The Predicament of Efficiency

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ABSTRACT

In contemporary American energy policy, energy efficiency has superseded energy conservation as the principal metric by which consumer energy choices are judged. However, narrow application of the idea of energy efficiency focuses on technological aspects of energy use and overlooks the human behaviors that drive energy consumption. In addition, energy efficiency does not necessarily save energy. Although energy efficiency has increased in the United States during the past 30 years, so has net energy consumption per capita. This paper examines unintended consequences of focusing energy policies on energy efficiency. A better understanding of these consequences can lead to improvements in the effectiveness and equity of energy policies by helping to recast policy so that it more fully considers absolute levels of consumption in addition to technical efficiency.

Introduction

Campaigns to save energy rest on fundamental assumptions about why we use energy, why we save or should save it, and what can and cannot be changed. These assumptions are often unarticulated and unquestioned though they create or reinforce attitudes and behaviors with regard to energy consumption. Energy conservation has been the focus of U.S. energy policy at various times, particularly during wars and other crises. Its popularity most recently declined after it was associated with the Energy Crisis of the 1970s and the accompanying economic recession. In response to energy conservation's tarnished image, policy makers turned to the concept of energy efficiency as the centerpiece for their strategies. Promoting energy efficiency, however, is not necessarily the best way to save energy or reduce pollution. It may actually encourage energy consumption by conveying the message that consuming increasing amounts of energy is acceptable as long as the energy is consumed by technologies that have been deemed efficient. Energy efficiency may also promote overreliance on technical "solutions" to the problem of energy use, turning attention away from the fact that people, not machines, use fuel.

The terms "energy efficiency" and "energy conservation," sometimes used interchangeably, have come to have quite different connotations in the American energy policy community.[2] According to the Edison Electric Institute (EEI):

> Energy conservation means doing without to save money or energy. Electric energy efficiency means getting the most from every kilowatt-hour of electricity you pay for (EEI 1997).

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[1] Opinions expressed are those of the author and do not reflect those of Lawrence Berkeley National Laboratory, the U.S. Environmental Protection Agency, or the U.S. Department of Energy.

[2] This distinction is not necessarily global. It is clearly true in the United States (see, e.g., Kempton, Boster, and Hartley 1995, 138) and true in New Zealand (Gunn 1997), but may not be true in translation; in Norway, for example, the same distinction may not hold (Gyllenhammar 1997).

Energy conservation focuses on how much energy is consumed; energy efficiency focuses on how much energy is used relative to the services demanded. Energy efficiency may result in energy conservation, but it may also serve as permission to consume. For example, a large appliance that uses more total energy may be more energy efficient, i.e. "produce" more per kilowatt hour of electricity, than a small one with fewer features that uses less total electricity. An electric toothbrush may be labeled as efficient while a manual toothbrush will not be. For a long time the purpose of energy policy was to save energy, toward alleviating potential supply problems and the dependence on foreign oil (see Lutzenhiser 1990, 102-03). Energy policy's shift to energy efficiency implicitly shifts the goal to economic productivity. Though motivations and definitions vary, energy efficiency has become, at official levels at least, an unquestioned virtue for the modern American, energy professional and layperson alike. The premise of the arguments that follow is that something—pollution, stewardship of exhaustible resources, or equity within policy—other than economic efficiency is at stake.

Net primary energy consumption per capita in the United States was 354 MMBtu per person in 1996 according to Energy Information Administration estimates (EIA 1998), higher that it has been since at least 1949, when EIA's records begin. The previous peak was 352 MMBtu per person in 1978, the year after the Department of Energy was formed, after which levels dropped 17% in five years. Thereafter per capita consumption has continued to increase at a rate close to that of the post-World-War-II boom. Although energy policy in the United States may have staved off possibly higher rates of consumption and increased comfort and productivity per unit energy, energy consumption per capita is increasing despite or perhaps because of the emphasis on energy efficiency in energy policies.[3]

The successes of energy efficiency policies in reducing energy consumption for certain classes of products[4] and in increasing economic productivity (EIA 1996, 4-5) are widely recognized among energy policy professionals. Classical economic theory and critics of energy-efficiency programs both suggest, however that consumers or society take back by means of price elasticity some or all of the savings achieved through increased efficiency. The importance of this "take-back effect" has been extensively discussed in energy policy literature, and remains controversial (Howarth 1997; see also Khazzoom 1980). The extent of take-back is usually estimated to be small, somewhere between 1% and 20% relative to savings (Sanstad 1998). Nonetheless, the idea of take-back points to some other problems of relying on energy efficiency as the central goal of energy policy.

Back in the 1970s, the public face of energy policy focused instead on energy conservation. Energy conservation is defined and quantified in relation to some necessarily hypothetical alternative: one "conserves" by not doing something one would have done otherwise (including by using fewer resources to achieve the same end, one component of efficiency). Conservation was seen as virtuous but painful, as implied by the EEI passage above. The paradigm of energy efficiency, in contrast, fixes or makes irreducible the demand for energy services, so the focus for saving energy rests on making machines perform the same tasks using less energy, or making them supply more services for the same amount of energy (see EIA 1995, 3-4). As is characteristic in economics, the energy question has shifted to one that considers means, not ends (see Blumstein 1992; Bromley 1990). People are responsible for energy use only in so far as they do or don't buy energy-efficient equipment. The specifications of the machine or the context for the energy-using activity—e.g., the capacity of the equipment, the frequency of its use, the actual "need" for such equipment—are not questioned. As a result, focusing on energy efficiency as the

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[3] See Inhaber (1997) and Inhaber and Saunders (1994) as examples of recent critiques of energy policy.

[4] For example, refrigerators have become much more efficient (see, e.g., Meier & Obst 1993).

goal of energy policies, while understandable in the political and economic context in which these policies are embedded, often (1) fails to conserve energy, (2) overlooks or draws attention away from the real sources of energy consumption, (3) and may lead energy consumers to the conclusion that conservation is or should be almost entirely a technical problem rather than a behavioral one. This is not to suggest that current energy policy should be dismantled. However, critiquing energy efficiency as the focus of energy policy points toward changes that could be made in consumer education and in the way that decisions that affect energy consumption are framed. Such changes could lead to greater reductions in overall energy use and pollution than have been accomplished through policies focused on efficiency.

Policy Examples

Energy efficiency appears to be an objective concept because it is grounded in a thermodynamic definitions: the ratio of all energy inputs to that of useful energy outputs. Even within the realm of engineering and the context of specific machines, however, there are alternative energy efficiency indicators and disagreements on how to quantify (Patterson 1996). As the concept of energy efficiency is applied to broader and more complex systems, the definitions become vaguer and less objective. At the level of energy policy discussion, "energy efficiency" is rarely defined explicitly; though it takes on many meanings, all of which engage value judgements and are thus cultural rather than absolute (Boulding 1981; Lutzenhiser 1990, 109; Patterson 1996; Winner 1982).

Defining the Energy Efficiency of Houses

Building standards worldwide rely on expressions of consumption per unit of floor area as a standard energy efficiency indicator (Meier 1998). In the U.S. residential sector, for example, under current definitions, a 10,000-square-foot house might be labeled energy efficient but tens of millions of "typical" households, each using much less energy than the 10,000-square-foot house, would not earn this distinction. This is because current definitions of household-level energy efficiency rely largely on comparisons of energy consumption per square foot, or otherwise per "comparable," same-size, house. These per-floor-area measures are simple and convenient but fail to incorporate the social and thermal logics that consumption would not be expected to be proportional to floor area. Any indicator as shortcomings, but alternative indices, like energy consumption per house or energy consumption per household member above some baseline level for a house, would yield a substantially different picture of what is efficient and what is not.

The current National Home Energy Rating System (HERS) uses the Model Energy Code (MEC) standards as the basis of comparison. The EPA awards an Energy Star label for new houses with HERS ratings of 86 or above. Houses to be rated are judged in comparison to a house that just meets MEC standards and has the same equipment, the same configuration, and is the same size, as if it represents what would have been built otherwise. Thus a 4,000-square-foot fully conditioned house can get a higher energy efficiency rating than a 1,400-square-foot house using half as much energy because the 4,000-square-foot house is compared only to another 4,000-square-foot house. A more troubling example is boiler-heated houses in the northeast without air conditioning, which may be very difficult to bring up to the HERS rating of 86 because boilers, at least those in the MEC-standard house, are already relatively efficient. The most cost-effective way to bring such a house up to an 86 level, may, in fact, be to add an air conditioner, so that cooling energy savings could be factored in. Passive design may not be credited. These are not criticisms of the HERS system per se (see, e.g., Collins 1998, 8) but rather of what it may be taken to mean. No inspection or modeling system could account for variation in the behavior of a building's occupants, though behavior is the ultimate determinant of energy consumption. However, a system that incorporates a measure of absolute consumption, such as energy consumption per household, may better reflect the energy implications of particular housing choices.

Energy-efficiency comparisons are made between systems that provide equivalent services, conventionally defined. Conventions are based on a number of assumptions that may not correspond with actual energy use patterns. For example, a house can get "energy efficiency" credit for installation of a programmable thermostat even though the programmable features are rarely used; even if they are used, they "save energy" only by providing reduced space conditioning relative to what would hypothetically be provided with a conventional thermostat (it is implicit that this change in conditioning services is what the consumer wants, as it may be). As is often the case with energy-efficiency ratings, these "savings" are possible only by technology, not by changes in human behavior.

Addressing "Leaking"Electricity

"Leaking" electricity is commonly used to describe electricity drawn for equipment that is not "on" or is in "standby" mode (see, e.g., Thorne & Suozzo 1998). Leaking electricity has been recently identified as an energy consumption problem in conjunction with the growing miscellaneous, or "all other" end use, such as estimated by EIA in the 1997 Annual Energy Outlook (1996, 39, 102-03). Because of the large number of products that might eventually be addressed by a leaking electricity program, a generalized policy (rather than specialized policies pertaining to each product class) is being debated. One proposal calls for assigning energy-efficiency labels to electronic equipment that uses less than one watt of standby power (Thorne & Suozzo 1998, 17).

Reducing standby power draw necessarily reduces energy consumption of any appliance that is at least sometimes plugged in, has a standby mode, and is not always "on," and thus makes it more "energy efficient" than before. But total energy consumption is not being taken into account, so a big projection TV may be labeled "energy efficient," but a smaller TV that draws less power overall may not be. That is, not only is there the potential pitfall of labeling an energy intensive end use so that it appears energy efficient solely by virtue of its low consumption in standby mode, such a product may also appear efficient relative to alternatives that actually use less energy per unit of "on" time. If any electronic equipment whose standby mode draws some amount of energy less than one watt can be labeled energy efficient, then a fully loaded kitchen can end up appearing more energy efficient than a simple one. Given the low levels of electricity savings possible from increasing the efficiency of equipment standby modes, consumers who pay attention to energy-efficiency ratings in this case would be motivated by psychological rather than economic benefits. In other words, for the small luxury products among those that would be affected by a standby mode efficiency guideline, the value of energy efficiency labeling may be primarily in making consumers feel better about their purchases rather than actually saving energy, perhaps leading to symbolic actions rather than more effective solutions. Thus, aside from the technical information provided on a label, the social messages conveyed matter very much.

Showcasing the Large

In 1993, Whirlpool won the Consortium for Energy Efficiency's $30 million "Golden Carrot" award for a 22-cubic-foot, side-by-side refrigerator, also offered in 25-cubic-foot and 27-cubic-foot models. These "Super-Efficient Refrigerator Program" (SERP) refrigerators were very efficient compared to other side-by-side refrigerators of the same size but questionable in comparison to the typical new refrigerator: although the 22-cubic-foot model's estimated annual energy consumption of 760 kWh/year (Rocky Mountain Institute n.d.) exceeded then-current standards by 30%, it was not only bigger than the average refrigerator sold in 1993 (19.8 cubic feet), but it had higher energy consumption than the maximum allowed by the NAECA standard for a top-mounted-freezer model of the same capacity (Wenzel et al.1997, 77). Only 20% of the refrigerators sold annually are side-by-side models; side-by-side refrigerators, as a class, use about 7-13% more energy than similarly sized standard top-mount refrigerators (Rocky Mountain Institute n.d.), and tend to be larger than average (Wenzel et al. 1997, 77). In other words, Whirlpool's award-winning refrigerator, while admirably CFC-free, actually had higher energy consumption than the average refrigerator sold in the previous year. The technical innovations of the "Golden Carrot" refrigerator may be applicable to other product sizes and classes, but in this example, they apparently were not. The efficiency award does not take into account the relative inefficiency of the entire product class in question.

A similar example of showcasing the energy efficiency of a relatively less efficient class of products is the 1997 "Your ENERGY STAR Home" calendar, published by the Alliance to Save Energy. This calendar features seven new houses; four are larger than 3,800 square feet even though the average new house nationwide is 2,100 square feet (Bureau of the Census 1997).

Technology Changes Behavior

In a case study on behavioral aspects of lighting and occupancy sensors, Pigg et al. (1996, 164) found that people who worked in offices with occupancy sensors were only half as likely to turn off the lights when leaving the room as were those working in offices without sensors. This observation implies that the technical fact that occupancy sensors were installed may have led to modifications in occupants' light switching behavior that counteract the energy saved by a "smart" technology. The study estimated that the behavioral shift reduced the lighting energy saved by occupancy sensors 30% from what would be expected had behavior not changed (Pigg et al. 1996, 165). That is, people in offices with occupancy sensors seem to have been more lax in turning off lights as they left the room than they would have been had occupancy sensors not been installed. Thus, an apparent behavioral response to a technology lead to a substantial reduction relative to the savings expected on a technical basis alone, though the results still indicate net energy savings for the offices in question. It is possible, however, that the behavior modification to "not shutting off the lights" carries over to outside of the offices with occupancy sensors and into the home or other realms without occupancy sensors. If this is so, then the net energy savings attributable to the occupancy sensor would be reduced even further. Whether this carryover occurs or not, the occupancy sensor example illustrates an unintended consequence of relying on technology to save energy. Sherman (1996) makes a similar conjecture for the energy-saving "sleep" state of computer monitors, suggesting that some users may choose to leave their monitor on overnight *because* of the sleep mode, whereas they otherwise would have manually turned it off. The net energy savings may still be positive. But in any case the technically-derived savings of using "standby" instead of "on" must be balanced against a behaviorally-driven choice between "off" and "standby," where the very existence of "standby" may discourage the use of "off."

Summary of Examples

Most energy policy analysts are aware of examples like the ones listed above. These examples are anecdotes—and some will argue that they are atypical examples. In any case, the examples alone do not invalidate a focus on energy efficiency as an important component of energy policy. Examples like these may be dismissed as representing initial, short-term irregularities that are inconsequential if energy policies are intended to achieve market transformation in the long term. Energy efficiency policy advocates may also argue that consumers can't be stopped from using energy in the ways described in the examples, so at least some energy is being saved by encouraging consumers to do things efficiently. Others argue that conservation doesn't sell well to politicians or consumers and that increased productivity or comfort for a fixed amount of energy is a worthwhile goal in itself. It would be absurd to try to legislate or otherwise explicitly dictate which combinations of energy-consuming activities are moral and which are not. However, we need to consider whether we want our energy policies to accept and even reinforce the above arguments, by emphasizing technological and economic fixes to the problem of energy consumption in such a way that the consumer's "guilt of consumption" is eased. Consumption is not a bad thing in absolute, but it should be seen for what it is.

One of the difficulties in moralizing about energy consumption is that most energy, and thus most energy savings, is invisible at the point of use. Using labels as rewards for increased efficiency and as a means to convey information about "high-efficiency" system is an attempt to make energy use and savings visible. This is a good strategy if the goal is to get customers to buy, which is a foundation of a market-driven approach to energy efficiency. However, there may be some long-term danger in awarding ratings that imply environmental beneficence to activities that could hardly be considered environmentally beneficent in the absolute but are only less environmentally damaging with respect to their downstream energy consumption than their conjectured alternatives. Labels implying that energy efficiency leads to conservation are misleading if they cause people to buy more, or larger, products than they otherwise would have because these products are designated energy efficient.

Implications for Policy

The examples above point to ways in which energy policy's current focus on energy efficiency may fail to yield energy savings or to reduce pollution, and also may lead to overreliance on technology for a problem whose solution also requires changes in perception and behavior.[5] There is no single way to improve energy policies, but some changes could increase the chance that these policies will save energy. Generally, as the examples above imply, energy policy should (1) attend to overall consumption as well as efficiency, and (2) make it clear that technology itself is not responsible for consumption. Some possible steps toward these goals are:

Education and labels. Product energy labels currently interpret a technology's energy characteristics within a narrowly defined framework. On the technical side, one possibility is that efficiency labels be made to better reflect total consumption with respect to the consumer's energy environment. Efficiency labels could compare not just to other products within a narrow class of products similar to the one being rated, but also to all products of that type and possibly to other types of products as well. The

[5] This preference to rely on technology is not unusual: Americans, among others, historically have held great faith in technology.

consumer could use this information to make choices in the context of total consumption, rather than within the efficiency of one category of product. For example, the Federal Trade Commission's yellow-and-black EnergyGuide label for a product, say refrigerators, considers only consider "similar" models of like size, but if the comparison were expanded to incorporate all refrigerators then the consumer would have a better idea of the overall energy implications of his choice. On the consumer psychology side, labels should be careful about crediting "environmental responsibility" when, in a larger context, none is due (where it is due is of course a subjective matter). The possible short-term gains from encouraging a consumer to buy something that may use less energy than a specific alternative for a fixed amount of use must be balanced against the long-term concern that such labels or encouragement train consumers to adopt symbolic responses to environmentalism rather than ones that are very effective in saving energy or reducing pollution.

Defining efficiency through standards and guidelines. Energy efficiency is not an absolute concept but instead a notion that is technically and socially defined and interpreted by energy standards and guidelines themselves. Efficiency measures are often defined linearly within a class, as in per square foot of floor area, per cubic foot of refrigeration capacity, or (inversely) miles driven per gallon. For both physical and economic reasons, it is often easier to make bigger products "efficient" under such linear definition than it is to make smaller ones efficient. This practical property of product size or scale in relationship to current definitions of efficiency can antagonize the goal of saving energy. One possibility, therefore, is to make guidelines that better reflect total consumption, perhaps by adopting a structure that specifies not only efficiency but specifies consumption limits or guidelines as well. While this dual structure still focuses savings on technology rather than the behavior, it helps better integrate scale rather than just efficiency into policy's judgement framework.

Interpretation and debate. The standards and guidelines inherent in energy policies reveal moral and technical judgements about what is "good" and what is possible. When evaluating any particular standard, guideline, or other message related to energy conservation or efficiency, it is critical to consider not only "energy saved" in a narrow sense, but what underlying messages are being conveyed and how they might affect the cultural perceptions of efficiency and consumption in short and long terms. By choosing specifications that better reflect absolute rather than solely relative consumption, policies may encourage an ideological as well as practical shift in perceptions of energy use.

Psychological Aspects of Consumption and Efficiency

No completely objective, value-free system of judging energy usage or savings is possible. The EIA points out that energy efficiency is "a value-based, philosophical concept" (EIA 1995, 83). However, the way energy efficiency claims are articulated on product "energy efficiency" labels, for example, affects how people think of energy consumption and their responsibilities in relation to it. Huber (1998, 306) compares energy efficiency with dieting:

> To understand the conundrum of energy conservation, look no further than your bathroom scale. You've been "conserving" calories for years--with diet sodas, low-fat milk, and lately with fat-free potato chips. Yet your contumacious scale simply refuses to acknowledge the facts. You think it maybe broken.

Huber's calorie conservation resembles energy efficiency: if calories represent the quantity or cost of fuel consumed, the food itself represents the energy services demanded. Does the food eaten by Huber's well-fed hypothetical person need to be low in calories to enable the person to consume larger quantities, or does the person eat more of particular foods because they are low calorie (calorie-elasticity) and thus "healthy?" Or could the increases in low-calorie foods and net calorie consumption be largely unrelated?

It is conventional wisdom in energy policy that consumers want energy services, not energy per se (e.g., Flavin & Durning 1988, 50). However, the distinction between energy consumption and energy services can be slippery. Arguably, people seem to find psychological pleasure in the act of consuming fuel or wielding fuel's power as their own. For example, Americans (and others) like to buy and drive sport utility vehicles, which together with vans and light trucks constituted 45% of the U.S. passenger vehicle market in 1996 (*Economist* 1997, 29), and in hot climates to cool houses and buildings in the summer to levels that would be considered too cold in the winter (Prins 1992).[6] The act of consumption, or at least the control over the environment fuel consumption provides, may be a service in itself.

Of course not just consumption, but conservation and efficiency as well, have complex social meanings.[7] "Energy conservation is becoming the political tonic of the 1990s," according to libertarian Jerry Taylor (1993), though where Taylor writes "energy conservation," "energy efficiency" may be more precise. In the United States, the notion that efficiency is socially good and progressive dates at least to the beginning of the 20th century, when the idea of efficiency in both human and mechanical systems was popularly embraced, as exemplified by Frederick Taylor's notion of the "one best way."[8] In contemporary American energy policy, the idea of progress through technical efficiency remains strong, though not without criticism. For example, at an October 1997 global warming symposium, President Clinton reports that he has asked himself "Why am I so irresponsible that I have not put this [compact fluorescent light bulb]" in every White House lighting fixture (Chandler 1997). Chandler's interpretation is that:

> Implicit in [Clinton's] query is the idea that the solutions to the problem can be painless, and even beneficial. However, this attitude makes behavioral analysts cringe. The president, they say, is peddling a 'feel good' solution that defies much of what we know about human nature.

The idea of energy efficiency through technology was strategically deployed by the U.S. energy policy community in the 1980s, toward disassociating energy conservation with pain, sacrifice, the to-the-soul national trauma of the Energy Crisis era, and the dire supply shortage predictions of that time did not come true. But efficiency itself has its own meanings, not all of which are consistent with energy conservation.

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[6] See also Wilhite & Lutzenhiser (1997) for a more general discussion of relationships between energy and consumption.

[7] For comments on the social history of the notion of "efficiency" in the United States see, for example, Bromley (1990), Hays (1975), and Winner (1982). For discussion of some of the cultural aspects of energy consumption, see, for example, Nye (1998), Radkau (1996), and White (1987).

[8] At about the same time, 1906, William James gave a speech in which he stated: "It would simply be preposterous if the only force that could work ideals of honor and standards of efficiency into English or American natures should be the fear of being killed by the Germans or Japanese" (James 1906), his very statement seeming to contain the seeds of self-doubt. Through this speech James refers to relationships between efficiency and war. In the same speech James refers to the "moral equivalent of war," later made famous by Jimmy Carter's 1977 use of it in reference to the Energy Crisis (see Bournc 1997, 445).

Conclusions

The moralistic, anti-consumption tone of the energy conservation campaigns of the 1970s and early 1980s led the energy policy community to consciously turn away from a conservation focus toward an efficiency-oriented one. Changes in how the "energy problem" was conceived, whether it was a short-term or instead a long-term supply problem, also motivated this conceptual shift to efficiency. Through this shift, however, energy policy may have gone too far in sidestepping the goals of saving energy and (as has become increasingly important recently through the 1997 Kyoto Protocol and other concerns about global warming) reducing pollution. The frequent omission of absolute energy consumption from energy-efficiency-driven policies is evidenced by current energy guidelines, policies, and educational material, which sometimes seem to encourage consumption rather than moderate it. Although it is impractical and inconceivable, at least for the time being, that absolute energy consumption be limited, energy policy should not send the message that technical efficiency is enough to constitute environmentalism.

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