Efficient Use of Energy

Efficient use of energy is one of the main strategic measures not only for the conservation of fossil energy resources but also for abatement of air pollution and the slowing down of anthropogenic climate change. Accordingly, economic and technical measures to reduce specific energy demand should be priorities across all sectors of an economy. Many opportunities exist for improving efficiency, but progress has been disappointingly slow in many cases. This chapter identifies some of the key areas where improvements are possible and describes the World Bank Group's support for energy efficiency, drawing heavily on the recent strategy paper "Fuel for Thought."

The term *efficient use of energy* includes all the technical and economical measures aimed at reducing the specific energy demand of a production system or economic sector. Although implementation of energy-saving techniques may require initial investments, short-term financial returns can often be achieved through lower fuel costs due to the reduced energy demand.

Improving the use of energy is a issue in virtually all sectors of an economy, but the focus here is on the power sector and the industrial sector, which have the highest primary energy demand and thus the highest potential for energy savings.

Growth in Energy Use

Energy is vital to economic development in developing countries. Poverty will not be reduced without greater use of modern forms of energy. Assuming that energy demand in developing countries grows by 2.6% per year (a likely figure, given current trends; see World Energy Council 1995), their total consumption of energy will be double the level of total consumption in industrial countries by 2050. Even then, each person in the developing countries will be using, on average, a mere quarter of the energy consumed by each inhabitant of the industrial world. As they seek to improve their standards of living, developing countries have the opportunity to do things differently from what has happened in the past. The challenge is to break the link between economic growth and energy consumption by pursuing efficient production processes and reducing waste and, at the same time, to break the link between energy consumption and pollution by relying more on renewables and by using fossil fuels more efficiently.

According to World Energy Council projections, fossil fuels will still account for almost two thirds of primary energy even decades from now. Some long-term scenarios (for example, by Shell International and the Intergovernmental Panel on Climate Change, IPCC) postulate a rapidly increasing share of renewable technologies—solar, wind, geothermal, and modern biomass, as well as the more traditional hydroelectric. Under these scenarios, with appropriate policies and new technological developments, renewables could reach up to 50% of the total by the middle of the twenty-first century. However, even in fairly optimistic scenarios, carbon emissions from burning fossil fuels (in the form of carbon dioxide) are predicted to increase dramatically. Industrial countries are responsible for the bulk of the buildup of heat-trapping gases currently in the atmosphere, and only they have made firm commitments to cut their emissions at the Conference of the Parties to the United Nations Framework Convention on Climate Change in Kyoto in December 1997. Yet emissions from developing countries are already growing rapidly, and by early in the next century they are expected to exceed those of industrial countries. The funda-

mental question is how to reconcile economic growth, primarily fueled by coal, oil, and gas, with protection of the environment.

The Approach of the World Bank Group

The guiding principles for the Bank's work in energy efficiency have been set out in a number of policy papers (e.g., World Bank 1993a, 1993b) and the strategy paper "Fuel for Thought" (World Bank 1998). Among them are these:

- The World Bank Group will not invest in a country's energy sector unless that country shows a commitment to improving efficiency, whether by restructuring the sector or by reforming its policies.
- It will support competition, private sector investment, and sound regulation of the energy sector.
- It will promote energy efficiency both on the supply side and on the demand side and will integrate energy pricing with environmental policies.
- It will help to improve access to modern forms of energy for the 2 billion people in rural areas who must rely on traditional forms of energy such as fuelwood and agricultural waste.

A recent internal Bank study indicates that market-based restructuring of the energy sector is already yielding financial and operational efficiency rewards in some developing countries. However, the study concluded that much more time than initially estimated is needed in other countries to implement the necessary reforms. It also found that there was not yet much evidence of the environmental impact of reforms, and the evidence of much progress on energy efficiency—on either the supply side or the demand side—is still thin.

Supply-Side Efficiency

Power industries in developing countries often lose more than 20% of their electricity to theft or inefficiency. One way to stop this is to encourage either private-sector participation (as in Côte d'Ivoire) or complete privatization (as in Argentina and Chile, where losses are now at an acceptable level of 10–12%). However, many projects that were aimed in part at cutting electricity losses in publicly owned utilities have achieved much less than hoped, indicating that the Bank and its borrowers need to increase substantially their efforts in this area.

There is huge scope for reducing energy losses in countries that use district heating systems, and the Bank has achieved successes in this area. The World Bank recently assisted a project to rehabilitate district heating in major Polish cities, and the improvements there are remarkable: 15–20% of energy has been saved; government subsidies—once 80% of cost—have been eliminated; and emissions of pollutants have fallen by 15–20%.

Demand-Side Management

Bank Involvement

Bank lending for industrial energy conservation has had mixed success. Over 70% of the projects reviewed did not meet their objectives fully. The barriers included lack of interest by consumers, lack of credit, and—most notably—a low level of commitment on the part of the borrower. Those project that did succeed were mostly in East European countries, where access to foreign exchange after the collapse of communism allowed firms to buy new, more efficient machinery. End-use energy efficiency programs in the electric power sector and in other sectors such as industry and district heating are still in early stages, but currently, more than 20 projects include energy efficiency measures. Much of this assistance is for projects outside the energy sector—for example, retrofitting apartment blocks in Russia. Projects are currently under way in Thailand, and major operations are planned in Brazil and China; these will include establishment of energy service companies (ESCOs).

In the area of energy efficiency, the International Finance Corporation (IFC) has invested in numerous projects that improve the efficiency of industrial energy use through the rehabilitation and upgrading of plants in energy-intensive sectors such as cement, chemicals, and pulp and paper. In addition to these process improvements, the IFC has invested more directly in energy efficiency through several different types of projects:

improvements in transmission and distribution equipment owned by private electric utilities; manufacturing of goods such as efficient light bulbs and insulation material; profit-oriented ESCOs that upgrade equipment and change processes to reduce energy consumption in client companies; and financial intermediaries with credit facilities targeted at improvements in energy efficiency. The IFC is actively pursuing further investments in this area. (For an overview of the IFC's strategy in the energy sector, see Box 1.)

Power Sector Opportunities

Greater Efficiency in Conventional Power Plants

Between 35% and 40% of total annual primary energy demand in the industrialized countries is used in power plants to generate electricity or heat. As a result, between 25% and 33% of total annual carbon dioxide emissions arise from power plants. These figures underline the importance of efficient use of energy in the energy supply sector.

Various technical measures are available for increasing the efficiency of generation of electricity and heat in existing and new conventional fossil-fuel-fired power plants. Replacement or further optimization of main process items may be an option; for example, replacement of steam turbines in several power plants in the former East Germany after reunification resulted in an overall system efficiency increase of about 1.7 percentage points. Other measures include lowering condenser pressure, optimizing the feedwater preheat system, utilizing waste heat, and using ultracritical steam cycle conditions. The total system efficiencies that can be attained by taking advantage of current developments in power plant technology can be about 43% for hard-coal-fired plants, 41% for lignite-fired plants, and 56% for gas-fired combined-cycle plants.

Since combustion of fossil fuels contributes greatly to emissions of carbon dioxide—the most important greenhouse gas—fuel switching has to be regarded as a major option for the reduction of carbon dioxide emissions.

Cogeneration

Use of cogeneration plants, which produce both electricity and heat, can reduce overall energy consumption by 10–30%, in comparison with separate generation of electricity and heat. Cogeneration plants are based on currently available standard technologies, and thus no technical risks are involved. However, reasonable and cost-effective utilization of this technology is only feasible if the heat can be supplied to a district heating network or to a nearby industrial plant where it can be used for process heating purposes.

Box 1. The IFC's Strategy

In view of the increasing commercial viability of renewable energy technologies, and in anticipation of potential changes in how the market values environmental externalities such as emissions of greenhouse gases, the IFC is actively investigating—and in certain cases financing—environmentally friendly energy projects. In approaching newer technologies, the IFC seeks out projects that fall into two basic categories:

- Ventures that appear to be commercially viable from the IFC's perspective but that are still perceived as too risky by private sector investors or lenders
- Ventures that the IFC and the private sector consider to be close to, but not quite at, commercial viability.

The IFC's efforts reflect a commitment by the corporation's senior management to expand investments in this area and to help accelerate market acceptance of environmentally sustainable energy projects. The IFC is considering renewable energy projects ranging from those that are often competitive with conventional energy sources (e.g., small-scale hydroelectric, biomass, and wind) to those that usually require some level of concessional assistance, such as solar photovoltaics. The IFC is also assessing various types of energy efficiency projects, including energy service companies (ESCOs), transmission and distribution improvements, and industrial upgrades. The IFC has identified a large potential market in this sector but has also noted many barriers (small project size, lack of collateral, and so on).

Emerging Power Plant Technologies

New energy technologies are being developed, such as integrated gasification combined-cycle power plants, pressurized pulverized-coal-firing technology, humid air turbines, and fuel cells. Some of these technologies, although they are capable of efficiencies well in advance of current technology and show greatly reduced emissions, are yet not in a mature state of development. Currently, several large integrated gasification combined-cycle demonstration projects are being assessed, but it is too early to rely on these approaches as technically and economically viable alternatives to conventional plants.

Industrial Power and Heat Utilization

Industrial production processes often show a high specific energy demand. Industry is estimated to account for between 25% and 35% of total final energy consumption. Although great progress has been made in the rational use of energy in the industrial sector during the last two decades, improvements in cost-effective energy utilization have not nearly been exhausted. This holds true for new plants as well as for existing plants. Improvement in energy end-use efficiency offers the largest opportunity of all alternatives for meeting the energy requirements of a growing world economy.

It is impossible to list all the measures that have been implemented or that show promise for further improvements in special industrial branches. Many of the technical options for energy saving require only small investments and are easy to implement. In several cases, even simple organizational changes bring about considerable energy savings, yielding not only environmental benefits but also financial returns. Energy-saving measures often show very short payback times, especially in industrial applications. However, as in the case of cleaner production approaches, it is often difficult to generate management interest in and support for the identification and implementation of energy-saving measures. Without such support, success is almost always limited.

Energy Audits and Efficiency Planning

The first step in identifying energy-saving potential within an industrial plant is to carry out an energy audit, taking into account the specific conditions at the plant and the local conditions at the production site. This energy audit is required to determine the scope of the energy efficiency project, to achieve a broad view of all the equipment installed at the production site, and to establish a consistent methodology of evaluation. Preparation of an improved energy utilization scheme starts with an inventory of the equipment, its energy demand, and the flow of energy through the plant. Electrical energy and heat should be recorded separately, and the time dependence of the energy demand should be taken into account. A few key areas can be identified on which to focus conservation efforts.

- Electricity production typically requires three times as much primary energy as direct heat use. Therefore, electricity should only be used if it cannot be replaced by other, more direct energy sources.
- The chemical energy contained in fuels should be utilized as efficiently as possible. When combustion processes are used to meet the energy demand of a process or an industrial plant, high combustion efficiencies should be achieved by utilizing as much as possible of the thermal energy contained in the flue gases, by minimizing heat losses (through use of insulation), and by recovering the thermal energy contained in combustion by-products such as ashes and slag.
- Special attention should be given to separation processes for recovering and purifying products, which account for up to 40% of the total energy demand of chemical processes. Energy savings of 10–40% can be achieved through heat integration of the reboiler and the condenser of distillation columns, by using heat pumps or water compression systems. In several applications, it may also be possible to replace the common but very energy-intensive distillation process with advanced separation processes, such as membrane processes, that show a significantly reduced energy demand.

Residential Sector

There is a huge potential for energy savings in the residential sector. Energy can be saved by increasing the thermal integrity of buildings or by using energy-saving lighting such as fluorescent lamps. Because people's behavior is so important for residential energy consumption, information campaigns and demand-side management measures are the most important options for reducing energy consumption in the residential sector.

Capturing the Easy Opportunities

The first step in breaking the energy-environment link is to capture the opportunities for reaping environmental benefits through economically attractive solutions at no additional cost. These opportunities include, at the very least, energy sector reform and restructuring, improvements in energy efficiency on the supply and demand sides, and a switch to less polluting energy sources (see Box 2). Such "win-win" measures can go a long way toward reducing local environmental degradation, but they will not be sufficient. The objective must be for all countries to integrate local environmental and social externality costs into energy pricing and investment decisions so that the polluter pays for the additional costs of environmental protection and pollution abatement.

The Global Dimension

The Bank accepts the IPCC's conclusion that emissions of greenhouse gases from human activities are affecting the global climate. It also believes that the consequences of climate change will disproportionately affect both poor people and poor countries. The World Bank Group has an important role to play in helping to avert climate change, and it will assist its clients in meeting their obligations under the United Nations Framework Convention on Climate Change (UNFCCC). Under the 1997 Kyoto Protocol, some client countries with economies in transition have obligations to reduce emissions of greenhouse gases. Other clients—developing nations—have obligations to measure and monitor GHG emissions within their countries but do not have to reduce emissions yet. In the case of developing country clients, the World Bank Group will seek additional resources to ensure that they do not bear the additional costs of adopting climate-friendly technologies and policies and that their

Box 2. "Win-Win" Opportunities

On the Demand Side

- Improved customer billing and metering (electricity, gas, district heating) to link prices and the rational use of energy
- Industrial boiler tune-ups
- Temperature and lighting controls
- Replacement of motors and lights
- Cogeneration of electricity from waste heat
- Reduction of energy losses through building codes
- Optimization of water pumping through time-of-day tariffs, metering, and replacement of pumps
- Streamlining regulatory requirements

On the Supply Side

- Promotion of competition and private investment within a sound regulatory framework
- Cleanup of oil and gas leaks
- Improvements in coal mining and production
- Rehabilitation of power plants and district heating systems; loss reduction programs in transmission and distribution
- Fuel switching to natural gas
- Large hydroelectric projects, under the right conditions
- Gas trade (liquefied natural gas, pipelines) and power trade
- Wind power, photovoltaics, and small hydroelectric installations

Obstacles to "Win-Win" Strategies

- Lack of information or interest among consumers about potential and techniques
- Lack of access to financing
- Small absolute returns that make efficiency measures less interesting for firms than big projects · Legal constraints (e.g., tenants may not be allowed to improve building structures)
- High real or perceived risk
- Weak institutions and high transaction costs
- Inconsistent or ineffectual monitoring of energy savings over the lifetime of the investment

goals for national economic development and environmental quality are not compromised.

Additional Resources

The Bank has established a Thematic Group on Energy Efficiency that can be contacted through the Knowledge Manager for the Energy, Mining, and Telecommunications Department (IEN) or through the Bank's Website (www.worldbank.org).

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