



Balancing Policies for Energy Efficiency and Climate Change

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While improving energy efficiency through technology offers a significant opportunity to reduce greenhouse gas emissions, the best means for reaching climate policy goals may be by creating market incentives that encourage the development and use of climate-friendly technologies in general.

Decisionmakers responsible for climate change policy must address challenging questions and face competing goals when setting priorities. Changes in greenhouse gas (GHG) emissions can be driven by a number of factors, including shifts in population, economic activity per capita, energy use per unit of economic activity (energy efficiency), and the carbon intensity of energy used (carbon efficiency). To change emissions, decisionmakers must consider a number of policy options, which can vary greatly in their cost and effectiveness.

Limiting economic activity as a means of reducing GHG emissions has scant political appeal for rich countries, let alone poor ones. Technological improvements that generate enhanced energy and carbon efficiency have therefore been the principal means discussed for addressing climate change. Recent policy proposals have, for example, included tax credits for the purchase of energy-efficient equipment, public-private partnerships aimed at developing and deploying energy-efficient technologies, and energy-efficiency standards for products.

Energy efficiency is often regarded as a goal unto itself. Politicians, government officials, and the public have embraced energy efficiency perhaps because it is relatively tangible and accessible. However, it is important

to sound a note of caution about viewing direct control of energy efficiency per se as a primary means for meeting climate policy goals. Policy initiatives should be directed toward supporting efforts aimed at addressing problems—such as the environmental externality of global climate change and inadequate information on technological opportunities—where the marketplace will not or has not operated effectively.

The path of technology development and diffusion through the marketplace is complex and uncertain. To better comprehend it, we will consider the cost of improving energy efficiency to limit GHG emissions; the “energy-efficiency gap” that occurs when the marketplace does not adopt the most energy-efficient technologies available; typical patterns for technology invention, innovation, diffusion, and use; and finally, implications for climate change policy.

Making Energy Efficiency More Cost-effective

The importance of energy efficiency in limiting GHG emissions is not in question; however, there is intense debate about both its cost effectiveness and the government policies that should be pursued to enhance energy efficiency. Essentially, there are two sides to this argument.

“Technologists” (our shorthand term) are those who believe there are plenty of opportunities for low-cost, or even “negative-cost,” improvements in energy efficiency. In their opinion, realizing these opportunities will require active intervention in markets for energy-using equipment to overcome barriers to the use of more efficient technologies. This view implies that with the appropriate technology and market creation policies, significant GHG reduction can be achieved at very low cost.

Most economists, on the other hand, acknowledge that there are “market barriers” to the penetration of technologies that enhance energy efficiency, but that only some of these barriers represent real “market failures” that reduce economic efficiency. There are tradeoffs between economic efficiency and energy efficiency, according to the economic perspective. It is possible to get more of the latter, but typically only at the cost of less of the former. GHG reduction is therefore more costly than the technologists argue. Economists also tend to put more emphasis on market-based GHG control policies, such as carbon taxes or tradable carbon permit systems, to encourage the least costly means of carbon efficiency (not necessarily energy efficiency) enhancement available to individual energy users.

Although energy and technology markets certainly are not perfect (no markets are), the balance of evidence supports the view that there is less “free lunch” in energy efficiency than some have suggested. Nonetheless, a case can be made for the existence of certain inefficiencies in energy-technology markets, thus raising the possibility of some inexpensive GHG control through energy-efficiency enhancement.

Understanding the “Energy-efficiency Gap”

Many analysts contend that an “energy-efficiency gap” exists between the most energy-efficient technologies available at some point in time and those that are actually in use. However, the extent to which there are low-cost or no-cost options for reducing fossil-fuel energy use through improved energy efficiency remains open to debate. Economists and technologists involved in setting climate change policy have different views of this energy-efficiency gap. Their split is about whether and to what degree the gap is the result of market failures that might be amenable to policy intervention or simply market barriers that would be surmountable only at relatively high cost.

To understand the basic elements of this debate, it is helpful to distinguish first between energy efficiency and economic efficiency. Consider two air conditioners that are identical except

that one has higher energy efficiency and, as a result, is more costly to manufacture because high-efficiency units require more cooling coils, a larger evaporator, and a larger condenser, as well as a research and development effort. Whether it makes sense for an individual consumer to invest in more energy efficiency depends on balancing the value of energy saved against the increased purchase price, which is based on the value of the additional materials and labor spent to manufacture the high-efficiency unit. The value to society of saving energy should also include the value of reducing any associated environmental externalities, such as air pollution.

Adoption of more energy-efficient technology will not always enhance economic efficiency. It is possible to simultaneously increase energy efficiency and economic efficiency; this will be the case if there are market failures that impede the efficient allocation of society’s energy, capital, and knowledge resources in ways that also reduce energy efficiency. When people speak of “no-cost,” “win-win,” or “no regrets” climate policies based on energy-efficiency enhancement, they are often implicitly or explicitly assuming the presence of market failures specifically in energy efficiency (as opposed to environmental externalities). Some of these are noncontroversial, such as inadequate private sector incentives for research and development, and information shortages for purchasers regarding the benefits and costs of adopting more efficient equipment.

Other more controversial market failures include: the extent to which investment in energy efficiency is limited because of financing constraints; the degree to which there are market failures because landlords rather than tenants pay utility bills; and the possibility that businesses do not pursue potentially rewarding energy efficiency investments because their managers are not adequately rewarded. Even where market failures exist, however, not all market failures can be eliminated at an acceptable cost. In cases where implementation costs outweigh the gains from corrective government intervention, it will be more efficient *not* to attempt to overcome particular market failures.

In contrast to the economists, technologists have focused on a simple “engineering-economic” model. The technologists’ definition of optimal energy efficiency is found by minimizing the total purchase and operating costs of an investment, where energy-operating costs are discounted at a rate the technologist (not necessarily the purchaser) feels is appropriate.

However, the problem with this approach is that it does not accurately describe all the issues that can influence energy-

efficiency investment decisions. First, the importance of certain factors can vary considerably among purchasers, including the purchaser's discount rate, the investment lifetime, the price of energy, the purchase price, and other costs. For example, it may not make sense for someone who will only rarely use an air conditioner to spend significantly more purchasing an energy-efficient model; there simply may not be adequate opportunity to recoup the investment through energy savings.

Second, the technologists' engineering-economic analysis typically does not account for changes over time in the savings that purchasers might enjoy from an extra investment in energy efficiency, which depends on trends and uncertainties in the prices of energy and conservation technologies. When making irreversible investments that can be delayed, such as the purchase of air-conditioning equipment, the presence of this uncertainty can lead to a higher investment-hurdle rate. The magnitude of this "option-to-wait" effect depends on project-specific factors, such as the degree of energy-price volatility, the degree of uncertainty in the cost of the investment, and how fast energy and conservation technology prices change over time.

Finally, there is evidence that energy savings from higher efficiency levels have routinely been overestimated, partly because projections often are based on highly controlled studies that do not necessarily apply to actual, realized savings in a particular situation. For example, studies have found that actual savings from utility-sponsored programs typically may achieve only 50% to 80% of predicted savings. Another study found that the actual internal rate of return to residential energy conservation investments on insulation was about 10%, which is substantially below typical engineering estimates that the returns for such investments would be 50% or more.

Requiring consumers to purchase appliances with a higher level of efficiency based on a simplistic analysis could, in effect, impose extra costs on consumers. The result might be a higher level of energy efficiency but decreased economic efficiency, because consumers could be forced to bear costs that they had otherwise avoided.

Invention, Innovation, Diffusion, and Use

To understand the potential for public policy to improve energy efficiency, it is necessary to understand that technology evolves through a process of invention, innovation, diffusion, and product use. Policies can affect each stage of this process in specific and different ways. Invention involves the development of a new

idea, process, or piece of equipment. The second step is the process of innovation, in which new processes or products are brought to market; another term for this stage is commercialization. The next step is diffusion, the gradual adoption of new processes or products by firms and individuals, who then also decide how intensively to use new products or processes. In this context, the energy-efficiency gap essentially is a debate about the gradual diffusion of energy-saving technologies that at least appear to be cost-effective.

An example of invention would be a fundamentally new kind of automobile engine that could serve as an alternative to the internal combustion engine, such as a system dependent upon fuel cells. The innovation step would be the work carried out by automobile manufacturers to bring this new engine to market. The diffusion process, then, would reflect the purchase by firms and individuals of automobiles with this new engine. Finally, the degree of use of these new automobiles would be of great significance to the demand for particular types of energy, which, in turn, would affect GHG emissions.

The reason it is so important to distinguish carefully among these different conceptual steps—invention, innovation, diffusion, and use—is that public policies can be designed to affect various stages and will have specific effects. Economic incentives and conventional regulations can be targeted to any of these stages, but with varying degrees of success. The rate or speed of invention (increased energy-related patent applications), innovation (commercialization of more energy-efficient products), and diffusion (greater penetration of energy-efficient technologies) tends to be higher when energy is more expensive. Although the methods used to demonstrate and measure this link are complex, the underlying phenomenon makes common sense. Manufacturers develop products to meet consumers' desires, and consumers (be they individuals or firms) will want greater energy efficiency when energy is more expensive. The same reasoning would apply to carbon emissions—if they had some price.

While a substantial amount of innovation in the energy efficiency of products we have investigated resulted simply from the passage of time, changes in energy prices and energy-efficiency standards had significant effects. Energy price changes induced both commercialization of new models and elimination of old models. And introduction of energy-efficiency standards required manufacturers to stop manufacturing certain less-efficient products.

The typical pattern for technology diffusion is for a given technology to be gradually adopted, with the pace picking up over time. At some point, the technology becomes saturated in the economy, and adoption slows down; a good example of this phenomenon would be cellular telephones, which are much earlier in the diffusion process than, say, clothes washers or televisions. The explanation for this typical diffusion path that has most relevance for energy-conservation investments relates to differences in the characteristics of adopters and potential adopters. These differences include the type and vintage of existing equipment; access to as well as the cost of labor, materials, and energy; and access to technical information.

The investment return from adopting a given technology will vary from one individual to another; as a result, only potential adopters for whom it is especially profitable will adopt at first. Over time, however, more and more will find it profitable as the cost of the technology falls, its quality improves, information about the technology becomes more widely available, and existing equipment stocks depreciate.

Implications for Climate Change Policy

Government officials trying to determine an appropriate course of action regarding energy conservation must ultimately decide on their primary policy objective: economic efficiency (including environmental externalities) or energy efficiency. Technological studies that demonstrate the existence on the laboratory shelf of particular energy- or carbon-efficient technologies are a useful first step, but they are not sufficient to address important policy questions. It is necessary to examine whether and how specific policies will affect the processes of invention, innovation, diffusion, and intensity of use of products, and how much these policies will cost.

One factor clearly influences the development, adoption, and diffusion of technology, according to our research. Economic motivations—operating directly through higher energy prices and falling costs of technological alternatives due to innovation—are effective in promoting the commercialization, market penetration, and use of more energy-efficient, GHG-reducing technologies. Policies that support the effects of these direct market signals also can be useful; these include subsidies for basic research and development to compensate for an imperfect patent system, reform of energy-sector regulation, reduction of subsidies that encourage uneconomic energy use, and provision of information about product attributes and new technological opportunities.

Energy-efficiency improvements certainly can be relevant for climate policy; however, it is also important to remember that primary fuels differ substantially in terms of their GHG emissions per unit of energy consumed. Policies focused on energy use rather than GHG emissions run the risk of orienting incentives and efforts in a direction that is not cost-effective. In particular, policies focused on energy efficiency ignore the other important way in which GHG emissions can be reduced—namely, by reducing the carbon content of energy.

Economists generally prefer to focus policy instruments directly at the source of a market failure. Policies focused on carbon emissions—such as tradeable carbon permits or carbon fees—will provide incentives for conserving particular fuels in proportion to the fuels' GHG content. For example, these policies would raise the price of oil by a higher percentage than the price of natural gas, thereby targeting incentives for energy-efficiency improvements to oil-fired furnaces relatively more than to gas furnaces. In addition, policies focused on GHGs rather than energy per se, would also provide incentives for the purchase of gas rather than oil-fired furnaces.

Market failures may be caused by other factors besides the environmental externality of global climate change associated with energy-efficiency investments; the most salient factor is that purchasers potentially lack information about the value and cost of energy efficiency. If the magnitude of these non-environmental market failures is large enough and the cost of correcting them small enough to warrant policy intervention, an argument can be made for attacking these other market failures directly. Any attendant reduction in GHGs can then be viewed as a bonus; this line of argument is often used by proponents of energy-efficiency policy in the context of climate change policy discussions. Therefore, it becomes crucial to investigate the magnitude of these other market failures and to assess which policies would be most cost-effective in addressing them. There is a need to emphasize policies that create clear incentives for changes in energy use and technology by raising the price of GHG emissions, as well as targeting those informational market failures that do represent opportunities for cost-effective improvements in market performance.

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