The Importance of Comprehensiveness in Renewable Electricity and Energy-Efficiency Policy

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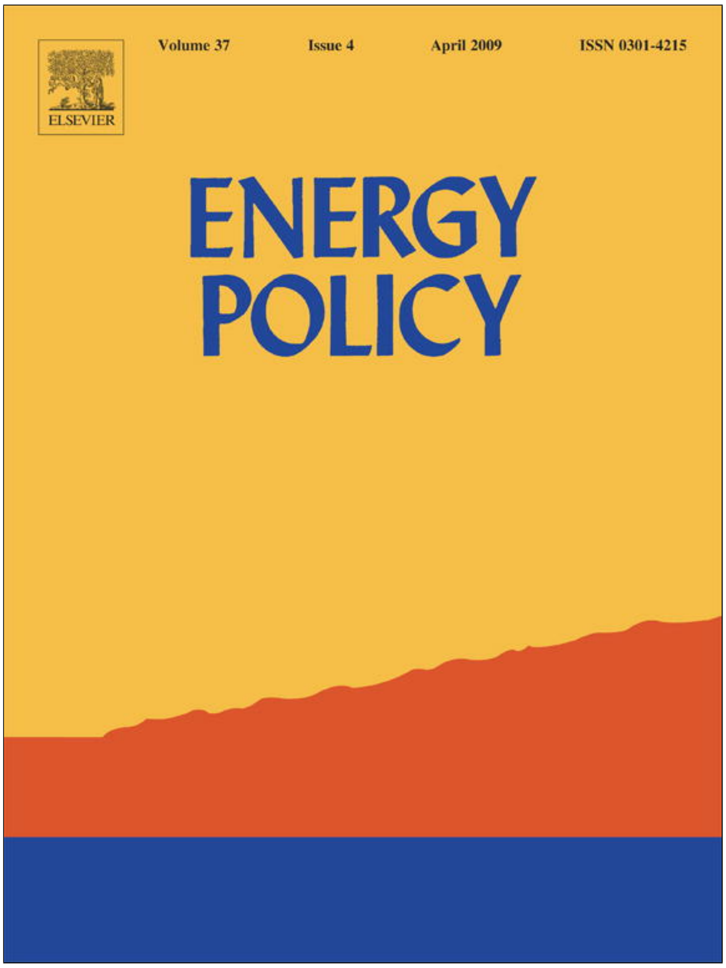
Benjamin Sovacool
University of Sussex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The importance of comprehensiveness in renewable electricity and energy-efficiency policy

Benjamin K. Sovacool *

Energy Governance Program, Centre on Asia and Globalisation, Lee Kuan Yew School of Public Policy, National University of Singapore, Singapore 259772, Singapore

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ABSTRACT

Based on extensive research interviews and supplemented with a review of the academic literature, this article assesses the best way to promote renewable energy and energy efficiency. It begins by briefly laying out why government intervention is needed, and then details the four most favored policy mechanisms identified by participants: eliminating subsidies for conventional and mature electricity technologies, pricing electricity accurately, passing a national feed-in tariff, and implementing a nationwide systems benefit fund to raise public awareness, protect lower income households, and administer demand side management programs. Drawing mostly from case studies in the United States, the article also discusses why these policy mechanisms must be implemented comprehensively, not individually, if the barriers to renewables and energy efficiency are to be overcome.

1. Introduction

Milton Friedman once said that "if you put the federal government in charge of the Sahara desert, in five years there'd be a shortage of sand". While his comment implies that some government administrations can possibly mismanage anything, there is a growing consensus that intervention by the national governments may be essential to effectively promote renewable power generators and energy-efficiency programs.

Consider the United States, the world's largest electricity consumer. Among others, Wiser et al. (2007) and Bird et al. (2005) call on the federal government to extend its production tax credit for wind and other renewables. Cooper and Sovacool (2007) and Rader and Hempling (2001) argue for a national renewable portfolio standard and renewable energy credit trading market. Haddad and Jefferiss (1999) suggest the creation of a national systems benefit fund; Rickerson et al. (2007) recommend a federal feed-in tariff; Lewis and Wiser (2005) note the success of nationalized low-interest loans and public financing. An equally multitudinous assortment of policy tools are highlighted to promote energy efficiency, including a national energy-efficiency portfolio standard (Bjornstad and Brown, 2004), stricter performance standards for buildings and appliances (Brown, 1993), federally sponsored energy-efficiency mortgages and loans (Brown, 1997), and nationally funded performance contracting, home energy rating systems, building retrofitting, and energy audits (Jaffe and Stavins, 1994).

This practically dizzying array of policy mechanisms, plus the dozens of other options not mentioned, leaves two questions unanswered: which would perform the best in global electricity markets? And are any of these policies sufficient by themselves to overcome the impediments faced by cleaner sources of power, or is a bundle of policies necessary?

Based on extensive research interviews supplemented with a review of the academic literature, this article assesses the best way to promote renewable energy and energy efficiency. It begins by briefly explaining the study's methodology and laying out why government intervention is needed, and then details the four most favored policy mechanisms: eliminating subsidies for conventional and mature electricity technologies, pricing electricity accurately, passing a nationwide feed-in tariff, and implementing a national systems benefit fund to raise public awareness, protect lower income households, and administer demand side management programs. Drawing mostly from case studies in the United States, the article finally discusses why these policy mechanisms must be implemented comprehensively, not individually, if the barriers to renewables and energy efficiency are to be overcome.

2. Research and theoretical methods

To explore the favored policy mechanisms for renewables and energy efficiency in greater detail, this study draws from interviews of energy experts and textual analysis. The author conducted 181 semi-structured ethnographic interviews at 93 institutions in Belgium, Canada, Denmark, France, Germany, Japan, Korea, the Philippines, Singapore, Spain, Switzerland, United Kingdom, and the United States over the course of 3 years. Those interviewed

* Tel.: +65 6516 7501; fax: +65 6468 4186.
E-mail address: bsovacool@nus.edu.sg

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were selected to represent the diverse array of stakeholders in the electricity sector, and the author included participants in Asia, Europe, and North America to gain a fuller perspective about available policy options. Participants included members of

- investor-owned electric utilities, independent power providers, energy trading firms, and rural electric cooperatives;
- regulatory agencies at the state and federal level, including public utility commissions;
- energy systems manufacturers;
- electricity interest groups, industry-sponsored institutes, consultants, lobbyists, and nonprofit organizations;
- research institutes, including universities and national laboratories; and
- consumers and consumer advocates.

While participants were guaranteed anonymity to encourage candor, a list of their institutions is provided in Appendix 1. Interviews lasted between 30 and 90 min, and participants were asked "What can be done to overcome the impediments facing renewable energy and energy efficiency?." Participants were

Table 1
The impediments to energy efficiency and renewable power in the United States.

Category	Barrier	Explanation
Financial and market impediments	Information failure	Producers do not distribute accurate or readily available information about renewable power projects. Consumers lack information about renewable power technologies, a trend exacerbated by transaction costs and "bounded rationality". Real-time electricity costs are masked through customer aggregation, average billing, and regulated rate plans.
	Returns on investment	Homeowners lack available capital or access to it to purchase renewable power technologies. A large gap exists between private and social discount rates energy investments. Consumers, businesses, and utilities are more concerned with "first costs" than "lifetime costs".
	Split incentives/principal-agent problem	Builders make energy decisions for homeowners. Landlords make energy decisions for tenants. Businesses remained focused on core missions and maximizing profit. Fiscal or regulatory policies discourage energy efficiency. A limited supply and availability of energy-efficient technologies exists.
	Predatory market power	Strenuous interconnection requirements and stranded costs prevent access to the grid. The intermittent nature of some renewable resources convinces utilities that they are ill suited to provide base-load and peaking power. Intellectual property rights, patent blocking, and patent suppression are used to prevent entry into the industry.
Political and regulatory obstacles	Flawed expectations	Early renewable power advocates had inflated hopes and expectations.
	Variable and inconsistent incentives	Renewable power programs and subsidies, such as the production tax credit, were allowed to expire or never fully implemented.
	Varying state standards	State programs have differing and sometimes contradictory definitions, standards, goals, and requirements for renewable power.
	Underfunded R&D	Public funding of R&D has declined precipitously since the 1980s. Private funding of R&D has been reduced as utilities and energy companies consolidate and restructure for competitive electricity markets.
	Bureaucracy	A "top-down" approach to energy R&D plagues DOE programs on wind and solar.
Cultural and behavioral barriers	Public apathy and misunderstanding	People remain uniformed and apathetic about electricity technologies and express preference for familiar energy systems.
	Consumption and abundance	Historical antagonism towards nature, industriousness, industrialization, and the promotion of leisure have resulted in values predisposed towards excess energy consumption and waste.
	Psychological resistance	Comfort, freedom, control, and trust are prioritized more than energy conservation and renewable power use.
Aesthetic and environmental challenges	Environmental costs not included in the price of power	Consumers cannot make rational comparisons between conventional and renewable power sources.
	Environmental objections to renewable power technologies	Renewable power technologies are believed to be aesthetically unpleasing and to harm the environment and degrade land and property.
	Symbolism	Renewable power technologies can symbolize distrust in government or a clash between rural/urban and rich/poor constituents.
	Internal fighting	Renewable power technology firms fight amongst themselves instead of coordinating policy.

permitted to identify as many different mechanisms as they wished. Participants were also asked to suggest specific studies confirming their points, and these recommended articles served as the basis for an extensive literature review.

The author chose semi-structured ethnographic interviews because they were structured enough to ask the same question, but flexible enough so that the question could be worked into a conversational flow. Participants were encouraged to give their own explanations, and the author had the ability to follow-up with additional questions to provide more complete information than that offered by closed format interviews and survey questionnaires.

In brief, the author decided to focus on the policy mechanisms intended to promote renewable electricity and energy efficiency because numerous studies have documented that these technologies and programs remain challenged by a host of market failures, market impediments, and socio-technical barriers. While the literature on these impediments is much too vast to explore here in detail, it is summarized in Table 1, which divides the obstacles into financial and market, political and regulatory, cultural and behavioral, and aesthetic and environmental categories. An in-depth discussion of these challenges for the United States is provided in Sovacool (2008a, pp. 123–200).

Financial and market impediments include the lack of readily available information on energy efficiency and renewable electricity to both users and producers; improper discount rates and unacceptably high rates of return for energy investments; the principal-agent problem; the invisibility of energy savings; predatory practices undertaken by some energy firms and electric utilities; and a desire for businesses and industries to stick to their core missions rather than invest in different forms of energy supply.

Political and regulatory obstacles encompass unrealistic expectations about the performance of renewables and energy efficiency; inconsistent government standards and fragmented policymaking; underfunded research and development; and a bureaucratic approach to research projects.

Cultural and behavioral barriers relate to public misunderstanding about electricity and energy efficiency; public expectations about cheap and abundant forms of electricity supply; and a strong personal desire among consumers to prioritize comfort, control, and freedom rather than sustainability or frugality.

Aesthetic and environmental challenges include improperly assessing negative externalities; aesthetic values; the symbolic nature of energy efficiency and renewable energy; and internal fighting among renewable power advocates.

The point is that the barriers facing energy efficiency and renewables are tenacious, interconnected, and deeply embedded in the social fabric. As such, equally rigorous policies are required to overcome these interrelated impediments.

3. Four favored policy mechanisms

Given that the impediments facing energy efficiency and renewables are simultaneously technical, economic, political, and social, it makes sense that the optimal policies chosen by those interviewed target each of these dimensions. While participants identified 30 different policy mechanisms, the four policy mechanisms with the strongest support were eliminating subsidies, altering electricity prices, forcing utilities to adopt renewables, and increasing funding for renewable power through a national systems benefit charge (see Table 2 for a summary of these four mechanisms, and Table 3 and Fig. 1 for a breakdown of all 30 mechanisms identified). It should be noted that virtually none of the 30 mechanisms identified by participants were truly "new" (almost all of them have existed in some form for many years, with the possible exception of one respondent's desire to create an "energy police" to coerce people to waste less electricity). Moreover, the support for the four mechanisms

Table 2
Four preferred energy efficiency and renewable power policy mechanisms.

Impediment	Policy	Details
Political support for renewable power has been inconsistent and unfair	Eliminate subsidies	Immediately repeal federal government subsidies for mature energy technologies
Consumers do not receive accurate price signals for electricity	Create accurate electricity prices	Abolish electricity rate caps, eliminate declining block rate pricing, reflect time of use in electricity rates, and internalize external costs
Utilities and businesses generally will not invest in renewable power	Make renewable energy mandatory	Create a national feed-in tariff (FIT) and guarantee renewable power generators access to the grid
The public is uninformed about energy efficiency and renewable energy	Inform the public and protect the poor	Establish a national systems benefit charge (SBC) to generate revenue to distribute information and educate the public, provide low-income assistance and weatherization, and fund energy efficiency and DSM programs

Table 3
Thirty policy mechanisms identified by participants.

Mechanism	Number of supporters	% overall support
Eliminate subsidies	131	72
Create accurate electricity prices and encourage feedback	110	61
Pass a national feed-in tariff	90	50
Enact a systems benefit charge (to fund energy efficiency)	50	28
Enact a systems benefit charge (to educate the public and disseminate information)	47	26
Enact a systems benefit charge (to assist low-income families)	46	25
Strengthen appliance standards/product labeling	35	19
Increase funding for energy R&D	34	19
Offer low-interest loans and/or government financing	33	18
Implement stricter building codes	31	17
Pass a renewable portfolio standard	25	14
Interconnection standards	24	13
Green-power programs	23	13
Offer rebates and/or free energy-efficient equipment	22	12
Extend and bolster tax credits	22	12
Net metering	21	12
Unbundling of generation, transmission, and distribution	20	11
Streamlined permitting and siting	18	10
Offer workshops and training seminars	11	6
Government-sponsored energy audits	10	6
Energy-efficient mortgages	9	5
Energy-efficiency portfolio standards	9	5
Government procurement	4	2
Create and fund an Advanced Research Projects Agency—Energy	2	1
Force building managers to disclose energy use	2	1
Provide leases on government land	1	<1
Prohibit master-metering in apartment complexes	1	<1
Ban incandescent light bulbs	1	<1
Coal moratorium	1	<1
Energy police	1	<1

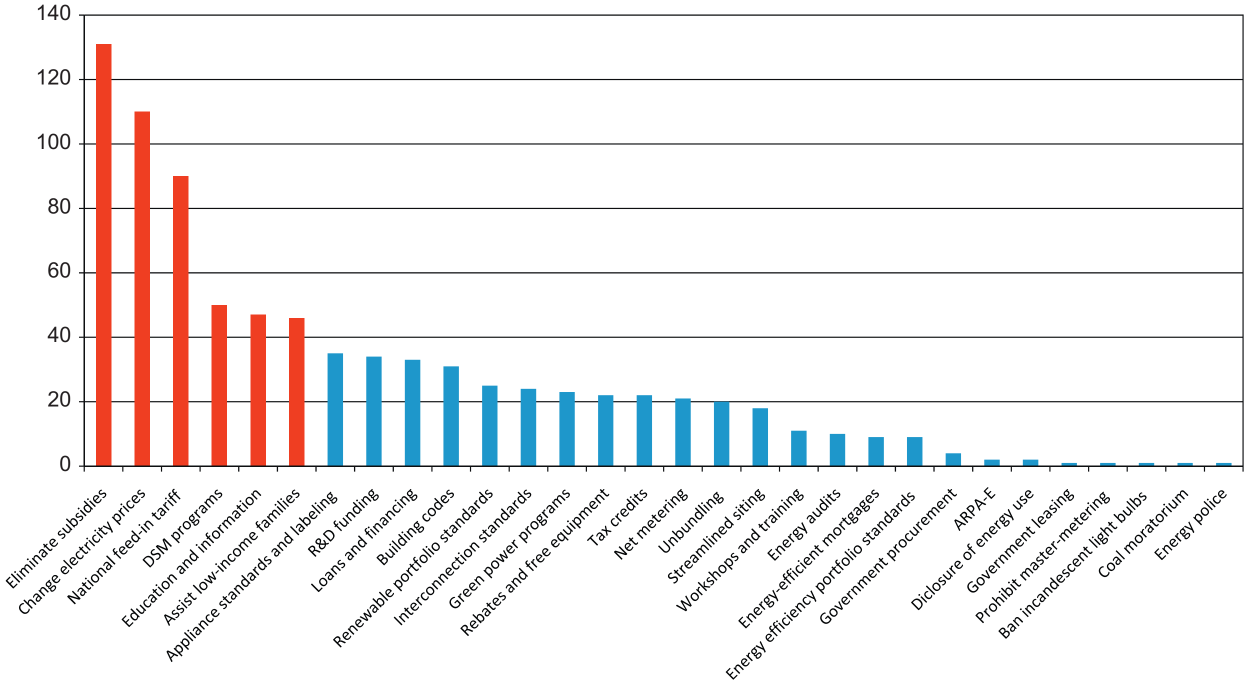

Fig. 1. Policy mechanisms identified by interview participants. The policies in red, on the left, are the most popular ones selected by participants for this study. The remaining 24 mechanisms on the right, in blue, were not selected. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 4
Major types of energy subsidies.

Direct financial transfer	Preferential tax treatment	Trade restrictions	Public funding	Direct regulation
Grants to producers	Rebates	Quotas	Direct investment in infrastructure	Mandated deployment rates
Grants to consumers	Exemptions	Technical restrictions	Public R&D expenditures	Price control
Low-interest or preferential loans and guarantees	Sales taxes	Trade embargoes	Federal procurement and direct ownership of assets	Market access restrictions
	Producer levies		Administration of regulatory costs	Federal market planning
	Tariffs			Assumption of legal risk and indemnification
	Accelerated depreciation			
	Reductions in the tax rate			
	Reductions in the tax base			
	Altering taxable entity			

elaborated below did not vary significantly according to the institutional affiliation, professional training, or specific geographic location of participants. Endorsement for the most favored mechanisms, in other words, was remarkably uniform despite differences in age, gender, employment, education, and culture.

3.1. *Eliminate conventional subsidies*

The single most consistent response from participants—more than 70%—was to eliminate government subsidies for conventional and mature energy systems. Governments subsidize energy technologies to protect domestic industries (and employment in them) and to develop a technological lead over other countries. In many OECD countries, these subsidies take 24 different forms and have mostly included direct financial transfer, preferential tax treatment, trade restrictions, public funding, and direct regulation (see Table 4). They, thus, affect all stages of different electricity fuel cycles, from preproduction (such as direct expenditures on R&D and surveys that help identify location and composition of resources), production (such as leasing access to public lands or accelerated depreciation), consumption (such as targeted exemptions for using coke in industry or funding for weatherization), and post-production (such as decommissioning or funds for reclamation and remediation). The five largest energy subsidies in order of magnitude per year in the United States (adjusted to $2007) are accelerated depreciation of energy-related capital stock (at $16.6 billion); R&D funding for the DOE ($9.1 billion); assumption of legal risk for nuclear plants ($4.9 billion); maintenance of the strategic petroleum reserve ($3.6 billion); and the general investment tax credit ($3.5 billion). These five subsidies account for a total of half of all government expenditures on energy (Koplow, 1993, 2004; Koplow and Dernbach, 2001).

Because they spread government benefits unevenly, however, immediate repeal of existing subsidies (potentially including those for mature renewable power systems such as hydroelectric facilities and onshore wind turbines) would bring about three drastic and important changes. First and most important, removal of subsidies would send market signals to consumers and encourage more rational use and valuation of power resources. Subsidies actively discourage consumers from seeking cleaner alternatives, encourage the overconsumption of resources and thus higher electricity use, and lead to capacity developments and consumer patterns in excess of true needs. Funds used to develop intercoastal waterways and deepwater channels, for example, make it cheaper to deliver coal and oil to markets that would otherwise suffer higher fuel transportation costs. Koplow (1993) found that conventional subsidies distorted price signals for electricity by at least 11%. It is both "good economics" and "fair" to adopt policies that force consumers to pay for the true costs that their consumption imposes on society (Stelzer, 1990).

Second, elimination of subsidies would improve competition in the electricity industry, eliminating the unfair advantage given to nuclear and fossil-fuel technologies. The United States is the most egregious example. From the moment the federal government formally began funding energy R&D in 1882 (by supporting coal research by the US Geologic Survey), it has heavily focused on promoting oil and gas development at the expense of alternative and unconventional technologies. Since then, the pattern of subsidization has favored mature, conventional energy sources by a ratio of more than eight to one. End-use energy efficiency has received only $1 worth of subsidies for every $35 spent on forms of conventional supply (Sovacool, 2008b; Gaffigan, 2008). Readers are invited to view Fig. 2 for a general depiction of government spending on energy R&D.

Looking closely at the numbers, conventional sources have received almost 90% of all subsidies for the past six decades. From 1943 to 1999, for instance, federal subsidies for nuclear power totaled $144.5 billion, more than 25 times the cumulative spending on wind and solar ($4.4 billion for solar thermal and PV and only $1.3 billion for wind) (Goldberg, 2000). In 1973, before the energy crisis, the federal government awarded 93% of its subsidies to fossil energy but only 6% to energy efficiency and renewables. Between 1978 and 1995, federal subsidies for clean coal exceeded $12 billion, nearly two-and-a-half times the total funding for wind (Sawin, 2001). Even in fiscal year 1979, when subsidies for renewable power peaked at $1.5 billion, subsidies for fossil fuels were greater at $1.9 billion and more than 58% of the DOE R&D budget was focused on nuclear power (Orr, 1981). Nuclear power development received subsidies worth $15.30 per kWh between 1947 and 1961 (the formative years for the industry), which compares with subsidies worth only $7.19 per kWh for solar and 46 cents per kWh for wind between 1975 and 1989 (their formative years) (Goldberg, 2000). In its first 15 years, nuclear and wind produced about the same amount of energy—2.6 billion kWh for nuclear and 1.9 billion kWh for wind—but nuclear subsidies outweighed wind subsidies by more than a factor of 40, receiving $39.4 billion compared to wind's $900 million. Taken as a whole, from 1947 to 2000 cumulative subsidies for nuclear power amounted to $1411 per US household, compared to just $11 per household for wind. (And these figures underestimate subsidies for nuclear power because they exclude price guarantees, discovery and production bonuses for uranium miners, accelerated depreciation, tax exemptions for industrial development bonds, investment tax credits, and all non-DOE R&D on fusion, high-energy physics, and metallurgy.)

Recently, not much had changed, with fossil energy receiving 86% of government subsidies in 2004, nuclear energy 8%, and renewables and energy efficiency only 6% (US Government Accountability Office, 2006). An examination of current federal electricity subsidies over the past 6 years shows that government policymakers remain heavily committed to supporting conventional sources. Consider two of the more prominent types of subsidies: R&D appropriations and tax credits. During 2002–2007, nuclear power received 54% of all DOE-related R&D subsidies ($6.2 billion out of $11.5 billion), and the amount given to nuclear significantly increased by 59% over the same period, from $775 million in 2002 to $1.2 billion in 2007 (US Government Accountability Office, 2007). Fossil-fuel-related energy R&D received 27% of federal subsidies ($3.1 billion) while the entire class of renewable power technologies received a miserly 12% ($1.4 billion). Again, these numbers underestimate the amount awarded to conventional sources, because they exclude subsidies such as limited nuclear liability provided under the Price Anderson Act and low-cost financing given to federal power entities that operate nuclear power plants.

Looking at tax credits and incentives, a review of US Department of Treasury data indicates that the energy sector, excluding nuclear power, received $18.2 billion in lost tax expenditures from 2002 to 2007 (US Government Accountability Office, 2007). Here, fossil fuels received 75% of all energy-related tax credits ($13.7 billion) while renewable power systems received a meager 15% ($2.8 billion). The DOE intends to worsen

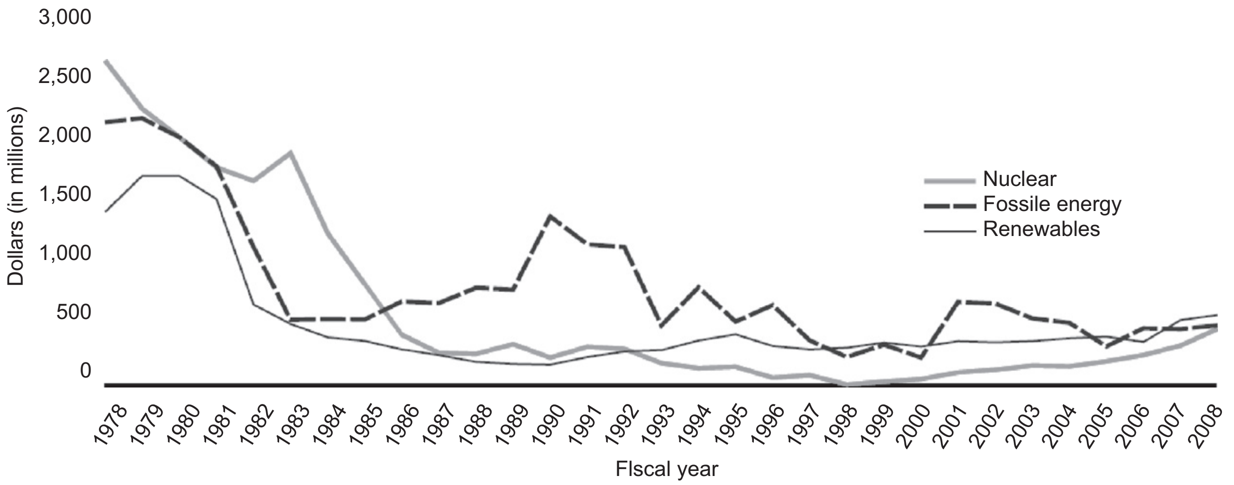

Fig. 2. US Department of Energy Budget Authority for Renewable, Fossil, and Nuclear R&D, 1978–2008 (by category in real terms, adjusted to $2008).

this bias even further in their request for FY 2009 appropriations by calling for a 34% increase in R&D funding for fossil energy and a 44% increase for nuclear power but a decline in funding for renewables and energy efficiency (Sovacool, 2008b).

Third, abolishing energy subsidies would free up billions of dollars of government revenue that could be funneled back into R&D on newer technologies, reduce national deficits, or fund other programs. The elimination of energy subsidies could also untangle much-needed revenue for underfunded programs such as social security, education, and health care. The $30 billion from energy subsidies in the United States, for instance, could completely fund two more National Aeronautics and Space Administrations or increase the Department of Education's budget by 50%.

3.2. Price electricity more accurately

Approximately 60% of respondents indicated that electricity prices should be changed. Respondents noted that policymakers could implement four changes concerning how electricity is priced by abolishing price caps, eliminating declining block-rate pricing, reflecting time of use in electricity rates and bills, and internalizing the cost of externalities.

Abolishing price caps would enable electricity rates to reflect current market prices and volatility. Many states and countries have some type of price cap on residential or industrial electricity rates (Showalter, 2007; Rose, 2007). By keeping prices artificially low, price caps fuel excessive consumption, inhibit exploration and investment, undervalue energy efficiency, and distort the ability for consumers to make rational decisions based on the actual cost of electricity. They can also force utilities to go bankrupt when unexpected outages and price increases cannot be passed on to consumers. During the 2001 electricity crisis in California, for instance, price caps of $250/MWh prevented PG&E and Southern California Edison from recovering imported power and fuel costs (up to five times greater than capped electricity rates) for its industrial and residential customers.

Eliminating declining block-rate pricing would create an incentive for industries to promote energy efficiency and consume less electricity. Economic theory holds that the more one consumes a precious commodity, the more its price ought to reflect marginal cost (within the constraints of cost-of-service ratemaking). The opposite occurs with declining block-rate pricing, where consumers of small amounts of electricity pay higher prices for electricity and larger consumers (often industrial or commercial customers) pay lower prices.

Declining block-rate pricing also partially explains why industrial customers pay 41% less for electricity than the residential rate in the United States. Utilities in Virginia, Indiana, Kentucky, Ohio, Nebraska, Montana, North Dakota, West Virginia, and Arkansas still rely on declining block rates for either residential or industrial customers (or both). The promotion of inverse block-rate pricing, where customers are charged higher rates for electricity the more they consume, encourages more rational use. At least three utility companies have experimented with this type of an approach for residential customers.

In California, PG&E residential customers pay about 11.6 ¢/kWh for normal electricity use but those consuming 30% more than the average pay 13.3 ¢/kWh, those consuming twice as much pay 22.8 ¢/kWh, and those consuming three times as much pay about 24.8 ¢/kWh. The Arizona Public Service Company also structures their rates this way: for 0–400 kWh, customers pay about 7.6 ¢/kWh, but have to pay 10.6 ¢/kWh for 401–800 kWh and 12.4 ¢/kWh for more than 800 kWh. The Idaho Power Company charges their customers 6.2 ¢/kWh for up to 800 kWh but 8.4 ¢/kWh for customers consuming more than 2000 kWh. These programs, while all relatively new, have reduced rate charges for large customers by as much as 9.5% (Carter, 2001).

Reflecting time-of-use through "real-time," "interval metering," "time-of-use," or "seasonal" rates would show customers how electricity production and consumption varies according to the time of day, week, and month. The regulation of utilities has been based historically on average prices, set in rates revealed to customers in monthly bills. There are some markets where hourly electricity prices can vary by factors of 100 or more, but these prices are all always averaged, so consumers never see them. Most electricity bills combine charges for several appliances, lighting, water heating, space heating, and cooling all into a lump sum. It is impossible for consumers to tell, without careful monitoring and experimentation, how much of the bill results from the individual use of appliances or technologies, or how much the bill could be decreased by using more efficient models.

If other commodities were priced the way electricity is, telephone bills might give a single dollar figure for long-distance or roaming service without having calls itemized. Groceries would have no price markings, and customers would instead be billed via a monthly statement that would say something like "Amount Due: $1056.55 for 2371 food units in January" (Kempton and Layne, 1994). Alfred Kahn (quoted in McCraw, 1984, p. 226) noted that charging a flat rate for electricity regardless of when it was used seemed like "charging a flat price per pound for all items in a grocery department store. What would happen if everything that came out of the cow—steak, hamburger, suet, bones, and hide—-were priced at average cost per pound?". The result is that everyone would always eat steak!

The Energy Policy Act of 2005 implicitly recognized this flaw in electricity pricing and encouraged utilities to provide time-based rate schedules reflecting variations during the day to all individual customers requesting it. However, the Act also said, ambiguously, that each state regulatory authority could decide whether to implement that provision. Correspondingly, LBNL Environmental Energy Technologies Division (2007) estimates that only about 100 utilities (less than 2%) offered some sort of time-of-use rate for electricity customers in 2007.

Time-differentiated or de-averaged rates would not necessarily mean instant minute-by-minute prices, but would at least reflect meaningful differences between peak and off-peak consumption. Studies have shown that three forms of relatively simple information would be most valuable and effective: energy use histories, such as month-to-month comparisons of current year consumption with past years, adjusted for weather and price fluctuations; comparisons to the usage of other customers in the same neighborhood or with similar-sized residences; and calculations of change in energy use before and after investment in a new appliance or home improvement (Brown, 1993, 1997; Anderson, 1995).

New York has experimented with some of these "alternative rate designs" by offering time-of-use rates, day-ahead real-time pricing, critical peak pricing, and pricing at real-time market rates. Researchers at LBNL surveyed 149 commercial and industrial customers in the Niagara Mohawk Power Corporation service area where the utility offered time-of-use tariffs for large customers with peak demand needs. They found that more than 30% of industrial customers responded by foregoing discretionary electricity usage and 15% shifted usage from peak periods to off-peak periods; 45% of respondents installed demand reduction enabling technologies on site; and peak load for the utility was reduced by 15% (Goldman et al., 2004a, b). Further south, Georgia Power introduced time-of-use meters for large industrial customers and, from 1992 to 2002, enrolled 1650 customers to reduce peak demand by 17% (Sovacool, 2008a, p. 211). In the West, a recent pilot program in California also had very promising results with time-of-use rates at the residential level. The program installed more than 2400 time-of-use meters or residential customers and, after combining them with time-of-use tariffs, found that participants shifted more than 20% of their peak consumption to off-peak hours (Sovacool, 2008a, p. 211).

Internalizing external costs would drastically raise electricity prices but would also ensure that electricity is accurately priced. Utilities sold approximately $360 billion of electricity in 2007 in the United States, but the social cost of power outages and air pollution not covered by electricity rates amounted to more than $400 billion (Sovacool, 2008a, p. 212). While some states, such as New York, Massachusetts, Nevada, and California, internalize some externalities in retail prices, none of them internalize all externalities, and 18 states do not require explicit consideration of environmental externalities at all.

A preponderance of evidence suggests that pricing electricity more accurately will greatly improve the efficiency of the electricity industry, provide customers with proper price signals, and reduce wasteful energy use. One study provided residents with daily electricity prices for a month and found a 10.5% reduction in electricity use (Kempton and Layne, 1994). Another analysis of residential electricity use from 1973 to 1980 found that "feedback" in the form of information detailing daily and weekly electricity prices reduced consumption between 6% and 20% (Winkler and Winnett, 1982). When Princeton University researchers gave residents of Twin Rivers, New Jersey, information about their level of electricity and natural gas use on a daily basis, consumption dropped 10–15% (Socolow, 1978). Yet another survey reviewed 19 sets of data from experimental studies where households were informed frequently (often daily) about how much electricity they were using and found a 20% reduction in consumption (Stern and Aronson, 1984). A random sample of 414 Delaware residents, matched with utility company records, also found that merely telling consumers that peak consumption was more expensive reduced electricity use all year round (Byrne et al., 1985). Still another study involved eight experiments tracking electricity use at 602 households over the course of many years. In some experiments, feedback was given three to four times a week, and in one experiment it was given continuously and informed households of the cost of their consumption every half hour. The researchers found that frequent, credible feedback about electricity prices resulted in 10–13% less electricity use than control groups (Becker et al., 1979).

3.3. *Enact a national feed-in tariff (FIT)*

Since many electric utilities and businesses are risk-averse, are unfamiliar with renewable power technologies, face split incentives even when they decide to promote them, and underinvest in R&D, about half of respondents were strong advocates of making renewable power mandatory by implementing national feed-in tariffs (FIT) and guaranteeing renewable power suppliers access to the grid. (It should be noted that FIT advocates have recently discussed renaming the mechanism "Renewable Energy Payments" to avoid the term "tariff" in their campaigning.)

FITs force utilities to purchase renewable power by setting a fixed price above market rates (say, 20 ¢/kWh for wind or 40 ¢/kWh for solar PV) that they have to pay all suppliers. FITs obligate electric utilities to purchase the electricity from renewable energy resources in their service area at these elevated tariffs for a specified period of time (usually about 15–20 years). They also typically cover the costs of grid interconnection and net metering and spread these across all electricity customers, and slowly decline the tariff over time to pressure suppliers to lower costs further (a technique known as "degression"). Unlike production tax credits, which can only be "collected" periodically during tax returns, and renewable portfolio standards, which mandate that electricity suppliers provide a fixed percentage of renewable power but leave the price up to the market, FITs offer a fixed rate for renewable power providers.

Germany stands as the paradigmatic example of effective FIT regulation. The country implemented its Electricity Feed-In Law in 1991 in order to create a market for wind electricity by offering providers a fixed but attractive price for the recovery of generation costs (Meyer, 2003; Lauber, 2004; Blok, 2006). The newer FIT, passed in 2003, also includes a degression component that reduces the FIT for new installations each and every year (but then it is kept constant over 20 years). The German rate of degression for their solar PV FIT, for example, is 8% per year, placing pressure on suppliers to construct and operate solar capacity as quickly as possible.

FITs have many advantages over other mechanisms. Rather than leaving renewable power prices to the market, FITs ensure a stable investment stream for project developers, as the profitability of projects is guaranteed (Rickerson et al., 2007). This type of pricing system makes it easier for developers to obtain bank financing for investments in renewable energy. Suppliers also get paid immediately, rather than having to wait for the sale of renewable energy credits or reimbursement of tax credits. Generators and power providers are likely to put pressure on equipment producers for lower prices and on developers for the best available locations, shifting competition from electricity prices to equipment prices.

Making renewable power mandatory through a FIT at the national level—offering renewable producers a fixed price but differentiating it for technologies (i.e., wind receives less than solar), guaranteeing access to the grid, and creating strict penalties for noncompliance—provides three immediate benefits.

First, experience in Canada and Germany implies that a national FIT is the best way to encourage quick expansion of renewable power. The FIT program in Ontario, Canada, started in November 2006 and provided a fixed rate of 11 ¢/kWh for small-scale hydroelectric, biomass, and wind projects and 42 ¢/kWh for solar PV facilities, set in 20-year contracts with guaranteed access to the grid. In just 15 months, the FIT signed more than 655 MW of wind, 316 MW of solar PV, 66 MW of hydroelectric, and 67 MW of biomass capacity (Etcheverry, 2008). The Canadian FIT was so successful it exceeded its 10 years anticipated target of 1000 MW in less than 2 years, with more than 1300 MW of contracts fulfilled by the end of June 2008 (Lacey and Riahi, 2008). The FIT in Germany, which enables solar PV systems to sell power at 49 €¢/kWh (Eurocents per kWh) and onshore wind producers to sell at 8 €¢/kWh, increased renewable power deployment from 6.3% of national capacity in 2000 to 14.2% in 2007—an increase of more than 200% in 8 years (Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety, 2008). Under the FIT in its current form, German policymakers expect renewable electricity supply to grow to 15.5% of gross electricity production by 2010 and 27% by 2020. German utilities that buy power at these higher rates do pass extra costs back to consumers, but by 2007 the national FIT had increased household electricity bills by only €3 per month.

Second, despite the extra initial cost, national FIT policies quickly depress electricity prices. The German Federal Ministry of Environment, Nature Conservation, and Nuclear Safety (2008) estimates that while their FIT cost consumers $3.3 billion in higher electricity rates and administrative expenses in 2007, it saved them $5 billion in depressed fossil-fuel costs and $9.4 billion in overall costs. In Spain, where a similar national FIT saw the deployment of 26.7 TWh of wind energy in 2007, the policy cost consumers about $1 billion but depressed the market prices of fossil fuels by 0.6 €¢/kWh, saving utilities (and thus consumers) $1.7 billion in avoided costs (for a net savings of more than €640 million). The FIT also lowered the average delivered cost of wind energy to 3.8 ¢/kWh, and if Spanish policymakers achieve their goal of 20,000 MW of wind by 2010, they expect the FIT to produce a net savings of €2.3 billion per year (Gasco, 2008). A follow-up study estimated that Spanish FIT (de Miera et al., 2008) cost consumers $2.2 billion from 2005 to 2007, but saved them $4.3 billion in depressed wholesale electricity prices, a net savings of $2.1 billion. Compare these trends to France and the United Kingdom, still heavily reliant on fossil fuels and nuclear power, where electricity prices for some electric utilities have risen 96% cumulatively from 2003 to 2008 and are set to rise 40% more by the end of 2009.

Third, national FITs create harmonization, consistency, and predictability for financers, investors, manufacturers, and producers. National FITs help manufacturers and industry by providing a consistent and predictable statutory environment. This industry, in turns, brings new and high paying jobs. Economists in Germany, for instance, have credited their FIT with creating at least 157,000 jobs in renewable energy manufacturing and installation (Kratzat, 2008). QCells, based in Wolfen, Germany, overtook Sharp to become the world's largest manufacturer of PV cells in 2008, because of the German FIT, which encouraged the solar industry to grow by a factor of 4 from 2000 to 2006. Enercon, the leading German wind-energy manufacturer, expects employment in the domestic renewables industry to increase to 710,000 by 2030, matching the number of jobs offered by the German automobile industry. Correspondingly, the FIT has created 188,682 new jobs in Spain, which has enabled the country to become the third largest manufacturer of wind turbines.

3.4. *Educate the public, protect the poor, and fund demand side management*

Finally, one-quarter of participants recommended that a national systems benefit charge (SBC) should be created to distribute public information, protect poor households, and promote energy efficiency. SBCs (also called public benefit funds, system benefit funds, and clean energy funds) originated in the 1990s at a time when state policymakers were considering electric utility restructuring in the United States. Afraid that gains made in pursuing research, development, and implementation of environmentally preferable technologies would end after markets were deregulated, advocates won concessions in some states for a new funding mechanism for high-risk or long-term projects. A SBC places a very small tax, often a tenth of a cent, on every kWh of electricity generated and utilizes those funds to pursue socially beneficial energy projects.

Using SBC funds to educate the public would go a long way toward minimizing the aesthetic and environmental objections some people have toward renewable power technologies. National electricity information and education campaigns could include grade-school classes on energy and the environment; public demonstrations and tours of renewable power facilities; mandatory disclosure of electricity usage for the construction of new buildings and the renting and leasing of existing ones; free-energy audits and training sessions for industrial, commercial, and residential electricity customers; improved labeling, rating, and certification programs for appliances and electricity-using devices; and a national information "clearing house" consisting of Web sites, free books, indexing services, and libraries to help consumers gather and process information in order to make more informed choices about their electricity use.

To be effective, however, such information programs must be carefully tailored and significantly ramped up. Information is less likely to be used if it requires effort or arrives when a household owner or business manager is busy with other things. Households and industries consume different fuels, in different kinds of buildings, and vary in their income, building stock, facility tenure, and individual needs. To avoid creating information that is merely a distraction, "general" or "generic" distribution strategies must be avoided. Because of the invisibility of energy, most people have little experience with energy-consuming devices, and may find information about them difficult to comprehend. Moreover, government agencies may be convinced its information is accurate and reliable, but energy users may be skeptical over past performance.

Using SBC funds to protect poorer households would minimize environmental racism and classism. Since less affluent families spend a larger proportion of their income on electricity (some as much as 20%), more accurately pricing it by removing price caps, eliminating block-rate pricing, creating time-of-use rates, and internalizing externalities will likely raise electricity prices and hurt them the most. States such as California and New York, along with countries such as Australia and Denmark, have already recognized this and offer a range of concessions (including a percentage reduction in energy bills, special loans, and extra rebates) to the unemployed, elderly, disabled, and low-income households.

Low-income assistance and weatherization can serve as a hedge against these rising prices. In the United States, the DOE currently runs a Weatherization Assistance Program that provides households below the poverty line with free energy-efficiency improvements. These improvements are not just traditional "weatherizing" (such as caulking, leak plugging, and adding weather stripping to doors and windows to save energy) but also a wide variety of energy-efficiency measures that encompass the building envelope, home heating and cooling systems, electricity, and electrical appliances. The basic premise is to make multifamily and low-income homes the most energy efficient to permanently reduce energy bills. From 1976 to 2006, the program has provided weatherization services to more than 5.5 million families.

Despite having weatherized millions of homes, the DOE estimates that they have served only 16% of eligible households, and project that more than 27 million homes are currently eligible for assistance (if the DOE program had the funds). By reducing the energy bills of low-income families instead of distributing one-time dispensations of aid, weatherization helps minimize dependency by lowering heating bills by an average of 31% and overall energy bills by hundreds of dollars per year. Because weatherization enhances the infrastructure of homes and buildings, it also increases the value of housing stock. Local industry is stimulated as well, and the DOE estimates that the national weatherization program already supports 8000 technical jobs in low-income communities. For those especially hard hit, SBC funds could provide further assistance through grants, no interest loans, and other targeted subsidies to offset rising electricity prices.

Using SBC funds to promote energy efficiency could produce billions in economic savings and displace the need to invest in expensive T&D systems, and it is already well-known which energy-efficiency measures are most effective. Researchers at ORNL (Schweitzer and Tonn, 2005) surveyed 18 energy-efficiency project areas and found that the five most effective mechanisms in terms of energy savings were the following:

- workshops and training, accounting for 22.1% of all savings;
- building codes and standards, accounting for 19.8% of all savings;

- energy audits, accounting for 15.9%;
- building retrofits, accounting for 10.9%; and
- technical assistance, accounting for 7.0%.

The survey found that the least effective energy-efficiency measures were carpools and vanpools, interest reduction programs, procurement, and Home Energy Rating systems, each responsible for less than 1% of savings.

The former US Office of Technology Assessment (1993) also found, after reviewing 58 DSM programs in the early 1990s, that the biggest areas of energy-efficiency opportunity remain improvements in thermal integrity of building shells and envelopes, electric equipment, and lighting, along with substituting energy fuels and installing energy-management controls that shift time of electricity use. The study concluded that the most effective energy efficiency and DSM programs had the following five elements:

- marketing strategies that used multiple approaches, such as direct mail and media, combined with personal contacts with the target audience. Particularly successful were those DSM programs that developed regular, person-to-person contacts and follow-ups after installation to ensure measures are working properly, and those that offered assistance with future projects;
- approaches and programs that targeted specific audiences, such as customers, architects, equipment suppliers, and engineers, and different types of investment decisions, such as new construction, remodeling, retrofitting, or replacement;
- technical assistance that helped targeted customers assess energy-efficiency opportunities and implement DSM measures, such as energy audits, advice on equipment, recommendation of contractors, computer modeling of possible savings, and information on new technologies;
- simple program procedures and materials that made it easier for customers to understand program potential; and
- financial incentives that attracted customer attention and reduced first costs. Those offering free measures produced the highest participation rates.

A third assessment of utility DSM programs (Schultz and Eto, 1990) found that the most successful programs among the states had consistent definitions of energy-efficiency resources, did not rely on voluntary action, provided incentives to utilities, and established strict penalties for noncompliance or poor performance.

More recently, Brown et al. (2005) evaluated energy-efficiency policies and noted that four have been the most effective: federal appliance standards, building codes, financial incentives, and weatherization. They estimated that the cumulative cost of the efficiency standards set under the Energy Star program cost manufacturers \$200–250 million between 1987 and 2000, but ended up saving consumers and businesses \$17 billion over the same period. Brown et al. also projected that the annual savings from these measures amounted to about 3.4 Quadrillion BTUs and 65 million metric tons of displaced CO_2, representing 10% of all country-wide CO_2 emissions from buildings.

The DOE and ORNL (2008) surveyed the "most effective" energy-efficiency policies in 2007 and found that the best programs were designed to address multiple barriers at once. They typically combined forms of influence (such as information, persuasion, and financial incentives), and attempted to understand behavior from the household's perspective rather than presuming customer motives. Successful programs also recognized that household behavior faced constraints beyond the owner's control (such as the practices of repair personnel or manufacturers) and required continual monitoring so they could be adjusted as needed.

4. The necessity of comprehensiveness

Too often, regulators and advocates of particular policies tend to view different options as substitutes for each other, rather than components or pieces of an effective whole (Vandenbergh, 2004). In the case of promoting renewable energy and energy efficiency, pursuing the collection of four policy mechanisms identified here will not work in isolation. Making renewable power mandatory through a national FIT, for example, but not removing conventional subsidies and continuing to price electricity inaccurately decreases the economic viability of renewable power projects and interferes with the ability of users to sell power back to the grid (or conserve it). Making renewable power mandatory without promoting public information and education will ensure that consumers remain uninformed about energy-efficient technologies and practices. Promoting a national FIT without funding energy efficiency and DSM would force utilities to procure significantly more electricity supply. The savings from energy efficiency, put another way, can (partially) offset the increased costs of needing to install renewable supply. Relying solely on changes in pricing also becomes risky when prices unexpectedly change. Pricing electricity accurately but not coupling it with information programs, additionally, does nothing to eliminate unrealistic payback rates among property owners and investors.

4.1. Eliminating subsidies is not enough

For instance, the effectiveness of removing energy subsidies without fundamentally changing the way electricity is priced would be limited. Many large apartment complexes from Cleveland to Copenhagen do not measure electricity consumption according to individual use, but instead rely on metering individual buildings (that divide energy costs by the number of tenants). Several landlords and property managers prefer to have units metered collectively to take advantage of declining block-rate pricing structures. Removing subsidies without reforming electricity prices still clouds the price signals sent to these types of consumers.

Moreover, Bigdeli (2008) surveyed the economic studies looking at the consequences of removing energy subsidies and found that it would be inadequate to correct market barriers alone and could even be counterproductive. Bigdeli noted that the effect of eliminating coal subsidies in five European countries would have a minimal effect on reducing the use of coal, since those countries would merely switch to cheaper international imports if domestic prices rose. The evidence suggests that changes in behavior and significant greenhouse gas reductions will happen only if policy reforms include at least the removal of subsidies and more accurate electricity pricing.

4.2. Changing prices is not enough

Simply changing the price of electricity is insufficient as well. For most people, the only visible sign of electricity use is at the payment time, when utility bills periodically reach the household (Rosa et al., 1988). Extensive interviews with residential electricity consumers have found more than half of them (55%) pay all of their bills the same time each month. This "processing and batch" treatment implies that for the majority of consumers, electricity prices will be ignored because they are injected into an activity primarily concerned with verifying dollar amounts and writing checks. Only 40% of those surveyed, for instance, looked at their actual usage of electricity when paying the bill (Kempton and Layne, 1994). Honest accounting by those customers that do attempt to track their energy use is complicated by the invisibility and difficulty of quantifying energy savings. Many people, including experts, generally understand the services provided by energy and electricity in non-monetary terms, and they instead make decisions based on the amount of time saved and the avoidance of inconvenience (Lutzenhiser, 1993). Furthermore, decisions about energy efficiency are often made by people who are not paying the energy bills, such as landlords or developers of commercial office space. Many buildings, moreover, are occupied for their entire lives by temporary owners and renters, each unwilling to make long-term investments in efficiency (Cavanagh, 1995).

Without compensatory modification, rising prices are inherently inequitable to low-income families, and relying on financial mechanisms alone can entrench classism. Pitts and Wittenbach (1981) evaluated the effectiveness of the US Residential Energy Conservation Tax Credit of 1978, passed as a means of motivating homeowners to install more efficient windows, caulking and weather stripping, and found not a single respondent considered the tax credit important enough that their energy-efficiency purchases would not have been made without it (40% actually learned about the credit only after they had completed the installation). Furthermore, the authors noted that almost no low-income families took advantage of the tax credit, since they had less capital available to retrofit their homes, and could not wait until the end of the year for reimbursement.

History confirms the inadequacy of relying solely on even sharp increases in price to influence behavior. Between 1974 and 1979, home electricity costs increased as much as 108% in some countries but did not reduce consumption more than 20% (Huggins and Lutzenhiser, 1995). Only small proportions of the population adopted energy-conserving practices during these years, as less than 10% of residents changed their home heating systems or installed additional insulation (Olsen, 1978). A similar study found that the use of monetary payments, provision of information, and daily feedback on electricity consumption did nothing by themselves to change behavior, and were effective only when used together (Hayes and Cone, 1977). When Norway experienced a shortage of hydroelectric capacity in the Winter of 2003 and electricity prices suddenly rose by 43%, consumers responded by cutting their electricity consumption only by 2.3% (Aune, 2007).

More recently, Robert Cialdini (2005) found that relying on social norms (in this case, a card asking hotel guests to reuse their towels) increased reuse rates from 35% to 58% without any changes in price. Another 2007 study delivered notices to household doorsteps informing homeowners how their energy consumption compared to the neighborhood average and reduced consumption without any additional financial incentive (Schultz et al., 2007). Vandenbergh and Steinemann (2007, p. 1710) reported that recycling programs that have an active "block captain," someone in the neighborhood that reminds individuals about their responsibility to recycle, increase recycling rates by about one-third merely by creating a social norm. Lutzenhiser (1993) surveyed dozens of studies relating to energy and electricity consumption, where energy conservation or improved efficiency took place with little or no evidence of economic calculation. Instead values such as "reducing waste" and "being independent" motivated behavioral change. In another study, the use of bumper stickers created a social stigma against excessive energy waste at a cost of a few hundred dollars (needed to print the decals) and resulted in tens of thousands of dollars of savings (McKenzie-Mohr, 2000). During 1991 and 1996, utilities in Seattle, Washington, invested in energy efficiency a factor of 12 greater than those in Chicago, Illinois, even though power in Chicago was twice as expensive (Lovins, 2007, p. 240). These examples imply that price alone cannot always explain or induce energy savings.

4.3. FITs are not enough

Without forcing utilities and system operators to use renewable power through a FIT, information and pricing can be manipulated. During the energy crisis of the 1970s, many utilities, afraid of losing revenue, increased electricity prices in direct proportion to the level that consumers invested in energy efficiency. When customers invested in efficiency but saw that their bills did not change, they concluded that conservation efforts simply did not work, and that participation had no correlation with saving money (Becker et al., 1979). Also, energy-efficiency and DSM programs are much more cost effective than building all types of electricity supply, including renewable ones. Prompting a national FIT but not these cheaper options will end up costing utilities and consumers more.

4.4. Education and information are not enough

Improved information and education, by itself, are also inadequate. Surveys of customers have found that less than 38% read bill inserts, a problem compounded when some inserts are mailed out at periodic intervals and information is repetitive, contributing to an "information glut" that reduces attentiveness (Kempton and Layne, 1994). An assessment of energy-efficiency programs involving refrigerators, natural gas ranges, washers and dryers, dishwashers, and room air conditioners found that energy labels were inadequate alone to cause substantial changes in consumer preferences (Shorey and Eckman, 2000). One study investigated the effectiveness of informational material designed to increase knowledge about electricity distributed to apartment complexes in Wisconsin and found that neither information nor short-term increases in prices reduced consumption (Heberlein, 1975). Matsukawa (2004) evaluated a utility program that gave customers continuous information about their electricity consumption and electricity prices on an hourly basis, and found it reduced consumption less than 1 kWh per day compared to control groups. One study distributed a free booklet to households that had participated in a 10-week study of water conversation, detailing how homeowners and electricity customers could cost-effectively conserve water and electricity, and found it had no effect on either water or electricity consumption (Geller et al., 1983). While slightly beyond the realm of electricity, Bickman (1972) interviewed 500 people about their personal responsibility to stop littering, and found that while more than 90% acknowledged such responsibility, only 2% picked up litter that had been "planted" by the researcher after the interview.

Perhaps the most telling example of the insufficiency of relying on information alone comes from an extensive study conducted by Geller (1981). Geller managed a series of workshops where energy users were presented with techniques for improving the energy efficiency of their homes, such as installing insulation, purchasing efficient showerheads, and making simple changes in lifestyle. Geller and his research team presented information through lectures, discussions, slide shows, and demonstrations. They then followed-up with respondents 6–8 weeks later, gave residents additional information describing optimal use of water heaters and other energy-efficient devices, and even specified the amount of money that particular homeowners could save by following suggestions. The research team followed up 6 weeks after that, and for those that had still not improved energy efficiency, they presented information pamphlets and specific estimates of cost savings for that home again. The authors found that less than 2% of workshops attendants implemented changes after the first visit, and less than 10% after the second visit. The study indicates that the distribution of information alone can have little behavioral affects, even when done repeatedly and using different communicative techniques. The study also suggests that efforts to evaluate the effectiveness of energy-efficiency programs should include behavior checks and self-reporting indices, for the follow-ups by the research team did improve participation rates by a factor of five.

To their credit, some utilities offered free or low-cost home energy audits in the early 1980s, but typical response rates were less than 5% during the duration of programs. In California, electric and gas utilities publicized their audits in media releases and bill inserts, and publicly discussed the benefits of audits in terms of savings and the environment at public meetings, but by 1982 just 2% of eligible Californian customers took advantage of the program. Follow-up interviews found that consumers did not trust utilities as a source of information, did not believe that one could get "something" for "nothing," were unable to arrange a convenient time for the energy audit to take place, did not see the announcement or publicity, or were unwilling or unable to act on information about energy-efficiency investments because they could not find a reliable contractor (Stern and Aronson, 1984). Indeed, Flynn et al. (2006) have noted that trust often shades information about energy technologies more than accuracy or even its potential value. Faced with the unknown, customers tend to make energy decisions based on whether they trust the person or source delivering information to them instead of the content of the information itself. Persuasion is also extremely difficult in a message-saturated environment. In one extreme situation, PG&E ran an advertising campaign in the early 1980s on the benefits of home insulation that cost more than simply installing it themselves in targeted households (Jackson, 2005). In another case, an 8-week mass media campaign in the Netherlands involved billboards, posters, television commercials, advertisements, and a free online brochure in an attempt to educate consumers about climate change and the consequences of their electricity consumption. Follow-up surveys involving thousands of Dutch citizens found that the campaign had only a "negligible" effect on increasing knowledge and awareness and did not change perceptions regarding the seriousness of the climate crisis (Staats et al., 1996).

5. Conclusion

Of the dozens of available policy mechanisms to promote renewable energy and energy efficiency, this study found that the pool of experts surveyed most strongly favored removing subsidies, pricing electricity accurately, implementing a national FIT, and undertaking forms of wealth redistribution to fund education programs, protect the poor, and provide money for energy efficiency and DSM projects. Interestingly, each of these policy options have been available to regulators and utility commissioners for decades: subsidies for electricity-related fuels have existed at least since the 1880s, alternative rate designs since the 1950s, feed-in tariffs, systems benefits charges, and the rest since the 1970s and 1980s. In addition, each of the policies and tools identified by the study could easily be applied or adapted to promote bio-fuels, distributed generation, combined heat and power, and other important alternatives. What seems to be lacking is not the availability of robust public policy mechanisms, but the political and social will to implement them.

As the barriers facing renewable energy and energy efficiency are diffuse, a multitude of policies must be comprehensively implemented to eliminate them. Making clean power mandatory without changing electricity prices will not send proper price signals to consumers. Removing subsidies does little to eliminate the market power already afforded to conventional systems. More accurate electricity prices without low-income assistance will hurt poorer families the most. Distributing information about clean power without internalizing the costs of negative externalities erodes the incentive to follow through with energy-efficiency investments. An effective and synergistic approach would need to treat each of these policy mechanisms as complementary, rather than as competitors that must constantly win approval from policymakers. No single-policy mechanism is a panacea, and until comprehensive policy changes are implemented, renewable energy and energy efficiency will never realize their full potential.

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Appendix 1. Institutions interviewed for the study

Agencia d'Energia de Barcelona (Spain)
Alliance to Save Energy (United States)
American Council for an Energy-Efficient Economy (United States)
American Electric Power (United States)
Asian Development Bank (Philippines)
California Energy Commission (United States)
California Independent System Operator (United States)
Cambridge Energy Research Associates (United States)
Chatham House (United Kingdom)
Danish Energy Authority (Denmark)
David Suzuki Foundation (Canada)
DNV (Det Norske Veritas) (Germany)
Dominion Power (United States)
DONG Energy (Denmark)
EA Energlananalyse (Denmark)
Ecotope Consulting, Research, and Design (United States)
Edison Electric Institute (United States)
Edison International Company (United States)
Electric Power Research Institute (United States)
EnergiNet DK (Denmark)
Enercon (Germany)
Energy Trust of Oregon (United States)
European Association for Renewable Energy (Belgium)
Exelon Corporation (United States)
Federal Energy Regulatory Commission (United States)
Fraunhofer-Institut für Solare Energiesysteme ISE (Germany)
General Electric (United States)

Georgia Institute of Technology (United States)
German Aerospace Center (Germany)
German Federal Ministry for the Environment (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit) (Germany)
German Solar Industry Association (BSW-Solar) (Germany)
Global Wind Energy Council (Belgium)
Iberdrola (Spain)
Idaho National Laboratory (United States)
Ingersoll Rand Company (United States)
International Energy Agency (France)
International Finance Corporation (United States)
Japanese Bank for International Cooperation (Japan)
Korea Hydro and Nuclear Power Company Limited (Korea)
Lawrence Berkeley National Laboratory (United States)
LM Glasfiber (Denmark)
MBD Offshore Power A/S (Denmark)
MidAmerican Corporation (United States)
National Academies of Science (United States)
National Commission on Energy Policy (United States)
New York Independent System Operator (United States)
New York State Department of Public Service (United States)
New York State Energy Research and Development Authority (United States)
Nextant Incorporated (United States)
Oak Ridge National Laboratory (United States)
Optimal Energy Consulting (United States)
Orbicon (Germany)
Pacific Gas and Electric (United States)
Pareto Energy Limited (United States)
Pew Center on Global Climate Change (United States)
Primary Energy (United States)
Ramboll Denmark A/S (Denmark)
Ramboll Wind Energy (Denmark)
Riso National Laboratory (Denmark)
Sandia National Laboratory (United States)
Singapore Ministry of the Environment and Water Resources (Singapore)
Solar-Fabrik AG (Germany)
Southern California Edison (United States)
State Corporation Commission of Virginia (United States)
Stella Group Incorporated (United States)
Tennessee Valley Authority (United States)
The Open University (United Kingdom)
UK Department for Business, Enterprise and Regulatory Reform (United Kingdom)
United Nations Environment Programme (Switzerland)
United Technologies (United States)
University of Barcelona (Spain)
University of Birmingham (United Kingdom)
University of California Berkeley (United States)
University of Cambridge (United Kingdom)
University of Illinois at Chicago (United States)
University of Tennessee (United States)
University of Virginia (United States)
US Department of Energy (United States)
US Energy Information Administration (United States)
US Environmental Protection Agency (United States)
Vermont Energy Investment Corporation (United States)
Vestas (Denmark)
Virginia Center for Coal and Energy Research (United States)
Virginia Department of Environmental Quality (United States)
Virginia Department of Mines, Minerals, and Energy (United States)
Virginia Polytechnic Institute and State University (United States)
Wood Mackenzie (Singapore)
World Bank (United States)
World Future Council (United Kingdom and Germany)
World Resources Institute (United States)
Worldwatch Institute (United States)
Xcel Energy (United States)
Zentrum fur Sonnenenergie und Wasserstoff-Forschung Baden-Wurrtemberg (Germany)

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