Realizing the Potential of Energy Efficiency

Targets, Policies, and Measures for G8 Countries

UNITED NATIONS FOUNDATION

Expert Report

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FOREWORD

Global climate change represents the greatest economic, political, developmental, and environmental challenge the world has ever faced. There is no longer a question of whether the world should act—it is clear that we must and we will act. In doing so, new markets, new jobs, and new opportunities will be created that will advance the common economic and environmental aspirations of all nations.

The world's scientists have spoken conclusively on the basic science of climate change. The Intergovernmental Panel on Climate Change, jointly established by the World Meteorological Organization and the United Nations Environment Programme, represents one of the most sweeping and successful scientific collaborations in history. Its Fourth Assessment reports issued throughout 2007 could not be any clearer: Human activities are altering the atmosphere, and the planet is warming. Unless we act now, with a sense of great urgency, there is an incalculable risk that the Earth's environmental systems will cross a tipping point beyond which costly, disruptive, and irreversible impacts will be inevitable.

We can avert these catastrophic impacts by moving rapidly to transform the global energy system. The good news is that energy transformation presents a historic opportunity for developed and developing countries alike. It is now clear that the costs of inaction are far greater than the costs of action. First and foremost, we have an opportunity to use energy more efficiently. Energy efficiency represents the cheapest and surest means of curbing carbon emissions and saving money for other productive uses.

Recognizing the potential of energy efficiency and the importance of spurring decisive action on climate change in the next decade, the United Nations Foundation convened a distinguished international panel of experts to identify the size of the energy efficiency opportunity and strategies for seizing it. Under the leadership of Dr. Richard Moss, this expert report proposes an ambitious but achievable goal for the Group of Eight (G8) countries—doubling their historical rate of energy efficiency improvement in sectors such as buildings, transportation, industry, and energy supply by accelerating deployment of existing technologies and altering economic incentives. The result of reaching this goal would be not only significant environmental gains, but also expanded economic opportunities, reduced energy costs, and enhanced security.

This report offers great promise and hope for accelerating the global response to the climate challenge—and for alleviating poverty and enhancing international security. Some say that efficiency lacks the constituency of other energy policy solutions, but political leaders in the G8 and elsewhere have an opportunity to change these misperceptions by aggressively promoting this low-cost, high-impact "energy source." Let us seize this opportunity for the sake of better tomorrows for all nations and future generations.

Ted Turner

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ACKNOWLEDGMENTS

Over a period of eight months, the Expert Group on Energy Efficiency debated and came to consensus on a set of policy options to inform and guide G8 efforts to improve the energy efficiency of their economies. I thank the members for their vision, which ensured that the recommendations were far reaching, and their commitment, which enabled the project to meet its ambitious deadlines.

A draft of the report benefited from the comments and suggestions of the following individuals: Dolf Geilen, International Energy Agency; Christine Egan, Collaborative Labeling and Appliance Standards Project; Wolfgang Eichhammer, Fraunhofer Institute for Systems and Innovation Research; Jose Goldemberg, University of Sao Paolo; Danny Harvey, University of Toronto; Benoit Lebot, United Nations Environment Programme; Shen Longhai, Energy Research Institute; Ajay Mathur, Bureau of Energy Efficiency; Lutz Mez, Freie Universität Berlin; Srinivasan Padmanaban, Agency for International Development; Prosanto Pal, The Energy & Resources Institute; Andrea Ricci, Istituto di Studi per l'Integrazione dei Sistemi; Walter Stahel, University of Surrey; and Hiroshi Yoshino, Tohoku University. Of course, the judgments and opinions expressed in the report do not necessarily reflect the views of the reviewers; any errors remain our own.

The project benefited from an able and supportive group of colleagues. John Schellnhuber gave us a mission and encouraged us to "think big." Jennifer Morgan provided strategic advice. Bill Chandler and Holly Gwin of Transition Energy contributed invaluable insights and helped integrate the contributions of the members of the expert group into a compelling draft. Lelani Arris edited the draft with care and insight. Leon Clarke and Skip Laitner carried out model-based analyses that add to the report's rigor. Monique Hoogwijk and Ernst Worrell worked to improve the accuracy of our depiction of the costs of the technologies we describe.

Finally, I would like to thank my colleagues at the United Nations Foundation: David Harwood, Reid Detchon, Mohamed El Ashry, Peper Long, Kurt Shickman, Ryan Hobert, Tripta Singh, Jana Gastellum, Jonathan Cass, Naja Davis, Ladeene Freimuth, Dilip Ahuja, David Gardiner, and Paul Oakley. Each made a unique contribution and helped to coalesce the many ideas, comments, and opinions we received into this final report.

Richard Moss

July 2007

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EXECUTIVE SUMMARY

Key Points

- World governments should exploit energy efficiency as their energy resource of first choice because it is the least expensive and most readily scalable option to support sustainable economic growth, enhance national security, and reduce further damage to the climate system.

- This report urges the G8 nations to increase their rate of energy efficiency improvement to 2.5 percent per year (double the global average), provides a menu of proven policy options to help guide and inform national strategies, and suggests a framework for cooperation and action within the G8+5 and beyond.

- Doubling the rate of energy efficiency improvement would:
    - Allow the world to hold CO_2 concentrations below 550 ppmv
    - Avoid $3.0 trillion worth of new generation
    - Save consumers $500 billion per year by 2030
    - Eliminate the same amount of energy supplied by 2,000 coal power plants
    - Return the globe to 2004 energy consumption levels
    - Drive business productivity improvements and new employment opportunities

Efficiency First

The need to provide adequate, sustainable, and environmentally sound supplies of energy to fuel global economic growth has created an imperative for increased energy efficiency. A strategy that emphasizes energy efficiency is the most economically and environmentally sensible way of meeting the twin objectives of providing energy for sustainable development and avoiding dangerous interference in the climate system.

Supplying energy for sustainable economic development is an objective shared by developed and developing countries alike, although the urgency is particularly great in the developing world, where large populations do not have access to modern energy services such as electricity and instead rely on traditional and often unsustainable energy sources such as fuel wood. Demand for global energy services to support economic growth has grown by 50 percent since 1980 and is expected to grow another 50 percent by 2030.

There are two options available to meet the increased demand for energy: supply more energy or improve energy end-use and supply efficiencies. Clearly, both approaches are needed. However, of the two, only energy efficiency can generate nearly immediate results with existing technology and proven policies and do so while generating strong financial returns that exceed those from investments in conventional energy supply. Simply increasing conventional energy supply is not a viable option because continued reliance on the predominant energy source, fossil fuel, exacerbates energy insecurity and raises serious environmental concerns, especially related to climate change. Deploying clean energy alternatives will be needed to meet global development and environmental objectives.

G8 Leadership Toward an Efficiency Goal

These recommendations call for the Group of Eight (G8) countries[1] to commit to a collective goal of doubling the global historic annual rate of energy efficiency improvement to 2.5 percent per year from approximately 2012 through 2030. The G8 countries have the opportunity and responsibility to take the lead and can gain clear economic and security benefits from improving their own efficiency performance. The G8 countries are economically well-positioned to begin the drive toward this goal and represent a significant share of world primary energy consumption (46 percent). In addition to improving their internal efficiency performance, G8 countries should reach out beyond their borders to the +5 and other developing countries.[2] Greater opportunities exist for significant efficiency improvements in these countries that will help them meet their goals for energy efficiency improvement and sustainable development. By working effectively with the +5 nations, the G8 countries can spur efficiency improvements in economies that together consume nearly 70 percent of global primary energy.

In a series of summit declarations, G8 leaders have recognized the importance of promoting energy efficiency as a means to save valuable resources and money, reduce pollution, and mitigate climate change. The 2005 Gleneagles Declaration expressed support for specific energy efficiency activities and policies related to buildings, appliances, transportation, industry, power generation, and other sectors. The 2006 St. Petersburg declaration reiterated support for existing proposals and extended discussions to improve efficiency to the energy supply sector. At their 2007 Summit in Heiligendamm, Germany, the G8 leaders issued a declaration that placed even more emphasis on improving energy efficiency as a means to address climate change, energy security, and sustainable development.

While important statements of principle, the Summit declarations are short on commitments to action that will bring about the substantial changes needed to improve efficiency at scales relevant to sustainable economic development and climate stabilization. The statements of the Summit should serve as a basis for G8 countries to make much more ambitious commitments to concrete actions, which would constitute a practical approach to making significant energy efficiency gains. The recommendations in this report are intended to inform and deepen the discussion of efficiency among the G8+5 countries.

This document represents the consensus of a team of international energy experts convened by the United Nations Foundation. It presents 21 proven policy options to reach the goal of 2.5 percent per year efficiency improvements and calls for a robust evaluation and review process that combines high-level political coordination with ongoing technical cooperation. The recommended implementation process includes:

a) formulating individualized national efficiency strategies by participating countries,

b) convening an annual high-level "summit" consisting of G8+5 countries to maintain the momentum of attaining efficiency goals, with supporting working groups to facilitate technical cooperation, and

c) collecting and analyzing internationally comparable data by a body such as the International Energy Agency (IEA), working with an agency of the United Nations.

The report cites a number of definitive studies that draw on the full range of established knowledge in this field. These analyses cover a wide variety of regions and countries.

1 The G8 countries are Canada, France, Germany, Italy, Japan, Russia, the United Kingdom, and the United States.
2 The +5 countries are Brazil, China, India, Mexico, and South Africa.

Doubling Efficiency: Ambitious but Achievable

There is a wide body of evidence demonstrating that a significant proportion of the potential for energy efficiency improvement remains untapped. The difference between the actual level of investment in energy efficiency and the higher level that would be economically beneficial from the consumer's (i.e., the individual's or firm's) point of view is often referred to as the "efficiency gap" and is generally caused by market failures and barriers.

This gap can be reduced with significant economic and environmental benefits. Attaining a 2.5 percent annual improvement in energy efficiency would reduce G8 energy demand by about 20 percent in 2030, avoid the consumption of 55 exajoules[3] of primary energy in the G8 (equivalent to the output of more than 2,000 power stations), and return energy consumption to 2004 levels.[4] While 55 exajoules is only about 25 percent of the total global demand growth projected by the IEA, reducing energy demand by that amount in only the G8 countries would offset the equivalent of 80 percent of the increased energy supply needs currently projected to be met by coal-generated power.

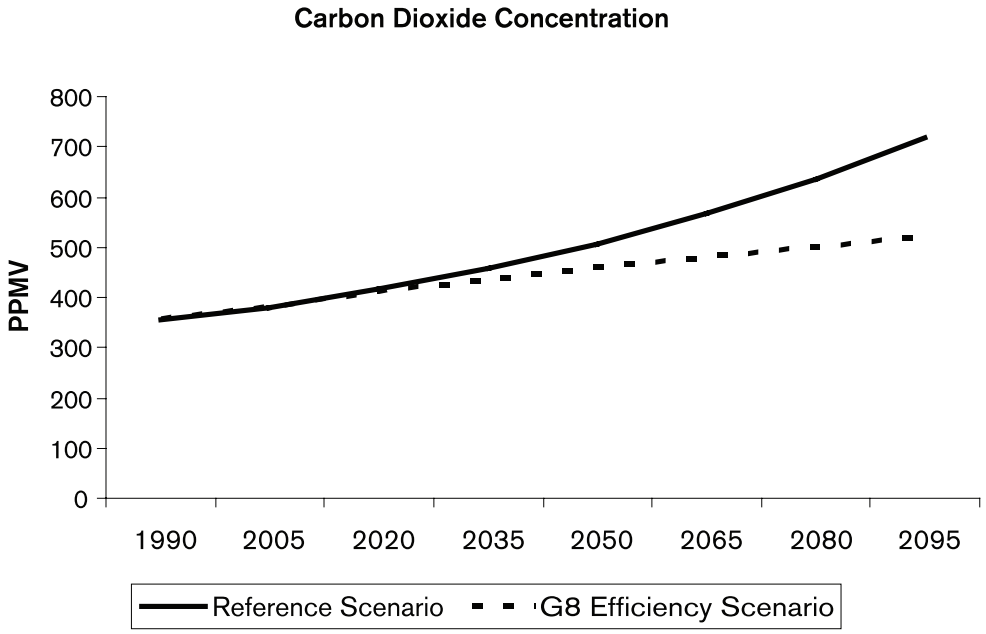


Figure ES-1. Comparison of the "2.5 percent efficiency scenario" proposed in this report to a reference scenario prepared for the US Climate Change Science Program. If extended globally, this scenario would hold atmospheric CO_2 concentrations below 550 ppm. The reference scenario for these calculations is defined in Clarke et al. (2007) and differs from the IEA reference scenario cited elsewhere in this report in that it assumes lower economic growth. Results for the 2.5 percent scenario were calculated using the Pacific Northwest National Laboratory's "MiniCAM" integrated assessment model specifically for this report.

3 An exajoule (EJ) is slightly less than a quadrillion British thermal units (BTUs), more commonly shortened to "quad." Thus, 55 EJ is about 52 quads.

4 The calculation assumes the Reference Case of the IEA World Energy Outlook 2006 (IEA, 2006c) as the baseline scenario. The power plant calculation assumes a 1,000 megawatt (MW) generating facility operating at 85% annual availability. Achieving this goal globally would avoid the consumption of 97 EJ.

Improvements in efficiency drive down energy consumption and, in turn, reduce greenhouse gas emissions. The calculations in this document assume that the 2.5 percent rate of efficiency improvement is maintained through 2030 and then declines linearly to 1.0 percent in 2100. As figure ES-1 shows, modeling completed for this report reveals how integral an ambitious efficiency strategy is to addressing the looming climate crisis.

If the goal of doubling the rate of energy efficiency improvement were extended worldwide, it would be possible to keep carbon dioxide (CO_2) concentrations in the atmosphere below 550 parts per million through the end of the century.[5] If development of low- or non-CO_2 emitting supply technologies were accelerated, attaining even lower stabilization levels would be possible.

Doubling the rate of energy efficiency improvement in the G8 is neither trivial nor impossible. The target is proposed as an average for the G8, and different nations will achieve different rates of improvement. Some countries are already much more efficient than others. As Figure ES-2 shows, a strategy to achieve 2.5 percent annual efficiency improvements is more ambitious than, but not significantly beyond, assumptions in existing global and regional energy forecasts.

To achieve this goal, the G8 must apply ingenuity, technology, and capital to get more economic benefit out of every unit of energy produced and consumed. While each G8 nation will strive for its goal using a different collection of policies and measures, a sustained, high-level commitment to improve energy efficiency is a common requirement for success.

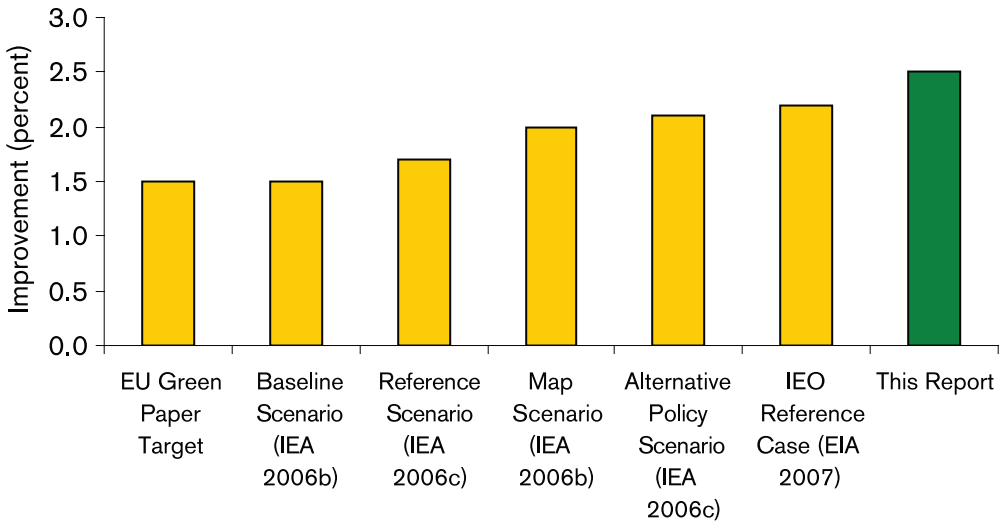


Figure ES-2: Assumptions of annual efficiency improvements from selected energy projections. Recommendations in this report call for slightly more aggressive annual improvements in efficiency than recent energy scenarios assume.

5 These results were prepared for this study using the MiniCAM Model of the Joint Global Change Research Institute, a partnership between the Pacific Northwest National Laboratory and the University of Maryland (see Clarke et al., 2007).

Economic Benefits of Energy Efficiency

Given the need to support sustainable global economic development, investments in efficiency offer the most financially favorable returns of any energy policy option. The Reference Scenario in the IEA's *World Energy Outlook 2006* (IEA, 2006c) estimates that investments of US$20 trillion for energy supply will be needed to meet global demand through 2030.[6] This report estimates that an investment of US$3.2 trillion[7] will be required worldwide to double the rate of energy efficiency improvement, US$2.3 trillion of which will be invested by the G8 countries. These efficiency investments avoid new supply investments of US$3 trillion worldwide and US$1.9 trillion in the G8 countries, and result in a net incremental investment of US$200 billion worldwide and US$400 billion in the G8 countries.

These relatively small net efficiency investments generate significant additional benefits in improved business productivity and reduced consumer energy bills worth approximately US$500 billion annually by 2030. This implies an average payback of approximately three to five years for the efficiency investments needed to reach the target suggested in this report.

Other major forecasts have also identified the significant economic benefits of efficiency investments. The IEA's *World Energy Outlook* (WEO) 2006 (IEA, 2006c) and the 2007 Report of Working Group III of the Intergovernmental Panel on Climate Change (IPCC, 2007) identified significant cost-effective potential for energy efficiency to reduce greenhouse gas emissions over the next 20 to 30 years. For example, the WEO (IEA, 2006c) showed that the high-efficiency Alternative Policy Scenario yielded "substantial savings in energy consumption and imports compared with the Reference Scenario. They thereby enhance energy security and help mitigate damaging environmental effects. *Those benefits are achieved at lower total investment cost than in the Reference Scenario*" (emphasis added). Similarly, the IPCC (2007) report clearly showed that energy efficiency policies play a critical part in cost-effective strategies for reducing CO_2 emissions in the near term.

Many corporations, including multinationals Wal-Mart, Dow, Philips, Unilever, and 3M, have voluntarily undertaken substantial internal energy efficiency campaigns because these projects represented a good return on their investment.

In addition to the inherent economic advantage of efficiency investments, improved efficiency will help mitigate energy price increases and volatility by easing short- and medium-term imbalances between demand and supply and will also help reduce CO_2 emissions.

The Way Forward: Policy Options to Meet the Goal

This document does not recommend a "one size fits all" strategy but rather suggests a menu of policy options and measures to help countries achieve their efficiency targets. Each country will select the policies that best suit its efficiency commitment as well as its unique economic, social, and political situation. Examples of policy recommendations detailed in this report include:

Economy-Wide Policies to Improve Efficiency: There are pro-efficiency policies that have impacts across the economy and in all sectors. G8 governments have a variety of options to consider. For example, they could consider phasing out subsidies to established energy sources, many of which are also carbon-intensive. Energy

6 Reference Case, IEA 2006c. The high-efficiency Advanced Policy Scenario of the IEA *World Energy Outlook 2006* assumes an incremental investment in efficiency of US$600 billion that is offset by US$700 billion in avoided investment in new generation.

7 Investments include the costs of physical upgrades and the purchase of high-efficiency appliances and vehicles.

supply subsidies distort the price signal for demand-side energy efficiency investments, and reduce costs to energy companies and consumers at the expense of the taxpayer.

The G8 governments could establish a small surcharge (e.g., 0.5 to 1 percent) on every dollar of energy sales to fund efficiency activity and investment. Several US states, South Korea, and Switzerland have successful surcharge programs currently in place.

Creating innovative financing structures and developing a more robust energy service company (ESCO)[8] industry to reduce the risks and up-front costs of energy efficiency investments is another option. Additionally, multilateral organizations and export credit agencies need guidance from international leaders to direct investments and foreign aid in the energy arena toward energy efficiency in newly industrialized, transition economy, and developing countries.

G8 governments could emphasize efficiency in procurement strategies. Governments should routinely review procurement specifications for vehicles, equipment, and buildings to ensure that each achieves "best-in-class" efficiency performance. National governments can provide incentives to exceed minimum efficiency purchasing standards and encourage procurement of efficient fleets and products at a regional and local level to drive further improvements.

Public information on the importance of efficient energy consumption as well as practical ways to adopt efficient practices in homes and businesses are two other important strategic options.

Improving Efficiency of Buildings and Equipment: Residential electricity consumption is one of the fastest-growing areas of energy use, especially in developing countries.

In the commercial sector, electricity consumption is growing faster than the overall economy, especially in countries with air conditioning requirements. There are many potential improvements to be made in this sector.

This report recommends that countries adopt stronger building codes, engage the ESCO market to aggressively refurbish existing building stock, and encourage the installation of advanced lighting. Governments should also develop and implement incentives and other measures to ensure that new buildings are designed and constructed to be as energy efficient as possible.

In the appliance sector, the document recommends that internationally coordinated minimum performance standards be adopted for specific equipment classes in conjunction with support for research and development to help manufacturers achieve the new targets. The IEA and other bodies have initiated work in this area, but product labeling should be further standardized and improved to allow consumers to make more informed decisions, and incentives should be provided to improve market penetration of the most energy efficient products.

Improving Industrial Efficiency: Industry accounts for nearly 40 percent of worldwide energy use. Historically, industrial energy efficiency has improved at a rate of 1 percent annually, but experience demonstrates that improvements can occur at twice this rate over medium- or longer-term time frames (i.e., 10 years or more). The necessary conditions to set the stage for substantial improvements in industrial energy efficiency include access to information; improved decision-making processes; access to financing, company (human) resources, and technology; and the ability to measure and verify the achieved energy savings.

8 Energy service companies (ESCOs) invest in energy efficiency improvements for third parties and rely on a contract with owners to recoup their investment.

A variety of policies and measures can help create these necessary conditions and reduce actual or perceived barriers. Governments can focus the attention of corporate senior leadership on efficiency by working with industrial users to establish an energy management standard and by providing forums to share best practices across firms and industrial sectors. Governments and industry may also choose to work together to establish binding targets similar to the Long-Term Agreement process in the Netherlands.

Improving Transportation Efficiency: Transportation accounted for 26 percent of total global energy use in 2004 (IEA, 2006c). Light-duty vehicles and freight trucks accounted for some 45 percent and 25 percent of this global total, respectively. Energy use for transportation is likely to increase dramatically in the coming decades as the world's economies develop. If transportation services are not made more efficient, energy use in the sector will continue to grow rapidly in both absolute and relative terms.

The costs of energy consumption in the transportation sector are huge, in terms of overall expenditures, oil imports, climate change, and other environmental impacts, yet many countries' transportation systems are surprisingly inefficient. The development and penetration of advanced technologies will depend as much on political and institutional issues as on technological ones.

Policy options include establishing coordinated standards to reduce carbon emissions from vehicles, providing incentives for the purchase of fuel-efficient, low-emission vehicles, and directing the replacement and/or recycling of the existing inefficient vehicle stock. Governments should lead by example and aggressively reduce both fuel and carbon intensities of the public vehicle fleet. Greater use of more efficient mass transit, rail, and air transportation should be encouraged through national and local policies. Governments should also consider upgrading transportation infrastructure to improve efficiency and providing incentives for "teleworking."

Improving Energy Supply Efficiency: Four policies in particular offer great potential for savings from energy suppliers: innovative utility rate structures that provide incentives for efficiency; more combined heating, cooling, and power installations; greater efficiency in existing generation and transmission infrastructure; and reductions in natural gas flaring.

Utility regulations can be realigned to provide utilities with incentives for reduced consumption rather than increased generation. Historically, electric utilities have been compensated for building power generation and transmission infrastructure, and for selling electricity. Rate structures should be revised to reward utilities for meeting the demand for energy services by increasing end-use energy efficiency. Modernization of the electricity grid should also be encouraged and will have many other benefits in addition to greatly enhancing energy efficiency, including reducing the need for new capacity, increasing the ability to integrate intermittent renewable energy generation into the grid, and greatly improving grid security and reliability.

Highly efficient combined heating and power operations should be expanded. Combined heating, cooling, and power (CHP, or cogeneration), the conversion of fuels to electric power in conjunction with the generation of heat for industrial processes or buildings, can be twice as efficient as current central station power generation. Generating power simultaneously with heat uses 80 percent or more of the useful energy in fuel compared to 35 to 50 percent of the useful energy in fuel when used for power alone. Governments should aim to increase penetration of CHP to at least 20 percent of total generation by 2020 by making it easier for facilities to sell excess electricity and heat into distribution grids and encouraging municipalities to adopt CHP where feasible.

Governments should help drive greater efficiency in existing coal and natural gas facilities by setting minimum efficiency targets and pursuing public–private partnerships to encourage research and development and reduce risks associated with demonstration projects. The report recommends a minimum standard for new and

recommissioned fossil fuel power plants of 50 percent efficiency for coal plants and 60 percent for natural gas plants by 2030. Transmission infrastructure, particularly for natural gas, should be improved to reduce energy loss during transportation.

Reducing gas flaring is an area that is particularly ripe for able, enlightened leadership. Governments should immediately encourage the natural gas industry to accelerate modernization of high-pressure transmission pipelines. Over the next year, governments could also restructure gas utility pricing to create incentives for reduced leakage. In particular, governments could ensure through regulatory reform that producers of associated gas[9] have access at a market-based price to existing high-pressure transmission pipelines that could connect them to a ready marketplace.

Improving Energy Efficiency in Developing and Transition Economies: It is unavoidable that energy consumption will continue to grow in developing countries. Developing and transition-economy countries may have more energy-intensive growth than developed nations because of their need to manufacture energy-intensive materials for construction and infrastructure. Recognizing the need for this difference in the structure of economic activity, there is still scope for attaining more economic benefit from each unit of energy consumed thus making the citizens of all countries better off. Acute energy shortages in key developing economies such as China and India highlight that energy efficiency is key to sustained and sustainable economic development. Many rapidly developing countries have already set ambitious objectives for improving energy efficiency.

The G8 countries can play a critically important role in driving global sustainable development by helping developing and transition economies to incorporate modern and efficient technologies in both the supply and the demand sectors as they develop. Specifically, G8 countries can provide technical assistance, work with international financial institutions to establish loan guarantee funds for efficiency investments, invest in human and institutional capacity building, and foster the export market for energy efficient technologies while simultaneously reducing the flow of inefficient second-hand technology.

Working Together To Achieve the Goal

Efficiency improvements at the scale proposed in this report will provide a bridge to affordable low- and zero-carbon energy systems of the future. Leaders of the G8 countries must find the will to take advantage of this opportunity to increase energy efficiency and make it the essential first step for avoiding dangerous human interference in the climate system. Nongovernmental organizations, interested businesses, financial institutions, and other levels of government must also play a role by holding G8 leaders to account and issuing periodic evaluations on national progress. Climate stabilization, sustainable development, and energy security ultimately depend on society's steps along this path, and we must work together to ensure progress.

9 Associated gas is natural gas that is co-located with oil deposits.

I. OVERVIEW: THE OPPORTUNITY AND THE GOAL

The need to provide adequate, sustainable, and environmentally sound supplies of energy to fuel global economic growth has created an imperative for increased energy efficiency. A strategy that emphasizes energy efficiency is the most economically and environmentally sensible way of meeting the twin objectives of providing energy for sustainable development and avoiding dangerous interference in the climate system. Energy efficiency can generate nearly immediate results with existing technology and policies and do so while generating strong financial returns. Efforts to promote efficient use of energy in the past have been limited in scope yet have driven significant energy and economic savings. An ambitious strategy to remove further barriers to efficiency will address both the energy and climate challenges that confront humankind in the 21st century. Efficiency improvements at the scale proposed in this approach will provide the bridge to more promising low- or zero net carbon energy technologies of the future.

The recommendations in this document are addressed to the Group of Eight (G8) governments (Canada, France, Germany, Italy, Japan, Russia, the United Kingdom, and the United States) to encourage them to demonstrate leadership. The study's recommendations are built around an overall global goal, a process of national pledges or targets for energy efficiency improvement at the economy-wide and sectoral levels, a menu of proven policy options to close the efficiency gap for implementation within countries, and an international process for monitoring progress and identifying options for international cooperation to accelerate this progress.

The energy efficiency options included in this report can also benefit countries outside of the G8. Indeed, several major developing countries have already set even more ambitious goals for themselves. By implementing the recommendations in this report on supporting developing countries, G8 countries can accelerate efficiency improvements in developing countries, thereby laying the foundation for partnerships that will augment sustainable economic growth.

The G8+5 and Energy Efficiency

The G8 is an informal forum for eight countries that together comprise some two-thirds of the global economy and 70 percent of global energy consumption. Under a rotating Presidency, the eight countries gather each year in several ministerial meetings and a summit for heads of state to share information and coordinate policies on key issues such as the economy, terrorism, trade, foreign affairs, energy, and the environment. The G8 countries have coordinated with five key developing countries (China, Indian, Brazil, Mexico, and South Africa) through a process known as the "G8+5."

The Gleneagles Summit declaration recognized the importance of promoting energy efficiency as a means to save valuable resources and money, reduce pollution, and mitigate climate change. The 2005 Gleneagles Plan of Action called for specific energy efficiency activities and policies related to buildings, appliances, transportation, industry, power generation, and other sectors. G8+5 leaders also established the Gleneagles Dialogue on Climate Change, Clean Energy and Sustainable Development to explore, in a more informal setting, measures for addressing climate change.

The St. Petersburg Plan of Action reiterated support for existing proposals, such as the International Energy Agency's (IEA) 1-Watt Initiative[10] on standby power, and extended discussions to improve efficiency in the energy supply sector, including natural gas.

10 The 1-Watt Initiative is an attempt to harmonize energy policies to reduce appliance standby power usage to one watt per device.

At the 2007 Summit in Heiligendamm, Germany, the G8 issued a declaration that placed even more emphasis on improving energy efficiency as a means to address climate change, energy security, and sustainable development, noting that the "global potential for saving energy is huge" and that "successfully implemented energy efficiency policies could contribute to 80% of avoided greenhouse gases while substantially increasing security of supply." The declaration highlights opportunities for efficiency improvements in several end-use sectors and establishes a "Sustainable Buildings Network."

The energy efficiency statements adopted at prior G8 summits are important recognitions of the potential importance of energy efficiency in cost-effectively addressing climate change and energy security challenges. However, the Summit declarations are short on commitments to action that will bring about the substantial changes needed to improve efficiency at scales relevant to sustainable economic development and climate stabilization. Moving forward, the statements of the Summit should be used as a basis for G8 countries to make much more ambitious commitments to take concrete actions, which would constitute a practical approach to making significant energy efficiency gains.

These recommendations are intended to inform and deepen the discussion of efficiency among the G8+5 countries through their existing dialogues and meetings and to support the extension of the important first steps taken at Heiligendamm into a formal pledge to act followed by concrete actions.

Meeting Growing Energy Demand

Demand for global energy services to support economic growth has grown by 50 percent since 1980 and is projected to grow another 50 percent by 2030, or nearly 250 exajoules[11] (IEA, 2006c). There are two options available to meet the increased demand for energy: increase supply or improve energy end-use and supply efficiencies. Clearly, both approaches are needed. But of the two, only energy efficiency can generate nearly immediate results with existing technology and proven policies and do so while generating strong financial returns that exceed those from investments in conventional energy supply.

Box 1: A Note on Cited Studies

The existing literature, with some limited new economic and integrated assessment modeling, forms the basis of this report. Different studies focus on different groups of countries–the G8, the Organisation for Economic Co-operation and Development (OECD), the +5, and the global economy–and thus this report describes energy and economic savings for different country groupings, which sometimes makes comparisons of results difficult. The table below compares the relative size of different regions cited in studies throughout the report so readers can better understand how they relate to one another.

	Primary Energy Consumption (2005)				
	G8	**OECD**	**+5**	**G8+5**	**World**
Exajoules	204	233	102	306	443
G8 as a percent of region	100%	88%	n/a	67%	46%
G8+5 as a percent of region	n/a	131%	n/a	100%	69%

Energy consumption in the G8 and G8+5 comprises a significant share of consumption of regional groupings used in some of the supporting analyses in this document.

11 An exajoule is slightly less than a quadrillion British thermal units (BTUs), more commonly shortened to "quad." The amount cited here, 55 EJ, is thus about 52 quads.

Simply increasing conventional energy supply is not a viable option for the future because continued reliance on the predominant source, fossil fuel, exacerbates energy insecurity and raises serious environmental concerns, especially related to climate change. The burning of fossil fuels to meet energy demand has increased atmospheric concentrations of greenhouse gases, thus altering the Earth's climate, with potentially disastrous consequences. Humankind must rapidly reduce greenhouse gas emissions to avoid dangerous interference in the climate system. Alternative low- or non-carbon energy sources, while promising, still require significant development before they are ready to meet future demand for energy services at the scale required.

Supplying energy services for sustainable economic development is not just a priority for developed countries, it is also an objective shared by developing countries, where large populations do not have access to modern energy services such as electricity and instead rely on traditional and often unsustainable energy sources such as fuel wood. Developing countries that currently use far less energy per capita than the G8 will account for 70 percent of the new growth in energy demand. Designing and building efficient energy infrastructure in developing countries is the most promising approach for supplying energy services in an environmentally sustainable way.

Deploying clean energy alternatives to fossil fuels is an important part of the long-term strategy to meet global development and environmental objectives. However, a strategy with a singular focus on clean energy supply that is not matched with an urgent, full-scale effort to improve energy productivity will come too late and cost too much.

Doubling Efficiency: An Ambitious Goal

Based on extensive consultations with senior energy experts from around the world, this report proposes that G8 countries pledge to double their historical rate of energy efficiency improvement. This translates roughly to a 2.5 percent annual improvement. If the G8 countries achieve that level by approximately 2012 and maintain it through 2030, it would reduce their energy demand by about 20 percent in 2030 and avoid the consumption of 55 exajoules (EJ) of primary energy in the G8[12]—avoiding about 2,000 coal-fired power stations[13] or the equivalent of 80 percent of the 70 EJ of future demand projected by the IEA to be met by coal power. Accomplishing a 2.5 percent efficiency improvement on a worldwide basis would save 97 EJ and return energy consumption to 2004 levels.[14]

Importantly, doubling the rate of energy efficiency would make it possible to keep carbon dioxide (CO_2) concentrations in the atmosphere below 550 parts per million (ppm) through the end of the century if the goal were expanded worldwide.[15] This calculation is based on the assumption that the 2.5 percent improvement through 2030 then linearly falls to 1 percent by 2100, a conservative approach intended to address the view that efficiency improvements will become marginally more expensive in the long run. Figure 1 illustrates the importance of robust efficiency improvements in the strategy to mitigate climate change.

12 The G8 goal has been evaluated by the United Nations Foundation expert group as having little net impact on Gross Domestic Product growth (Laitner, 2007b).
13 The power plant calculation assumes a 1,000 megawatt (MW) generating facility operating at 85% annual availability
14 The calculation assumes the Reference Case of the IEA World Energy Outlook 2006 (IEA, 2006c) as the baseline scenario.
15 These results were prepared for this study using the MiniCAM Model of the Joint Global Change Research Institute, a partnership between the Pacific Northwest National Laboratory and the University of Maryland (see Clarke et al., 2007).

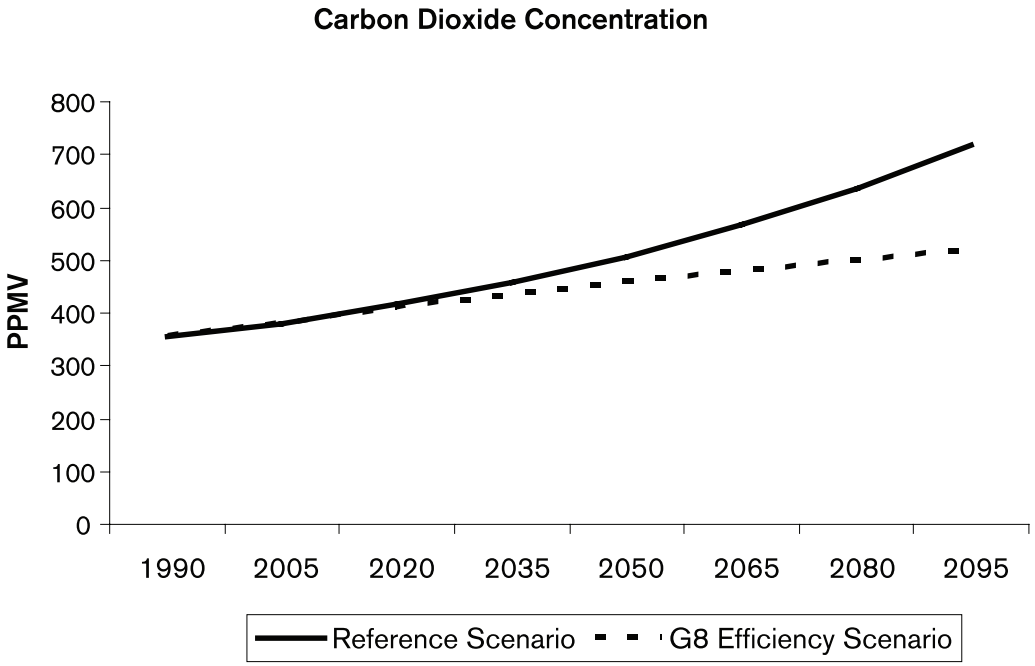


Figure 1. Comparison of the "2.5 percent efficiency scenario" proposed in this report to a reference scenario prepared for the US Climate Change Science Program. If extended globally, this scenario would hold atmospheric CO_2 concentrations below 550 ppm. The reference scenario for these calculations is defined in Clarke et al. (2007) and differs from the IEA reference scenario cited elsewhere in this report in that it assumes lower economic growth. Results for the 2.5 percent scenario were calculated using the Pacific Northwest National Laboratory's "MiniCAM" integrated assessment model specifically for this report.

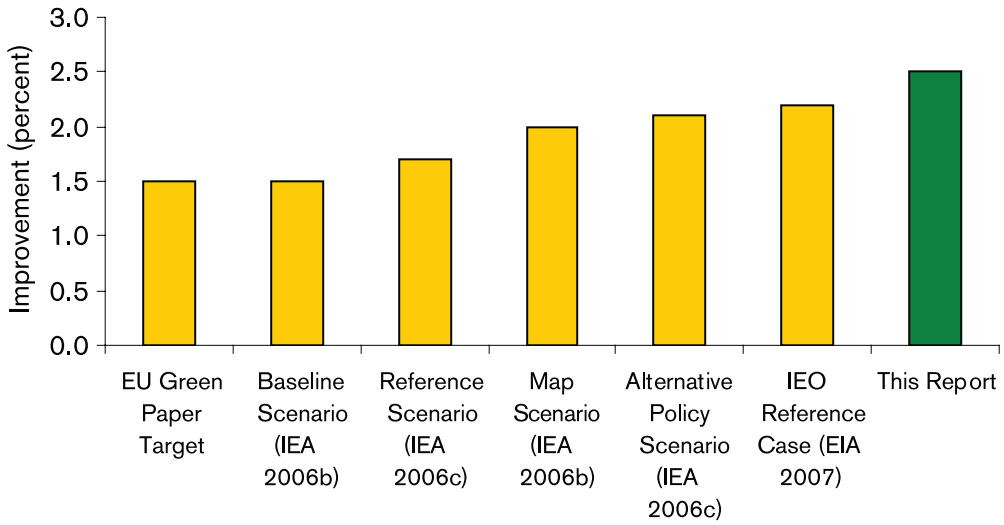


Figure 2. Assumptions of annual efficiency improvements from selected energy projections. Recommendations in this report call for slightly more aggressive annual improvements in efficiency than recent energy scenarios assume.

The goal suggested for the G8 is neither trivial nor impossible. The target is proposed as an average for the G8, and different nations will achieve different rates of improvement based on their unique conditions. Some countries are already much more efficient than others and may have less opportunity to earn strong returns from efficiency. However, studies indicate that improvements of almost 25 percent (that is, greater than the 20 percent improvements needed to meet a 2.5 percent annual target) are economically and technically achievable prior to 2030, even in the most energy-efficient countries, including Japan (Kanekiyo, 2006). As Figure 2 shows, a strategy to achieve 2.5 percent annual efficiency improvements is more ambitious than, but not significantly beyond, assumptions in existing global and regional energy forecasts.

To achieve this goal, the G8 must apply ingenuity, technology, and capital to get more economic benefit out of every unit of energy produced and consumed. This average international target applies across all sectors–industry, buildings, transport, and residential–and thus offers numerous differentiated national opportunities for attaining it.

Feasibility of the Goal: Experience and Evaluations of Efficiency Potential

Between 1990 and 2005, global energy intensity fell at a relatively steady rate, between 1.0 percent and 1.5 percent per year. Driven by market forces alone, the rate of efficiency improves relatively slowly due to market failures and barriers. In fact, economists once thought that energy use and the economy moved in lockstep, and that the economy could not grow without commensurate growth in energy consumption. Many countries, however, including the United States in the 1970s, China during the 1980s and 1990s, and the Commonwealth of Independent States (CIS) during 2000 to 2005, have shown a remarkable ability to decouple the demand for energy services and economic growth. These nations have at times exceeded the rate of efficiency improvement proposed in this report. Figure 3 illustrates energy intensity trends by region from 1980 to 2005.

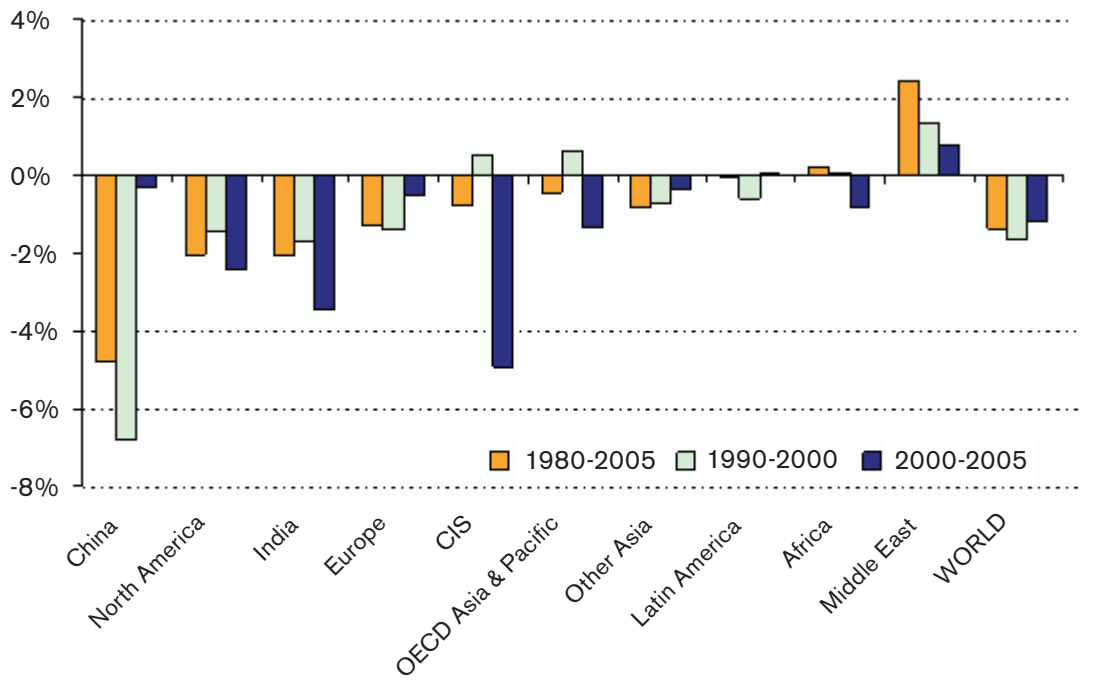


Figure 3. Energy intensity trends by region, 1980 to 2005. Energy intensity is measured in purchasing power parity, which corrects for distortions in exchange rates (WEC-ADEME, 2007).

There is a wide body of evidence demonstrating that a significant proportion of energy efficiency improvement potential remains untapped. The difference between the actual level of investment in energy efficiency and the higher level that would be economically beneficial from the consumer's (i.e., the individual's or firm's) point of view is often referred to as the "efficiency gap" and is generally caused by market failures and barriers. Many studies have documented the existence of this gap (Ecofys, 2001; Interlaboratory Working Group, 2000; DLR, 2007; IPCC, 2001, 2007).[16]

As illustrated in Figure 4, between 1990 and 2006 energy productivity improvements saved more energy than was provided by new energy supplies (e.g., new oil and gas fields, coal, nuclear, hydropower, and renewable resources), even without an ambitious effort to accelerate energy efficiency as recommended in this report. In other words, since 1990, *energy efficiency met more than half of all new demand for worldwide energy services*. These annual savings—amounting to 127 EJ in 2006, a reduction of more than 20 percent compared to a business-as-usual path—have a value of US$1.5 trillion.[17]

Governments have traditionally approached energy efficiency policy in a piecemeal fashion rather than from a comprehensive economy-wide perspective. Table 1 provides an overview of efficiency policies in place in G8 countries in 2006. Often, governments provide incentives to accelerate the uptake of a particular technology or product (e.g., compact fluorescent lamps). Countries in the OECD have achieved many successes using targeted actions to improve energy efficiency. Japan, for example, has improved the efficiency of electrical appliances using increasingly ambitious standards established under its "Top Runner" program (discussed in Section IV). The United States also has a record of great success with appliance efficiency standards. The European experience with voluntary industrial energy efficiency goals is also positive, with European

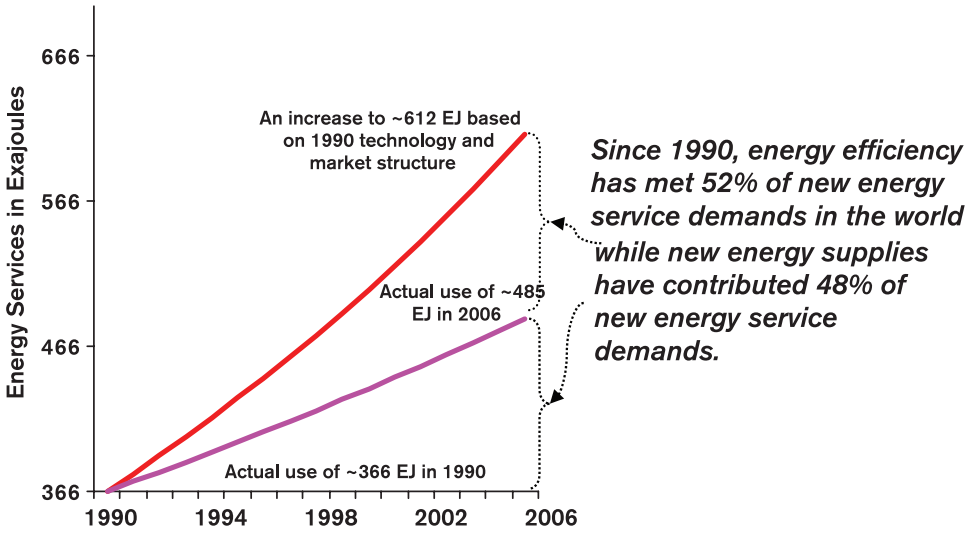


Figure 4. Meeting demand for energy services with energy efficiency. Without new efficiency investments, worldwide energy use in 2006 would have been twice the 1990 level. "Energy efficiency" is broadly defined here as the difference between the 1990 and 2006 energy intensities.

16 Although there is some debate about the actual existence of the energy efficiency gap (see for example Sutherland, 1991).

17 This calculation of energy savings compares recent energy use with projected use based on "frozen energy efficiency" levels using average energy prices at the point of end use. It assumes an average price of energy of about US$12 per gigajoule (Private Communication, John "Skip" Laitner, American Council for an Energy-Efficient Economy, Washington, DC, April 2007).

manufacturers reaching their goal of cutting energy use by 20 percent between 1994 and 2000 ahead of schedule. In Russia, the energy required per unit volume in new buildings has been cut by 60 percent compared to just one decade ago, and plans are underway to further tighten these standards. While these efforts are laudable, they leave much efficiency potential untapped, especially when compared to what could be achieved with a more comprehensive approach.

In addition to programmatic approaches, efforts have been made to bolster financial programs to facilitate efficiency improvements. For example, the International Finance Corporation has implemented a number of successful energy efficiency loan guarantee programs, including one in Central Europe and another in China. Pilot programs to test trading mechanisms based on verified efficiency gains in the United Kingdom, France, Italy, and Australia are underway and appear to have met with some early success. Much more could be done to ensure international financial institutions and donor agencies incorporate efficiency when analyzing potential projects.

A large number of studies demonstrate the huge technical and economic potential of energy efficiency, and expert organizations have already identified it as a "top priority" in meeting world energy needs.[18] The McKinsey

Table 1. Elements of national energy efficiency policies in place in 2006 (derived from Annex 2 of WEC-ADEME, 2007).

Policy	Canada	France	Germany	Italy	Japan	Russia	UK	US
Appliance Labels & Standards[1]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Building Standards[2]	No	Yes	Yes	Modest	Yes	Yes	Yes	Modest[3]
Fiscal Incentives[4]	Few	Some	Yes	Few	Yes	Few	Yes	Some
Voluntary Agreements	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Auto/Fuel Policies[5]	No	Yes	Yes	Yes	Yes	No	Yes	No

Notes:

[1] "Yes" means mandatory standards are imposed on several major appliances surveyed, including refrigerators, washing machines, air conditioners, lamps, and water heaters.

[2] "Yes" means that standards requirements have been increased for the last five years; "No" means that standards are not mandatory.

[3] Construction standards in the United States are promulgated and implemented at the state and local government levels.

[4] "Few" means incentives do not cover all sectors or involve only audits and not tax credits, soft loans, or guarantees. "Some" means partial coverage of one or more sectors.

[5] "Yes" means high taxes on motor fuels and annual or purchase taxes on cars, or high fuel economy standards.

18 The terms energy productivity and energy efficiency can be used interchangeably with the phrase "reduction in energy intensity," where the latter is defined as a reduction in energy per unit of Gross Domestic Product. Indeed, the United Nations formally defines energy efficiency improvement as the reciprocal of reduction in energy intensity. Energy intensity is not necessarily a measure of economic efficiency, because industrial structures and climates influence the level of energy intensities. High energy intensity could be economically efficient in places where energy costs are low, or where a less-developed country must produce large quantities of energy-intensive basic materials for building up their infrastructures and capital stock. But high energy intensities may also point to economic inefficiencies. (See also Chandler, 2000).

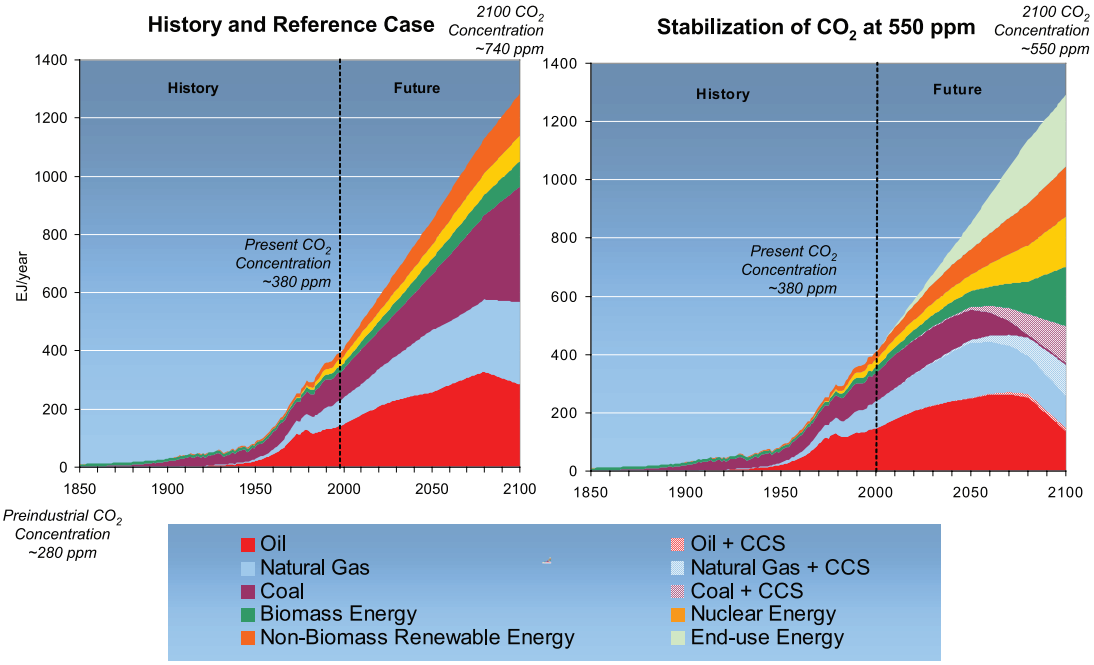


Figure 5. Contribution of various energy sources to global energy demand for a reference case (left panel) and a stabilization case (right panel). Estimates from the Battelle Global Energy Technology Strategy Project show that energy efficiency ("End-use Energy" shown in the top wedge at right) will play a critical role in keeping atmospheric CO2 concentrations below 550 ppm.

Global Institute recently reported that efforts to improve energy productivity could cut worldwide energy demand growth by more than half between now and 2020,[19] totaling 142 EJ of avoided annual energy demand, which is equivalent to almost 150 percent of current total US energy consumption (McKinsey Global Institute, 2007) or the production of over 5,000 power plants.[20]

In the IEA's Accelerated Technology Scenarios, prepared to support the G8 Gleneagles Plan of Action, efficiency improvements made the single largest contribution to slowing growth in baseline energy demand and reducing CO_2 emissions. Energy efficient end-use technologies can hold total primary energy use in 2030 in the G8 countries to roughly the same level as in 2004 (IEA, 2006b)—a reduction of 22 percent compared to the Reference Scenario.[21] Figure 5, from a recent study by the Battelle Global Energy Technology Strategy Project (Edmonds, 2007), highlights the importance of realizing the potential of energy efficiency if atmospheric CO_2 concentrations are to remain under 550 ppm.

19 The McKinsey report assumed that energy demand growth of 2.2 percent is reduced to approximately 1 percent and conservatively assumes a static policy environment and minimal changes in technology. The cumulative improvements exceed this report's forecasts (142 EJ versus 97 EJ) primarily because of the difference in estimated demand growth (2.2 percent in McKinsey versus 1.1 percent in this report).

20 An exajoule is slightly less than a quadrillion BTUs (British thermal units), more commonly shortened to "quad." The amount cited here, 142 EJ, is thus about 135 quads. The power plant calculation assumes 1,000 MW generating facility operating at 85% annual availability.

21 The rate of efficiency improvement for this scenario is 2 percent and is shown in Figure ES-1 as the "IEA Map Scenario"

Economic Benefits of Energy Efficiency

Given the need to support sustainable global economic development, investments in efficiency offer the most financially favorable returns of any energy policy option. The Reference Scenario in the IEA *World Energy Outlook* (WEO) 2006 (IEA, 2006c) estimates that investments of US$20 trillion for energy supply will be needed to meet global demand through 2030. More than half of the demand growth is projected to occur in developing countries.[22] This report estimates that an investment of US$3.2 trillion will be required worldwide to double the rate of energy efficiency improvement, US$2.3 trillion of which will be invested by the G8 countries. These efficiency investments avoid new supply investments of US$3 trillion worldwide and US$1.9 trillion in the G8, and result in a net incremental investment of US$200 billion worldwide and US$400 billion in the G8 countries. Investments will include physical upgrades and the purchase of high-efficiency appliances and vehicles.

Efficiency investments generate additional benefits by improving business productivity and reducing consumer energy bills. Businesses and consumers in the G8 economies will save more than US$500 billion annually by 2030[23] as a result of the recommended investment in efficiency. The benefits generated by the net incremental investment imply an average payback of approximately three to five years. With this more productive pattern of investment, G8 leaders will improve the energy productivity of their countries–at a substantial benefit to both their economies and the global climate.[24]

Many studies have attempted to quantify the economic benefits of energy efficiency improvements, including the US National Academy of Sciences (1991), the Intergovernmental Panel on Climate Change, (IPCC, 1996, 2001), and the Australian government (Commonwealth of Australia, 2004). The IPCC (2001) concluded that *half* of the potential emission reductions could be achieved through energy efficiency improvements by 2020 with direct benefits (energy savings) exceeding direct costs (net capital, operating, and maintenance costs).

More recently, the IEA's WEO (IEA 2006c) and the IPCC's Working Group III report (IPCC, 2007) concluded that many measures to improve energy efficiency have negative costs. For example, the substantial savings in energy consumption in the high-efficiency Alternative Policy Scenario in the WEO "are achieved at lower total investment cost than in the Reference Scenario." Similarly, the IPCC (2007) clearly showed that energy efficiency policies play a critical part in cost-effective strategies for reducing CO_2 emissions.

In addition to the inherent economic advantage of efficiency investments, improved efficiency will help mitigate energy price increases and volatility by easing short- and medium-term imbalances between demand and supply.

Policy Option Summary

The efficiency goals proposed in this report reflect the magnitude of energy efficiency resources available for exploitation using existing technologies. Like estimates of conventional energy reserves, the efficiency resources that can be accessed using existing technologies will vary over time as prices change and technologies advance. The recommendations also include implementation options for consideration by national and state/local governments, depending on their circumstances. The options presented in this document are based on proven, field-tested approaches to address market barriers or failures that impede more substantial

22 The high-efficiency Advanced Policy Scenario of the IEA WEO 2006 assumes an incremental investment in efficiency of US$600 billion that is offset by US$700 billion in avoided investment in new generation.
23 Using more efficient equipment and processes often reduces energy costs by more than 50 percent.
24 The methodology and calculations that underpin these indicative financial impacts can be found in Laitner (2007a).

progress in improving energy efficiency. These recommendations:

- Cost-effectively create large efficiency gains, thereby saving energy and reducing future supply needs.
- Reduce greenhouse gas emissions.
- Can be widely applied.
- Do not present any unusual problems with political and public acceptance or administration.
- Reduce overall capital and operating costs.
- Result in co-benefits such as improved air quality and increased employment opportunities.
- Promote equity across countries by pointing to opportunities for the G8 to assist +5 countries in improving energy efficiency.

Examples of measures that would support the goal proposed in this report and are described in the remainder of this document include:

- Economy-wide: tax incentives, creation of larger markets for efficient products through public procurement, and other activities.
- Buildings: stronger appliance and building codes, and encouragement of advanced lighting initiatives.
- Industry: research, incentives, and standards to facilitate improvements in technologies such as advanced motors, and negotiated sectoral improvement targets.
- Transport: improved fuel economy, advanced vehicle designs, mode switching, and improved regional planning.
- Energy Supply: rate restructuring to decouple profits from sales and to reward investments in energy efficiency more generously than investments in new energy supplies.
- Supporting Efficiency in Developing and Transition Economies: technical assistance, establishing loan guarantee funds for efficiency investments, strengthening institutional capacity, and fostering the export market for energy efficient technologies while reducing trade in inefficient secondhand equipment.

The next chapter sets out a pledge and review process for G8 countries to meet the goal of a 2.5 percent annual rate of energy efficiency improvement. The following chapters focus on actions that G8 countries could take to improve energy productivity in their own economies—actions that should be equally attractive to the +5 countries (and other developing and transition-economy countries)—and also recommend steps for the G8 to take to improve cooperation with +5 and other developing countries.

II. HIGH-LEVEL RECOMMENDATIONS FOR REALIZING THE POTENTIAL OF ENERGY EFFICIENCY

The magnitude of energy efficiency improvements described in this approach will not result from a single set of decisions made at one point in time. The improvements can only be achieved through ongoing national efforts and international policy coordination motivated by leadership from the highest levels of government and industry. Action will be required at all levels, including provincial, state, and local governments, the private sector, consumers, and international organizations including international financial institutions. Industry can play a leading role by pursuing profitable energy efficiency opportunities worldwide. But national governments must provide leadership by creating the policy environment that establishes market and other incentives for decision making at all levels.

Recommendation: Beginning in 2008, prepare national strategies for energy efficiency improvements.

Commitments to improve energy efficiency will not be met without detailed national and international planning and follow-up. National strategic energy efficiency action plans should establish near-term objectives to facilitate realization of the overall efficiency improvement goals. The plans should establish national targets for performance improvement by sectors or for the economy as a whole. They should set programmatic objectives and describe implementation plans for attaining them. The specific elements of the national plans should vary according to each country's situation and draw on strengths of current planning processes, where these exist.

The plans will be more effective if they are as concrete as possible and if governments work in cooperation with the private sector to develop them. Preparation of the plans will also serve to coordinate policy and programs more effectively across the several ministries in a government that usually address energy supply and demand. Plans should also reflect regional diversity within large countries, and thus need to engage state, provincial, and municipal stakeholders.

The plans should establish near-term milestones as well as medium- and long-term goals. Sample milestones include establishing regulatory, funding, and policy measures to support the national/sectoral goals. Each country's plan should be updated periodically and should be open to public input and comment. The nature of the plan will vary according to each country's regulatory, policy, legislative, and institutional structures, as well as its decision-making processes.

To facilitate cooperation and information sharing, each plan should include internationally comparable data collection methodologies and compilations used to establish baseline and energy savings data. Each subsequent plan should include: (1) reporting on progress made toward implementing efficiency policies that will help achieve the G8/national goal(s); and (2) verification of energy savings, to the extent practicable. The IEA has already developed internationally comparable indicators on which to build, and a network of European energy agencies (known as ODYSSEE-MURE) has developed methodologies and indices to determine overall progress in energy productivity, as well as to attribute progress to structural change, policy effectiveness, and technical change. This network of participating countries should be broadened over time to include the +5 and other developing countries (ADEME – European Commission, 2005).

Recommendation: Beginning in 2008, convene technically oriented annual energy efficiency summits to coordinate international implementation and review progress.

Energy efficiency improvements on the scale described in these recommendations are attainable only with ongoing technical coordination over an extended period of time. The G8 should establish an ongoing high-level forum for coordinating energy efficiency improvements through annual or bi-annual "summits," the location of which would rotate among the G8 countries. These meetings would be similar to those currently held by G8 finance ministers. The process should have a flexible architecture that begins with G8 countries but soon expands to include the +5 and additional countries as opportunities present themselves. Current G8 activities such as the Gleneagles Dialogue provide a foundation but are insufficient to achieve the objectives outlined in these recommendations.

The pledge and review process proposed here draws on many other cases in which governments have negotiated non-binding targets (e.g., the North Sea pollution regime, the Baltic Sea action plan, and European commitments to control nitrogen oxides) and then worked cooperatively to implement them through sustained coordination and ongoing review (see Victor, 2007). A number of aspects of the process will need to be determined, for example determination of review and verification mechanisms, and agreement on consequences for non-attainment of the agreed pledges. Subsidiary technical working groups and other coordination mechanisms would provide follow-up support focused on implementing the key sectoral policies and measures. The process would need to be supported by national energy ministries, with assistance from the IEA (through its technical working groups) and possibly other groups such as international standards organizations. The IEA working groups encourage long-term cooperation among IEA member countries to improve their collective energy security, the economic efficiency of their energy sectors, and the provision of energy services in an environmentally sustainable fashion. Such groups would also support achievement of national energy goals.

The high-level energy efficiency forum would attract and maintain significant attention focused on the issue of energy efficiency. It would provide a venue for governments, private-sector leaders, and technical experts to update one another on their respective progress toward meeting the efficiency improvement goal(s), exchange information, and coordinate implementation of commitments.

Recommendation: Establish internationally coordinated data collection and monitoring of energy productivity through an international agency such as the International Energy Agency.

Data collection and monitoring will be critical to ensure progress in meeting efficiency improvement objectives. Countries must take responsibility for tracking and monitoring their own energy efficiency policies. This is important, because it also provides leaders and officials with opportunities to learn from such a review process.

However, to ensure the credibility and transparency of the national evaluation processes, it is important that an international organization independently review national reports and results. Currently, some internationally comparable data and indicators are monitored and collected by G8 (and other) countries. But there are important data gaps that will need to be filled to support policy coordination. An agency such as the IEA or one within the United Nations should be given the mandate and the necessary resources to coordinate international data collection and analysis to support national and international initiatives. Data collection and analysis should be organized to support the international summit process, including its working groups. Data collection and analysis will permit verification of the energy savings and economic benefits of agreed-upon policies and measures, and support mid-course corrections in implementation.

Table 2. Policy options to improve energy efficiency discussed in this report.

Sector:	Options
Crosscutting Policies and Measures	• Phase out subsidies for established energy sources in G8 countries, and work with governments in +5 and other countries toward a similar change. • Levy an "efficiency penny" surcharge on all energy end-users in G8 countries to support energy efficiency programs. • Accelerate capital deployment for mitigating risks and costs unique to improving demand-side energy efficiency. • Commit to government procurement of equipment, vehicles, and new facilities with the highest standards of efficiency. • Increase public awareness through information and education campaigns.
Buildings and Equipment	• Realize energy savings of 25 to 30 percent in equipment and appliances by 2020 (compared to business-as-usual) by instituting minimum energy performance standards and standardized product labeling. • Reduce energy consumption of the buildings sector by 30 percent by 2030 relative to present consumption by instituting minimum energy performance standards for new construction and building capacity to refurbish existing buildings to a higher efficiency level.
Industry	• Reduce industry sector energy consumption by 25 percent by 2020 and 40 percent by 2030. • Develop an energy management standard for large industrial energy users and support the use of energy management systems by smaller users. • Set binding targets to reduce industrial energy consumption over a 10 to 15 year period. • Adopt minimum energy efficiency standards for crosscutting technologies such as motors, boilers, pumps, compressors, and other large energy-using systems.
Transportation	• Establish a goal of a 35 percent increase in fuel economy by 2020 and a 60 percent increase by 2030 for new light-duty vehicles. • Increase the effective energy efficiency of heavy-duty vehicles and rail, air, and marine travel by at least 20 percent by 2020, and 35 percent by 2030, through a combination of technological improvements and actions to promote a changing pattern of freight and passenger movement. • Reduce vehicle travel and freight movement by 10 percent by 2020 and 15 percent by 2030.
Energy Supply	• Structure utility rates to provide higher rates of return on investments in end-use energy efficiency than on investments in energy supply, and ensure that at least 30 percent of demand for new capacity is met by demand-side management. • Introduce tradable certificates to encourage the most cost-effective approaches to energy efficiency. • Set an average efficiency standard for fossil-fueled electric power systems by 2030. Efficiency standards for new and recommissioned plants should be 50 percent for coal-fired and 60 percent for natural gas-fired by 2015. • Obtain 20 percent of electric power from combined heating, cooling, and power generation by 2020. • Produce 30 billion cubic meters (1.1 EJ) of marketable natural gas per year by eliminating losses from leaks and flaring.
Developing/ Transition Economies	• Create multiple energy efficiency loan guarantee funds in developing countries to offer guarantees for efficiency investments. • Invest in the people and institutions needed to capture the full benefits of energy efficiency in the buildings/appliances, transportation, industrial, and energy supply sectors. • Foster export of energy efficient technologies and limit trading of used equipment.

III. CROSSCUTTING POLICIES AND MEASURES

This chapter describes recommended actions the G8 countries should consider to level the playing field for energy efficiency and increase awareness of the opportunities it offers. Most countries have policies that (intentionally or consequentially) undercut efforts to accelerate energy efficiency improvements in their economies. These policies run the gamut from national subsidies for fossil fuels to municipal regulations on electric power lines. All can result in unnecessary economic costs.

The options in this section suggest a policy framework to support the sectoral measures that appear in the following sections.

Subsidies

Recommendation: Phase out subsidies for established energy sources in G8 countries, and work with governments in +5 and other countries toward a similar change.

To implement this recommendation, G8 countries could:

a) Undertake an inventory and review of all energy subsidies.

b) Phase out subsidies for established energy supplies.

c) Shift some of the savings from avoided subsidies to improving efficiency of energy supply, and the remainder to support research, development, demonstration, and deployment (RDD&D) for energy efficiency technologies.

Energy supply subsidies distort the price signal for demand-side energy efficiency investments, and reduce costs to energy companies and consumers at the expense of the taxpayer. Directed toward established energy sources—those that have been in extensive use for long periods, such as coal, oil, gas, and nuclear power—subsidies typically reduce net energy costs to consumers, increasing consumption, worsening environmental pollution, and weakening efforts to reduce dependence on such fuels for security reasons. Direct subsidies for fossil fuels alone have totaled as much as US$200 billion worldwide annually, and estimates of indirect subsidies vary widely but are as much as US$30 to $50 billion annually just in the United States.[25]

Implementation

The G8 countries should create a comprehensive inventory of direct and indirect energy subsidies, including duration and funding level. Each country may undertake this process internally or collectively, with the assistance of some international organization such as the IEA. The inventory will raise awareness of the subsidies and support the effort to identify and remove specific subsidies for established energy sources. Removing subsidies will face significant opposition from sectors that have benefited from them, and a transition period may be required. One way to reduce opposition is to re-invest the subsidy revenue into improving efficiency in the affected sectors. Box 2 describes this approach and its potential benefits in more detail.

25 Estimates of global energy subsidies vary widely and reflect the inherently subjective and amorphous nature of the topic. It is often not possible to find subsidy studies that cover the same time periods. The figures used in this report are based on calculations made by Koplow (2004) and de Moor and Calamai (1997).

Box 2: Redirecting Subsidies to Support Energy Efficiency Investments

Economists have warned that India's large and growing fiscal deficit prevents it from achieving its full development potential. The central government estimates that its fiscal deficit is 4.8 percent of Gross Domestic Product (GDP) but is trying to narrow the gap using a variety of measures. There is a strong link between energy efficiency and central government and state fiscal deficits. In state after state, the electricity subsidy is the largest component of state expenditures, and is, simplistically speaking, the difference between the cost of supply and the subsidized tariff offered to users. Reducing power subsidies offers a cost-effective, near-term option for deficit reduction.

Energy efficiency improvements would lessen the impact of reduced subsidies and free up energy that is presently wasted so that it can be redirected to productive use. Eliminating electricity shortages could have a large impact on the state treasury, since economic output and hence tax revenue will rise with the elimination of the shortages. Stable electricity resources are also likely to attract foreign investment. A preliminary analysis in Maharashtra (Phadke et al., 2005) indicates that energy efficiency improvements could provide US$631 million in deficit reduction through reduced subsidies and increased tax revenues from added economic activity. If pilot projects are any indication of broader potential, the case for a state-level energy efficiency program with a one-time investment of US$83 to $145 million is strong.

Efficacy of Subsidy Reduction Recommendation

Removing subsidies to established energy industries will change price signals and reduce fuel and electricity consumption, which in turn will reduce market distortion, benefit the environment, and stimulate more efficient use of associated resources. Because subsidies by their very nature are economically inefficient, their elimination will reduce net economic costs. For previously subsidized industries, however, the loss of subsidies may be keenly felt.

Public Funds for Energy Efficiency Investment

Energy efficiency companies, technologies, and projects potentially offer high rates of return. The combination of fossil fuel subsidies, investors' lack of familiarity with ways in which to finance energy efficiency, the current lack of information about and awareness of the benefits of efficiency, and the small scale and distributed nature of efficiency opportunities tends to mask the long-term profitability of energy efficiency investments. These problems are worst in situations in which finance is needed most–in small and medium size firms and in rapidly growing developing and transition economies where mature financing mechanisms do not exist and where energy users are generally low-income households or small-business service providers, whose credit history and collateral may be lacking. A modest charge on final energy consumers could be used to finance activities to address some of these issues and assist in achieving the target of a 2.5 percent reduction in energy intensity.

Recommendation: Levy an "Efficiency Penny" surcharge on end-use energy consumption in G8 countries.

To implement this recommendation, G8 countries could:

a) Impose a small surcharge (e.g., 0.5 to 1 percent, 1 cent per dollar of sales, or 1 cent per unit of consumption) on end-use energy consumption (e.g., electricity, natural gas, and transportation fuels).

b) Earmark the revenues from this surcharge for investment in energy efficiency measures.

c) Agree to allocate at least 25 percent of revenues from this surcharge to energy efficiency policies, programs, and projects in developing and transition economies.

Implementation

Energy distribution companies and/or state and federal governments—alone or in partnership—can levy and administer "efficiency penny" programs. Most of the revenue from the surcharge should be used for domestic energy efficiency incentives. Areas with high potential payoffs include using the funds to:

- Establish programs that provide practical advice to consumers and small to medium size enterprises on saving energy.
- Introduce consumers to highly efficient technologies through at-cost sales and other offers.
- Intensify research and development (R&D), an option insufficiently funded by industrialized countries for the last 20 years.
- Reduce regulatory, financial, and legal costs of implementing energy efficiency measures.
- Overcome barriers such as lack of access to financing, lack of information, and inadequate capacity for project and program implementation.

Efficacy of the Efficiency Penny Recommendation

The "efficiency penny" surcharge assumed in this analysis would raise about US$20 billion per year in G8 countries (US$8 billion from electricity, US$6 billion from natural gas, and US$6 billion from oil) without significantly affecting macroeconomic conditions.[26] Box 3 describes some successes with an "efficiency penny" in countries, provinces, or cities where it has been employed.

26 The surcharge structure used in this calculation assumes surcharges of 1 cent per 10 kWh of electricity, 1 cent per 100 cubic feet of natural gas, and 1 cent per gallon of oil. Volumes based on EIA (2006).

Box 3: The "Efficiency Penny" in South Korea, Switzerland, and the United States

South Korea imposes a levy on imports of petroleum, petroleum products, and liquid natural gas equal to 1.7 US cents per liter. The levy raised US$1.2 billion in 2006 that financed R&D and demand side management (DSM) in the energy sector and renewable energy development. The South Korean government also imposes a 3.7 percent levy on electricity consumption, which raised US$800 million in 2006 for investment in efficient lighting systems, efficient motors, and similar projects.

Switzerland has added a charge of 1 Swiss cent per liter to gasoline and diesel since 2006. About 70 percent of the revenue (€80 million per year) has been used for domestic energy efficiency incentives. The rest of the surcharge has been used to co-finance efficiency and renewable energy projects in countries with developing or transition economies.

In the United States, 18 states levy a public benefits charge of 1.1 US cents per 10 kWh (on average) on electricity consumers. Revenues have been used for various utility DSM programs, including weatherization for low-income households. The public benefits charges have been credited with slowing the growth of electricity consumption by 0.4 percent.

Incentives for Private Sector Investment in Energy Efficiency

Some private sector firms are independently launching efforts to improve the efficiency of their operations to improve their corporate bottom lines. They realize that the initial investments yield tremendous energy and financial savings in relatively short periods of time. Such initial investments in energy efficient technologies and products are often more difficult for small and medium size enterprises to undertake, because they often lack credit and collateral, and have more difficulty obtaining traditional types of financing. Hence, the types of measures proposed below are designed to help small and medium size enterprises, as well as developing and transition economies with relatively weaker economies.[27]

Recommendation: Accelerate private sector investment by mitigating risks and costs unique to demand-side energy efficiency.

To implement this recommendation, G8 countries could:

a) Create equity support and loan guarantee programs to support energy efficiency investments by small and medium size businesses and their customers.

b) Encourage the growth of energy service companies (ESCOs) by providing favorable funding options.[28]

c) Reduce or share transaction costs for distributed and small-scale projects, using tax holidays, direct payments for consultants, and other creative measures.

d) Promote the transfer of new energy efficient technologies and reduce trade in used, inefficient equipment from OECD countries to transition-economy and developing countries.

27 This recommendation expanded and adapted from Chandler et al. (2004).

28 Energy service companies (ESCOs) invest in assets of third parties and rely on a contract with owners to recoup their investment. They use performance contracting and standard protocols to overcome the lack of clearly defined property rights to energy savings.

Implementation

The G8 and +5 governments can leverage private sector investments in energy efficiency with incentives and policy frameworks.

For small and medium size businesses, these measures could include direct capital subsidies or enhanced capital allowances such as accelerated depreciation. For investors, the measures could include green investment tax credits. Similar approaches could be used with homeowners through income tax reductions and other fiscal incentives.

Many stakeholders in the energy finance sector could benefit from national and international policies designed to facilitate energy efficiency policies and projects. Third-party financing models such as ESCOs merit special attention because they can be capitalized one time to serve many different customers. Training and support for project development could be provided to improve the quality of energy efficiency funding applications. Banks need technical assistance to assess, price, and promote energy efficiency financing opportunities. Finally, multilateral organizations and export credit agencies need direction from international leaders to leverage domestic and foreign direct investments in energy efficiency in newly industrialized, transition-economy, and developing countries.

Transfer of energy efficient technologies could be accelerated by providing tax incentives to entities that license technology to developing countries, establishing effective competition in developing countries, and ensuring that the benefits of publicly funded research are available to all through open access to scientific databases.

Efficacy of Private Sector Investment Recommendation

Many efficiency investments currently offer return of capital within a year or two, which should make them attractive to venture capital funds. Small investments can quickly reap benefits in terms of large energy savings for G8 countries and in profits and returns on the investments themselves.

Leadership through Procurement

Governments can, through their purchases and investments, help build markets for efficient products and practices by increasing sales volume and market share, thus lowering unit costs as well as demonstrating good practices.

Recommendation: Commit to government procurement of equipment, vehicles, and new facilities with the highest standards of efficiency.

To implement this recommendation, G8 countries could:

a) Regularly update and enforce procurement guidelines for office equipment and vehicle fleets, requiring government managers to acquire energy efficient products with low life-cycle costs, not just those with lowest initial costs.
b) Construct and upgrade public buildings to achieve the greatest possible energy efficiency.
c) Offer local governments grants or awards from central governments for exceeding mandatory building standards.
d) Encourage private investment in refurbishing old and inefficient public buildings.

Office and other equipment, vehicle fleets, and building construction are obvious opportunities for local, state, and federal procurement–thereby demonstrating leadership in this area and creating opportunities for new

markets. Public buildings at the national, provincial, and municipal levels can also be used to showcase energy efficient technologies and practices and to establish new best practices.

Procurement policies have been employed successfully in China, Korea, Japan, Mexico, and several European Union (EU) countries (sometimes as part of larger "green" purchasing efforts). These policies take advantage of the fact that governments are generally very large purchasers. In most countries, government spending represents between 10 and 25 percent of all economic activity. The US government is the world's largest volume buyer of energy-related products (US$10 billion per year). The Federal Energy Management Program's (FEMP) "Buying Energy Efficient Products" program began in 1996, and federal buyers are now required by the Energy Policy Act of 2005 to purchase products that are ENERGY STAR®–qualified or FEMP–designated. (These products are in the upper 25 percent of energy efficiency in their class.) The products purchased through the program have an estimated energy savings potential of nearly a quarter of a billion dollars per year.

Realizing the potential of energy savings from procuring energy efficient products, the Ministry of Finance of the People's Republic of China, in a 17 December 2004 communiqué, directed that "Government organs at all levels, public sector non-profit units and organizations (collectively "procurers"), when using fiscal resources for procurement, should preferentially procure energy efficient products and gradually eliminate low-efficiency products."[29]

Construction and retrofit of public buildings offers a particular area of opportunity and challenge. Government authorities should be encouraged to invest in constructing and upgrading buildings to achieve the greatest possible energy efficiency. Local governments could be offered grants from central governments for exceeding mandatory standards (e.g., for meeting local "passive building" or "low-energy building" standards that are more efficient than mandatory minimum standards). In addition, financial mechanisms should be set up to encourage private investment in refurbishing old and inefficient public buildings, with investors receiving a return on investment through energy savings. Energy performance contracting[30] (EPC) and third-party financing through ESCOs can overcome the many barriers prevailing in the public sector, including the lack of available financing and misplaced incentives.

In Austria, close to half of all public buildings are already being renovated through the EPC concept. The investment volume amounts to about €300 million, which will result in an estimated annual energy cost savings of around €50 to €60 million and an associated reduction in annual CO_2 emissions of 600,000 to 700,000 tonnes (Bertoldi and Rezessy, 2005). In Berlin, Germany, more than 900 public buildings have been renovated since 1995 through public-private partnerships (ESCOs), resulting in total guaranteed annual energy savings worth over €7.8 million from a total investment of around €32 million. These orders to upgrade building energy efficiency have also substantially strengthened the German ESCO industry, which today is the most mature in Europe, with an annual turnover through energy efficiency services of about €3 billion.

29 For an overview of the Chinese Government procurement policy for energy-efficient products and a list of product categories covered under the procurement directive, see http://mail.mtprog.com/CD_Layout/Day_3_23.06.06/1115-1300/ID68_Caifeng_final.pdf.

30 Energy performance contracting is an innovative financing technique that uses cost savings from reduced energy consumption to repay the higher initial cost of installing energy conservation measures. Building owners do not bear large up-front capital expenses because these costs are borne by the performance contractor and paid back out of the energy savings.

Implementation

Legislation and public purchase regulations often impose "least-cost" criteria on purchases, which can encourage use of inefficient equipment. While this may reduce initial capital costs, in the longer term it burdens government and other large purchasers with higher operating costs. Of equal importance, these criteria can lead to missed opportunities for public demonstration of efficient practices and the growth of markets for efficient products. These requirements should be updated to promote purchase of efficient products–for example, by considering full life-cycle costs. Working with experienced facilities managers and industry trade groups can help improve implementation, as can improving data collection about government purchasing to incorporate energy efficiency as well as cost characteristics of purchased goods and services.

Efficacy of Public Procurement Recommendations

Procurement policies and programs can help efficient products and construction practices penetrate the market, which over time helps eliminate the cost difference between efficient and inefficient goods, establishes good practices as standards, and helps establish a construction industry well experienced in low-energy construction and retrofitting. Bulk purchasing has the potential to reduce purchase costs by 30 to 40 percent compared to the retail price. Cumulative experience lowers costs, which are further reduced by increasing sales volume and economies of scale. In the United States, it is estimated that by 2010 the combined savings from federal energy efficient procurement policies will range from 12 to 44 petajoules per year (Gillingham et al., 2004). This represents an annual energy cost savings of US$140 to US$530 million per year.

Promoting Effective Use of Efficient Technologies through Public Information and Education

Improving energy efficiency will depend on three essential factors: (1) the theoretical energy performance of technologies; (2) the rate of their market penetration; and (3) the extent to which their theoretical performance is actually achieved when they are used. Most of the recommendations in this report address the first two factors. This recommendation addresses the third. Public information and education programs for all types of energy users provide an essential contribution to the success of other energy efficiency programs and policies.

Recommendation: Increase public awareness through public information campaigns.

Obvious examples of the added value of public information can be found in the building, appliance, and transportation sectors. While it is important to convey the message that efficient products such as compact fluorescent lamps and hybrid automobiles are at the cutting edge, it is also important to convey that end users can contribute to, and benefit from, improved efficiency simply through their behavior. For example, by switching off lamps when not in use, unplugging mobile phone chargers, or avoiding "jackrabbit" starts and stops when driving, consumers can reduce their costs and help address climate change. Displays that provide feedback on the efficiency of utilization could be encouraged for a variety of products from vehicles to appliances to reinforce efficient use.

Implementation

Education and training (including in schools) and awareness campaigns (similar to those for smoking and other health issues) can encourage adoption of new technology and should therefore be an integral component of comprehensive energy efficiency policies anywhere in the world. In the Netherlands, for example, sales of highly

efficient electric appliances improved after television campaigns that included music and cinema stars aired in the late 1990s.

Efficacy of Public Information Recommendations

Education measures seek to induce changes in the purchase and use of equipment and have relatively low costs. They can supplement, in the short and medium term, policies that aim at improving the efficiency of technology. These measures are especially important in those sectors where market transformation can only reasonably happen in the longer term.

IV. BUILDINGS AND EQUIPMENT

Potential Efficiency Gains in the Buildings Sector to 2030

Residential and commercial buildings (including installed equipment and appliances) consumed the equivalent of 114 EJ worldwide in 2005. Residential electricity consumption is one of the fastest growing areas of energy use, especially in developing countries. World average per capita residential electricity consumption is about 600 kWh per year but reaches 1,500 kWh per year in Western Europe and is more than 4,000 kWh per year in North America (WEC, 2004). In the commercial sector, electricity consumption is also growing faster than the growth rate of the economy, especially in countries with air conditioning requirements.

Making use of energy efficient technologies and practices in new and existing buildings could save as much as 34 percent of the projected primary energy consumption by the world's buildings by 2020 (Urge-Vorsatz et al., 2006). This estimate would represent a reduction of 52 to 57 EJ (3.8 to 4.7 billion tonnes of CO_2) by 2020 and a reduction of 79 to 84 EJ (5.8 to 6.9 billion tonnes of CO_2) by 2030. The potential global energy savings in buildings by 2030 are equal to the current energy consumption for all uses in Europe.

Little of the energy efficiency potential in this sector has been captured, due to characteristics of markets, technologies, and end users that inhibit rational choices in building construction and appliance purchase and use. This chapter outlines measures for overcoming the barriers to efficiency improvements in the buildings sector.

Equipment and Appliances

Appliances and equipment include:

- Boilers and water heaters.
- Heating, ventilation, and air conditioning systems for commercial and residential buildings.
- Cooking equipment.
- Domestic appliances such as refrigerators, washing machines, dishwashers, and other small appliances.
- Lighting.
- Electronic appliances (televisions, computers, digital video recorders).
- Office equipment (copiers, fax machines).
- Miscellaneous electric devices (power supplies, stand-by power).

These items have a useful life of just 5 to 15 years, providing opportunities to incorporate significant energy efficiency improvements in the short and medium term.

Recommendation: Realize energy savings of 25 to 30 percent in equipment and appliances by 2020 (compared to business-as-usual).

To implement this recommendation, G8 countries could:

a) Establish regularly updated minimum energy performance standards (MEPS) to ensure the phase-out of inefficient equipment.

b) Design labels (comparison labels and endorsement labels) to inform consumers of the differences in energy consumption, costs, and benefits between appliances on the market. (Figure 6 provides some examples of product labeling).

c) Encourage well-monitored voluntary or negotiated agreements with appliance manufacturers to enhance the overall efficiency of products.

d) Create financial incentives through fiscal measures or demand-side programs and use procurement policies to stimulate market penetration of efficient equipment. (Box 4 details an example where such policies have been effective).

e) Support research and development, including encouraging manufacturers to integrate energy efficiency considerations into the early stages of product design. (Box 5 describes a successful example of this policy recommendation).

EU
Refrigerator

China
Clothes Washer

Australia
Air Conditioner

Figure 6: Illustrative appliance labels.

Implementation

Over 50 countries have standards and/or labeling programs for appliances, and these programs have already resulted in substantial energy savings. The EU labeling scheme helped increase refrigeration efficiency by 25 percent from 1992 to 1999. The European Union is currently considering new minimum energy performance standards for 20 product categories to take effect in three years and will take immediate action on computers, lighting, and standby power. It is also planning to extend the labeling program and make it more effective and informative. The US residential energy efficiency standards will result in US$130 billion in savings over the lifetimes of the covered products and will reduce residential energy use by 8 percent in 2020. Estimates for China's Standards and Labels program during the first 10 years of implementation show savings of 200 TWh (equivalent to all of China's residential electricity consumption in 2002) and 250 megatonnes of CO_2 (almost 70 megatonnes of carbon).[31]

Existing programs provide a solid base on which to build. G8 governments should encourage efforts to harmonize standards for these products at an international level. International standards will allow manufacturers to design

31 Collaborative Labeling and Standards Program. Information Clearing House. http://www.clasponline.org/resource.php?nnx=5.

Box 4: Creating Markets for Efficient Lighting

Compact fluorescent lamps (CFLs) consume roughly one-fourth of the energy used by traditional incandescent lamps and provide the same level of light. Compact fluorescent lamps also have much longer lifetimes, with rated life spans of 5,000 to 25,000 hours compared to 1,000 hours on average for incandescent lamps.

Globally, incandescent lamps are estimated to have accounted for 970 terawatt hours (TWh) or about 6 percent of total final electricity consumption in 2005. About 60 percent of this demand was in the residential sector, with most of the rest in commercial and public buildings. If current trends continue, incandescent lamps could use 1,610 TWh of final electricity by 2030. If all these lamps were to be replaced by CFLs, it would save roughly 800 TWh in 2010, rising to 1,200 TWh in 2030.

Australia has announced a phase-out of incandescent lamps, and several countries are considering such measures. Implementation could be eased by banning incandescent lamps that draw 40 watts or more and subsidizing purchase of CFLs for low-income households.

Other countries have stopped short of a ban but are pursuing other policies. These include performance certification schemes to ensure the quality of CFLs available on the market, subsidies to increase CFL distribution, utility demand-side management programs, and cooperative bulk purchase programs to obtain lower prices (IEA, 2006d; Lefevre et al., 2006).

In the long term, a shift to use of light-emitting diode (LED) lighting holds great promise of improved lighting services with lower energy consumption.

innovative equipment for larger markets and prevent competition distortions that impede international trade.

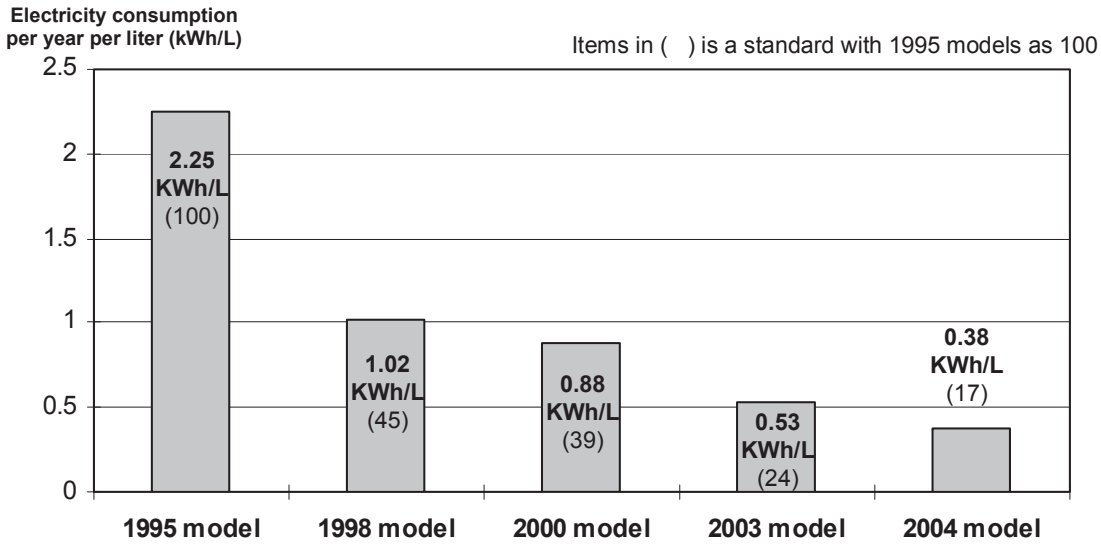
National and local governments should also promote the most efficient equipment on the market through public procurement. This allows for the widespread penetration of high-efficiency equipment into the marketplace and makes these products more competitive by reducing production costs through economies of scale. Table 3 provides an overview of existing standards and labeling programs in the G8 and +5 countries.

Box 5: Setting Target Efficiency Standards: Japan's "Top Runner" Program

When the Japanese government revised its Energy Conservation Law in 1998, it introduced the Top Runner Standards system (Murakami et al., 2006). The Top Runner system establishes stringent energy efficiency standards for 18 energy-intensive product classes including vehicles, air conditioners, fluorescent lights, television sets, video cassette recorders, photocopying machines, computers, magnetic disk units, freight vehicles, electric refrigerators/freezers, space heaters, gas cooking appliances, gas hot-water suppliers, oil hot-water suppliers, electric toilet seats, vending machines, and transformers. Top Runner sets both the minimum efficiency standard and a timeframe for achieving the target. The goal is for manufacturers to produce products better than those with the highest energy efficiency on the market. As the figure below demonstrates, the program has driven significant improvements in energy efficiency performance since inception.

The Energy Efficiency Labeling program provides for labels that indicate how these appliances achieve the target energy conservation values stipulated in the Top Runner Standards. Energy efficiency values and indicator labels are voluntarily displayed in catalogs and other advertising and publicity material so that consumers can consider energy efficiency when making purchases.

Effects of Top Runner Program
(Performance Trend of Electric Refrigerators)



Average values of annual power consumption per liter of representative electric refrigerator units

Source: The Japan Electrical Manufacturers Association

Change in efficiency of Japanese refrigerators between 1995 and 2004 as a result of the Top Runner Program. Liters are a unit of volume measurement comparable to a cubic foot.

Table 3: Appliance standards and labeling programs in G8+5 countries.

G8 Countries	Standards and Labeling Programs	Products Covered
Canada	Label - Mandatory	10
	Label - Voluntary	46
	Minimum Energy Performance Standard - Mandatory	34
	Energy Performance Testing Standard	47
EU Countries	Label - Mandatory	9
-France	Label - Voluntary	16
-Germany	Minimum Energy Performance Standard - Mandatory	4
-Italy	Minimum Energy Performance Standard - Voluntary	7
-UK	Energy Performance Testing Standard	10
Japan	Label - Voluntary	30
	Minimum Energy Performance Standard - Mandatory	2
	Other Standards	21
	Energy Performance Testing Standard	36
Russia	Label - Mandatory	1
	Minimum Energy Performance Standard - Mandatory	12
	Energy Performance Testing Standard	30
United States	Label - Mandatory	17
	Label - Voluntary	25
	Minimum Energy Performance Standard - Mandatory	20
	Minimum Energy Performance Standard - Voluntary	2
	Energy Performance Testing Standard	43
+5 Countries		
Brazil	Label - Mandatory	9
	Label - Voluntary	31
	Minimum Energy Performance Standard - Mandatory	3
	Minimum Energy Performance Standard - Voluntary	10
	Energy Performance Testing Standard	33
China	Label - Mandatory	2
	Label - Voluntary	36
	Minimum Energy Performance Standard - Mandatory	23
	Energy Performance Testing Standard	43
India	Label - Voluntary	9
	Minimum Energy Performance Standard - Voluntary	3
	Energy Performance Testing Standard	5
Mexico	Label - Mandatory	12
	Label - Voluntary	12
	Minimum Energy Performance Standard - Mandatory	23
	Energy Performance Testing Standard	23
South Africa	Label - Voluntary	7
	Energy Performance Testing Standard	8

Buildings

Buildings have long lifetimes; in Europe, for example, two-thirds of the stock of buildings anticipated to be in use in 2050 has already been constructed. Since new construction represents only a small percent of overall building stock in developed countries, the G8 needs policies to improve existing stock through thermal rehabilitation as well as ambitious minimum efficiency standards for new buildings.

Recommendation: Reduce energy consumption of the buildings sector by 30 percent by 2030 relative to present consumption.

To implement this recommendation, G8 countries could:

a) Improve building design and adopt minimum energy performance standards for new buildings.
b) Encourage refurbishing of existing buildings through energy performance contracting by ESCOs and fiscal incentives.
c) Require inspections and audits to verify compliance with standards.
d) Establish building energy efficiency certificate programs to inform owners and occupants about the energy efficiency of buildings.
e) Promote ultra-low energy consuming buildings to highlight the most efficient practices in building construction.
f) Construct and refurbish public buildings using state-of-the-art technologies.
g) Encourage retraining and education for the construction trades, architects, and building engineers in the design of energy-efficient buildings.

Implementation

Implementing energy efficiency in buildings poses several unique challenges. Building codes need to be designed according to local climatic conditions. Thus, there may be several different sets of codes for different climatic zones within a given country.

Energy audits are a useful tool for pointing out inefficiencies and consist of a detailed survey by a specialist of the energy used in an industrial firm or building. The objective is to provide technical and financial information to consumers about what actions they can take to reduce their energy bills and at what cost. Evaluations of audits have shown that typically a broad range of measures is proposed, addressing small and large equipment, entire system replacements, and facility structure retrofits, and that many of the suggested measures are implemented. In fact, audits have proven to be one of the most successful policy instruments, as consumers take actions at very high rates given proper information. Nonetheless, recent surveys have shown that realized energy savings are below achievable savings as a result of the combined effect of behavioral factors and non-compliance with building standards.

Lack of information regarding the opportunities and benefits of improved efficiency in residential and commercial buildings and equipment slows penetration of these technologies. Information campaigns to foster public awareness and local information centers that provide advice to households and small-to-medium enterprises would help address this problem.

There are other barriers to refurbishing old and inefficient government buildings because, in many countries, the investment budget for public entities is separate from their operational budget, preventing energy efficiency

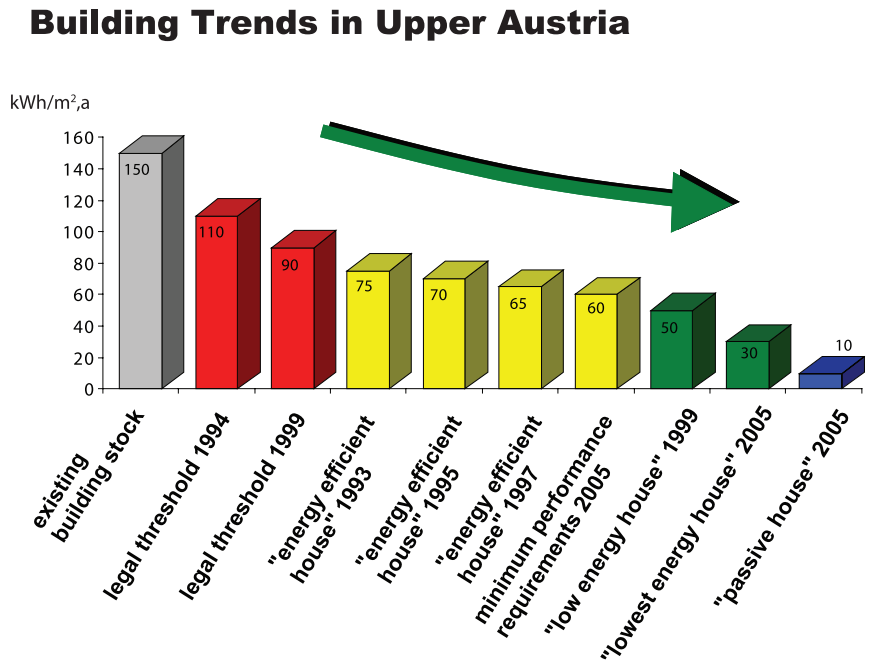


Figure 7. Final energy demand of new buildings in Austria illustrating how standards and labels lead to higher efficiency. Source: Dell et al. (2006).

investments from being reimbursed by energy savings. Specific financial mechanisms should be set up to allow these investments to be realized. Public–private partnerships may allow private investors to be reimbursed through energy savings. Commissioning exemplary buildings in the public sector and engaging the private sector to implement and finance them has been very effective in moving the construction industry toward more efficient practices, and also has significantly boosted the ESCO industry (such as in Germany and Austria; Bertoldi and Rezessy, 2005). Figure 7 illustrates Austria's successful building efficiency program.

Recent surveys have shown that the effective energy performance of new constructed buildings is sometimes below theoretical performance as a result of non-compliance with building standards. It is important to ensure that standards are complied with through verification procedures and penalties for non-compliance.

Efficacy of Buildings and Equipment Sector Recommendations

Efficient new appliances and equipment generally cost slightly more than the lowest-cost models available on the market, but the extra costs are more than offset by savings over the operating life of the appliance. Targeting the lowest life-cycle cost for residential appliances could achieve up to a 33 percent reduction in residential electricity consumption in OECD countries (IEA, 2003b). In addition, appliance MEPS (minimum energy performance standards) and labels have been among the most cost-effective instruments to reduce CO_2 emissions. According to a recent study, the cost of reducing one tonne of CO_2 emissions was minus US$190 for the European Union by 2020, minus US$65 for the United States by 2020, and minus US$30 for Australia (ex-post) (Urge-Vorsatz et al., forthcoming).

Transaction costs for the implementation of labels and MEPS are quite low, but for the instrument to be effective, it is essential that a dynamic process be set up to regularly raise the threshold of labels and standards. This

requires a continuous dialogue between governments and manufacturing associations.

Households, local authorities, and companies are the main investors in building construction and refurbishing. Higher initial investment costs are often a barrier to use of appliances and building components with higher energy performance standards even though lifetime costs of more efficient products are lower because of lower operating costs. There are also principal-agent problems in this sector: Builders use low-cost, inefficient components to keep prices low, even though consumers' interests would be better served with more efficient dwellings and appliances. One approach that is being explored is to encourage utility rate restructuring that permits utilities to earn a rate of return on financing/installing more efficient appliances and equipment (see energy supply chapter). Since the most important potential lies in existing buildings, at least for G8 countries, access to capital through low-interest loans is an important method to motivate refurbishing decisions. Several G8 countries have already set up such financial mechanisms (Germany, France, Netherlands) with the participation of private banks and public incentives.

V. INDUSTRY

Potential Efficiency Gains in the Industrial Sector to 2030

Industry accounts for nearly 40 percent of worldwide energy use. Historically, industrial energy efficiency has improved at a rate of 1 percent annually. Experience demonstrates that improvements can occur at twice this rate over medium- or longer-term timeframes (i.e., 10 years or more). New policy initiatives from the European Commission and elsewhere are set to capitalize on the success of efficiency targets. A G8 initiative to reduce the overall energy intensity of the industrial sector by 25 percent by 2020 (equal to 1.8 percent annually or 30 EJ[32]), and by 40 percent by 2030 (2 percent annually) would establish an ambitious but reasonable framework for progress in this field. Capital stock turnover of key industrial equipment and RDD&D advances in the longer term will make deeper reductions possible over the longer period.[33] Some progress has already been made in this area. Figure 8 shows the impact of improvements in Canadian industrial energy efficiency.

The necessary conditions to set the stage for achieving substantial improvements in industrial energy efficiency (as in other sectors, in most cases) include access to information; improved decision-making processes; access to financing, company (human) resources, and technology; and the ability to measure and verify the achieved energy savings. A variety of policies and measures can help create these necessary conditions and reduce actual or perceived barriers. Due to the diversity of industrial processes, there is no "silver bullet," that is, no single measure that will provide an incentive for all industries. Instead, to realize this potential, G8 governments should develop an integrated set of policies to meet the challenges faced by the large variety of stakeholders.

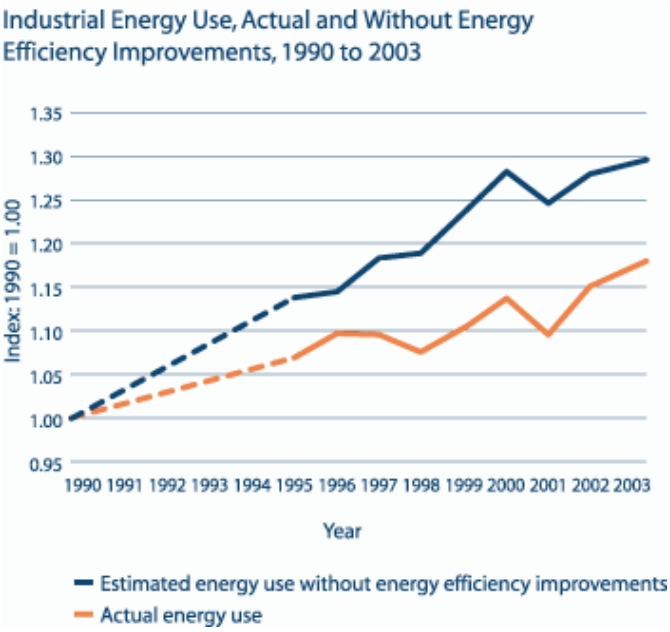


Figure 8. Actual industrial energy use in Canada between 1990 and 2003 compared to estimated energy use without energy efficiency improvements. Source: NRC (2005).

32 Based on the aggressive case presented in *Doing More With Less* (European Commission, 2005b).

33 Worrell and Biermans (2005) studied the energy efficiency improvement rate in electric arc furnaces, and found that both stock turnover (addition of new plants and retirement of old plants) and retrofitting contributed to the energy efficiency improvements. Stock turnover contributed two-thirds of the improvement, and retrofitting and improved management the remaining one-third.

Box 6: An Efficiency Bull's Eye

3M

This highly diversified global chemicals and consumer products company has a long and successful history with targets for corporate-wide energy efficiency improvement. Their recent five-year plans included the following goals:

Years	**Reduction** (energy use per pound of product)
1990–1995:	20 percent
1995–2000:	15 percent
2000–2005:	20 percent

In 2006, 3M used approximately 50 percent less energy to drive a dollar of sales than it did in 1990. These efficiency improvements are the result of worldwide targets for energy consumption reductions that call for a 4 percent annual reduction in energy use per facility. The company uses a three-pronged approach to meet (and routinely exceed) their targets. First, 3M has employee programs that increase energy efficiency awareness. Second, employees are encouraged to proactively review existing operations and to make or suggest efficiency improvements. New product development teams at 3M facilities around the globe continue to improve the efficiency performance of 3M products by considering energy efficiency in their choices of raw materials, product formulations, and manufacturing processes. For example, 3M France focused its employees on minimizing energy costs, identifying energy-saving opportunities, and sharing and implementing subsequent best practices. This policy was accomplished by carefully auditing energy use and implementing a continuous improvement doctrine that encourages maintenance operators to

This section describes a framework of instruments to develop an enabling environment for industry to achieve ambitious goals. The framework consists of a management culture that values efficiency, tools to identify and capture opportunities, and targets for sectors and companies that take into account the needs of a variety of stakeholders. In addition, there is a need to develop international progressive minimum efficiency standards for major crosscutting unit operations in industry. Some companies have already realized benefits from an increased corporate focus on energy efficiency. Box 6 details some of these experiences.

Strategic Energy Management

Companies that include energy management in their strategic plans make the greatest strides in energy efficiency. However, this experience needs to be more broadly replicated. Energy efficiency is still viewed as a "boiler room" subject and not as a "board room" issue. It must receive more commitment and attention from top-level corporate decision makers. Governments can facilitate private sector action by encouraging industries to organize themselves for success and by providing policies and incentives to make such changes occur.

submit energy-saving ideas based on their hands-on assessments of opportunities to reduce energy use. Finally, 3M actively invests in new, more efficient equipment and makes energy efficiency a top priority when designing new facilities.

3M is not alone, however, in meeting aggressive targets for efficiency improvement. A small sampling of other success stories includes:

Philips

The facilities of the multinational electronics company Philips in the Netherlands participated in the Long-Term Agreements with the Dutch government. Within a 10-year period, Philips achieved a 26 percent reduction in energy intensity, exceeding the target of a 20 percent reduction.

Unilever

Unilever improved its ability to track and manage its energy use by simply consolidating its energy use data into a central spreadsheet. This cut the company's energy use by 16 percent over a two-year period and resulted in a 9 percent reduction in annual energy costs.

ExxonMobil

Significant improvements and energy efficiency are also possible in the energy-intensive activities of the oil and chemical industry. ExxonMobil achieved a 35 percent reduction in the energy intensity of its global petroleum refining and chemical operations in the period 1974 to 1999. Notwithstanding these achievements, a newly implemented energy management system has identified a further 10 to 15 percent in cost-effective energy savings at nearly all plants around the world.

Recommendation: Develop an energy management standard for large industrial energy users and support the use of energy management systems by smaller users.

To implement this recommendation, G8 countries could:

a) Require companies that consume more than 1 petajoule per year to employ a dedicated energy manager and to develop a strategic energy management program.[34]

b) Develop and provide energy management tools, including auditing, monitoring, and reporting, analytical software, benchmarking programs, and networking opportunities.

c) Develop long-term, sector-specific programs for small and medium size enterprises, and support development of sectoral and regional programs for these sectors.

d) Through the International Organization for Standardization (ISO), support the development of an international standard for energy management, following the example of a number of countries that have implemented such standards.

e) Include supply chain management options in the energy management standards.

34 This criterion describes plants with total energy costs exceeding US$10 million per year, or annual energy use of more than 165,000 barrels of oil equivalent.

Implementation

The process of creating and putting into effect an energy management standard—or practice—will vary by industrial sector and country. In most cases, ensuring that private sector stakeholders are involved will be of key importance. Governments should work with these stakeholders to identify benchmark performance standards, training materials, and analytic tools such as energy audit guidelines and other technical assistance.

Several countries, including Denmark, Ireland, and Sweden, have already implemented mandatory standards for energy management, while other countries, such as the United States, have developed voluntary standards. These standards can serve as a basis for other countries to develop national energy standards and an internationally accepted standard within five years.

Establishing networks of similar firms can serve as an effective tool to increase the dissemination rate of practices that meet the established standards. Such networks have been used on a regional basis in Switzerland and Germany, and within specific sectors in the Netherlands and the United States. Regional networks may be particularly helpful to small and medium size enterprises. Experience has shown that the efficiency improvements of companies participating in such networks are at least 2 percent per year on average (compared to an industry average of about 1 percent per year).[35]

Negotiated Agreements to Improve Energy Productivity

Widespread experience with voluntary and negotiated agreements for energy performance improvements has shown that ambitious targets can be a driving force for innovation and continuous energy efficiency improvement. Negotiated agreements have been more successful than strictly voluntary approaches in achieving reductions in energy intensity, especially when combined with other instruments, including audits (which can be subsidized) and fiscal incentives (e.g., investment subsidies or tax incentives). Experience has shown that a suitable framework of "sticks" and "carrots" is necessary to ensure that the program is successful. The agreements must also be accompanied by well designed monitoring and reporting procedures.

Box 7: Long-Term Agreements in the Netherlands

In the early 1990s, the Dutch Ministry of Economic Affairs made voluntary long-term agreements (LTAs) with various energy-intensive sectors of the Dutch economy to improve energy efficiency. Companies that signed an LTA were required to develop their own energy savings target that Dutch authorities then approved. This target was accompanied by a detailed strategy to achieve the target that had to be updated every four years. Each participant also had to prepare an annual progress update. The Dutch government and ESCOs provided participants with shared best practices and technical support to help them achieve their targets. Sectors covered under the LTA quickly spread to less energy-intensive industries, and by 2000, almost 90 percent of Dutch industrial energy consumption was covered by an LTA. The original LTA period concluded in 2000 and was successful enough to spawn a second covenant for 2001 to 2012. Long-term agreements now play an important role in the Dutch strategy to meet its Kyoto commitments. Policies involving LTAs are also in place in Italy, Norway, and Austria.

35 Jochem and Gruber (2007) recently analyzed these "local learning efficiency networks."

Recommendation: Set binding targets to reduce industrial energy consumption over a 10- to 15-year period.

To implement this recommendation, G8 countries could:

a) Emulate successful programs such as those in the Netherlands, Finland, and Denmark that set performance targets and include sanctions for non-performance, such as future taxes or regulations.

b) Set targets that vary by sector, dependent on improvement potentials, future technology development, period of the agreement, and level of support offered.

c) Include sufficient government support for ambitious targets, including long-term commitments and flexibility in technology and timing. Box 7 provides an example of one such program.

Implementation

The most effective agreements are those that set realistic yet ambitious targets, include sufficient government support—often as part of a larger environmental policy package—and include sanctions if targets are not achieved. Governments and industry should jointly develop a set of ambitious targets for the industrial sectors within a period of two years. Targets are set for a 10- to 15-year time period, with annual reporting and monitoring to evaluate progress. Targets can be set in various ways: by sector or for industry as a whole (e.g., through an emission trading system). Responsibilities have to be clearly assigned to all stakeholders, including individual companies participating in the agreement. Governments can support the implementation of the agreements by providing support to companies participating in the agreements. Companies are given flexibility in the timing and methods used to achieve the target, which allows for a cost-effective and efficient strategy tailored to the needs of each company and even each individual facility.

Energy Efficiency Standards for Industrial Infrastructure

Crosscutting technologies are found throughout industry in a huge variety of applications. For example, the motor systems found in all plants and processes consume an estimated 60 to 70 percent of all electricity use by industry. Boilers, another key piece of energy conversion equipment, consume an estimated 30 percent of industrial fuel use. Using efficient components and optimizing performance for these systems could result in large energy savings across all industries and processes.

Recommendation: Adopt minimum energy efficiency standards for crosscutting technologies such as motors, boilers, pumps, compressors, and other large energy-using systems.

To increase energy efficiency of these systems, G8 countries could:

a) Create “industrial standards frameworks” that include standards, policies, training, and tools that make system optimization for energy efficiency a routine aspect of typical industrial operating practices.

b) Monitor market developments of new equipment and establish new standards as technology improves.

c) Promote harmonized testing procedures and standards for comparing the performance of crosscutting technologies.

d) Introduce internationally harmonized energy consumption labels for crosscutting technologies.

Implementation

The transaction costs for individual plant operators are often too high to allow them to identify and acquire the most efficient equipment. Hence, this is a key area for governments to develop and implement standards for the manufacturers of these components, and/or provide other incentives. Based on experiences with other products in a number of countries, it should be feasible to establish standards within three to four years. Setting progressive standards based on (future) technology development will ensure that supplier innovation is rewarded and that energy efficiency improvement is continuous. International harmonization of testing procedures and standards through the ISO could help disseminate energy efficient equipment to other countries and sectors. In addition, government and industry should work together to develop audit protocols and ensure that new personnel are trained in efficient system operation. Governments should supplement standards through pilot programs, public–private partnerships, incentives, federal technical assistance, training, and related capacity building.

Efficacy of Industry Sector Recommendations

Meeting these ambitious goals will require substantial investment. According to the IEA, global industry will need to invest an additional US$360 billion in energy efficient technology. However, the lifetime resulting savings in energy costs are estimated to be more than US$900 billion. Furthermore, the IEA states that "the payback period of the additional demand-side investments is very short" for those policies included in the IEA analysis (Carr, 2006).

In addition to the energy savings, targets and related measures have important longer-term impacts, including increasing awareness of energy efficiency, reducing barriers to innovation and technology adoption, creating market transformations to establish greater potential for sustainable energy efficiency investments, providing incentives for RDD&D efforts for energy efficient equipment, and facilitating cooperative arrangements that provide learning mechanisms within an industry.

VI. TRANSPORTATION

Potential Efficiency Gains in the Transportation Sector to 2030

Transportation—the movement of people and goods and the delivery of a wide range of services—accounted for 26 percent of total world energy use in 2004 (IEA, 2006c). Light-duty vehicles and freight trucks accounted for some 45 percent and 25 percent of this world total, respectively. Other modes of travel, notably rail, air, and marine shipping, accounted for the balance of transportation energy (WBCSD, 2004). Although almost all countries in the world have experienced significant and sustained increases in passenger travel over the past decades, much of the world is not yet motorized because of income constraints. As the world's economies develop, however, energy use for transportation is likely to increase dramatically in the coming decades. If transportation services are not made more efficient, energy use in the sector will continue to grow rapidly in both absolute and percentage terms.

The costs of energy consumption in the transportation sector are huge, in terms of overall expenditures, oil imports, climate change, and other environmental impacts, yet many countries' transportation systems are surprisingly inefficient. This chapter highlights a series of measures to improve both vehicle technology performance and system efficiencies within the G8 transportation systems. Improvements in vehicle technology refer to cost-effective increases in fuel economy, that is, reducing the amount of energy needed per kilometer traveled or per tonne of freight moved. Improvements in system efficiencies refer to upgrades in transportation infrastructure and modes of travel so that the need to move people and goods, individually and collectively, or to provide needed services, is reduced or made easier. These improvements also imply that such movement of people and freight uses the most energy-efficient means of travel. Each area of improvement offers significant energy savings, but policy leadership is required to capture that full potential.

The opportunities for the development and penetration of advanced technologies are really a question of how to manage the transition. In other words, the issue is a political or institutional question rather than a purely technological one. Cooperation is clearly needed at all levels—within all levels of governments, between nations, between fleet owners and users, between consumers and manufacturers, and among the public and private sectors. On the policy side, some combination of incentives, such as feebates,[36] progressive taxation, and tradable Corporate Average Fuel Economy standards might be one way to accomplish this goal.

Improvements in Vehicle Technology

Improvements in fuel economy can produce a net gain for consumers when operating and capital costs are considered. Such improvements and gains can be achieved while maintaining vehicle safety as a top priority. A technology-forcing fuel economy standard could accelerate advances in all technical aspects of engine, transmission, vehicle, and battery technologies (such as aerodynamics, and advanced lightweight materials). In addition, enhanced RDD&D is especially important in the area of battery technologies.

36 A "feebate" can be applied to a manufacturer and/or consumer to encourage the manufacture and purchase of more fuel-efficient vehicles, and to pay for the incentives—at no net cost to a government. For more information, see http://www.ase.org/uploaded_files/policy/transportation_feebate_fact-sheet.pdf.

Recommendation: Establish a goal of a 35 percent increase in fuel economy by 2020 and a 60 percent increase by 2030 for new light-duty vehicles.

To implement this recommendation, G8 countries could:

a) Provide consumer incentives (e.g., feebates) for the purchase of vehicles that are highly fuel efficient/have high fuel economy, such as hybrids, flex-fuel vehicles, and advanced diesel vehicles. Improvements in fuel economy of 10 to 12 percent have been obtained even using ethanol blends (Brusstar and Bakenhus, 2005).

b) Direct the retirement and scrapping/recycling of inefficient older vehicles (both individually owned and in commercial or government-owned fleets) and their replacement with new, more efficient vehicles.

c) Require stronger inspection and vehicle maintenance programs, widespread driver training, and better enforcement and control of vehicle speeds (a 5 to 10 percent reduction in fuel consumption is possible).

d) Promote internationally coordinated and regularly updated maximum carbon emissions standards per light-duty vehicle manufacturer.

e) Implement public procurement at highest efficiency standards for government transportation fleets, and encourage similar procurement practices within major corporations.

Implementation

The above measures are important milestones in implementation that will accelerate fuel efficiency. Implementation should initially focus on incremental improvements in current vehicle technologies. At present, virtually all light-duty vehicles and trucks are powered by internal combustion engines and use petroleum (gasoline or diesel) or, increasingly, but still on a limited basis, bio-based fuels. Government and industry, working in partnership, can more rapidly accelerate the gradual improvement in fuel efficiency by encouraging higher standards and increased RDD&D for all aspects of vehicle design. This includes engine, transmission, and vehicle technologies, such as aerodynamics, weight reduction, batteries, tires, and efficient accessories, as well as hybrid-electric and fuel cell vehicles ("hybrid-electric propulsion systems"), which can greatly enhance the standard power train. Fuel cell vehicles have the potential to offer both the highest overall propulsion system efficiency and, if run on carbon-neutral hydrogen sources, the lowest greenhouse gas (GHG) and conventional atmospheric emissions. Vehicle efficiency improvements can also be achieved and designed based on a goal of reducing vehicle carbon emissions. For example, the State of California in the United States has introduced the Pavley Standard, or low-carbon fuel standard, which limits GHG emissions from new vehicles. The legislation calls for reductions of 20 percent by Model Year 2012 and 30 percent by Model Year 2016.[37]

Recommendation: Increase the effective energy efficiency of heavy-duty vehicles and rail, air, and marine travel by at least 20 percent by 2020, and 35 percent by 2030, through a combination of technological improvements and actions to promote a changing pattern of freight and passenger movement.

To implement this recommendation, G8 countries could:

a) Use all possible measures to improve the technical aspects of air travel equipment from improved jet engines and aerodynamics to reducing plane weight through the development and deployment of special

37 Legislative text for AB 1493, or the Pavley Standard, can be found at http://www.arb.ca.gov/cc/ab1493.pdf.

metal alloys and composite materials.[38]

b) Provide incentives, such as feebates, to accelerate the purchase of vehicles that have high fuel economy.

c) Require retirement and scrapping/recycling of inefficient older vehicles and their replacement with new, more efficient vehicles.

d) Create a funding mechanism to build and operate high-speed rail for passenger \ travel, and to create disincentives to use air travel for short distances, with complementary incentives to use the most efficient rail travel.

e) Provide technical support and incentives to improve both the technology (e.g., reduced idling, advanced lightweight materials) and the logistics of freight movement in ways that optimize for greater fuel economy.

f) Promote internationally coordinated and regularly updated energy efficiency standards per vehicle size and class.

g) Practice public procurement at highest efficiency standards for government transportation fleets, and encourage similar procurement practices within major corporations.

Implementation

The emphasis for heavy-duty vehicles should be on "effective" fuel economy. The G8 should implement policies, programs, and market arrangements that encourage reduced shipping demands, mode switching, and teleworking and teleconferencing–all as a means to achieve an "effective" or "an equivalent 35 percent or more increase" in fuel economy by 2030 for all segments of the transportation sector. An international mechanism/ body should be established to review and coordinate efficiency standards and update them on a regular basis.

In addition, because newer vehicles are generally more efficient than the comparable, older vehicles they replace, requirements (and/or incentives) should be established to facilitate the retirement of older vehicles, so consumers are encouraged to purchase newer, more efficient vehicles. The incentive could be made proportional to the increase in efficiency between the new vehicle and the one being replaced.

Some companies are already using this approach because of its economic benefits. For example, in the United States, United Parcel Service (UPS) spent about 5 percent of its revenue on fuel in 2005, which is low for the industry, but still significant. Therefore, it is constantly working to identify opportunities to make its fleet more efficient. UPS is replacing older, inefficient vehicles with more efficient ones and working to reduce dependence on petroleum. It invested about $15 million in 1,500 hundred alternative-fueled vehicles over the past few years,[39] and is working with the U.S. Environmental Protection Agency and others on a hydraulic hybrid vehicle that is substantially more efficient than conventional vehicles (and today's hybrid-electric vehicles, presumably) and has the potential to produce substantially fewer GHG emissions (Hall and Kargul, 2006). FedEx Express and Environmental Defense collaborated to develop a special hybrid-electric vehicle, known as the "E700," that increases fuel economy by more than 40 percent and decreases GHG emissions by 25 percent and particulates by 90 percent. There are 93 such vehicles on the road today.[40] This type of innovation could lead to many more such technological advances in the near and long term.

38 For example, the recently announced Boeing 787 Dream Liner jet plane is built mostly with composite materials and, because of its relatively low weight and advanced aerodynamics, is expected to consume 20% less fuel than comparably sized jet planes.

39 "UPS Sustainability – Ground Fleet," available at: http://www.sustainability.ups.com/environmental/fuel/ground.html.

40 *Ibid.*

The same line of thinking applies to air shipments. FedEx Express "consumed more than 1.3 billion gallons of fuel" in 2006. That figure decreased by 3 percent from the prior two years, due to the implementation of some fuel-saving measures, and the company is working to make its fleet even more efficient.[41] FedEx Express plans, over the next 10 years, to retire "Boeing 727s and replace them with more efficient 757s. The 757 is 20 percent larger but uses 36% less fuel." FedEx Express also is adding a 777 freighter for longer flights–to carry more payload "while burning 18% less fuel compared to the aircraft in today's fleet."[42]

Tremendous federal policy and financial support, as well as private support, will be needed to substantially enhance the mass transit infrastructure in countries where this infrastructure is currently lacking. The buildup should be directly to high-speed rail, where feasible, rather than older and slower rail technologies.

Consumers should be provided with incentives (e.g., discounted tickets, and/or credit toward future discounted or free travel) to travel by rail rather than by plane over short distances, because rail travel would help reduce GHG emissions and petroleum consumption in these instances. Similarly, tickets should be more costly, and/or other financial penalties should apply, for traveling short distances by plane.

Federal support also is needed to advance RDD&D for lighter-weight materials and other components for airplanes, as well as for battery technologies for vehicles.

Improvements in the transportation infrastructure and systems needed to enable these changes are discussed in greater detail below.

Improvements in Transportation Systems and Services

The transition from a commodity-based to a service-based economy calls for adapting transportation systems and services to make it easier to reduce travel and use less energy-intensive modes of transportation. This includes infrastructure changes, incentives, and means to encourage switching from personal vehicles to mass transit, as well as encouraging teleconferencing and telecommuting. This transition will greatly reduce energy use without sacrificing consumer value.

Recommendation: Reduce vehicle travel and freight movement 10 percent by 2020 and 15 percent by 2030.

To implement this recommendation, G8 countries could:

a) Invest in infrastructure and systems that increase the efficiency of travel patterns and shipments, including improving interconnections between private and public transit.

b) Encourage shipment of goods by rail instead of by road.

c) Promote efficient and sustainable land use planning and patterns, the building of "compact cities," and other smart growth initiatives that improve energy efficiency through technical support for local planning boards/councils.

d) Offer incentives to increase vehicle occupancy and/or use public transit, including time-of-day user charges and city tolls that discourage use of private vehicles when traffic congestion is high.

e) Expand opportunities for urban and rural public transit services, both publicly and privately owned.

41 Testimony of William J. Logue, Executive Vice President, FedEx Express, on Transportation Sector Fuel Efficiency to the Committee on Energy and Natural Resources, United States Senate, 30 January 2007, http://energy.senate.gov/public/_files/loguetestimony.doc.

42 *Ibid.*

f) Explore the use of feebates and other incentives to facilitate the purchase of teleworking and teleconferencing facilities and equipment.

g) Rationalize spatial patterns in manufacturing to reduce the need to transport inputs and outputs over long distances.

Implementation

Workplace programs that encourage teleworking/working "remotely" from home, and teleconferencing, can reduce the need for air and ground travel, as well as traffic congestion, and can thereby help reduce emissions from idling vehicles and airplanes, and help reduce overall vehicle miles traveled. The same is true for mode switching/mass transit and improved land use planning. Holding a teleconference (or videoconference) for participants from various countries can save a substantial amount of energy and GHG emissions; today's video capabilities dramatically reduce the need for in-person meetings. Existing Internet, mobile phone, mobile computing, and other technologies also reduce the need for working in a physical office space with other workers and managers. These technologies facilitate working "remotely," and reduce travel time, congestion, GHG emissions, and other harmful air pollutants.

Federal, state, and local, as well as corporate fleets should be required and/or provided with incentives to be as efficient, and low-carbon emitting as possible. Some companies have realized the financial savings that can accrue by having hybrid and/or flexible-fuel vehicles in their fleets, as well as using idling technologies that eliminate the need to run an engine to power a truck's air conditioning or heat, lighting, etc. Wal-Mart in the United States is reducing packing by 5 percent to decrease the number of freight vehicles used to ship their products and is using auxiliary power units to reduce idling.[43]

Efficacy of Transportation Sector Recommendations

Large investments will be required to generate the kinds of energy savings and related infrastructure changes envisioned here. Although no single number can be provided, the evidence suggests that a 35 percent reduction in transportation energy use within the G8 nations is achievable with efficient technologies and infrastructure improvements that have an average payback period of between three and seven years. The benefits of making this critical investment now and over the next quarter-century will be huge. The appropriate mix of price and policy signals and a serious national commitment to increased transportation system efficiencies can reduce G8 countries' dependence on petroleum fuels while saving money, reducing GHG emissions, and improving their overall international energy security.

43 "Wal-Mart Launches 5-Year Plan to Reduce Packaging," Press Release, 22 September 2006. http://www.walmartfacts.com/articles/4466.aspx.

VII. ENERGY SUPPLY

This chapter outlines recommended measures to improve the efficiency of utility energy supply in G8 markets, specifically coal- and gas-fired central station power generation, combined heating, cooling, and power production, and production and delivery of natural gas. Each of these areas offers significant energy savings opportunities, but policy leadership is required to capture that potential.[44]

Utility Sector Reform

Historically, electric utilities have been compensated for building power generation and transmission infrastructure, and for selling electricity. There is nothing in such a compensation structure and the resulting relationship with the consumer that promotes end-use energy efficiency. Typically, the more power generation the utility builds and the more electricity it sells, the more money it makes. Indeed, successful energy efficiency programs can dramatically reduce a utility's profit. Rather than reducing demand, the historic electric utility regulatory and ratemaking regime has been structured to increase energy demand. Recently, however, US state public utility commissions have been curtailing investments in new capacity and requiring that utilities meet a portion of new demand for energy services with energy efficiency. In California and in some European countries (the United Kingdom, France, Italy), energy efficiency services to end users are part of utility business plans and are a source of profit through energy efficiency commitments.

To encourage improved management of energy demand across all sectors of the economy, there should be a decoupling of the historic relationship between utility compensation and energy sales.

Recommendation: Structure utility rates to provide the same or higher rate of return on investments in end-use energy efficiency as on investments in energy supply, and ensure that at least 30 percent of demand for new capacity is met by demand-side management.

To implement this recommendation, G8 countries could:

a) Modify policies to align utility incentives with the delivery of cost-effective, efficient energy services.

b) Encourage rate designs that promote energy efficiency, such as on-bill financing of energy efficiency investments, programs that provide new energy management technologies (e.g., smart meters), and a rising rate structure to discourage high levels of electricity use.

c) Promote investment in a modernized, digitally connected electricity grid to enable better management of power flows, reduced losses, and remote management of electricity demand.

Implementation

Utilities are well positioned to overcome consumer reticence to make energy efficiency investments. In many communities, utilities have a relationship of trust with their customers, and they should be empowered to be full-service providers of both energy and energy savings to break down barriers to efficiency. With regulatory permission and the right kind of incentives, utilities could break through those barriers and provide the information, financing, and improvements that consumers need. One such program is described in Box 8.

44 Nuclear, hydroelectric, and wind power systems can also benefit from efficiency standards, but are beyond the scope of this report.

Box 8: Pacific Gas and Electric's Proposal for Meeting Increased Energy Demand with Efficiency

In a filing currently under review by the California Public Utilities Commission, Pacific Gas and Electric (PG&E) proposes an incentive scheme to provide a profit motive to reach California's efficiency targets. The plan, known as a "shared-savings" approach, calls for PG&E to receive a share of the net economic benefit to ratepayers resulting from greater efficiency, estimated at US$1.1 billion, if it meets certain program performance targets representing reductions in energy (677 gigawatt hours), power (132 megawatts), and gas usage (10 million therms). The company would receive annual payments based on preliminary evaluations by the California Energy Commission with an adjustment process after the final results are quantified.

Reactions to the shared-savings concept have been generally favorable, although the exact percentage PG&E should receive is still under discussion.

Efficacy of Utility Sector Reform Recommendation

This approach would result in a more sustainable and cost-effective system that will substantially increase energy efficiency and reduce demand. The resulting improvements to the electricity grid will have many other benefits–reduced need for new capacity, increased ability to integrate intermittent renewable energy generation into the grid, and greatly improved grid security and reliability. Together, these grid improvements will allow quicker restoration of power after outages and the ability to avert large-scale blackouts.

Trading Efficiency Obligations

Several countries have begun to build on the success of utility portfolio standards by turning them into cap-and-trade programs. Under such schemes, energy suppliers and distributors have mandatory obligations for energy efficiency improvements that can be met through their own programs or by buying energy efficiency credits from ESCOs or other providers–depending on which solution is the most cost-effective. An independent agency certifies improvements and issues the tradable certificates.

Recommendation: Introduce tradable certificates to encourage the most cost-effective approaches to energy efficiency.

To implement this recommendation, G8 countries could:

a) Continue to evaluate pilot trading programs to identify best practices.
b) Establish mandatory energy efficiency targets/obligations for energy suppliers.
c) Establish audit, certification, and trading systems.
d) Require regular monitoring and reporting.
e) Create conditions to integrate national trading systems increasingly into an international system, taking into account other types of certificates (e.g., for carbon trading or renewables).
f) Adopt meaningful sanctions for nonperformance.

Implementation

Some G8 countries are already experimenting with such programs. In the United Kingdom, the scope of the system is limited to the residential sector. In Italy and France, it is extended to small and medium size industries. In Italy and France, the certificates are freely exchanged among suppliers (or distributors) and ESCOs. In France, sanctions for noncompliance include a payment of €0.02 (US$0.027) per kWh for unmet obligations. Currently, the EU has not integrated the pilot efficiency trading programs into the larger Emissions Trading Scheme. Countries currently operating these programs should continue reviewing program performance and assessing linkages between efficiency trading systems and other schemes.

Efficacy of Trading Systems Recommendation

Tradable certificates lower costs of meeting agreed targets, reduce pressure on public budgets, stimulate the market for ESCOs, and encourage new participants to start energy efficiency programs. Possible drawbacks include high transaction costs. Cap-and-trade schemes will require substantial harmonization of energy efficiency policies and targets if implemented across countries.

Central Station Power Supply

Electric power generation consumes one-fifth of the world's primary energy. Experts expect that demand for power worldwide will double by 2030, and that the share of coal in power generation will increase. Central station power plants have an effective lifespan of 30 years or more, so new policies that encourage more efficient facilities will have very long-term consequences.

The efficiency of central station power generation has increased significantly over the past three decades, but even greater improvements in large coal- and gas-fired power plants can be achieved (see Figure 9). The global average efficiency of coal-fired power plants is only about 30 percent, but the best available technology today yields up to 46 percent efficiency. A goal of 50 percent efficiency for new central station coal-fired plants and 60 percent for combined cycle gas-fired plants is achievable by the year 2015.[45] In some countries, up to 20 percent of the power generated is lost in transmission and distribution lines, but solutions exist to avoid these losses. Efforts should be made to improve the average efficiency of the overall grid, including generation, transmission, and distribution.

Recommendation: Require fossil-fueled electric power systems operating in 2030 to be more than 50 percent efficient.

To implement this recommendation, G8 countries could:

a) Establish minimum generation efficiency standards for new power plants and re-powered (life-extended) plants of 50 percent efficiency for coal-fired plants by 2020 and 60 percent efficiency for gas-fired plants by 2015.[46]

b) Develop policies and build institutional capacity to reduce losses in transmission and distribution lines.

c) Create joint research and development programs with the +5 countries as well as other transition economies.

45 These efficiency values are presented in terms of "Lower Heating Value," the index widely used in Europe. The equivalent percentages expressed in "Higher Heating Values," as is typically done in the United States, are two to five percentage points lower, depending on the fuel burned and the specific circumstances of plant siting and operation.

46 This standard applies to net plant efficiency before any carbon capture and storage, is based on lower heating value, and excludes any efficiency credits from heat supply (see cogeneration).

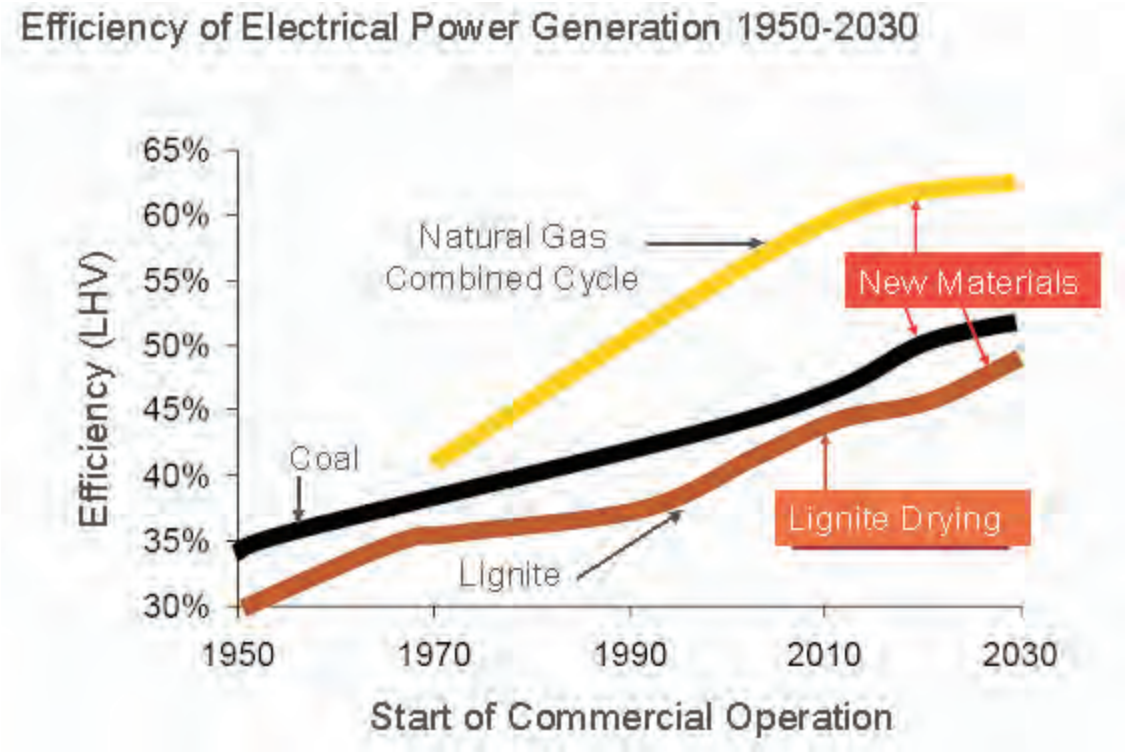


Figure 9. Change in efficiency of electrical power generation between 1950 and 2030 (projected). Source: Kaiser, Alstom (Switzerland) Ltd.

Implementation

State-of-the-art coal-fired and natural gas-fired plants already come close to meeting the proposed standard for 2015. Implementation would be constrained less by technical advances, which are expected to make the goal feasible, than by concerns about constraints on vendors' ability to deliver plants on time. Delivery of ultra-super-critical coal-fired plants could be constrained by availability of certain advanced alloys and manufacturers' ability to incorporate them into new designs. On the other hand, the long lead time between the initial order for and design and construction of new power plants permits government and industry to plan ahead to enact the new standards. Implementing the standard by 2015 will require planning to begin immediately to satisfy a surge in demand for highly efficient plants. The most important driver for meeting this requirement is certainty that the requirement will be imposed. Therefore, development of national standards and coordination across national boundaries to ensure consistent standards across service areas will be vital.

Efficacy of Central Power Supply Recommendation

The OECD countries are projected to spend US$4 trillion to replace and add to electric power generating capacity between now and 2030 (IEA, 2006c). China and India together are expected to spend an additional US$4 trillion on new and replacement capacity in the same time period. Indeed, China in 2006 added 105 gigawatts of capacity, at a cost of roughly US$50 billion.[47] Requiring the most energy-efficient coal-fired power plants might add only about US$30 per kW to the cost of a plant, or a total of less than US$20 billion to the cost

47 Private Communication, Zhou Dadi, Director General Emeritus, Energy Research Institute, National Development and Reform Commission, Beijing, China, March 2007.

of adding to and replacing OECD power generating capacity over the next 23 years. And fewer plants would be needed, saving more than US$24 billion in capital outlays in Europe alone and US$270 billion worldwide. Fuel savings of almost US$0.001 per kWh would offset the capital cost in only four years (MIT, 2007). A standard for coal-fired plants alone would likely save OECD countries US$5 billion per year and reduce CO_2 emissions by almost 1.8 billion tonnes per year in 2030.[48]

In addition, establishing a standard of 60 percent efficiency in generating power from natural gas would reduce total OECD power generation costs by almost US$60 billion in 2030, and would cut carbon emissions by an additional 400 million tonnes per year. If replicated globally, this policy would reduce projected CO_2 emissions in 2030 by 5 billion tonnes per year.

Combined Heating, Cooling, and Power

Combined heating, cooling, and power (CHP, or cogeneration)—the conversion of fuels to electric power in conjunction with the generation of heat for process heating or building heat supply—can be as much as twice as efficient as current central station power generation. Generating power simultaneously with heat uses 80 percent or more of the useful energy in fuel, while central station power generation on average uses only one-third. Many nations, including Denmark, the Netherlands, and Russia, already take advantage of this efficiency and use cogeneration systems to provide more than one-third of their power. Others, including the United Kingdom and

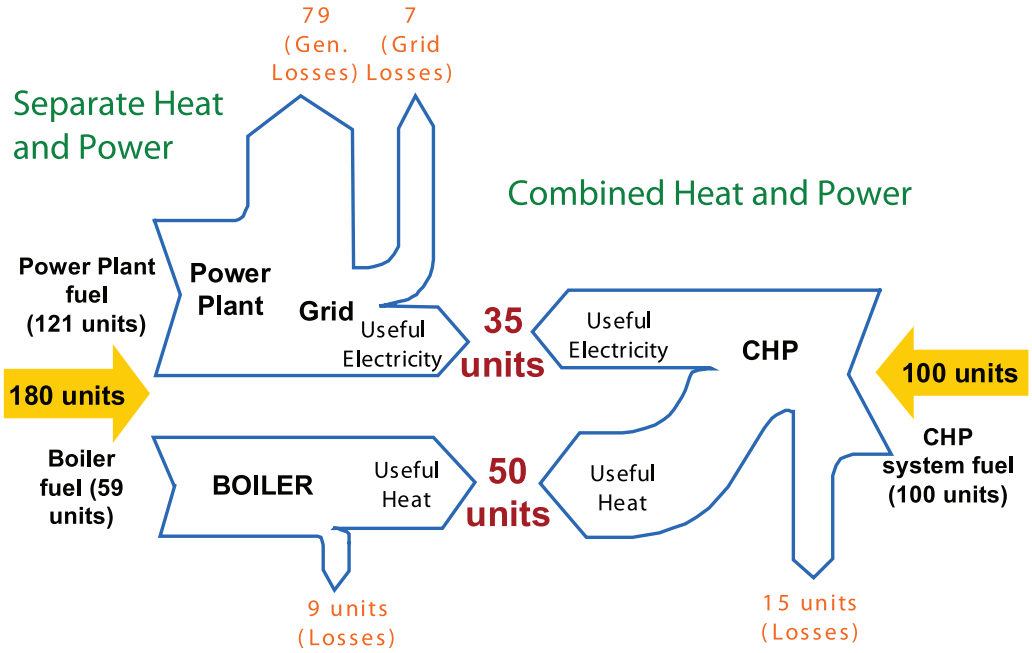


Figure 10. Efficiencies of conventional electric power and heat generation compared to combined heat and power (CHP) generation. By reducing losses from the system, CHP requires 44 percent less fuel than conventional systems to generate the same amount of power and heat.[49] Source: Elliott and Hedman (2001).

48 Assuming OECD coal-fired power generation grows to 5,351 TWh per year and that the efficiency of ultra-super-critical coal-fired power plants brings CO_2 emissions down to 738 g/kWh as compared to 830 g/kWh for super critical plants.

49 The Elliot and Hedman (2001) calculation assumes power plant efficiencies of 34.7 percent, which is in line with older existing coal-fired power plants in the United States. Efficiency at newer coal plants in the United States and Europe can average 45 percent, and gas-fired combined cycle plants can achieve 55 percent.

the United States, use this efficient technique far less often. Overall, CHP generation accounts for only 7 percent of global power generation. The benefits of this technology are so significant that they can lead to cost savings as high as US$30 per ton of CO_2 emissions reduction (Aunan et al., 2004).

A technological revolution over the last 20 years has transformed CHP from steam turbine, back-pressure steam systems to gas turbines and combined cycle systems. The new technologies have increased the ratio between electricity and heat produced by a factor of five and introduced a new flexibility that allows operators to take account of the value of the electricity generated as well as the demand for heat. These new developments open up many additional opportunities for CHP applications in industrial and building sectors (district heating), and for large-scale, medium, and small plants. Figure 10 demonstrates the improved efficiency and effectiveness of CHP over separate heat and power configurations.

Specialists have for more than a decade advocated that cogeneration be developed as a source of 20 percent of all OECD power (PCAST, 1997; WADE, 2005). Markets could readily deploy this widely available technology if governments would help create the necessary market conditions.

Recommendation: Obtain 20 percent of electric power from combined heating, cooling, and power generation by 2020.

To implement this recommendation, G8 countries could:

a) Level the playing field for CHP generation by requiring easy access to the grid for power and heat sales to third parties and by requiring grid companies to pay fair market value for cogenerated electricity.

b) Work with regions having large municipal heating systems to require sustainable municipal energy plans, develop heat supply reliability and efficiency standards for regions and municipalities, and provide a menu of heat market "business models."

Implementation

The first step for national governments is to require easy access to the grid and heat supply system for distributed producers. Nations could also develop and enact portfolio standards for utilities requiring 20 percent of supply from CHP. This would require drafting of codes and standards over the next 6 months and enacting legislation over the next 12 to 18 months. An exception could be made for nations generating more than half their power from non-carbon energy sources. Governments will need to fund technical and economic expertise for regulatory agencies to promote efficiency.

National governments should immediately examine their policies for other subsidies and distortions that create a financial advantage for inefficient power companies. Subsidies are not needed to promote distributed energy, but governments may need to revise financial, tax, and regulatory policies to ensure equal access to markets for the most efficient technologies.

As part of this effort, governments should require sustainable municipal energy plans and supply efficiency standards. Governments should encourage consumers to establish bargaining units and help develop pilot projects in this area.

Efficacy of Combined, Heating, Cooling, and Power Recommendation

Combined heating and power would reduce investment in transmission and distribution infrastructure in the OECD countries by US$130 billion, or 8 percent of global power transmission and distribution investment, before 2030 (IEA, 2003a).

Natural Gas

The IEA (2006e) has indicated that some 30 billion cubic meters (BCM) or 1.1 EJ of natural gas annually could be saved by reducing leaks in gas transmission lines in Russia (6 BCM), reducing the amount of gas flared in oil fields in Russia (15 BCM), and improving the efficiency of the gas compressor and pumping stations that transport gas to Europe (8 BCM). Although this opportunity pertains mainly to Russia, significant losses occur while providing gas via long-distance trunk pipelines to Europe.

National leaders should encourage modernization of the high-pressure pipeline systems, provide incentives and technical assistance to distribution companies to make it easy and desirable to take on leak reduction as a new business opportunity, and seek to provide access to markets for associated gas (gas produced in association with oil) that is currently flared. These actions will ensure access to affordable, market-priced natural gas at current or growing quantities for the next two decades.

Recommendation: Produce 30 billion cubic meters (1.1 EJ) of marketable natural gas per year by eliminating losses from leaks and flaring.

To implement this recommendation, G8 countries could:

a) Improve the efficiency of natural gas transmission across Russia and Eastern and Central Europe by encouraging industry to upgrade inefficient, obsolete pumping stations.

b) Create incentives to make leak reduction profitable for natural gas distribution companies.

c) Require access to gas transmission pipelines on a “common carrier” basis to bring to market 15 BCM (0.6 EJ) of gas that is now uselessly flared.

Implementation

This area is ripe for able, enlightened leadership. Governments should immediately encourage the natural gas industry to speed up modernization of high-pressure transmission pipelines. Over the next year, governments could also restructure gas utility pricing to create incentives for reducing leakage. In particular, governments could ensure through regulatory reform that producers of associated gas have access at a market-based price to existing high-pressure transmission pipelines that could connect them to a ready marketplace. To achieve this policy reform, governments may first need to fund technical and economic expertise for regulatory agencies to promote efficiency. Figure 11 shows major areas of flaring activity.

Utility companies also need to change their budgeting and project development plans to allow for energy efficiency investments and management. Over the next 2 to 10 years, governments will need to cooperate with utilities to review progress, and to evaluate the need for further actions.

The G8 could easily extend this initiative to developing countries where gas flaring is a major problem. The total associated natural gas currently flared worldwide, estimated by the World Bank at about 150 BCM (5.7 EJ)

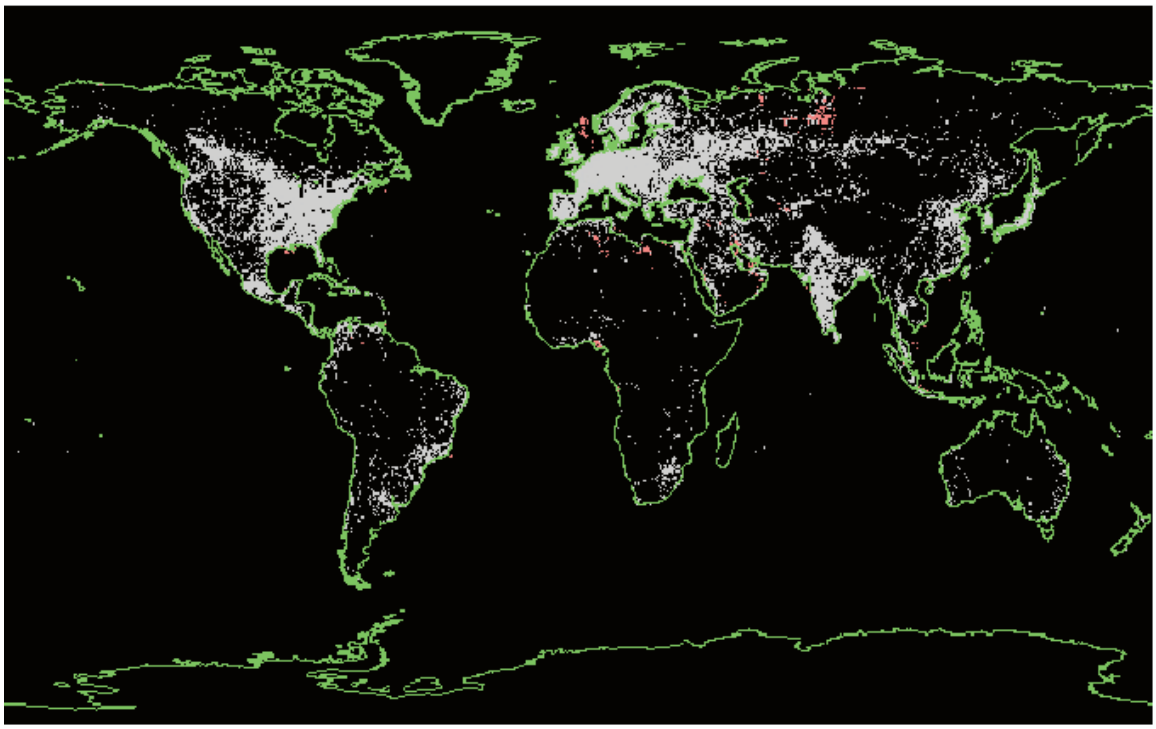


Figure 11. Areas of major flaring activity are indicated by red dots. Source: World Bank, 2006.

per year, is an attractive target for recovery.[50] One such effort is underway, and could be expanded. The Global Gas-Flaring Reduction Public-Private Partnership includes the governments of oil-producing countries as well as international and state-owned oil companies. Consistent with this effort, private firms are pursuing opportunities to reduce flaring in operations around the world. Projects are underway to address the major sources of flaring related to production.

Efficacy of Natural Gas Recommendation

The value of gas saved could be worth as much as US$8 billion per year beginning in the next two to five years, given the current export price of Russian gas to Europe. This sum dwarfs the cost of modernizing compressor stations and the necessary infrastructure for the treatment and transport of the associated gas to the market. These costs will be less than the exploration and development of new gas wells. Action in this area will boost the overall economy, although monopolies and other vested interests may lose some advantage and resist even modest reforms.

50 A report on worldwide emissions from vented and flared natural gas was issued in July 2004 by the U.S. Government Accountability Office (GAO, 2004). The report refers to more than 3 EJ of natural gas wasted each year, and recommends more accurate records to determine the amount of the resource that is flared and vented, and the volume of GHGs these practices contribute to the atmosphere each year.

VIII. SUPPORTING ENERGY EFFICIENCY IMPROVEMENTS IN DEVELOPING AND TRANSITION-ECONOMY COUNTRIES

Energy consumption per capita in the developing countries—where three-fourths of the world population lives—is much lower than in industrialized countries. It is thus unavoidable that energy consumption will continue to grow in developing countries. Because of the need to manufacture energy-intensive materials for construction and infrastructure, developing and transition-economy countries may have more energy-intensive growth than developed nations. Recognizing the need for this difference in the structure of economic activity, there is still scope for attaining more economic benefit from each unit of energy consumed, making the citizens of all countries better off. Acute energy shortages in key developing economies such as China and India highlight that energy efficiency is key to sustained and sustainable economic development.

The fundamental challenge is to incorporate modern and efficient technologies in both the supply and the demand sectors early in the process of development. This will enable developing countries to "leapfrog" the traditional energy-intensive development process. Many developing and transition-economy countries have already established ambitious efficiency targets for themselves, and new industrial installations are often among the most efficient in the world. An important task of the G8 countries is to support developing countries in meeting their own objectives through technical cooperation and financing instruments. A key barrier to the use of more efficient products and technologies in developing countries is their higher initial cost. While most energy efficiency measures have a good return rate and pay for themselves in two or three years, a large number of people in developing countries who live at or close to the poverty line simply cannot afford the higher initial investment. Enlightened national and international policies are needed to address this issue.

Currently, the G8 process enables the participating nations to develop a better understanding of one another's perceptions of and approaches to common problems. In some cases, consensus is reached on joint actions. While other countries are sometimes invited to participate on the margins, there needs to be a more concerted effort to expand participation in the process of improving energy efficiency. To realize the full potential of energy efficiency, G8+5 governments need to broaden the framework and forum for international cooperation in such a manner that gives developing and transition-economy countries an equal voice in the process.

In the communiqué agreed at the Gleneagles summit in July 2005, G8 leaders pledged to interact closely with developing nations on climate change and related issues. They established the Gleneagles Dialogue on Climate Change, Clean Energy, and Sustainable Development and invited all interested parties to participate. Currently, this process includes the G8+5 countries and Indonesia, Nigeria, Poland, Australia, Spain, and South Korea. Energy efficiency is one of the four main priorities of the dialogue. The inclusion of the +5 countries and other nations in the Gleneagles Dialogue is a good step but does not provide the forum for ongoing technical coordination that will be needed to implement the recommendations in this document. Existing organizations, such as the IEA, provide a forum for developed countries, but developing countries do not participate in the organization's decision-making processes. The G8 should expand the Gleneagles Dialogue to include technical cooperation and coordination or consider constructing a permanent parallel process.

Facilitating Investment in Energy Efficiency

Recommendation: Create multiple energy efficiency loan guarantee funds in developing countries for efficiency investments.

To implement this recommendation, G8 countries could:

a) Provide funds to qualified organizations such as the International Finance Corporation to serve as guarantors of consumer credit, providing guarantees through commercial banks.

b) Provide technical assistance to develop a "pipeline" of these projects by identifying and helping perform financial due diligence for these types of investments.

A vast literature details market opportunities for and well-known constraints on energy efficiency project investments. The most common barriers include:

- Lack of credit history or collateral for securing loans.
- Lack of experience preparing *pro forma* documents for business models and financial statements.
- Small project size, which translates into relatively high transaction costs.
- Financial sector unfamiliarity with energy efficiency and clean energy projects and the perception that they are risky.

The condition of banking systems in transition-economy and developing countries also presents a major barrier to energy efficiency project financing. Many countries, including China, the world's fastest growing energy consumer, regulate interest rates on loans. Banks are not allowed to price loans according to risk. This problem, and lack of familiarity with efficiency technology, biases bankers to lend to large, credit-worthy energy supply institutions, to the near exclusion of the smaller firms that compose the market for efficiency projects.

The lack of ready access to information about the potential profitability of energy efficiency projects, particularly information about successful demonstrations, hinders lending to small firms. Banks need more information about the potential size of the market for efficiency and renewable projects, technical options for them, and proven methods of implementing such projects to raise their comfort with these types of undertakings. Technical assistance to the banking sector to help identify loans is a proven method of accelerating energy efficiency investments and use of loan guarantee funds.

Implementation

A combined approach would leverage investments and loans from commercial banks, build the confidence of lenders by working with them on the guarantee process and feasibility study, and lower the risk for lenders. These programs have been demonstrated to become profitable and self-sustaining in the private banking sector.

End-user equipment finance programs can also be created with utilities—either electric or gas—enabled to arrange financing for end-users to acquire more efficient equipment. The utilities can lend directly or facilitate commercial loans or investments in lieu of the lender. The utility can collect payments on the electric or gas utility bill. In addition to financing, the utility could provide other services to customers to develop and prepare projects, including feasibility assessment, engineering, equipment procurement, and operations services. The utility could act as a market organizer and work with a qualified set of equipment supply, engineering, and related companies who offer products and services. Targeted end-user sectors for gas utilities could include gas-fired CHP installations, highly efficient heating and cooling systems for commercial buildings, efficient boilers and furnaces throughout industry, energy efficient processes for fertilizer, methanol, and hydrogen manufacturing, and

others. In the electric sector, targeted end users could include users of large industrial electric motors, aluminum manufacturers, and household appliance purchasers.

Efficacy of Recommendation Facilitating Investment

Multilateral donors have already enabled the expansion of private sector energy efficiency financing in some parts of the world. For example, the Commercializing Energy-Efficiency Finance (CEEF) program has provided partial guarantees on loans for energy efficiency projects in the Czech Republic, Slovakia, Estonia, Latvia, and Lithuania. In addition to the guarantees, CEEF includes a technical assistance program to address high transaction costs and market barriers. That US$90 million investment has leveraged over US$225 million in project finance over the course of the program. By working through local financial institutions, CEEF makes loans more affordable for small and medium size enterprises and also enables financial institutions to gain the type of experience with energy efficiency loans that will help ensure that lending continues even in the absence of guarantees.

Capacity Building

Effective support for energy efficiency requires strong institutions and a well-trained, diverse workforce. Developing countries are already taking steps to build their own capacity, but there is scope for additional international cooperation. Capacity building should focus on creating platforms that advance energy efficiency business and market transformation, and on enhancing the capabilities of individuals, organizations, and networks to implement energy efficiency projects and programs, to conduct basic and applied research and development, and to perform monitoring and verification. Priorities for capacity building should be set in reference to national energy efficiency policies already enacted. A potentially effective approach is for countries to build capacity by setting up specific institutions at the government level to coordinate energy efficiency policies.

Recommendation: Invest in the people and institutions needed to capture the full benefits of energy efficiency in the buildings/appliances, transportation, industrial, and energy supply sectors.

To implement this recommendation, G8 countries could:

a) Promote business development and market transformation through:
   - Executive training seminars in energy efficiency management.
   - Training small and medium size enterprises on the development and dissemination of energy efficiency products and services.
   - Strengthening local industry capacities in marketing, outreach, and product promotion.
   - Training staff in commercial banking institutions to appropriately evaluate and manage loans and equity funding for energy efficiency.

b) Promote research, development, demonstration, and deployment through:
   - Joint research on major innovative fields where significant improvements in energy efficiency are possible (e.g., vacuum insulation, membrane and biotechnological processes).
   - Inter-laboratory exchange and/or joint research on energy efficiency technologies.
   - Student exchange programs focused on efficient energy use from the technical, economic, and policy point of view.

c) Promote monitoring and verification by providing support to establish audit services and protocols.

In the buildings sector, the most important areas for cooperation include establishing priorities for equipment and appliance standards, underwriting capacity in national testing and standards agencies, and providing technical support for establishment and enforcement of building codes adapted to the requirements of different climate zones in cooperating countries. In addition, progress could also be accelerated by promoting cooperative R&D on energy efficient air conditioning appliances and systems for hot and humid climates and encouraging their integration in building codes.

New greenfield industrial facilities are mainly constructed in developing countries, while new technology is developed in industrialized countries. Hence, increased collaboration between the two is essential to develop increasingly efficient process technology. Key areas include new process technologies, systems optimization of plants and utility systems to decrease energy use and investment costs, and increased training in energy management and product and plant design, in both the private and public sectors.

In the transportation sector, the best opportunities for G8 attention include coordinating and regularly updating energy efficiency standards for different vehicle classes and for tire efficiency; strengthening national testing and standards agencies; establishing fuel efficiency labeling programs; transferring experience in transportation logistics; and building a collaborative network for exchange of information and best practices.

Implementation

Overseas development assistance programs should be aimed at building the capacity of energy researchers, suppliers, ESCOs, regulators, and consumers in the +5 countries and other developing countries. Activities should include training programs and site visits in G8 and host countries, technical assistance, applied joint research, regional efficiency centers, and international exchanges. These activities enhance the capabilities of both institutions and individuals. G8 countries should promote a global research alliance between developing and developed country research institutions.

Efficacy of Capacity Building Recommendation

Investing in people and institutions yields long-term benefits, both nationally and internationally. Individual countries will be responsible for implementation of these goals, and it is vital that in-country expertise exists. Capacity-building programs have been successful at all levels, including government, business, and nongovernmental organizations.

"Trading Up"

Capital shortages in developing countries have led to a substantial trade in used industrial equipment from industrialized to developing and transition-economy countries. Entire industrial facilities, such as blast furnaces, rolling mills, refineries, and cogeneration plants have been taken apart, shipped, and rebuilt in China, India, and Central Europe, for example. This practice meets the needs for low-cost production capacity. It also burdens developing countries with large future energy bills and increased GHG emissions—costs far in excess of the savings on the initial investments. Fortunately, in some industrial sectors and countries, globalization of trade has led to the introduction of state-of-the-art facilities (e.g., the cement industry in India and China).

The problem exists in the appliance and transportation sectors as well. For example, there is a brisk trade in used refrigerators between European manufacturers and African firms. It is estimated that Europe has exported as many as 3 million refrigerators to Africa. This equipment is not only energy inefficient, thus imposing high

operating costs on those who purchase it, but this trade in turn fuels the trade in chlorofluorocarbons (CFCs).[51] Definitive estimates of the volume of second-hand vehicle trade are not available but sources indicate high volumes.[52] The ISO is currently preparing a set of environmental and safety standards for trade in used vehicles. Individual countries are also addressing the impact of second-hand vehicles to varying degrees. New Zealand recently announced plans to develop age and weight limits on imported used cars in a direct effort to reduce the nation's GHG emissions. Preliminary estimates are that the NZ program will drive a 12 percent improvement in vehicle efficiency.

Recommendation: Foster export of energy efficient technologies and limit the import of used equipment.

To implement this recommendation, G8 countries could:

a) Work through international organizations such as the ISO to develop standards for cross-border second-hand trade that address minimum health and safety standards, including environmental impacts.

b) Encourage developing countries to set minimum energy performance standards and remove trade barriers for the import of used and new equipment.

Implementation

Practices for limiting imports of low energy performance equipment have been in place since the 1970s oil price increase, when Asian countries limited imports of vehicles with large engine sizes. Recent appliance standards adopted by Ghana will raise the energy performance of refrigerators and air conditioners. In India, the elimination of trade barriers and removal of price and quantity controls on paper manufacture led to a rapid closure of small inefficient paper plants in the 1990s.

Efficacy of "Trading Up" Recommendation

Limiting imports of inefficient but low-cost appliances will face opposition on equity grounds, but since this does not immediately affect the internal market for used goods, the opposition may be muted. Removing subsidies to manufacturers will add to overall economic growth; bring in modern, more energy efficient, and less polluting technology; and promote economies of scale.

51 According to the UNEP Division of Technology, Industry, and Economics, 20,000 to 30,000 tonnes of CFCs with a market value of US$300 to US$450 million were illegally traded in the developing world in 2000 (Koeppen, 2001).

52 Some nations publish official trade figures, but these often do not separate new from used vehicles and do not report on the robust black market in used vehicles. The US Census Bureau, for example, reported that 80,000 used cars were exported to Mexico in 2004. Based on media accounts, however, the number of used vehicles in Mexico increased from 500,000 in 1999 to 3 million in 2005, or an average of 417,000 imported used cars per year. The most often cited used-car only trade numbers come from the Japanese, who shipped over US$1 billion in used cars in 2003. Qualitative information is more readily available and confirms the seriousness of this issue. A study by the Sustainability Council of the German Government estimates the volume of the second-hand market for vehicles at about $50 billion in 2002 and that for investment goods at about $100 billion (Janischweski et al., 2003).

IX. IN CONCLUSION

It is a truism that energy efficiency alone cannot solve global energy problems. It is also beside the point. Every imaginable energy supply alternative consistent with a carbon-constrained future will come too late, be too small, and cost too much to make a real difference unless matched with an urgent, full-scale effort to reduce demand for energy.

Realizing the potential of energy efficiency requires G8 governments to demonstrate leadership. Leadership means getting the G8's own energy house in order first, and then collaborating with key developing countries to create a global commitment to energy efficiency.

This process is too important to leave to national governments alone. Nongovernmental organizations, interested businesses, financial institutions, and other levels of government should come together to issue periodic report cards on progress.

Change at the scale required means adopting efficiency measures across every sector of the G8 economy, appropriating the means necessarily to implement them, and monitoring and enforcing their implementation.

Efficiency improvements at the scale proposed in this approach will provide a bridge to affordable low- and zero-carbon energy systems in the future. Climate stabilization, sustainable development, and energy security ultimately depend on global leaders' steps along this way.

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