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Viewpoint

Getting the engineering right is not always enough: Researching the human dimensions of the new energy technologies

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ABSTRACT

Achieving the ambitious targets for carbon emissions reductions that are necessary to reduce the risks associated with climate change will require significant changes in the way people use energy. Redesigning energy technologies at a societal level is certainly a major scientific challenge, however, succeeding in this endeavor requires more than getting the engineering right. Technologies can fail to win public approval for a variety of reasons. Good social science research, coordinated properly with technological R&D, is an essential part of the solution. Social science research is needed to: clarify the behavioral changes that can reduce energy consumption; characterize public understandings and concerns of new energy technologies; help overcome barriers to public adoption; maximize the benefits for users; and better understand society's needs and abilities to make energy transitions. We argue that social science research into the human dimensions of new energy technologies be promoted and overseen by a new office of social science research to be established in the United States Department of Energy. The funding levels needed for these endeavors are a tiny fraction of the amount that was allocated to carbon sequestration research in the 2009 stimulus bill.

The risks associated with climate change are spurring research and development of decarbonizing energy technologies with major support from the Obama administration. Key among these technologies are solar, wind, and biotechnology-enhanced renewables, nuclear power, techniques for stripping and sequestering carbon from fossil fuel emission streams, technologies for improved end-use efficiency, energy information technologies such as smart meters that are intended to change human behavior, and zero-energy buildings. Rapid, simultaneous implementation of many such technologies will probably be needed to reach the ambitious emissions reduction targets now being promoted (Pacala and Socolow, 2004).

Significant scientific and engineering challenges certainly need to be overcome, but the human dimensions of the technologies must also be considered. History reminds us that getting the science and technology right is not always enough to get new technologies adopted or used as intended. Neither is making them affordable. Some technologies fail because they involve siting facilities that people do not accept. Yucca Mountain is an outstanding example, and opposition to siting wind farms shows that the problem is not restricted to nuclear power (Firestone and Kempton, 2007). Sometimes technologies fail because designers do not adequately address users' needs and practices. For example, programmable thermostats are designed to save energy, but many people override them much of the time (Lutzenhiser, 1993). Smart meters and zero-energy buildings could face similar failures to meet expectations. A large "energy efficiency gap" indicates the extent to which cost-effective technologies are not adopted because of barriers that may lie in regulations, institutional structures, misplaced incentives, consumers' cognitive heuristics, or the costs of acquiring trustworthy and decision-relevant information. Residential energy efficiency has long been recognized as a paradigm case of technology failing to achieve performance goals because the human dimensions were not properly understood (US National Research Council, 1984; Stern, 2008).

For energy technologies to approach their potential, they need to be accepted, adopted, and used appropriately by the intended users. Many barriers exist (Committee on Climate Change Science and Technology Integration, 2009). Identifying them early on is of critical importance for accelerating the use of new technologies, particularly when ambitious policy targets and the threat of future catastrophe leave little time for false starts. Social science research can help identify barriers and incentives early on so that technology R&D can be reoriented to better suit human needs and appropriate design modifications, incentives, and institutional changes can be put in place. Doing this requires that technological R&D be better synchronized with social science R&D that investigates the human dimensions of technology design, acceptance, and use.

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Both fundamental and applied social science research will be needed (Stern and Wilbanks, 2009). First, research should identify the behavioral changes that can help achieve carbon emissions targets. For example, it has recently been shown that significant reductions in energy consumption (corresponding to 7.4% of annual USA carbon emissions) can be achieved in the short term with existing technology and behavioral changes that do not significantly alter lifestyle (Dietz et al., 2009).

Second, research should characterize public understandings and concerns about emerging energy technologies and their infrastructures. Focus groups, Q methodology, surveys, and participatory processes that bring energy consumers together with the institutions designing energy infrastructures can help elicit concerns, identify constraints and catalysts, and improve the quality and legitimacy of environmental choices (US National Research Council, 1996, 2008). Finding the most effective processes and technology management systems requires research tailored to each specific application (US National Research Council, 2008).

Third, research is needed to overcome barriers to adoption and use of cost-effective energy technologies in both residential and non-residential applications. Previous research has shown that, for the same set of financial incentives, adoption rates can vary by an order of magnitude, arguably making the case for the importance of social science research beyond economics (Stern et al., 1986). The most effective interventions to improve the efficiency of existing housing typically combine institutional changes, incentives, information, and other policy tools (Gardner and Stern, 2002; US National Research Council, 2005). Nevertheless, federal policies typically rely on only one tool at a time, such as the tax credits offered in the 2009 stimulus package. Policies that combine complementary incentives (such as development of energy cost-of-ownership indices with disclosure requirements) and public education are likely to be more cost-effective and successful than policies that rely only on incentives or education. Research is required to find the right combinations.

Fourth, human factors research at the interface of technologies and users is needed to design technologies for maximum benefit. For example, research can help design smart buildings that consumers will use effectively to reduce energy consumption. Information technologies also need human factors research so that smart meters, carbon calculators, appliance labels, and the like provide information that is credible, convenient, and easily used.

Fifth, fundamental research is also needed into the anthropogenic drivers of energy consumption and the social and behavioral processes that affect society's ability to make the needed energy transitions (Stern and Wilbanks, 2009; US National Research Council, 2009, 1992; Rosa et al., 2004; Dietz et al., 2007). Among the important research needs are studies of: the effects of socioeconomic growth, affluence, and cultural change on demand for energy services; citizens' judgments of the risks of energy technologies and the perceived risks of failing to implement them in the face of climate change; and methods for considering the economic and noneconomic values associated with energy technologies and system designs.

The challenges of climate change call for a reorganization of scientific efforts around societal needs. Synchronizing technological and social R&D needs to take place in many government agencies, but the need is nowhere greater than in the Department of Energy (DOE), which has traditionally defined itself as a technological R&D agency and has invested little in social science. Recent major investments in new energy technologies have heightened the need for a social and behavioral science research capability in DOE to help advance efforts to decarbonize both the supply side and the demand side of the energy equation. To do this, DOE would initially need to draw on outside expertise. A significant cultural change will also be required, but the costs will be miniscule compared with the costs of new technologies or tax credits. Only a few percent of the $2.4B from the present stimulus package being allocated to carbon sequestration or the $3B for tax credits could doubtless fund all the necessary social science research on multiple energy technologies. Commitment from the highest levels of the agency and the government will be necessary. To achieve national goals for reducing the drivers of climate change, this commitment needs to be put into place.

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