

Reducing Carbon-Based Energy Consumption through Changes in Household Behavior

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Abstract: Actions by individuals and households to reduce carbon-based energy consumption have the potential to change the picture of U.S. energy consumption and carbon dioxide emissions in the near term. To tap this potential, however, energy policies and programs need to replace outmoded assumptions about what drives human behavior; they must integrate insights from the behavioral and social sciences with those from engineering and economics. This integrated approach has thus far only occasionally been implemented. This essay summarizes knowledge from the social sciences and from highly successful energy programs to show what the potential is and how it can be achieved.

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Individuals and households make many decisions that are critical in shaping our energy future. As citizens, people favor some policies and oppose others, support some candidates for elective office and not others, write op-eds, comment on blogs, and otherwise engage in political action. They attempt to influence decisions that help determine which kind of local, state, federal, and international policies are adopted, and such policies in turn shape the energy system of the future. People sometimes engage in more direct politics by organizing to support or oppose proposed technological changes, especially the siting of new facilities. For example, the use of nuclear power in the United States stopped expanding in the 1980s largely as a result of massive public opposition to new nuclear power plants.¹ Current proposals for developing wind power facilities often face serious local opposition, as do efforts to develop unconventional shale gas deposits and to implement smart electrical grids and smart home metering.²

Such political actions are critically important to the energy futures of democracies. We focus here,

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however, on the decisions made when individuals and households act as consumers. These consequential decisions are diverse: selecting a car and deciding when to use it, how to maintain it, and how to drive it; buying and using appliances; and modifying and using the basic space and water heating and cooling systems of dwellings. In some cases, these are “non-decisions,” in that actions are taken without much conscious reflection. Often when reflection does occur, it takes no account of energy use per se or is based on poor understanding of the energy consumption and related (for example, climate) consequences of choices and actions. We limit our discussion to decisions that directly affect energy use. Many other consumer decisions, such as food choices or residential location, also have immense consequences for the energy system, although these are harder to analyze. The energy consequences of a dietary choice, for instance, depend on not only the food chosen but how and where it was produced and processed. Some quantitative estimates of the carbon emissions impacts of consumer food choices are beginning to appear; they suggest that at least in Europe, these emissions approach the magnitude of those from direct energy use.³ In this review, we stick to simpler cases, where the actions taken have direct and easily identifiable impacts on energy use.

The important role of individual and household decisions in the trajectory of our energy future is sometimes overlooked in discussions of energy policy. Analyses of energy use based on the economic sectors where use occurs (for example, in electricity generation, agriculture, or transportation) typically suggest that residential sector uses constitute only about 5 percent of U.S. CO₂ emissions. Such small numbers have probably led many researchers and policy-makers to

ignore household choices. But for policy purposes, it makes sense to subdivide energy use according to who makes the choices about energy use, because policies are intended first of all to influence decision-makers. If we classify energy use in this way, household decisions that directly affect energy consumption – choices about personal transportation, appliance purchase and use, or home heating and cooling, for instance – are very consequential. A conservative estimate suggests that these decisions account for more than 30 percent of U.S. CO₂ emissions and a comparable amount of overall energy use.⁴

In policy circles, prices are believed to dominate household energy decisions. This assumption follows from the standard economic model of consumer decisions. If price drives decisions, then changing energy prices is a logical energy-policy strategy; higher prices driven by an energy tax or a cap-and-trade policy would drive consumption down in a predictable way for all decision-makers. But a substantial body of research shows that this “prices only” model is not sufficient to explain real world choices by either households or companies. Economists who consider energy consumption have acknowledged this problem and label it the *energy efficiency gap*.⁵ Households and businesses do not make investments in energy efficiency that would yield highly competitive rates of return. For that matter, they often fail to take actions – reducing unnecessarily hot water temperatures, for example – that would cut their energy expenditures at no cost whatsoever. Clearly, energy consumers do not always behave as simple versions of economic theory would predict. The result is a gap between the behavior that would make economic sense to energy consumers and the behavior that is actually observed. The size of the gap is particularly large

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with investments that would reduce household energy use and CO₂ emissions. Thus, policies that only increase energy prices will not be sufficient to steer the energy future toward more efficiency; indeed, they will not even come close to being sufficient.

The effects of financial incentives to encourage home energy efficiency vary by at least a factor of ten, depending on how those incentives are structured and implemented.⁶ A similarly large variation occurs when incentives are provided for the purchase of hybrid cars and vans.⁷ State sales-tax exemptions increased purchases seven times as much per dollar of incentive than did the federal income-tax credit. This difference shows that it is not just the potential costs and savings that matter, but also how they appear to decision-makers. We do not always notice opportunities, we do not take the time to evaluate our options carefully, and our mental calculations do not always match the best practices of accounting. To close the energy efficiency gap, we have to design programs for the ways real people make choices, not for the formally rational decision-makers of economic theory. The design and implementation of policy interventions must account for the full range of human motivation and the ways people process information about options, costs, and benefits. Policy design needs to consider that people use cognitive shortcuts, for example, and that they use different mental accounts for different kinds of costs and benefits.⁸

What drives household decision-making about energy consumption and choice of energy-using technologies? How are costs and benefits interpreted and balanced, and what other factors matter? How can we deploy what we know about the influences on household decisions to help shape a more sustainable energy

future? To answer these questions, we draw from social science research, especially efforts to understand the effects of policies and programs on household decision-making. By learning lessons from the most successful behavioral-change programs of the past, it is possible to design new programs that can be highly effective in making household energy use more efficient.

A starting point for any energy policy is to focus on decisions that can have substantial impact. The overall impact of a potential decision is the product of three factors. One is the amount of change in energy consumption that will take place with more efficient practices: that is, the technical potential of energy savings for the household that adopts the new technology or practice. A second factor is the number of households that could make the change. Some homes are already well weatherized, some drivers already carpool or operate highly efficient vehicles, and many water heaters are set at an optimal temperature. These two factors – the technical potential and the size of the target population – set an upper bound on what a policy or program might achieve, not a realistic goal.

A third factor, much neglected in energy policy analysis, is the likelihood that a household will make the change that a policy or program encourages. The proportion of households that will change in response to a well-designed policy has been called the *plasticity* of the behavior.⁹ For example, shifting household trips from individual drivers to carpooling has substantial technical potential (energy savings per trip shifted from individual cars to a shared trip) and could possibly be adopted by a large number of households. But we know that this is a very difficult behavior to change. Home weatherization also has large technical potential and could benefit many homes, but un-

like carpooling, change in this behavior has been achieved in large proportions of households by well-designed programs. Plasticity is not an inherent attribute of particular human choices; rather, it depends on context. A useful estimate of plasticity for a choice in a particular technical, economic, and regulatory context can be provided by the most effective non-coercive policies or programs for influencing that choice. Only by assessing the product of technical potential, number of eligible households, and behavioral plasticity can we determine if a behavior is a reasonable target for policies intended to reduce energy consumption or greenhouse gas emissions.¹⁰

Thomas Dietz and colleagues were able to estimate the plasticity as well as the technical potential and size of the target populations for seventeen household energy-efficiency actions.¹¹ The list included such items as home weatherization, line-drying of clothes, carpooling, and trip chaining. By multiplying the technical potential of each household change, the number of households eligible to take the action, and the proportion of households that have made the change under well-designed policies or programs, Dietz and his team estimated the Reasonably Achievable Emissions Reductions (RAER).¹² Generally, the actions with the highest RAER values, and thus the most promising targets for policies intended to shape a more sustainable energy future, are those that involve the *adoption* of more efficient equipment rather than those that involve the *use* of equipment. This may reflect the fact that we know more about how to encourage the one-time adoption of new equipment than we do about how to change behaviors that must be repeated regularly to achieve savings. It certainly reflects the fact that once more efficient equipment is adopted, the savings are usually locked in; in a sense, policies

directed at adoption have to work only once, while policies directed at use have to work continuously. Intermediate categories of behavior, such as getting home heating and cooling systems tuned or checking tire pressure, need to be repeated periodically but infrequently, and tend to have relatively low RAER values.

The most attractive targets for household behavioral change involve adoption of household technologies that reduce fossil energy consumption, including building weatherization, motor vehicles, heating and cooling systems, and major appliances. These are not the choices that most households think of first when they consider ways to save energy.¹³ Instead, most people tend to think of behaviors that are easy to recall, and these tend to be frequently repeated behaviors. They also overemphasize the potential of these behaviors to save energy, relative to actions that are harder to recall and especially to actions that involve invisible factors in energy use: for example, upgrading wall insulation, replacing water heaters hidden in basements, or perhaps tuning up cars and furnaces.¹⁴ The behaviors that first come to mind – the daily use of energy-consuming household equipment – can be changed by well-designed interventions, but the impact achieved by these interventions has never approached what has been achieved by well-designed, integrated programs directed at upgrading household technologies.

Efforts to encourage increased household energy efficiency should begin with a careful analysis of reasonably achievable reductions. Analysis of technical potential for reductions is necessary, but it is by no means sufficient. Behavioral plasticity must be examined as well, raising a number of questions about household decision-making:

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- Do households have a reasonable understanding of the energy use and energy savings associated with various activities and technologies? Studies show that people typically make substantial errors in estimating energy use and potential energy savings in the household.¹⁵ They tend to overestimate the effect of actions that have little impact – commonly repeated actions, in particular – and underestimate the effect of behaviors that have great impact.
- Is the behavior that needs to change a one-time fix, as in buying a new appliance or setting the temperature of a water heater? Or does it require daily action, such as air-drying clothes or carpooling? If the latter, how conscious are the decision-makers of the actions they are taking?
- Do choices involve a bundle of characteristics that matter to consumers as much or more than energy use? Carpooling is different from driving alone in many ways, while the only notable differences between a high- and a low-efficiency water heater are the differences in initial cost and energy consumption.
- Do those who take the actions benefit from them? In rental housing, for example, if the renter pays the utility bills, little benefit accrues to the landlord from spending extra money on weatherization or high-efficiency appliances.
- Do changes require breaking old habits or undertaking actions that are unfamiliar? Setting back a thermostat is a simple action that nearly everyone knows how to do. Furnace tune-ups may be unfamiliar to those who do not do them regularly.
- Are substantial up-front investments of time, money, and effort required?

Weatherizing a home requires an initial investment even if the economic rate of return is favorable, and finding a trusted and skilled contractor is challenging. Adjusting tire pressure is awkward and dirty, and requires finding a filling station with a working air pump. Resetting the thermostat on a home space conditioning system or a water heater takes little time and effort, and has no financial cost.

Of course, the purpose of policies to reduce fossil energy use is to overcome these difficulties. The key question is, how much change can effective policies and programs bring about? Experience, summarized by the RAER estimates, indicates that some kinds of behavior have proven much more difficult to change on a large scale than others. In addition, programs to reduce household energy use have varied greatly in effectiveness, both across types of actions and across programs with the same behavioral goals. Estimates of plasticity across seventeen household actions range from 90 percent for home weatherization to 15 percent for carpooling and trip chaining.¹⁶ Substantial variation also arises across types of programs for a single behavior. In the case of home weatherization, while the most effective programs were able to secure a 90 percent participation rate, programs that were not well designed achieved less than 10 percent uptake, even with the same financial incentives.¹⁷

The most effective interventions implement five design principles in addition to targeting actions that will have the greatest impact.¹⁸ First, for many actions with high RAER, financial incentives are essential, even though they are not sufficient by themselves. Steps like home weatherization and equipment upgrades, whatever their long-term benefits, can have up-front costs that are daunting to many house-

holds. A substantial financial incentive can get households to pay attention to a choice that it had not previously considered feasible and may also help signal the desirability of the action if the incentive is offered by a trusted source. The size of the incentive may be less important than the fact that it is large enough to open up consideration.

Second, the program has to be smartly communicated. Providing information effectively may not mean depending on mass advertising. We should consider when the information will be useful for making decisions. We are bombarded with information and ignore most of it. But a reminder about the value of car tune-ups at the gas pump is likely to have more impact than a public service announcement on evening television. Word of mouth through people's informal social networks was critical to the outstanding success of the Hood River, Oregon, energy-efficiency program of the early 1980s, as discussed below.¹⁹

Third, information must be accurate and come from credible sources. Admonishments about the value of smoke detectors come from fire departments, a credible source in most communities. But we are likely to be skeptical of flyers from home improvement contractors telling us how much energy we can save if we hire their services. It is much easier to provide accurate and credible information about the energy attributes of mass-produced items such as motor vehicles and appliances than about individualized products and services like home weatherization. For this reason, a record of results from independent energy audits can be an important element of credibility for weatherization programs.

Fourth, simple processes lead to adoption, complex processes often do not. The Cash for Clunkers rebate for trading in an old car was not exemplary for the amount of enhanced fuel efficiency it achieved.²⁰

But it was a very well-designed program in terms of how easy it was for a consumer to use it; the car retailer completed the paperwork, and consumers collected the incentive with no extra effort when they traded in their old vehicles. In contrast, tax rebates on home energy-efficiency improvements involve multiple steps: picking a qualifying improvement that makes economic sense, finding a contractor, making sure the work is done properly, keeping track of the paperwork to document the improvement, filing extra forms on a tax return, and so on.

Fifth, quality assurance is essential. The United States and many other countries have good systems for quality assurance for mass-produced consumer goods like motor vehicles and appliances. There are government mandated recalls of faulty products at manufacturers' expense, which assures consumers that product defects will be rare, and there are independent consumer organizations that publicize their assessments of the products. For home improvements, the system is not so good, largely because the products and services are individualized. Some solar energy companies have tried to provide quality assurance as part of their business plans, as we discuss below.

Each of these design features is important individually, but their combined effect is critical. For example, a financial incentive may take the form of a sales-tax subsidy on the purchase of a hybrid vehicle, or a rebate on income tax. Even if the dollar amounts are the same, the sales-tax rebate is likely to have far greater impact for several reasons. First, it results in a change to the "bottom line" that the purchaser sees immediately, rather than a change in some future tax bill or refund. This makes it more desirable to consumers who tend to discount future rewards very substantially.²¹ Second, the income-tax rebate requires additional paperwork

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and the effort of remembering to do the paperwork in the future, while the sales-tax refund paperwork is processed by the car dealer during the sale. In addition, because sales taxes are regressive, reducing them provides a larger incentive to those who are most likely to be influenced by financial costs.

The potential for combining these design features is illustrated by the Cash for Clunkers program, which combined a sizable financial incentive – about 30 percent of the price of a low-end new vehicle – with strong marketing by manufacturers and with features that reduced the level of effort involved in capturing the incentive. And the program involved a product whose quality is easy for consumers to evaluate. Potential can also be seen in the business plans of some private companies that offer power purchase agreements for residential solar energy installations. These companies install solar collectors on a home and provide quality assurance by insuring the homeowner against damage from the installation and guaranteeing under contract to provide a predetermined amount of power per year for many years at a preset price. The company simplifies the process by doing the considerable paperwork required to take advantage of available federal, state, local, and utility incentives and to provide connectivity to the utility grid. The financial benefit to the homeowner, which may be considerable, is easily calculated and guaranteed by contract.

There are many ways these general principles manifest themselves in the design of policies and programs. In the following paragraphs, we offer some examples and describe the social science underlying them. The discussion gives a sense of how substantial changes in the energy system could be brought about at low to moderate cost through effective program design.

The communication element of program design can be enhanced by engaging social norms, which can be powerful for encouraging certain kinds of behavioral change.²² For example, Opower is a company that helps utilities reduce household energy use with strategies based on social science understanding of household decision-making, including the influence of norms. It provides detailed feedback to households, including comparisons of their energy consumption to that of their neighbors. This information induces individuals to compare themselves to others; those who are above the community average tend to reduce consumption.²³ To discourage those who are below average from adjusting up, Opower uses other feedback, such as a smiley face icon, to encourage continued low consumption.²⁴ More research is needed to know whether these effects will persist over time, but there is some evidence that invoking norms does produce persistent changes.²⁵ In addition, the experience of the Hood River project suggests that social norms can help influence people to make expensive investments to reduce fossil energy consumption, but this requires more extensive social interaction and discussion. The municipal utility in Hood River employed a team of sociologists to design a communication element of the program that relied on existing neighborhood and community organizations to spread the word. This effort, together with a sizable incentive and other program features, led to major energy-efficiency retrofits in almost 90 percent of the homes in the city. To our knowledge, the Hood River approach has not been replicated elsewhere to influence investments in residential efficiency or renewable energy.

Research in both laboratory and field settings shows that people tend to maintain current behavior. While this stability could be an obstacle in getting people to

start conserving energy, it also may mean that behaviors that promote efficiency will endure once they are started. The fact that consumers make many decisions habitually, and thus relatively automatically, helps explain the weak short-term response to price signals alone; but it also argues for the importance of instilling good energy-use habits early on, and thus for targeting educational initiatives to the young.²⁶ Desirable current behavior can also be signaled in ways that do not reduce choice options, for example in programs that establish efficiency as a default, such as those that allow utility customers to choose energy sources and make the more expensive green (rather than the current brown) providers of electricity the source if no choice is made.²⁷ Such use of default choices has been shown to be effective because, like a habit, it achieves a desired goal without requiring much information-processing.²⁸

Technologies that reduce fossil energy use are not adopted simply because of their technical advantages or their economic benefits. Many other factors influence decision-making, and in many cases, energy consumption never rises to the level of consideration in making a decision. This is particularly the case for many home improvements that have major impacts on energy consumption but that are undertaken with the intent of providing amenities, often out of emotional motivation.²⁹ The hidden market for energy improvements as amenities (for example, solar collectors, in some communities) provides opportunities for using emotional motives to affect high-impact energy choices.

There is debate about how single energy actions might affect overall household impacts on fossil fuel use. The economist William Stanley Jevons once observed that increased efficiencies in the useful work produced by coal technologies led to increased uses of coal as more applica-

tions were found.³⁰ Some have expressed concern that households undertaking a few actions to reduce energy consumption will become more profligate in other forms of energy consumption. Others have argued that household and individual actions to cut fossil energy use might reduce effort expended on political and policy changes.³¹ This concern is consistent with the idea that people have a finite pool of worry: increased concern about one issue reduces concern about other issues.³² The single-action bias – that is, the propensity to take only a single action to alleviate a concern, even in situations where a broader set of remedies might be called for – also points to such a tendency.³³ However, the exact opposite is also plausible: that those who start down a path of reduced energy use with small initial steps become committed to further steps, and that those who are making personal changes to protect the environment will demand the same of government and other organizations. At present, we lack strong evidence about which of these effects is dominant for the kinds of energy-efficiency actions that will have the most impact in U.S. households.³⁴

The potential for household choices to reduce fossil energy consumption is substantial. The estimate we have used – 7 percent reduction in U.S. greenhouse gas emissions – is conservative in two regards. First, it is based on estimates of plasticity from the best programs that have been examined in the literature. But almost no program has drawn on our full understanding of effective program design. Future programs could produce much higher adoption rates than have been observed in the past. Second, the 7 percent estimate is based only on existing, “on the shelf” technology and does not include emerging energy-efficiency technologies (for example, heat pump heating

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and cooling or LED lighting), residential renewable energy technologies, or technologies that will emerge in the near future. In addition to advances in the engineering of energy-efficiency technology, we will need to take advantage of existing and future advances in the social science of policy design and delivery. New insights from social science will help create environments that support both active and passive decisions: for example, using environmentally and financially desirable no-choice default options, priming longer time horizons and long-term goals, or describing and framing choice options to match household concerns. In turn, we will minimize choices that do not optimize either individual or collective welfare.³⁵

As noted above, one of the biggest obstacles comes from programs that are overly complex and require substantial paperwork. We suspect that these problems arise from demands for detailed accountability. For example, in the 1980s, three financial grant programs for energy-efficient home improvements in the United States offered a median subsidy of 77 percent and achieved participation of 4 percent of eligible households per year. In Canada and Europe, five similar programs offered a median subsidy of 50 percent and achieved a participation rate of 8 percent per year. The most likely explanation for this difference is that all the U.S. programs and none of the others required a home energy audit as a precondition for receiving the grant.³⁶ The audit arguably reduced fraud, but also reduced participation. Program designers would do well to compare relative risks and benefits. If onerous procedures are required to prevent fraud, then the costs in time and the tepid response to programs should be weighed against the savings from fraud prevention.

Given the importance of increasing equipment efficiency, more attention

should be paid to policies that engage when equipment turns over – that is, to timely evocation of goals related to energy savings or amenity production – for financial, environmental, or other reasons. The city of Davis, California, for example, has had rules that include energy-efficiency standards as part of building sale requirements for more than thirty years.³⁷ When a house is bought or sold, the costs of upgrading energy-efficiency features is usually a small fraction of the price, and thus is not burdensome. The costs in such a program could be included in the mortgage, with a lower financing rate than for typical home improvements. Further, home buying is a transaction that already involves a substantial amount of paperwork that is usually handled by a professional realtor or attorney paid to do so, and professional home inspections are nearly always required. So the certification of energy standards does not add much complexity to the transaction. To give another example, most people replace home water heaters when the previous heater fails. Consumer choice is often limited to what the plumber has on the truck. So an incentives program might be designed to encourage the plumber to supply high-efficiency units. Standards may be the simplest way to do that, although standards have their own complex dynamics.³⁸ Undoubtedly, there are other potential points of intervention that can be identified by thinking carefully about when and how households make decisions and about their motives for choice.

Although the potential for reducing fossil energy consumption through household decisions is immense, it can be realized only through effective programs. Such programs need to build on understanding of household choice processes, and this understanding must be rooted in behavioral and social science that goes

far beyond current assumptions about rational and deliberative information use. Much of this understanding exists. Our current challenge is to put existing

theory and methods to use for more effective design and implementation of policies targeting fossil energy use.

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