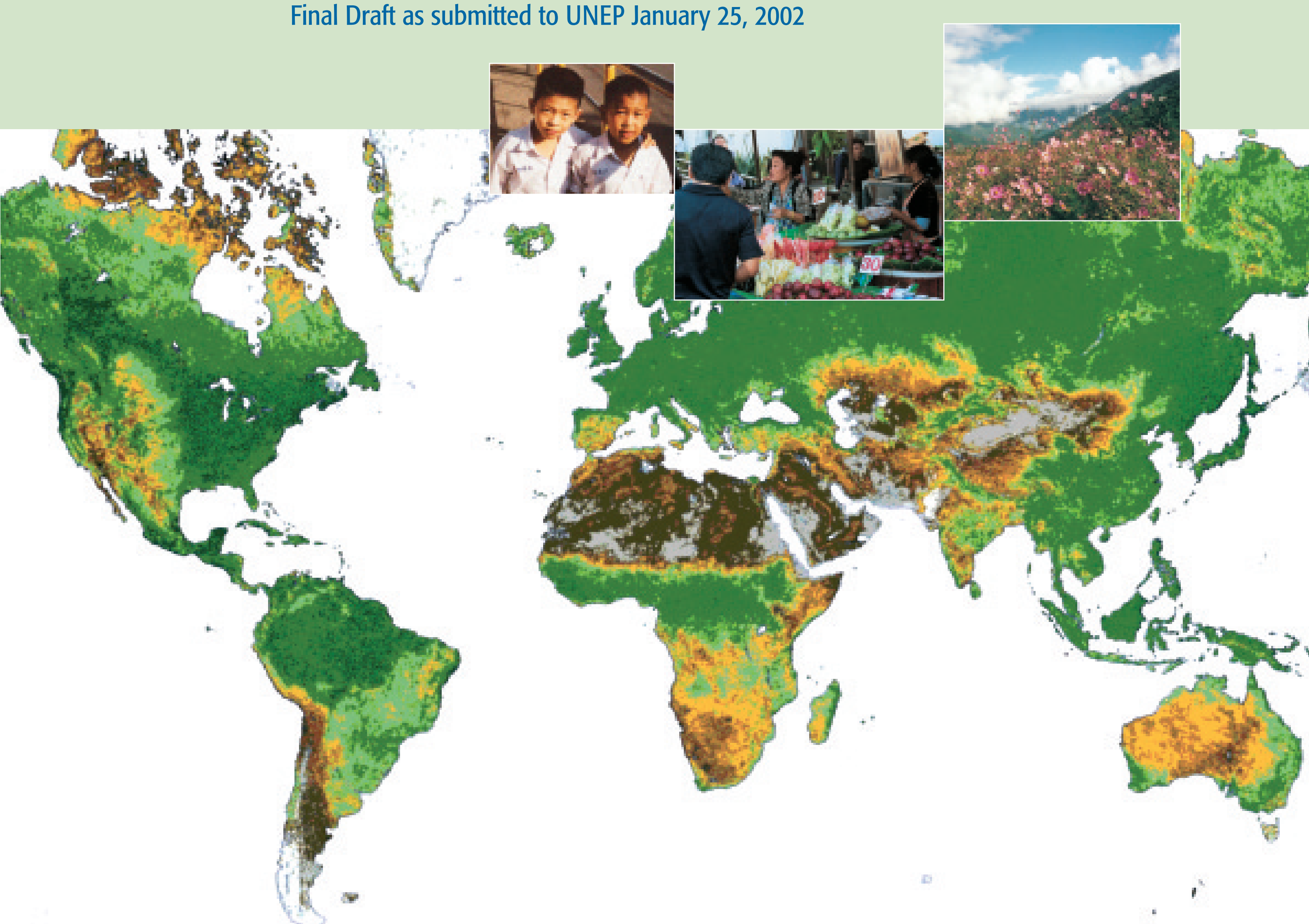
Electricity Sector Report for the World Summit on Sustainable Development

Final Draft as submitted to UNEP January 25, 2002



Prepared by the e7
and its world-wide partners
at the request of the United Nations
Environment Programme

United Nations Environment Programme Disclaimer

In a multi-stakeholder consultation facilitated by the United Nations Environment Programme, a number of groups (including representatives from non-governmental organisations, labour unions, research institutes and national governments) provided comments on a preliminary draft of this report prepared by the e7. The report was then revised, benefiting from stakeholder perspectives and input. The views expressed in the report remain those of the authors, and do not necessarily reflect the views of the United Nations Environment Programme or the individuals and organisations that participated in the consultation.

This report is part of a series facilitated by UNEP DTIE as a contribution to the World Summit on Sustainable Development. UNEP DTIE provided a report outline based on Agenda 21 to interested industrial sectors and co-ordinated a consultation process with relevant stakeholders. In turn, participating industry sectors committed themselves to producing an honest account of performance against sustainability goals. The full set of reports is available from UNEP DTIE's website (www.uneptie.org/wssd), which gives further details on the process and the organisations that made it possible.

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1 Executive Summary

Since the 1992 Earth Summit, the electricity sector has made steady progress towards sustainable development. In a sustainable world, everyone will have access to electricity. On a voluntary basis, electric companies have adopted many practices that contribute to the social, environmental and economic dimensions of sustainable development. Today, the sector has the opportunity to accelerate these efforts with new advances in technology and a more interconnected society. This report documents the electricity sector's progress and challenges in fostering sustainable development. On the basis of this experience, the e_7 proposes two goals to help overcome the challenges of making electricity available, accessible and affordable. First, electric power companies should implement *Guidelines for Best Practices* to guide their operations in a sustainable manner. Second, all electricity stakeholders including governments and non-governmental organisations, financial and development institutions, and technology providers should focus their sustainable development activities on expanding access to electricity for all people.

Key points of this report are as follows:

- Energy is intrinsically linked to environmental, social and economic dimensions of sustainable development. Providing reliable and secure electricity supplies, reducing environmental impacts, and providing access to electricity to people currently without it are key challenges of the electricity sector;
- Residential, commercial and industrial demands for electricity have increased with rising economic prosperity. While the electricity sector has met these demands, it has strived to, and will continue to, promote efficient use of natural resources, protect the global and local environment, and improve quality of life for both present and future generations; and
- Two billion people do not have access to electricity. Expanded access to affordable electricity could be accelerated, and higher levels of environmental protection could be attained, if 1) electric companies implemented *Guidelines for Best Practices*, and 2) government, financial and development institutions; technology developers and non-governmental organisations; and the sector focused their partnerships on sustainable electric power development.

The United Nations Environment Programme (UNEP) invited the e_7 to prepare this report on behalf of the global electricity sector for the 2002 World Summit on Sustainable Development.

The e7 is a non-profit group comprised of nine leading electricity companies from G7 countries working together for sustainable energy development. The e7's members are Hydro-Québec and Ontario Power Generation (Canada), Electricité de France (France), RWE (Germany), Enel (Italy), Kansai Electric Power Co. and Tokyo Electric Power Co. (Japan), ScottishPower (UK), and American Electric Power (USA). Its mission is to "play an active role in protecting the global environment and in promoting the efficient generation and use of electricity."

With its expertise in electricity generation, the e7 implements renewable energy projects and provides electricity-related capacity building assistance to developing countries. Since its creation in the wake of the Rio Summit in 1992, the e7's Network of Expertise has completed more than 30 human capacity building and technical assistance projects in developing countries, as well as two AIJ (Activity Implemented Jointly) projects in Indonesia and Jordan. Through the e7 Fund for Sustainable Energy Development (an accredited NGO established in 1998), the e7 has initiated projects in Bolivia, Ecuador, Zimbabwe and Western Africa that promote sustainable energy development.

The e7's Working Groups examine specific policy issues of interest to the global electricity industry (e.g., Climate Change, Social Trust, Internationalisation, Regional Electricity Cooperation or Nuclear Energy) and facilitate exchange with NGOs and international organisations, government officials and electric utilities from developing countries. For more information, please visit www.e7.org.

Electricity is an essential component of sustainable development. In preparing this report following UNEP guidelines, the e7 analysed historical data related to the generation and delivery of electricity (Section 2) and past approaches to electrification (Section 3). The e7 concludes that unless stakeholders representing governments, financial and development institutions, technology developers, and other non-governmental organisations focus their efforts, extending electricity to the two billion people who do not now have it will occur very slowly, or perhaps not at all. Electric companies alone cannot provide electricity where it currently is not commercially available. Two goals and the means to achieve them are fully described in Section 4 of this report and on the e7 web site.

The e7 has served in a leadership role in the sector's sustainable development activities by sharing its expertise with partners in many countries. The e7 looks forward to joining forces with stakeholders and other electric companies to achieve the sustainable development goals described in this report.

1.1 Contributing to Sustainable Development

The e7 subscribes to the definition of sustainable development resulting from the World Commission on Environment and Development in 1987 as: "…development that meets the needs and aspirations of the present generation without compromising the ability of future generations to meet their own needs."

In the context of the electricity sector, sustainable development means: promoting available, accessible and affordable electricity to benefit the environment, the economy and society; making economical end use of energy sources; maximising economic use of low- and zero-carbon emitting generation; and maximising the efficiency and minimising the environmental impacts of the generation, transmission, distribution and use of the electricity in a cost-effective manner.

Electricity can be an economically affordable, technically and environmentally sustainable form of energy. Economic growth typically requires an increasing use of electricity, which may contribute to an increase in emissions.

Over the past decade, the electricity sector has steadily contributed to making development sustainable by helping people achieve environmental protection, social progress and economic growth.

1.1.1 Environmental Protection

- Improvements in electricity generation, transmission efficiency and pollution control technologies have reduced primary fuel consumption, and associated emissions and waste;
- Many electric companies have adopted life cycle analysis to evaluate environmental performance of generation options, and they have improved environmental impact assessments with stakeholder consultations;
- Electricity sector investments in research and development have resulted in the development and deployment of new generation and distribution technologies, and improvements to existing technologies, including renewable energy technologies;
- Environmental management has improved due to the development of international standards for environmental management systems (EMS). Many electric companies have achieved the ISO 14001 international standard for EMS;
- Electricity generation has substantially increased to meet demand, yet emissions per kilowatt-hour have significantly decreased, due to improvements in efficiency and combustion control technologies; and
- Electric companies have helped slow the increase of CO_2 emissions through appropriate fuel choices, continued technological development, end use energy efficiency (demand-side management), and carbon sequestration projects, despite growing energy consumption.

1.1.2 Social Progress

- Improved healthcare, agricultural practices and food storage, telecommunications and education have resulted from the increased availability and supply of electricity;

- Secure employment and its ancillary benefits have been fostered by electricity supply;

- Processes for involving stakeholders in electricity projects have been improved, resulting in more informed decision-making; and

- The e7 capacity building activities have provided host country utilities and institutional entities with the skills, knowledge and training to meet their own sustainable energy development objectives while implementing sound environmental practices.

1.1.3 Economic Growth

- Electricity has an increasingly critical role in energising industrial processes and commercial activities;

- In many countries, growth in electricity consumption and economic productivity (Gross Domestic Product) are closely linked. Furthermore, electricity consumption frequently rises even faster than the GDP, particularly in developing countries;

- Electricity has enabled revolutionary efficiency and productivity improvements in both developing and industrialised economies; and

- Market mechanisms for reducing pollution such as tax credits, emission fees and emission trading, have been used to achieve compliance while reducing costs and spurring technological innovation.

Most citizens and businesses enjoying the benefits of electricity now consider it to be a necessity, so basic that few pause to think about it, except when power is in short supply or is interrupted.

Specific examples from the e7 companies show how the sector has advanced sustainable development through power systems utilising the full complement of energy sources, energy efficiency, electrotechnologies and generation, transmission and distribution infrastructures (Annex 1).

1.2 Remaining Challenges

Despite the substantial progress achieved to date, three key challenges remain for the electricity sector in collaboration with governments and other stakeholders: the availability, accessibility and affordability of electricity for all people.

1.2.1 Availability

- All forms of energy should be considered to achieve mass availability. In terms of sustainable development, no electricity should be unacceptable;

- Solar, wind and geothermal technologies remain relatively high priced. Moreover, the first two technologies alone cannot provide sufficient electricity to meet demand and must be coupled with storage facilities and/or other means of electricity generation;

- To address climate change without compromising the goal of expanding economic growth and access to electricity, it is imperative that market penetration of low-carbon emitting energy systems and zero-carbon emitting technologies occur. Low-carbon emitting energy systems include existing efficient gas combined cycle, and new advanced fossil fuel generation technologies such as coal gasification, fuel cells and biomass. Zero-carbon emitting technologies include wind, nuclear, geothermal, hydro and solar as well as future fossil fuel plants that capture and permanently dispose of carbon emissions in geologic formations; and

- Global demand for electricity will increase. With focused initiatives, this demand can be met with low- and zero-carbon emitting technologies.

1.2.2 Accessibility

- The most important challenge is to provide electricity to the two billion people who do not yet have access to it. The electric industry should help to provide a stable supply of electricity in an environmentally friendly, efficient and sustainable manner;

- Electric companies experience public concern to proposed plans and decisions involving fuel choice, facility siting, mitigation of environmental and social impacts, and tariffs. The concerns have at times resulted in projects being cancelled; and

- An appropriate institutional framework is needed to create a level playing field and to reap the full benefits that liberalised electricity markets can provide.

1.2.3 Affordability

- In many developing countries, limited economic resources have hampered electrification, especially the financing of energy infrastructures that require a long-term return on investment; and

- It is sometimes difficult to provide low-income customers with affordable tariffs. In the absence of a strong regulatory framework, companies often utilise only the cheapest available fuel.

1.3 Goals to Overcome these Challenges

The electricity sector believes that the following two goals will support relevant sustainable development initiatives identified for this Summit by the United Nations Commission on Sustainable Development. The initiatives are: sustainable consumption and production, energy, and technology transfer and capacity building.

Goal 1
Electric companies should implement 'Best Practices' to guide their operations.

The e7 has already adopted guidelines to enhance sustainable development, based on the principles set by policy makers at the Rio Earth Summit. The *Guidelines for Best Practices* should serve as a universal guide for electricity providers around the world (Annex 2). By adopting these best practices, the electricity sector will use indigenous energy resources in each country and region to efficiently generate and deliver electricity while protecting the environment.

Goal 2
Electric companies should share their expertise in partnership with governments and non-governmental organisations, financial and development institutions and technology providers from around the world to help focus their sustainable development activities on expanding access to electricity for all people.

Given the importance and complexity of the electrification challenges that the sector faces, cooperation with all stakeholders is vital. Therefore, the electricity industry should make every effort to reach out to all stakeholders, explain the need for focused and coordinated initiatives, and seek their participation.

Governments have the authority to establish policy priorities, legal structures and governance systems necessary for electrification. Development of an appropriate regulatory framework is absolutely essential to attract the foreign investment needed to expand electrification. Investments could create an efficient and large enough transmission network to pool demand and supply in most regions of the world. In less densely populated rural areas, distributed generation solutions would be implemented.

Key to expanding access to electricity is the right and intention of nations to use their indigenous energy resources, including fossil fuels. By capitalising upon regional initiatives for economic integration and fostering the deployment of new energy technologies, the electricity sector can help to optimise the use of these resources, increase economic development, and protect the environment. For sustainable development, it is essential that the most efficient technologies are employed for each fuel. This will not happen without the appropriate framework conditions. The electricity industry needs to contribute its technical expertise and experience to the development of public policies related to electricity and advocate strong legal structures to support financial investment.

The financial world plays a key role in leveraging the capital resources necessary for large-scale investments typically associated with electrification. Through cooperative partnerships, the electricity sector can work with banks, funding agencies and other investors to develop innovative financing mechanisms to reduce investment risks that have so far proven prohibitive, and support the goal of expanding access to electricity.

Technology developers have access to options for energy conversion that can provide fuel flexibility and pollution control, and lead to efficient use of resources. The electricity sector must work with developers to:

- Upgrade electric power systems currently in operation around the world;
- Introduce sustainable electric technologies to currently unconnected or underpowered areas; and
- Allocate and focus adequate resources for research and development to accelerate timelines for the commercial use of new technologies.

Finally, representatives from non-governmental organisations can provide knowledge of local needs related to electrification and sustainable development.

The e7 has identified four priorities that could form the basis for a strategy that leads to greater access to affordable, reliable, and environmentally sound electricity (Annex 3).

This report describes the contributions of the electricity sector to sustainable development and many remaining challenges. The e7 encourages the electricity sector and its stakeholders to join forces in working to address these challenges.

2 Contributing to Sustainable Development

2.1 Introduction

Energy, particularly electricity, lies at the heart of sustainable development; it powers economic and social progress and also impacts the environment. The electricity sector merits special attention due to the complex trade-offs involved in choosing between competing fuels – that is, in deciding upon the “fuel mix” for electric power. This section highlights progress achieved by the electricity sector in the effort towards achieving sustainable development.

Public policies governing electric power have changed dramatically in recent years. Historically, nations have determined energy sources comprising their own electricity mixes by using a variety of policy instruments to promote resources according to national priorities. Today, environmental concerns gain increasing influence on electricity mix policies at all levels. Energy policy has evolved into an international issue, brought under the scrutiny of public opinion through international government and non-governmental organisations. The concept of the “global energy mix” has emerged.

Without duplicating the data that is available from the many organisations dedicated to energy, environment and development issues (Annexes 4 and 7), this section will summarise how historical trends in the global fuel mix for electric power have influenced the sector’s impact on the environment, social progress and economic development.

2.2 Growth Trends in Electric Power

The electricity infrastructure influences the sustainability of electric power, and trends in electric power, in turn, reflect and affect patterns in overall economic development. Recent decades have brought about changes in the structure of the electric power sector that set the stage for directions that will emerge in the future.

Economic growth is closely linked to electric power. Since the 1980s, rising world electricity consumption has corresponded with growing GDP (Annex 4). Over the past three decades, the electricity intensity of OECD countries has remained unchanged, but most credible long-term projections assume that the world economy will continue to grow at a rate of about 3% per year in the next quarter century – split between 2% in OECD countries, 3% in economies in transition, and 4.3% in emerging countries (5% growth in China and India). As in past decades, this continuing economic growth will contribute to demand for electric power.

Population trends also impact energy demand. Population growth in the OECD is expected to remain at 0.3% per annum, while the population in developing regions will grow by an average of 1.3% per annum. World population is projected to grow 1.1% annually to 7.5 billion by 2020 and to 10 billion by 2050, taking place mostly in the developing world. Energy-intensive industries will likely grow in emerging economies, while industrialised economies will tend toward less energy-intensive activities.

Within this economic and demographic context, world energy demand and electricity production is expected to increase steadily. In terms of electricity, the average annual growth rate of demand is currently about 3%. This is due to economic growth and electricity replacing the direct combustion of fossil fuels for many end uses. To satisfy this demand, electric power generation has been, and will continue to be, the fastest-growing energy user in the industrialised economies (1.5% to 2% per year), as well as in the emerging economies (+5% to +10% per year).

2.2.1 The Electricity Mix

The electricity mix influences the environmental impacts of the electric power sector, and the fuel mix choice has become a turning point of global energy policy for two main reasons:

1. Power generation presently consumes a large and growing share of global primary energy resources. The 3 500 Mtoe (million tonnes of oil equivalent) used to generate electric power represents 37% of global energy, making electricity the largest annual consumer of primary energy, well above transportation (1,800 Mtoe) and industry (2,100 Mtoe). Electricity is also experiencing the highest growth rate in consumption at 2.5 - 3.0% per annum.

2. Modifying energy consumption patterns in transportation, industry and other end uses involves overcoming difficult and time-intensive challenges. Energy conservation and efficiency efforts alone will not suffice in mitigating global climate change. Changes to the global electricity mix, however, aimed at promoting clean energy sources and technologies, represent prime opportunities for effective progress in both the near and long term.

Past trends in the global electricity mix in the past thirty years have reflected different national priorities and variations in generation costs (see box below). Relative stability in the share of electricity generated from coal (38% to 40%) has been the result of abundant reserves, improved extraction techniques and the reliability of combustion technologies.

Comparative Costs of Electric Power Generation

Raw economic costs will continue to drive the future energy mix. Price per unit of energy is derived from optimisation of capital and operating costs, taking into account the discount rate, the use of equipment for base-load or peak-load, etc. Investment decisions consider capital and fuel costs. The following figures are in U.S. dollars.

Respective shares of capital and fuel costs in the overall cost of generating electricity vary considerably from plant to plant and with the discounted rates applied to equity and borrowed finance. The most capital-intensive technologies are hydro and other renewables: $2,000 to $3,000 per kilowatt (kW) of capacity for large hydro, and $4,000/kW and above for small hydro and new renewables including costs of electricity storage (i.e., wind and solar photovoltaic systems). For modern nuclear plants, total investment costs range between $2,000 and $2,500/kW, which means an investment exceeding $2 billion for a 1,000 MW plant. For coal-fired plants, capital costs generally range between $1,000 and $2,000/kW. For gas-fired plants, capital costs are significantly lower, ranging between $500 and $900/kW. Construction times also are markedly different: 1-2 years for solar and wind farms, 2-3 years for gas, 5 years for coal, 7 years for nuclear and up to 10 years for hydro.

Fuel costs are equally variable. For hydro and other renewables, fuel costs are zero. For nuclear energy, fuel is a small proportion of total costs. For coal, the cost of fuel is medium in total cost but relatively stable over time. Oil and gas represent a high proportion of total cost for such plants and are also potentially volatile due to market forces. Hydrocarbon prices have been low from 1986 to 1999, but they have increased significantly in the past two years.

The decline in other hydrocarbons (34% to 24%) largely reflects political responses to the energy crisis of the 1970s, resulting in reduced interest in oil-fired generation capacity in many regions. However, modern gas-fired technologies have become the driving force behind new capacity additions in many countries today.

The share of hydropower has also fallen (23% to 18%) as environmental opposition has challenged the political momentum behind many large, government-sponsored projects, and more economically attractive sites have been developed. The increase in nuclear energy (from 2% to 17%) reflects maturation of these technologies and political responses to the energy crises of the 1970s. Non-hydro renewables have penetrated the global energy mix (from 0% to 2%), benefiting largely from government sponsorship and technological innovations.

2.3 Electric Power and its Impacts on the Environment and Social Development

The essence of sustainable development is the preservation of choices for future generations in economic, environmental and social dimensions. Sustainable development applied to electricity includes conserving resources, maximising its contribution to economic and social development, and minimising its environmental impact.

How has the electricity sector progressed in these terms in recent years? Many electricity providers, including the e7 companies, have undertaken numerous activities in the areas of power systems, customer energy efficient services, environmental impact reduction, research and development on electrotechnologies, and pollution control technologies. The chart in Annex 1 provides examples of the e7 members' portfolio of sustainable energy development activities. More detailed descriptions are available on the web sites of the e7 (www.e7.org) and its members.

Assessment efforts, such as the Global Reporting Initiative launched by the United Nations Environment Programme, have attempted to quantify complex variables, such as the risks of nuclear power, the impact of carbon emissions, the benefits of energy security and the value of access to electricity. The following discussion examines issues of particular relevance to the electric power sector's impacts on the environment and social development.

2.3.1 Sustainability of Different Fuels

Different fuels have different sustainability characteristics. The following summarises the sustainability characteristics of the five principal sources of power generation – coal, natural gas, oil, nuclear and renewables (including hydroelectricity). All sources of energy present challenges to sustainable development, but all sources can be managed sustainably. In keeping with the underlying philosophy of sustainable development to prevent excessive risks for future generations, the best strategy is to not rely on any one source for the entirety of a country's or a region's electricity supply. Sustainable development requires a well-balanced energy mix.

Coal

Coal is currently the main fuel for the electric power industry, comprising about 43% of the energy mix. It is widely available and based on well-proven, comparatively simple technologies. Many of the environmental impacts of coal have been significantly reduced in industrialised countries; they, however, remain of concern because of the fast rising demand and outdated technologies in developing countries. The use of existing emission control technology, the development of new technologies for coal gasification for use in combined cycle units, and greenhouse gas emission sequestration are expected to further reduce its environmental impacts.

Oil

Oil is easy to transport and burn. Its environmental impacts are less (per unit of electricity) than those of coal but more than those of natural gas. A major drawback is its limited geographic availability.

Natural Gas

Gas-fired power generation has witnessed high growth rates in recent years and is well set to continue to do so in the medium-term future. Gas-fired power generation has less local and global environmental impacts than other fossil fuels. Gas burns almost residue-free. Combined cycle gas turbines achieve very high efficiencies. Release of methane, a potent greenhouse gas, may occur during gas production and transport. The grid-based nature of natural gas transport (with the exception of technologically demanding liquid gas installations) limits consumer flexibility.

Nuclear

Use of nuclear energy has grown in OECD countries since 1956. It grew quickly between the 1960s and 1980s when prices of fossil fuels were high and energy security was a primary issue. Nuclear energy is a carbon-free source of electricity. Issues related to nuclear energy include the fear of accidents, the management of radioactive waste and proliferation of nuclear material.

Renewable Sources

Renewable energy sources (hydroelectric, solar, wind energy and biomass) are known for having great potential for sustainable development. Renewable energy is carbon-neutral, emission free and, in many cases, supports off-grid technologies and application. Current high costs, compared to other technologies and their fuels, should decrease as more renewable energy projects are installed. A common environmental impact is land use, e.g., biomass plantations, hydroelectric reservoirs, and wind and solar panel farms. Aesthetic (visual) impacts, injuries to birds and fish through wind and hydroelectric turbines respectively, and emissions from biomass use are associated with these sources. Batteries with off-grid renewables can cause environmental impacts if they are not properly maintained and disposed of.

In summary, no single, perfect source of electricity exists in terms of sustainable development.

2.3.2 Electricity and Energy Security

In its 2001 report, Toward a Sustainable Future, the International Energy Agency (IEA) defines energy security as: "the physical availability of supplies to satisfy demand at a given price." Energy security is also the reduction of risk associated with any single technology. Limiting imports of primary resources, diversifying energy supply, and adopting a balanced mix of technology options should serve as pillars of national energy security policies.

It is difficult to develop indicators of energy security, since they in part depend on the dynamics of geo-politics. Electricity must be considered together with energy consumption in other sectors. As power generators can, in principle, use all types of fuels, many governments have turned to the electricity industry as a leading instrument for energy security.

Reducing dependence on oil and gas to generate electricity is the main energy concern of many countries, as these two primary energies are concentrated in a limited number of countries. Approximately 75% of oil and gas reserves are situated in two regions of the world, the Middle East and the former USSR. While the Middle East has 66% of the oil reserves, it has only 33% of the gas reserves.

Coal resources are well distributed globally and do not pose the same energy security concerns. The same can apply to nuclear and renewable sources. Hydropower can also pose a number of issues that relate to energy security, since annual fluctuations in runoff (i.e., water availability) depend on meteorological conditions.

Looking beyond primary fuels, electricity as a secondary energy form can motivate countries to increase energy security. For instance, imports account for only 3% of total consumption in OECD countries, but some countries favour development of domestic electricity resources and raising barriers to imports. This distorts international electricity trading markets.

2.3.3 Electricity and the Environment

There are a number of environmental consequences associated with electricity production and use. Over the past three decades, the industry has gained much experience in addressing these consequences, and has achieved a remarkable reduction in environmental impacts without compromising growth in electricity supply.

A well-designed transmission and distribution network may help minimise loss of electricity and enable pooling of supply and demand. This can help maximise efficiency of the electric power system and reduce environmental impacts of power generation.

Environmental impacts of electricity occur at the local, regional and global levels. Greenhouse gas and mercury emissions and biodiversity losses are issues best addressed globally. Emissions of sulphur dioxide and nitrogen oxides have more of a regional impact, as do water flow issues. Local considerations include airborne pollutant emissions, cooling water intake and discharges, landfills, injury to animal and plant populations, and land use changes.

2.3.4 CO_2 Emissions

According to the IEA, CO_2 emissions from the electric power industry worldwide have increased by 20% between 1990 and 1998. Emissions of the electricity industry of OECD countries have risen significantly during this same period, while nations with economies in transition have reduced emissions due to economic downturns.

It should be recognised that electricity is among the most efficient means of converting primary fossil fuels into usable energy. Thus, as direct combustion of fossil fuels is displaced by electricity use in the developing world, there will likely be an increase in overall electricity sector emissions. However, this increase would in fact, represent a net reduction in carbon emissions from the total energy system.

Electrification can affect CO_2 emissions by reducing direct fossil fuel combustion and by utilising low- and zero-carbon emitting technologies.

The e7 Climate Change Working Group

In 1995, the e7 Climate Change Working Group (CCWG) was established in the wake of the United Nations Framework Convention on Climate Change's (UNFCCC) first Conference of Parties (COP I) in Berlin. The CCWG was formed to identify and examine issues surrounding climate change and greenhouse gas emissions (GHGs) in order to make recommendations or implement policies for the concrete advancement of the global debate. Since its creation, the CCWG has produced several position papers in collaboration with developing country electric utilities and international organisations that support the e7's commitment to GHG reductions. These papers are accessible on the e7 web site. In addition, the CCWG frequently holds workshops and forums at COPs to discuss climate change issues and gather feedback on its papers.

For example, in December 2001, the e7's Climate Change Working Group assembled representatives from government, developing country utilities and international organisations in Paris to discuss a draft position paper on the practical aspects of CDM project implementation. One result was the development of specific case studies that focus on some of the still undetermined aspects of the CDM.

2.3.5 Developing New Technologies to Help Combat Climate Change

Population expansion and economic growth will increase energy use and continue the upward trend in carbon dioxide emissions, which contribute to global climate change. To address this challenge without compromising legitimate aspirations for economic growth and social progress, it is imperative to promote and accelerate the development and global deployment of low- and zero-carbon emitting technologies. Low-carbon emitting energy systems include existing efficient gas combined cycle, and new advanced fossil fuel generation technologies such as coal gasification, fuel cells and biomass. Zero-carbon emitting technologies include wind, nuclear, geothermal, hydro and solar as well as future fossil fuel plants that capture and permanently dispose of carbon emissions in geologic formations. These low- and zero-carbon emitting technologies, together with storage technologies and carbon sequestration techniques, will help to de-couple rising electricity production from greenhouse gas emissions. Technology development roadmaps are available (Section 3.2.6) to guide the process.

Available storage technologies, such as electrochemical batteries and compressed air storage, and efficient distributed generation, such as fuel cells, are not used widely because of their limited capacities and high capital costs. Storage technologies would also allow increased use of renewable sources, such as wind, solar and run-of-the-river hydro, with output that cannot be modulated according to demand. They are also a necessary complement to distributed generation, since they can solve problems of reliability and power quality inherent to these systems.

Perhaps even more important is the development of new electric power technologies able to accommodate different geographies and economies and make optimal use of locally available power resources while minimising CO_2 emissions. One promising example for meeting the needs of China, India and other nations with large coal deposits is the use of integrated coal gasification combined cycle (IGCC), coupled with carbon capture and disposal. Unfortunately, experience suggests that research and development of such technologies could last several years or decades. It is thus important to approach the matter with appropriate timeframes for policies.

In the meantime, technology transfer holds the greatest promise. Improving the thermal efficiency of fossil fuel generation from an average of 28% in the developing world to the 37% presently achieved in developed countries could immediately and significantly reduce carbon emissions. New coal plants are averaging 40% efficiency and new gas combined cycle plants average 55% efficiency. Governments need to implement policies to encourage such transfers.

To ensure that low- and zero-carbon emitting energy systems penetrate the market successfully and are deployed globally, both public and private efforts will be necessary. Public policies promoting technology dissemination to developing countries can help emerging economies to bypass less sustainable energy systems. Financial institutions, both public and private, need to enhance funding mechanisms to address capital cost challenges of electric power infrastructure investments, as well as to promote storage technologies and low-carbon emitting energy systems. For its part, the electric power sector is willing to contribute its substantial technical expertise and operating experience to the required effort for the research, demonstration and deployment of these vital technologies.

2.3.6 Local and Regional Pollutants

Most pollutants arising from electric power at local and regional levels originate from generating plants using natural gas, oil and coal. The pollution of most concern is airborne in nature, although activities in the electric power sector also affect other areas, such as water quality, land use and solid waste disposal.

Most new natural gas-fired generation is being utilised in combined cycle power plants, which enjoy high efficiency and minimal environmental impacts. Such facilities may only require controls for NO_x emissions.

Compared to the relatively minor share of the electricity mix represented by oil, the bulk of airborne emissions originate from coal-fired power generation. Coal contains significant levels of conventional pollutants, such as sulphur, nitrogen oxides, particulates and heavy metals. The main challenge for operators of coal power plants is to minimise SO_x, NO_x and mercury emissions without significantly impacting the efficiency and investment cost of the plant.

Technologies to control SO_x and NO_x are commercially available but are not widely deployed due to costs, especially in developing countries. This is the case for flue gas desulphurisation (FGD), which is only used in OECD countries. Since FGD may add up to 30% to a unit's investment cost and decrease thermal efficiency by 1% or 2%, developing countries have been reluctant to embrace this advanced environmental control technology. Disposal of large volumes of sludge generated by these systems also discourages widespread use. Similar costs are associated with electrostatic precipitation technologies (ESP) to capture particulate emissions and selective catalytic reduction (SCR systems) to reduce NO_x emissions.

Through the management of local pollutants, the electricity sector has become a central player in advancing market-based systems as an alternative to traditional command-and-control regulations. In the United States, rules to reduce acid deposition relied on allocation and trading of SO_2 emission allowances. This has proven to be a highly successful, innovative approach that has harnessed the forces of markets to minimise costs of compliance without compromising – and often even enhancing – the integrity of environmental protection goals. The electric power sector's contributions to the development of market-based regulation will continue to prove useful in addressing emerging environmental issues.

No commercial technology is currently available to control mercury. However, mercury emissions can be reduced with some SO_x and NO_x controls on some types of coal.

Improving commercial availability of environmental controls (FGD, SCR, ESP) and clean coal technologies (IGCC, carbon capture/disposal) and discouraging use of older and less efficient power plants in developing countries will prove to be the biggest challenges of technology transfer for the electricity sector. Indeed, success will require more than the efforts of the electricity sector alone to address this challenge – the cooperation of other stakeholders will be necessary. Fostering this cooperation should be a key theme at the World Summit on Sustainable Development.

2.3.7 Electric Power and Social Development

Sustainable development offers the promise of reconciling economic growth, social development and environmental protection. Sustainability not only attempts to deliver economic growth and environmental protection simultaneously, but it also challenges norms of social equity among the nations and citizens of our common planet. The role of energy in sustainable development has been well recognised; this section will underscore the significance of electricity's contribution to social development.

Access to electricity transforms life from every point of view, including healthcare, industrial competitiveness, job creation, domestic comfort, pollution control and income growth. In these ways, electricity contributes greatly to social welfare. Many nations have come to recognise the right of access to this essential service for all citizens by establishing public monopolies, obliged to provide electricity and rooted in the principle of equality in treatment and rates.

This worthy goal, however, remains far from completion. Two billion people today do not have access to electricity, and persistent inequalities exist among those with access. Developing countries, home to over 75% of the world population, account for only 25% of world electricity consumption. Put another way, the 800 million inhabitants of the 25 richest countries have a per capita electricity consumption and production capacity 100 times greater than the 3 billion inhabitants of the 40 poorest countries.

Equal access to the benefits of electricity stands at the heart of sustainable development. For the rural poor, the best options may be those offered by off-grid, distributed renewable power systems. A growing number of niche applications, especially in rural electrification, could successfully rely on such technologies to provide electric power to currently unserved areas. A significant, coordinated global effort should be undertaken to foster the development of small-hydro power, biomass, wind, solar and geothermal to supply electricity to remote locations in developing countries.

For the world's growing mega-cities, the electricity mix will need to include large centralised power plants to match concentrated electricity demand in urban populations.

The electricity sector can contribute further to economic growth and technological progress through research and development. One of the critical issues in this context is that new technologies arrive within the next few decades where and when they are most needed in the fast-growing developing countries. The innovative, market-driven participation of the private sector will be crucial to this effort. One of the most promising initiatives today to link social development and private enterprise is the proposed Clean Development Mechanism (CDM) under the Kyoto Protocol (see box that follows). Given the longevity of power generation investments, emission reduction targets set by the Kyoto Protocol will most likely not be achieved by the electric power industry without flexible mechanisms.

The CDM – An Opportunity for Technology Transfer

Among the three flexibility mechanisms contained in the Kyoto Protocol, the Clean Development Mechanism (CDM) certainly is the most promising for promoting sustainable development. The CDM bridges the gap between those developed countries with firm commitments to control greenhouse gases (GHGs) and developing nations that do not yet have control obligations. The CDM is based on investment projects in developing countries, which can earn both the investor and host country Certified Emissions Reductions (CERs).

Through such projects, businesses have the opportunity to play the decisive role in enabling the mechanism. The CDM has the potential to generate high transnational transfers of capital and technology by 1) providing incentives for industrialised nations to undertake relatively inexpensive emissions reduction efforts abroad, thus reducing obligations for domestic reductions, and 2) providing incentives for developing nations to "leapfrog" to the most advanced and GHG-minimising technologies available today, thus avoiding potentially long-lived and environmentally-costly investments in GHG-intensive infrastructures. The reduced value of CERs in the first commitment period negotiated at COP 7, however, could limit the benefits of the CDM for sustainable development.

A particularly divisive issue is whether nuclear energy, a carbon-free source with few environmental side effects but also one burdened by concerns of accidental releases of radiation and proliferation of radioactive materials, should be allowed to earn CDM credits. This ongoing debate will not be solved easily. The e_7 believes any project that results in measurable GHG reductions as well as other environmental and social benefits should be eligible to be certified as a CDM project. Nuclear energy should be considered to earn CERs in the second commitment period.

3 Achieving Progress

The progress in the electricity sector towards sustainable development was described in Section 2. Section 3 describes frameworks and tools that have facilitated this progress, discusses remaining barriers and lays the foundation for a path towards future development.

3.1 Regulatory Frameworks

Throughout the last ten years, new regulatory frameworks have had a positive impact on the electric industry's practices towards sustainability. For example, required Environmental Impact Assessment (EIA) processes have become more demanding for new projects, thus resulting in environmental improvements.

Governmental institutions in many nations control consumer prices. Where prices to final consumers are lower than the marginal costs of additional generation, new development becomes very difficult. There are also many barriers that prevent increased energy efficiency including lack of awareness by customers of their actual use, and customers not receiving bills for electricity they have used. Incentives to use electricity wisely and reduce consumption often do not exist.

It is difficult to assess the impact that market liberalisation might have on sustainable energy development because widespread market transformation has not yet occurred. In a competitive market, appropriate institutional frameworks are needed to ensure that the market can support the protection of the environment.

In the last decade, the World Bank and other donor agencies have made financial assistance contingent upon a series of policy measures. These measures have pushed developing countries to restructure/deregulate and often privatise electric utilities in an effort to improve productivity and allow access to affordable electricity service to more people.

3.2 Tools and Measures Used by the Industry

This section outlines some of the major tools and measures used by electric utilities to achieve progress towards sustainable development goals.

3.2.1 Environmental Management

Life-Cycle Assessment of Electricity Generation Options

Over the last decade, the environmental performance of generation options has been more accurately assessed. Many companies have adopted life-cycle assessment (LCA) to evaluate options. The goal of life-cycle assessment is to provide a realistic picture of a project's impact by including all significant "upstream" and "downstream" activities. In the electricity sector, assessment normally considers fuel extraction, processing and transportation, power plant construction, electricity production, and waste disposal.

An LCA-based comparison of power generation options can be considered "generic," because it presents a general overview of environmental impacts that can normally be expected. A generic comparison can be useful for decision-makers for the following reasons:

- Policy decisions are often needed before site-specific information is available. A generic comparison can guide these decisions;
- Many debates on energy systems do not consider impacts of entire energy systems, thus neglecting activities such as extraction and processing of fuels; and
- LCAs can provide an indication of impact, which may require the most mitigation.

The assessment of generation options has improved by taking into account the reliability of each electricity generation option. For example, because wind does not always blow at sufficient speeds to generate electricity, wind power is best supplemented by storage technologies and/or mixed with other energy sources.

The generation option should be selected based on its potential for optimising direct uses and ancillary benefits from that generation source. Meanwhile, mitigation of potential negative impacts is now better understood, which can lead to impact reduction. For instance, a hydro project with a reservoir can be multi-purposed; the reservoir not only provides reliable supply and energy storage but also irrigation, drinking water and recreational use.

Environmental Management Systems

Over the last 10 years, environmental management of electric utilities has improved largely due to international standards for environmental management systems (EMS), similar to those for financial reporting. Many electric power utilities use the international standard ISO 14001 as a starting point to manage environmental performance. Standards for reporting environmental performance have also been adopted, including the Global Reporting Initiative, Dow Jones Sustainability Index, and emission-specific reports such as the World Resources Institute/ World Business Council on Sustainable Development Greenhouse Gas Reporting Protocol.

Various associations active in the electric industry advocate the establishment of EMS. For example, the Canadian Electricity Association is initiating the Environmental Commitment & Responsibility (ECR) Programme. The Union of the Electricity Industry has been established in Europe.

An EMS ensures that environmental issues are integrated into the operations of a company, taking into account the organisation's activities, products and services, and stakeholders' concerns. An EMS enables a company to comply with environmental laws, prevent pollution and continuously improve environmental performance. Environmental management systems are an efficient tool to make tangible contributions to sustainable development.

Environmental Impact Assessment

Beyond complying with mandatory legal requirements, the electricity industry must assume responsibility for conducting credible Environmental Impact Assessments (EIA). EIA is a tool used in all stages of power development, but mainly at the project level. EIA is a continuous process, including assessment starting at the policy level, through planning and building electric infrastructures, and monitoring environmental and social impacts of completed projects throughout its life span. The flow chart in Annex 5 presents the EIA process.

Applying Strategic Environmental Assessment (SEA) to public policies may improve project-specific EIA and licensing processes, if it incorporates fundamental interests of various stakeholders early in the process of developing policies. SEA is a systematic, ongoing process for evaluating, at the earliest appropriate stage of publicly accountable decision-making, the environmental quality and consequences of alternative visions and development intentions incorporated in policy, planning or programme initiatives. It ensures full integration or relevant biophysical, economic, social and political considerations. It helps to ensure that energy choices benefit society as a whole and that they take into account all development concerns, global environmental issues and rights of affected people.

Some important issues relating to SEA include:

- Public participation must be an integral part of an SEA to legitimise the decision making process. Public participation allows governments to make informed policy choices about energy production, ensures that citizens are aware of and can influence choices made, and creates greater certainty for the project's proponent; and

- A clear distinction must be made between a country's energy policy and the merits of a specific project. Once debates about a country's energy policy are resolved during the SEA process, project-specific EIA can focus on matters relating directly to that proposed project, avoiding needless issue reassessment such as its justification at the project level.

Despite its benefits, few countries have integrated an SEA process into their policy planning, and experience shows that energy policies established through SEA may not necessarily guarantee project acceptance.

In general, EIA processes focus more on potential adverse impacts and required remedial measures than on providing a balanced analysis of potential adverse impacts and potential benefits. Some have raised this question specifically in the case of developing countries by stating, for example, "It is high time that we ask ourselves if we have made a fair evaluation between improvement of poverty and backwardness on the one hand and the protection of our environment on the other." (Thanh and Tam 1992).

A key role of the EIA process is to weigh a project's potential adverse impacts against its potential benefits. It is essential that EIA address questions such as: What long-term benefits are likely to result from the project to offset its long-term environmental impacts? The considerations should be taken in a holistic perspective not limited to the present and near future conditions of the directly affected area, of a specific economic sector, or of a segment of the population. This requires delicate trade-offs and is a very complex task, and requires that all intervening parties be well represented in the process.

3.2.2 End-Use Energy Efficiency

Demand-side management (DSM), defined as the wise and efficient use of electricity by all classes of consumers, is useful towards meeting sustainable development goals. Where DSM is intensively employed, base load demand growth can be slowed, peak demand shaved and minimum loads raised. During the last decade, sector DSM initiatives have included improving industrial processes, electro-technologies, electric motors, lighting and gas and oil space heating. However, DSM's success is contingent upon strong financial incentives for end-users to change their habits and/or discard inefficient equipment. Also, there can be large differences in effectiveness of DSM, with only modest results when the price of electricity is very low.

Many public utilities and regulatory agencies in industrialised countries undertook DSM efforts during the last decade. These efforts were, however, all or partially abandoned after facing natural or structural constraints:

- Reducing consumption creates a revenue loss for distributors;
- Public Utilities Commissions must protect captive customers against severe rate hikes; they tend to moderate efforts in DSM that could induce or contribute to such hikes;
- A "rebound effect" of lower energy bills may lead to increased usage for an improvement in comfort. Another rebound effect: higher energy efficiency may bring more economic prosperity, thus inducing a growth in energy demand;
- Efficiency gains in space heating primarily originate from reducing heat losses, not in furnace technology. Also, efficiency gains in lighting and appliances are not obvious to consumers, as basic functions of lights and appliances have not changed;
- Manufacturers recognised the profitability of developing energy efficient products;
- Restructuring of the public utility sector also helped to prevent DSM efforts from succeeding during the last decade;
- Low electricity rates, relative to growth in average wealth, do not encourage customers to conserve energy;
- The introduction of price caps motivates the distributor to encourage demand growth as a way to enhance profits;
- Organising the electric industry into autonomous units of production, transmission, and distribution hinders integrated resource planning. It leaves the distributor with all of the expenditures associated with DSM programmes, along with revenue losses, but without any real avoided costs on the supply side; and
- Reducing consumption lowers revenues for distributors.

In the developing world and in emerging economies, more pressing issues have overshadowed concern for DSM. Attention has been focused on the reform or privatisation of state-owned companies often considered inefficient, on the reliability of supply, tracking of illegal connections, and availability of capital for production capacity. The management of a demand that is already relatively low captured little attention among those priorities.

At the same time, however, growth in demand was attenuated by increased use of electro-technologies by industrial and commercial customers and improvements in the energy efficiency of all kinds of appliances, construction code requirements and standards, and electric processes and motors. These improvements came from spontaneous or directed technological innovation such as R&D and reinforcement of the performance and manufacturing standards. The "carryover effects" that resulted often show results that are much more robust than those of DSM programmes initiated by public utilities. Other advantages include:

- Energy efficiency measures are insensitive to issues of restructuring the utility industry;
- They can be acted upon on a large scale by the imposition of standards of manufacturing, emissions or process; and
- Energy efficiency does not interfere, nor is redundant with, the use of economic instruments.

Strongly increased efforts in R&D and the promulgation of high performance standards, upstream and at a supranational level, appear more resilient than scattered DSM initiatives at the public utilities' level, notably in developing and emerging economies. To produce verifiable results, such upstream strategy needs monitoring and measuring standards, together with an economic instrument (e.g. subsidy for R&D, technology transfer, price signal).

3.2.3 Market Mechanisms

Market mechanisms for reducing pollution include a variety of economic incentives such as tax credits, emissions fees and emissions trading. The use of market mechanisms for addressing environmental objectives has shown them to achieve equal or better compliance while reducing costs and spurring technological innovation.

Experiences of the U.S., New Zealand and Europe show that harnessing competitive forces of the marketplace in favour of pollution reduction can enable governments, industries, and non-governmental organisations (NGOs) to reach political consensus regarding pollution limits. In particular, emissions trading programmes can deliver powerful incentives for sources to innovatively develop more environmentally effective and more cost-effective ways of reducing emissions in cases where a variety of cost-effective emissions control options exist.

In the U.S., partly in response to concerns about the high cost of environmental protection, regulation has evolved from command-and-control and technology mandates to market-based approaches. These approaches provide emitters with incentives to undertake a continuous search for better, cheaper, faster ways of reducing emissions. In the European Union, concerns about harmonisation have predominated, particularly for product standards. Voluntary agreements, pollution taxes and charges have been used in a number of European Union member states. Green certificate mechanisms to promote renewable energy have been adopted in many EU countries. The European commission is proposing a CO_2 emissions trading programme.

In most industrialised nations, the vast bulk of money spent resolving environmental problems comes from the private sector, or from government corporations operating in market conditions. Emissions trading programmes aim to ensure that when environmental expenditures are made, markets apply the forces of competition and innovation to reduce cost. Examples are as follows:

- The U.S. SO_2 programme has achieved broad environmental benefits from trading. Sources have met their targets faster, and at lower cost, than projected prior to the programme. The "savings" feature of the programme spurred emitters to initially reduce emissions 35% below required levels. Most of the decrease from projected compliance costs is attributable to the emissions trading programme. Further, there has been a strong market response to this stimulus for finding better, cheaper pathways to compliance.

- The 1987 "Montreal Protocol on Substances That Deplete The Ozone Layer" requires industrialised nations to phase out ozone-depleting chemicals, but does not mandate specific policies or measures to meet these obligations. Implementation of a trading programme greatly helped the United States to achieve and do better than its Montreal Protocol targets without major disruptions and with cost savings of up to 30%.

- New Zealand's programme for maintaining fish stocks at sustainable levels, The Fisheries Act 1996, established a Quota Management System (QMS) as the primary mechanism for managing commercial fisheries in New Zealand. Quotas are tradable property rights held by the commercial angler to fish for a particular species.

Based on several successes of market mechanisms in solving environmental challenges when they are appropriately applied, they should likewise be employed in meeting the goals of sustainable development.

3.2.4 Sector Guidelines

Electric companies have experienced growing public concern and opposition to proposed plans and decisions involving fuel choice, facility siting and mitigation of environmental and social impacts and tariffs, sometimes resulting in project cancellation. In order to meet growing public needs and high expectations for sustainable and reliable electricity services, while addressing various local, global and environmental concerns, companies must balance a variety of competing interests. Hence, the e7 developed the following industry guidelines and principles to frame its conduct in the rapidly changing context of globalisation, diversification and market restructuring:

Guidelines for Best Practices in the Electricity Sector

Based on the e7's 1994 Sustainable Energy Charter, the *Guidelines for Best Practices* in the electricity sector stresses the e7 members' commitment to provide support in developing countries and economies in transition on sustainable energy-related issues. The Guidelines are consistent with Agenda 21 of the World Summit on Sustainable Development (Annex 2).

Social Trust and the Electricity Industry

The e7 developed, with assistance from stakeholders, a set of 'social trust' principles that focus on essential aspects of the corporation-stakeholder relationship. (See www.e7.org/Pages/Pu-Papers.html) For the purpose of the electricity industry, social trust has been defined as: the quality of a relationship between a company and its stakeholders, where company policies, plans, procedures, actions, services and information meet the needs, expectations and concerns of all parties involved.

The following factors have been associated with social trust as essential components for interactions with stakeholders: competence, commitment, consistency, fairness, respect, caring and empathy. To each of these factors, a principle was devised according to four areas: corporate and general issues; facility planning, construction and operation; risk management; and customer relations.

In applying social trust policies, guidelines and best practices, electric power companies demonstrate that they place the highest priority on stakeholder needs and environmental protection.

3.2.5 Human Capacity Building

As outlined in Chapter 37 of Agenda 21, the ability of a country to follow sustainable development paths is determined to a large extent by the capacity of its people and its institutions and by its ecological and geographical conditions. A fundamental goal of capacity building is to enhance the ability of citizens to evaluate and address their own needs. Crucial questions are answered related to policy choices and modes of implementation among development options, based on an improved understanding of environmental potentials and limits. As a result, the need to strengthen national capacities is shared by all countries.

It is essential for individual countries to identify priorities and determine the means for building the capacity and capability to implement Agenda 21, taking into account energy, environmental and economic needs. Skills, knowledge and technical know-how at the individual and government levels are necessary for institution building, policy analysis and development management. Alternative courses of action, such as enhancing access to and transferring technology and promoting economic development, are also important.

Technical cooperation encompasses the whole range of activities to develop or strengthen individual and community-level capabilities supported by a nation's own development strategies and environmental priorities.

The e7's Network of Expertise for the Global Environment, the implementing arm for human capacity building activities, was created to provide pro-bono capacity building and technical assistance on electricity related issues to host countries. These e7 capacity building activities have succeeded in providing host country utilities and institutional entities with the skills, knowledge and training to meet their own sustainable energy development objectives while implementing sound environmental practices.

3.2.6 Research and Development

The electric sector has conducted significant R&D for developing new generation and distribution technologies, and improving existing technologies. Accomplishments at the generation level are as follows:

- Combined cycle gas turbine efficiencies have increased from 45% to about 58%;
- New coal-fired technologies have been developed, with much lower levels of air emissions;
- New combustion and scrubbing technologies have been developed to reduce emissions;
- Efficiency improvements have been installed on existing coal-fired generation;
- Wind turbine efficiency has been increased while cost per kW has been reduced;
- Small-scale nuclear reactors have been developed, and the reliability and use factor of existing plants have been increased;
- Improvements in size, mobility, and costs have brought fuel cells much closer to commercial deployment;
- Computer technology and telecommunications advances have resulted in efficiencies; and
- Improved maintenance and upgrades with additional equipment have increased the efficiency and output of existing hydroelectric installations.

There is great potential for technological improvements both in electricity generation and end use. In order to achieve sustainable development goals, it is imperative that research and development in these areas be increased.

Technology roadmaps for using nuclear, fossil and renewable fuels have been created to address sustainable development goals. Annex 7 contains a list of some web sites that provide fossil fuel roadmaps.

3.3 Conclusion

In the past decade, the following conditions have led to difficulties in achieving sustainable development in the electricity sector:

- The failure to use a life-cycle approach in evaluating new electricity projects has prevented, or unduly delayed and complicated, their completion;
- Regional system integration and planning has not been implemented in some cases, as a result of a country's desire to have an autonomous electric system. However, regional systems may provide optimal electrification solutions;
- Many DSM programmes have had limited success, because of information deficits or electric prices that are too low to make programmes attractive for final consumers;
- The use of market mechanisms to solve environmental issues has not been fully embraced; "command and control" approaches are still favoured by many stakeholders;
- Many low-carbon emitting electricity systems were not installed because they are more expensive than existing developments. These developments are often the backbone of local economies and therefore receive more government support;
- In many countries, the use of important zero-carbon emitting technologies, such as hydropower and nuclear energy, has been constrained because of environmental concerns;
- In the authorisation processes for new projects, regulations often delay the introduction of new improved technologies, indirectly favouring more traditional developments; and
- Governments have implemented a piecemeal approach to address power plant emissions by trying to control one pollutant at a time. An integrated "multi-pollutant approach" is needed to give clear indications as to what technologies will be needed in the future.

These issues show that the electricity industry alone cannot achieve sustainable energy development. This can only be achieved with support of governments and through multi-stakeholder involvement and improvements in institutional governance, including the regulatory and fiscal context. Future challenges and proposed solutions are discussed in Section 4.

4 Remaining Challenges and Goals to Overcome Them

4.1 Challenges Facing the Electricity Sector

The electricity sector is striving to provide an affordable, stable supply of electricity in an efficient and sustainable manner.

Despite substantial progress achieved to date, several important challenges must be addressed by the electricity sector in collaboration with governments and other stakeholders. The challenges fall into four categories: public policy, economics, markets and investments, and technology development.

Development cannot occur without electricity. It is a basic component of most industrial processes, many lifesaving technologies and basic quality of life enhancements. The electricity industry can satisfy an ever-expanding demand, provide cleaner power and strive to maintain low prices. It cannot, however, achieve all three objectives simultaneously in every market. Trade-offs have to be made. For example, there is constant conflict between cleaner, more expensive technologies, and cheaper, dirtier technologies. Experience also shows that electrification, especially in less densely populated areas, cannot be achieved on a purely commercial basis.

An approach must be devised to allow the global community to make the necessary trade-offs to ensure access to sustainable and affordable electricity for the world population. The success of the approach will be measured in terms of the availability, accessibility and affordability of electricity.

4.1.1 Availability

Until now, one could say that electricity development was closely linked to local availability of cheap sources of energy (e.g., water, coal, gas, oil). Where those sources are not available, people may use firewood or dung as home fuel sources, creating local air pollution and deforestation/desertification problems.

All forms of energy should therefore be considered to achieve mass availability. Each regional community must decide what fuel source is to be used. There should not be 'bad' energy, only 'bad' uses of energy. From a sustainable development point of view, having **no electricity** is the worst-case scenario.

Solar, wind and geothermal technologies remain relatively high priced. Moreover, the first two technologies alone cannot provide sufficient electricity to meet demand and must be coupled with storage facilities and/or other means of electricity generation.

To address climate change without compromising the goal of expanding economic growth and access to electricity, it is imperative that market penetration of low-carbon emitting energy systems and zero-carbon emitting technologies occurs. Low-carbon emitting energy systems include existing efficient gas combined cycle, and new advanced fossil fuel generation technologies such as coal gasification, fuel cells and biomass. Zero-carbon emitting technologies include wind, nuclear, geothermal, hydro and solar as well as future fossil fuel plants that capture and permanently dispose of carbon emissions in geologic formations.

Global demand for electricity will increase, even if technologies, markets and public policies are able to reduce demand in developed countries. With focused initiatives, demand in developing countries can be met with low- and zero-carbon emitting technologies.

4.1.2 Accessibility

Since sustainable development was initially addressed at the Rio Earth Summit, there has been no significant progress in accessibility. Because electricity is a prerequisite for economic development in general, and sustainable development in particular, the world community should consider making electricity accessibility for all human beings a top priority.

All forms of energy should be considered. Without electricity, there is no development, which means no improvement in standards of living, no access to modern health services, and no access to the Internet and other telecommunication technologies.

4.1.3 Affordability

In any market, price level and price predictability are key factors of stability. High prices usually yield lower levels of consumption when consumers are not able to pay. Throughout the world, access to electricity is strongly linked to market price. Experience with many types of markets has shown that certain market structures are more efficient than others for making electricity more accessible to consumers. At the same time, some types of structures could lead to a level of electricity consumption that is environmentally unsustainable.

Stakeholders focused on providing energy access need to determine the most appropriate market frameworks to eventually make electricity affordable to all citizens, to recognise the benefits competition creates and to develop an institutional framework that allows market forces to support sustainable development.

No market structure is intrinsically better than the others in as much as it strives to reconcile the objective of maximum affordability with the imperatives of sustainable development.

4.2 Public/Private Partnerships to Address Sustainability Challenges in the Electricity Sector

Given the importance of the electrification challenges the sector faces, cooperation with stakeholders is vital. The sector should reach out to all of these stakeholders, explain the need for focused, coordinated initiatives, and ask stakeholders to participate. Governments, financial and development institutions, technology developers and other non-governmental organisations are key stakeholders. The e7 has identified two areas in which cooperation among the different groups can be particularly helpful:

1. Development of an appropriate regulatory framework to attract needed foreign investment in the electricity sector; and

2. Development of an efficient and sufficiently large transmission network to pool demand and supply in most regions of the world. In less densely populated areas, distributed generation solutions should be promoted. A mix of distributed and centralised electricity generation is important for sustainable development. Both are briefly discussed below.

Design a Regulatory Framework to Attract Foreign Investment

Market forces within a well-designed framework can bring about a reduction of costs. These forces are critical to meeting the challenge of sustainable development.

Sustainable development means development that lasts. For example, purely short-term financial considerations tend to put an important premium on small-size and low-capital cost generation technologies, but generation technologies requiring a longer-term return on investment (e.g., hydro, nuclear, clean coal) should not be precluded.

Among the most prominent issues associated with providing electricity are public acceptance, market dominance, necessary co-ordination with the transmission systems, long lead times between the price signal and the required investment, and optimisation of fuel and technology mix from a global environmental point of view.

An institutional framework is needed at the appropriate level (regionally or globally) to:

- Guide market forces by providing them with a stable legal and regulatory environment, which avoids uncertainties and fosters private investments;
- Promote construction of renewable plants (which would include wind, solar, hydro, biomass and geothermal) with tax credits;
- Foster regional cooperation to build and integrate transmission networks for cross-border electricity exchange;
- Foster regional cooperation to plan the use of resources, taking into account cross-boundary impacts of power generation facilities and to ensure standards of operational safety (including management procedures for installations with potential cross-border environmental impacts); and
- Identify pathways for development and deployment of advanced generating technologies that use natural gas, coal, and nuclear fuels, and advanced storage technologies. Encourage the pathways to be followed.

Integration of Electric Power Systems

The development of electric power systems is an essential component of a country's sustainable development. The state of development of electric power systems is often considered to be an indicator of a country's overall development. In developing countries around the world, this varies widely; nonetheless, several countries share some specific features that are important when considering the opportunity and feasibility of furthering the development of regional electric power systems and, hence, the countries' overall development:

- A high actual or potential growth rate of consumption of electric power;
- Significant unexploited hydroelectric resources;
- Complementary forms of primary energy; and
- A lack of national financial resources to develop the electric power system.

Furthermore, given that many electric utilities in developing countries are state-owned monopolies, they have been assigned ambitious electrification objectives, particularly for rural areas. Considering that many customers are subsidised by national governments through lower rates, however, electric utilities in developing countries are faced with deteriorating financial performances due to their inability to fully recover costs they incur. In turn, this impedes their investment capacity and their efforts to provide the population with access to electricity services.

To address these issues, among others, most developing countries, encouraged by leading international organisations, are presently reforming their electric power systems and moving towards liberalisation and the introduction of private independent electricity generators. These reforms, as several developing countries are currently experiencing, can be optimised through sharing resources, from engineering expertise to electricity generation capacity, on a regional basis. Sharing resources further offers unique, value-added advantages:

- Allows optimum use of available resources;
- Enhances environmental protection efforts;
- Facilitates a sustainable development approach;
- Reduces the cost of electricity services to customers;
- Increases the ability to meet potential customers demand; and
- Constitutes a lever for the country's economic development.

The actual implementation of such resource pooling is made possible by the interconnection of electric power systems. Interconnecting isolated electric power systems also offers unique, value-added advantages by:

- Allowing shared power generation sources throughout a larger area;
- Bringing forth new revenue opportunities; and
- Reducing risks of power shortages.

The 18th World Energy Congress has affirmed these benefits of regional integration following its October 2001 meeting:

"Market reform including trade and regional integration: Experience with energy market reform in most countries has been beneficial in terms of energy acceptability and availability. Because conditions in developed and developing countries vary in terms of the use of energy subsidies, their political structure, or their resource base, each country needs to foster reforms consistent with its own structure and conditions; however, in all regions there is a need to accelerate energy trade and regional integration. Energy projects need to be planned on the basis of what makes economic sense for the region without undue regard to political boundaries. It is market reform and impartial regulation, which are the cornerstones for attracting private capital to specific energy projects. The elimination of producer subsidies is important, but well targeted consumer subsidies could be justified, on a temporary basis, to address accessibility and affordability issues related to market reform. Energy consumers in every country should support reforms which improve customer choice, the quality of service, and affordable energy services."

The interconnection of electric power systems, however, may likely bring forth new constraints in planning, and increase the complexity of operations. The development of regional electricity cooperation and integration (RECI), through the implementation of a RECI organisation on a regional (bi- or multinational) basis, will help circumvent these difficulties and will be instrumental in fulfilling the necessary conditions for the pooling of resources and the interconnection of electric power systems. Regional electricity cooperation and integration involves:

- Partnerships among electric utilities;
- Coordinated implementation of interconnections;

- Harmonised regional design and operation criteria;
- Coordinated operation of electric power systems; and, in the long term,
- A regional approach to resource planning.

Above and beyond the physical pooling of resources and interconnection of electric power systems, regional electricity cooperation and integration is expected to yield:

- Significant social, economic and environmental benefits;
- More reliable and stable electric power systems;
- An extended market; and
- Important new business opportunities.

Following two years of collaboration with developing country utilities and international organisations, the e7's Regional Electricity Cooperation and Integration (RECI) Working Group developed the e7 Guidelines for the Pooling of Resources and the Interconnection of Electric Power Systems. The document has proven to be very valuable for electric utilities interested in regional interconnection, particularly in Southeast Asia, Latin America and Southern Africa. More information on the RECI concept, the e7 RECI Working Group, and the e7 RECI Guidelines is located on the e7 web site at www.e7.org/Pages/A-WG-RECI.html.

4.3 Two Goals for the Electricity Sector

The electricity sector stands ready to play its part in addressing the remaining challenges in the pursuit of sustainable energy development.

The sector supports relevant sustainable development initiatives identified for the World Summit by the United Nations Commission on Sustainable Development:

- "Sustainable consumption and production: [The Summit should support] measures to encourage sustainable production and consumption, particularly increasing energy efficiency. [An objective should be] to decouple economic growth from pressures on the environment or natural resource base.
- Energy: The Summit should deliver a deal that promotes global access to energy. [It should include] special initiatives for promoting renewable and affordable energy.
- Transfer of technology and capacity building: The Summit should foster the establishment of effective means of facilitating the transfer of technology and measures to promote capacity building."

As early as 1992, the e7 Chairmen underscored the urgency to encourage implementation of the main principles of sustainable development in the field of energy. The e7 has served in a leadership role in the sector's sustainable development activities as it has shared its expertise with partners in many countries. The e7 looks forward to joining forces with stakeholders and other electric companies to achieve the sustainable development goals described below.

Goal 1
Electric companies should implement 'Best Practices' to guide their operations

The e7 has adopted guidelines based on principles endorsed by policymakers at the Rio Earth Summit to enhance sustainable development. Here the guidelines have been customised for international stakeholders in the electric power system of developing countries to take action:

- Work to create long-term sustainable energy strategies to promote a quality environment and improve the standard of living;
- Practice environmental, energy and economic efficiency to create the most value with the least amount of resources and environmental impact;

- Work to increase the capacity of people and institutions to follow a sustainable development path, in part through training and enhancement of skills, including expertise in environmental issues management. Promote use of local manufacturing services in developing countries and countries with transitioning economies;

- Recognising each nation's right to develop its own resources, recommend use of cost-effective advanced and proven technologies and the transfer of expertise, taking into account natural resources, economic and social conditions, education and available skill levels;

- Work in partnership with governments and non-governmental organisations to ensure successful projects, especially by helping to define institutional frameworks appropriate for local social, economic and cultural conditions;

- Work to minimise public and employee health and safety risks associated with electricity providers' activities; and

- Recognise the importance of and encourage stakeholder consultation.

Equipped with these principles, the electricity industry is prepared to work with stakeholders to provide more people with access to electricity.

Goal 2
Electric companies should share their expertise in partnership with governments and non-governmental organisations, financial and development institutions, and technology providers from around the world to help focus their sustainable development activities on expanding access to electricity for all people.

Given the importance and complexity of the electrification challenges that the sector faces, cooperation with all stakeholders is vital. Therefore, the electricity industry should make every effort to reach out to all stakeholders, explain the need for focussed and coordinated initiatives, and seek their participation.

Governments have the authority to establish policy priorities, legal structures, and governance systems necessary for electrification. Development of an appropriate regulatory framework is absolutely essential to attract the foreign investment needed to expand electrification. Investments could create an efficient and large enough transmission network to pool demand and supply in most regions of the world. In less densely populated rural areas, distributed generation solutions would be implemented.

Key to expanding access to electricity is the right and intention of nations to use their indigenous energy resources, including fossil fuels. By capitalising upon regional initiatives for economic integration and fostering the deployment of new energy technologies, the electricity sector can help to optimise the use of these resources, increase economic development, and protect the environment. For sustainable deployment, it is essential that the most efficient technologies are employed for each fuel. This will not happen without the appropriate framework conditions. The electricity industry needs to contribute its technical expertise and experience to the development of public policies related to electricity and advocate strong legal structures to support financial investment.

The financial world plays a key role in leveraging the capital resources necessary for large-scale investments typically associated with electrification. Through cooperative partnerships, the electricity sector can work with banks, funding agencies and other investors to develop innovative financing mechanisms to reduce investment risks that have so far proven prohibitive and support the goal of expanding access to electricity.

Technology developers have access to options for energy conversion that can provide fuel flexibility and pollution control, and lead to efficient use of resources. The electricity sector must work with developers to:

- Upgrade the electric power systems currently in operation around the world;
- Introduce sustainable electric technologies to currently unconnected or underpowered areas; and
- Allocate and focus adequate resources for research and development to accelerate timelines for the commercial use of new technologies.

Finally, representatives from non-governmental organisations can provide knowledge of local needs related to electrification and sustainable development.

The e7 has identified four priorities that could form the basis for a strategy that leads to greater access to affordable, reliable, and environmentally sound electricity (Annex 3).

This report has described the contributions of the electricity sector to sustainable development and many remaining challenges. The e7 encourages the electricity sector and its stakeholders to join forces in working to address these challenges.

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Annex 1

e_7 Sustainable Energy Development Portfolio

Areas	Technologies/Programmes	e_7 Activity/Role
Power Systems	• Advanced environmentally-benign combustion • Improved thermal efficiency • Nuclear generation • Hydro • Other renewables (e.g., geothermal, wind, solar, biomass) • Resource diversity and balancing • Loss reduction in transmission and distribution • Integrated electrical system operation	• Sharing/transferring: – Experiences with advanced generation technologies (including renewables) and standardised units – Best operation and maintenance practices for generation plants and emission abatement – Advanced technologies for controlling losses – Integrated resource planning (IRP) techniques – Analysis techniques • Maintaining/regaining public acceptance of nuclear energy • Advising on: – System engineering – Management of fuel costs • Training of operators and engineers
Customer Energy Efficiency Services	• Energy Conservation – Building design (envelope and technological services) – Appliance specifications • Efficient end-use systems (e.g., air conditioning, refrigeration) • Load and other demand side management (DSM) • Pricing	• Sharing/transferring: – Design of utility infrastructure to promote energy efficiency – Experience of lessons learned (e.g., energy conservation, load management programmes, tariff levels and structures) – Customer information programmes and design of related centres
Environment	• Greenhouse gases (GHG) mitigation • Flue gas pollutants reduction • Use of clean fuels • Waste streams and recycling • Electromagnetic field (EMF)	• Development of knowledge/ database of experience • Training of utility/government personnel in practices and techniques • Sharing/transferring programmes for: – Integrated waste management – Controlling/reducing emissions • EMS, Audits, Training Programmes, etc.
Electro-technologies	• Lighting, microwave, infrared and ultraviolet • Heat pumps • Advanced motors • Electric vehicles (EV)	• Promoting new electrotechnologies • Advising on use and advantages of electrotechnologies • Support EV development
Energy and Infrastructures	• Dispersed generation (e.g., photovoltaic, fuel cells) • Energy storage • Controls and communications	• Demonstration projects • Increase market size to reduce costs • Sharing/transferring advanced technologies • Support infrastructure technologies

Annex 2

e7 Proposal for International Guidelines (for Best Practices) Promoting Sustainable Development in the Global Electricity Industry

Introduction

There is a close link between electricity and development, and the enormous needs still to be met in developing countries in the years and decades to come. Even at the beginning of the 21st century, two billion people in less advanced countries are still deprived of electricity and yet aspire to the norms of the developed countries. Clearly, such aspirations would rapidly accelerate the exhaustion of global resources unless a paradigm shift related to those norms occurs. As such, it is important that the future growth and development of the electricity sector occurs in a manner consistent with sustainable development.[1]

The e7 recognises that the electricity business is becoming an international marketplace and the creation of an infrastructure that produces a sustainable, affordable and reliable supply of electricity is fundamental to all for the development and well being of the population of all nations, and in the interest of the global community in general. As a result, the group encourages the use of a consistent framework by all players in the international electricity market place (electric utilities, independent power producers, energy services companies, manufacturers, etc.). The e7 also encourages the use of such a framework by international institutions (financing institutions, trade organisations, universities and other academic and research institutions, etc.) and host countries to evaluate proposals for international electricity sector activities with respect to sustainable energy development (SED).[2]

In 1994, the e7 developed a Sustainable Energy Charter that established a set of principles to provide the framework to govern the operation of the e7 members. The Charter stresses the global commitment of the e7 members to provide support in developing countries and economies in transition, and for electric projects and other activities (human capacity building, etc.) that are consistent with the principles of sustainable development. This Charter is consistent with the Rio Declaration on Environment and Development.

Using its Sustainable Energy Charter as the base, the e7 has developed a set of guidelines for international activities in the electricity sector. It is the e7's hope that these proposed guidelines serve as a basis for an international framework to ensure that electricity development in the context of internationalisation will be sustainable.

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[1] The e7 subscribes to the definition of sustainable development resulting from the World Commission on Environment and Development in 1987, as: "…development that meets the needs and aspirations of the present generation without compromising the ability of future generations to meet their own needs."

[2] In the context of the energy sector, sustainable development means: making the best end-use of energy resources, maximising the use of renewable energy resources, maximising efficiency in the generation, transmission, distribution and use of electricity, minimising environmental impacts associated with energy production and use, promoting creative solutions that provide win-win benefits for the environment, the economy and the society.

Principle 1

Work to create long-term sustainable energy strategies that promote a quality environment and improve the standard of living.

1st Guideline

Use the principles of SED when developing plans, projects, programmes and activities.

Potential Activities:

- Apply standardised and internationally recognised environment assessment techniques (e.g., Environmental Impact Assessment, Strategic Environmental Assessment, etc.);
- Support host country environmental programmes and encourage integration of SED considerations appropriate to the host country's unique local circumstances or reconsider conditions of participation;
- To the extent possible, identify and evaluate the direct and indirect life cycle impacts (economic, social, and environmental) of proposed projects;
- Develop balanced targets and action plans that take into account national energy needs, differing SED priorities, cultural, economic and technical factors in planning, proposal and project implementation phases;
- Determine the extent to which SED is supported in proposals;
- Integrate the results of SED assessments (environmental, social and economic analysis) into the proposal and project decision-making processes and describe how SED was addressed;
- Develop projects that apply these SED considerations; and
- For investors, develop and continually improve corporate policies for conducting business in a manner consistent with the principles of sustainable development and apply these policies to all international activities.

2nd Guideline

Advocate regional approaches to energy development where they produce better overall outcomes than individual projects, while respecting the right of individual countries to develop their own resources.

Potential Activities:

- Take into account the positions of regional planning organisations in project proposal, planning and development;
- Where feasible, identify optimal solutions under a regional approach prior to developing and assessing individual projects (e.g., watershed development, integrated resource planning);
- Propose to advise countries or regions in developing capacity planning strategies, especially concerning consumption patterns and local distribution.
- Propose to assist countries to develop transmission strategies to optimise use of resources; and
- Facilitate the development of regional facilities and infrastructures that could support the capacity of the region to sustain regional initiatives.

Principle 2

Practice environmental, energy and economic efficiency, which create the most value with the least resources and the least amount of environmental impact.

1st Guideline

Develop assessment and integration tools that foster SED practices.

Potential Activities:

- Favour broad stakeholder participation in planning and decision-making (such as integrated resource planning, multi-criteria assessment including public participation, etc.);

- Promote projects that reduce environmental impacts while maintaining or enhancing competitiveness;
- In project proposals, include component for monitoring of sustainable development considerations, using measurable indicators;
- Promote the development and implementation of realistic energy pricing practices; and
- Where feasible, advise on the identification and removal of tax and subsidy policies that may impede SED practices.

2nd Guideline

Implement supply-side options consistent with the principles of SED.

Potential Activities:

- Gain a better knowledge of, and when appropriate use analytical tools, such as life-cycle analysis, externalities assessment, etc., to develop the best information upon which to base decisions regarding options that achieve the same purpose;
- Consider local development needs, culture and resource and technology base of project host in order to assess feasibility for renewable technology based projects;
- Support development of comprehensive plans (short, medium and long-term) that assess all options prior to developing individual projects;
- Support research and development as well as local piloting of new technologies that are more efficient, create less environmental impact, use renewable fuels, etc.; and
- Support the development of a local resource and skills base to apply and sustain supply-side options that support the principles of SED.

3rd Guideline

Where feasible, implement demand-side management initiatives consistent with the principles of SED.

Potential Activities:

- Identify potential energy efficiency improvements anticipated from projects;
- Cooperate and dialogue with plant and building designers and equipment manufacturers in order to include utility experience in technology and plant design;
- Provide advice to end use consumers on energy efficiency; and
- Demonstrate economic returns obtainable from energy efficiency programmes in domestic, commercial and industrial sectors.

4th Guideline

Foster innovative financing options that maximise the opportunity for energy efficient and renewable projects to come to fruition.

Potential Activities:

- Consider use of green investment funds to test and market the best SED ideas;
- Consider the option of loans for energy efficient and renewable energy projects;
- Build partnerships that enhance financing of projects, including utilisation of public funds, where available, (e.g., government, international financing institutions, etc.) to improve economic viability of such projects;
- Where applicable, use market instruments, such as emissions trading, joint implementation approaches or incentives for renewable and energy efficiency programmes, green pricing, etc.; and
- Identify other innovative financing mechanisms to encourage uptake of efficient technologies.

Principle 3

Work to increase the capacity of people and institutions to follow a sustainable development path in part through training and enhancement of skills, including expertise in the management of environmental issues. In developing and Eastern European countries, also promote the use of local manufacturing and services.

1st Guideline

Inform stakeholders to increase their awareness of the environmental impacts of choices and actions.

Potential Activities:

- Develop customer-focussed energy efficiency programmes;
- Work with local governmental and community organisations to provide a framework to increase understanding of environmental impacts by the local community;
- Support forums for communication and dialogue among the various local and regional players;
- Develop tools to communicate benefits and opportunities for sustainable energy use; and
- Develop the means of communicating total impacts of an activity or action on a community. In particular, look at local, regional and global benefits of electricity utilisation and electrification programmes.

2nd Guideline

Identify and employ appropriate training, capacity building and transfer of knowledge to enhance the capability of energy providers to apply the best SED practices.

Potential Activities:

- Train, encourage and empower people to conduct their activities in an environmentally responsible and sustainable manner by including a component for human capacity building into project packages (e.g., software and training packages to develop capacity, workshops on operational and management practices, decision and analysis tools available and methods to undertake them, etc.);
- Consider cultural factors in capacity building and adapt programmes accordingly;
- Strengthen institutional capabilities of project host to conduct SED analysis;
- Implement pilot projects using local resources (manufacturers and providers) and skills, where feasible;
- Strengthen the infrastructure, institutional and skills base to operate, maintain and sustain project(s) after implementation; and
- Recognise the need to monitor the capacity to sustain a project and the need to apply remedial measures for further developing the skills base should it be required.

Principle 4

Recognising each nation's right to develop its own resources, recommend the use of modern and proven technologies (including renewables, where cost-effective) as well as expertise, taking into account the natural resources, economic and social conditions, and education and skills levels available.

1st Guideline

Implement technologies, including new promising technologies that are efficient and appropriate to the local resources, conditions, and capabilities. Implement those technologies that also lead to an improvement in the overall environmental quality of the project, that are acceptable to the host country, and that correspond to the objectives of developing countries in general.

Potential Activities:

- Pursue the most appropriate technical standards (e.g., ISO or other standards) taking into account local conditions and development objectives;
- Where possible, make use of local resources;
- Transfer knowledge that is consistent with the needs and situation of the host country, and the environmental gains to be made at both local and global level through the choice of the most appropriate technology options possible to meet the requirements;
- In project proposals, describe how local and regional concerns are addressed and mitigated;
- Propose research and development, including pilot projects, to adapt proven technologies to local conditions by developing alliances with academic, corporate and governmental research bodies;
- Identify opportunities to further advance promising, new energy efficient and renewable technologies and projects through the formation of effective partnership arrangements; and
- Evaluate the potential for integration of technologies with the indigenous technology base.

Principle 5

Work in partnership with governments and governmental and non-governmental organisations to ensure successful projects, especially by helping to define the institutional frameworks appropriate to local social, economic and cultural conditions.

1st Guideline

Develop partnerships with key players to promote appropriate institutional and organisational arrangements.

Potential Activities:

- When developing and implementing projects, work in partnership with stakeholders to promote business decisions and practices that will move towards sustainable development;
- Where possible, contribute to the development of public policy that promotes sustainable development through business, government, non-government and educational initiatives;
- Develop information exchange programmes with key local players; and
- Identify and recognise the local skills base and strengths in creating mutually beneficial partnerships.

2nd Guideline

Develop partnerships with key players to execute local long-term sustainable energy strategies that especially include the development of necessary infrastructures (e.g., electricity networks, rural electrification).

Potential Activities:

- Liase with funding partners, government agencies and local utilities in addressing long-term planning.

3rd Guideline

Where possible, undertake joint actions to reduce greenhouse gas emissions in the long-term development of the electricity market (such as Kyoto Protocol mechanisms).

Potential Activities:

- Participate in developing appropriate, fair and equitable mechanisms to foster reductions in global greenhouse gas emissions;
- Where applicable, use market mechanisms, such as activities implemented jointly, emissions trading and other voluntary approaches (e.g., Clean Development Mechanism) in projects; and
- Ensure that local capacity exists to manage the above-mentioned mechanisms and consider all components of the trade prior to implementation.

Principle 6

Work to minimise public and employee health and safety risks associated with activities.

1st Guideline

Adopt a precautionary approach to decision making, taking into account the increasing availability of information and level of knowledge.

Potential Activities:

- Take all economically acceptable measures to minimise potential unfavourable public health and safety impacts in each activity;
- Where potential significant hazards exist, develop and maintain emergency preparedness plans in conjunction with local authorities/services; and
- Promote continued research and development to increase the understanding and knowledge of issues where scientific uncertainty still exists.

2nd Guideline

Minimise unfavourable impacts on worker health and safety.

Potential Activities:

- Develop on-site worker safety programmes;
- Provide training focussing on operating procedures; and
- Continually improve on the standards and measurement of worker and public safety.

3rd Guideline

Where required, aid in the development of appropriate institutional structures to facilitate the inspection and/or audit of facilities for safety requirements.

Potential Activities:

- Include component in project package focussing on development of appropriate institutional structures, where applicable.

Annex 3

Priorities for Stakeholders to Expand Access to Electricity for all People

Objectives

- To bring electricity in a sustainable manner to the two billion people who do not yet have access to it, in order to meet their basic needs and alleviate poverty;

- To help expand access to affordable electricity for all residential, commercial and industrial users in developing countries to accelerate economic growth and social development with increased protection for local, regional and global environments; and

- To foster the development and global market deployment of existing and new low-carbon emitting energy systems and zero-carbon emitting technologies. Low-carbon emitting energy systems will consist of existing efficient gas combined cycle, new advanced fossil fuel generation technologies such as coal gasification, fuel cells, and bio-mass. Zero-carbon emitting technologies include wind, nuclear, geothermal, hydro and solar as well as future fossil fuel plants that capture and permanently dispose of carbon emissions in geologic formations.

Role of Stakeholders

Stakeholders include governments, financial and development institutions, technology developers and other non-governmental organisations.

- Reduce investment risks and costs by adopting appropriate institutional frameworks;

- Provide funding to boost additional investment needed for electrification in areas where it cannot be done on a commercial basis; and

- Transfer technologies, best practices, and human capacity building for management and local institutional frameworks.

Immediate Discussion Topics

1. Institutional Frameworks

A multi-level institutional framework could be necessary to ensure that objectives are implemented cost-effectively, and that appropriate governance structures are in place in all regional/local markets.

2. Funding Mechanisms

- A mechanism is necessary to ensure appropriate funding levels for investments and for Human Capability Building (HCB) to provide electricity to the most impoverished areas of the world that are not currently connected. Renewable energy generation would likely be able to satisfy these basic needs. Approximately $250 billion (U.S.) is the estimated cost of providing renewable energy to 1 billion people by 2010, according to the G-8 Task Force on Renewable Energy (2001);

- In addition, HCB would be required for sustainable economic development. This would also include investment in new generation, transmission networks in Regional Electricity Cooperation and Integration (RECI) areas, distribution infrastructure, and for both connected and off-grid areas; and

- A mechanism is needed to foster global penetration of the most efficient existing electric technologies both for generation and end-use equipment, coupled with HCB projects in developing countries, thus ensuring long-term sustainability through local expertise.

3. Sector Practices

The electricity sector would be urged to adopt *Guidelines for Best Practices* consistent with the objectives of sustainable energy development.

4. Political Momentum

Political momentum could come from national governments that would collectively agree, by way of a cooperative agreement or binding document, to put in place necessary measures to facilitate plans for implementation, in accordance with national priorities and circumstances.

Annex 4

Monitoring Progress: Agency Data Sources, e_7 Member Web Sites and Illustrative Graphs

The electricity sector has been and continues to be an intensely monitored industry. An extensive database exists, and is maintained and analysed by environmental, energy and development agencies as well as trade associations, individual companies and non-governmental organisations.

Agency Data Sources

Rather than duplicating readily available data, the reader is invited to review data from these and other agencies:

- Electric Power Research Institute
- International Energy Agency
- Oak Ridge National Laboratory
- United Nations Development Programme
- United Nations Environment Programme
- U.S. Department of Energy – Energy Information Administration
- World Bank

e_7 Member Web Sites

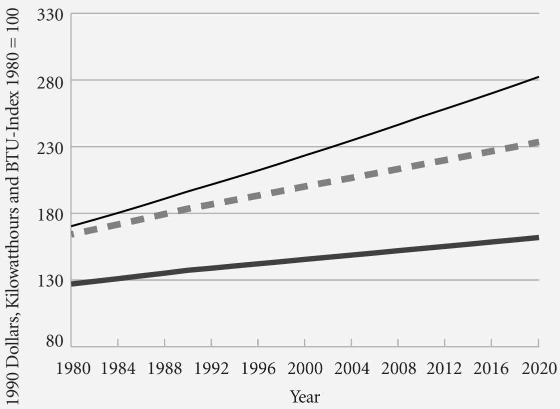
Many companies describe their environmental performance on their web sites. For example, here are the Internet sites for the e_7 members.

- American Electric Power: www.aep.com
- Electricité de France: www.edf.fr
- Enel: www.enel.it
- Hydro-Quebec: www.hydro.qc.ca
- Kansai Electric Power Company: www.kepco.co.jp
- Ontario Power Generation: www.opg.com
- RWE: www.rwe.com
- ScottishPower: www.scottishpower.com
- Tokyo Electric Power Company: www.tepco.co.jp

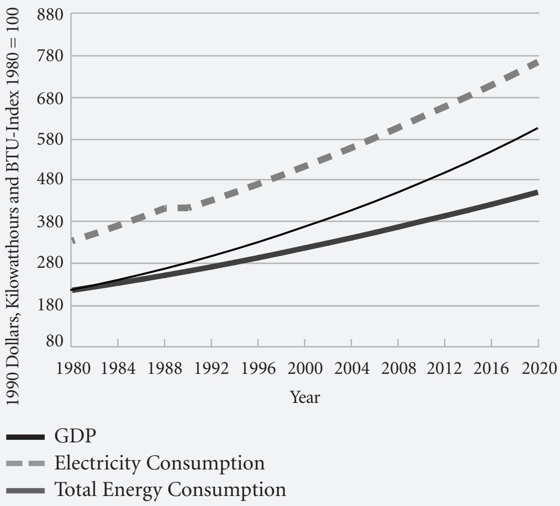
Illustrative Graphs

The e_7 analysed monitoring data from agencies to prepare Sections 2 and 3 of this report. Here is a sample of the data used.

OECD Countries GDP, Electricity Consumption and Total Energy Consumption



Non-OECD Countries GDP, Electricity Consumption and Total Energy Consumption



Source: U.S. DOE/EIA

Annex 5

Power Project Development and Environmental Impact Assessment Tools

	Policy	Tools	Type of impact
Background	National strategies for sustainable development	Strategic environmental assessment	Transboundary + cumulative impacts (for example: green house gas emissions, acid rain, degradation of biodiversity, deforestation, depletion of the ozone layer, climate change, nuclear waste disposal, etc.)
Background	Energy and Resource Planning	Sectoral environmental assessment	Cumulative impacts
Project Phases	Project Phases	Environmental impact studies (EIA on the project level)	Impact avoiding
Project Phases	Planning Phase Inventory Study	Regional environmental assessment	Cumulative impacts
Project Phases	Prefeasibility Study – selecting individual projects for study	Preliminary EIA study (Compare alternatives – Screening)	Potential impacts
Project Phases	Feasibility Study – study of one project	EIA study (Compare alternatives, scoping, impact significance, trade-off between benefits and costs) – Elaboration of an environmental management plan including guidelines for a contingency plan	Anticipated impacts
Project Phases		**Do you continue with the project?**	**NO → END**
Project Phases		**YES**	
Project Phases	Implementation Phase Detailed Design/Engineering	– Consideration of environmental sound design criteria – Integration of appropriate mitigation and compensation measures identified by the EIA study – Compliance audit	Impact minimizing
Project Phases	Tendering and Contracting	– Choice of environmentally trained contractors (ex. ISO 14001 certified companies)	None
Project Phases	Construction	– Site monitoring – Contingency plans	Temporary impacts
Project Phases	Operation Phase	– Integrated resource management plan – Environmental Management System (including monitoring and auditing procedures) – Follow-up studies and contingency plans	Real impacts
Project Phases	Refurbishment/Modernization/ Uprating/Relicensing Phase	– EIA study according to the magnitude of the project – Site monitoring during the work	Residual impacts
Project Phases	Decommissioning Phase	– EIA study to determine degree of renaturalization – Site-monitoring during the works – Regular inspections after abandonment of the site	Residual impacts
		END	

Annex 6

e7 Examples of Projects and Human Capacity Building

The e7 companies have shown that the *Guidelines* are workable through more than 30 projects ranging from installing renewable energy hardware to providing human capacity building on electricity related issues (Section 3.2.).

The e7's Network of Expertise for the Global Environment, the implementing arm for human capacity building activities, was created to provide pro-bono capacity building and technical assistance on electricity related issues to host countries.

To implement projects, the e7 created the e7 Fund for Sustainable Energy Development. This fund, a UN accredited NGO, provides a financial instrument from which the e7 companies can contribute to sustainable energy development projects. Other financial institutions also bring direct financial support to promote principles of sustainable development and contribute to the economic welfare of beneficiary communities.

This Fund also allows the e7 to participate in global forums, such as the Conference of the Parties to the United Nations Framework Convention on Climate Change.

The e7 Fund offers a new financial model for investing in small sustainable development projects under $30 million. In the future it will foster investment in projects certified under the Clean Development Mechanism of the Kyoto Protocol.

Examples of e7 projects and human capacity building activities are:

- In Bolivia, the e7 is conducting a feasibility study for a mini-hydro facility to provide electricity to a local area with the potential to export surplus production to the surrounding region;
- In the W Park region of Western Africa (within Benin, Burkina Faso and Niger), the e7 is demonstrating use of photovoltaics in remote areas and ranger stations while providing constant water supplies for the park's wildlife;
- In Indonesia, the e7 provided 200 solar home systems, 4 micro-hydro units and 1 PV/Wind hybrid system with a combined generation of approximately 1 million kWh per year. The project provides electricity to 8 remote communities with more than 4,000 people;
- In India, the e7 conducted seminars, site visits and training programmes, sharing information with electric utility representatives on subjects such as air and water pollution, thermal plant efficiency, and resettlement and rehabilitation;
- The e7 provided assistance to the Ministry of Electric Power of China to improve its management of the country's electricity consumption;
- In South Africa, the e7 prepared a DSM assessment and provided training to ESKOM personnel at some of the e7 companies' facilities;

- In 1997, the e₇ conducted a series of customised workshops on the environmental impact assessment process used by the e₇ companies for each of the following countries: Egypt, Mexico, Malaysia, Paraguay, Syria, Thailand and Tunisia;
- In 1998, a workshop on environmental impact assessments for transmission lines was held in Mexico with representatives from Columbia, Costa Rica, El Salvador and Mexico; and
- In Jordan, the e_7 completed an Activity Implemented Jointly (AIJ) with the Central Electricity Generating Company (CEGCO) of Jordan and the Hashemite Kingdom of Jordan as represented by the Ministry of Planning. The project provided technical assistance and equipment to CEGCO to improve the efficiency of the operation of its electricity generating units. Improvements in energy efficiency can reduce fossil fuel consumption and reduce greenhouse gas emissions. Total emissions savings resulting from this project, estimated over a three-year period, are 141,983 Mg CO_2 and 3420 Mg SO_2.

These and other e_7 capacity building activities have succeeded in providing host country utilities and institutional entities with the skills, knowledge and training to meet their own sustainable energy development objectives while implementing sound environmental practices.

Annex 7

Sustainable Pathways for Using Fossil Fuels

Many countries will consider using their coal resources to generate electricity in the future. Potential technology pathways for the continued, sustainable use of coal have been identified, including the following:

www.coal.org

www.doe.gov/coal_power/ccttoday.html

www.eia.doe.gov

www.eei.org

www.stanford.edu/group/EMF/home/index.htm

www.eren.doe.gov

www.energy.gov

www.epri.com

www.epa.gov

www.ferc.fed.us

www.gri.org

www.gasification.org

www.globalchange.org/current.htm

www.greentie.org

www.tellus.org

www.iea.org

www.coal.org

web.mit.edu/energylab/www

www.ornl.gov/fossil

www.pewclimate.org

www.pacinst.org/climate.html

www.tai.org.au

www.pnl.gov/gtsp

www.eurelectric.org

One technology pathway would anticipate that new, advanced technologies such as integrated gasification combined cycle generation would be deployed by 2010. This technology could begin to replace conventional pulverised coal fired units in the United States between 2010 to 2020 when new base load generation will be required due to plant retirements and to meet demand growth.

The overall electrical conversion efficiency of this technology could approach 44% by that time and possibly reach 55% by 2020. This prediction is supported by the experience of Germany and Northern European countries where very cold water helps improve plant efficiency to more than 47%. Adding a fuel cell with integrated gasification combined cycle technology could increase the overall efficiency to 60% by 2025-2030. With cogeneration, an overall efficiency of 80% could be achieved.

Furthermore, by purifying gas through membrane separation technology, it will be possible to generate hydrogen that could be used as a clean fuel for the gas turbine as well as fuel cells, with virtually no carbon emissions. It is expected that this technology would be commercially available by the 2035-2040 time frame.

While the efficiency of coal fired generation is being improved, efforts are underway to develop methods to manage carbon dioxide emissions. Economically feasible carbon separation, storage and disposal technologies could also be available by the 2020-2050 time frame to be applied to CO_2 generated from coal combustion.

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