Issue Brief

THE EFFICIENCY OF ENERGY USE AND THE ROLE OF ELECTRICITY UTILITIES

ENERGY & ELECTRICITY INTENSITY

There are large differences in per capita energy use at similar levels of prosperity within any society. And there are also large differences in average per capita energy use between different societies with similar per capita incomes. These differences are influenced by culture, climate, lifestyles, personal choices and government policies. They suggest the existence of substantial potential for efficiency improvements.

Energy demand and economic output

Even though throughout history economic development has shown a consistent trend of increased energy use with increasing prosperity, overall energy use grows more slowly than the economy. This means that the energy intensity of modern economies (energy/GDP) is decreasing, or that their energy efficiency (GDP/energy) is increasing. In terms of the global average, there was a continuous decline in primary energy intensity of approximately 1.5% per year between 1990 and 2002.[1]

Demand for electricity, on the other hand, has been growing at roughly the same rate as the world economy, since electricity is becoming a more important energy carrier in almost all major energy demand sectors.

Electricity demand

Demand for electricity is not fixed – the level of consumption is decided by the choices of consumers and industry, and influenced by many factors including ownership of electrical and non-electrical devices, the prices of electricity and alternative forms of energy, the income, preference and lifestyles of consumers and government energy policies and subsidies.

Industry has the largest share in global final electricity demand, followed by the residential and commercial sectors, where the principal use of electricity is in buildings (see Figure 1).

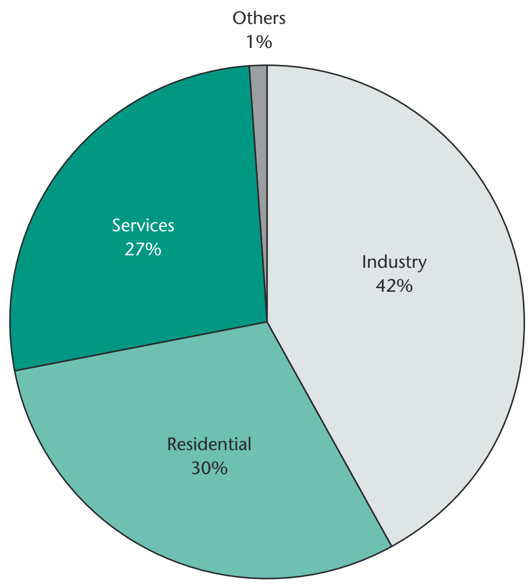

Figure 1: Shares of global electricity consumption, 2002

Source: International Energy Agency. *World Energy Outlook 2004.*

Demand for electricity in transport is currently largely limited to trains, trams and trolley buses, but road transport (e.g., electric cars) could offer a much larger source of demand in the future.

Trends by sector

The industrial sector has seen continuous switching from direct fossil fuel to electricity, both for non-mechanical (e.g., electro-static paint drying, electro-steel making and electric glass melting) and mechanical processes (lifting, spinning, rolling, etc.). The share of electricity in industrial energy consumption has risen from 13% in 1971 to 21% in 2002, and this share is projected to keep climbing.[2] Industrial motors are a particularly important category. In the EU-15, for example, electric motors in industry and manufacturing used about 24% of total electricity consumption in 2000.[3]

Demand has also grown strongly in the commercial (services) and residential sectors, which mainly represent electricity use in buildings. Increased power needs for computers, air conditioners, lighting and other electricity-driven devices, particularly within the residential sector, has outpaced the substantial increase in the efficiency of appliances in the last 20 years. The share of electricity in sectors other than transport and industry (hence mainly in buildings) has increased from 9% in 1971 to 23% in 2002, and is projected to continue growing strongly.[4]

VALUE CHAIN ENERGY EFFICIENCY

Global or overall energy efficiency is the result of efficiency along the whole energy value chain, including energy supply and delivery by utilities and end use by consumers.

Electricity is a "premium" energy source. Its final use is clean, flexible and characterized by high efficiency.

As it is an energy carrier derived from primary energy in generation plants and transported over long distances, its supply gives rise to losses in transmission and distribution (T&D)[5] and, more importantly, in generation: efficiencies of gas-fired generating plants, for instance, range from 50-60%, and those of coal-fired plants from 30-40%. This means that one unit of electricity requires around three units of coal for its generation. Electricity is more expensive per unit of primary energy because of this energy conversion loss, and it also requires infrastructure investments for power plants and T&D lines.

This is why, for applications like space and water heating, using primary energy directly is usually more efficient than using electricity. Innovation in electric heat pump technology, however, has advanced efficiency levels and is now dramatically changing this picture, making electricity an increasingly viable source of heat.

SUSTAINABILITY BENEFITS

It is important to note that consumers do not wish to consume energy – they wish to enjoy heating, lighting or air conditioning, or make use of mechanical power, computers, etc. If the same services can be provided using less energy (i.e., more efficiently), the consumer will benefit from a lower energy bill.

The implementation of energy efficiency measures must however be done in a cost-effective manner. From a consumer perspective, for example, the individual investments in energy efficient appliances (which may come at a premium) must at least be matched by energy cost savings.

One of the primary benefits of energy efficiency is the mitigation of resource and investment challenges. Rapid economic growth naturally leads to the need for more resources and investments in infrastructure on the supply side. At the same time, however, it should trigger the consideration of end-use efficiency as an investment alternative to new generation and other supply-side developments. As such, efficiency can help overcome both capacity constraints and a dependence on imported fuels, and hence make energy and especially electricity more affordable and reliable, which ultimately benefits the consumer.

Supply disruptions in China

In the summer of 2003, China experienced higher than expected growth rates for electricity (principally from demand for air conditioning and rapid industrial production growth). As a result, the government had to require more than half of the provinces, (government ruled) municipalities and autonomous regions in the mainland to enforce power supply restrictions (as reported by the State Electricity Regulatory Commission, SERC), such that whole factories were told to shut down on certain days because of power shortages. A major DSM energy efficiency program was implemented to address the situation.

"In order to mitigate the situation, the state decided to proceed with power development and the augmentation & stable operation of the network, and to promote the demand-side management and rationalization of the electricity's end-use. Considering the time required for power development and the network expansion, demand-side management and end-use efficiency improvement naturally play a crucial role in the short to medium term."[6]

Furthermore, as a way of "meeting demand", efficiency improvements are clearly the option with the least environmental impact, since any impacts associated with incremental generation, transmission and distribution – be it global climate change or the local environmental footprint – are avoided through end-use savings.

Such environmental impact reductions do however depend on how the electricity is generated. Saving electricity generated largely from hydropower, for example, would hardly result in any reduction of CO_2 emissions, whereas saving electricity generated from coal may result in a considerable improvement.

It has also been shown that low-income households in particular can benefit from energy efficiency programs (see box).

An example of non-energy benefits in energy efficiency programs[7]

"The non-energy benefits of a low-income housing weatherization and education program implemented by Pacific Gas & Electric Company in California were analyzed in 1998 […]. This study estimated that the non-energy benefits were worth US$ 305 per year, 2.4 times the value of direct energy savings. The main non-energy benefits were reduced water and wastewater costs, fewer energy terminations, improved quality of the housing stock and fewer illnesses."

Last but not least, if energy efficiency is recognized as a real resource option, it will also attract financing and investment. This in turn can lead to something like a market for energy efficiency, together with the employment and business opportunities that any other market brings with it.

Utility benefits

The electricity utility industry is responsible for investments in the generation, transmission and distribution of electricity. A recent analysis by the International Energy Agency (IEA)[8] demonstrates that utility companies have also become increasingly engaged in end-use efficiency. Methods of engagement include promotion (advertising, mail or customer relationship meetings), information on how to save energy, information on energy-saving technology, incentives for technology use (e.g., cash rebates or rewards for savings), or demand-side management (see *load leveling*). From an efficiency and cost perspective, these initiatives have had varying degrees of success (i.e., varying discrepancy between actual energy savings and *ex-ante* engineering estimates).

While it is clear that utilities do not always have strong incentives to promote end-use efficiency, the challenges we are facing raise the societal expectation that the electricity industry should use its expertise and access to capital to make a more substantial contribution. Below are some additional good reasons for utilities to become players in this field, even without specific government support.

Load leveling through demand side management

Peak demand for electricity typically occurs during office hours on working days. Delivering peak electricity requires using the most expensive plant on the system, which is used infrequently and thus tends to have low capital costs but also low efficiency (leading to high operating costs and emissions). The level of the peak also largely determines the amount of peaking generation, and transmission & distribution capacity that is needed to ensure reliability of supply.

Programs such as "time of use pricing" can be used to promote energy efficiency and conservation during peak hours, when electricity is especially expensive to deliver: as higher peak prices result in shifting some of the demand from peak times to others, capacity needs are lowered. Special provisions are often required, however, to avoid harming low-income customers. Thermal storage air conditioning systems are commonly used devices that level operations, thus downsizing the required system capacity and bringing about efficiency and economic gains. Programs of this type are often referred to as demand side management (DSM).

Electricity-based applications

Technologies that improve end-use energy efficiency can lead to the development of new electricity-based applications and new customers, who switch from another form of energy use to electricity.[9]

Customer loyalty and secured license to operate

Helping customers save energy is likely to increase their loyalty (fewer kWh per customer but more customers remaining in the base). In the coming decades, with increasing demand for electricity-related services, increasingly liberalized electricity markets, and public concern regarding environmental impacts, utilities might find assisting customers in using less electricity to be a part of their license to operate.

CASE STUDY: ECO-Support Plan

TEPCO launched the "ECO-Support Plan" in Japan with the objective of raising the awareness of residential customers for a new energy efficient product (the CO_2 refrigerant heat-pump water heater) and to support energy service companies (ESCOs) for energy saving activities in small- to medium-scale offices and commercial buildings. The plan provides a financial incentive for customers who buy the product and offers an independently certified CO_2 emission reduction certificate based on the reduction potential of the product. A matching benefit (equal to the financial incentive) is also provided for forest management activities. Users are widely subscribing to the program.

COST-EFFECTIVE POTENTIAL FOR HIGHER ENERGY EFFICIENCY

It has been widely demonstrated that a wide range of technologies exists in which investments could be made to more or less dramatically reduce energy (and electricity) use.

For example, it is estimated that up to 7% of global electricity demand could be saved if the energy efficiency of industrial motors (for pumps, fans, blowers, air compressors, etc.) and their related drive systems were to be cost-optimized from an end-user perspective.[10] The application of heat pumps to low-temperature thermal demand in food and fabric productions is another example. The potential for efficiency improvement through substitution is especially substantial in developing countries and economies in transition. The following box highlights examples from the building sector.

Technological innovation in air conditioning/buildings

Demand for air conditioning is growing rapidly in many parts of the world, and is efficiently being met by electric heat pumps. Policies on performance standards, backed by research and technological innovation, have almost doubled their efficiency over the past 10 years. Using the most efficient heat pumps that meet the Japanese frontrunner standard to replace China's existing stock and to meet new demand being developed for air conditioning, mainly in urban areas, could result in 215 TWh of electricity savings in 2020 (7.6% of 2020 national demand).

As heat pump technology is a crucial element for heating, ventilation and air conditioning (HVAC), refrigeration, and now water heating, improvements in its efficiency are expected to substantially contribute to energy efficiency in buildings. Building energy management systems, which conduct the optimal control of air conditioning and lighting based on the data derived from humidity and temperature sensors and human detective sensors (for occupancy control), and its similar but simpler application to households, will further enhance the benefit of electrification and realize the savings in commercial and residential sectors.

A number of further innovations are also emerging in this field, leading to intelligent energy management systems and new systems with the ability to generate savings under time of use pricing schemes.

Elements of energy efficiency in buildings

1. Envelope	Insulation & windows Building materials
2. Equipment & appliances	HVAC Water heating Cooking appliances Refrigeration High efficiency lighting
3. Intelligent systems	Sensors Integrated control networks
4. Enabling technologies	Measurements & control

A wide range of estimates has been made of the total cost-effective potential that could be realized from energy efficiency projects. Results depend critically on the assumptions made, particularly those relating to the cost of capital, economic/technical lifetime of investments and the transaction costs needed to develop projects and processes. Estimates of potential energy savings generally range from 5-30% of current electricity demand, with potential varying by sector.[11] Such reductions could not, however, be made immediately as there are constraints on capital availability and the capacity of industry to manufacture and install equipment.

The IEA has estimated in its *Alternative Policy Scenario* that electricity use could be 12% lower than in the business-as-usual *Reference Scenario* in 2030. "The electricity sector contributes the biggest reduction compared with the *Reference Scenario* in CO_2 emissions in all regions. In 2030, it accounts for two-thirds of the difference between the two scenarios. Of the 3,900 million metric ton reduction in electricity sector emissions, nearly 40% comes from reduced electricity demand."[12]

Further, the IEA points out that achieving this would require a substantial shift in the social investment focus from the supply side to the demand side. However, this shift does not necessarily imply higher overall costs to society (see Figure 2), since even without taking avoided fuel costs into account, the IEA estimates that this could be achieved without any extra investment on a global basis.

Source: International Energy Agency. *World Energy Outlook 2004.*

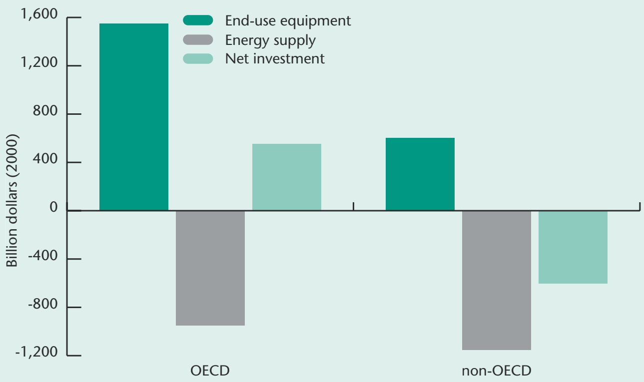

Figure 2: Difference in cumulative energy investment between the reference and alternative scenarios by region, 2003-2030[13]

Barriers to Energy Efficiency[14]

The level of energy efficiency improvements actually observed in the marketplace is almost always below the estimates of the cost-effective potential that could theoretically be realized. This is primarily due to market barriers.

How can the desired shift to increased investment in energy efficiency be brought about? Electricity consumers, consciously or otherwise, make a certain level of investment in energy efficiency based on their assessment or perception of the trade-off between the extra ("investment") costs of more efficient equipment and the energy savings they can realize over time.

Certain economists argue that the markets for electricity and energy efficient equipment do not contain serious "market failures" and that consumers should simply be left to decide on the appropriate level of energy efficiency investment. Many other commentators believe that the market exhibits certain failures, which warrant policy intervention to encourage efficiency investments.

The following lists a number of commonly cited barriers. Some of these barriers (such as lack of information and energy prices that do not include externalities) are market failures that warrant policy intervention, others can also be interpreted as simply increasing the costs of enhancing efficiency beyond what is normally estimated.

- *Lack and cost of information:* It is difficult for consumers to acquire information about real savings potential (available technologies, uncertainty regarding future energy prices) and the financial implications.
- *Energy pricing:* Some efficiency options do not pay for themselves since energy pricing is not designed to reflect full supply costs including those to the environment.
- *Time preference:* Many consumers strongly prefer saving money now to saving later, and this prevents them from making the required upfront investments.
- *Priority:* For any business, effective efficiency measures represent pure cost reductions, and therefore may be regarded as inferior to longer-term investments that may increase market share.
- *The "split incentives" problem:* For construction projects both in industry and for commercial and residential buildings, those who make decisions about energy efficiency are not the ones that benefit.
- *Financing:* End users tend to have more difficulties in securing adequate financing than suppliers do.
- *Transaction costs:* End-use investments are spread across millions of consumers, rather than concentrated in big power plants; this means higher transaction costs per kWh saved than per kWh supplied.
- *Restrictions on entry:* Regulation has for a long time prevented electricity utilities from entering efficiency markets in many countries and continues to do so in some.
- *Lack of competence:* Often consumers lack the technical competence to maintain their investment, but suppliers commonly lack the competence needed to correctly install and adjust the equipment, which results in a bottleneck in the search for customer-oriented solutions.
- *The status quo:* Especially in industry, operational barriers persist, a certain fear of "rocking the boat" and the implicit cost of "doing things differently".
- *The rebound effect:* Engineering cost estimates often neglect the potential for a "rebound" or "snap back" towards previous consumption levels (e.g., savings in heating energy demand in residential buildings are often largely taken up by higher comfort levels).

ENERGY EFFICIENCY POLICIES AND THE ROLE OF UTILITIES

In order to address many of these challenges and barriers, the use of energy efficiency policies and programs has gained prominence, particularly since the oil shocks of the 1970s. These have been implemented through a wide variety of measures, including regulations, grants for more efficient equipment, support for R&D, electricity tariff reform, electricity taxes, best practice programs, equipment labeling/ standards (as practiced in Europe, Japan and many other parts of the world), market certificates and many others.

Such policies and programs have been faced with the high expectation that they would serve to defer supply side investment while improving consumer welfare. Numerous examples of policies and practices are available, some of which are highlighted below. They show – among other things – that utilities, with their access to capital and customers, can play a very important role in the implementation of these programs.

It is important to mention the crucial role of price measures in this context. Energy price signals (for example through taxes) are undoubtedly among the most effective ways not only of encouraging investment in energy efficient equipment, but also of encouraging efficient behavior. However, price signals clearly have their political limits, as they can have implications for social policy and the competitiveness of a nation's industry. The examples below mainly focus on non-price measures.

Least cost planning

Least cost planning (LCP) has been used in many countries to set up large-scale schemes.[15] Under this scheme, when evaluating the options for meeting energy demand, the cost of infrastructure expansion on the supply side is consistently compared with alternative investments in energy efficiency improvements on the demand side. This helps optimize the supply-demand balance at the lowest cost to the customers. LCP takes into account the full range of options available for meeting new demand for services: end-use energy efficiency, load-management, supply-side efficiency improvements, capacity expansion and power purchase. The organization responsible for LCP is generally a government or regulatory authority, while the implementing entities are utilities. One example includes the current "Energy Saving Support Plan" in California, which involves Californian utilities using their expertise to manage a state-financed program for energy efficiency (see box). An important high-level facilitator for the effectiveness of this program is a law that requires utilities to consider energy efficiency as the first option in the "loading order" whenever considering how to meet new demand.

Current situation	Approved by the California Public Utilities Commission (CPUC) in September 2005
Period, Budget	US$ 2 billion in funding for 2006 to 2008
Regulatory Agency	CPUC
Object bodies	Public utilities, e.g., Southern California Edison, Pacific Gas & Electric Company, San Diego Gas & Electric Company
Contents	• Rebates, which range from US$ 10 to US$ 600, for Energy Star™ appliances such as refrigerators, air conditioners, water heaters and clothes washers • Sustainable communities programs, integrated offerings to targeted markets, such as agricultural and food processing • A variety of energy efficiency measures, such as online energy audits for homes and voluntary energy audits for businesses, schools, hospitals • "The Green Building Initiative" which budgets US$ 230 million per year to make commercial and government buildings more energy efficient by 20%
Features	These programs will cut energy costs for homes and businesses by more than US$ 5 billion and reduce global warming pollution by an estimated 3.4 million tons of carbon dioxide by 2008

Table 2: California's Energy Saving Support Plan

Market-based mechanisms

Supported markets for energy efficiency have equally begun to emerge. Energy service companies (ESCOs) serve to help companies and customers improve their energy efficiency. ESCOs are crucial in identifying and implementing cost-effective energy efficiency projects. The professional services provided by ESCOs can help overcome the transaction costs associated with responding to the following questions:

- What are the energy services the customers are paying for?
- What technology alternatives are available to provide the equivalent services?
- What are the potential energy savings, the required investment and the expected payback period?

The business rationale for ESCOs – reinforced through higher energy prices – is to secure a share of the financial savings achieved, and to extend service to monitoring & rationalization of operation on behalf of customers. The demand for such professional services by customers may lead to new business opportunities for electric utilities.

"White certificates" are another market-based mechanism for the promotion of energy efficiency. In France, for example, energy suppliers have been mandated to meet energy savings targets. The French white certificate system (similar to the one in the UK) allows industry to meet these targets through direct investment in efficiency projects or by buying certificates from other organizations that have implemented projects, giving the market flexibility to find the lowest cost solution. ESCOs can be a major provider of credits in this type of market. The first phase of this system is to be implemented from 2006 to 2008 (see the following box for details).

Similar schemes have been implemented in Italy (as of January 2005) and the UK. The UK's "Energy Efficiency Commitment" scheme differs from the French scheme as it is based on units of avoided carbon rather than units of energy saved. Additionally, participation in the UK scheme is limited to those actors who must meet targets. The scheme is a successor to the long-running Energy Efficiency Standards of Performance (EESOP) scheme, which required electricity utilities to invest in residential energy efficiency measures through a surcharge placed on residential customers' bills.

Current situation	Proposed as a tool to meet targets on energy savings by energy suppliers in the "White Paper on Energy" of November 2003. Approved in the basic energy law established in July 2005.
Timing, target	The first phase of this system to be implemented from 2006 to 2008 as a test period (the amount of total savings is 54 TWh in three years). From 2009, implemented into regular operation.
Regulatory Agency	Implemented by ADEME (French Environment and Energy Management Agency) and verified by the DRIRE (French regional management bodies for industry, research and the environment).
Object bodies	Energy suppliers which sell, to some extent, energy products to end-use customers.
Contents	Energy suppliers have to implement financial support for their customer on, for example, the purchase of high-efficiency appliances, the replacement of old boilers and the insulation of premises.
Features	Energy suppliers are required to meet their targets, either by implementing efficiency projects by themselves or buying certificates from other organizations that have implemented projects. If they miss their targets, they have to pay € 0.02 per unachieved kWh.

Table 3: "White certificates" in France

The table summarizes the scheme.

Cost & benefit recovery programs

The use of conventional cost & benefit recovery designs is commonly implemented in various countries. Investment in energy efficiency (particularly in poor households) or subsidizing energy efficient products, for example, is enabled through additional residential customer charges that utilities can use to recover the cost. As these measures can have substantial price implications, they require strong government or legislative support.

Consumer focused initiatives

Perhaps the most common barrier to reaching energy efficiency's full potential is the indifference or unawareness of consumers. Stable regulations and significant communication campaigns are essential to increase awareness and encourage behavioral changes, i.e., trends towards sustainable consumption. Labeling schemes and standards are also crucial, and are taking hold in many places in the world, for example, the US government's "Energy Star" scheme or the European Union's Energy Label (with ratings from A to G).

Sustainable Consumption

Increasingly, people are beginning to think about alternatives to the "more is better" approach to living – choosing lifestyles with modest environmental footprints and high social value. "Sustainable consumption" refers to the practice of buying and using products and services that are produced using sustainable processes and resources. Sustainable consumption also means playing one's part as a responsible consumer by using materials and resources in moderation and joining the circle of reducing, reusing and recycling. As applied to electricity, sustainable consumption includes a wide variety of measures, such as:

- Purchase/procurement of socially and environmentally preferred energy (e.g., less carbon intensive electricity including renewables);
- Lifestyle changes such as conservative use of heating and cooling;
- Use of energy-saving devices such as motion-detectors to deactivate lighting;
- Use of low-energy supplies such as high-efficiency light bulbs;
- Use of innovative technology such as heat pumps and electric vehicles;
- Purchase of efficient appliances such as washing machines and refrigerators identified by energy efficiency labeling schemes.

MOVING FORWARD

While many energy-efficient technologies are available today, we need technology to keep improving in the future. Sustainability in the medium to long term requires a massive innovation effort in all major demand sectors. While it is mainly the task of technology manufacturers (i.e., industrial equipment and appliance manufacturers, as well as the building industry) to undertake the necessary research, this research will only be successful if broad partnerships can be set up and made to work. Within these partnerships, electricity utilities have a key role to play in researching solutions that meet the needs of their customers.

On the supply side, we need to remove the remaining regulatory barriers to the development of efficiency markets, create training programs that improve supplier capabilities, and devise innovative energy efficiency funds to promote the activities of ESCOs. Systems that can cost-effectively and fairly define the amount of benefit a measure provides (i.e., monitoring and verification protocols for efficiency projects) will further boost the impact of ESCOs, and move the debate from mere energy audits to certification of benefits achieved.

In liberalized electricity markets, where T&D and generation/supply activities are "unbundled", using the savings in T&D investment achieved by regulated T&D operators to support the energy efficiency actions undertaken by generators and/or suppliers would be reasonable.

Overall, there are is no one magic solution, and often different policy options have to be applied in combination with each other. Fundamental is that we need everyone to be aware of the benefits that efficiency has in store. In addition, we need to reward those that make the right decisions – in favor of energy efficiency. For utilities, this means that we need ways to turn sales lost due to efficiency programs into some other form of value. This will allow utilities to go beyond customer awareness programs, recognize efficiency as a business opportunity, and become active players in energy efficiency markets.

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13 Please note that the figure refers to overall energy investments, not just the power sector.

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15 The concept of "negawatts" is one representation of LCP. The idea was inspired by the work of Amory Lovins of the Rocky Mountain Institute in 1976. In recent years, "negawatts" has developed into a full energy efficiency services business, offering products, services and consultation on buildings.

About the WBCSD

The World Business Council for Sustainable Development (WBCSD) brings together some 180 international companies in a shared commitment to sustainable development through economic growth, ecological balance and social progress. Our members are drawn from more than 30 countries and 20 major industrial sectors. We also benefit from a global network of 50+ national and regional business councils and partner organizations.

Our **mission** is to provide business leadership as a catalyst for change toward sustainable development, and to support the business license to operate, innovate and grow in a world increasingly shaped by sustainable development issues.

Our **objectives** include:

- **Business Leadership** – to be a leading business advocate on sustainable development;
- **Policy Development** – to help develop policies that create framework conditions for the business contribution to sustainable development;
- **The Business Case** – to develop and promote the business case for sustainable development;
- **Best Practice** – to demonstrate the business contribution to sustainable development and share best practices among members;
- **Global Outreach** – contribute to a sustainable future for developing nations and nations in transition.

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