PRODUCING POWER: THE SEMIOTIZATION OF ALTERNATIVE ENERGY IN MEDIA AND POLITICS

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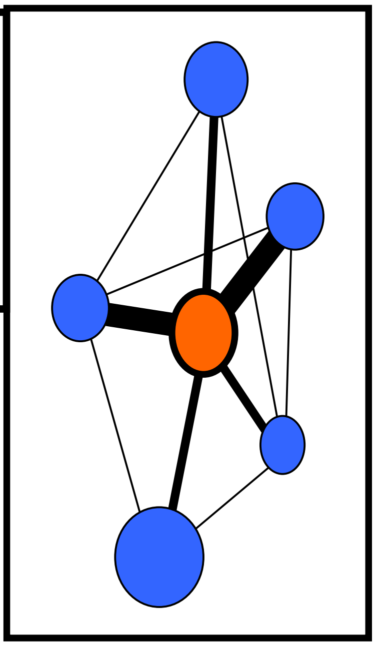

Producing Power:
The Semiotization of Alternative Energy in Media and Politics

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00 » Introduction

As I peeled back the layers of newspaper and masking tape from the windows of my new live-work studio in Washington, DC, light poured over my desk and filled my office to paint the slate walls white. It was earth day and the good weather augered well for the public opening of my architecture studio. I had often dreamed of starting my own firm to design ecotectural habitations. My funds were limited, so I had to be creative in the green design of my urban workspace. First, I was able to increase the functional footprint by using spaces twice. For example, a partition wall enclosing the plumbing for a urinal was hollowed out on the opposite side to form a bookshelf. The empty space over a doorway and the gap left by a raised platform became a storage closets. The space over the refrigerator was reclaimed to hang my bicycle. Through these strategies, I was able to expand the effective floor plan by 15% without expanding the building's structural envelope or volume of space to be heated and cooled. Second, after some quick calculations, I decided to double-insulate all of the exterior walls and roof. This enabled me to downsize to the smallest furnace allowable by local building code, which reduced both my installation and energy costs. Third, I was careful to locate the building near public transportation. I also reused existing beams from the deteriorated historic shell and complimented them with other construction materials with low embodied energies. My office was lit with indirect natural light, while the remaining interior spaces were equipped with energy-saving lamps. The result was an incredibly inexpensive, low-energy urban live-work studio that became the focus of several architectural tours and fashion photo shoots.

One of my early clients was a liberal-minded diplomat who wanted to live in a solar house. Previously, I had considered installing solar panels on the roof of my studio but due to the high costs I decided against it without much in-depth research. So, I took this new opportunity to learn more about solar cell installations. First, I was dismayed to find that no matter how firmly I massaged the numbers, the solar cells would never yield a monetary payback even under the most favorable weather conditions. I was further shocked by the embodied environmental costs to produce the solar arrays, from the mining of minerals to the transportation and installation of the finished product. Cleaning and maintenance costs were also projected to be high because of the relative inaccessibility of the rooftop units. Furthermore, they rely on a thinly-spread solar radiation from a sun that only shines half of the day, a cosmological constant showing no signs of improving. I was also alerted by concerns about global solar markets. While solar technology holds meaningful hope for developing regions that lack energy grids, most cells are sent to rich countries like Germany and Japan. Elevated demand for silicon fuelled by subsidies in cloudy Germany was artificially raising prices out of the reach to those who could benefit the most. It seemed solar energy was evolving as a first-world fetish, an expensive one at that! In the end, I advised my client against a solar installation. He was irritated – certainly I had miscalculated. Or, he inferred, I simply did not care about the environment as much as he did. I did suggest many of the energy-reduction strategies employed in my studio, to which he expressed a passing interest. But those were not sexy enough; his real concern, he explained to me, was to have solar cells; he wanted a house that really *meant* something.

Soon after I had lost that client and several states away, good friends of mine were unpacking boxes in their new home. Wouldn't it be great, they called to tell me, if they could put solar cells on the roof? I immediately gushed into a lecture. By the end of it, their poor ears were numb to my recommendations about low-energy lighting and insulation. That wasn't really what they were calling about; they were interested in *solar* energy, not energy conservation. I was beginning to question whether there had been some kind of mass hypnosis regarding the endless frontier of solar energy that I had inadvertently avoided. It seemed like I was being attacked from all sides by zombies chanting a solar-cell mantra scripted by Vannevar Bush (1945).

What was it about solar energy that was so alluring? I could understand a bit of the magic. I remember being fascinated by solar energy possibilities as early as grade school. My librarian had a small fan that hummed softly on the check-out desk. The small plastic blades magically spun without battery power but through the energy generated by a small solar cell on its base. In middle school, solar-powered calculators were all the rage. And in high school my twin friends had identical solar watches. No matter that they seemed to fall out of sync after a few days, the watches were cool and attracted plenty of attention. They represented the solar future – an obstinate sort of future with the ability to sneak just out of reach every time it seemed to be getting close enough to grasp.

The day I was moving out of my architectural studio to attend graduate school, a clothing designer was moving into the unit. The flexible layout allowed him to slip comfortably into a fresh configuration of the space without a renovation. At the University of Amsterdam in the department of Science and Technology Studies, I developed more questions on how and why we value certain modes of energy use over others. The result of those inquiries culminated in this thesis project.

In the first chapter, I outline an energy-reduction paradox. Namely, while many energy-reduction strategies make economic and ecological sense, they are not employed. Economists have aimed to explain the paradox. I show how their explanations are lacking and I develop alternative ways of viewing the paradox, which are based on social and symbolic values attached to energy technologies. In the second chapter I outline specific research questions involving symbolic values of energy-reduction and production mechanisms. The difference between valuations of energy-efficiency (i.e. making devices more efficient) and energy-conservation (i.e. eliminating consumption) is often contested (Herring 2000). For simplicity, I will use the term *energy-reduction mechanisms* to indicate both strategies for increasing efficiency and reducing consumption of energy.

In the third chapter, I outline the methods I use to explore semiotic energy associations in media and political speech. The fourth chapter justifies a comparison between solar cells as an energy-production mechanism and LEDs as an energy-reduction mechanism. I also explain some basic benefits and drawbacks to each technology. The results of the media and political analyses are presented and discussed in the fifth chapter. The sixth chapter contains conclusions about the semiotization of energy-production and reduction mechanisms and the final chapter shows how those conclusions can help to better shape approaches to energy policy.

01 » Theoretical Framework

Many energy-saving technologies that are available and have been available for years are often not employed. The *1995 Second Assessment Report of the Intergovernmental Panel on Climate Change* notes that energy efficiency improvements of 10-30% are possible at little cost or even with a net economic benefit in some cases (Houghton 1996; Jaffe, Newell, and Stavins 1999). This estimate is conservative since it does not take into effect the additional latent environmental or political benefits to reducing energy consumption. The American Institute of Architects (2007) claims that significant reductions in building energy efficiency are possible at little cost and through the use of basic and existing technologies. Embarrassingly simple strategies like natural ventilation and insulation can cut a wasteful building's heating and cooling expenditures in half (Spindler, Gliksman, and Norford 2002; USDOE 2007). Considering that 40% of US raw material consumption goes toward building construction and that building operations account for 65% of electricity consumption and 36% of overall energy consumption, even a small percentage of energy reduction becomes significant (Loftness 2004).

Energy-Reduction Paradox

Considering contemporary ecological awareness, the situation outlined above seems paradoxical. With public concerns for high energy costs, greenhouse gas emissions, air pollution and political effects of international energy trade, why don't businesses, individuals and governments invest more in those energy-reduction mechanisms, which may even lead to cost savings? The reasons for this gap have inspired much discussion, almost all of which is based in economic theory (Kolstad and Toman 2000; Metcalf 1994; Mulder, de Groot, and Hofkes 2003; Ruderman, Levine, and McMahon 1987; Sanstad, Hanemann, and Auffhammer 2006). A common theme in many discussions is the concept of market failures and the extent to which they are responsible for interrupting the deployment of energy-reduction mechanisms and strategies. Indeed some cases of underinvestment in energy-reduction mechanisms may be characterized simply as market failures. Nevertheless, as Southerland (1991) points out, this is not usually the case. In order for consumers or firms to invest in energy-saving strategies that are neither liquid investments nor risk diversified, they require a premium rate of return. Liquidity concerns and uncertainty risks associated with irreversible investments are central to many other explanations regarding energy-reduction strategies. Research covers diverse areas from landlord and homeowner interest in building efficiency improvements (Levinson and Niemann 2004; Metcalf and Hassett 1999) to the implementation of energy-reduction strategies by firms and governments (Diederen, van Tongeren, and van der Veen 2003; Dixit and Pindyck 1994; Missfeldt 2003). Illiquid investment concerns are even more salient for governments and organizations in poor regions (Fafchamps 2003; OECD 2002).

Mulder (2003) points out that several economists link energy-reduction underinvestment by firms to strategic issues. In this explanation, firms engaged in intense rivalry are likely to postpone investments in energy-reduction strategies especially if there is no incentive to outperform competitors (Kamien and Schwartz 1972; Reinganum 1989). Upgrading to a new energy-related technology may also be associated with a loss of expertise when compared to maintaining an older and less efficient technology (Krusell and Rios-Rull 1996; Mokyr 1990). Mulder adds two additional explanations for the slow diffusion of energy-reduction strategies to the list. First, he claims that the imperfect substitutability of new technologies as a result of past investment decisions by firms can stifle adoption of newer alternatives that don't quite fit. Second, he points out that learning-by-using increases the productivity of an energy technology. Hence, switching to new technologies creates a lag. During this period, new forms of expertise develop over time, enabling more efficient operation.

According to the studies above, underinvestment in energy-saving devices by firms and individuals is not always a case of market failures, but often a reflection of the real costs of investment in a market environment. These explanations have one thing in common; they are decidedly grounded in economic theory. Many assume functional-level rationality on the part of the actors involved in decision-making. One challenge to this type of analysis on decision-making is being challenged by researchers working from a cognitive perspective. Behavioral finance research shows that people tend to apply discount rates differently based on short-term or long-term payback as compared to orthodox economic theory which assumes a constant rate (Economist 2005a). For example, given the option between receiving \$100 immediately or \$115 next week, most people will opt for the \$100 reward now, even though waiting would produce an impressive 15% return on investment in just 7 days. Given the same choice a year from now, that is, \$100 in one year or \$115 in one year and a week, people tend to opt for the larger sum a week later.

One study (McClure, Laibson, Lowenstein & Cohen, 2004) attempts to describe this inconsistent behavior. While asking study participants economic questions during a brain scan, the researchers were able to identify which parts of the brain are functioning and to what degree those sections are active during each decision-making process. Decisions based on short-term gains or losses activate neural activity in the limbic system, a part of the brain that deals with emotion. Meanwhile, choices to be made further into the future stimulate a region of the brain correlated with reasoning and logic, the prefrontal cortex. Options involving immediate gratification tend to be given precedence over a delayed financial reward, even if that reward might be considered financially efficient for the decision-maker. So, the implementation of energy-reduction technologies would not be simply subject to considerations of long payback times but also, according to McClure, bio-cognitive phenomena that don't follow economic rules of function-based rationality.

I do not intend to challenge the validity or investigate the application of these theories in this paper. Nevertheless, rational-actor models lack insight into the social conceptualizations involved in decision-making and the promotion of interests surrounding energy-production and reduction mechanisms. Energy-related decisions are all taking place on a social field that is influenced not just by the use-value or economic-value of energy but also the symbolic meaning that energy mechanisms represent. I begin by pointing out some considerations that produce drag for many new technologies. The first involves technological competence. A buyer standing in the isle of the hardware store may not understand the technology and the benefits or risks that it produces. Furthermore, there is an issue of trust in a new technology that must be overcome. Consumers also tend to feel comfortable with technologies with which they are familiar – and some consumers can be just plain stubborn (Kahneman 2004). Economic and cognitive theories become less helpful when we start to discuss trust, risk, comfort and stubbornness. An investigation beyond the manifest purposes and explicit understandings of energy-production and reduction mechanisms is necessary to obtain a more complete picture of energy-related decisions.

Evolutionary Economics

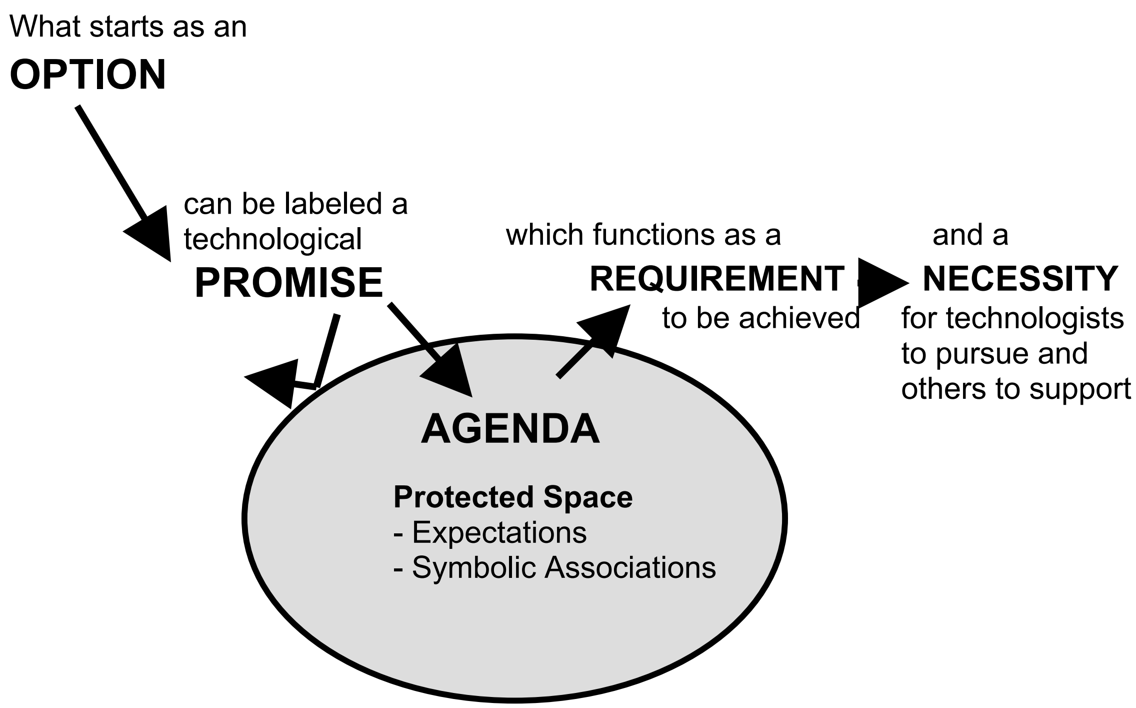
In neoclassical economics, innovation is interpreted primarily as a demand-pull activity. However, innovative events are not always so straightforward since economic incentive alone can not explain the particular sequences and related timing of an innovative pursuit according to Rosenburg (1976). In these instances, efficient-market theories may not provide accurate portrayals of reality. Dosi (1982) is critical of the demand-pull and technology-push theories since they can not alone reconcile interaction of needs and economic considerations. The source of trajectories, according to Dosi, is a fizzing 'Schumpeterian phase' during which new technologies are driven by a search for profit with entrepreneurship, profit motives, economic factors and institutional structures as formative influences. Schumpeter (1943) views capitalism as an evolutionary process that is often overlooked with simple factor analysis or profit maximization theory. He views the drivers of technology to be more complex and historically contextualized, involving factors like new production methods, emergent markets and organization.

Nelson (1994) identifies a shortcoming of economic analysis in the development of dominant designs. Traditional economic analysis is helpful when one design stands out among many as simply being better. But what about cases where one technology gets a better start or offers a standard for complementary products? In these instances, efficient-market theories may not provide accurate portrayals of reality. Instead, Nelson suggests an evolutionary model to account for variables like firm profitability, dedication to technologies, customer diversity and dynamic returns. He introduces the concept of 'punctuated equilibrium' to describe the challenge that new technologies introduce to established industries. If a new technology requires the same type of knowledge structure found in the present industry, incumbents may prevail. However, if new modes of knowledge and technical expertise are required, new entrants can gain an advantage.

Innovations can also be socially motivated and selected as discussed by Pinch and Bijker (1987). They identify cases where innovation activities can be skewed through social rhetorical closure, advertising and redefinition of problems. They outline a development of technology that is iterative. They see technology as a process growing out of the alternation between variation and selection. They research the historical development of the bicycle to show how social groups can identify problems to be addressed. The solutions in turn are a response to this social interaction with the artifact. They point out that the "successful stages of development are not the only possible ones" (1987: 28). In a related vein, Callon (1986) shows how the innovative process can be linked to the social and natural context of its development within actor networks. He presents the concept of an actor world which is inherently in conflict but stabilized through a process of translation.

From Promise to Requirement

Another disruption to the traditional economic mode of analysis, is presented by Van Lente and Rip (1998). They identify how social expectations can form a structure that in turn guides or constrains action. They use the example of Moore's law as a self-fulfilling prophecy; the expectation of the continuation of the pattern motivates firms to expend extra effort to prevent from falling short. They also show how technologies can become macro-actors through social means and also how certain technologies can become self-justifying. They outline a progression of process to requirement in which an *option* can be labeled a *promise* which functions as a *requirement* to be achieved and eventually a *necessity* for technologists to support. A key component to this process is a *protected space* in which agenda-building allows some promises to become requirements. Van Lente and Rip show how agency and structure can influence each other and grow together leading to a process of articulation that gravitates toward stabilization.



Searching for Energy Meanings

Far removed from economic or cognitive theories, Leggett and Finlay (2001) develop a way to overcome the barriers that technical language presents to non-specialists in their study designed to understand the tacit meanings that participants attach to energy forms in a collage-building project. Leggett and Finlay begin by discussing how the Kyoto protocol has pushed governments and energy producers to consider alternate forms of production. Resultantly, they identify a need to understand public perceptions of these alternatives since they are certain to have political, environmental and social consequences. Leggett and Finlay inquire on the site where "energy" is defined on a micro-sociological level. Specifically looking at renewable energy, they offer their study participants the chance to interact with image-building in order to investigate the development and uncover the diversity of energy meanings. They ask study participants simply to build collages from magazine clippings to describe how they feel about energy and its possible future. Afterward, they follow-up with interviews of the participants in a group setting. Leggett and Finlay are interested in two issues. First, they are concerned with depth and breadth of understanding of renewable energy among non-experts. Second, they are concerned with the placement of this understanding within a "broader social context" (Leggett and Finlay 2001: 159).

In order to address these concerns, the authors reject the idea of textbook knowledge as an adequate indicator of understanding. Leggett and Finlay are interested in the tacit knowledge of the participants of the study. Furthermore, they are interested in discovering how people construct meaning around energy, not just in technological terms, but also in social, historical and cultural terms. Since all knowledge can not be explicitly spelled out, the gap left behind embodies a complex and often subtle knowledge that is sociologically interesting because it is shaped by society and individuals in an interactive way. Since this shaping is performed on levels not recognized by the actors, objects of sociological inquiry are formed.

Collins (2001) distinguishes three groups of tacit knowledge. His first group involves motor skills. For example whistling a tune requires not just the explicit knowledge of the notes in the song but also the more tacit ability to blow air through ones lips in order to produce those notes. No matter how detailed the concept of whistling is explained to a non-whistler (or perhaps even a deaf person), it is unlikely the understudy would be able to whistle on their first try. However, once acquired and ingrained, it is a skill that can be easily be conjured up without hesitation. Collins also identifies a forms-of-life approach in which people in different groups take different things to be knowledge; they do this without realizing they are relying on assumptions that are socially based. Another form of tacit knowledge Collins identifies is the rules-regress model.[1] This model identifies that rules have the ability to turn the implicit into explicit but do not come with the rules required for their own path of application. The gap between rules and their application is filled by a tacit knowledge, according to Collins, which is not reducible to something outside the social. This opens up inquiry into areas where there is assumed knowledge or physically inherent knowledge. The concept of tacit knowledge also lends insight into how social or sensory-motor influence can affect individual and political decision-making.

Leggett and Finlay's analysis steps away from technical explanations and cost/benefit analyses often associated with energy dialogs. Instead, they develop a way to avoid technical jargon. They design the collage-building method to draw out

[1] He employs the rules-regress theory, which is borrowed from Wittgenstein

the tacit understandings of energy that people experience. Here, technical jargon is eliminated in favor of a more visceral engagement with energy technology, which involves creative reflection. Through group interviews, the researchers are able to probe the depth of the participants' understandings of alternative energy, which reveals the "complex way in which participants move between the human, technological, ethical, social, emotional and spiritual aspects of energy" (Leggett and Finlay 2001: 157). This method yields a qualitative look at individuals and their own capacity for engaging in dialogs on energy. The study does not concentrate on how individuals are shaped by outside forces, but rather how the meanings that surround energy are constructed by the actors themselves through creative interpretation. Highlighted, are the participants' uses of representations like old-tree roots, childhood and ancestors. Society is accepted as a factor in this interpretation rather than a dominant creator of it.

To Leggett and Finlay, the actors are seen as achieving literacy on energy concepts through a "reflective practice,"[2] engaging in storytelling as a form of inquiry and affecting change though "the use of image" (2001: 160). The participants work on their collages independently and present them to the group. Thus, there are limited social elements involved in this method of analysis on meaning-making; there are no complex interrelations among the participants. A different approach is needed to understand the meanings associated with energy interactions in situ on a larger scale.

Latent Effects of Energy Classifications

I will soon describe how the Leggett and Finlay study leads us to a better understanding of how personal understandings and symbolic values surrounding energy are embodied to a certain degree in energy classifications. I will also highlight an important latency effect associated with such classifications. To begin, it is appropriate to briefly describe the theoretical underpinnings of my classificatory analysis based on the concepts of Bloor (1982). Also, since the idea of latent functioning is involved to a certain degree in the development of my research question as well as in subsequent analysis, I will clarify some relevant terms. I use the term "manifest function" to refer to an objective intended consequence and the

[2] The term "reflexive practice" was introduced by Donald Schön to describe the way literacy or professional knowledge culminates not just from technical knowledge, but also from a form of artistry based in personal experience.

term “latent function” or “latency effect” to describe unintended consequences. Sociologists have made broad use of the latent function concept in analysis ranging from fashion to national security (Calhoun, Gerteis, Moody, Pfaff, and Virk 2002).

Latent functions could be overlooked in analysis focused simply on measuring manifest functions of a practice. Merton (1947) uses the example of Hopi rain ceremonies to show how identifying latent functions from the ritual, like reinforcing group identity, can be more engaging than simply judging the manifest function of the ritual’s efficacy in producing rainfall. Merton explains that sociologists, through the latent-function concept, can extend inquiry into areas that show the most promise for the discipline. For example, after the St. Elizabeth’s day flood in 1421, groups of farmers banded together into “heemraadschappen” to prevent future tragedies by building dykes (Betsky and Eeuwens 2004). While the manifest functions were important to protect against an encroaching sea, equally powerful were the latent functions of these social organizations. The heemraadschappen offered political and social alternatives to fiefdom and resulted in early democratic institutions and a method of consensus building through a “polder model” that still influences Dutch politics today.

Semiotic Classifications of Energy

This thesis inquires into latent effects of the classification of energy production and reduction mechanisms. I will be drawing from the classificatory theory of Bloor (1982). Overall, Bloor concurs with the thrust of the work by Durkheim and Mauss (1967) dealing with classification. Though, he sees the theory in need of a renovation.[3] For example, Bloor starts with explaining how the organization of a whole can take precedence over the parts. He portrays the story of a

[3] Bloor begins by pointing out a few criticisms of Durkheim and Mauss’ theory. First, he calls into question simple ethnographic facts. Second, he makes a theoretical objection that the classifications-based-on-society do not explain the success and utility of such classifications. And third, he takes issue with the circularity of the argument on logical grounds that it presupposes a classification that it intends to explain. However, Bloor’s overarching critique is, that while the surface of Durkheim and Mauss’ thesis is coherent, it is lacking a fully-developed infrastructure or ‘systematic account’ (p269). It is here that Bloor takes the opportunity to construct such an infrastructure, bolstered by the employment of a ‘network model’ and leveraged with further historical examples. One concept Bloor takes from Durkheim and Mauss is that there is a role played by society in shaping human cognition. Like Durkheim and Mauss, Bloor believes that social relations do provide the template for logical relations (classifications). Though, instead of building up from simple elements such as Durkheim and Mauss’ dual-moiety-to-totem approach, he chooses to use a network model to build a theoretical framework. Throughout the construction of this framework, we can see Bloor’s constructions running at times in parallel with Durkheim and Mauss while at other times diverging to bring in new material or concepts.

child learning to associate words with conventionally discriminated objects and features. In order for the child to generalize this case, Bloor introduces a concept of "primitive recognition of similarity" (1982: 270). This concept folds into the framework to support Durkheim's collective representations which are psychologically confirmed after being sociologically acquired. Again, Bloor introduces another concept, this time a correspondence postulate[4] that refers to "any viable relationship that can be established with the environment" (1982: 278). Extending beyond Durkheim and Mauss, he shows how these "loose" representations can evolve into favored theoretical models, metaphors, analogies as well as boundaries and distinctions. Bloor dives into far more complex examples[5] to tease out the ways in which certain laws are protected through their utility for justification, legitimation and social persuasion. He displays how social control interests can guide and shape the flow of knowledge development. He eventually comes back in direct line with Durkheim and Mauss to where he agrees with a fundamental premise that "the classification of things reproduces the classification of men" (1982: 267).

In the Leggett and Finlay article, knowledge is conceptualized and classified on two different levels. Most basically, the authors identify the types of energy that the participants spoke about (i.e. solar power, wind power, water power, tidal and wave power, geothermal power, biomass and animal power). Second, and of more interest to the researchers, was the study groups' way of associating energy with contexts outside the aforementioned list of explicit energy production methods. Participants identified energy with youth, vitality, dancing, renewability and personal energy. This is where the utility of Leggett and Finlay's method becomes clear. While alternative-energy classifications serve a manifest function of identifying power-generation mechanisms they also perform a latent function of reinforcing feelings of youth, vitality and personal energy. The researchers are able to link these energy metaphors with the implicit importance of energy production over energy reduction in the lives of the actors. For example, they state that "The identification of physical wellness with an abundance of personal energy may generate a resistance to exhortations to manage with less" (Leggett and Finlay 2001: 169).

Here, metaphors carry the meaning of energy for the participants. Leggett and Finlay tease out these energy metaphors from inside the actors' emotional and

[4] Bloor attributes this to Mary Hesse
[5] Examples involving orbits, metallic combustion, Pasteur, Boyle and Newton

cognitive space – a space that is not immediately accessible through consideration of standard textbook knowledge or other forms of direct testing. Leggett and Finlay stress the practical importance of such a discovery: "If the identification of energy with personal energy is widespread, then those who wish to sell energy efficiency as a major way of reducing carbon dioxide emissions may need to analyze their messages carefully. For if energy is associated with wellbeing, then messages to use less energy and save money may well be intellectually acceptable but emotionally counterproductive" (2001: 169). Leggett and Finlay hesitate to generalize their claim that energy is associated with wellbeing (note the "if" in the beginning of the above excerpt). Nye is not so shy in his historical account of electrical development when he claims that there was "never a time that ordinary Americans understood electricity in purely functional terms; they have always responded to it with a touch of wonder and ascribed to it symbolic dimensions" (Nye 1990: 382).

Leggett and Finlay are not looking at individual associations exclusively shaped by structures from above but rather reflexively through the contribution of meaning on an individual level. While their study is bottom-up and from a micro-level perspective, it is not psychological. Rather, it is interactional. And, since interactions are continually initiated, perpetuated and concluded, this construction of reality is occurring continuously. Construction and reconstruction of energy meanings occur over and over at the sites of interaction. Leggett and Finlay show that when we are looking at the interactional origins and classificatory construction of energy conceptualizations, the manifest knowledge that scientists and technologists provide about a particular field can be viewed only as one factor in the development of meaning, not an overriding determinant of meaning.

Restrictions of Leggett and Finlay Study

Leggett and Finlay's study allows for an understanding of meaning-making only within an acutely particularized context. Whereas an ethnomethodological study might follow people in their daily lives and observe them making choices about energy, this study brings a select set of participants into the laboratory. How would have the results of this study have changed by observing energy choices and conversations in situ? For example, do the participants always turn off the lights when they leave a room? What kind of cars do they drive – or do they bike to work? While this study identifies modes of energy perception, it can not show us actual outcomes of those perceptions in the context of real-life exposure to choice. This is a natural limitation of the type of laboratory approach employed by Leggett and Finlay.

The researchers' understanding of the energy issues involved may play a part in this study. Leggett and Finlay point out that their ideas emerged from their "own individual experiences in the face of an immediate problem" (2001: 160). One of the researchers is a physicist and science communicator. The other is a facilitator/ storyteller. They both are interested in poetry, education and evidently, environmental issues surrounding energy. Since these researchers framed the study, gave the directions to the participants and coded the results from the informal interviews, we must question to what degree their own understandings are embodied in the study's findings. We also have to question the diversity of the participants. The Leggett and Finlay article is written around 15 people: "Participants ranged in age from their early thirties to late fifties. One group consisted of professional women, the second professional men, and the third non-professional women. All participants were interested in education, although their formal qualifications were diverse, with the level of education ranging from the equivalent of 10 years to a university degree" (2001: 166). Investigating energy conceptualizations on a broader scale may produce findings that could be more reasonably generalized.

02 » Research Question

Mannheim (1936) develops two modes of conceptualizing ideology, "particular" and "total." Mannheim's particular conception of ideology can be seen as a bias; it is affected by the personality of individuals and is therefore a psychological phenomenon. For example, the background and expectations of an individual scientist can taint the findings of a study. In this way, Mannheim's particular conception of ideology is related to Thorstein Veblen's term, trained incapacity, which describes how through the nature of training, we become desensitized to the undercurrents of a discipline as well as the resulting implications (Burke 1984).

More important to Mannheim though, is the total conception of ideology. This is the ideology of a group, an age or a class – the "epoch" of a group. In this case, the whole belief structure is in question. When an explanation of the world is created within a belief structure, it is difficult to see the bias effects from within that same belief structure. The total conception of ideology does not refer to the distortion of particular beliefs, but is rather a reference to the structure of the framework itself.

While the perspective gained through the interviews performed by Leggett and Finlay can help elucidate a predisposition toward energy production on an individual level, how would it be possible view this phenomenon on a larger social scale? While economic explanations operate at this level, they offer us little insight into the symbolic values attributed to energy production and reduction mechanisms. Meanwhile, it would be tenuous to build generalizations from the Leggett and Finlay study of 15 people in Northern California. Though together, these explanations offer us a place to begin; viewing energy conceptualizations with a broader scope calls for different questions and a different approach. A macro-level approach exploring media and political speech in the United Sates should help to address larger political and organizational inquiries. Such an approach should create a complimentary inquiry by bypassing some of the concerns outlined above regarding Leggett and

Finlay's small study population and potential for interviewer bias while inquiring on a scale appropriate for generalization and useful for policy analysis.

Certainly there are political, economic, strategic, environmental and organizational considerations that are explicitly and implicitly incorporated into the construction of energy goals. However, are there implicit social or cognitive conceptualizations of energy shaping these goals as well? Do these formations spring from a process that Bloor (1982) describes as a primitive recognition of similarity? Can these conceptualizations be considered a deep-logic that is generated individually and manifested socially, vice versa or both? Do they predispose individuals and society to value certain forms of energy use over others? If so, how are these meanings translated into action through government energy funding, subsidies and regulations? What effects do expectations have on the promotion of energy production and energy reduction mechanisms? These inquiries lead to the following research question for this thesis:

What role does semiotization (i.e. sign-value over functional-value driving selection) of energy- production and reduction mechanisms play in prioritizing certain technologies for policy-makers to pursue?

More specifically, I will investigate media and political coverage of solar cells as an energy-production mechanism and light-emitting diodes as an energy-reduction mechanism during the 2003-2006 energy crisis. At the end of this period, in 2006, solar energy had become the de facto victor in terms of funding. In California, the governor supported the introduction of a $3 billion program to install a million solar roofs in the state by 2017. I argue that this denouement was not necessarily the result of solar cells being a better candidate for reaching the stated objectives of the policy-makers. In fact, I argue that their objectives may have been exceeded by funding light-emitting diode installations.

Meanwhile, a push for using light-emitting diodes began in early 2007 but not by the government. The effort was lead by industry and environmental groups. This leads to a more specific focus:

By 2007, why was solar energy seen as a necessity for policy-makers to pursue in California, while light-emitting diodes were not?

I expect to find that alternative-energy production is viewed preferentially in politics and mass media as way to deal with externalities from conventional-energy production. This preferential treatment may narrow energy debates to options based in production. I intend to show that energy production is not "naturally" the right way to deal with energy crises but rather one way toward a solution that is largely socially tethered. Decisions on energy reduction or production, whether manifested personally or publicly may not start from *tabulae rasae*, which are then further inscribed with empirical knowledge, but may rather be founded on *a priori* intuitions involving energy on many levels. These intuitions may be informed by personal desires for freedom and vitality.

I also expect to find that while this energy-production dialog operates contemporaneously with a dialog of energy-reduction, its dominate position causes both competing dialogs to be socially reproduced on a field favoring dialogs of *production* over dialogs of *reduction*. In the methodology chapter, I outline my plan to research whether such energy conceptualizations are visible through a quantitative media analysis and political analysis during the 2003-2006 energy shock. I will also research the Million Solar Roofs program in California to discover how symbolic meanings implicit in energy production dialogs can be manifested through energy funding.

I first hypothesize that in the US, during the time of rising energy costs from 2003-2006, solutions based on production were valued over solutions based on energy-reduction in terms of media coverage, political attention by policy-makers and government technology funding. I expect to find that the number of articles on energy-production technologies and energy-reduction technologies both increased over this timeframe. However, I hypothesize that there will be more energy-production related articles overall and that their increase during the energy crisis will be more pronounced.

I suspect that some government funding of energy may be incongruent with the explicitly stated objectives of certain energy programs. However, I expect to find that such funding may be congruent with social conceptualizations of energy. This may point to a degree of semiotization of energy-production imbedded in energy policy.

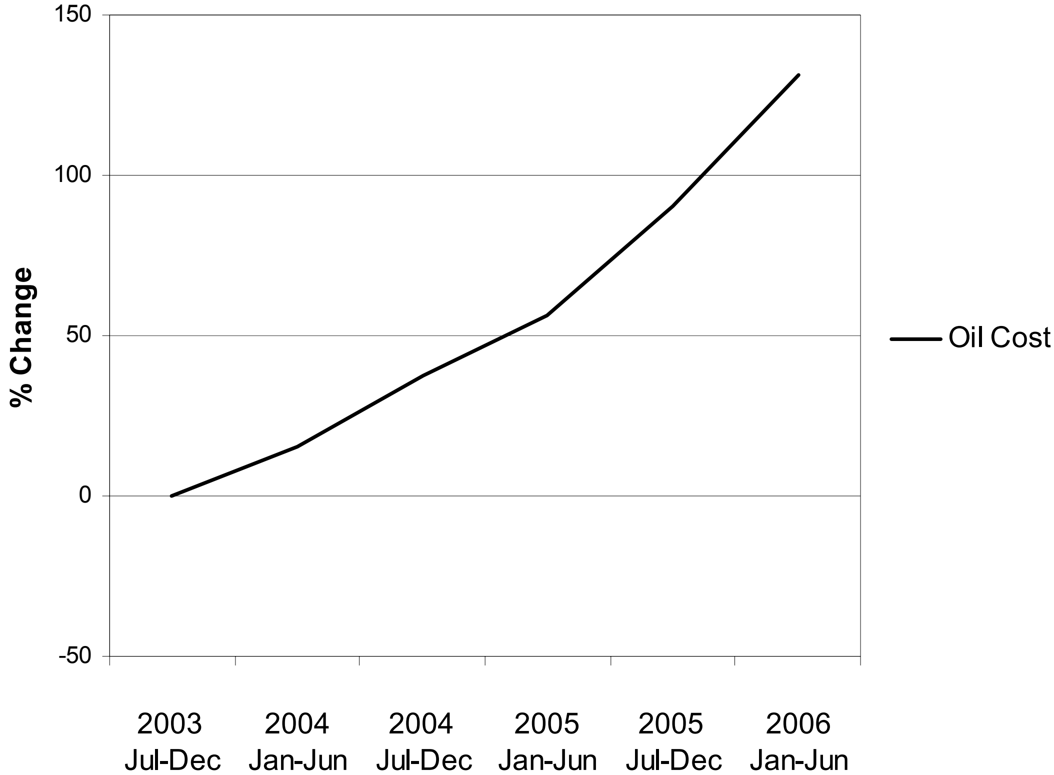
Second, I hypothesize that language maps of popular science articles will indicate differences in the way energy-production and energy-reduction mechanisms are portrayed in such publications. I expect that mechanisms for energy-reduction are characterized with technical language and associated with restraint and responsibility. Meanwhile, based on the micro-level findings from Leggett and Finlay, I expect mechanisms for energy-production are characterized more with emotional language and associated with freedom, independence and vitality.

03 » Methodology

The group-interview process of Leggett and Finlay (2001) can help elucidate a predisposition toward energy-production on an individual level. I intend to discover if this phenomenon is visible on a larger social scale. If it is prevalent in media and political dialogs, understanding the way these predispositions are manifested in policy can lead to the development of interruption mechanisms in an effort to develop a broader policy dialog that more appropriately engages energy-reduction strategies.

The following plan is designed to establish whether such energy conceptualizations are visible through a quantitative media analysis during the 2003-2006 energy shock. During the period from July 2003 to June 2006, oil costs more than doubled. Figure 3.1 charts the increase in the cost of oil over this period (USDOE 2007).

Figure 3.1: Percent Change in Crude Oil Costs 2003-2006



This timeframe is significant because of the concomitant rise of general energy awareness in the United States. By performing a media analysis during this period, we can aim to better understand how solutions to the energy crisis were presented. During such a period, we would expect energy concepts to be covered more often more in the press. By understanding how journalists and politicians treat energy systems during a crisis, we can gain better insight onto their valuation of various energy mechanisms.

I first identify the volume of articles written on energy production and reduction mechanisms during the energy shock. I then research to what degree energy production and reduction articles are associated with energy independence. Third, I build semantic maps based on the words and associations between words in the articles using a visualization tool called Pajek[6] as well as data processing and matrix-building programs developed by Loet Leydesdorff at the University of Amsterdam.

[6] Pajek is a freeware network visualization program available at: http://vlado.fmf.uni-lj.si/pub/networks/pajek/

Leydesdorff uses co-word analysis in a variety of inquiries from the different meanings of the term “stem cell” in policy, application and research to controversies involving monarch butterflies, frankenfoods, and stem-cell therapies (Leydesdorff 2003; Leydesdorff and Hellsten 2005; 2006). Fourth, I analyze political speeches on energy by the governor of California, Arnold Schwarzenegger during the period of rising energy costs. I used LEDs and solar cells as examples of energy-reduction and production mechanisms.

Volume of Articles on Energy Production and Reduction 2003-2006

In order to identify the number of articles written about energy-reduction and energy-production devices, I searched the LexisNexis database because of its broad coverage of many US publishers. I specifically searched the LexisNexis database of United States news sources during the period of rising oil prices from July 2003 to June 2006. I compared the number of articles written on three alternative energy-production mechanisms (solar cells, wind energy and biomass)[7] with those written on three energy-reduction mechanisms (LEDs, building insulation and light rail).[8] I tallied the number of search results returned by the database by six-month increments and charted the number of articles returned on each theme. Since I am interested only in the increase or decrease of coverage and not the raw number of articles, the resulting graphs were formatted to show a percent change from the first period in 2003.

Associations with “Energy Independence”

The coupling of the energy shock with the war in Iraq resulted in a discussion in the United States about energy independence as Americans became sensitive to reliance on foreign oil reserves. I am interested in discovering if energy-production mechanisms are more or less associated with discussions of energy independence than energy-reduction mechanisms. I narrowed the search for each of the terms down to

[7] I selected these technologies because they are widely covered in media and because they are seen as alternatives to fossil fuel consumption.
[8] I selected light rail and building insulation as energy-reduction technologies because of the size of their potential impact and large volume of articles written on the technologies. I selected LEDs because of the reasons outlined in the third chapter of this thesis regarding their relationship to solar cells.

only those articles discussing “energy independence.” For example, the solar cell articles were narrowed using the search string:

“solar cells” AND “energy independence”

I recorded the number of articles returned by the database from July 2003 to June 2006 that contained both phrases. I then produced pie charts showing these numbers as a percentage of the total articles.

Semantic Maps of Articles

While the previous step helps identify the attention given to energy-production and reduction-mechanisms by media outlets, it will offer little insight into the protected space where meanings are attributed to such technologies. Through this step, I aim to clarify this crucial transition. I collected all articles from 2003-2006 containing the term solar cells (an energy-production mechanism) or LEDs (an energy-reduction mechanism) from the New York Times and the three most widely circulated popular science magazines in the United States: Popular Science, Discover and WIRED (ABC 2006). There were 62 articles total. Some of the articles were written on topics unrelated to solar cells or LEDs but happened to mention one of the terms. Some articles contained multiple sections, of which only one or two sections were relevant to solar cells or LEDs. I reviewed each of the 62 articles and selected only the articles or excerpts of articles that discussed solar cells or LEDs. I was left with 19 core texts on LEDs and 20 core texts on solar cells. I made notes on the articles and identified how the journalists presented the two technologies. I converted all of the core texts to lower-case and saved each as a DOS text file. I then imported the texts into the concordance program TextSTAT[9] to build a word frequency list from the articles. The solar-cell articles together contained 10,417 words total and 2,699 unique word forms. The LED articles together contained 7,026 words total and 2,185 unique word forms. A semantic map with 2000+ words would be very difficult to understand. So, I filtered out only the most common words used in each set of articles. By choosing the most common words, the difference in size of the two databases becomes roughly normalized. Of the 10,417 words used in the solar cell

[9] TextSTAT is a freeware program from the Free University of Berlin available from http://www.niederlandistik.fu-berlin.de/textstat/software-en.html

articles, 293 were used more than 6 times. Of the 7,026 words used in the LED articles, 313 were used more than 4 times. The ratio of total words between the two databases (7,026/10,417=0.674) is roughly the same as the frequency ratio (4/6=0.667). I used the same normalization technique for all related word list descriptions that follow.

Most of the high-frequency words were word forms that carry little meaning such as *the, if, but, to, for,* etc. I used a standard stopword list (Van Rijsbergen 1979) to filter the high-frequency word lists. I then inspected the word lists and removed any other conjunctions, numbers and transition words that the stoplist did not remove.

Next, I used the program fulltext.exe[10] to create a co-occurrence matrix of the words from the filtered word list used in each set of articles. The fulltext.exe program produces a cosine-normalized word matrix (McGill and Salton 1983). I imported this matrix into the visualization tool Pajek to create a semantic map of the words associated with both solar cells and LEDs. Pajek allows for further reduction (by displaying only the most central words and links in the network) and scaling of the dataset improving the visualization of complex matrices. These maps are included in the following discussions.

In the following chapters, which contain the results of this analysis, I begin by outlining my observations from reading through the collected articles on solar cells and LEDs. Through these observations, I discovered several reoccurring associations and themes. One of these was that LEDs tended to be presented by journalists in highly technical terms while solar cell dialogs tended to be centered on personal stories that employed more emotional language. I developed the following strategy to visualize these linguistic differences in the journalistic treatment of the two technologies.

First, I constructed a list of technology words. I started with a list of the roughly 500 most commonly-used words in each set of articles and selected those words that were directly related to the measurement or construction of LEDs or solar cells. For example, I did not select words like "education" or "California" but did select words like "silicon" and "solder." The resulting list is included in the appendix. I again used the program fulltext.exe to create a co-occurrence matrix of the words from the technology word list employed. I imported the cosine-normalized matrix

[10] The program fulltext.exe is available from Loet Leydesdorff, University of Amsterdam at http://www.leydesdorff.net/software/fulltext/index.htm

into the visualization tool, Pajek to create semantic maps of the technological and emotional words associated with both solar cells and LEDs. The frequency of words is normalized between the two datasets by considering only the most commonly-used words in each set as described above. The resulting semantic maps are included in the following chapters.

Starting from my observations from reading the articles on solar cells and LEDs, I assembled two additional lists of words to visualize journalistic treatment of the two technologies. In addition to the list of technology words outlined above, I assembled lists involving climate change and expectations. The method I used to create these lists differs from the strategy I used in forming the technology-word list. In order to find the words most commonly associated with climate change, I performed a Google search for “climate change” and saved the top 300 search return titles and short descriptions as a text file. I imported this file into TextSTAT to find the most commonly-reoccurring words in the Google search results. From this list, it was easy to select words associated with climate change like *sustainable, green, atmosphere* and *clean*. The full list of 58 words is included in the appendix. For words dealing with expectation, I used a slightly different method. I began with a short list of expectation words, *could, possibly, can, may, should* and *expect*. I looked up these words into Roget’s New Millennium Thesaurus (2006) and recorded the associated expectation words. I then input these new expectation words into the thesaurus and recorded even more expectation words. I went through several iterations until no new expectation words were returned by the thesaurus. I also included future dates mentioned in the articles. The resulting list of 76 words is included in the appendix. I compared these two word lists to the two datasets in the same manner outlined previously. The resulting semantic maps are included in the following chapters.

Semantic Map of Political Speeches

The previous step was designed to discover the differences in presentation in US media sources between energy-production and energy-reduction devices. An analysis of political speeches over the timeframe from 2003 to 2006 will help to visualize the energy mechanisms given the most political attention. In this case, I plan to focus on a smaller scale by mapping the speeches by the governor of California, Arnold Schwarzenegger. California is an appropriate research target because of its substantial size, reputation for being environmentally conscious and because its policies are often used as models for programs in other states.

I began by obtaining the speeches available from the Office of the Governor of California website during the 2004-2006 period. I read each speech and pulled out entire speeches involving energy as well as energy-related excerpts from other speeches. Two speeches were not available in full-text format. However, a press release about each speech was available. These press releases were primarily composed of speech excerpts. So, in the two cases where a speech was not available, I included in my analysis the sections of the press releases that dealt with energy.

I made notes on the speeches and identified the common themes throughout the corpus of speeches. I converted all of the speech texts to lower-case and saved each as a DOS text file. I then imported the texts into the concordance program TextSTAT to build a word-frequency list from the speeches. The speeches together contained 18,659 words total with 2,339 unique word forms. 284 of the words were used more than 10 times. I filtered these words with the stopword list as described above and compared the words to the corpus of speeches using the fulltext.exe program. I imported the resulting cosine-normalized matrix into Pajek and employed a Kamada-Kawai free association of the data (Kamada and Kawai 1989). The resulting graphic is included in the following discussions.

04 » Energy Production and Reduction Mechanisms

Naturally, there are many mechanisms to create energy and even more mechanisms through which energy can be conserved. This thesis reviews primarily issues around light-emitting diodes and solar energy. So, I will provide a closer investigation into the capacities of these swiftly-changing technologies as they stand at the beginning of 2007. I will begin with a short acknowledgment of the commonly-used energy-production methods throughout the world; I have split the energy sources into those generally considered to be renewable and those considered to be non-renewable resources (Figure 4.1). Seen as an alternative to non-renewable gas and coal sources, renewable-energy mechanisms are often labeled as alternative energies. Nuclear energy is a special case. While it is technically a non-renewable energy source, uranium reserves are plentiful. Nuclear power generation is often considered to be an alternative-energy mechanism as well.

Figure 4.1: Energy Resource Types

Considered Renewable / Alternative	Considered Non-Renewable
Solar photovoltaics	Lignite (brown coal)
Solar thermal	Natural gas
Wood and charcoal (made from wood)	Coal
Biomass and biogas	Mineral oil
Tidal	Petroleum
Human muscular energy	Nuclear/uranium ore
Wind	
Hydropower and micro-hydropower	
Geothermal	

It is important to keep in mind that even though in principle renewable sources can be continuously replenished, they are not without their own costs. For example, windmills and hydropower have been employed for generations. However, construction and maintenance of early windmills and watermills, like their contemporary counterparts, was energy intensive. Stone was quarried, trees were chopped down and horses were employed for construction. All of these steps required energy inputs; human and mechanical energy means were employed to gather the construction materials and horses ate feed that required energy and labor inputs for planting, growing and harvesting.

Also, just because a resource is renewable does not mean that it is clean as well. Firewood, a renewable resource, is still widely used in many parts of the world. Burning of firewood is inefficient and produces smoke, soot and other emissions. Ecological problems stemming from the widespread felling of trees are another concern with firewood use in some regions. Analyses of the negative externalities associated with the deforestation and other ecological concerns about energy-production are complex and do not always yield straightforward answers (Forsyth 2003).

A second example that highlights the difficulty in measuring the ecological impact of alternative energy technologies relates to biomass-derived fuel production. Biomass conversion of plant materials to biofuel is an alternative to wood-burning. Since energy is often used in the forms of liquid fuel or gaseous fuel, a biomass process converts the sugar or starches from plants into a liquid or gas form, which can be used as an additive or even as a replacement for gasoline or natural gas. Essentially, biomass is a way of harnessing solar energy through photosynthesis. Biomass fuels have generally been more expensive than fossil-fuel sources, but they become competitive during times of high oil prices. However, biomass conversion has been criticized for producing airborne heavy metals, waste water and for the employment of pesticides and petroleum-based fertilizers for growing the required vegetation (Puppan 2002). These issues are highlighted in the example of Brazil, which has produced biomass energy for decades. Due to pollution from biomass conversion, many Brazilian river and sea beds were declared biologically dead by ecologists as early as the 1980s (Goricke and Reimann 1982).

While biomass is touted to be CO_2 – neutral (i.e. the growing process absorbs as much CO_2 as is emitted during combustion), the process can have the opposite effect in poor regions where destructive farming methods are employed for biofuel export. For example in Indonesia, where swamps have been drained for palm-oil plantations, soil decomposition has accelerated. This results in 33 tons of carbon dioxide emissions for each ton of palm oil produced (Ali, Taylor, and Inubushi 2007). Since the burning of palm oil over conventional fuel only saves three tons of carbon dioxide per ton of fuel, a net excess of 30 tons of carbon dioxide is released in the process. This has led the Dutch government to apologize for its promoting of the fuel source (Economist 2007a). The European Union's environmental agency is also questioning its support and targets for biofuels throughout the EU (EU 2006).

Solar Cells

Specifically, this thesis will deal with issues regarding the use of solar photovoltaics (PV), or simply, solar cells. The sun delivers the largest portion of the earth's power. The sum would be equivalent to holding a 180-watt light bulb over every square meter of the planet (Actually about 250 watts/m2 in the equatorial regions and 100 watts/m2 in the polar ones) (Craig, Vaughan, and Skinner 1996). In theory, a square field of solar cells measuring 469 km (291 miles) per side could power the entire planet. Distributing solar electricity from such a concentrated source, however, would be absurd; transmission losses would be enormous. The real strength of photovoltaic technology is that it can be located close to the end user.

The cost per kilowatt-hour (kWh) of energy produced through solar cells dropped during the 1970s, 80s and 90s. Over the past decade, the costs associated with energy production through solar cells have continued to decrease, though at a markedly slower pace. In fact recently the cost per kWh of energy produced through solar cells increased due to a silicon shortage. Some environmentalist groups claim that through mass production, photovoltaic chips will drop in price. However, there are limits to economies of scale; automobiles, for example, have not decreased in cost in the same manner that computers have since the 1950s. Also, unlike the computer industry, which replaces high-cost data processing, solar cells are positioned to replace relatively cheap and plentiful electricity that costs just cents per kilowatt-hour. Furthermore, solar energy production is criticized because of the significant sums of energy that are consumed through the mining, smelting and purification of raw materials for the cells and the fabrication of solar arrays and related hardware. According to a study by Fthenakis & Kim (2007), photovoltaic systems come with a carbon price tag, effectively resulting in 22 to 49 grams of CO2 per kWh of solar energy produced.

Newer technologies like thin-film solar cells, organic solar cells and quantum-dot solar clusters could relieve some of the drawbacks related to silicon-based solar.

However, according to the Economist (2005b), these technologies are likely more than a decade away from becoming competitive for broad application.

Energy-Reduction and the LED

All energy-production mechanisms encounter limitations and produce latent effects. These latent effects are largely considered to be negative externalities, which are difficult to measure or fairly price into energy production calculations. As a result, these externalities are often downplayed or even completely left out of many public and political dialogs on energy production (Beck 1992). Conversely, energy-reduction mechanisms are associated with latent effects that are considered to be positive. Again, these effects are difficult to measure and are difficult to weight in energy calculations.

Energy-conservation and energy-efficiency strategies are numerous. These technologies may involve using less energy to perform a given task, changing the way a task is conceived or valued or even eliminating an energy-consuming activity altogether. For example, a project goal of reducing gasoline consumption in automobiles could take various forms. First, petroleum-based gasoline could be replaced or augmented through the use of a more efficient fuel. Second, auto manufacturers could be subjected to higher fuel economy regulations, which would reduce fuel consumption. Or third, mindful urban planning departments could stimulate urban growth (instead of suburban expansion) in ways that make bicycling, walking or public transit viable alternatives to automotive transportation, thereby eliminating instances of gasoline consumption altogether. In brief, these three strategies involve substitution, reduction or elimination.

The way these possibilities evolve to become policy initiatives is a central focus of my research. In the following chapters, I will specifically consider the use of light-emitting diodes to reduce energy use in residential and commercial lighting. I will present data on media coverage of LEDs as well as home insulation and light rail.

Light-emitting diodes, or LEDs, have been commercially available since the 1960s. Appreciated for their incredibly long lifespan, they were primarily used as indicator lights. They were initially only available in yellow-green, orange and red. Additionally, they were dim and expensive. However over the last couple decades these limitations have been dramatically reduced through technical innovations leading to both efficiency and overall output gains. During the 1970s, the cost per lumen of light output of a standard LED was about $10. This quickly dropped to about $1/lumen in the 1980s and $0.1/lumen in the 1990s (Steele 2007b). The exponential decrease in cost is currently showing no signs of slowing. In the 1990s, a new generation of inexpensive high-brightness LEDs was developed to provide blue and white-light output in addition to the original colors. A more complete spectrum of LED illumination is available to lighting engineers, who now tinker with subtleties of “warm” or “cool” white LED output. In addition to the growth of cost-per-lumen efficiency, light-output efficiency per LED bulb has been increasing even faster at a factor of 20 each decade (Steele 2007b). This combination of exponentially-decreasing costs and exponentially-increasing efficiency has been termed the Haitz effect after Roland Haitz who first studied this virulent technological dynamic.

The efficiency of a lighting source is measured by the lumens of light it can produce with one watt of power. For comparison, the most efficient incandescent lights (i.e. standard filament light bulbs) can convert one watt of electricity into 17 lumens of light output. A compact-fluorescent bulb, like the spiraling tubes of glass that fit into a standard outlet, produce about 60 lumens per watt while linear fluorescent bulbs, the most efficient type of lighting in widespread use today, can achieve 80 lumens of output per watt. In 2006, commercially-available white LEDs surpassed the efficiency of linear fluorescent technology. And, unlike fluorescent bulbs, which have now leveled-off in terms of device efficiency, LEDs are expected to yield 150 lumens of output per watt by 2010 (Krames, Amano, Brown, and Heremans 2002; Steele 2007a).

Beyond efficiency, LEDs offer several other benefits according to proponents (Economist 2002; Economist 2006; Economist 2007b; Krames, Amano, Brown, and Heremans 2002; Steele 2007b). Since they don’t have filaments or glass, they are more durable than incandescents. They provide excellent light quality and don’t flicker or hum like fluorescents. They shine brightly for decades without requiring replacement. LED arrays allow lighting designers increased flexibility since they are small, offer directional light, dim without color-shifts, use low-voltage DC power and produce comparatively little heat[11] or UV radiation. Furthermore, they don’t employ regulated toxic substances like the mercury found in fluorescent lighting.

[11] While LEDs produce less heat overall than incandescent lights, the heat is not as easily dissipated by the bulb.

Nevertheless, LEDs are not yet in wide use for lighting applications and may present unintended side effects, positive or negative. Also, the total economic benefits of switching to LEDs over conventional sources are only realized over their long life; the up-front cost of purchasing LEDs is considerably higher than other available alternatives. LED technologies must not only compete on a long-term efficiency scale, but also in up-front cost to consumers. However, even given these considerations, LEDs have been highly successful in select markets. From 1995 to 2005, the market for high-brightness LEDs increased 42% per year (Steele 2007b). This rapid growth was primarily driven by the use of LEDs in traffic signals, brake lights, signage and backlighting in mobile phones and automotive instrument panels.

Validating a Comparison between LED and Solar Technologies

Up to this point, I have briefly presented some of the advantages and disadvantages of LEDs and solar cells. The high up-front costs of LEDs and solar cells would seem to make both technologies candidates for government programs to mitigate the impact of initial costs for consumers and businesses interested in making more sustainable energy choices. However, solar cell installation initiatives have received far more funding than LED installations in the US and, more specifically, in California. Also, escalating media and blog coverage of solar cells seems to point to a public that is not willing to be held back by the economic technicalities of solar energy production. So, why is there a discrepancy? Why are the high up-front costs of solar cell installations ameliorated through public funding while LEDs are left largely to compete in the marketplace?

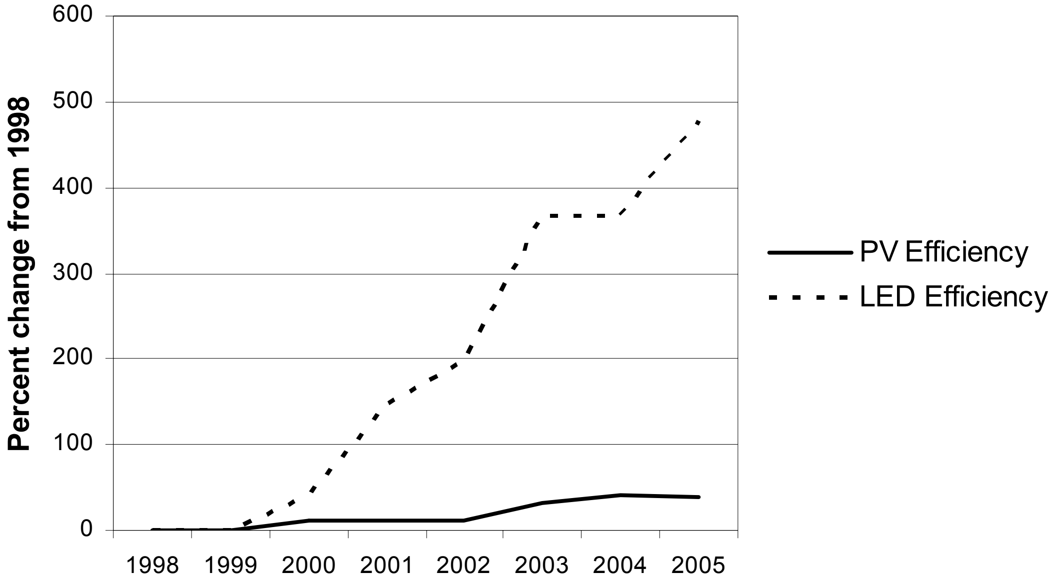
The answer from many people would be simple; solar energy can produce energy for many applications and once established, produces clean energy forever, while savings through LEDs are limited by the energy consumption savings of the fixtures they replace. As one person pointed out to me, “You can’t drive a car with LEDs.” Also, solar energy leads to greater energy independence or at least a reduced reliance on foreign oil. Furthermore, solar energy reduces greenhouse gas emissions which are in part a solution to climate change.

Taking these widespread beliefs about solar cells as undisputed fact could understandably lead an observer to question the validity of my comparison of LEDs with solar cells. For if solar cells clearly offer a higher use-value than LEDs, then my comparison is bogus. For example, comparing California power production through an analysis of solar cells versus large hamsters-on-wheels results in such an obvious use-value discrepancy as to make a socially-oriented comparison between the two perfectly ridiculous.

In order to bring into question the basis for some common assumptions about the virtues of solar energy production versus energy-reduction through LEDs, I will compare the history of LED and solar cell technology efficiencies and discuss some other related considerations. *I do not intend to show that one of these two technologies is better than the other or that one should be pursued by humanity and the other should not.* I do however aim to investigate in subsequent chapters how the dialogs surrounding each of these technologies affect the way we value them. And to make such a comparison, it is important to establish that the selection of these two technologies, in particular, is valid and appropriate. An exhaustive cost-benefit analysis is neither required, nor even reasonable in this case. I simply include the following analysis to problematize the possible impression that solar cells are naturally a better choice over LEDs or that the future for solar cells is necessarily more promising from a technical standpoint.

Figure 4.2 displays the efficiency gains of solar cells and LEDs from 1998 to 2005 in terms of cost-per-kilowatt used or saved. Here the above discussions involving efficiencies of solar cells and LEDs are compared graphically. The cost-efficiency of LEDs increased rapidly over the period, achieving an almost 500% gain from 1998 to 2005 (Steele 2007b). The efficiency of solar cells increased at a significantly slower pace, representing under one tenth of the cost-efficiency gains achieved by LED technology over the same period (AWPIR 2007; Wiser, Bolinger, Cappers, and Margolis 2006).

Figure 4.2: Cost-Efficiency of LEDs and Photovoltaic Cells[12]



In addition to cost efficiency, other external costs, which are more difficult to quantify, must be taken into account. For example, solar cell arrays utilize complex electrical hardware, which employ large quantities of minerals, metals and plastics that have to be mined or created through petroleum processing. Since solar cells are energy-intensive to build, they have a net carbon price tag as discussed above. Moreover, they are incredibly expensive – so expensive that the recent initiatives in the United States to provide solar panel subsidies warn purchasers that they could wait up to a decade just to break even on their highly subsidized purchase (UPI 2007). However, such calculations do not account for the time value of money, in which case the payback period in most cases becomes nonexistent.[13]

Meanwhile, employing LEDs to conserve power would also incur up-front costs, but on a scale that is an order of magnitude less than the cost for solar cells. LEDs use less material input than the fixtures they replace, meaning less mining of metals and minerals, they are not energy-intensive to build, are easy to install, needn't

[12] Compares contiguous datasets (AWPIR 2007; Steele 2007a; Wiser, Bolinger, Cappers, and Margolis 2006)

[13] The related opportunity costs must be considered in this situation. Take for example a family pondering a $10,000 purchase of a rooftop solar system with a home-equity loan. While the system may save them several hundred dollars per year in utility costs, the interest on their loan may cost more than that, which would eliminate the economic benefits of owning the solar system. Even if the family pays cash for the system, the opportunity costs are represented by comparing the same $10,000 invested at a market rate.

be cleaned or maintained and are able to save energy even on cloudy days. These limited considerations do not necessarily make LED-funding a better policy choice, I argue only that LEDs are not necessarily inferior to solar cells based on functional-value alone and a valid comparison may be presented between them.

Both technologies are touted as solutions, in part, to our unsustainable use of fossil-fuel resources. Both technologies seem to currently be on the cusp of making meaningful progress toward this goal. The two technologies are relatively new; they both became commercially available around 1960. They were both nascent technologies during the oil shock of the 1970s. Both were exposed to political pressure and military funding initiatives during the Cold War and have enjoyed worldwide attention from the scientific and industrial communities. Furthermore, the two technologies can easily co-exist; they are not in competition with one another. The main difference is that solar photovoltaics *produce* energy and light emitting diodes *conserve* energy.

In summary, while the impact of LEDs may be restricted by the number of light fixtures available to be replaced, solar cells are limited by available sunlight, solar-electric conversion efficiency, fixture maintenance costs and a carbon legacy. These restrictions together limit the impact that solar cells could have on a macro-environmental level. Of course, to determine the utility that a solar cell or LED system could provide in a certain context, a far more exhaustive analysis than the one outlined here would be necessary to account for local constraints and requirements. If solar-cell funding does not offer a clear-cut economic or environmental advantage when compared directly to LED funding, why are solar cells are given preference in media and political dialogs as a means of moving toward a more sustainable use of energy? We will have to look for an answer outside discussions regarding instrumental rationalities.

05 » Results

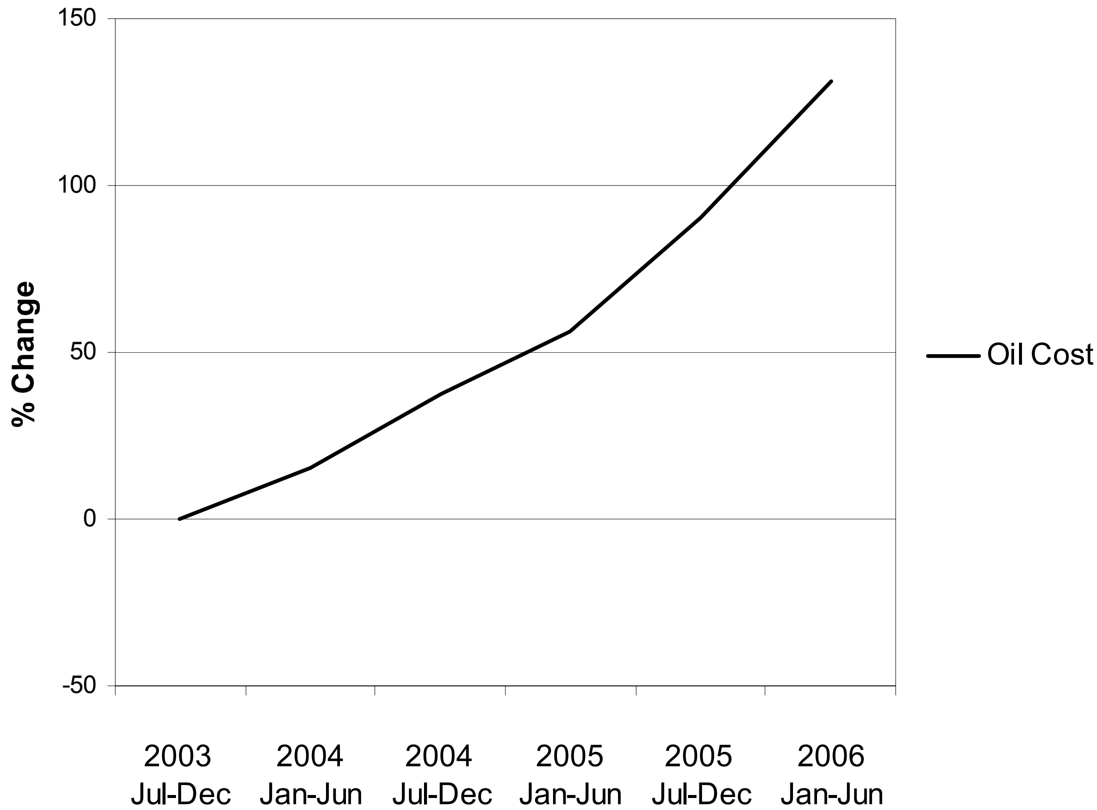
The impact of society on technological development is not a one-way street. Interactions with technology also change individuals and society more broadly (Salomon, Perkins, and Globerson 1991). Human abilities are linked to the artifacts we use. Consider numbering systems, which have the ability to restructure human cognition. These technologies involve symbolic systems that, when tied to media, result in skilled development. Intelligence in mathematics is then defined, not socially, but through the skills associated with the symbolic system (Sternberg and Preiss 2005).

Like Van Lente and Rip, I agree that expectations are a large constituent of the protected space where promises become requirements. Expectations alone, however, offer an incomplete picture of the meanings applied to a technology during agenda-building. The explicit nature of an operational expectation can not fully account for implicit meanings attached to a technology through memory, interaction and expectation itself. I argue that these symbolic associations are important influences on the path that an energy-production or energy-reduction mechanism follows from option to necessity. Investigating the semiotization of a particular energy-production or reduction technology can be a useful way of probing the operationalization of symbolic associations in the process of option to necessity.

Expectations for Energy Mechanisms

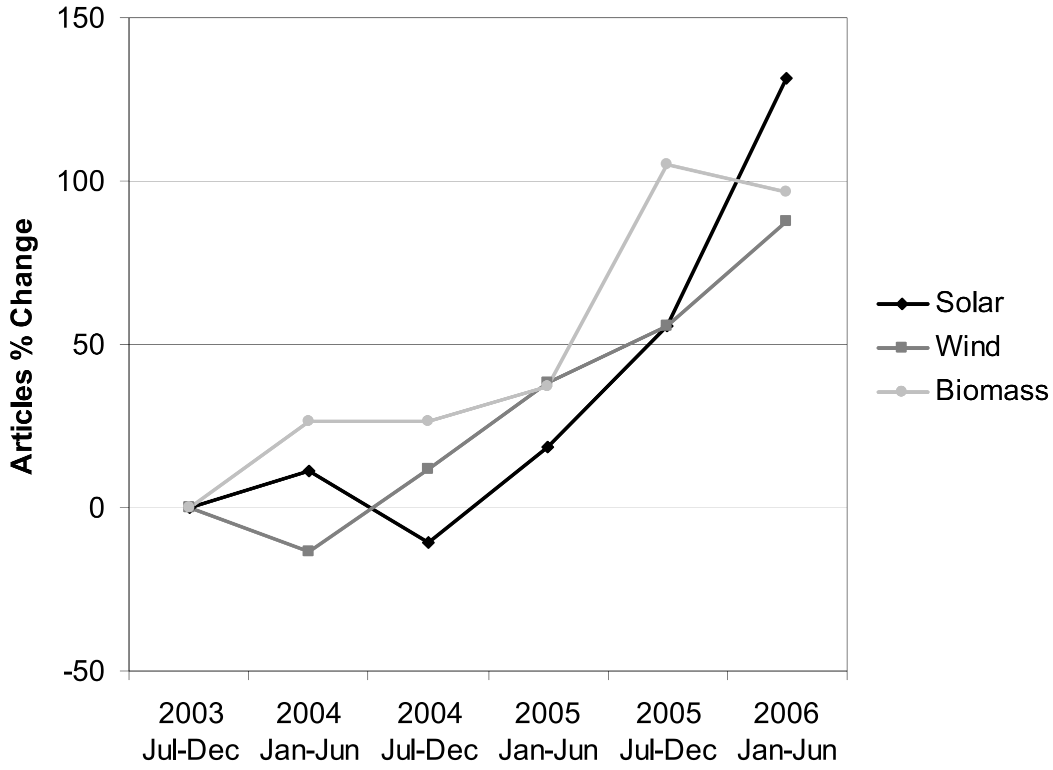
As discussed previously, I have chosen to probe media and political treatment of solar cells and LEDs to better understand how symbolic associations are involved in the selection of (and become imbedded in) energy policies. The energy shock from July 2003 to June 2006 is an ideal timeframe for investigating meanings applied to energy mechanisms because of the general concern about energy-production and use during the period. I return to Figure 5.1 (USDOE 2007) below charting the increase in oil prices over this period. The price of oil more than doubled.

Figure 5.1: Percent Change in Crude Oil Costs 2003-2006



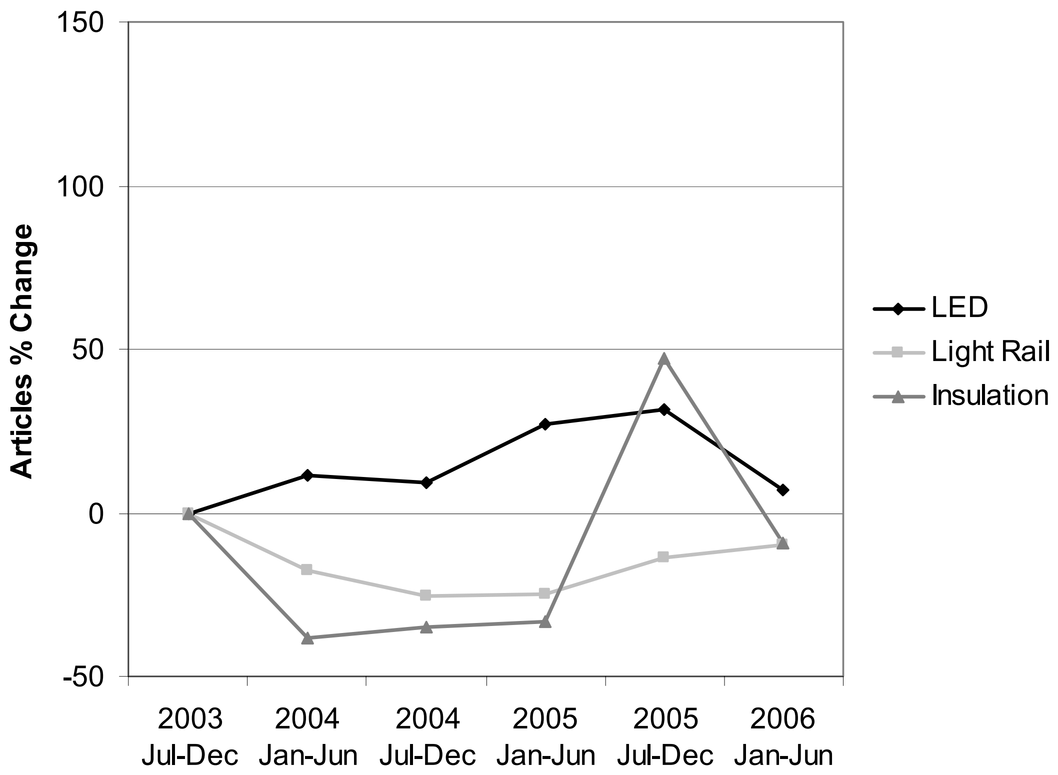
During this time period, we would expect articles written on energy-production and energy-reduction mechanisms to increase as public concern increased. Articles returned from the LexisNexis database during the six-month increments are charted below (Figure 5.2) for three alternative-energy production mechanisms: solar cells, wind energy and biomass. There were 8,826 articles in all. The graph is formatted to show a percent change from the first period in 2003. The number of articles returned from LexisNexis on each technology increased at a rate roughly corresponding with the cost of oil and doubled over the entire period.

Figure 5.2: Increase in Alternative-Energy Production Articles 2003-2006



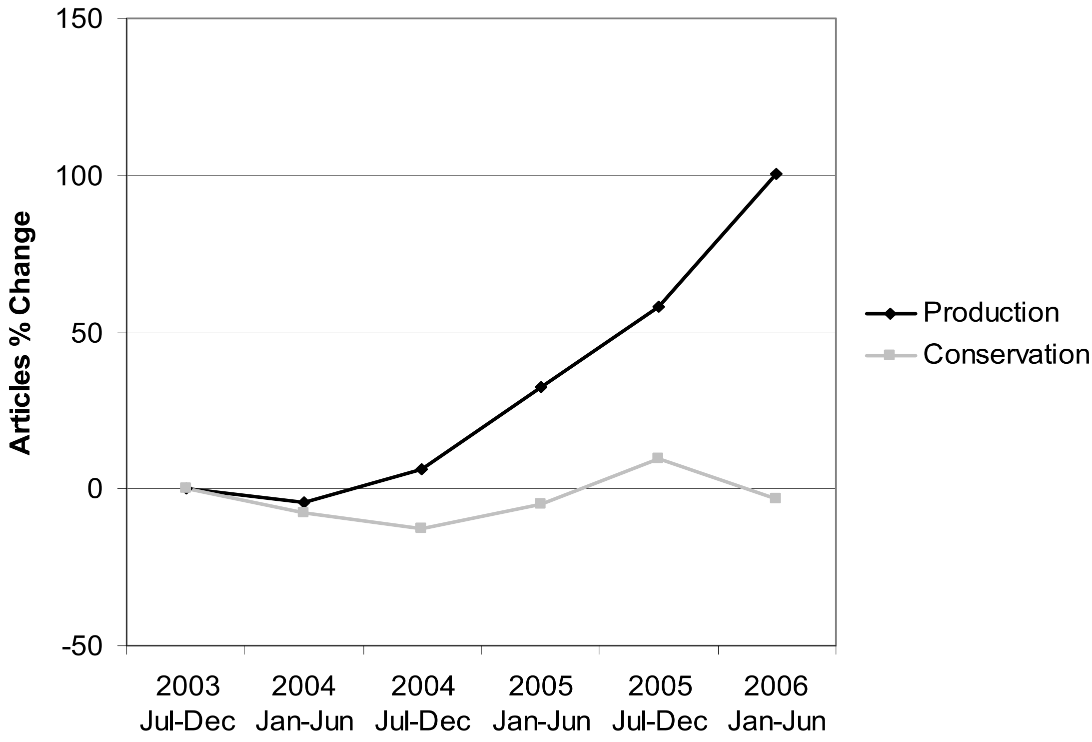
I expected the number of articles written on energy-reduction mechanisms to increase as well, but at a slower pace. Due to the energy-saving capacity of light emitting diodes, which is at least on par with the potential gains through solar power, we would expect a similar upward trend in media coverage of LEDs during the same period. I was surprised to find that the 6,972 returns from the LexisNexis database for energy-reduction strategies changed little from 2003 to 2006 when compared to the energy-production mechanisms shown above. The results are potted below in Figure 5.3.

Figure 5.3: Constancy in Energy-Reduction Articles 2003-2006



We see very little change at all in the number of articles written on LEDs. A review of the literature on building insulation, another large energy-saving strategy, showed similar flat-line interest. The coverage of light rail, an alternative to inefficient automotive transport, was also flat. This difference indicates that media outlets dealt with increasing energy costs by concentrating their coverage on energy-production over energy-reduction strategies to deal with the crisis. In other words, if given the choice between creating 10 units of alternative energy or reducing consumption by 10 units, more media attention was given to creation. And, this phenomenon is not limited to the solar photovoltaic mode of production and the LED mode of reduction. The same trends are apparent in the other modes of energy production and reduction. Figure 5.4 consolidates the data from Figures 2 and 3 into energy-production and energy-reduction mechanisms. Here the contrast between media attention of the two strategies becomes even clearer.

Figure 5.4: Energy Production and Reduction Coverage 2003-2006



These media results suggest an expectation that alternative forms of energy production are better suited to deal with an energy shock than forms of energy reduction. A concordance between journalistic treatment in the actual language employed in the articles and a list of expectation words would help to further support this claim. We can of course learn much more from these articles than their mere prevalence over time. We can look into the articles to find words and associations with other words. The following discussions will search deep within the articles to identify these networks.

For this section of the analysis, I collected and read all articles from 2003-2006 dealing with solar cells (an energy-production mechanism) or LEDs (an energy-reduction mechanism) from the New York Times and the three most widely-circulated popular science magazines in the United States: Popular Science, Discover and WIRED (Audit Bureau of Circulations, 2006). Through reading the 39 articles, I was able to identify specific themes, which I then used to structure my approach to creating semantic maps. While my analysis will concentrate mostly on these cognitive maps, I will briefly introduce some of my observations from reading the articles. The journalistic treatment of solar cells starkly differed from the treatment of

LEDs across the publications. These differences were instrumental in guiding my approach and interesting in their own right as well.

For instance, I observed that the articles on LEDs tended to deal with current applications of the technology in flashlights, automobile headlamps and other lighting devices already in production. The articles often cited the past growth in LED efficiency but most did not project those gains into the future or outline possible scenarios for the technology. Meanwhile, articles dealing with solar cells were noticeably more forward-looking. Primary concerns with efficiency concentrated on future expectations for solar energy, new types of solar cells under development and plausible future scenarios.

As described in the methodology section, I created semantic maps of the articles. The first of these is a basic map showing the most common technology words used in the two sets of articles. These semantic maps are laid out simply to show words and connections between words. The size of the nodes indicates how often the word is used in the document set. The connecting lines indicate the use of that word with other words. I formatted the maps using a Kamada-Kawai free association. The Kamada-Kawai free association is a force-directed placement method for undirected graphs which arranges formless distributions of points into relational clusters (Kamada and Kawai 1989).

In Figure 5.5, words dealing with anticipation or projection into the future are mapped for the combined set of articles dealing with LEDs. Figure 5.6 maps the expectation words used in the corresponding set of solar cell articles.

Figure 5.5: Networks of Expectation Words Found in LED Articles

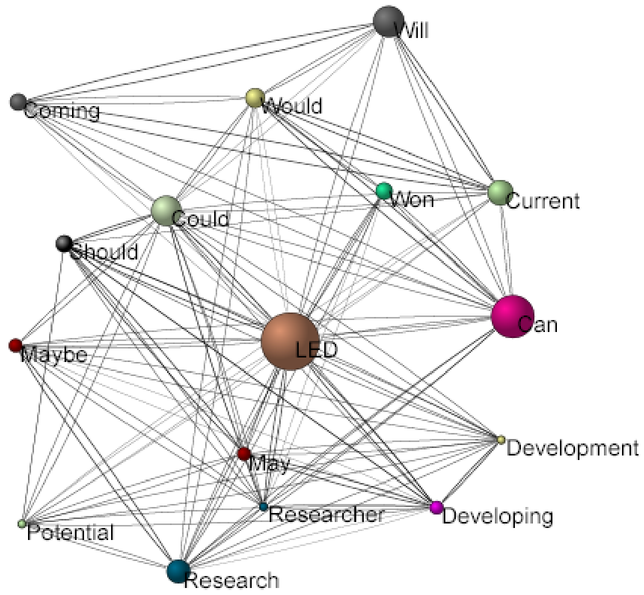
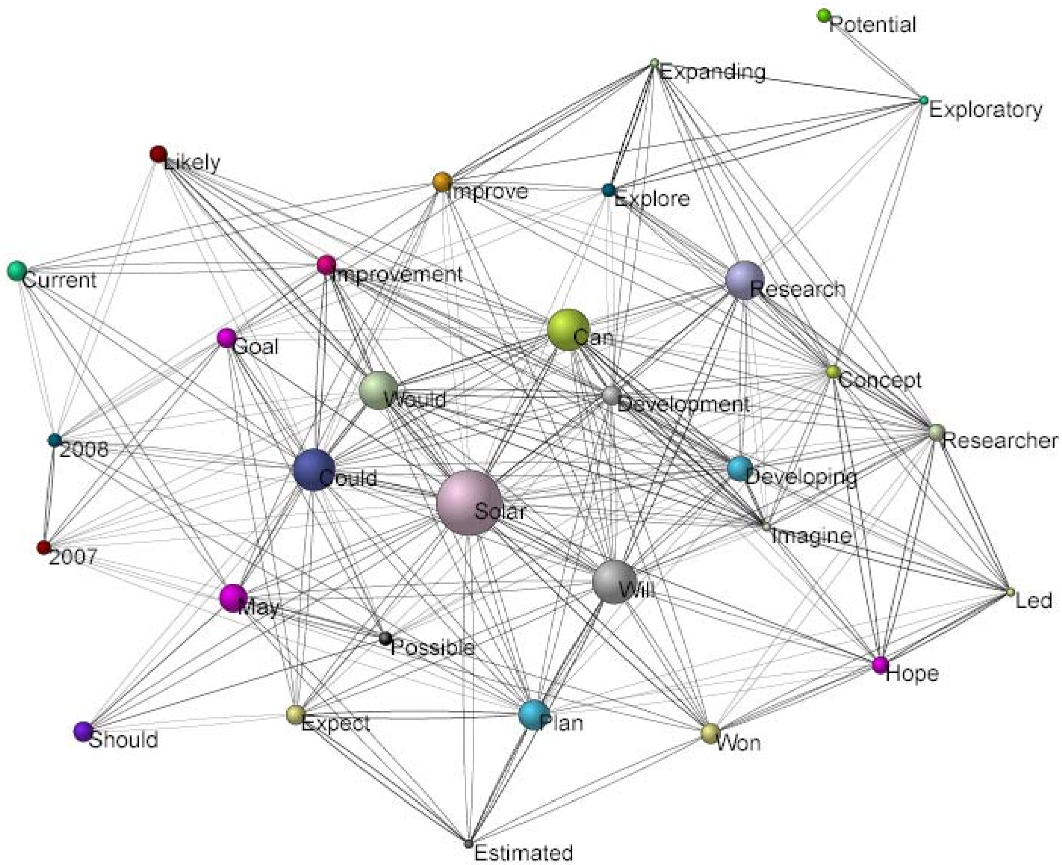


Figure 5.6: Networks of Expectation Words Found in Solar Cell Articles



Articles on LEDs contain few expectation words compared to the solar cell articles which contain many expectation words. The solar-cell semantic map also indicates a more developed network of relational links between the words. This supports my observations from reading the articles. Solar cells are presented in terms of future expectations while LEDs are presented in terms of present practicalities. The expectations surrounding solar cells allow them to more easily pass from promise to requirement in the stages outlines by Van Lente and Rip (1998).

Symbolic Associations

Artifacts such as language, objects and acts embody meaning from and through human values, beliefs and feelings. These values are not immediately visible as they are often tacit and movable. However, they become apparent as they are communicated through dress, language and actions. The meaning carried in language objects and acts can be interpreted by policy makers, citizen groups and other stakeholders. Human interaction with artifacts then becomes reflexively involved in the development of meaning through artifactual interaction (Gagliardi 1990). Lakoff and Johnson point out that "we draw inferences, set goals, make commitments, and execute plans, all on the basis of how we in part structure our experience, consciously and unconsciously, by means of metaphor" (2003;158). They describe how complex metaphors can link sensory-motor experience to the domain of subjective judgment. This process of neural recruitment leads to a stabilized system. An example learned in childhood is the metaphor "affection is warmth." Here, a physical sensation, warmth, is linked with the concept of affection. Evidently, this relates well to Leggett and Finlay's (2001) link between the often physical feelings of personal energy, empowerment and vitality with the concept of alternative-energy production.

An analysis of the association between sensory-motor experience and subjective judgment can help to elucidate if and how such an association can become manifested in public policy. Yanow argues that "in practice, policies are intended to achieve something material, expressive or both" (Yanow 1996: 12). For example, a policy for the provision of housing for homeless individuals does more than just provide shelter. This is particularly salient in the film *The Pursuit of Happyness* *sic* based on the real life experiences of Chris Gardner (Muccino 2006). Gardner is portrayed as a good father who stumbles into financial trouble while starting a medical-instrument sales business. A particularly wrenching scene involves Mr.

Gardner and his son Christopher after being evicted from their apartment. Mr. Gardner, a broken man, barricades himself and his son inside a cramped subway bathroom where they attempt to sleep on a urine-stained tile floor during their first night of being homeless. Here, the lost home of Mr. Gardner and his son carried far more than shelter-value. The loss of their home also symbolized a loss of dignity, status and wellbeing. How effective would a homeless policy be if it concentrated exclusively on the function of sheltering families and individuals? The answer leads us to conclude that a positivist view of policy as purely instrumental or materially based is an incomplete one.

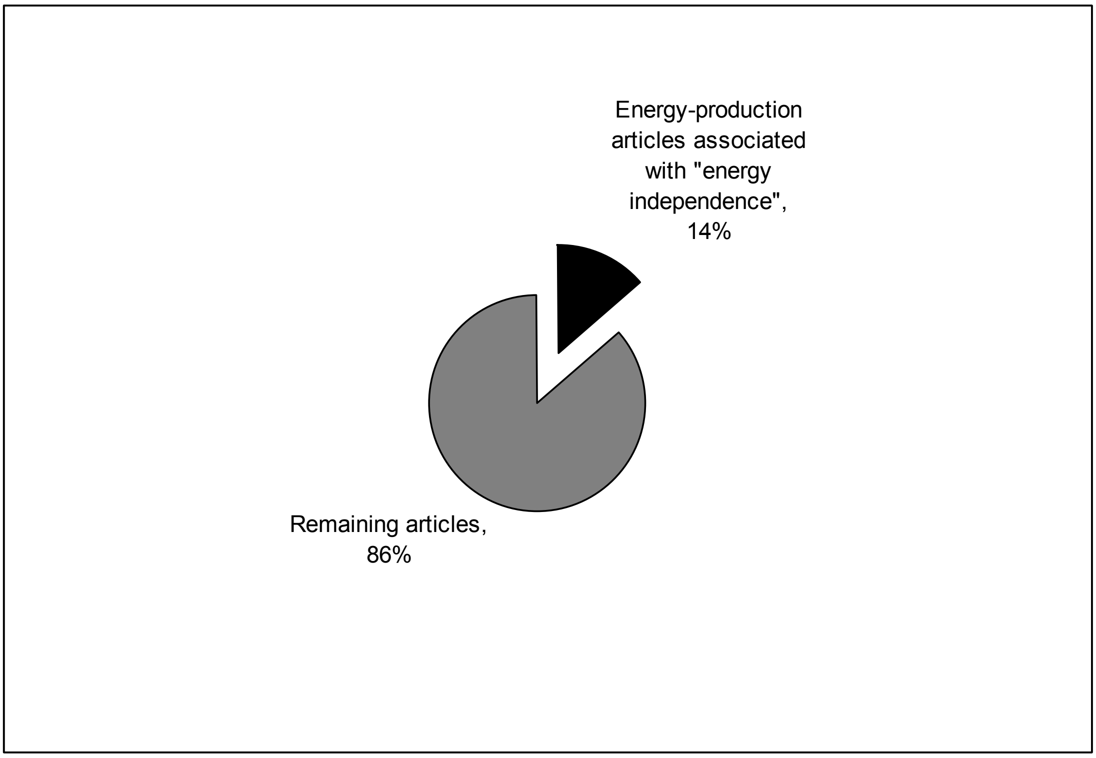
Policy acts are at least in part constituted by symbolic representations, whether those representations are explicitly stated or not. There exists no unmediated version of policy (Yanow 1996). An amusing story highlights the powerful influence symbols can have in policy:

> When in 1334 the Duchess of Tyrol, Margareta Maultasch, encircled the castle of Hochosterwitz in the province of Carinthia, she knew only too well that the fortress, situated on an incredibly steep rock rising high above the valley floor, was impregnable to direct attack and would yield only to a long siege. In due course, the situation of the defenders became critical: they were down to their last ox and had only two bags of barley corn left. Margareta's situation was becoming equally pressing, albeit for different reasons: her troops were beginning to be unruly, there seemed to be no end to the siege in sight, and she had similarly urgent military business, elsewhere. At this point the commandant of the castle decided on a desperate course of action which to his men must have seemed sheer folly: he had the last ox slaughtered, had its abdominal cavity filled with the remaining barley, and ordered the carcass thrown down the steep cliff onto a meadow in front of the enemy camp. Upon receiving this scornful message from above, the discouraged duchess abandoned the siege and moved on (Watzlawick, Weakland, and Fisch 1974).

As argued earlier, the symbolic associations surrounding a technology are also an important component of the protected space whereby a technology can move from a promise to a requirement. I aim to show that alternative energy-production mechanisms carry symbolic associations different from those carried by energy-reduction mechanisms. The positive valence of associations stemming from production mechanisms allows related technologies passage from promise to requirement.

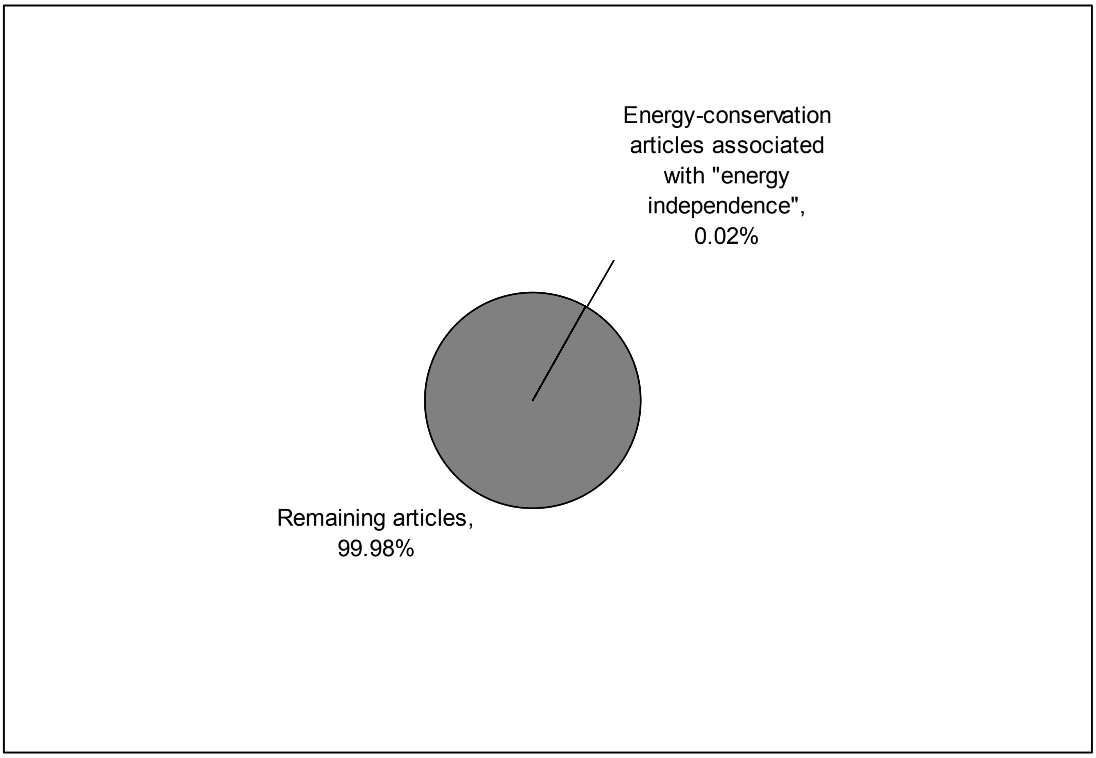
For now, I will introduce this concept in my data by again considering the articles returned by the LexisNexis database dealing with energy-reduction and energy-production mechanisms totaled over the entire period from July 2003 to June 2006. I am interested in discovering if energy-production mechanisms are more or less associated with discussions of energy independence than energy-reduction mechanisms. Figures 5.7 and 5.8 display that energy-production mechanisms considered here are often associated with "energy independence" while reduction mechanisms almost never are.

Figure 5.7: Energy-Production Association with "Energy Independence"



n=8,826

Figure 5.8: Energy-Reduction Association with "Energy Independence"



n=6,972

These findings are significant because they clearly show that solar cells, wind energy and biomass energy-production mechanisms are associated with independence while the three energy-reduction mechanisms, LEDs, light rail and building insulation are not. This discrepancy can not be explained in functional terms. For example, the biomass fuel, ethanol, derived from plants like corn and sugarcane, is understood to offset petroleum based oil sources and therefore reduce the demand for imported oil. Similarly, installation of light-rail networks in urban areas reduces the number of trips in relatively energy-inefficient cars, thus reducing the demand for foreign oil. It is well accepted that both strategies have the potential to decrease oil imports, all else equal. But, only the energy-production mechanism, biomass in this case, is associated in articles explicitly with energy independence.

Reading the popular science articles published during the energy shock, I observed that the treatment of the physical technological descriptions differed. LED articles involved various technical terms and descriptions of the physical devices. Several articles associated LEDs with "geeks" or "geeky" activity. Meanwhile, none of the solar cell articles associated solar cells with geeks. Conversely, there was a tendency for journalists to write about solar cells through the success stories of entrepreneurs and developers of new solar technologies. Generally in the solar-cell articles, the stories came first and the technical descriptions came second. Figures 5.9 and 5.10 on the following page display this observation graphically by mapping words describing LED and solar cell constructions or measurement of those constructions. The solar-cell articles contained fewer technology-based words and weaker connections between them when compared to the LED articles, which contained more technical discussions.

Figure 5.9: Networks of Technical Words Found in LED Articles

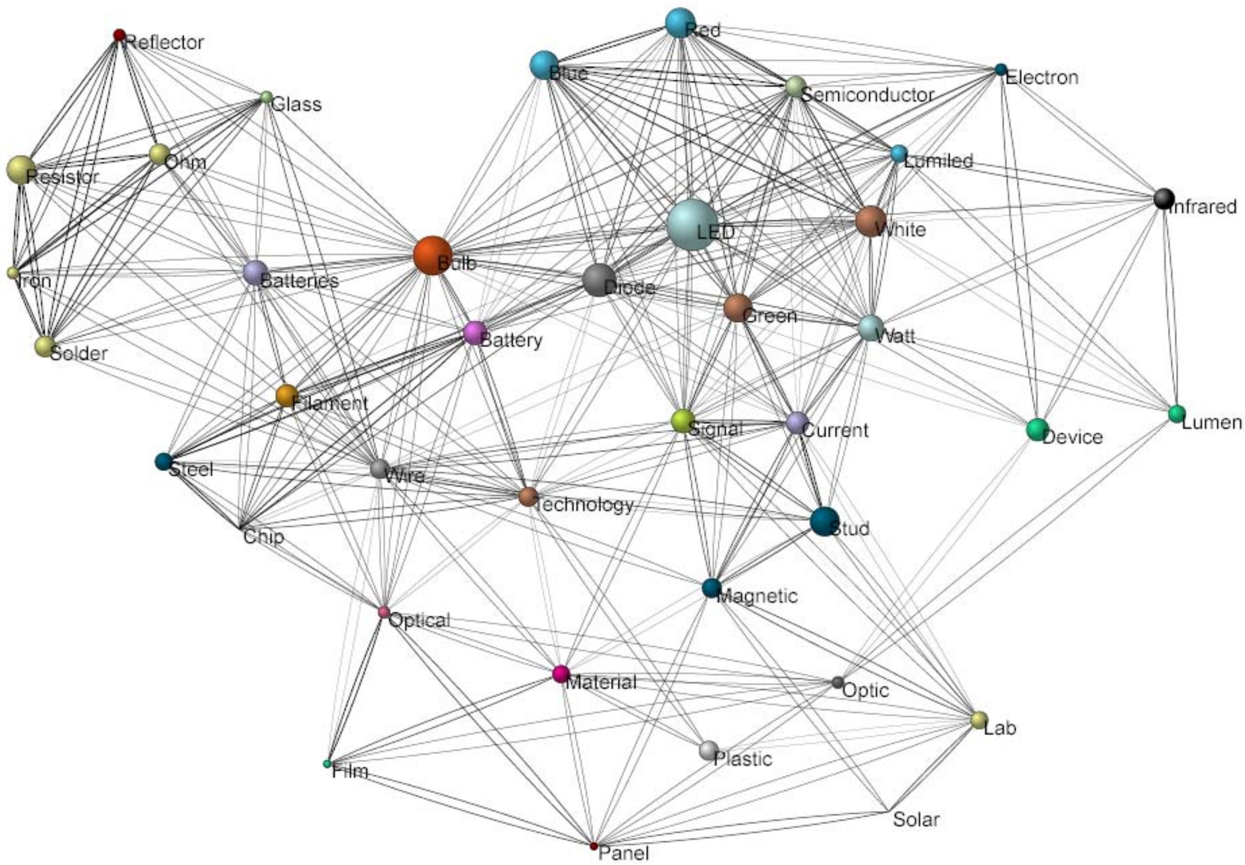
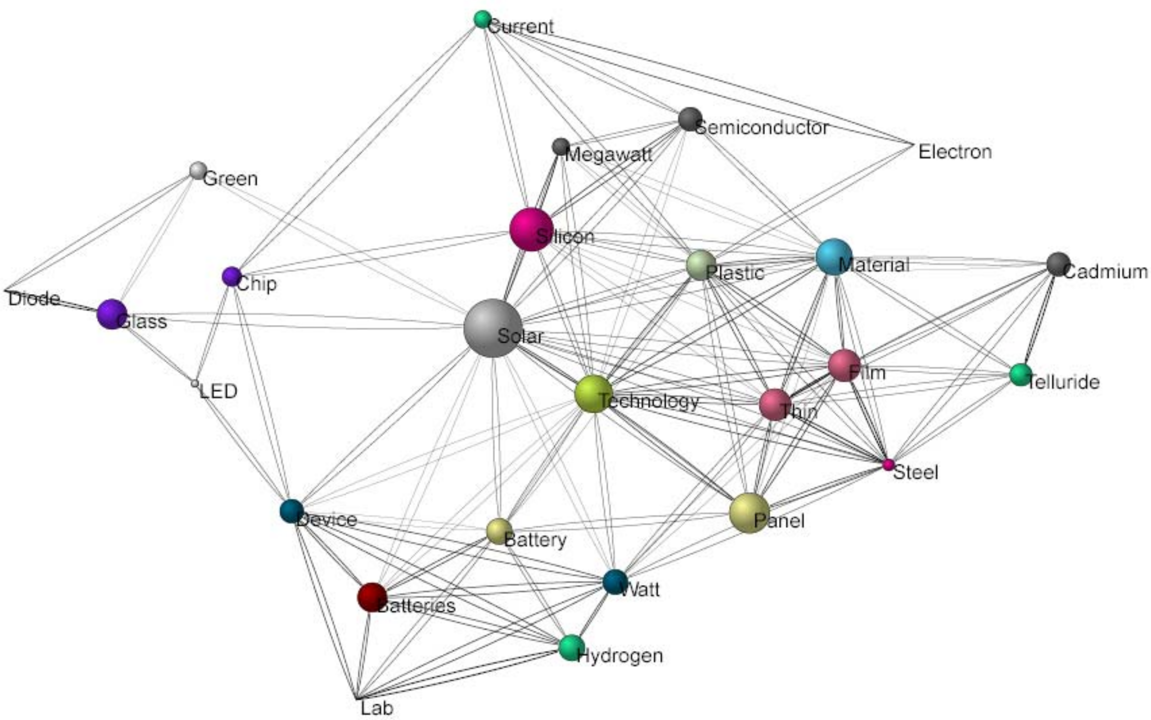


Figure 5.10: Networks of Technical Words Found in Solar Cell Articles



The third and the most striking of these three comparisons deals with the association of solar cells and LEDs with climate change. Through a reading of the corpus of articles, it was obvious that solar cells were presented as a solution to deal with global warming, climate change and greenhouse gas emissions. Solar energy was often described as a "clean" alternative. Solar cell articles also covered companies that were employing the technology as part of their socially-responsible planning. Articles on LEDs did discuss device efficiency but generally did not link energy savings to climate change or greenhouse-gas reductions. There was little association between LEDs and pollution reduction or other discussions around clean air or water from reduced coal-based power generation. Also, largely absent were references to companies using LEDs to reduce their ecological footprint. Figures 5.11 and 5.12 on the following page map these differences.

Figure 5.11: Climate-Change Networks in LED Articles

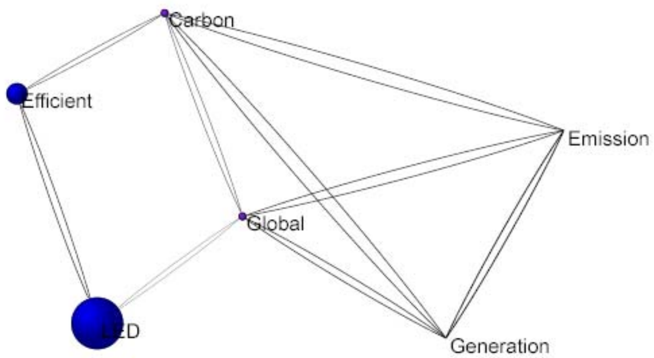
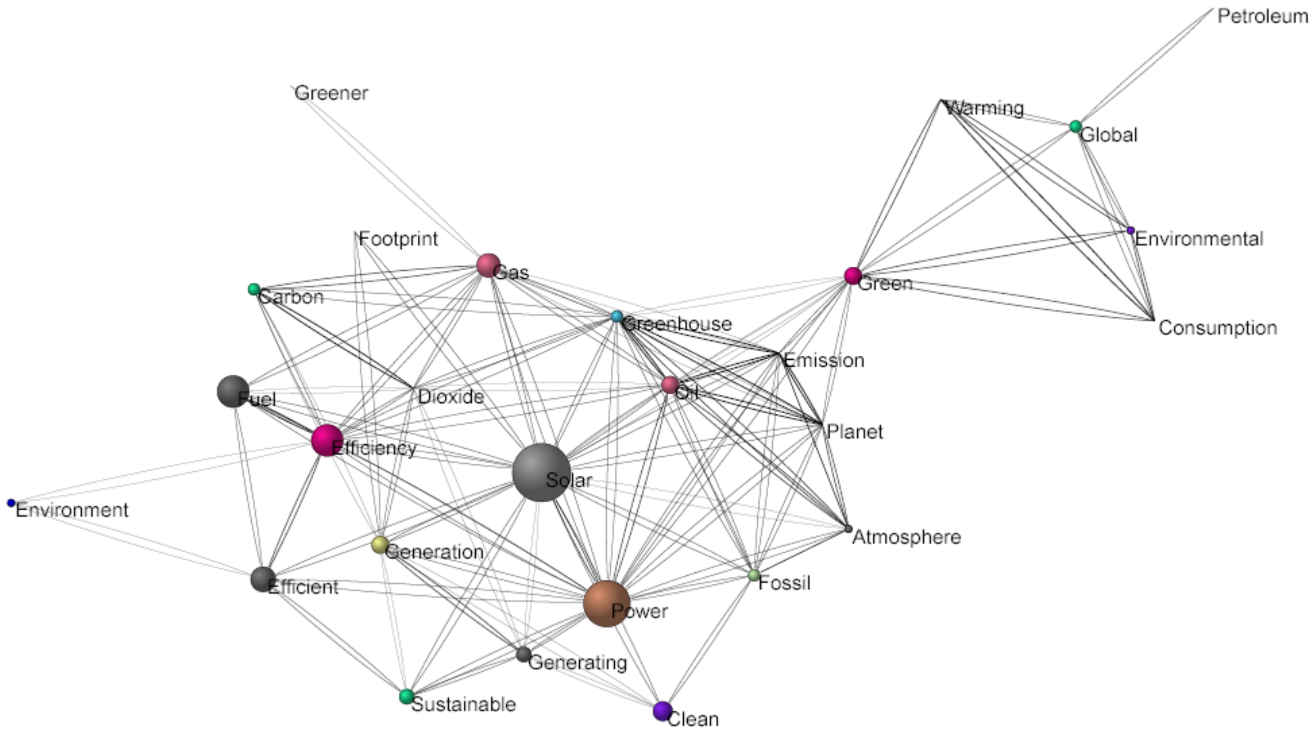


Figure 5.12: Climate-Change Networks in Solar Cell Articles



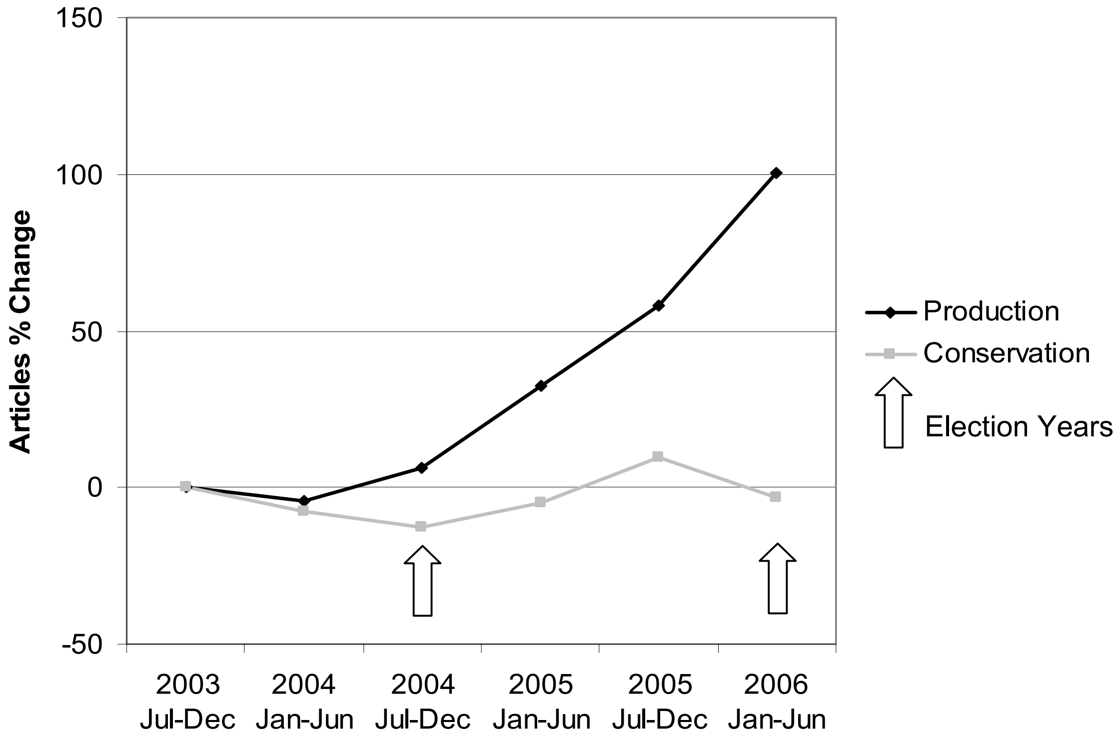
The semantic map of LED articles indicates weak association between LEDs, climate change and related issues. Conversely, the solar-cell map displays strong associations and a developed network of discussion involving solar cells and climate-change concerns. These symbolic associations of energy independence and climate change surrounding solar cell technology are an important component contributing to the political and social promotion of the technology. Meanwhile, LEDs are not associated with energy independence or climate change even though they could arguably have a greater impact. The only network involving "consumption" does not show up in the LED articles where we would expect such a discussion, but in the articles based on energy-production (see upper-right network in Figure 5.12). The positive valence of associations stemming from alternative-energy production mechanisms assists technologies like solar cells in passing from a promise to a requirement in the development of policy.

Energy in Political Speech

Yanow (1996) is concerned that the gap between policy intentions and policy outcomes is commonly explained exclusively in terms of ambiguities, lack of incentives, poor organization, insufficient communications between layers of government and other related factors. These explanations share a positivist assumption that problems are concrete and unambiguous. Explaining gaps between intentions and outcomes in these terms assumes that some kind of policy exists that is not affected by such pressures – a policy not dependant on human perception, understanding, beliefs and values. The entire project of policy from development through implementation is a human activity. And since human perception is not a "mirror of nature," (Rorty 1979) but one interpretation of a nature, an interpretive analysis is appropriate to entice the tacit components of policy to speak.

In the United States, the periods of data collected for this study from July through December in the years 2004 and 2006 represent run-ups to elections, which took place in November of those years. Because of increased election coverage, the number of articles written on any topic generally diminishes during this period unless it is tied to an electoral issue (Kahn 1991; 1995). In Figure 5.4 above, there are two distinct lulls in coverage of energy-reduction mechanisms that correspond to the election periods in 2004 and 2006. The same lulls are not evident in energy-production coverage. Figure 5.13 is a reprint of Figure 5.4 with the periods of election coverage identified.

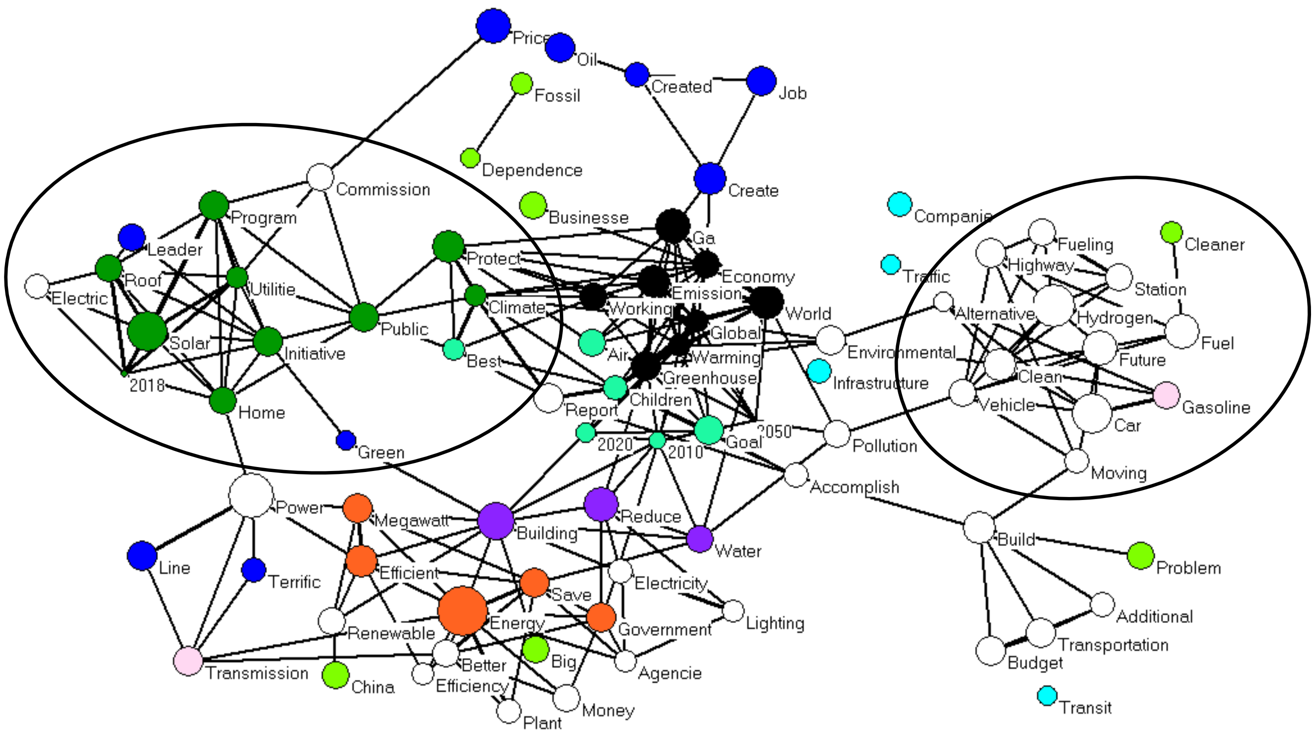
Figure 5.13: Energy Coverage During U.S. Elections in 2004 and 2006



The figure above assembles all of the articles returned by the LexisNexis database sorted into energy-production and energy-reduction mechanisms. Energy-reduction technology coverage drops during election cycles while energy-production coverage increases and actually accelerates during both periods. This difference between the coverage of energy-production and energy-reduction mechanisms during election periods indicates a preference on the part of politicians to politicize energy-production over energy-reduction during a time of increasing energy costs. This could also indicate complacency for media outlets to publicize those political messages at the expense of challenging them with coverage of alternatives.

In addition to viewing solutions to the energy crisis in public science writings, we can also look to the way solutions were proposed in political rhetoric during the crisis. I created a cognitive map of speeches and sections of speeches by the governor of California, Arnold Schwarzenegger, which dealt with energy issues from 2004-2006. There were 40 full speeches or excerpts of speeches in all. I combined these speeches into the semantic map in Figure 5.14. There are distinct networks centering on discussions of solar energy and hydrogen power (circled). There is also a global-warming network in the center cluster, an oil-cost network and an alternative/clean-energy network, though these networks are less distinct. Note that there are no distinct networks formed for energy-reduction strategies, programs or technologies. Energy-efficient lighting and power plants show up, but not in networks as distinct as the solar and hydrogen networks circled. Transit appears alone in the lower right-hand corner and so is not central to energy discussions. The topic of energy-efficient buildings does come up in the speeches, but again, does not form a distinct network of its own. It is worth noting that the large size of the "building" node is not only due to discussions on energy-efficient buildings. Its size is mostly an artifact in the data resulting from Schwarzenegger's use of phrases like "building a better California."

Figure 5.14: Energy-Production Themes in Schwarzenegger's Speeches



This cognitive map is very telling in its clear display that the governor's political messages during the energy crisis concentrated on energy-production over energy-reduction. Of course in practice there is no barrier to employing energy-reduction and cleaner energy-production strategies at the same time. However, the space for political attention is limited. Only limited mechanisms seen as solutions to deal with a crisis can be covered in a 30-minute speech. It is on this front that energy-reduction strategies compete with energy-production strategies. Here, the production-based strategies clearly take the lead.

06 » Conclusions

The development of energy-reduction and energy-production technologies is not simply a story detailing the construction or trade of material things. The development of these technologies is reflexively involved in the rendering and interpretation of the social world. Nye (1990) outlines the process of electrification in the United States from 1880 to 1940 in social terms. According to Nye, the electrification era was not a product of technological forces imposed on society. Rather, he analyses these developments as inseparable from social forces. He outlines a division of labor, not just in technical terms but also in terms of social values. Some groups of individuals were responsible for building the electrical generating capacity. Some were involved in the design and construction of distribution networks. Many people just used the electricity while others opposed its development.

Regardless of their level of involvement in electrification, all of these participants interpreted energy in a certain way and consequently derived meaning from it. Perceiving homes, cities or devices merely as objects to be transformed by electrification neglects the social space involved in the creation, direction and use of electricity. A richer view of electrical devices and generation mechanisms is achieved through the consideration of the meanings that electrification induced in society. Nye insists that every institution is a terrain, a social space that incorporates electricity at a certain historical juncture as part of its ongoing development. The process of "electrification is a series of choices based only partly on technical considerations, and its meaning must be looked for in the many contexts in which Americans decided how to use it" (Nye 1990: x). The generation, distribution, resistance and use of electrification was shaped not only by technological possibilities developed over time but by meanings people attributed to electricity.

Electricity had more than immediate technological utility; it symbolized modernity, excitement, novelty, wealth, power and privilege. Electric distribution networks allowed for increased individualism and atomization as household electrical service became popularized. For example, public services for washing clothes and central heating were rejected in the US for private washing machines and individual furnaces. This was a cultural development as much as a technical one. In contrast, Danish communities employed central heating systems for whole blocks of buildings. This community-cogeneration system was more efficient and reinforced a sense of community instead of independence.

From the electrification of performances to increased mobility and flexibility through street lighting and electric streetcars, electrification became synonymous with progress and strength in early 20th century America. Even language took on energy meanings. Semantic concepts, still widely used, evolved to describe how people "recharge their batteries", "get their wires crossed" or even experience "short circuits." By the mid 20th century, almost no aspect of American life was left untouched by electrification.

Semiotization of Energy

In considering contemporary development of alternative energy technologies, is it not also appropriate to consider the meanings applied to and implicit in the development of these technologies? The development of energy technologies, whether designed to produce energy or reduce energy consumption, is not simply a story of technological possibility, inventors, scientific discoveries and profits. It is a story of meanings, metaphor and human experience as well. Meanings are not simply imprinted onto the surface of technological developments but are instead threads, which in part constitute the fabric. And through this reflexive involvement in technological development, meanings of energy on personal and societal levels become entwined in the social construction of possible and probable futures for energy production and use.

Too often the past or future of a technology is left out of analysis or denied salience with regard to the present use, development and understanding of a technology. Understanding the past and the future of a technology should be a central part of any discussion about energy production and reduction mechanisms. The past and the future are actively involved in the development of meanings and values. The past becomes salient through memory, whether experienced or culturally recorded.[14] The future becomes salient through expectations on both individual and social levels. Through exploration into memories and expectations, abstractions of past and future are made useful to the discussion of energy-production and reduction mechanisms.

When we speak of semiotization, we are speaking in terms of understandings, which are caught up in a reflexive interaction with memories and expectations. In other words, understandings shape memories and expectations, but understandings are also created through memories and expectations. Interactions with a technology are also central to the understanding of it as highlighted by evolutionary economists and energy historians. These interactions may be physical, but need not be. For example, most of us develop our understanding of city sewage and water supply systems through interaction only with the exposed faucets and flushers, which constitute only a small part of the overall system. Luckily, one needn't become physically familiar with the bowels of the municipal sewer system to appreciate the utility of a toilet. It is in this way that we can effectively operate with the handicap of partial knowledge. Indeed, there seems to be no other alternative.

Inquiries into the slow adoption of energy-reduction technologies by individuals, firms and governments should inquire into the site where meanings are applied, in different degrees and in different combinations, through these three factors, memory, interaction and expectation. Meanings allow even the scarcest bits of knowledge to be rolled into a thin film by society to effectively wrap around concepts. These films represent convergences in thoughts, beliefs, attitudes among many members of society and can act to narrow debate into conformist rhetoric or even characterize certain ideas as immoral or otherwise improper (Lindblom 1990; Zigler and Child 1969).

Just as the answer to an inquiry is largely shaped by the questions asked, the options we consider in energy usage are largely shaped by the symbolic value that those options have for us. This symbolic value is at once involved with memories, interactions and expectations but operates and influences choice in the way the tide affects a boat; the force is significant, but imperceptible unless we are looking for it. While we may not assume some god-trick (Haraway 1991) with an all-encompassing

[14] I do not claim that these are the only modes through which memory can travel. I use the term memory in a general sense to include everything from explicit childhood memories based on experience to the cultural memory represented by the incest taboo. Different assumptions could be made regarding the operationalization of memory without affecting my argument.

view from nowhere from which to judge these symbolic (tidal) values of energy, or what I call the semiotization of energy, I have shown that their traces are left behind in media coverage and political speech. From these traces, we can at least partially reconstruct the impact of interpretive schemes on our choices about energy production and reduction. However the symbolic dimension is only one part of a reflexive structure interacting with actions surrounding energy. I have also pointed out the importance and asymmetries involved with the allocation of finite economic, political and media resources to energy reduction and production technologies. I will also indicate how these power structures and symbolic dimensions are involved in the legitimation of narrowed scopes of through routine "performances."

Signification, Domination and Legitimation

The University of Chicago's urban sociology program in the 1920s-1930s marked a shift in the focus of social science inquiry. Previously, there was a priority given by social scientists to explanations based on social forces over individual actors; society was seen to come first with the individual following. George Herbert Mead (1934; 1982), an integral part of the Chicago School's shift, characterizes actors as having a simultaneous capacity for open, creative thought with purposeful action. Though, he sees the community as the basis for such capacities (Albert, 1998). In this case, humans are not understood as sticks in a river, tossed about by social currents, but are able to react by themselves constructing the "other." While Durkheim portrays the individual as determined by society, Mead sees the individual with a degree of creative autonomy. He makes a distinction between the "me" and the "I." The "me" (similar to Freud's super-ego) refers to the way a person treats himself or herself as an object that is subject to rules and regulations. The "I" is similar to Freud's concept of ego, which can make autonomous decisions even in contrast to social norms. This in turn leads to creativity.

Mead's theory maintains actors and structures as separate entities or even juxtaposes them against one another. We can observe the built-in divisions between actors and structures in related dialogs such as "individual against society" or perhaps more subtle and less confrontational representations of "people in the social world." The way agency is understood within sociology of science and society in general affects the ways that norms are established and individual responsibilities are assigned.

Weber (2002) investigates the complexity of action. All action, according to Weber, is meaningful. Instead of describing the simple actions of an object of study, Weber argues that social scientists must also understand the meaning behind action. This contextual and subjective motivation of the actor, or *verstehen*, must be uncovered to more fully understand phenomena. Weber stresses that objects of social science research attach meaning to their activities.

The degree to which actors have control over their world or the extent to which they are products of their environment is a central feature of Durkheim's analyses. Durkheim treats suicide as a "social fact," while keeping the actual event of suicide, the action component in this case, separated. Functionalist explanations explore consequences or purposes of phenomena in society-as-an-entirety structures. Such explanations are founded on the metaphor of an organism, where functional parts of an organism fit in order to constitute the whole. So, institutions like governmental bodies and family units are viewed along with their underlying actions (like governance and familial operations) as serving certain purposes for the operation of society as a whole. Beyond functionalism, structures have often been regarded as existing separately from actors and always shaping the actor. According to Lemert (1997a), structures have two characteristics. First, they "make order out of some set of things" and second, these orders have some degree of permanence (1997: 127).

Purely structural explanations are unable to account for human agency and creativity while purely phenomenological accounts can not account for institutions and large social forces (power). Even though many theoretical inquiries are not purely structural or purely actor oriented, they often maintain the dichotomy. According to Giddens (1998), a problem with the ideas of agency and structure are the way in which they are each conceptualized. Structure, for example, is often conceptualized as having sort of form, tangible or not. Meanwhile, agency is often seen as residing in the actor alone. Giddens envisions these interactions differently. He does not view social life simply as the product of individuals or as a reflection of something larger. He instead argues that social life is an integration of various individual practices which lead to other activities while also reproducing certain institutions. Giddens prefers to see action as situated practices that are historically located. He views intentionality as a process that is produced through an abstraction involving self-monitoring, relations to other people and position within the physical environment. He claims that rationalization is manifested within conduct. And, he accounts for tacit knowledge as implicit in action. Overall, the actor can follow a practice while at the same time engaging in self-monitoring action, responding reflexively, innovating and rationalizing. In this case, the actor neither produces action from nothing nor is subject purely to act out in accordance with social structures.

In order to define his concept of structure, Giddens uses the example of language. Like language, he perceives structure as virtual – something that exists outside of space and time. Loyal (2003: 73) points out that "just as language is a structure which forms a condition of possibility for speech (agency), so more generally social structure provides the conditions of possibility for social action." While this interpretation of structure's likeness with language may extend a bit beyond Giddens', it does highlight the recursive quality that he feels language and structure have in common. This leaves structure with three qualities, according to Giddens. First, structure does not just constrain action, but also enables it. Second, structure is a medium for action at the same time as it is an outcome of it (even if that reproduction occurs on a subconscious level). Finally, structure is fluid, or it has the capacity to be static or dynamic.

Giddens (2002) claims that society is actively and regularly constructed by its members. However, this construction is built on conditions and draws on resources and rules, which the actors are unable to perceive of, either in part or in totality. Also, while social structures are the consequence of action, they also form the basis for further action and reconstruction of the social structure. Giddens refers to this as the duality of structure.

This reproduction of structures is based on three modalities, according to Giddens: constitution of meaning, morality and relations of power. Giddens writes that the construction and reconstruction of domination and power structures "express asymmetries in the form of meaning and morality" (2002: 227). It is here that we start to see how Giddens' theory of structuration yields implications for the previous discussion on interpretive schemes (signification), allocation of resources (power) and legitimation as they relate to the development of energy-production and reduction mechanisms.

Giddens constructs a set of rules for these sociological methods[15] in order for sociologists to frame their questions. In brief, he encourages sociological inquiry to look not at a pre-given universe but rather one "produced by the active doings of subjects" (2003: 229), who can be seen as skilled performers, whether they are fully aware of those skills or not. He states that action is historically situated. He argues structures must be seen as enabling behavior, not just constraining it and he adds that "processes of structuration involve interplay of meanings, norms and power" (2003: 227). The semiotization of energy is not simply an event comprised of meaning-making and interpretation. It also involves norms through legitimation and power through the authorization and allocation of resources. In the case of energy-production and reduction, those resources involve media and political attention as well as explicit public policy and funding.

Public Policy as Identity

Public policies can function as expressive acts aside from any instrumentally use-oriented considerations. Taylor (1988) identifies that a polity can position itself within a certain identity by aligning policy with shared values of the group. In this way, the policy embodies a component of meaning beyond the explicitly-state goals of the policy. Consequently, the policy can then be understood in part as a communication device. An example from California can be seen while driving through Berkeley, Oakland or Santa Cruz. A few decades ago, these cities posted signs to publicize the establishment of nuclear-free zones by local governments. However, transnational shipments of nuclear material move through the federal highway system and are therefore not subject to local regulations. While these road signs may not perform the function they explicitly state (i.e. preventing the shipment of nuclear materials through the community) they perform an expressive function to residents and others driving through the communities. In this case, it could be argued, the performative aspect of the policy had become the policy.

The policy then becomes a site of enactment of an identity. In the same way that performativity of gender becomes part of the power associated with gender (Butler 1997; 1999), so this policy becomes a part of the flow of power, not through its functional-value, but through its performance. The policy is "doing

[15] He states that he uses this terminology ironically. He does not view this as a sociological programme but rather part of sociological inquiry.

environmentalism." And through the doing of environmentalism, it enters into the flow of power surrounding the identity. A key aspect to performativity is repetition. It is through repetition that the performance builds power. A single act only gains strength through the orchestration of an ensemble. Unlike the anti-nuclear shipping movement in Californian communities, whose road signs are slowly rusting along with the public activism surrounding such shipments, solar cells have enjoyed center-stage attention in environmental and climate-related debates throughout the last 40 years.

Articles examined in this study feature companies that are using the power of solar cells to communicate an association with the environmental movement. Whether a small bicycle shop in San Diego or a large company like BP, corporations can tap into the ready-built associations made with solar energy by customers. It is doubtful, based on the findings of this study, that these companies would achieve similar approbation through the implementation of energy-conservation devices like insulation or LED lighting. Solar panels are visible signifiers of an identity. They stand propped up on roofs like advertising billboards for all to see. Exemplified by the desktop solar fan, which captured my attention as a youth, every solar installation is a performance. Through these performances, solar cells have attained a level of power beyond their use-related utility. They cannot be separated from a second layer of power, which has built up through their association with an identity. So, when we speak of solar cells, we are not just speaking in terms of solar power but also in terms of solar *power*.

Repetition of performance also strengthens the validity of a concept as a meaningful pursuit. By supporting a particular pursuit, the government effectively bolsters the validity of the program (Yanow 1996). This support can be spoken, written, enacted or implicitly embodied through a policy. In addition to validating the pursuit itself, reinforcing the response to a public claim for attention by government lends legitimacy to the claimant as a justified actor pursuing legitimate activity. Such reinforcement can then lead to increasing calls for political attention, which start from this higher level of legitimacy. On a policy level, this cycle results in a mode of reinforcement similar to Van Lente's (1998) self-reinforcing technologies. At the metaphor level, this relates to Lakoff and Johnson's assertion that "metaphors can be self-fulfilling prophecies" (2003: 156). However, these theorists stress less of the reflexivity that Yanow highlights. They instead concentrate on the way definitions of reality are influenced by political leaders imposing their own metaphors in such a way as to highlight some aspects of real situations while hiding others.

Beyond Traditional Economic Explanations

Traditional economic explanations seem to explain why firms might not adopt energy-reduction strategies if we accept certain assumptions about the rationality of actors. For example, an up-front investment that is illiquid calls for a higher rate of return. And, new energy-conservation devices carry with them degrees of risk, uncertainty and a loss of experience when compared to an existing technology. However, accepting these arguments, we are faced with an even more daunting explanation; why would companies and individuals go out of their way to adopt solar energy when its implementation incurs similar or even greater risks, illiquidity, irreversibility, uncertainty, lack of expertise and imperfect substitution? Traditional economic theories are unable to adequately account for this glaring discrepancy.

Evolutionary economic theories start to open some doors to a fuller appreciation of social forces in technological development. However, the two technologies selected in this study, LEDs and solar cells, were invented at the same time and were exposed to many of the same social forces like the Cold War and the environmental movement. Nevertheless, their acceptance by the media and politicians as a solution to the energy shock markedly differs, a difference that can not be explained through functional differences. Van Lente and Rip (1998) offer us the best opportunity to discover how solar cells have achieved the leap from promise to requirement through an agenda-building phase enabled by positive expectations for solar energy. Indeed, this thesis confirms that during the 2003-2006 energy shock in the US, solar energy was surrounded by dialogs of expectation while LEDs were not. In addition to the contribution of expectations, the political, economic, and normative acceptance of solar energy and other alternative-energy technologies is further emboldened through a positive-valence semiotization. This semiotic event extends the power of solar cells beyond their functional attributes to include enhanced characteristics of affordability, clean energy, future-orientation, success and independence.

Leggett and Finlay (2001) show that individuals attach meanings such as youth and vitality to energy-production. This thesis extends their account to a social level. The semantic maps clearly show that during the energy shock from 2003 to

2006, energy-production mechanisms were associated by the media and politicians with energy independence, a clean environment and positive future expectations. Despite their functional impact being at least as positive, energy-reduction mechanisms were not associated with energy independence, clean ecosystems or characterized as holding future promise. In the case of LEDs, they were even associated with "geeky" activity. Articles on LEDs were highly technical and concentrated on current applications of the devices. Meanwhile, solar cells were associated with personal success stories of budding entrepreneurs and their forward-looking visions.

So, while actors perform energy-related duties, rationalize and choose positions, self-monitor their actions, respond to others and innovate with new technologies, they do so in concert with tacit understandings, which are partly informed by symbolic associations. I have shown that these semiotic associations differ between energy-production and energy-reduction mechanisms. These differences in appreciation are apparent in political agenda-building and are manifested in energy policy. Energy semiotizations are legitimated through a series of performances, whereby requests are made (by citizens), acknowledged (by policy-makers), fulfilled (by technologists) and displayed (in media and physical icons such a solar panels). Validations of energy-production pursuits through this process recognize claimants as justified in pursuing a legitimate cause.

We witness patterns of continuity in an evolving virtual structure that relates well to Giddens' (1984) three structural modalities. First, the central findings of this research provide that signification is evident in communicative interactions, both explicit and tacit. Second, the structural characteristic of domination plays out through flows of power stemming from the allocation and authorization of political, economic and media resources toward modes of energy production. And finally, the process is legitimated through a cycle of requests and validations. No part of these modalities exists outside the world of actors. Actors are central in every stage, from the making of meaning and allocation of resources to the process of legitimation.

This account acts as an additional chapter to Nye's (1990) landscape of social and symbolic influences, which reflexively interact with the historical development of energy mechanisms. It should be no surprise that solar cells and other energy-productions mechanisms carry value beyond their manifest functional characteristics. Solar cells are not embraced because they are ecologically more sustainable than the alternatives or because they are less expensive, or because they last longer, but because they have become a symbol for something much grander than any technology could be expected to provide. References to alternative-energy production mechanisms conjure up visions of a clean environment, energy independence and utopian possibilities. The images created through this *leitbild* , or guiding image, act to guide further action (Grin 2000). Solar energy has understandably become an identity-tool embraced by politicians to assure their favorable standing in ecological debates. Gracefully tilted toward the highway, solar arrays perched atop filling stations sparkle with a message stronger than any billboard could communicate. These performative actions not only call upon semiotic associations but also, through their repetition, act to further reinforce associated semiotic powers. Through this cycle, ends become replaced by means, which have a way of forming their own endings.

The bearings of this machine performing the translation from production-mechanism to clean-energy symbol are heavily greased with personal conceptions of energy and associations with vitality, independence and future possibilities. The actual costs, benefits and externalities that are generally associated with technology debates are often left out of discussions on alternative energies. In this process of narrowing, such inquiries are neither politically profitable nor socially amenable. Herbert Blumer (2002) states that people act on the basis of the meaning that they find in objects. While individuals are interested in sustainable energy use, they are perhaps less likely to support that goal than to support a representation of it – especially if that representation carries with it symbolic values congruent with their own. With the positive-valence symbolic associations with wind, solar, biomass and other alternative forms of energy, congruence can be achieved between people's desires and their support for sustainable choices. In this way, consumption patterns are reinforced and given the power to symbolize that which they are not. Alternative energies, in part, then become commodified manifestations of an identity.

07 » Policy Implications

In order to understand the meanings attributed to and created by (and through) situated actors, we need to look beyond simple positivist explanations. An understanding of core social values and theories of human behavior are essential to creating an atmosphere in which successful policy can be developed (Cohn 2004). Yannow (1996) provides a method of interpretive analysis which accounts for meanings. Interpretive policy analysis relies on the stakeholders in a problem to define problems and solutions through argumentative exchange. The aim is an outcome with congruency, which through innovative and creative insight makes sense for each stakeholder (Grin, Felix, Bos, and Spoelstra 2004). Consideration of semiotic associations can afford insight to meanings created by actors in a situation while contesting the idea of a stable, unbiased observation. In this way, we are able to inquire into not just the actions involved in an endeavor but also the meanings applied to action (Blumer 1969).

With a concentration on quantitative analysis, the US misses out on many benefits of qualitative policy analysis (Pierson 2007). However, qualitative inquiry does incur certain considerations, which are not encountered by quantitative approaches. Take for example the movement of a bicycle rider in Amsterdam. A physicist might ask quantitative questions about the size of the wheels, the materials for the frame or the centripetal acceleration involved in the locomotion. The physicist would not inquire into the *opinion* the wheels had about turning, or what *meanings* are derived from the frame as it supports the rotational axes of the wheels. On the other hand, a sociologist inquiring about the rider would need to account for the meanings and intentionality of the rider's motion. A description of the biker's motions exclusively would provide an incomplete account of the movement. For the physicist, there is only one step between inquiry and discovery in this case. Meanwhile, the sociologist is trying to understand a phenomenon, which is already being understood by the actor – a two-step process that Giddens (2002) terms a double-hermeneutic.

The social scientist is not just an observer of society, but unavoidably a part of it as well. So, where does this leave the utility of sociological explanations about the development of energy meanings? This double hermeneutic "problem" is actually part of the answer. Social scientists can dive into a social world and come up on the other side with a description in their mouth. This will be just a certain kind of description; that is unavoidable. Though, according to the double-hermeneutic concept, that "type of description" is then thrown back into the social world. The description may eventually become an accepted feature of the social world and can then modify future conduct within it. Here, the power of sociological inquiry becomes evident. It can transform the world it analyses. Social science has provided concepts like "social status" and "moral panics" which are widely acknowledged. Also, social science research on income, lifestyles, media and other such themes affects the way we in turn view our own lives, laws and institutions (Giddens and Pierson 1998).

Narrowed Thought and Impoverished Imagination

Lindblom (1990) argues that inquiry should be structured as a set of probing actions. Though, he warns against a narrowing of debate. For example, the findings of this thesis indicate that during an energy crisis we don't witness a free and reasoned debate on solutions to the crisis, but a debate within the confines of narrowed patterns of thought centering on production. In observing American society, Szilard (1961: 42) claimed that Americans "were free to say what they think, because they did not think what they were not free to say." In implying a coerced narrowing of vision, Szilard is not alone. Many other voices resonate with the same frequency. Tocqueville ([1835]1972) speaks of the lack of independent minds in America, White (2004) bemoans an impoverished imagination, Engels (1893) identifies a false consciousness and Schumpeter a "manufactured will" (Schumpeter 1942: 263).

How are these visions selected? The question can not be simply answered through the identification of a particular political or social interest. How these visions come about involves a complex mixture of economic, political, social and I would add semiotic interactions. An analysis of the energy crisis investigating just one or two of these factors would be incomplete. To borrow a concept from Foucault (1980), it is the ebb and flow of knowledge-power relations between these factors that colors the options emergent in public and political discourse. Lindblom (1977) argues that there exists no single, monolithic power that shapes discourse. Rather control emerges from compromises and competition among elite interests in government, media and industry. It is sometimes not so easy to delineate a clear separation between the three. They are caught in a tangle, which makes exclusive comparisons amongst them precarious.

Beck (1992) identifies the growing influence of transnational companies and their associated willingness to take risks in areas such as climate change, food, and ecological destruction, which would not be viewed as reasonable by the general public. Corporate interests are a large component of the political process as well. Governments are essential to business as they provide R&D funds, maintain national security, open markets and protect foreign investment (through diplomacy, coercion or force), maintain rule of law and provide other benefits. To a large extent, governments are made viable through the success of providing these benefits to business and elite interests while presenting themselves as representatives of the greater public.

Of course there is still a component remaining in a free government to represent public concerns. But, public opinion too can be colored by industry manipulations in a way that echoes authoritarian government propaganda. First, industrial organizations have the ability to spend large sums of money on advertising to influence public opinion on energy-related developments. Second, the media rely on being seen as credible when reporting on scientific inquiry or findings; they resultantly look for sources that will be identified as credible as well. Well-funded corporate PR firms assure there is no lack of "raw material" for the media to adopt and use in their programming. From simple press releases to renderings of drug-delivery methods to complex video simulations of military technologies, firms make every effort to assure technological pursuits are envisioned in a light sympathetic to their perspective. Their approach is no less aggressive when promoting energy-production technologies.

I have shown that the role of symbolic values in understanding technologies and strategies must also be considered in these flows of power. The semiotic value that society associates with a technology or strategy is at once created by individuals in society and at the same time a guiding constraint to the way such mechanisms are envisioned. The result of this reflexive interaction does not always result in a list of options most preferred or beneficial to individuals in a society. This dissonance is evident in the findings of Ray and Anderson (2001), which indicate that political affiliations of individuals are often discordant with their own beliefs and values. Lindblom (1977) attributes the discrepancy to a business polyarchy in a privileged position that is able to effectively shape the outcomes of political inquiry by limiting the options available to such inquiry in the first place.

A related example involves a Gallop poll (Jones 2007) that asks participants whether they see energy production or energy conservation as more important. More Americans choose conservation when presented with this dichotomy. There seems to be an incongruence between these Gallop polls, which highlight public preferences toward energy-conservation and political and media rhetoric that stresses increased production. But manifest opinions are not always reliable guides to action. Meanwhile, tacit opinions are informed by expectations and symbolic meanings, which can structure political allegiance, desire and action. This apparent incongruence is can be explained if we understand alternative energies, not as energy-production mechanisms, but as symbols for sustainable use of resources and a clean-energy society. This production-symbol is then congruent with public preferences for energy conservation. So, in the state of California, where the Governor stresses options of production and media coverage highlights alternative-energy production over energy reduction, a Million Solar Roofs program based on increased production can be funded and praised.

Through the concepts of structuration and knowledge-power flows, we can better illuminate the issues involving the negative externalities from energy-production and positive externalities from energy-reduction that were highlighted in the fourth chapter. We can now identify that concentrating support for energy-production strategies leads to unrefined consumption patterns and calls for further production. Concentrating support for energy-reduction strategies leads to wiser consumption patterns and calls for further reduction. The choice to value one path over the other in policy is a societal choice more than a technical one. In the introduction, I outlined many energy-conservation devices employing widely-available and existing technologies. All of these strategies are mind-numbingly simple and economically profitable. It is in these cases, when cost savings, profit and energy-reduction go hand-in-hand, where we can most profitably develop congruency among actors.

Interruption Mechanisms

In many parts of the world, energy production is a highly personal endeavor. Burning firewood for cooking involves gathering firewood and incurs local production of smoke and soot. Plowing fields with oxen involves growing animal feed and caring for the animals as well as the drawbacks involved with manure production. In rich nations, all of these considerations are external to the lives of most people. The negative externalities associated with energy production are removed from privileged communities and transferred to poor neighborhoods or countries. Sophisticated generation and distribution systems are not generally understood in detail. Few people are familiar with the details of biomass fuel production or solar-electric conversion in silicon photovoltaic panels. As a result, people rely on symbolic representations as heuristic devices whereby they can more easily grasp and discuss otherwise complex mechanisms. The gap between people's comprehension of energy-production technologies and the actual mechanisms that are involved will continue to widen as production mechanisms become more diverse and technical. As a result, this will likely lead to further intensification of exaggerated expectations, skewed risk and reward perceptions of technological advances and continuing depoliticization. However, my statements are tempered by the belief that it is possible to interrupt what has been characterized by others as shift from "modern" to "postmodern" technologies, thereby protecting the grounds for democratic processes. To open this window of opportunity, I will suggest adding a "late modern" transition phase to this dichotomy.[16]

Merelman (2000) identifies a break in the early 1900s away from a modernist technological culture, which was more conducive to enlightenment values and therefore the liberal democratic process, to a postmodern technological culture, which is not conducive to enlightenment values. Of course, technology can only force such a shift if it is given the power to do so. Here, Merelman builds the idea of a "culture of technology." He claims technology is a key link between society and the self. The modernist technologies acted as a cohesive link between people and their surroundings. Merelman claims "Modernist technology provided the opportunity for

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[16] I should note that I believe the terms modern and postmodern are imprecise and generally deficient for anything more than cursory analysis. Nevertheless, they are in wide use and I feel they suffice to explain my concept of an interruption mechanism.

people to manipulate machines to expand human control over nature. The self acted, technology responded, and nature yielded to the civilized control of society" (2000: 168). Merelman travels beyond this self-social interaction to show how such an interaction, mediated in part by technology, formed a synergy with the liberal democratic process. He claims modernist technologies such as steam engines, automobiles, and mechanical cotton-pickers drew people "outward from themselves and focused their attention on the subjugation of nature" (2000: 172).

Due to their human scale, accessibility and straightforward uses, simple methods of energy-production are accessible to the public in concept and through immediacy of returns on investment. These technologies allowed citizens to be equals in controlling nature. This technological empowerment led to a political empowerment of the average citizen. Politics too was seen as a path to discovery. By increasing the rate of division of labor and creating new occupations, modernist technological advances formed a basis for class-based and occupational-based political organization.

The shift, as Merelman sees it, is a movement away from modernist technologies that deliver the self to the social world and toward postmodern technologies that direct the self inward. He identifies shifts in funding from the physical, or outward-looking, sciences to the inward biological, communication and information sciences. Science has also been slipping out of the realm of the average person's understanding, reducing the informed contribution they enjoyed with modernist technologies. Like Beck (1992), Merelman sees this slippage bringing the public closer to serious harms, perhaps unknowingly. Ultimately, he warns that the "absence of confidence and judgment may also discourage competent democratic participation in America" (2000: 183).

Working within the realm of simple energy-production mechanisms in a modernist mode, people have the option to intervene, contribute, cease or commence engagement with those mechanisms through at least a basic conceptual model involving the drawbacks, benefits and side effects that could be encountered. Postmodern technologies, working on a framework that is not immediately accessible to lay individuals, can not be approached through simple engagement. Instead, a complex mode of engagement is necessary. Since a level of technical expertise can rarely be individually acquired or understood, a user can travel only to a certain point before they are required to proceed on faith. This faith can be compared to a child crossing a pond by jumping from rock to rock. Eventually, the rocks become farther and farther apart until finally there are no more. The child, almost to the other side, sees the opportunity to swing from a vine winding down from the mist overhead. The vine has no visible foothold above. The child can remain on the rock or swing on the vine to continue on. The child is stuck with a dilemma, going back is no longer an option and the only way forward is by entrusting a slimy vine of unknown foundation and stability. This is the Hobson's choice of postmodern technology. The only way forward is to hold on to technologies that we don't fully comprehend. The alternative is to remove ourselves from society completely, and even then, we would not be entirely removed from the postmodern risks created through others (Beck 1992). Is such a system a challenge to democracy? Absolutely. It erodes informed choice and bypasses the feedback mechanism that democracy relies upon.

While I agree there is a difference in comparing a typical modern technology with a postmodern one, I do not believe the bifurcation between modernist and postmodern technologies as it has often been characterized is the best way of envisioning the shift. Rather, I feel the concept of a ratchet-effect would be more appropriate to elucidate this transition. A big assumption built into a two-step process is that step one is distinct from step two. This is where my real issue lies. Postmodern critics get into murky waters when they try to separate themselves so boldly with theorists critical of modernism. It seems they have more in common than they are willing to admit (Latour 1993; Lemert 1997b). While critical theorists may stress critiques of technological rationality, they are not confined just to that track. Marcuse's historical development of the individual postures the individual as "motivated, guided and measured by standards external…" (Held 1980: 67), which starts to sound like a postmodern critique. I am not accusing postmodern critics of being critical theorists in disguise; I just feel that their arguments are not as distinct from the modernist critics as they may claim. While the transition from modernist to postmodernist technologies is often characterized as a 180-degree flip, I would like to see it as a 40-degree rotation. And, in order to view this technological rotation from "modern" to "postmodern" without it being a two-stage process, I shall introduce the term, "late modern," which will act as a shaded part of the continuum between the modern and postmodern technologies.

Why have I gone through all of this fuss? Because I feel that if there is a chance to interrupt the postmodern's assault on democratic modes of engagement in terms of energy policy, it is during this late-modern development stage. Considering policy development exclusively through the lens of the postmodern construct, places emphasis on the symptoms of democratic decline only, not the sources. For example, automotive developments along with prosperity led to road construction, then suburbs, then atomization of families and individuals. Instead of developing automobiles that run on alternative fuels or operate more efficiently, policy could aim to interrupt suburban sprawl by supporting modes of living and transportation infrastructures, which make stakeholders want to walk, bike or take public transportation.

Multiple interruption mechanisms could interact concurrently to achieve incremental changes toward a path away from unsustainable suburban growth patterns. Sahal (1985) stresses that it is through a process of morphogenesis rather than supply and demand that is central to innovative processes. These mechanisms need not be based in high-technology activity. For example, bike lanes, walking paths and enhancements in urban landscaping have been proven to be effective interruption mechanisms. These strategies could still be deployed on a much larger scale in the United States. Interruption mechanisms could take innovative or playful forms as well, which engage with stakeholders. For example, public transit tickets could double as lottery cards that randomly upgrade people to first-class or provide unexpected prizes.

I use the term *interruption mechanism* to characterize a strategy for democratic engagement with elite political, industrial and media powers and as a mode of circumventing the depoliticization that advanced technologies present. These interruption mechanisms should first concentrate on sources of problems rather than symptoms of problems.[17] Second, they should involve a multiplicity in both approach and probing in order to benefit from human ingenuity as described by Lindblom (Lindblom 1977; 1990). And third, they should engage actors into congruent agreements as described by Grin (Grin, Felix, Bos, and Spoelstra 2004; Grin and van de Graaf 1996).

I will continue with an example to highlight how interruption mechanisms could work and the challenges that they face in the development of energy policy.

[17] Of course, this could become an almost endless spiral of searching for sources of problems, which would eventually end in large philosophical questions. I present source-based problem-solving instead as a mode of thinking to spur creative thought – a guideline rather than a rule.

Consider the case of a regional government reviewing energy policy in light of an increase in population. Concentrating on the source of energy constraints could uncover ways of reducing energy consumption to allow for an expected increase in population. For instance, the energy use in buildings could be addressed. The government could regulate the type of lighting or insulation to be used. However, such regulations often represent regressions in thought to a narrow set of possibilities rather than employing human creativity. An improvement would allow a multiplicity of interruption mechanisms to compete, from regional urban planning to individual building design. A convenient way to achieve this multiplicity while fairly valuing stakeholder interests is through a standard market mechanism. Government action is required to create such markets. This can be achieved through a regulated system such as the international carbon-trading schemes now in use. Alternately, it can be achieved through taxation of various energy forms based on their negative externalities. This would allow space for creative thought and local considerations while fairly rewarding energy-reduction strategies. Reducing income taxes while shifting to so-called "sin" taxes could be revenue-neutral for the state while still being progressive enough to protect poor families and individuals from unjust tax burdens. However, given the free mobility of capital, such taxation systems hold most promise if implemented on an international scale (Stiglitz 2006). Another limitation, as this study emphasizes, is that we can not assume actors will invest in energy-conservation even if it is economically rational to do so.

Re-Inventing the Million Solar Roof Program

The $3 billion Million Solar Roofs Program was created on January 1st, 2007 with a goal to install 3000MW of solar panels on residential and commercial roofs by 2017 (CPUC 2007). The project is funded by the US federal government and the State of California. Bringing together my idea of interruption mechanisms and some evolutionary-economic theory, I will attempt to take one stab at re-working the $3 billion Million Solar Roofs project in California into a program that could better employ human creativity and financial resources. I do not claim the following plan to be anything more than a first probe into an alternative deployment of funding.

While the potential for displacing electricity consumption through power derived from solar cells is theoretically high, the enormous costs associated with such an expansion are likely to prohibitively restrain photovoltaic-derived solar power production in the near future even with subsidies for installations. The Economist (2007b) expects solar cells to represent a tiny fraction of total energy production for the foreseeable future. Even under the most optimistic scenario, solar cells will likely produce less than 1% of total energy output a decade from now. The OECD International Energy Agency is equally reserved, predicting only mild gains in power derived through solar cells in the coming decades (OECD 2006).

The impact from implementation of LEDs is striking in comparison. LED bulbs can in theory only impact energy consumption up to the amount of energy consumed by lighting. However, in the United States, lighting accounts for 22% of electricity use and 8% of overall energy consumption (USDOE 2007). Several studies, including one from the US Department of Energy, project no barriers for LEDs to displace most conventional lighting within the next 10 to 20 years (Ashdown, Bjornstad, Boudreau, Lapsa, Shumpert, and Southworth 2004; Economist 2006; Hinnells 2007). The combination of rapidly-increasing device efficiency together with a potential impact on 8% of the total energy market, places LEDs in a much stronger position to make an impact on fossil-fuel consumption when compared to the associated impact of solar cells.

Another significant consideration is the downward spiral of energy consumption that would result from widespread use of LED lighting. If LEDs were standard in new construction, building codes could be modified to allow for lower-gauge wiring and circuiting systems for lighting in buildings. This could significantly decrease new building construction costs and reduce energy-intensive mining and distribution of metals like copper that are used in wiring systems. Replacement of municipal sidewalk/street and traffic-signal lighting systems with LEDs would not just save electricity and raw-material costs but would also significantly reduce maintenance calls for burnt-out bulbs and increase traffic and pedestrian safety. Increasing public safety and decreasing maintenance fleet size in turn leads to further reductions in energy utilization.

The following chart (Figure 2) summarizes the points made above through a short illustration considering an investment in solar power or LEDs. Such an example might be appropriate for a family, school or small business interested in reducing their ecological footprint.[18] A similar chart could be created to compare ethanol as an energy-production mechanism for transportation by car as opposed to light rail as energy-reduction mechanism for mass transit on a municipal level. Another relationship could be made between alternative energies to fuel homes against better home insulation to conserve energy.

	Production: Solar Cells	**Reduction: LED bulbs**
Initial investment	$12,750	$900
Opportunity cost/yr	$765	$54
Electric bill savings/yr	$432	$208
Net savings (loss)/yr	$(333)	$154
Maintenance	- Yearly servicing and regular cleaning - Repair or replacement after wind or hail damage - Special recycling requirements at end of lifecycle	- Decreased maintenance compared to standard bulbs
Embodied energy from production of device	Since the solar cells are not replacing something already in the building, fabrication, transportation and mining of the minerals to produce the cells must be considered	One LED bulb replaces dozens of standard bulbs resulting in a net decrease in materials used
Net CO2 impact	Increase (22 to 49 grams per KWh)	Decrease
Heavy metals	- Increase due to mining, smelting, purification, fabrication, transportation, installation and construction - Heavy metals contained in solar cells themselves	Decrease in mercury compared to standard bulbs
Restrictions	- Must be sunny, unobstructed access to southern sunlight	

[18] Assumptions: $100/mo electricity bill, Kyocera My-Gen 1500kW solar system at a cost of $8,500/kW, optimal positioning at 30 degrees to the south with no obstructions in San Diego, CA, 10% DC to AC conversion loss, 6% loan or opportunity cost, building with 30 light bulbs, LED cost of $30 per bulb, lighting at 22% of total electricity bill, LEDs producing 80 lumens/watt

To illustrate these differences in a policy context, consider the $3 billion Million Solar Roofs Program. The California Public Utilities Commission website describes the program:

> Solar energy is one of our state's most abundant - and least utilized - renewable resources. As part of Governor Arnold Schwarzenegger's Million Solar Roofs Program, California has set a goal to create 3,000 megawatts of new, solar-produced electricity by 2017 - moving the state toward a cleaner energy future and helping lower the cost of solar systems for consumers (CPUC 2007).

The same money pledged to financing LED lighting across California would conserve at least 6 times more energy than the electrical power produced through the Million Roofs Program.[19] The power saved would be equivalent to the power produced by 280 power-plant generators. An LED program could likely be instituted in just a few years, not by 2017.

How could an alternative program draw on human creativity and the potential of LEDs while benefiting stakeholders and interrupting increasing consumption patterns? First, I would recommend concentrating on the goals of such a policy rather than the means. For example, I was recently asked to review a piece of legislation aimed to modify municipal codes by requiring LED bulbs in traffic signals. The introduction to the proposed legislation follows:

> The replacement of standard incandescent lamps with light emitting diodes (LEDs) in traffic signals offers a pragmatic and cost effective way of increasing California's energy efficiency. Currently, 40% of traffic signals in California use incandescent lamps; if every stoplight in the state were replaced with LEDs, the reduction in carbon emissions would be equivalent to removing 820,000 cars. Aggregating the energy savings if all California bulbs become LED standard leads to a cost savings of $520 million statewide for each bulb replacement period.

[19] This is a conservative estimate since I assumed current-level LED costs and efficiencies, which are expected to improve dramatically over the next few years. My calculations include the financing of 200 million LED bulbs at 50 watt per bulb savings on average. I assume the LED program could be instituted in 3 years and the solar program installations would last until 2017.

> We propose a mandatory, phased conversion of traffic lights from incandescent lamps to light emitting diodes in the State of California by the year 2015, effectively creating a LED standard. A corollary to this policy would expand upon current programs to provide low-interest loans to help municipalities cover initial transition costs (Atwell, Burow, and Santos 2007).

As the legislation was crafted, it centered on the means (LED lighting) instead of the ends (increasing energy-efficiency of traffic lights). Concentrating on the means has several drawbacks. First, mandating LED bulbs stifles creative exploration into better alternatives. Second, if a new technology is created several years from now that is better than LED-based lighting, this legislation will prevent it from being implemented. Third, the concentration on LEDs does not allow for flexible solutions for unforeseen or unintended consequences. For these reasons, I recommended drafting legislation that limits power consumption (the goal) rather than one mode of achieving that reduction. The same applies for a re-envisioning of the Million Solar Roof program. Achieving goals of conventional energy-reduction should allow for both solar, LED, or other installations without mandating them exclusively.

A redistribution of the Million Solar Roofs program funds could extend beyond simple installations to also include research and development (R&D) funding. Sahal (1985) envisions technologies traversing through a series of "guideposts" and "avenues," which are stretched over a socio-economic landscape. He feels that R&D funding is most useful when a new technology is breaking off onto a new avenue. Solar technology is encountering such a guidepost now. New thin-film technologies offer higher-efficiencies with less material input (Economist 2007a). Part of the $3 billion should be spent on R&D for these technologies instead of expensive rooftop installations of low-quality solar arrays, which employ heavy metals as well as exorbitant energy and material inputs.

Certainly solar technology holds meaningful hope for developing regions that lack energy grids. However, elevated demand for silicon fuelled by installations in cloudy Germany artificially raises prices for those who could benefit the most. Solar cells should remain primarily a research endeavor until they are able to compete on even turf with options for reducing energy use. There is plenty of room for more R&D funding for energy-generation mechanisms. According to the Economist (2007b), the US power-generation industries spent "less on R&D as a proportion of turnover than did the country's pet-food industry, which suggests there is scope for more investment."

While I have shown that we can not rely on rational-actor theories when considering the economics of energy production and consumption, it would be equally naïve to assume an entirely non-rational actor. The *probit model* helps to illuminate the diffusion of technology beyond the basic models based on demand. According to the probit model, a consumer or firm will make use of a product or innovation when its income or size exceeds a critical level. Over time, this critical level of income falls as the technology becomes cheaper (Freeman and Soete 1997). So, we can hope that there exists some trigger-point, above which individuals, firms and municipalities will employ energy-reduction mechanisms more enthusiastically. This trigger-point need not be exclusively economic. As this thesis shows, social and semiotic associations and understandings can block acceptance of energy-reduction technologies. Though, such associations could just as easily trigger the acceptance of certain technologies under the right conditions.

Part of the $3 billion in California could be used to finance energy-reduction installations such as LED lights through adjusting taxes on energy or subsidizing reduction-mechanisms in a way that adjusts the trigger-point for acceptance. A multiplicity of funding distributions could employ human creativity in efforts to associate energy-reduction with positive modalities, thus creating semiotic and social triggers as well as economic ones. Theodor Adorno claims that art "must intervene actively in consciousness" and not take instructions from one-sided positions. He feels that art preserves a critical perspective and should compel rather than demand a change in attitude. I like to believe that energy policy can be structured through the creative spirit of humans to act with a similar virulence.

» Appendix

Technology-Word List

This is a list of the words that were directly related to the measurement or construction of LEDs or solar cells extracted from the top 500 most frequent words in all articles from 2003-2006 containing the term solar cells (an energy-production mechanism) or LEDs (an energy-reduction mechanism) from the New York Times and the three most widely circulated popular science magazines in the United States: Popular Science, Discover and WIRED (ABC 2006).

LED
leds
bulb
diodes
bulbs
red
green
blue
white
studs
batteries
resistor
current
battery
solder
watt
infrared
magnetic
lumens
signal
technology
devices
semiconductor
lab
steel
lumileds
resistors
stud
ohms
diode
solar
silicon
panels
glass
film
plastic
material
hydrogen
cadmium
telluride
panel
thin-film
chips
filament
wires
optical
iron
reflector
wire
ohm
electrons
optics
helovolt
megawatts

Expectation Word List

This is a list of expectation words and future dates. I began with a short list of expectation words, *could, possibly, can, may, should* and *expect*. I looked up these words into Roget's New Millennium Thesaurus (2006) and recorded the associated expectation words. I then input these new expectation words into the thesaurus and recorded even more expectation words. I went through several iterations until no new expectation words were returned by the thesaurus. I also included future dates mentioned in the articles. The resulting list of 76 words is listed below.

2007
2008
anticipate
assumably
assume
assuming
can
coming
conceivable
conceivably
concept
conjecture
could
current
developing
development
doubtless
estimate
estimated
expanding
expect
expectation
expecting
expects
exploratory
explore
feasible
forecast
foresee
glean
goal
guess
guesstimate
hope
hopes
hypothesize
imaginably
imagine
impossible
impossibly
improve
improvement
led
likely
may
maybe
obtainable
perchance
perhaps
planning
plans
possible
postulate
potential
potentially
predict
presume
presuppose
probably
reckon
reckon
research
researchers
should
solar
speculate
suppose
supposing
supposition
suspect
theorize
will
wish
won't

would
wouldn't

Climate-Change Word List

In order to find the words most commonly associated with climate change, I performed a Google search for "climate change" and saved the top 300 search return titles and short descriptions as a text file. I imported this file into TextSTAT to find the most commonly-reoccurring words in the Google search results. From this list, it was easy to select words associated with climate change like *sustainable, green, atmosphere* and *clean*. All 58 words are listed below.

arctic
atmosphere
atmospheric
Brundtland
carbon
clean
cleaner
cleanly
climate
climate-change
climatologist
climatology
consumption
consuming
dioxide
ecological
ecologist
ecology
efficiency
efficient
emissions
environment
environmental
footprint
fossil
fuel
gas
gasses
generating
generation
glacial
glacier
global
green
greener
greenhouse
kyoto
led
methane
oil
petroleum
planet
pollute
polluting
pollution
population
power
smog
solar
Stern
stratosphere
sustain
sustainability
sustainable
unsustainable
warming

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