DEDICATED TO MAKING A DIFFERENCE

Powering a Sustainable Future

An agenda for concerted action

World Business Council for
Sustainable Development

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;

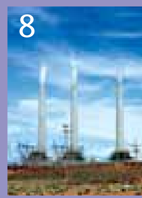
Best Practice – to demonstrate the business contribution to sustainable development and share best practices among members;

Global Outreach – to contribute to a sustainable future for developing nations and nations in transition.

An agenda for concerted action

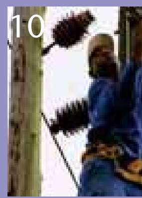
KEY OBJECTIVES[1]

1. Secure investments in infrastructure



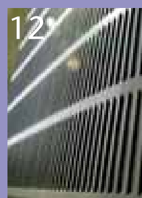
In the decades ahead, enormous capital investment will be needed in power generation and delivery infrastructure to meet both current and new energy needs. A clear, long-term vision for the future energy mix and environmental requirements will help inspire investor confidence and ensure that power for development will be there when needed.

2. Get more power to more people



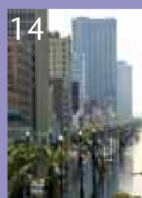
More than 1.5 billion people today have no access to commercial energy. Many of them live in rural areas, often too sparsely populated to justify the extension of existing power grids. Real political will must provide financial and other support for energy and other services for poverty alleviation. Long-term affordability and development of local businesses are key to the sustainability of electrification programs.

3. Use end-use efficiency as a resource



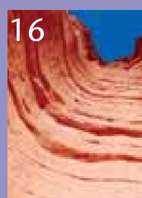
Energy efficiency in end-use applications has the potential for energy savings on the scale of other energy resources. Yet as a resource, it is vastly underutilized, despite its promise for cost savings and return on investment. New policies need to influence behavioral patterns, continuously channel investments to efficient technologies, and break down barriers by aligning the incentives of different players (including utilities).

4. Diversify and decarbonize the fuel mix



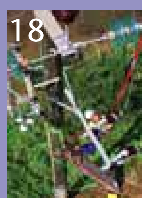
Choices on the fuel mix involve tough trade-offs. Curbing the growth in greenhouse gas emissions (GHG) will require fuel diversification to increase the use of lower carbon resources, as well as much more efficient use of fossil fuels. Every new power generation project should have a clear incentive to use technologies that avoid emissions of GHGs and other pollutants. We urgently need to make sure that these incentives are also effective in high-growth developing countries.

5. Accelerate research and development (R&D)



Current R&D expenditure by both business and governments combined is not nearly sufficient to develop the new solutions that will eventually be required due to the sheer scale of demand growth. Given the nature of R&D, governments will have to play a key role in financing and facilitating the development of clean coal, carbon capture and storage, generation IV nuclear power, solar photovoltaic technology and electricity storage systems.

6. Reinforce and smarten the grids



Recent blackouts have demonstrated the vulnerability of today's power grids. Reinforcement and upgrades are needed to ensure grid reliability. State-of-the-art technology is available to further reduce losses and minimize impacts. We also need smart meters and other new technologies to provide the flexibility to integrate regional markets, incorporate renewable sources, and accommodate customers who generate their own power.

In driving sustainable energy solutions, we see decentralized generation as a complement to, rather than a substitute for, centralized generation.

Technology facts and trends

See the inside back cover for our power technology fact sheets.

Our industry manifesto for a sustainable

Electricity is at the heart of the global energy challenge. It is a necessity of modern life and a basic requirement for development. At its point of use, electricity is the cleanest and most convenient energy carrier and its share of energy consumption is rising. While our sector is experiencing sustained growth, we are grappling with fundamental issues of security, reliability, affordability, environmental impacts and basic access. The power sector produces around 40% of global CO_2 emissions from fuel combustion. Concerns over gas/liquid fuel supplies and barriers to alternatives are accelerating the use of coal despite its impact on the global climate. Reliance on aging and over stressed networks increases the risk of blackouts. At the same time, more than 1.5 billion people still have no access to electricity. These trends are not sustainable. Action is urgently needed.

Electricity is also at the heart of the global energy challenge because it offers some of the best solutions. It has the potential to balance the world's energy mix because it can be generated from any source of primary energy, from fossils, nuclear, hydro to other renewables. We have many technologies *today* that can make a real difference in providing a secure, affordable and environmentally sound power supply. The industry has access to the enormous capital needed for investment in power generation and delivery. Yet today's investment climate seems to do very little to encourage the changes needed. We need *new policy frameworks* that take proper account of environmental externalities, and recognize the value of security, reliability and affordability, while ensuring adequate return on investment through a sound electricity market.

Energy choices require trade-offs between cost, performance and impact. The debate on nuclear power, fossil fuels and other resources is important and should be carried out. Equally important, however, is the fact that power infrastructures are capital intensive and long-lived, carrying energy choices far into the future. *Decisions must be made* in the near-term on energy mix; these will affect us for decades to come.

Fred Kindle
Chief Executive Officer
ABB Ltd.

Pierre Gadonneix
Chairman and Chief Executive Officer
EDF Group

Andrew Brandler
Chief Executive Officer
CLP

J. Wayne Leonard
Chief Executive Officer
Entergy Corporation

power sector

Due to the sheer scale of future growth in demand, and due to the scale of the challenges we face, we will also need innovations like coal gasification, carbon capture and storage, and closed nuclear fuel cycles – and the faster we develop and deploy these the better. Through dialogues with governments and other stakeholders, we need to build a clear vision of the future of our electricity infrastructure, which accommodates diversified paths based on the geographical and cultural nature of each nation/region. We also need a shared commitment, such as an international alliance with appropriate support from multilateral financial mechanisms, with *substantially greater resources* behind the development, demonstration and commercialization of these innovations, because these tasks are too huge for any one company to take on alone.

Energy efficiency as a resource is greatly underused, but has the potential to contribute to every aspect of sustainability. For billions of customers whose electricity use is moderate, energy efficiency may be too far down the priority list. Greater public awareness and stronger government policies and incentives are needed to *increase the uptake of energy efficiency*. The power industry can deliver the societal benefits of higher energy efficiency through cooperation with appliance manufacturers and the building industry.

With the unique global perspective of this group of power companies, we have shared our expertise within the WBCSD Electricity Utilities Sector Project. We have learned from each other, and identified issues in need of urgent attention. While we do not have all the answers, we hope that our agenda and the facts we offer will inform energy debates worldwide, and help drive effective concerted action by all stakeholders.

Thulani S. Gcabashe
Chief Executive
Eskom Holdings Limited

Gérard Mestrallet
Chairman and Chief Executive Officer
Suez

Shosuke Mori
President
Kansai Electric Power Company, Inc.

Tsunehisa Katsumata
President
The Tokyo Electric Power Company, Inc.

The WBCSD Electricity Utilities Sector Project

Member companies (Phase 2)

ABB
CLP
Electricité de France
Eskom
Entergy
Kansai
Suez
TEPCO

Assurance Group Members

David Victor, Stanford University (US; Chairman)

Fatih Birol, International Energy Agency (Europe)

Hisashi Ishitani, Keio University (Japan)

Ralph Cavanagh, Natural Resources Defense Council (US)

Partha Mukhopadyay, Infrastructure Development Finance Company (India)

Early in 2005, the member companies of the WBCSD's Electricity Utilities Sector Project launched Phase 2. The project provides a platform for collaboration among industry leaders to engage their stakeholders, defining a broad "agenda for concerted action" to address the sustainability challenges in the power sector.

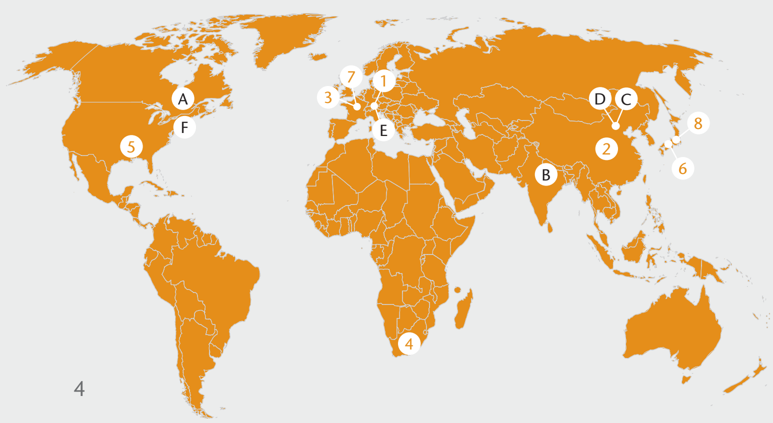
Phase 2 builds on the 2002 Phase 1 report, *Sustainability in the Electricity Utility Sector*, which details sustainability principles and strategies, collects member company best practice, and surveys challenges ahead.

The report notes that "demand for electricity is escalating against a backdrop of an unprecedented call to action to safeguard broad environmental and social interests." That statement is truer today than it was then. From our unique global industry perspective, we have developed a consensus on the means by which the sustainability challenges can be addressed. These pages aim to reinforce the call for action worldwide, starting now.

This agenda shares facts on the options available now in the power sector -- options that can meet the challenges of sustainability. Our report recognizes the need for debate on energy resources, markets and policy frameworks, and calls for prompt decisions about our energy future.

The project work began with in-depth analysis of the technologies and other options available today to address sustainability issues in the power sector. This work was supported by the lead consultants ERM, and was taken as a basis for an initial common perspective on the priority actions and policies needed. In order to test the validity and relevance of this perspective, several consultation sessions around the world were convened, as well as an online dialogue.[2] We also participate in the Global Reporting Initiative's (GRI) stakeholder consultations to develop a power sector supplement to the Sustainability Reporting Guidelines.

To enhance the objectivity of our work, we set up an independent Assurance Group of internationally recognized experts from different stakeholder groups and geographic regions. We have carefully considered the input from our stakeholders and the experts, and refined our vision and recommendations in light of it. This document represents the views of the member companies.



Headquarters

1 ABB
2 China Light and Power
3 Electricité de France
4 Eskom
5 Entergy
6 Kansai Electric
7 Suez
8 Tokyo Electric

Stakeholder consultations

A UNFCCC COP Side Event (Montreal)
B Delhi Focus Group Discussion
C Beijing International Roundtable
D WBCSD Internal Dialogue (Beijing)
E Glion Dialogue (Switzerland)
F UNCSD Side Event (New York)

@ Online consultation

Key features of the power sector

The power sector is unique among commodity and service markets.

- Electricity is a flexible energy carrier that can be generated from any energy resource. It is almost always delivered immediately for end use because it cannot be easily stored. Capacity must be in place to meet peak demand, but this capacity will not be needed at other times, since electricity demand fluctuates considerably over time (see Figure 1). Generating technologies vary widely in terms of their ability to meet demand exactly when it is needed.
- Power plants usually take several years to build, need huge up-front investments, and typically operate for 20 to 40 years or even longer. Changes in fuel prices, electricity tariffs, policies and regulations introduce risk elements into power sector investments because these are difficult to predict decades in advance.
- Because it uses a single integrated network for delivery — the electric "grid" and local service lines — the power sector has historically functioned as a "natural monopoly" in many respects. Mindful of this, many countries have "unbundled" their power systems to separate some parts of the business (power generation and marketing) that are amenable to competition from the parts that are not (see Figure 2). In most cases, this unbundling has also seen the privatization of some assets to allow for the full benefit of market competition. The progress of this "liberalization" varies from country to country, and its implications for sustainability can be mixed, especially if regulators focus exclusively on lower prices (without keeping for example R&D or energy efficiency objectives in mind).
- Whether liberalized or not, electricity markets continue to require government involvement. This involvement is important because electricity is crucial for development and economic well-being, and continues to contain elements of a public service. Electricity prices can be strong drivers for social policies or have considerable impact on the competitiveness of a nation's industry.

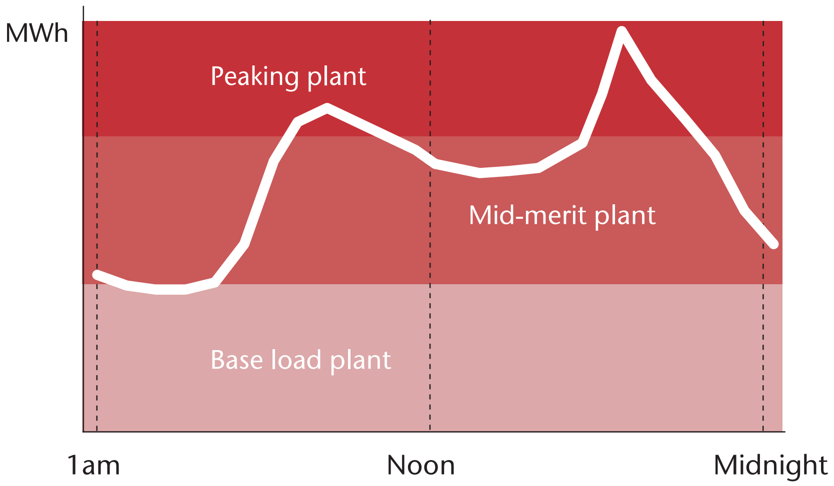


Figure 1: A typical daily demand profile

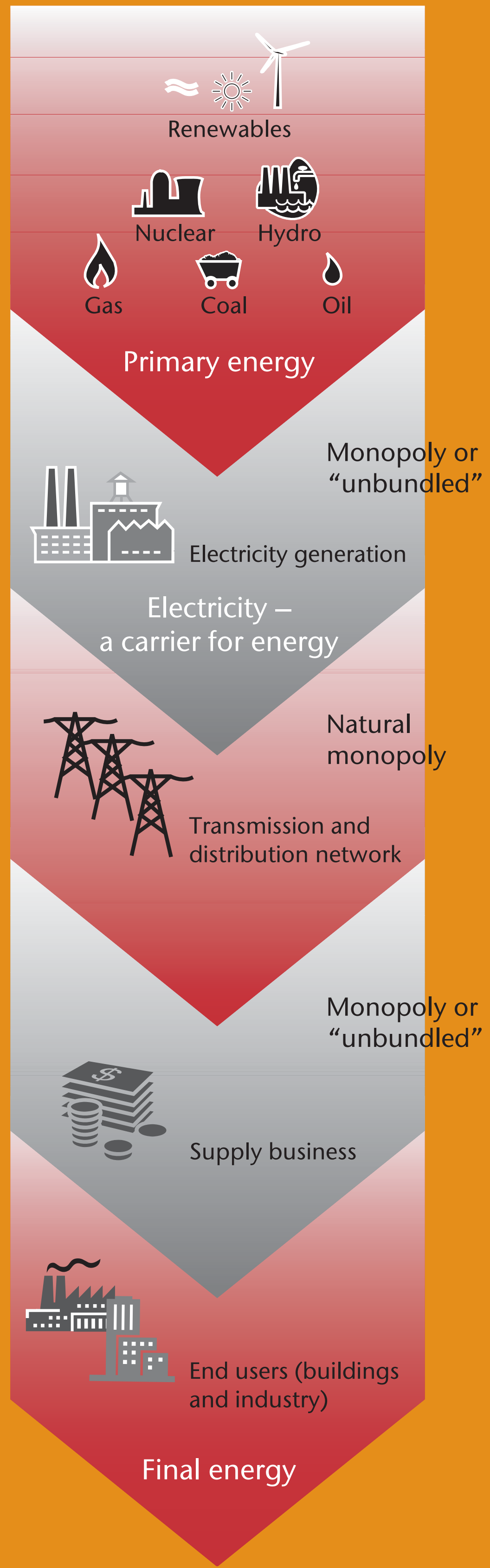


Figure 2: The power sector – structure and energy flows

Electricity: The heart of the world's

"Tomorrow's world will be much more 'electric' than today's. This will only increase the pressure on utilities to reduce environmental impacts of generation."

WBCSD Internal Dialogue

The energy challenge

Simply put, the world's energy challenge is to provide large quantities of affordable and secure energy to all while safeguarding the environment. Energy is a prerequisite for human development and the lifeblood of our societies that rely on the functioning of our transport systems, industry, offices and homes.

Population and economic growth may well increase the world's appetite for energy by more than 50% by 2030. The majority of this growth will take place in the urban areas of rapidly developing parts of the world. Efficiency improvements play an important role in limiting the extent of demand growth. But not only will huge investment in infrastructure still be needed to ensure that energy is there when needed, unless there is a marked shift in the way energy is produced and regulated worldwide, we will also face serious environmental impacts.

In 2002, some 1.6 billion people in the developing world still lacked access to electricity, and even more still rely on traditional biomass for cooking and heating.[3] Common business-as-usual projections show that population growth in developing countries will tend to offset energy access programs. This would mean that the number of people without access to commercial energy will remain high (see Section 2), even with energy investments of US$ 16 trillion (see Section 1) made over the next decades.

Energy supply security is high on the political agenda of both developed and developing countries. The majority of the world's energy demand is still satisfied by fossil fuels. We face ongoing risks of political turmoil in oil supplier countries, competition for resources in the international market, and record high oil prices (which have tended to drive up gas prices as well). Few new major reserves are being discovered. Concerns about reliability of supply also arise from recent power grid failures, as well as a demand/supply imbalance due to a lack of infrastructure.

Carbon emissions from the growing use of fossil fuels are the main driver of global climate change, threatening the world environment, our way of life and the lives of future generations. Air pollutant emissions threaten the environment in many parts of the world.

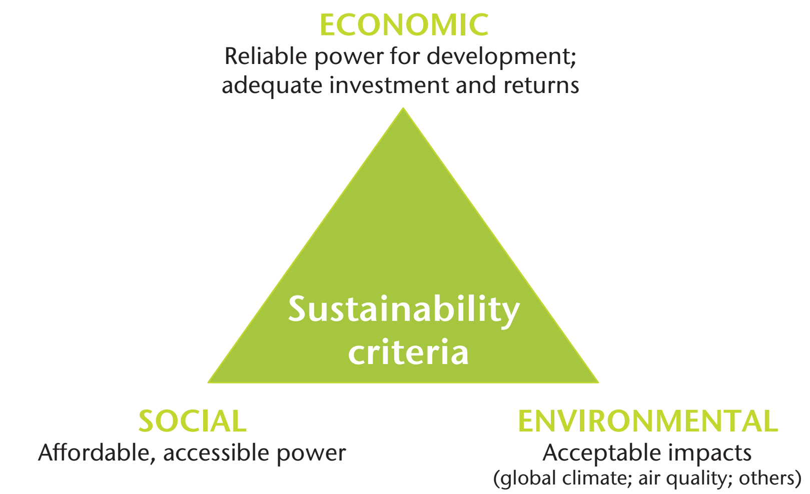
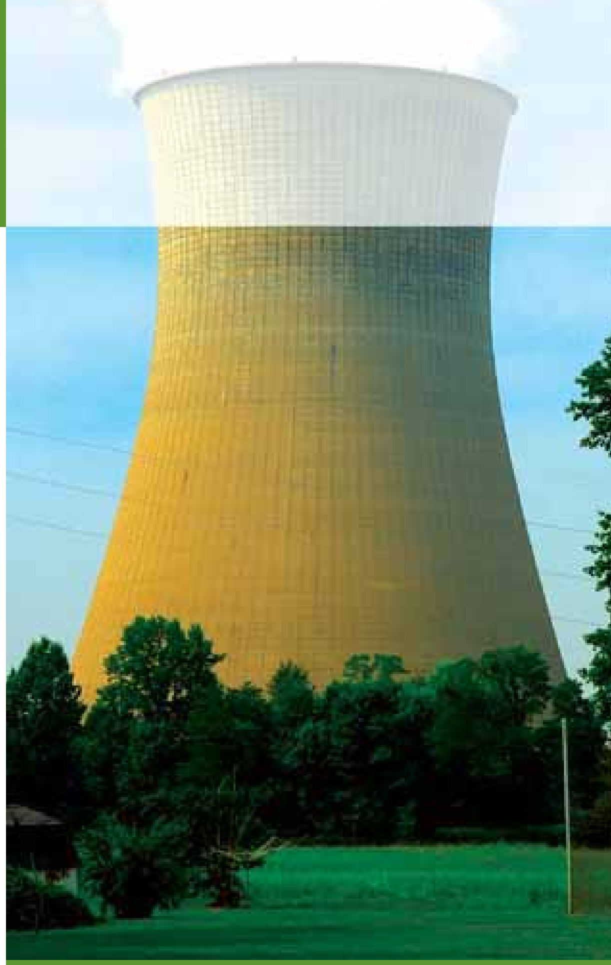


Figure 3: Sustainability in the power sector

energy challenge



Technological solutions exist today that drastically reduce greenhouse gas (GHG) emissions and other environmental impacts, but many of them are still more expensive than conventional options. This is a dilemma that we cannot ignore, as today's globalized economy demands international competitiveness, and energy prices remain a key driver of energy policy.

The role of electricity

Electric power companies are on the "front line" of the global energy challenge (see Figure 3). Our investment decisions will affect the availability, price and environmental impacts of a rapidly growing energy infrastructure for many years to come.

Electricity consumption is growing faster than that of any other form of energy. Most of the investment required in energy infrastructure will have to be made in the power sector. As economies develop and societies' needs become more sophisticated, electricity is increasingly the energy of choice. Electricity is a "premium" type of energy: technological progress increases its uses; it can be generated from any energy source; it comes to users safely in exactly the quantity that is required; and it has no environmental impact at its point of use. Wide-scale access to electricity is crucial to meeting the Millennium Development Goals (MDGs), as it has the power to reduce poverty by improving education, health, communications and industrial development.

Today, the power sector contributes 40% of all CO_2 emissions from fuel combustion, and these emissions are projected to nearly double by 2030 in business-as-usual scenarios.[4] Yet we know that global emissions in 2050 would have to be limited to roughly current rates to prevent the worst outcomes of climate change. In addition, local pollution (notably emissions of NO_x, SO_2 and particulates) and other local environmental impacts have to be managed better, particularly where environmental standards are still emerging. Finally, the dependence of power generation on cooling water may create new challenges as the sector competes for increasingly scarce water resources.

We have many technologies today that can meet these challenges along the entire electricity value chain (i.e., generation, transmission & distribution, end-use). If power supplies can be decarbonized using both current and future generation options, new electric end use technologies could even contribute to GHG emissions reductions outside today's power sector by replacing the direct use of fossil fuels. But from a practical perspective, what must the electricity industry and its stakeholders do to put these technologies to work? We do not have all the answers, but have created an agenda of six key actions[5] that we think need the collective efforts of all stakeholders:

1. **Secure investments in infrastructure**
2. **Get more power to more people**
3. **Use the resource of end-use efficiency**
4. **Diversify and decarbonize the fuel mix**
5. **Accelerate R&D**
6. **Reinforce and smarten the grids.**

1 Secure investments

> "No one can tell you how to get a power plant approved."

Beijing International Roundtable

Community engagement is key to success CLP

Early community engagement, designed and conducted in the context of the local culture and its expectations, is a key success factor for energy infrastructure projects. CLP's BLCP power plant in Thailand illustrates the range of issues about which communities may be concerned. Villagers, for example, expressed concerns about the economic impact of the plant on their livelihood, while environmentalists focused on issues regarding air quality.

The BLCP team worked with the community early in the development process to form a tripartite committee to address social, economic and environmental issues. It also maintains frequent dialogue with the community about the facility, inviting them to visit BLCP. The community engagement process is an ongoing one, from construction to operation and decommissioning stages. CLP believes that early and extensive engagement with the community was an important contribution to the timely commissioning of the project.

Globally, electricity supply infrastructure is projected to require a combined investment of US$ 10 trillion of the US$ 16 trillion in energy investments needed up to 2030 to replace existing plants, build new infrastructure and meet growing demand[6] (see Figure 4). The developing world accounts for around half of the investment needed.

Securing the upfront investment in the infrastructure that generates electricity from primary energy sources and delivers it to where it is needed can be a real bottleneck for development. For example, in India and sub-Saharan Africa, the electricity sector may have to compete hard with other sectors for limited sources of capital.

With demand surging and national budgets struggling in many developing economies, and with liberalization and privatization in many OECD countries, the private sector will be expected to make more of these investments. Making the business case for power sector investments thus becomes even more pressing than before. This requires agreement on certain basic principles and realities that are fundamental to all the other objectives in this agenda.

The financial viability of a project depends on the expectation of revenue exceeding investment and operating costs over the life of the project. Investors and lenders manage long-term risks in relation to fuel costs, electricity demand, environmental and other regulations, changing market structures and the ability to compete in increasingly competitive markets (see Figure 5).

High risks, on both the cost and revenue sides, can easily halt certain projects. With regard to capital costs, regulatory certainty regarding licensing and safety policies is extremely beneficial to all projects with long lead times and/or long lifetimes (e.g., many renewables, nuclear, coal). Moreover, early community engagement (see CLP case study) is another important factor in securing the viability of investments.

Renewables and nuclear have higher capital costs than conventional fossil fuel power plants, but they have lower operating costs and avoid the risks of volatile fossil fuel prices. Another key variable for costs are environmental

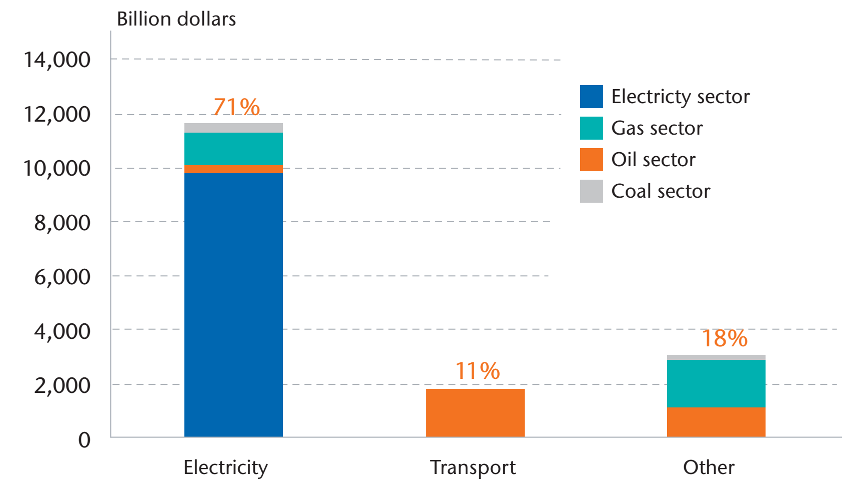


Figure 4: Cumulative world energy investment by energy use, 2001-2030

Source: IEA. *World Energy Investment Outlook 2003.*

in infrastructure

externalities, which can be internalized in different ways. For example, if power generators are required to pay a cost for their emissions of CO_2 or other pollutants then they will pursue options for generating electricity with lower emissions. Due to uncertainties surrounding both capital and operating costs, projects deploying new, less proven technologies find it more difficult to attract the necessary capital.

Attracting capital for power infrastructure, whether public or private, requires that expected costs be outweighed by expected returns, and therefore that a promising market can be secured for the power produced. All governments must strive to provide predictable rules for determining electricity tariffs. Wherever feasible, tariffs need to reflect the costs of supply (see Suez case study). On the other hand, there are often hard political choices to be made between this economically sustainable approach and the social implications, especially in places where the price of electricity traditionally has been set at levels far below its real cost.

By creating more cost pressure, liberalized markets for electricity can bring about additional investment risks in addition to lower prices for customers. This must be countered as much as possible by minimizing regulatory uncertainties. Even though state and multilateral development agencies such as the World Bank will continue to play important roles in financing, another key area for improvement is the development of financial markets and instruments that make it possible to manage currency risks and thus attract a fuller range of investors.

Choices made today create a legacy far into the future. Physically, power plants can survive up to 40 years and sometimes as long as 100 years (hydro plants). Thus utilities must hedge against major long-term risks. It is up to policy-makers to plan policies a long time in advance, and provide direction with long-term credibility.

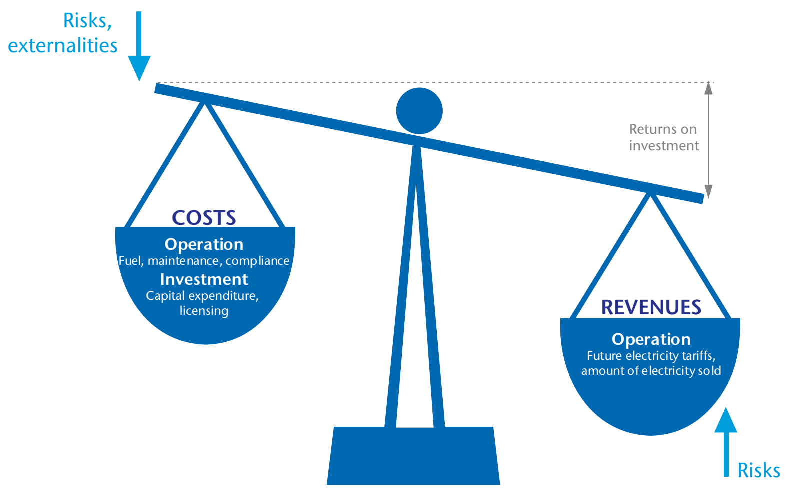


Figure 5: Basic decision-making framework for utility investments

The importance of stable market rules: São Salvador hydroelectric project Suez

In 2001, Suez was granted the São Salvador concession for a 241 MW hydroelectric power project in Brazil, having put in the highest bid for the license to operate. The regulatory environment at that time was a crucial driving force behind the decision to invest, as it allowed the free negotiation of contracts with any distribution company. However, a new regulatory model introduced in 2003 requires a competitive tender process for tariff settlement ("new energy auctions"). In 2006, these auctions have shown that the new system provides sufficient predictability for existing plants, but several new projects that were granted under the old framework are not competitive. As a result, Suez has been unable to justify the start of construction for São Salvador, since it could not secure the tariff needed to recover the initial royalty payment for the license.

The change of regulatory framework has increased the risk of power shortages from 2009 onwards, which are now being discussed in Brazil. In order to reduce this risk, the government will need to put in place adequate transitory arrangements to ensure that investments will be made in time.

2 Get more power

“Time is running out to meet the Millennium Development Goals, and what counts is getting energy to the people, and not necessarily whether this energy comes in the form of renewables, which are suited for many but not all applications. Utilities should partner with small enterprises to leverage more local knowledge.”

UNCSD Side Event

1.6 billion people (27% of the world’s population) had no access to residential electricity in 2002. Over 99% live in the developing world (principally South Asia, sub-Saharan Africa and East Asia, see Figure 6), and 80% live in rural areas. Taking into account population growth in these areas, IEA projections show 1.4 billion people without electricity in 2030.

Electrification, in combination with other social and economic developments, brings benefits: income-generating activities and jobs; longer access to lighting, allowing increased education, study and evening work; long-term refrigerated storage of healthcare products and food, improved sanitation, etc. Access to electricity is thus a necessary, but not sufficient, condition for poverty alleviation. There are two major elements:

- Electricity supply in the home
- Sufficient electricity supply to business and organizations.

In poor households, electricity is relatively expensive and is used where it vastly improves services (e.g., for lighting and radios). There is a strong link between low household income and low electrification rates. Meeting the Millennium Development Goals (MDGs) adopted by the United Nations (UN) in 2000, particularly that of eradicating extreme poverty, will require increased access to electricity. The electrification targets that can be derived from the MDGs represent a huge challenge, and current trends suggest that the required levels will not be reached. The gap between targets and trends indicates that big changes in electricity investment in many developing countries are urgently needed (see Figure 7).

Experiences from this project’s member companies offer the following lessons and observations (see also Eskom case study):

- Some current electrification schemes have only a moderate impact on poverty alleviation. Only affordable schemes are successful and sustainable over the long term. Schemes must be designed so that households and communities can consistently make payments over long periods. This is why development of local business, including small, medium and large enterprises, is crucial in sustaining the impact of electrification on poverty alleviation. Energy efficiency programs can make electricity more affordable.

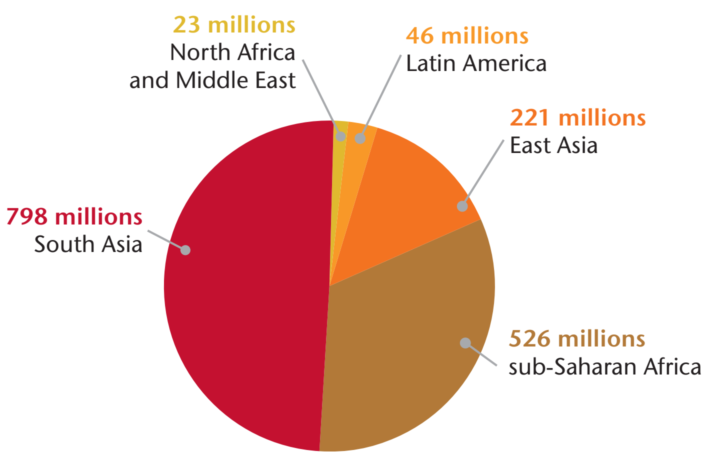


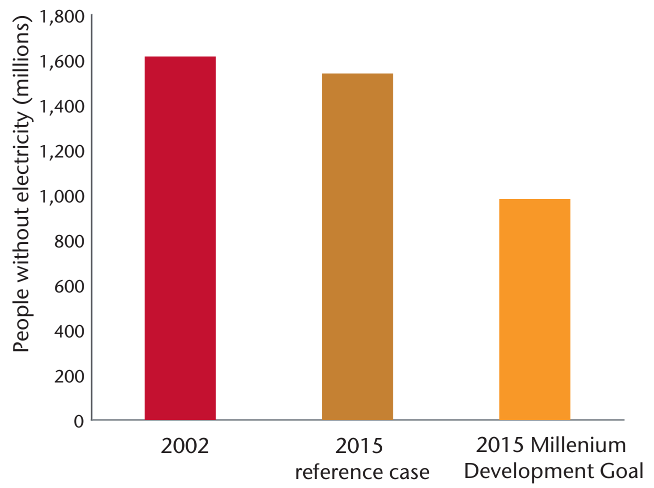
Figure 6: People without access to electricity (2002)

Source: IEA. *World Energy Outlook 2004.*

to more people

- Program evaluations must account for quality of life improvements and socio-economic development as well as financial cost-effectiveness.
- Residential customers are more expensive to supply than business, as they consume less electricity and require more infrastructure per unit of electricity supplied.
- Close to existing grids, which can deliver extra supplies reliably, grid extensions can be the cheapest option and provide the best reliability and availability. Further away, "mini-grids" or "off grid" approaches can be effective. All schemes must integrate ongoing maintenance, and trade off cost, availability and environmental impacts. The best options for small schemes may include diesel, liquefied petroleum gas (LPG) and renewables.
- Estimates of costs range from US$ 200-2,000/household connected, depending on local circumstances, and increasing with distance from the existing grid. "Learning by doing" during implementation can significantly reduce costs.
- Where utilities are not able to provide electricity, small-scale private sector providers (SPSPs) may offer niche electricity services, typically in rural or peri-urban areas. The World Bank estimates that 10 million customers in 32 countries already receive electricity in this way, and donors and other agencies are paying increasing attention to supporting SPSPs.
- Poor households and the business sectors in poor countries consume only relatively small amounts of electricity. So in the short term increasing access would have a relatively minor impact on GHG emissions.
- Electrification should be seen as one element in a broader energy and development strategy. It generally helps to reduce local pollution, but often the cheapest reductions in local impacts come from non-electricity measures such as substituting biomass in heating and cooking with fuels such as kerosene and LPG.

There is generally a weak business case for electrification in poor areas without government support. Worldwide, some form of subsidy and political commitment has almost always been required to realize the non-financial economic benefits of rural electrification. This is the case especially because private sector investment is generally focused on power generation rather than networks. However, partnerships with private companies that effectively "deliver" electrification on the ground can be effective. Here, the choice of business model can make the difference between success and failure. Depending on local circumstances, these models may or may not be utility-based.



Source: IEA. *World Energy Outlook 2004.*

Figure 7: Halving poverty by 2015: Have they got the power?

The electrification of South Africa
Eskom

Before 1994, only 12% of the rural population in South Africa had access to electricity, and 36% of the country was electrified. The South African government, the electricity distribution industry and Eskom committed themselves in 1994 to electrify 2.5 million households by the year 2000. This target was exceeded.

The electrification program was self-funded as part of Eskom's social investment, and it was critical to reduce the cost per new connection by more than 50% in order to maintain the financial viability of the program. The methods used and results obtained are sustainable and transferable.

The Department of Minerals and Energy (DME) began funding the National Electrification Programme in April 2001. Eskom is responsible for implementing the program in its licensed area of supply on behalf of the DME. At the end of 2003, approximately 71% of South Africa was electrified as well as 50.3% of rural households.

3 Use the resource of

"When people say that on the supply side different fuel mixes can be used to meet energy demand, they suggest that there are many paths to Rome. In fact we should not go to Rome at all, and save energy instead."

Beijing International Roundtable

"Policy-makers have to find ways of harnessing market forces that act on utilities, to encourage the delivery of energy efficiency as a product."

UNFCCC COP11 Side Event

"It is time to bring energy efficiency from the boiler to the board room."

"We need to move the discussion from mere 'energy audits' to effective certification of improvements achieved."

Delhi Focus Group Discussion

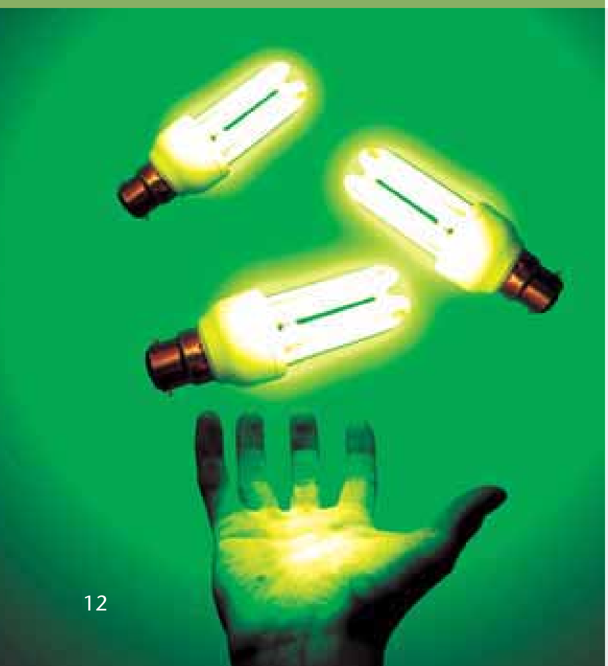
Currently, electricity use is growing at roughly the same rate as economic activity, driven by strong demand from our homes, offices and industry[7] (see Figure 8).

In any of these sectors, achieving the same economic benefits with less electricity (i.e., increasing energy efficiency) means that less power supply is required, resources are saved and emissions are avoided. If the savings are cost-effective, then efficiency improvements can help with all facets of the energy challenge. This makes energy efficiency a crucial strategy for sustainable development everywhere. It needs to be recognized as a real resource option.

There are large differences in per capita energy (and electricity) use among different countries, even among those with similar per capita incomes and climates, reflecting differences both in behavior or lifestyles and technology choices. Those already doing more with less illustrate the substantial potential for efficiency improvements. The International Energy Agency (IEA) estimates that reduced electricity consumption alone could be achieving nearly one-third of global CO_2 reductions compared to a business-as-usual scenario in 2030. Technology improvements are constantly pushing the boundaries of what is feasible and cost-effective, but making them penetrate the market requires a system that continuously encourages investments in the most efficient equipment.

It is increasingly evident that customers want, and are willing to buy, the end service of energy – lighting, heating, transportation, etc. – rather than energy and appliances themselves. This enlarges the window of opportunity for energy efficiency to save money. Yet there is substantial room for greater uptake of energy efficiency, due to a number of barriers:

- Customers have a hard time getting the information they need to evaluate the energy use of new equipment;
- The benefits of buying more efficient equipment only accrue in the future, while there are most likely some extra costs involved in the present; people focus more in the present, which often discourages investments;



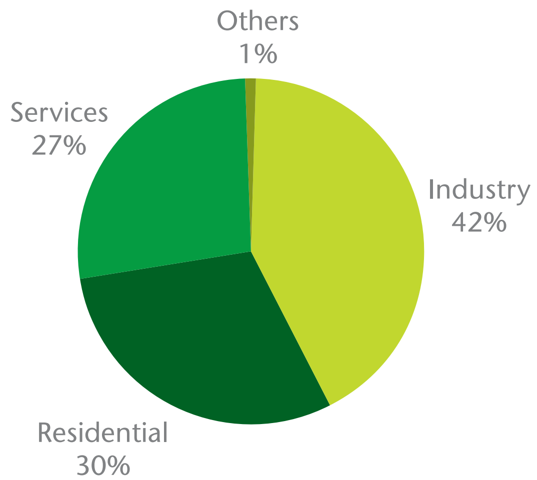


Figure 8: Shares of global electricity consumption (2002)

Source: IEA. *World Energy Outlook 2004.*

end-use efficiency

- Often the investment decisions are made by someone other than the customer who ultimately pays (e.g., where the landlord decides about the level of insulation, but the tenant pays the energy bill);
- As people and processes become more efficient at using a resource (i.e., energy), it becomes economically feasible to use more of it; with more efficient lighting, for example, we may leave our lights on longer.

Utilities have demonstrated that significant savings can be achieved through end-use energy efficiency. This has been used to avoid additional supply investments,[8] or to enhance customer loyalty. And many, if not most, utilities provide free and/or professional advice on the efficient use of energy. But end-use efficiency has not typically been a major role for most utilities. Implementation of end-use efficiency remains largely in the hands of the end-users.

We need to raise the profile of energy efficiency policies and improve on the wide range of programs (including utility-driven programs) that have been implemented. Key policy considerations include:

- Higher electricity prices can encourage energy efficiency but have political impacts. This is why we often need non-price measures such as regularly updated efficiency standards and labeling schemes (especially for high-potential categories such as lighting, appliances and industrial motors), communication campaigns to change customer behavior, and a flourishing market for competent energy service companies. Utilities, with their access to customers, can make an important contribution to all of these.
- The financial sector should be part of this market by providing innovative financing tools, for example those that transfer the future benefits of energy savings to customers now.
- To ensure cost-effectiveness and allocate rewards, we need clear methods for monitoring real savings.
- Technology manufacturers can contribute by stepping up research into and marketing of more efficient equipment. Electric technologies can significantly enhance efficiency in certain applications (see TEPCO case study).
- Utilities use electricity and can set an example by reducing their own consumption and optimizing efficiency.
- For utilities to really push end-use efficiency and recognize it as a business opportunity, we need ways to turn sales lost due to efficiency programs into some other form of value. Efficiency targets on suppliers, with the option of trading certificates ("white certificates"), are an example of policies that enable utilities to go beyond customer awareness programs and become active players in energy efficiency markets.

Development and deployment of heat pumps

Tokyo Electric Power Company

A heat pump (HP) is an electrically driven device that takes heat from air or water to transfer it to another place for cooling or heating purposes. A refrigerator is a type of HP. The energy efficiency of an HP is indicated by a coefficient of performance (COP), the ratio of energy output to electricity input. Due to dramatic technological innovation in collaboration with electricity utilities and manufacturers, and institutional support such as the "top-runner standard", the COP of an HP is now between 3 and 6 or even higher. "Eco Cute", one innovative HP technology, is an HP water heater that uses a CO_2 refrigerant and was introduced in Japan in 2001 as the world's first commercial product of its kind. The CO_2 refrigerant has less global warming potential than hydrofluorocarbons. Compared with combustion water heaters, the Eco Cute achieved 30% savings in primary energy and 40% GHG reductions. The government of Japan is subsidizing further installation.

4 Diversify and decar

"Utilities are in a particularly good position to create a less carbon-intensive power generation system, as they own the lion's share of power generation facilities and can provide a powerful driver for introducing new low-carbon technologies. Utilities have to work closely together with policy-makers and planners."

Online dialogue

"For deploying lower-carbon solutions in China, the biggest challenge is not the technology but the funding."

Beijing International Roundtable

"Certainty is too much to ask for. Uncertainty is the very foundation of business. What we need is a long-term vision with credibility."

Glion Dialogue

Creating sustainable deployment conditions for low-carbon technologies EDF

EDF is a European leader in CO_2- free power generation: its generation mix is 70% carbon-free, with 50% nuclear and 20% renewables, mainly hydro; it will invest € 3 billion in wind power by 2010 and € 3.3 billion in building a new nuclear plant by 2012. All its plants are systematically ISO 14001 certified. It continuously improves nuclear plant performance in terms of releases and safety (participation in the development of safer designs, waste storage research) and reduces (already very low) agents' exposure. It takes particular care of biodiversity, water usage and population displacements when developing hydropower where there is unexploited potential (e.g., Nam Theun in Laos) and promotes renewable decentralized generation in isolated rural areas (e.g., installation of photovoltaic kits in remote and rural areas in Africa). It is strongly engaged in R&D on promising technologies (e.g., 3rd generation photovoltaics in a common laboratory with the French national scientific research center (CNRS), and generation IV nuclear).

Today the global fuel mix for electricity consists of coal (40%), gas, nuclear and large hydro (15-20% each), oil (7%) and other renewables (2%). Figure 9 illustrates the CO_2 intensity of these different options.

The fuel mix depends on a range of factors, including local availability of fuels, technology costs, market structure, the political and regulatory framework, environmental considerations and others. Diversifying it by increasing the share of non-fossil fuels, and making fossil generation more efficient are must-dos, both for energy security and climate change mitigation (see Figure 9). To enhance our options for reducing carbon emissions in the future, we must also find practical ways to capture and store carbon (see Section 5). To the extent that low-carbon electricity can replace direct fossil fuel combustion, the power sector could actually make a net positive contribution to mitigating climate change.

The generating capacity to be built over the next 30 years (including replacements) is estimated at some 130% of today's installed capacity. This enormous infrastructure development provides a great opportunity to diversify and decarbonize the fuel mix. Whether we can take advantage of this opportunity to shift towards more sustainable energy systems will depend critically on investment conditions and particularly on government policy.

Hydrocarbons: Security of supply and reserves are pressing concerns for oil and gas. Gas supply also requires major infrastructure investments. Gas prices are rising as a result. The attractiveness of generation fired by coal, of which many countries have abundant reserves, is hence increasing. We must use all fossil resources wisely, by improving the efficiency of existing plants, using the best commercially available technologies, and ensuring that their diffusion is worldwide. Utilities would consider investment in lower-carbon fossil fuel technologies with higher capital costs right now if credible incentives with long-term stability were in place.

Zero carbon technologies: Wind, biomass and solar power are renewable power sources with very low or no GHG emissions. Their application should be encouraged where they are not already cost-competitive, but their high capital costs and low-energy density, combined with their interruptible nature, mean that their global share of power generation will most likely not exceed 10-15% by 2030. Two-thirds of the world's economically viable hydro potential remains unexploited, the majority of this found in developing countries. For this to be realized, biodiversity issues and displacements of local populations have to be managed effectively. Nuclear is a proven, safe, efficient and cost-effective technology that can generate electricity on a large scale with virtually no GHG emissions. It can avoid significant GHG emissions in countries that master the technology, if public and political concerns can be adequately addressed, including finding acceptable solutions for long-term waste disposal. Governments should consult all stakeholders on criteria for the acceptability of nuclear energy as a climate mitigation measure.[9]

Variety of sources: Each energy resource has its own set of specific characteristics, costs and impacts. Choosing among them, or rather, choosing the right mix, requires making tough choices, and a holistic view across the entire energy value chain. No energy resource is problem-free. Reducing one impact, risk or constraint inevitably leads to trade-offs. We need all energy

bonize the fuel mix

options to be kept open. The decisions at hand will vary depending on the location of the plant, local resource availability, national priorities, policies and legislation. It is part of the responsibility of utilities to provide complete information and explain the key dilemmas, including reducing environmental impacts while managing costs and technical constraints.

Incentive policies: Energy policy should focus on accentuating fuel diversity. All environmental values must be firmly integrated into the selection criteria of consumers and producers in the marketplace. To significantly curb the growth in GHG emissions from the power sector in the next 20 to 30 years, we must find ways of financing the incremental capital cost of available lower-carbon technologies. Ideally developers should have an incentive to use such technologies whenever a new project is considered. If well designed, public policies will be based on a long-term vision and avoid perverse incentives (e.g., to increase emissions in the short term to gain more emission allowances in the future). Prudent implementation of more sustainable energy policies can be done with only moderate additional costs. In the absence of such policies now, mitigation costs might increase.

International cooperation: Even small incremental costs may be an issue for developing countries, where economic priorities tend to strongly drive emissions growth, mainly due to the use of coal. International cooperation, such as through the Clean Development Mechanism (CDM) of the Kyoto Protocol, allows sharing of these incremental costs to achieve a common goal. If such mechanisms are to make a real difference, it is essential to further streamline the process and enable the delivery of large volumes of GHG reductions beyond 2012. Additional cooperative efforts are also needed to provide financial support and incentives for clean technologies. Globally, these mechanisms should be facilitated by a comprehensive framework that combines market-pull incentives as well as technology-push initiatives (see also Section 5), to achieve a global emissions goal for 2050.[10]

The face of global warming

Entergy

The 2005 hurricanes Katrina and Rita in the southern United States put a face on what the future impacts of climate change could be if effective action is not taken to reduce GHG emissions. Physical risks from future climate change are real, including sea level rise, the loss of wetlands that provide physical protection from more intense storms, and water shortages. Restoration costs for Entergy, the utility of New Orleans, were US$ 1.5 billion. Insured losses for the whole region are estimated to be US$ 75 billion, and the overall damages are expected to be as high as US$ 200 billion. Entergy believes mandatory regulation of CO_2 in the US, sending price signals for investment in clean energy technologies, is needed. Entergy has voluntarily reduced its CO_2 emissions to 7% below 1990 levels while growing energy sales by 21%, and is engaged in the energy efficient rebuilding of New Orleans.

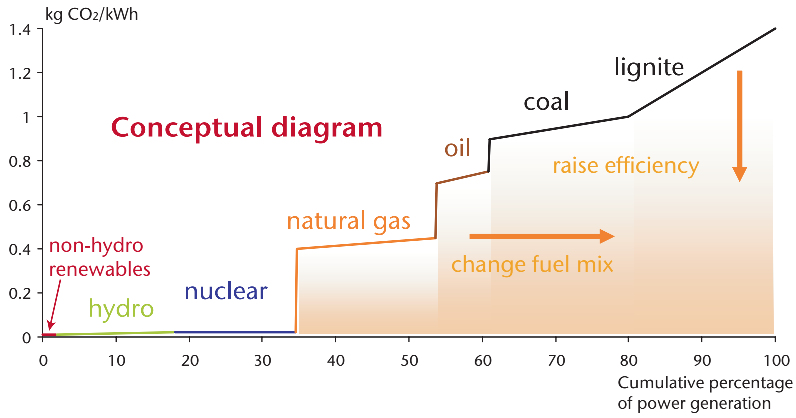


Figure 9: Options for decarbonizing the fuel mix

Carbon intensity ranges: World Energy Council. "Comparison of Energy Systems Using Life Cycle Assessment". Special Report. 2004; Fuel mix: IEA. *World Energy Outlook 2004.*

5 Accelerate research

> "Utilities must band together in large-scale investments in these technologies to reduce investment risks; governments must support this through subsidies […]. Also, companies and governments must publicly declare their intentions, to gain support from investors and the general public."
>
> Online dialogue

> "We must engage the private sector more effectively in flexible knowledge exchange networks facilitated by government to catalyze the development and deployment of clean energy technologies."
>
> UNCSD Side Event

Much can be done with technologies that are available today to address global climate change, pollution and energy security (see Section 4). However, due to the sheer scale of expected growth in demand, we will also need new and radically improved technologies, which are now at a much earlier stage of development (see Figure 10). We need a major step change in energy R&D to bring these technologies to market.

The necessary investment in energy R&D is unlikely to be delivered by the private sector alone because:

- The first stages of technology development, as well as the demonstration stage, involve very high costs that can often not be shouldered by individual companies.
- The pre-market stage of R&D has low returns, and very high risks, as it is not clear how many benefits the R&D investor will be able to obtain (as knowledge can "spill over" and benefit competitors, and it is uncertain how much the costs of certain technologies will come down).
- Much of the benefits from R&D come in the form of lower costs and better performance for more environmentally friendly technologies. Yet these technologies may not attract R&D investors unless the environmental benefits are rewarded in the marketplace.

This makes the case for strong government support for R&D, especially, but not only, for technologies that reduce environmental impacts. But public energy R&D has declined by roughly 15% over the last 15 years. Moreover, with market liberalization focusing the minds of investors on short-term market opportunities, private R&D expenditure on energy has also been declining. It is now estimated to be around half of public energy R&D.[11] These levels of public and private investment in R&D are not remotely commensurate with long-term challenges and opportunities. We urgently need:

- Increased allocation of resources for energy innovation, and more activity at a much larger scale;
- More effective technology transfer to developing countries, including mechanisms that effectively protect intellectual property rights.

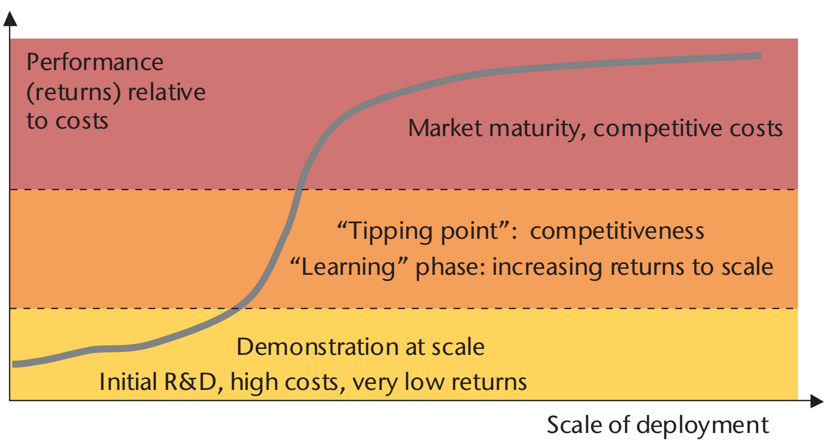


Figure 10: Stages of technology development and deployment

and development

There are many technologies that likely will need to come online by 2030-2050. Key among these are carbon capture and storage (CCS), generation IV nuclear, advanced solar technologies and electricity storage.[12]

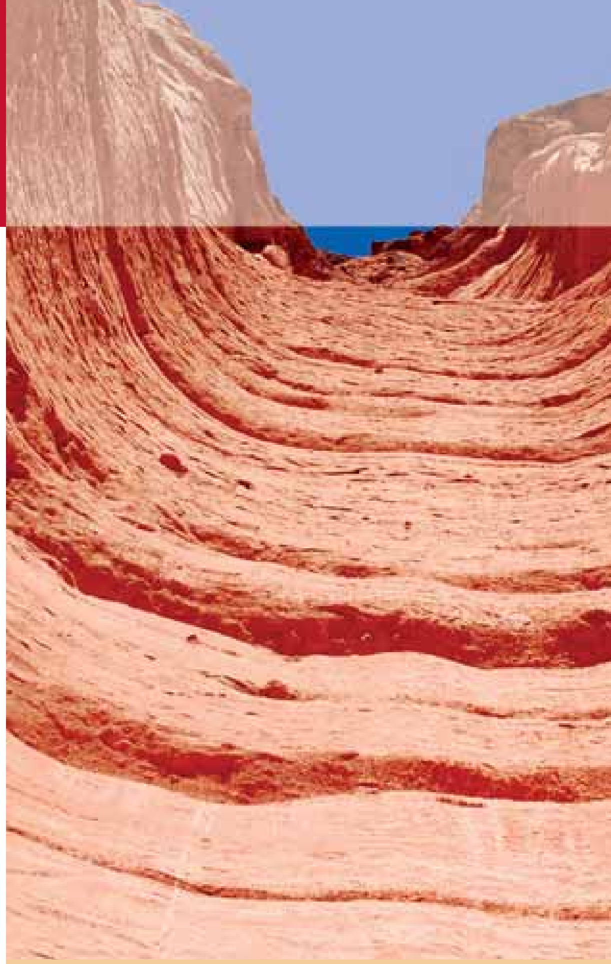
- It is estimated that to bring emissions back down to roughly current levels by 2050, 10 large power stations with full CCS have to be online by 2015.[13] Reaching this goal and further commercializing the technology will require large demonstration projects and many additional major initiatives like the Carbon Sequestration Leadership Forum and the FutureGen project (see also Kansai case study). In most cases, avoided GHG emissions are the only additional benefit of CCS-equipped plants over plants without CCS. Those with CSS will be more expensive both to build and to operate. Therefore, a strong government role is crucial to recognize this value, both in development and deployment.
- Ten countries are collaborating to develop generation IV nuclear reactors with the potential to extend the life of uranium reserves to more than 500 years, to drastically reduce high-level radioactive waste by closing the fuel cycle, and to produce hydrogen for use in transport and other sectors.
- The principal aim of more photovoltaic research is to reduce manufacturing costs, but improving lifetime, integration with building technologies, and the efficiency of converting light (from under 10% towards 40%) are important long-term aims. Solar-concentrating power holds promise for centralized systems.
- A technological breakthrough in electricity storage could improve the stability of intermittent renewables like wind and photovoltaic power. It could also enable the use of electricity in transport (see box on plug-in hybrids).

Hydrogen could eventually become an energy carrier complementary to electricity if cost-effective production, transportation and end-use technologies can be developed. Nuclear fusion, a radically different carbon-free source of electricity, will probably remain in the R&D stage beyond 2050.

Plug-in hybrid vehicles

Hybrid vehicles reduce fuel consumption by combining a combustion engine with a powerful battery and electric drive. The battery is charged through on-board generation by spare engine capacity and regenerative braking. Plug-in hybrid vehicles allow the additional option of the battery being charged from the grid, potentially utilizing spare generating capacity at night.

Improved battery technology could boost the overall efficiency and performance of hybrids, particularly plug-ins. Utilization of grid-based electricity for transportation could provide a path for decarbonization of the transport sector – if low-carbon power generation technologies can be deployed at a sufficient rate. Value chain energy efficiency gains can also be envisaged. High oil prices, environmental concerns and consumer demand are already driving the popularity of plug-ins in North America, and major auto manufacturers have announced their intention to advance R&D.



Driving pilot projects on carbon capture and storage in Japan

Kansai Electric Power Company

Since 1990, Kansai Electric Power has been pursuing R&D in carbon capture from the flue gas of fossil fuel power stations, in cooperation with Mitsubishi Heavy Industries. Kansai is also actively participating in the Japanese government's pilot program for carbon storage in depleted coal seams and methane recovery, initiated in 2002. This project is a joint platform for private companies, universities and research institutions in Japan. Kansai's subsidiary company KANSO is the project leader of this initiative.

The project involves fundamental research into the interaction between methane, CO_2 and coal, CO_2 monitoring technologies, cost reduction of CO_2 capture from flue gases, and the economics of sequestration. The project has reached the field test stage, and injection of approximately 1,000 metric tons of CO_2 is planned before the end of 2006.

6 Reinforce and

Future electricity systems must be built on existing infrastructure. Yet, future grids must do what today's grids were never designed to do: wheel power across continents to integrate regional markets, take up highly variable renewable power generation, and accommodate self-generating and even net-generating customers. Tomorrow's grid must be smarter and more interconnected than today's "islands".

Transmission and distribution (T&D) grids carry out:

1 Transmission – the transport of power over long distances of high-voltage lines, from large, "centralized" power plants or from plants with regional sources, e.g., hydro power; and
2 Distribution – the lower voltage transport of power into homes, offices and industrial facilities.

Investment needs for T&D grids over the next decades are likely to be greater than those for electricity generation (see Figure 11).

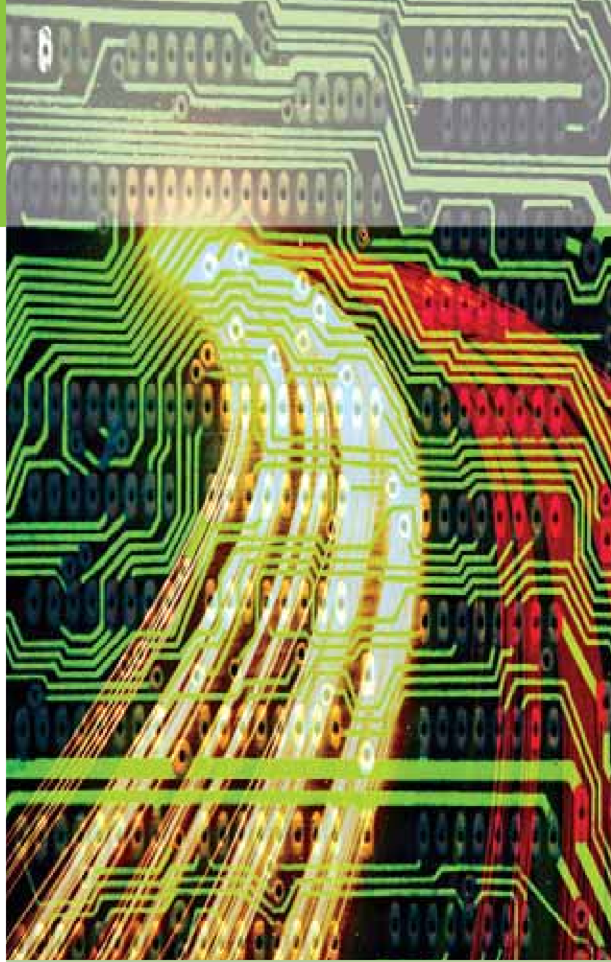
Reliability of supply: Our economies are growing increasingly dependent on electricity, and uninterruptible power supplies are becoming ever more valuable. Despite the availability of proven technologies, many countries, including some of the most developed, have underinvested in T&D, a contributory factor in several major blackouts. These highly publicized blackouts demonstrated the vulnerability of today's grids, strained by decades of neglect, "asset sweating", and increased power trading with bulk power crisscrossing over continents.

Market integration: The expansion of power grid interconnections may be necessary to facilitate regional market integration and development. Regional grids may bring lower prices to customers, and allow for selective dispatch of the most environmentally friendly resources. At the same time, increased reliance on cross-border trade could destabilize electricity grids, unless sufficient grid capacity and more sophisticated technologies are used. Liberalized markets put more cost pressures on utilities, often resulting in a lack of investment in grid capacity. In many countries independent system operators (ISO) are being created to ensure reliability while providing equal and fair access to all power generators. With appropriate investments in capacity and smart technology, networks can actually enhance security of supply, and can also provide flexibility for optimal investments

Helping China meet its increasing demand for energy
ABB

ABB's HVDC (high-voltage direct current) power transmission links convey bulk power over long distances – reliably and with low transmission losses. In China, for example, an HVDC link to the Three Gorges Dam is supplying power to major consumption centers like Guangdong and Shanghai, about 1,000 kilometers from the dam. It reduces the risk of blackouts for millions of people, improves industrial efficiency, and – by connecting hydropower – helps avoid carbon emissions.

Ultra HVDC systems of up to 800 kilovolts are now on the horizon. These will be able to tap even more remote renewable energy sources over distances of 2,000 kilometers and more (the distance from the upper reaches of the Yangtze River to Beijing).



and services in large integrated regional power markets.

Distribution: Information technology and “smart networks”, coupled with intelligent metering and time of use (TOU) tariffs, will allow customers with time of use flexibility to save money, and embedded generators to export to the grid, potentially reducing peak demand.

Renewables: Incorporating renewable energy on a large scale will require increased transmission investments, as many of the best renewable sources (notably sites with favorable winds and hydro potential) are located far away from demand centers (see ABB case study). Many countries have support schemes for renewables, but these have tended to focus on generation rather than T&D or additional energy storage capacity. This creates bottlenecks and instabilities, which do not allow optimal use of installed renewable capacity.

Reducing losses: Modern T&D systems tend to lose 6-7% of the power they transport, mostly in distribution. Reducing losses reduces the need for power generation, and hence environmental impacts. In many markets there is a need to improve equipment quality, especially in distribution to provide more access and reduce technical losses. However, commercial losses through theft and insufficient metering equipment may prevent the necessary investments.

Environmental impacts: As regards impacts of T&D lines on the environment, the drive for sustainable solutions will promote underground transmission. Related technologies, which reduce visual impacts and thus the resistance of local residents, are becoming more cost-effective. Further research is needed to determine the impact of electromagnetic fields near power lines and to further reduce emissions of SF_6 (a potent GHG) from switch gear.

All of these goals require policies and regulation that can attract the capital needed to develop the optimal grid. Liberalized, competitive markets stiffen the challenge; therefore, creating appropriate incentive structures and – last but not least – overcoming the not-in-my-backyard syndrome will be critical in attracting the required investments.

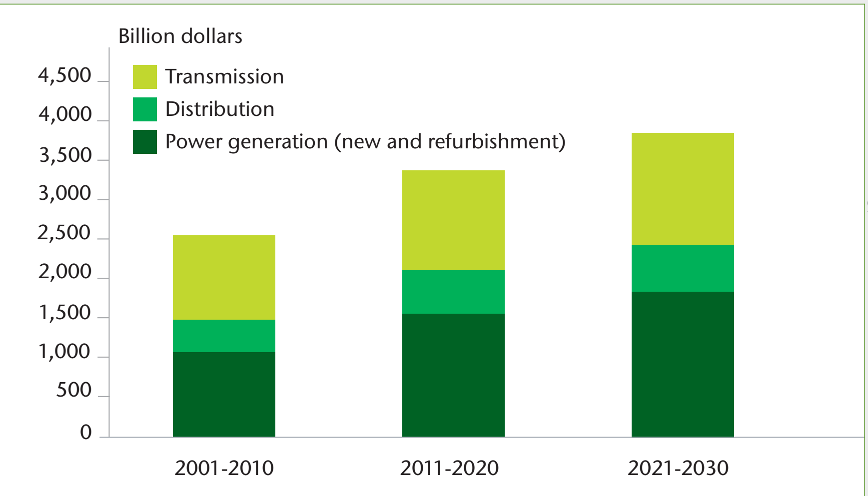


Figure 11: World Electricity Sector Investment, 2001-2030

Source: IEA. *World Energy Investment Outlook 2003.*

The role of decentralized generation (DG)

The bulk of today’s power generating capacity is based on centralized generation (CG), characterized by a relatively small number of large generating plants feeding into the high-voltage transmission system. Decentralized generation means smaller generators close to load centers (e.g., solar, biomass or gas-based combined heat and power (CHP) units) feeding directly into the more local distribution network, or in some cases, supplying electricity “off-grid” to remote communities.

Partially in relation to power grid issues, many of the participants in our stakeholder dialogues maintained that there is a need for more decentralized generation. See the special section overleaf for a discussion of this issue.

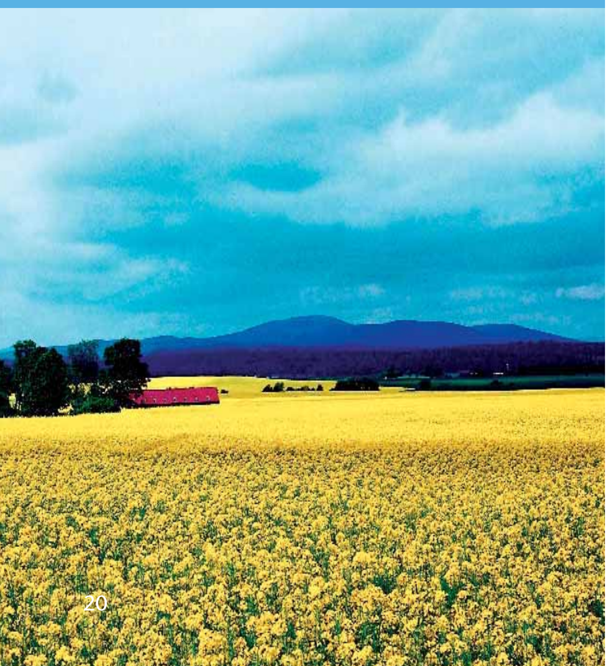
The role of decen

"Demand-side measures are key, but the best approaches bring demand-side efficiency and supply-side efficiency together [...]. Decentralizing the system [...] improves the efficiency of generation by using the heat output, it reduces the costs and impacts of the T&D network by reducing the transmission distance and total load carried, and improves user-efficiency by empowering people to manage their own energy supply and use patterns."

"The most effective way of creating reliable electricity delivery is through an interconnected system of decentralized generators."

"In fact, I believe that the utilities and their grids may become irrelevant if battery and green energy production get more efficient and modularized. Who will need the utilities?"

Online dialogue



Decentralized generation (DG) of electricity can be provided by both renewable (e.g., mini-hydro, biomass, solar photovoltaic) and fossil-fired technologies (e.g., gas-fired combined heat and power). DG is one of the most effective approaches for electrifying remote areas, and can bring a number of other advantages in terms of carbon emissions and energy security to urban environments. Yet DG alone would not be able to satisfy the immense electricity demands of rapidly developing economies in the coming decades. DG has to be part of an interconnected and smarter power grid. Effective pollution control for fossil-fired units is also crucial.

We believe that DG has a valuable contribution to make. We see it as a complement to, rather than a substitute for, centralized generation (CG). A number of trade-offs must be carefully considered, often on a case-by-case basis.

Energy conversion efficiency and costs

- Combined heat and power (CHP) DG can achieve higher overall efficiencies compared to a centralized plant if there is sufficient local heat demand that could not as easily be met by a centralized CHP plant.[14]
- A larger centralized plant offers advantages through economies of scale. It will have a higher conversion efficiency in producing electricity (which can be used to run, for example, heat pumps, see box). CG capital costs are generally much cheaper per unit of capacity than smaller plants; operating and maintenance costs per unit of electricity generated also tend to be lower, and asset utilization tends to be higher. How this plays out in the future will depend on the progress of DG technologies and the nature of local heat demand.

Power grid issues and reliability

- A certain amount of T&D infrastructure cost can be avoided through enhanced DG capacity.[15]
- On the other hand, DG imposes additional costs on the grid, including reverse flow of electricity in distribution lines, requiring R&D and hardware investment in "smart grids". A lack of synchronizing power is another issue (e.g., solar photovoltaic panels and fuel cells, which generate direct current (DC) rather than alternating current (AC)), as is power trading, backup, and adjusting dissonances between heat and electricity demand.
- Some DG solutions are intermittent and unpredictable in nature (e.g., solar photovoltaic panels), requiring back-up from CG or electricity storage.
- These additional costs should be taken into account when calculating "avoided costs".

tralized generation

Attractiveness from the customer's viewpoint

- For the customer, the attractiveness of a DG unit depends very much on grid electricity prices, the ratio of electricity prices to equipment and fuel prices for the DG plant, as well as the reliability of the grid.
- In Germany, there is political support for decentralized CHP guaranteeing feed-in tariffs above market level and reduced network access fees because of avoided network investments (see previous point). Despite the subsidies, there is not a real boom in decentralized CHP.

Emissions management and carbon capture and storage (CCS)

- Another important trade-off with DG concerns emissions. Gas-based CHP may increase efficiency and therefore decrease GHG emissions compared to CG. However, because of the high cost of emission control equipment in small installations, DG is unattractive when using coal. While local pollutants are less of an issue for gas, CCS systems for gas-based DG would be prohibitively expensive. In addition to emissions control, they would also require the transport of CO_2 back to a central storage point.

The way forward

- DG should be deployed wherever its specific advantages and low investment risks allow for viable projects. This may especially be the case in developing countries and in access programs.
- The electricity industry continues to play a role in the deployment and grid connection of DG technologies. It is ready to change its business model to accommodate technological developments if necessary.
- More research is needed to investigate the role of DG in the future of our energy systems. The electricity industry can help develop smarter grid technologies to accommodate DG; an R&D program currently being carried out by Japanese utilities is a good example (see picture below).

Solar photovoltaic panels, distribution lines and testing facilities at CRIEPI.

Heat pump technology and overall efficiency

When calculating the overall efficiency of a distributed CHP system, an alternative way of supplying local heat demand should be considered. An advanced combined cycle gas turbine (CCGT) plant is capable of generating electricity from natural gas with an efficiency of over 50% including T&D losses. An electricity-driven heat pump can produce three times as much heat output (or higher, see box on p. 13) as electricity input, if the heat demand is for hot water or space heating/cooling. This would make an overall energy efficiency of over 150%. CHP units can never reach a level of energy efficiency above 100%.

If heat demand is for high temperature pressurized steam such as required by industries a centralized CHP scheme is preferable (see the "facts and trends" in the back cover or the issue brief on natural gas on our website at www.wbcsd.org), because it is beyond the capability of today's heat pumps.

Glossary

advanced coal: Mainly refers to supercritical Pulverized coal (PC) plants that operate at higher steam pressure than conventional coal-fired plants. These systems offer higher efficiency than their conventional counterparts. Ultrasupercritical technology yields even higher efficiencies and is sometimes included in the clean coal category.

alternating current (AC): An electrical current whose magnitude and direction vary cyclically, as opposed to direct current (DC), whose direction remains constant.

asset sweating: Use of equipment beyond the end of its lifetime or without adequate maintenance or upgrades.

biodiesel: Any liquid biofuel suitable as a diesel fuel additive or extender. Biodiesel is typically made from oils such as soybeans, rapeseed or sunflowers, or from animal tallow. It can also be made from hydrocarbons derived from agricultural products such as rice hulls.

biofuel: Any type of liquid fuel that is produced from biomass products.

biomass: Biomass is a source of renewable energy and includes forest and mill residues, agricultural crops, wood, animal wastes, livestock operation residues, aquatic plants, fast-growing trees and plants, and the organic component of municipal and industrial wastes.

carbon capture and storage (CCS): A long-term alternative to emitting carbon dioxide to the atmosphere is capturing at its source of emission and storing it. Geological carbon storage involves the injection of CO_2 into subsurface geological formations.

carbon credit/offset: Represents a certificate for avoidance of carbon emissions. It can be used to meet a carbon target.

carrier of energy: Enables the transfer of energy from one point to another (as opposed to a primary energy source). Electricity and hydrogen are both energy carriers.

centralized generation (CG): The predominant way of generating electricity today, utilizing a relatively small number of large power plants.

Certified Emission Reduction (CER): A type of carbon credit/offset that is issued through the Clean Development Mechanism.

clean coal: Mainly refers to coal gasification and fluidized bed combustion (FBC) technology. Clean Coal offers more radical environmental improvements and is in an earlier stage of deployment than advanced coal technologies.

Clean Development Mechanism (CDM): An international mechanism put in place by the Kyoto Protocol to facilitate greenhouse gas emissions reductions in developing countries.

CO_2 intensity: CO_2 emissions per unit of another measure (e.g., energy or output).

coal gasification: Breaks down the coal into its components and produces higher concentrations of carbon dioxide, making carbon capture and storage (CCS) more economical than it otherwise would be. See also Integrated Gasification Combined Cycle.

coefficient of performance (COP): The ratio of energy output to energy input for a heat pump in operation.

combined cycle gas turbine (CCGT): The current state-of-the-art technology for power generation utilizing natural gas, combining steam and gas turbines.

combined heat and power (CHP): A process or technology that uses waste heat from power generation, and significantly raises the efficiency of energy exploitation.

combustion: A sequence of chemical reactions between a fuel and an oxidant accompanied by the production of heat or both heat and light.

decentralized generation (DG): Power generation using a large number of small generators (see special section in this report).

direct current (DC): The constant flow of electrons from low to high potential. In direct current, the electric charges flow in the same direction, distinguishing it from alternating current (AC).

economies of scale: Cost reduction per unit of production due to the expansion of production volume.

electrification targets: Targets aimed at providing access to electricity for a certain percentage of the population.

electrolysis: Chemical decomposition produced by passing an electric current through a liquid or solution containing ions. Electrolysis is used to generate hydrogen from water.

enhanced oil recovery (EOR): A process that increases the amount of oil extracted from a reservoir, typically by injecting a liquid (such as water) or a gas (such as nitrogen or carbon dioxide).

environmental externalities: Costs or benefits to the environment that are not born or appropriated by the actor who causes them (e.g., pollution caused by a factory).

feed-in tariffs: Tariffs that private generators can charge for electricity that they feed into the power grid. Feed-in tariffs are higher than the power price if they are designed as subsidies, e.g., to encourage the installation of renewable energy capacity.

flue gas desulfurization (FDG): The current state-of-the art technology used for removing sulfur dioxide (SO_2) from the exhaust flue gases in power plants that burn coal or oil.

fluidized bed combustion (FBC): In fluidized bed combustion (FBC), coal is burned in a reactor comprised of a bed through which gas is fed to keep the fuel in a turbulent state. This improves combustion efficiency, heat transfer and recovery of waste products.

fuel cell: An electrochemical engine that converts the chemical energy of a fuel (such as hydrogen), and an oxidant (such as oxygen), directly into electrical energy.

fuel reprocessing: The treatment of spent nuclear fuel to recycle unused uranium and to recover the plutonium produced in the reactor.

generation II light water reactors: The majority of nuclear reactors that exist today. They include pressurized water reactors and boiling water reactors.

generation III light water reactors: Designed to improve safety and improve economic performance. A small number have been built or are under construction in East Asia, Europe, India and China.

generation IV fast breeder reactors: In the R&D stage. Six different technologies are currently being explored.

geothermal energy: Heat from below the earth's surface. Generally referred to as a source of renewable energy.

greenhouse gases (GHG): Gases in the Earth's atmosphere that absorb and reemit infrared radiation thus allowing the atmosphere to retain heat. These gases occur through both natural and human-influenced processes. The major GHG is water vapor. Other primary GHGs include carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6).

heat pump (HP): An electrical device that takes heat from one location and transfers it to another. A typical refrigerator is a type of heat pump since it removes heat from an interior space and then rejects that heat outside. Heat pumps can work in either direction (i.e., they can take heat out of an interior space for cooling, or put heat into an interior space for heating purposes).

hydrofluorocarbon (HFC): A particularly potent GHG.

high-voltage direct current (HVDC): A technology for power transmission at high voltage.

high level (nuclear) waste (HLW): A byproduct of the reactions that occur inside nuclear reactors.

integrated gasification combined cycle (IGCC): This technology involves the gasification of coal to increase the efficiency of coal-fired power plants and provide a basis for pre-combustion carbon capture and storage (CCS).

internal combustion engine: Has one or more cylinders in which the process of combustion takes place, converting energy released from the rapid burning of a fuel-air mixture into mechanical energy. Most cars today have internal combustion engines.

International Energy Agency (IEA): An intergovernmental body committed to advancing security of energy supply, economic growth and environmental sustainability through energy policy co-operation.

Intergovernmental Panel on Climate Change (IPCC): Established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) to assess scientific, technical and socio-economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation.

ISO 14001: ISO 14001 specifies the requirements for an environmental management system. ISO stands for International Organization for Standardization.

kV: kilovolt. A measure of electric potential difference across a conductor (e.g., a power transmission or distribution line)

kW, MW, GW: kilowatt, megawatt (1,000 kW), gigawatt (1,000 MW). A measure of electrical capacity (e.g., of a power plant).

kWh, MWh, GWh: kilowatt hours, megawatt hours (1,000 KWhs), gigawatt hours (1,000 MWhs). A measure of electrical output or use (energy).

lignite: Lignite, often referred to as “brown coal”, is the lowest rank of coal, and the most carbon-intensive fuel for power generation.

liquefied natural gas (LNG): Natural gas that has been processed to remove impurities and heavy hydrocarbons and then condensed into a liquid.

liquefied petroleum gas (LPG): A mixture of hydrocarbon gases used as a fuel in heating appliances and vehicles, and as a propellant.

Millennium Development Goals (MDGs): Eight goals that all 191 United Nations member states have agreed to try to achieve by 2015. Electricity supply is recognized as important for reaching almost all of these goals.

MOX (mixed oxide) fuel: Contains both uranium and plutonium (generally from reprocessing spent nuclear fuel), can be used in many modern reactors.

not-in-my-backyard (NIMBY): Commonly cited term that refers to the resistance of local communities to infrastructure developments.

NOx (nitrogen oxides): Generic term for various nitrogen oxides produced during combustion.

nuclear fuel cycle: The progression of nuclear fuel through a series of stages. It includes the mining and preparation of the fuel (front end), fuel use during reactor operation (service period), and safely managing, containing, and either reprocessing or disposing of spent nuclear fuel (back end). If spent fuel is not reprocessed, the fuel cycle is referred to as an open fuel cycle (or a once-through fuel cycle). Likewise, if the spent fuel is reprocessed, it is referred to as a closed fuel cycle.

nuclear fusion: In this reaction, two light atomic nuclei fuse together to form a heavier nucleus and release energy. Nuclear fusion technology for power generation is currently being researched and developed in international experiments.

Organisation for Economic Co-operation and Development (OECD): Forum where the governments of 30 market democracies work together to address economic, social and governance challenges.

particulates: Particles of dust, soot, salt, sulfate compounds or other particles suspended in the atmosphere.

photochemical cells: Cells that can generate hydrogen from water using the energy of light.

primary energy: The energy contained in fossil fuels, or in renewable resources such as hydro, wind or solar power.

pulverized coal (PC): This technology, put into widespread use worldwide in the 1960s, involves “pulverizing” coal into very small fragments and then mixing these with air. This mixture is then injected into a boiler where it behaves very much like a gas and burns in a controlled manner.

pyrolysis: The decomposition of a chemical by extreme heat in the absence of oxygen.

recoverable reserves: Reserve estimates based on a demonstrated reserve base, adjusted for assumed accessibility and recovery factors.

SF_6 (sulfur hexafluoride): A particularly potent GHG. Used by the electricity industry for high-voltage electrical equipment.

smart meters: A type of advanced meter that identifies the details of electricity consumption (including time of consumption), and optionally communicates that information back to the local utility for monitoring, system management and billing purposes.

SO_2 (sulfur dioxide): Coal and petroleum contain various amounts of sulfur compounds; their combustion generates sulfur dioxide, a component of acid rain.

SOx (sulfur oxides): A general term used to describe the oxides of sulfur – gases formed primarily by the combustion of fossil fuels. Considered major air pollutants.

solar concentrating power: This technology uses reflective materials such as mirrors to concentrate the sun’s energy. This concentrated heat energy is then converted into electricity.

solar photovoltaic power: Power generated through the conversion of the sun’s electromagnetic waves by solar cells.

spent fuel: Nuclear fuel that has been used in nuclear reactors and needs to be disposed of or reprocessed.

SPSP: Small-scale private sector providers.

TOU (Time of use): These pricing models, in conjunction with smart meters, can be employed to reduce peak demand.

UNCSD – United Nations Commission on Sustainable Development: Responsible for reviewing progress in the implementation of Agenda 21 and the Rio Declaration on Environment and Development at the local, national, regional and international levels.

UNFCCC (COP) – United Nations Framework Convention on Climate Change (Conference of the Parties): An international treaty to begin to consider what can be done to reduce global warming and to cope with whatever temperature increases are inevitable. The Conference of the Parties refers to the meeting of those countries that signed the Kyoto Protocol, a Protocol to the Convention.

vitrification: Conversion into glass or a glasslike substance, typically by exposure to heat. This process can be used to prepare nuclear waste for long-term disposal.

white certificates: A market-based mechanism for the promotion of energy efficiency. White Certificates allow industry to meet energy efficiency targets through direct investment in efficiency projects or by buying certificates from other organizations that have implemented a project.

Notes and references

1 – Each of the six priorities presented in this paper is urgent. The sequence in which they are presented is not intended to indicate a priority of one over the other.

2 – We are grateful to all of the stakeholders who participated in our project consultations. The exchange of ideas in these consultations contributed to the development and refinement of our findings. We appreciate this input and recognize the value and the validity of the diverse points of view. We welcome further feedback.

3 – International Energy Agency (IEA). *World Energy Outlook 2004*. 2004. (The figure on traditional biomass refers to unsustainable ways of using biomass, i.e., not following practices that preserve the resource, such as sustainable forest management.)

4 – World Resources Institute (WRI). Climate Analysis Indicators Tool (CAIT). 2006. (http://cait.wri.org) (When emissions from land-use change and other GHGs are included in the total, the power sector's share is around 25%.) Projections from the IEA's *World Energy Outlook 2004*.

5 – See note 1.

6 – While this objective focuses on supply investments, investments in demand-side equipment are addressed in Section 3.

7 – Energy efficiency can and should be improved anywhere along the value chain, i.e., in power generation, transmission, distribution and end use. This part of our document focuses on end use. See sections 4 and 6, and the special section on decentralized generation (p. 20).

8 – Demand side management (DSM) as a device designed to "level power load" can be one tool to avoid supply side investment. It involves encouraging customers to shift demand away from or save energy at peak times.

9 – In making our recommendations, we acknowledge that some of our stakeholders disagree with our recommendations for the development and deployment of carbon capture and storage or nuclear power. A number of our stakeholders indicated a strong preference to address global challenges through much greater reliance on energy efficiency and conservation, and through much greater deployment of renewables. Others indicated a strong preference for greater reliance on distributed generation, both renewable and others. However, we concluded from our own analysis that the additional energy options are necessary to avoid more serious climate change.

10 – Many of the member companies of the WBCSD Electric Utilities Sector Project are also engaged in dialogue on international climate policy options through the WBCSD Energy and Climate Focus Area. Policy options include sectoral approaches to emissions trading and collaborative technology development and transfer agreements. More information is provided in the WBCSD's publications on energy and climate, available on the WBCSD website – www.wbcsd.org.

11 – OECD. Round Table on Sustainable Development (Background Paper), "Do we have the right R&D priorities and programmes to support the energy technologies of the future?" 2006.

12 – Please refer to the "facts and trends" in the back cover of this publication and issue briefs on our website – www.wbcsd.org – for a more exhaustive description.

13 – International Energy Agency. *Prospects for CO_2 Capture and Storage 2004*, Energy Technology Analysis. 2004.

14 – This is the case for example in the pulp and paper industry, whose production facilities need large amounts of heat.

15 – Note that this does not apply to large wind projects, which have the character of a centralized plant and require strong transmission grids.

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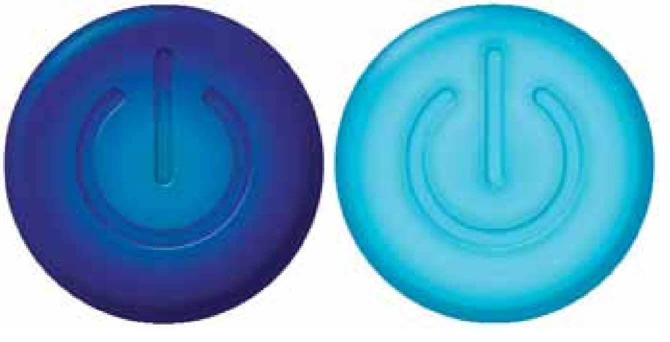

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