because they can shop around for an electric service provider. However, this presumes customers have access to helpful information about their options. In practice, customers still have to choose to become active participants.

6.5 Flexibility

Stability should not imply rigidity, though. The basic realization in Latour's *Aramis* is that an emerging node must be willing to adapt in order to fit with the existing network. The same need for adaptability, or flexibility, presents itself in the three cases. The windmill case is a very localized case: a single unit for a single use. However, the MES developed around the central station model. For widespread implementation, small-scale technologies like photovoltaics and wind turbines need to adapt. For example, utility-scale photovoltaic arrays and wind farms mimic[33] the central station model by aggregating individual generators together to form a large plant. While mimicking the MES structure, the arrays and farms have the added flexibility of remaining available even if a solar panel or wind turbine is down for maintenance. In the SMUD and Texas cases, developers are constructing large wind farms (50 MW to 200+ MW). They brought small elements together to create a larger whole. As the portion of MES to be converted increased, the alternative technologies had to adapt to fit the larger scale.

Another important process in integrating renewable technologies is providing a choice of implementation pathways for the utility. SB7 requires utility compliance, but the TPUC built flexibility into the rules for instituting SB7 and its RPS amendment. Utilities can choose the best path from several options for meeting their renewable energy requirements. This flexibility recognizes the complexity of the MES and that utilities must navigate through these complex relationships in making energy supply decisions.

6.6 Hopes for the Future

Pessimists may say that I have only shown three cases of success in a myriad of failures. The truth is, these cases could have easily become another statistic. But the importance lies in how and why they were successful. If the ETF could not have obtained loans or enlisted the support of the tenant-owners, the windmill would not have been installed at 519. If the customer-owners of SMUD had not voted in Ed Smeloff as Board

[33] Note I said "mimic" not "perfectly imitates". The wind turbines and photovoltaics still have the same characteristics and capabilities, but they are aggregated to form a plant that resembles a traditional combustion turbine plant.

President, and he in turn had not been able to hire S. David Freeman as general manager, then SMUD could have taken on a completely different mission statement. If in Texas, the TPUC had not required IOUs to obtain informed customer input regarding generation expansion plans, the customers had not overwhelmingly responded in favor of alternative energy, and if the legislature had not listened to its constituents, Texas would still be the land of oil instead of the U.S. leader in wind development. So yes, at several points in each case, the path to success could have been diverted. But it was not. In each case, parts of the four key groups (customers, utility executives, institutions, technology) built relationships around the idea of integrating renewable energy with the MES. By building this network of social relationships, utilities came to accept alternative energy into their physical electric system.

First, these cases show that change can occur at any level. We can make a change in our home, our community, our state. In our everyday lives, we can take control of our electric destiny. We do not have to remain point of load on the demand curve. We do not have to remain consumers. We can be active conservers and active producers, if we want.

Second, we do want to be active participants, and we want renewable technologies and conservation measures. When we educate consumers – when we give them the opportunity to learn, to evaluate, and to decide their energy destiny - the majority choose energy conservation and renewable energy technologies. The people want it, and we have the technological capability to provide it. However, the social system that sustains the momentum of the mature system needs more mechanisms like those in Texas to ensure that the relationship between customer and utility grows beyond the physical interconnection to a strong personal relationship.

Third, utilities can also change from within – SMUD points the way. But customers have to make sure that the right priorities are being set, and that the utility is delivering the goods they want. This is particularly true in an IOU, where maintaining the status quo has lead executives to promote individuals with similar viewpoints and backgrounds. To break this cycle, customers must speak up and let their opinions on current and future energy supply be known.

These cases give me hope. They are not unique cases that cannot be replicated. The key lies in building alliances among customers, utilities, other institutions, and technology. Hughes says that social systems shape technology while being shaped by technology, and that social networks maintain the mature technology system. By realizing and acting on their potential to change the MES to reflect their desires, formerly passive consumer nodes can infiltrate MES social networks and gain utility acceptance of alternative energy systems.

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Work Experience – Energy Sector

Global Energy Concepts
Kirkland, WA
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Will apply my independent engineering, due diligence, and economic analysis skills towards the development of wind energy projects.

Pamplin School of Business at Virginia Tech
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May 2002 – December 2002
Analyzed the possibility of siting an energy center in either New York, Virginia, North Carolina, or South Carolina. Analysis included discussion of need for generation, generation mix, customer mix, regulatory environment, siting process, technology overview, and renewable energy incentives within each state. From the analysis, developed state specific energy center conceptual designs. Presented findings to Dominion.

Black & Veatch:
Overland Park, KS
Energy Analyst, July 1996 to August 2001
Worked in the Energy Sector Consulting Services as a project engineer and study manager specializing in independent engineering, bank assessments, project development, and financial and economic studies. Responsible for contract review and pro forma model review. Lead the development of an Excel version of our in-house pro forma model. Conducted economic evaluations for domestic and international clients on projects ranging from cogeneration studies to biomass plant feasibility studies to the benefits of joint dispatch. Presented findings to clients via formal presentations and small working-group sessions. Compiled data and ran numerous production cost models, pro forma models, and least-cost option models. For a sample of my early work visit, *http://www.state.ak.us/rca/u97140/.*

Skills

Proficient in Word, Excel, Adobe Acrobat and Photoshop, Internet Explorer, and Dreamweaver. Good written and oral communication skills.

Professional Accreditation

Professional Engineer, Kansas, 2001
Engineer-in-Training, Missouri, 1996

Graduate Education

Virginia Tech:
August 2001 to May 2003
Earned a Masters degree in Science & Technology Studies. Masters thesis, titled "Network Infiltration: Gaining Utility Acceptance of Alternative Energy Systems," investigates three cases (urban windmill in NYC, SMUD energy efficiency programs, and Texas' RPS) to understand the relationships that lead to successful integration of renewable technologies with the American electric grid. Also, designed an on-line history web unit on Wind Energy in America. GPA = 3.82.

Graduate Assistantships

Virginia Tech Graduate Assistant
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Conducting a University assessment of the STS program. Creating fliers and brochures for the new undergraduate STS degree program. Updating the STS website with information that will enable prospective students to gain a better understanding of STS professors' various ideological interests.

Virginia Tech Graduate Teaching Assistant for "Engineering Cultures"
Fall 2001, Spring 2002, Fall 2002
100 percent responsible for conducting weekly recitation sessions. Recitation class size varied between 30 – 50 students. Developed homework assignments and exam questions. Graded all assignments and ¾ of exam questions. Conducted the Fall 2001 class on-line. Course evaluation of 3.4 out of 4. This experience speaks to my ability to present concepts and information to others.

Graduate Activities

Resuscitated the Women's Ultimate Frisbee Club at Virginia Tech. As President, I acted as player and coach, as well as obtained money from the Small Grant Fund to offset tournament fees and travel costs.

Virginia Tech Consortium on Energy Restructuring. Founding member and responsible for the first semester of the seminar series.

Undergraduate Education

University of Missouri-Columbia:
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Bachelors of Science in Mechanical Engineering, Honors
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Honors & Awards

Earned the Curators Scholarship, the Missouri Higher Education Scholarship ("Bright Flight"), and numerous other scholastic and professional scholarships.

Phi Beta Kappa – Distinguished Scholar Award
ASME – Outstanding Member Award
Pi Tau Sigma – Outstanding Sophomore in Mechanical Engineering

Honor Societies

Fulfilled requirements and inducted into the following honor societies:

- Phi Beta Kappa, Spring 1996
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- Mortar Board, Spring 1994
- Tau Beta Pi, Fall 1993
- Phi Kappa Phi, Spring 1993
- Phi Eta Sigma, Spring 1992