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Energy-Efficiency Policies in the Asia-Pacific: Can We Do Better?

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EXECUTIVE SUMMARY

This paper assesses the effectiveness of energy-efficiency policies pursued by governments in the Asia-Pacific region and elsewhere.

Main Findings

The empirical evidence on the cost-effectiveness of energy-efficiency initiatives widely pursued by governments is mixed. Despite the large descriptive literature on energy-efficiency and conservation policies, there is a relative dearth of independent *ex post* statistical analysis that measures the true costs of energy savings actually achieved. However, the road ahead for energy-efficiency policies in the Asia-Pacific is positive. Governments can play a constructive role in mitigating market failures while avoiding wasteful subsidies and onerous mandatory performance standards with hidden costs that can lead to unnecessary burdens being imposed on firms and households.

Policy Implications

- Typical *ex ante* engineering and accounting studies of energy efficiency are based on parameters that might not reflect actual conditions surrounding firms' and households' decisions to invest or make purchases. It is critical that new regulations considered for energy-efficiency objectives meet the tests of unbiased cost-benefit analysis.
- Randomized control trials and rigorous ex post analysis that takes into account actual consumer responses should be the basis of establishing the likely welfare impacts of various government energy-efficiency programs and initiatives.
- Before regulatory agencies consider intrusive forms of intervention to promote energy-efficiency objectives—such as subsidies or the imposition of mandatory standards based on technology or engineering criteria—it should be demonstrated that private decisions are flawed and informational remedies are inadequate.

Proponents of energy-efficiency improvements have long promoted them as a means of attaining multiple policy objectives: helping net-energy importing countries in their balance-of-payments accounts, reducing costs for households and firms, enhancing national security, and improving environmental outcomes. Given the widespread policy emphasis on energy efficiency, there is a clear need to assess how well such policies have fared in practice. In this paper, "energy-efficiency policies" refer to policies such as subsidies, mandatory standards, and labeling and information provisions that attempt to encourage energy-efficient investments but do not directly affect energy prices.[1] The first section of this paper provides background on the widespread adoption of such policies around the world. The second section describes trends in and the implementation of energy-efficiency policies in the Asia-Pacific region. The third section provides a critical analysis and evaluation of the effectiveness of energy-efficiency policies. Finally, the paper concludes with some general remarks about how policymaking on energy efficiency can be improved.

Motivations for Pursuing Energy Efficiency

The roots of today's widespread adoption of energy-efficiency policies date back to the 1970s. Energy-security concerns rose amid the crisis environment of the oil price shocks and stimulated major regulatory attempts to boost efficiency in several OECD countries. The United Kingdom, for instance, launched an energy-saving campaign in December 1973 as a direct policy response to the 1973 crisis.[2] Automobile fuel-efficiency standards were first established by the U.S. federal government in the Energy Policy and Conservation Act of 1975, and Japan established the Law Concerning the Rational Use of Energy in 1979 during the second oil crisis, a law that continues to form the cornerstone of the country's present-day energy-efficiency

[1] Such policies are distinguished from conservation that is achieved by reducing the consumption of energy services at the cost of some personal comfort or satisfaction (for example, driving less or buying small-capacity refrigerators). In much of the literature, the terms are used interchangeably. Additionally, while market-based instruments such as fuel taxes or emission permit trading regimes ("cap-and-trade") that directly alter energy prices improve energy-efficiency outcomes, often at lower costs, such policies are analytically distinct and not considered in this paper's policy analysis.

[2] Stephen Peake, *Transport in Transition: Lessons from the History of Energy* (London: Earthscan Publications, 1994).

policies.[3] By the end of the 1970s, most developed countries had adopted a range of energy-efficiency policies, including R&D programs, financial incentives and subsidies, energy-efficiency standards, and information and educational efforts.

Developing countries were slower to begin implementing energy-efficiency policies but by the 1990s most of the major economies in the Asia-Pacific region had policy frameworks in place. Before 1980, China emphasized rapid economic growth and paid little attention to energy efficiency, leading to high energy-intensity levels. From 1981 onward, though, China initiated extensive reforms to its energy policy, placing much greater emphasis on energy conservation in its subsequent five-year plans.[4] In India, concerns about efficiency and conservation began to formally influence energy policy as far back as 1974, and a draft of the Energy Conservation Bill was completed in 1988, though it was only passed as an act of parliament in 2001.[5]

Over the past decade, mounting concerns over global climate change have made the emission mitigation potential of energy-efficiency investments a declared core benefit for many policymakers. In its 2012 *World Energy Outlook*, the International Energy Agency (IEA) predicts that if a reduction occurs in global carbon dioxide (CO_2) emissions from the business-as-usual path, it is likely to be driven largely by energy-efficiency measures.[6] In IEA projections, energy-efficiency policies by 2035 will account for 68% and 70% of the cumulative global reduction in energy use and CO_2 emissions, respectively, in the "new policies scenario" relative to the "current policies scenario," and thus will have a much more significant effect than either renewables or nuclear energy.[7] If energy security and dependence on imports of fossil fuels were the initiating policy concerns for energy efficiency during the 1970s and 1980s, emission

[3] Howard Geller et al., "Policies for Increasing Energy Efficiency: Thirty Years of Experience in OECD Countries," *Energy Policy* 34 (2006): 556–73.

[4] Lynn Price, Ernst Worrell, and Jonathan E. Sinton, "Industrial Energy Efficiency Policy in China" (presentation to the 2001 ACEEE Summer Study on Energy Efficiency in Industry, 2001).

[5] P. Balachandra, D. Ravindranath, and N.H. Ravindranath, "Energy Efficiency in India: Assessing the Policy Regimes and Their Impacts," *Energy Policy* 38 (2010): 6428–38.

[6] International Energy Agency (IEA), *World Energy Outlook 2012* (Paris: OECD/IEA, 2012).

[7] The "current policies scenario" assumes no implementation of government policies beyond those already adopted by mid-2012, while the "new policies scenario" takes into account existing policy commitments and assumes that recently announced policies are implemented, though in a cautious manner. See IEA, *World Energy Outlook 2012*.

mitigation and the "green growth" aspects of efficiency improvements now occupy a central place in the rationale for energy-efficiency policies across the Asia-Pacific region.

Status of Energy-Efficiency Efforts in the Asia-Pacific Region

Recent Trends in Energy Intensity

As alluded to in the first section, most countries now implement a range of policy instruments targeted at improving energy efficiency across various economic sectors. A 2007 survey conducted by the World Energy Council in 76 major countries (accounting for 83% of the world's energy consumption) found that two-thirds of the countries have set up energy-efficiency agencies, while almost half of the countries have adopted national energy-efficiency programs.[8] Close to half of the countries surveyed by the World Energy Council have adopted laws with quantitative targets for energy efficiency.[9] **Table 1** lists energy-efficiency targets adopted by major countries around the world as well as selected Asia-Pacific countries.

Table 1 *Energy efficiency targets of selected countries*

Country	Nature of target	Base year	Target date
European Union	Reduce primary energy consumption by 20%	BAU 2020	2020
United States	No target	N/A	N/A
Japan	Reduce energy intensity by 30%	2003	2030
Brazil	Reduce projected power consumption by 10%	2011	2030
China	Reduce energy intensity by 16%	2011	2015
India	Improve energy efficiency by 20%	2007	2012
Thailand	Reduce energy intensity by 25%	2005	2030
Philippines	Reduce total annual energy demand of all sectors by 10%	2009	2030

Source: IEA, *World Energy Outlook 2012*; Tilak K. Doshi et al., "Regulatory Reform—Case Studies on Green Investments," Asia-Pacific Economic Cooperation (APEC), APEC Policy Support Unit, February 2013, http://publications.apec.org/publication-detail.php?pub_id=1397; Balachandra, Ravindranath, and Ravindranath, "Energy Efficiency in India"; European Commission, "Europe 2020 Targets," http://ec.europa.eu/europe2020/targets/eu-targets/index_en.htm; Asia Pacific Energy Research Center (APERC), "Compendium of Energy Efficiency Policies of APEC Economies," 2010; and Thailand Ministry of Energy, *Thailand 20-Year Energy Efficiency Development Plan* (Bangkok, 2011).

Most major economies—with the notable exception of the United States—and a number of smaller countries have adopted economy-wide energy-efficiency targets. There is considerable

[8] World Energy Council, *Energy Efficiency Policies around the World: Review and Evaluation*, 2008.

[9] World Energy Council, *Energy Efficiency Policies around the World.*

heterogeneity in how these targets are framed. At the economy-wide level, measures of energy intensity (expressed as the amount of energy used to produce a dollar of GDP) are often the most widely applied metric to assess trends in energy use over time and across countries. Almost all the countries set targets relative to either energy intensity or aggregate energy consumption, though neither of these is a reliable indicator of underlying energy-efficiency trends. One reason for this is simply the ease with which these measures can be computed and interpreted.[10] A more substantial reason is that purely from the standpoint of improving energy security and reducing greenhouse gas emissions, the relevant indicator is consumption, and it does not necessarily matter whether the target is achieved through efficiency improvements or compositional changes in the economy toward less energy-intensive industries.

Despite the limitations of these metrics, it is clear that worldwide energy-intensity levels have improved substantially. According to the IEA, the annual rate of decline in global energy intensity averaged 1.2% during 1980–2000 but slowed considerably to 0.5% between 2000 and 2010.[11] After the onset of the recession, global energy intensity actually increased in 2009 and 2010. While the global economic slowdown contracted the denominator in the energy-intensity ratio, the decline in consumption was not as pronounced. The latest data from the IEA suggests that energy intensity improved by 0.6% in 2011, getting back into alignment with the long-term trend of the past decade.

Figure 1 shows how energy intensity in various countries has evolved since 1980. Two broad patterns can be discerned: richer countries tend to have lower energy-intensity levels, and energy-intensity levels have fallen across the last three decades in most countries in the sample. As major natural resource producers, Canada and Australia are at higher absolute levels than the European Union (EU). The levels of the United States lie somewhere between Australia and Canada. Japan has the lowest intensity ratios among the OECD group, although given low or

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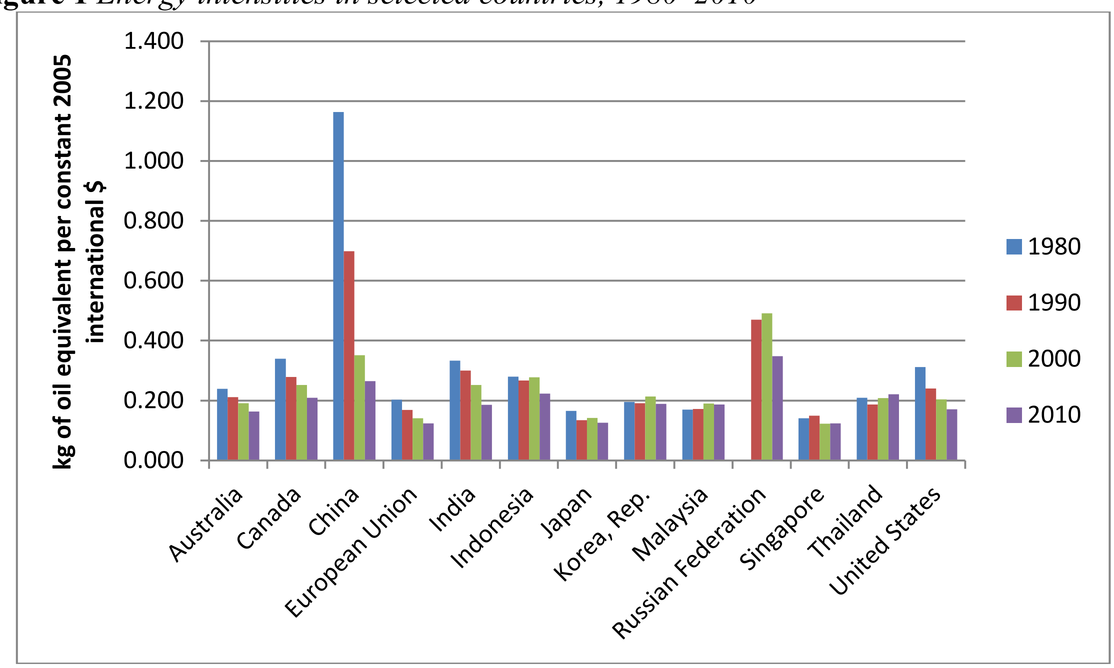
[10] Changes in energy intensity can be divided into three analytically distinct components: price-driven changes in demand, income-driven changes in demand, and autonomous energy efficiency improvements (AEEI). A variety of analytical techniques have been used to derive empirical estimates for AEEI, including statistical fitting of trends to historical energy/GDP data and establishing technical change parameters from estimated production functions. Forecasts for long-term AEEI derived from early studies on global emission mitigation scenarios range from 0.5% to 1.0% annually. The understanding of the AEEI remains incomplete, however, and it is important to note that minor differences in rates of change yield major differences over long-term horizons.

[11] The data cited in this paragraph is from IEA, *World Energy Outlook 2012*, 271–72.

negligible economic growth rates over the past two decades, its rate of energy intensity improvement since the 1990s is marginal.

The picture for developing Asia is more mixed. Rapidly industrializing countries such as Thailand, Malaysia, and South Korea show no trends of improvement. By contrast, the larger developing countries with lower per capita incomes, such as India and China, show dramatic improvements in energy intensity, reflecting both their rapid rates of economic growth and the very low levels of energy efficiency from which these countries began their impressive economic growth trajectories in the 1980s and 1990s. Most dramatic has been the nearly fivefold decline in energy intensity in China between 1980 and 2010, although China still remains one of the most energy-intensive major economies. While energy intensity tends to be higher in developing countries than in the OECD economies, there has been rapid convergence over the past three decades. According to the IEA, the ratio between the highest and lowest values has declined from a factor of nine in the 1980s to just below five in 2012.[12]

Figure 1 *Energy intensities in selected countries, 1980–2010*



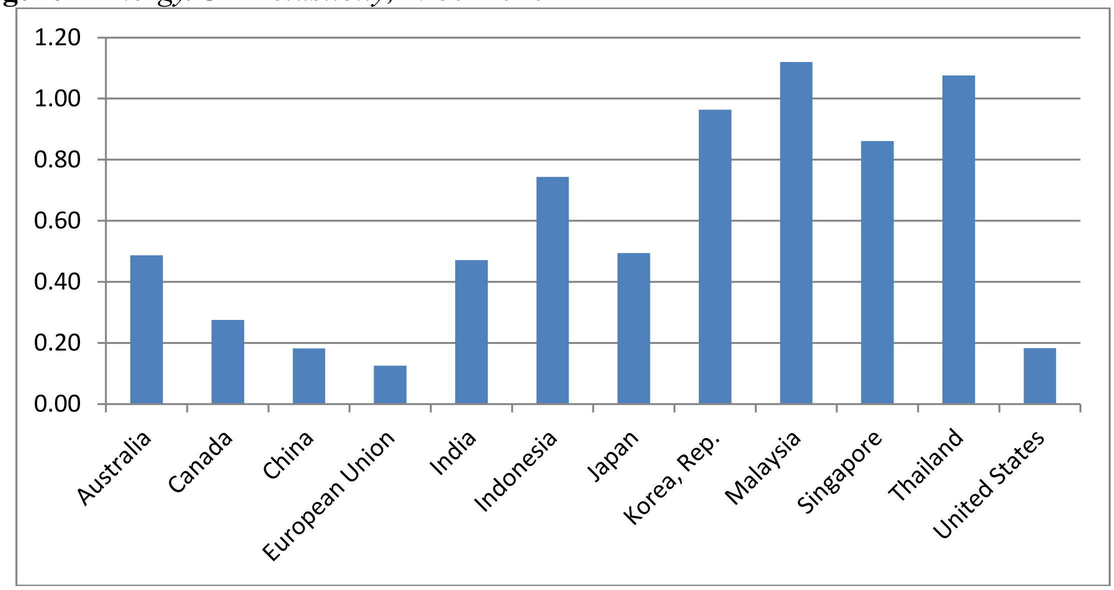
Source: Authors' calculations based on World Bank, *World Development Indicators*, 2012.

An analysis of energy consumption in the Asia-Pacific presents a similarly nuanced view of energy-efficiency improvements in the region. **Figure 2** illustrates the percentage growth of

[12] IEA, *World Energy Outlook 2012*, 272.

energy consumption divided by the percentage growth in GDP (measured in purchasing power parity terms) for various countries between 1980 and 2010.[13] The value is less than 0.2 in China, the EU, and the United States, implying that energy consumption grew at a rate over five times smaller than the growth in GDP. By contrast, in rapidly industrializing middle-income countries, such as Malaysia and Thailand, energy use has grown at a faster rate than GDP.

Figure 2 *Energy/GDP elasticity, 1980–2010*



Source: Authors' calculations based on World Bank, *World Development Indicators*, 2012.

However, using simple energy-GDP ratios to compare even proximally the energy-efficiency levels across countries is misleading. Such ratios conflate different effects, including the evolving composition of economies toward less energy-intensive sectors and the impact both of price trajectories of various fuels and of the rising incomes of households and firms in growing economies. For instance, it is to be expected that Australia, endowed with abundant energy resources, would specialize in energy-intensive extractive and industrial processing sectors, while Japan, devoid of its own energy resources, would tend to economize its use of energy. In economic analysis, both countries could be considered energy efficient relative to their factor endowments and comparative advantages, despite their divergence in energy intensities.

[13] Note that that this average measure differs from the instantaneous energy-GDP elasticity, which is the percentage change in energy consumption associated with a minute change in GDP from a given absolute level.

Energy-Efficiency Policies and Measures in the Asia-Pacific

Given the consistent and long-running policy emphasis on energy efficiency across the Asia-Pacific region, the descriptive literature on the subject is voluminous.[14] On its webpage dedicated to energy efficiency, the IEA has compiled the most comprehensive databases of energy-efficiency initiatives undertaken by governments in both the OECD and non-OECD regions of the world. The IEA's energy-efficiency database lists "policies and measures" under six categories—economic instruments, policy support, regulatory instruments, information and education, and research, development, and deployment—and breaks down efforts into a range of target sectors, including buildings, commercial and industrial equipment, energy utilities, industry, lighting, residential appliances, and transport.[15] To highlight efforts focused on sectors with the highest levels of energy consumption, the following section examines in greater detail how energy-efficiency efforts have targeted buildings, appliances, transportation, and industry.

Buildings. Buildings account for a third of the world's total energy consumption.[16] Most OECD countries have mandatory codes for new and existing buildings, and such standards are being increasingly implemented in developing countries. Direct energy-efficiency improvements in buildings, according to McKinsey's cost curve for global greenhouse gas abatement, could account for roughly 1.7 gigatons (billion metric tonnes) of CO_2 equivalent ($GtCO_2e$) out of a total of around 12 $GtCO_2e$ of cost-effective positive global abatement potential every year until 2030.[17] The most significant among such regulations are building energy codes—that is, energy-

[14] In Asia, for instance, major studies that have summarized the region's energy-efficiency policies include "Compendium of Energy Efficiency and Conservation: Policies/Programs, Regulations and Standards in the Asia Pacific Economic Cooperation (APEC) Member Economies," APEC Secretariat, 1994; Peter Ramsey and Ted Flanigan, "Compendium: Asian Energy Efficiency Success Stories," International Institute for Energy Conservation by Global Energy Efficiency Initiative, 1995; and "Energy Efficiency Indicators: A Study of Energy Efficiency Indicators in APEC Economies," Asia Pacific Energy Research Centre (APERC) and the Institute of Energy Economics, 2001.

[15] See IEA, "Energy Efficiency," Policies and Measures Databases, http://www.iea.org/policiesandmeasures/energyefficiency.

[16] IEA, *World Energy Outlook 2012*, 276; and Hong Wen, Madelaine Steller Chiang, Ruth A. Shapiro, and Mark L. Clifford, "Building Energy Efficiency—Why Green Buildings are Key to Asia's Future," Asia Business Council, 2007.

[17] See "Energy Efficiency: A Compelling Global Resource," McKinsey and Company, 2010, 5.

efficiency requirements for new buildings, for which it is much less costly to integrate design and equipment improvements. Building energy codes can also serve as the efficiency target for refurbishments or other improvements of existing buildings.[18] By 2003, most APEC economies had implemented building energy codes, although there were significant differences in coverage (residential vs. commercial buildings) and the compliance mechanism (voluntary vs. mandatory codes).[19] In addition, a range of other policies have been used to promote energy-efficiency improvements in buildings, including energy-performance labeling, financial incentives for energy management and audit programs, lead-by-example programs (such as government "test beds" and demonstration projects), information and awareness programs, and R&D programs.[20]

Appliances. The technical potential for energy-efficiency improvements in appliances is considerable according to engineering studies. The Lawrence Berkeley National Laboratory estimates that energy-efficient standards and labeling programs aimed at improving the efficiency of equipment (including both appliances and lighting) could lead to savings of 3,860 terawatt hours (TWh) of electricity and 1,041 TWh of fuel per year by 2030.[21] To put those savings in context, the world's total electricity generation in 2010 was 21,325 TWh.[22]

Efficiency improvements in appliances in industrialized economies over the past 30 years have been driven primarily by standards, labeling, and incentive purchase schemes. There has been a proliferation of energy-efficiency standards and labeling programs around the world, rising from only 12 programs in 1990 (largely concentrated in industrialized economies) to more than 60 in 2005 (including many in developing economies).[23] Almost all member economies of

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[18] IEA, "Promoting Energy Efficiency Investments, Case Studies in the Residential Sector," 2008, http://www.iea.org/textbase/nppdf/free/2008/PromotingEE2008.pdf.

[19] APERC, *Energy Efficiency Programmes in Developing and Transitional APEC Economies* (Berkeley: University of California, 2003).

[20] APERC, *Energy Efficiency Programmes in Developing and Transitional APEC Economies*; and Wen, Chiang, Shapiro, and Clifford, "Building Energy Efficiency."

[21] Michael A. McNeil, Virginia E. Letschert, and Stephane de la Rue du Can, "Global Potential of Energy Efficiency Standards and Labeling Programs," Lawrence Berkeley National Laboratory, 2008.

[22] "BP Statistical Review of World Energy," BP Plc, June 2011.

[23] McNeil, Letschert, and de la Rue du Can, "Global Potential of Energy Efficiency Standards."

the IEA have minimum energy performance standards (MEPS) and associated labeling programs for appliances, and all of them have policies in place to increase energy efficiency in lighting.[24]

Transport. Transportation accounted for approximately 19% of global final energy consumption in 2010.[25] The IEA notes that policies that help improve vehicle fuel economy are among the most cost-effective measures for achieving an overall CO_2 reduction target of 50% below 2005 levels by 2050 across the transport sector.[26] Most OECD countries, including the EU countries and Japan, have pursued improvements in fuel efficiency of internal combustion engine vehicles via high indirect taxes on gasoline and diesel sales. The EU countries, in particular, have among the highest gasoline taxes in the world.[27] In contrast, the United States has very low tax rates on transport fuels. As **Figure 3** illustrates, there is a high degree of correlation between end-use prices and taxes on transportation fuels: whereas the highest taxes and prices tend to be in Europe, the United States has both the lowest tax and the lowest fuel price among the OECD countries. The United States has instead pursued energy-efficiency improvements primarily through mandated fleet efficiency standards on manufacturers, known as the Corporate Average Fuel Economy (CAFE) standards that were first implemented in 1975 (making the United States one of the first countries to adopt mandatory fuel economy standards).[28]

Outside the OECD, however, there are a large number of countries in Asia and the Middle East that subsidize transport fuels, causing wasteful inefficiencies and burdening the public budgets in those economies. The estimated size of fossil fuel subsidies in 2010 was $409 billion; the Asia-Pacific region constitutes a significant proportion of these subsidies, with 10 out of the 21 member economies of APEC accounting for $105 billion in fossil fuel subsidies in 2010. In non-OECD countries, the economic impact has been especially significant given that subsidies amount to between 1% and 5% of GDP in several Asia-Pacific economies (such as Indonesia and

[24] IEA, *Implementing Energy Efficiency Policies—Are IEA Members On Track?* (Paris: IEA/OECD, 2009).

[25] IEA, *Energy Balances of Non-OECD Countries* (Paris: IEA/OECD, 2012).

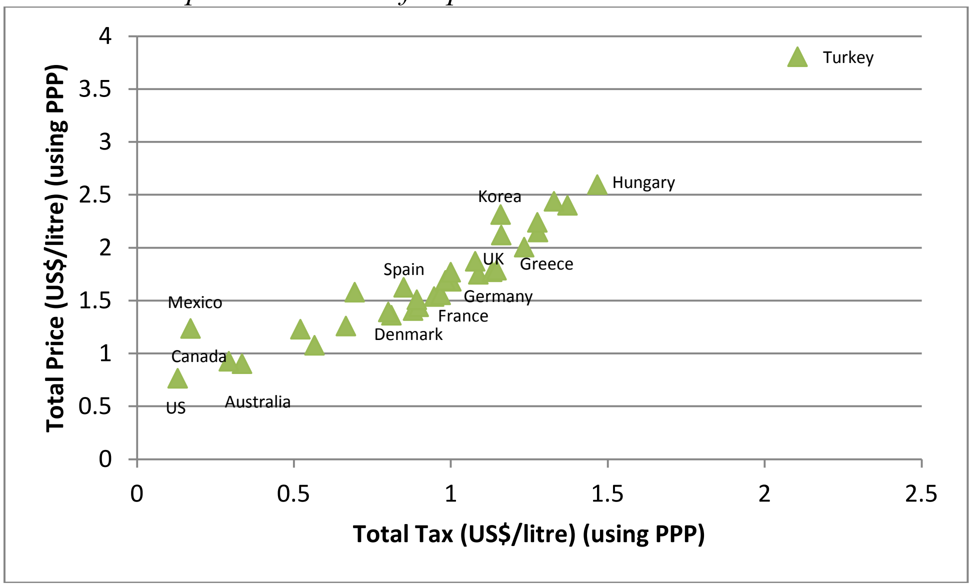
[26] Kazunori Kojima and Lisa Ryan, "Transport Energy Efficiency—Implementation of IEA Recommendations since 2009 and Next Steps," IEA, Information Paper, September 2010.

[27] World Energy Council, *Energy Efficiency Policies Around the World*.

[28] World Energy Council, *Energy Efficiency Policies Around the World*.

Malaysia) and over 5% in oil-exporting economies in the Middle East and North Africa.[29] Fossil fuel subsidies understate the real cost of energy and thus impede energy efficiency in the transportation sector.

Figure 3 *End-use prices and taxes for premium unleaded 95 RON in OECD countries, 2010*



Source: IEA, *Energy Prices and Taxes Statistics* (Paris: IEA/OECD, 2012).

Industry. In 2010 the industrial sector (excluding energy-transformation industries, such as refineries and power plants) accounted for 28% of worldwide final energy consumption. However, the energy-transformation sector, which converts primary energy into final energy for end-use sectors, is itself a major user of energy, accounting for 31% of worldwide primary energy consumption in 2010.[30] Thus, over half of the world's primary energy supply is consumed in industry if the energy-transformation sector is included.

In spite of this, the bulk of global energy-efficiency policy efforts have centered on nonindustrial energy use. This is in part because of the extreme heterogeneity of the industrial sector, ranging from energy-intensive sectors such as cement and steel plants to light industries that use little energy.[31] Regulations in Japan include efficiency standards (e.g., for combustion

[29] IEA, *World Energy Outlook 2011* (Paris: IEA/OECD, 2011).

[30] IEA, *Energy Balances of Non-OECD Countries.*

[31] Aimee McKane, Lynn Price, and Stephane de la Rue du Can, "Policies for Promoting Industrial Energy Efficiency in Developing Countries and Transition Economies," United Nations Industrial Development Organization (UNIDO), UNIDO Background Paper, 2008.

and heating equipment) as well as obligations for industrial energy users to develop conservation plans, hire certified energy managers, and report energy-consumption levels.[32] Japan has also established tax incentives, subsidies, and low-interest loans for industrial energy-efficiency measures and adoption of energy-saving technologies. The United States has adopted standards covering industrial equipment (e.g., induction motors), provides loan guarantees for commercial projects that adopt energy-efficient technologies, and offers technical-assistance programs to help industries identify energy conservation strategies.[33] In Europe, voluntary agreements have formed a major element of industrial energy-efficiency policy efforts, with the governments offering low-interest loans and other financial incentives in return for industries agreeing to increase their energy efficiency.[34]

Several countries have also implemented policies specifically directed toward improving power-generation efficiency. This is motivated by the fact that globally the power-generation sector alone consumes an amount of energy roughly equal to the energy consumed by the remainder of the industrial sector and greater than that consumed by the transportation sector.[35] These policies include utility demand-side management programs that have been widely used in the United States. Under these programs, utilities are required to operate energy-efficiency programs—for instance, by adopting time-of-use pricing to discourage peak demand or by providing cash incentives to consumers to reduce electricity demand when requested.[36] A number of countries have also implemented policies to directly enhance the efficiency of power generation by expanding the use of combined heat and power (CHP) systems, or cogeneration, through policies such as subsidies and other financial incentives for CHP (in Japan, the EU, and

[32] Geller et al., "Policies for Increasing Energy Efficiency."

[33] Kenneth Gillingham, Richard Newell, and Karen Palmer, "Energy Efficiency Policies: A Retrospective Examination," *Annual Review of Environment and Resources* 31 (2006): 161–92; and Elizabeth Doris, Jacquelin Cochran, and Martin Vorum, "Energy Efficiency Policy in the United States: Overview of Trends at Different Levels of Government," National Renewable Energy Laboratory (NREL), NREL Technical Report, December 2009.

[34] Geller et al., "Policies for Increasing Energy Efficiency." It should be noted that a major part of promoting emission mitigation efforts in the EU is incorporated in the EU Emission Trading System, a cap-and-trade system that affects energy prices directly.

[35] IEA, *Energy Balances of Non-OECD Countries.*

[36] Gillingham, Newell, and Palmer, "Energy Efficiency Policies"; Geller et al., "Policies for Increasing Energy Efficiency"; and Doris, Cochran, and Vorum, "Energy Efficiency Policy in the United States."

several U.S. states) as well as mandates requiring utilities to purchase electricity from cogenerators (in the United States).[37]

Assessing Energy-Efficiency Policies in the Asia-Pacific Region

The "Energy-Efficiency Gap" and Government Policy

Despite the vital role energy efficiency is envisaged to play in cost-effectively cutting energy demand, "only a small part of its economic potential is exploited."[38] The fact that cost-effective options to improve energy efficiency are not being adopted on a large scale has led to notions of an energy-efficiency gap. The efficiency gap, or the difference between the level of efficiency actually achieved and the level judged to be optimal at prevailing prices, has generated considerable debate in policy circles as well as in the academic literature. This paradox—the non-adoption or slow diffusion of apparently cost-effective energy-efficient technologies—has been the basis of a large literature on market barriers that discourage investments in such technologies.[39]

The notion of "barriers" to energy-efficiency choices, understood as market conditions that discourage energy-efficiency investments relative to an estimated optimal level, is a staple of many large-scale studies of energy efficiency. One early multi-laboratory study conducted for the U.S. Department of Energy's National Energy Strategy, which reviewed U.S. energy-efficiency literature written prior to 1990, concluded that "the constraint on efficiency improvements in the short term is not primarily technical. The primary barrier is insufficient implementation of existing cost-efficient technologies."[40] In a recent well-publicized study of energy options for the United States, McKinsey and Company notes: "By 2020, the U.S. could reduce annual energy consumption by 23% from business-as-usual baseline projections by deploying an array of NPV-positive efficiency measures…This potential exists because

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[37] Geller et al., "Policies for Increasing Energy Efficiency."

[38] IEA, *World Energy Outlook 2012*, 269.

[39] See references cited in Ronald J. Sutherland, "Market Barriers to Energy Efficiency Investments," *Energy Journal* 12, no. 3 (1991): 15–34.

[40] See Roger Carlsmith, William Chandler, James McMahon, and Danilo Santino, "Energy Efficiency: How Far Can We Go?" Oak Ridge National Laboratory, 1990.

significant barriers impede the deployment of energy-efficient practices and technologies."[41] Similarly, in its recent in-depth assessment of energy efficiency, the IEA notes "the existence of a number of barriers that discourage decision makers, such as households and firms, from making the best economic choices."[42] To address these barriers, governments have adopted a range of specific policy tools, including subsidies, mandated standards, and labeling programs. How these tools have been used to promote energy efficiency and their success at doing so to date are assessed below.

Subsidies

Governments have implemented a range of subsidies such as cash grants, cheap credit, tax exemptions, and co-financing with public-sector funds to encourage a range of energy-efficiency initiatives across several sectors. Tax exemptions or cash grants for upgrading industrial machinery and subsidies for retrofitting buildings, insulating homes, purchasing energy-efficient appliances and heating and air-conditioning systems, and trading in old vehicles for newer ones are typical examples. Subsidies for energy-efficiency programs are substantial in most OECD governments' energy policy budgets. For instance, EU funding for energy efficiency was about 5 billion euros for the budget period 2007–13, and the European Commission has proposed an increased budget of more than 17 billion euros for 2014–20.[43]

The unavailability of credit is often cited as a market barrier to energy-efficiency investments.[44] The lack of access to credit might force some purchasers to choose less energy-efficient products, resulting in underinvestment in energy efficiency. In a similar vein, high initial costs of energy-efficient technologies are often identified as a market barrier. This has provided a rationale to governments to offer financial incentives as a means of alleviating credit constraints or the high initial costs of investments. However, it is unclear why credit constraints should affect investments specifically in energy efficiency. Households or firms that are

[41] See "Energy Efficiency," 5.

[42] IEA, *World Energy Outlook 2012*, 280.

[43] "EU Energy Savings Grants Used Wastefully—Auditors," Reuters, January 14, 2011.

[44] See, for instance, Carl Blumstein, Betsy Krieg, Lee Schipper, and Carl York, "Overcoming Social and Institutional Barriers to Energy Conservation," *Energy* 5, no. 4 (1980): 355–71.

precluded from energy-efficient investments due to budget constraints are similarly precluded from all profitable investments that cost the same amount of money; the constraining factor is that incomes or budgets are too low rather than that credit is not forthcoming or that initial costs are too high.

Another rationale for using government subsidies and financial incentives to encourage energy-efficiency investments relates to the claim that consumers typically put too little weight on future energy savings and too much on upfront costs when buying appliances. For example, a much-cited early study of consumer purchases of air-conditioners found "implicit discount rates" of about 20%, much higher than market interest rates.[45] The empirical evidence, however, is mixed: in an econometric study of used cars, for example, the authors estimated the rate of interest implicit in a consumer's valuation of the discounted costs of the vehicle's lifetime operating costs and found that it was in the 11%–17% range, consistent with prevailing market interest rates for car loans.[46] Uncertainty over future energy savings, hidden costs such as the cognitive costs of searching for new products or reductions in other desirable product characteristics, the irreversibility of investments, and the associated option value of waiting are some of the reasons offered by economists to explain high discount rates. Indeed, for some economists, the so-called myopic behavior of consumers who underrate future energy savings is consistent with standard rationality assumptions of economic decision-making.[47]

Engineering studies of energy efficiency calculate the net present value (NPV) of the particular appliance or machinery chosen based on assumptions of capital costs, current and future fuel prices, duration and frequency of use, and discount rates. However, engineering estimates omit relevant variables that drive actual purchase decisions and cannot capture the heterogeneity of preferences across households and firms. Energy efficiency is only one among many attributes considered in the decision to invest or buy.

A typical example of the variance between *ex ante* engineering analysis and *ex post* studies that take into account observed consumer responses is a Mexican government subsidy program

[45] Jerry A. Hausman, "Individual Discount Rates and the Purchase and Utilization of Energy-Using Durables," *Bell Journal of Economics* 10 (1979): 33–54.

[46] Mark K. Dreyfus and W. Kip Viscusi, "Rates of Time Preference and Consumer Valuations of Automobile Safety and Fuel Efficiency," *Journal of Law and Economics* 38 (1995):79–105.

[47] See, for instance, Sutherland, "Market Barriers to Energy Efficiency Investments."

to replace older refrigerators and air conditioners with more efficient ones. The subsidies were projected to save energy by 30%; however, a follow-up analysis of the program estimated energy savings of only 7% once actual consumer responses were observed.[48] Buyers chose larger refrigerators with newer energy-using features, while many lowered their thermostat temperatures or installed more air-conditioning units in their homes as a result of the subsidy. The "rebound" effects of cheaper energy on energy demand have been widely noted but are not captured by the estimates often provided by manufacturers and installers of various energy systems. Another study found that realized returns from home insulation were only a fraction of the returns estimated by product engineers and manufacturers.[49] In a well-cited study of "demand-side management" conservation programs pursued by U.S. utilities, it was found that "some of these programs appear to be uneconomical even before correcting for biases in utility cost accounting and in the measurement of actual electricity savings…Furthermore, it is likely that the values for the cost per kWh saved that we derive from utility reports understate their true costs by a factor of two or more on average."[50]

Given the unreliability of much of the ex ante analysis that projects energy savings from various government subsidies for efficiency programs, it is not clear whether such subsidies have generally been cost-effective. For instance, the European Court of Auditors recently reported that the EU's spending on programs to spur energy savings has "gone to waste," and some of its building-insulation projects were found to be "so inefficient that it would take longer than the lifetime of an improved building to recover the costs."[51]

Mandated Standards

Governments have implemented an array of standards based on technology and performance criteria to promote energy efficiency. Building codes, minimum energy-

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[48] See Lucas Davis et al., "Cash for Coolers," National Bureau of Economic Research (NBER), NBER Working Paper 18044, May 2012; and Robert Michaels, "The Hidden Flaw of 'Energy Efficiency,'" *Wall Street Journal*, August 20, 2012.

[49] Gilbert E. Metcalf and Kevin A. Hassett, "Measuring the Energy Savings from Home Improvement Investments," *Review of Economics and Statistics* 81, no 3 (1999): 516–28.

[50] Paul L. Joskow and Donald B. Marron, "What Does a Negawatt Really Cost?" Massachusetts Institute of Technology (MIT), Discussion Paper MIT-CEPR 91-016WP, December 1991.

[51] "EU Energy Savings Grants Used Wastefully—Auditors."

performance standards for consumer durables, and standards for fuel efficiency in automobiles are some of the more obvious examples of government-mandated standards. These standards are usually implemented on the basis of cost-benefit analyses that purport to show the net benefits that result from restricting private choices by mandatory standards.

Perhaps one of the most debated examples of mandated standards in the literature is the regulation of CAFE for vehicles by the National Highway Traffic Safety Administration (NHTSA) in the United States. In December 2011 the NHTSA and the Environmental Protection Agency (EPA) proposed new fuel economy standards for passenger cars and light trucks for model years 2015 through 2025. The EPA and NHTSA used cost-benefit analysis to compute the net present value of CAFE standards, which involve key variables including the discount rate, miles driven annually, miles driven as a response to a change in fuel costs, increases in driving due to improvements in fuel efficiency (i.e., the rebound effect), projections of fuel prices, the lifetime of vehicle, and the relationship between measured and actual on-road fuel efficiency. The cost-benefit analysis by the agencies is essentially based on the cost of the vehicle and its miles-per-gallon efficiency. However, fuel efficiency is only one factor among many in a purchasing decision. Other factors include safety, style, speed, and comfort. The analysis thus ignores the loss in consumer welfare if mandated fuel-efficiency standards lead to changes in other desired characteristics of a car.[52]

The NHTSA estimates a total cost of implementing CAFE standards of $177 billion and a total benefit of $521 billion.[53] While environmental and energy security benefits account for $81 billion, the remaining $440 billion of benefits are attributed to private savings to consumers. With such large benefits accruing to car buyers, the obvious question arises as to why mandated CAFE standards are required in the first place. As the NHTSA itself concedes, the organization is "unable to reach a conclusive answer to the question of why the apparently large differences between its estimates of benefits from requiring higher fuel economy and the costs of supplying it do not result in higher average fuel economy for new cars and light trucks."[54] Put differently,

[52] See Ted Gayer and W. Kip Viscusi, "Overriding Consumer Preferences with Energy Regulations," Mercatus Center, George Mason University, Working Paper, no. 12-21, July 2012.

[53] "Preliminary Regulatory Impact Analysis: CAFE for MY 2017–MY 2025," National Highway Traffic and Safety Administration (NHTSA), November 2011, table 13.

[54] "Preliminary Regulatory Impact Analysis: CAFE for MY 2017–MY 2025," 711, as cited in Gayer and Viscusi, "Overriding Consumer Preferences with Energy Regulations," 22.

why do manufacturers fail to provide higher fuel economy even in the absence of increases in CAFE standards, given the very large private benefits estimated by the NHTSA's analysis?

Among the reasons offered by the NHTSA in explaining the results of its study are inadequate consumer information on the value of improved fuel economy, the low weight consumers typically place on long-term savings, the lack of salience of fuel savings in the purchasing decision, and ignorance on the part of manufacturers regarding the premiums consumers are willing to pay for improved fuel economy. To many economists, such explanations remain unconvincing in that they fail to establish the case that strict mandates are warranted rather than education campaigns that would offer consumers the basis to make better purchasing decisions.[55] Furthermore, mandated standards, unlike outright subsidies, lack explicit cost information, and hence are easier to legislate. The hidden costs of mandatory standards are, in the first instance, imposed on manufacturers and suppliers, and the ultimate cost to consumers is thus not transparent.

The principle of consumer rationality underpins cost-benefit analysis, and in most contexts individuals are best placed to make the market decisions that affect them. The heterogeneity of individuals' tastes, preferences, and financial resources suggests that analysis based on a hypothetical average consumer in formulating mandatory standards for energy-using durables may be deficient. If the assumption of consumer rationality is abandoned, it would lead to the presumption that the analyst or policymaker is better placed to make decisions on behalf of consumers, subverting the very basis of any objective cost-benefit analysis.[56]

Labels and Information Programs

Governments in the Asia-Pacific region have implemented a range of information provision and labeling programs for buildings, appliances, and the transportation and industrial sectors. Information programs can simply provide data, such as fuel-economy labels, or actively seek to encourage behavioral changes, such as Japan's Cool Biz program that encourages setting

[55] See, for instance, Gayer and Viscusi, "Overriding Consumer Preferences with Energy Regulations"; and Hunt Alcott and Michael Greenstone, "Is There an Energy Efficiency Gap?" Department of Economics, MIT, Working Paper 12-03, January 2012.

[56] Gayer and Viscusi, "Overriding Consumer Preferences with Energy Regulations," 7.

air conditioners at 28-degrees Celsius and allowing employees to dress casually in the summer.[57] These programs have been popular due to the relatively low costs of implementing them, but there is sparse evidence on how effective they actually are at reducing informational market failures.

Decisions made on the basis of costly or incomplete information will differ from those made with free and complete information. The appropriate question then is not whether information on energy efficiency is deficient but under what conditions private markets fail to supply such information at optimal levels. Clearly, when information on energy efficiency has the property of a public good (i.e., when its consumption cannot be effectively excluded from use and where use by one individual does not reduce availability to others), governments can play a useful role in providing increased access to such information for firms and households.

There is another class of market failures arising from information asymmetry in which one party to a transaction has more or better information than the other party. The principal-agent or "split incentive" problem describes a situation where the agent (for example, a builder or landlord) decides the level of energy efficiency in a building, while the principal (such as the purchaser or tenant) pays the utility bills. When the principal has incomplete information about the energy efficiency of the building, the agent may not be able to recoup the costs of energy-efficiency investments in the purchase price or rent for the building. The agent will then underinvest in energy efficiency relative to the social optimum, creating a market failure.[58] One policy solution for this sort of market failure could be the provision of credible information by a disinterested third party (possibly a government agency) about a building's energy attributes, so that buyers or renters can ascertain the present value of net energy savings.

Perhaps the body of literature most influential in assessing choices in energy use at the micro-level is behavioral economics, which uses cognitive psychology and experimental disciplines to understand how individuals make decisions. Behavioral economics has drawn attention to systematic biases in decision-making that may be relevant to decisions regarding investment in energy efficiency. Behavioral failures in the context of energy-efficient

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[57] Minna Sunikka-Blank and Yumiko Iwafune, "Sustainable Building in Japan—Observations on a Market Transformation Policy," *Environmental Policy and Governance* 21 (2011): 351–63.

[58] Adam Jaffe and Robert Stavins, "The Energy Paradox and the Diffusion of Conservation Technology," *Resource and Energy Economics* 16 (1994): 91–122.

investments center on the themes of "bounded rationality" and heuristic decision-making.[59] For instance, consumers are sometimes unable to optimize their energy consumption in response to a tiered rate structure of electricity prices;[60] or a large proportion of consumers might fail to use preinstalled programmable thermostats that could reduce their energy bills.[61] However, the empirical literature testing behavioral failures specifically in the context of energy decision-making is still very limited.[62]

Labeling programs and other information provision measures have often been designed with little attention to the possibility of behavioral failures.[63] Framing an energy-efficiency improvement as avoiding a loss (e.g., stating "the average appliance is half as efficient as this appliance") is likely to have a greater impact on behavior than the natural inclination to frame energy savings as a gain (e.g., stating "this appliance is twice as efficient as the average appliance"), given research that suggests individuals respond more strongly to losses than gains.[64] Policy "tweaks" recommended by behavioral economics can often be nearly costless, suggesting that more attention should be focused on behavioral responses when designing labels and other information programs.

In the analysis of the various behavioral attributes of individual decision-making in energy technology choices, it is important to note that there may be instances where no necessary policy implications emerge. For example, in making decisions regarding the purchase of durable

[59] "Bounded rationality" suggests that consumers are rational but face cognitive constraints in processing information that lead to deviations from rationality in certain contexts. See, for instance, Amos Tversky and Daniel Kahnemen, "The Framing of Decisions and the Psychology of Choice," *Science* 211, no. 4481 (1981): 453–58.

[60] See Lee S. Friedman and Karl Hausker, "Residential Energy Consumption: Models of Consumer Behavior and Their Implications for Rate Design," *Journal of Consumer Policy* 11 (1988): 287–313.

[61] See Kenneth Gillingham and James Sweeney, "Barriers to Implementing Low Carbon Technologies," *Climate Change Economics* (forthcoming).

[62] See Kenneth Gillingham, Richard G. Newell, and Karen Palmer, "Energy Efficiency Economics and Policy," *Annual Review of Resource Economics* 1 (2009): 597–619.

[63] See Neil. S. D'Souza and Nahim B. Zahur, "Behavioural Economics: Insights into Energy Labelling," ESI Bulletin 5, issue 2, 2012.

[64] See Richard H. Thaler and Cass R. Sunstein, *Nudge: Improving Decisions about Health, Wealth, and Happiness* (New Haven: Yale University Press, 2008); and Sebestian Houde and Anika Todd "List of Behavioral Economics Principles That Can Inform Energy Policy," Lawrence Berkeley National Lab and Precourt Energy Efficiency Center at Stanford University, 2011.

energy-efficient equipment, it may be rational for firms or households to wait before adopting a particular new technology or product due to uncertainty. As there is no presumption of market failure in this instance, there is no case for a policy response to those who rationally see an option value in waiting in the presence of uncertainty, consistent with standard economic theory.[65] There also may be cases where individual preferences do not match the product characteristics of new energy-efficient products. For example, consumers may not adopt compact fluorescent lights due to noticeable difference in the quality of light they emit.

While people might use "psychological heuristics" to process complex options, it does not necessarily mean that such behavioral anomalies are pervasive and of great consequence to the economy.[66] One should not overstate the policy differences brought on by the contrasts between behavioral economics and mainstream analysis. In particular, the extent to which behavioral anomalies affect individual choices needs to be established and empirically measured in randomized trials, if such findings are to be used to justify government regulations.

The Cost-effectiveness of Energy-Efficiency Programs

Despite the extensive literature on energy-efficiency and conservation efforts, there is a lack of independent ex post analyses using statistical methods to measure the cost of savings actually achieved. A predominant part of the work on quantitative estimates of energy-efficiency outcomes is done by government or multilateral agencies that implement or support conservation programs, such as the EPA and the IEA, or by interested parties such as manufacturers and suppliers of energy-efficient appliances and equipment.

Accurately measuring the costs and benefits of the different efficiency and conservation programs is difficult for several reasons. Among the first challenges faced by any cost-benefit analysis of government energy-efficiency regulations is defining baselines in order to assess the improvements that would have occurred in the absence of regulations. We have also noted the problem of unobserved costs and benefits in standard ex ante engineering analysis that make it difficult to measure the welfare impacts of various regulations. Yet another issue relates to the

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[65] The option value of waiting can be significant. See, for instance, Robert McDonald and Daniel Siegel, "The Value of Waiting to Invest," NBER, NBER Working Paper, no. 1019, March 1987.

[66] Gayer and Viscusi, "Overriding Consumer Preferences with Energy Regulations," 5.

existence of free riders—that is, those who receive subsidies for appliances or equipment that they would have bought anyway. The presence of rebound effects further complicates outcomes and often leads to an overestimation of energy savings.

With these caveats in mind, it is not surprising to find that the evidence on the cost-effectiveness of energy-efficiency and conservation programs is mixed. Given the wide range of government programs and measures in place to encourage energy efficiency, few general conclusions can be derived regarding their overall efficacy. Nevertheless, more recent empirical work based on randomized trials and ex post analysis suggests that "on average the magnitude of profitable unexploited investment opportunities is much smaller than engineering-accounting studies suggest."[67] While inefficiencies in energy use can appear in certain settings where market failures are apparent, there is limited rigorous evidence of the vast and pervasive energy-efficiency gap that is promulgated by some of the large-scale engineering studies cited in the literature.

Conclusion

Regulatory regimes for promoting energy efficiency, if poorly conceived, can be costly and unintentionally cause large welfare losses. Energy, like transport and telecommunications, is a key intermediate input in most sectors of the economy, and distortions in its price or reliability can have large economic and social costs. In formulating and implementing regulations to promote energy-efficiency initiatives, it is critical that new regulations meet the tests of unbiased cost-benefit analysis. Faulty or misconceived notions about costs and benefits can lead to unnecessary and significant burdens being imposed on businesses and households. Further research should utilize randomized controlled trials and ex post analysis to estimate the impact of energy-efficiency programs in the context of heterogeneous consumers and unobserved costs and benefits.

Perhaps the most fundamental observation on optimal energy-efficiency policy is that energy conservation requires information and price signals that reflect the true social costs to be provided to energy users who then make their own choices and adjustments. While market-based instruments such as carbon taxes or permit trading regimes are not within the purview of this

[67] Alcott and Greenstone, "Is There an Energy Efficiency Gap?" 1.

paper, it is clear that for a significant number of countries, often including those that can least afford it, the single most important example of market failure is fuel and power subsidies. To capture economic benefits from market-based pricing in the key natural resource, infrastructure, and energy sectors, countries need to wean off fuel and power subsidies in favor of programs that include well-targeted social safety nets. In the context of unsustainable public sector deficits, maintaining a stable investment climate for private sector investments while implementing needed energy-sector reforms has become a careful balancing act for policymakers. Governments in many developing countries face challenges in eliciting popular support for market-oriented energy-sector reforms when political viability and durability is a higher-order criterion than economic efficiency. Similar constraints of political feasibility—for example, that of imposing gasoline taxes—have shaped the United States' federally mandated approach toward fuel-efficiency standards in the road-transport sector.

If it is claimed that households and firms are poorly informed about energy-efficiency improvements that can be profitably exploited under current conditions, an information-disclosure policy would seem to be the most direct and appropriate solution. Before regulatory agencies consider more intrusive forms of intervention, such as subsidies or imposing mandatory standards based on technology or engineering performance criteria, it should be demonstrated that private decisions are flawed and informational remedies are inadequate. It thus behooves analysts to clearly assess the costs and benefits of government energy-efficiency policies as perceived by private decision-makers and why they could systematically diverge from expert views.

Can we do better? A reasonable reading of the evidence to date suggests that the road ahead for energy-efficiency policies in the Asia-Pacific is positive. It is becoming increasingly apparent that governments can play a constructive role in mitigating market failures while avoiding wasteful subsidies and onerous mandatory performance standards with hidden costs that can impose unnecessary burdens on firms and households.