

COAL INDUSTRY ADVISORY BOARD



INTERNATIONAL ENERGY AGENCY



Reducing Greenhouse Gas Emissions

The Potential of Coal

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The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

It carries out a comprehensive programme of energy co-operation among twenty-six of the OECD's thirty member countries. The basic aims of the IEA are:

- to maintain and improve systems for coping with oil supply disruptions;
- to promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations;
- to operate a permanent information system on the international oil market;
- to improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use;
- to assist in the integration of environmental and energy policies.

The IEA member countries are: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, the Republic of Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States. The European Commission takes part in the work of the IEA.

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The OECD is a unique forum where the governments of thirty democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

The OECD member countries are: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission takes part in the work of the OECD.

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The Coal Industry Advisory Board (CIAB) is a group of high-level executives from coal-related industrial enterprises, established by the International Energy Agency (IEA) in July 1979. Its purpose is to provide advice to the IEA from an industrial perspective on matters relating to coal in the worldwide energy system. The 37 current members are drawn from 15 countries accounting for about three-quarters of world coal production.

The original task of the CIAB was to assist the IEA in the practical implementation of the “Principles for IEA Action on Coal” - measures aimed at ensuring a ready supply and trade of coal to underpin energy security. While the security issue remains important, in recent years the CIAB has focused additionally on environmental compatibility (including the choice of modern technology in coal use) and issues arising from the increasingly liberalised energy markets, such as the restructuring and privatisation of coal industries in many countries.

Further information, including a list of current CIAB members, is available on the CIAB website <http://www.ciab.org.uk>.

FOREWORD

Coal plays an important role in ensuring secure, reliable and affordable energy supplies both in OECD and in non-OECD countries, and will continue to be a leading fuel for power generation on a global level for the foreseeable future.

However, its environmental performance needs to improve if coal is to continue to make an important contribution.

This report by the IEA's Coal Industry Advisory Board (CIAB) explores the potential for technology to substantially reduce greenhouse gas emissions from burning coal. It finds that coal-based technologies have the potential to make significant CO₂ emissions reductions and urges governments to assist by establishing regulatory frameworks that encourage the development and deployment of the latest technologies. It presents collaborative action by governments and industry to encourage co-ordinated research and action to develop and demonstrate clean coal technologies. I am pleased to distribute this report as part of the IEA's role to promote discussion between industry and government on these important issues.

This report builds on earlier studies by the CIAB which examine the relationship of coal to sustainable development. These studies, along with other information about CIAB activities, can be viewed on the CIAB's website (www.ciab.org.uk). This report is published under my authority as Executive Director. The views expressed are not necessarily shared by member governments of the IEA.

Claude Mandil
Executive Director

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1. SUMMARY

This report is written with the benefit of contributions from CIAB members and therefore reflects the regional weighting of the membership, which is drawn largely from "first world" countries. Developing countries are represented by the South African contribution. However, coal is also enormously significant in China, India and Indonesia which are however beyond the scope of the CIAB membership.

Diverse, secure, affordable and environmentally acceptable energy supplies are essential to sustainable development. Responding effectively to the risks of global climate change while continuing to meet the high energy demands of mature economies and the rapidly increasing energy demands of developing economies is a significant international challenge.

Longer-term global economic growth cannot be achieved without adequate and affordable energy supplies, which will require continuing significant contributions from fossil fuels, including coal. Coal provides the fuel for 39% of electricity production globally, and will continue to make an important contribution to energy security because of its widespread geographic distribution, and the extent of available resources relative to anticipated energy needs. At the present time, however, some market and policy frameworks discourage the investments that will be required to assure the capability of coal to serve as an environmentally sound cost-effective contributor to global energy needs in coming decades.

Numerous governments are now calling for very significant cuts in greenhouse gas emissions in the longer term (some of the order of 50% by 2050, and others on a carbon intensity basis), but action will be ineffective in the absence of participation of numerous countries that are major greenhouse gas emitters.

Coal-based technology has the potential to make significant CO₂ emissions reductions which are compatible with a low emissions future. In the short to medium term, this requires market and regulatory frameworks that encourage investments in the latest technologies that will improve the efficiency of coal-fired electricity generation and thus reduce specific CO₂ emissions. Collaborative action by governments and industry is also required now to encourage worldwide co-ordinated research, development and demonstration of clean coal technologies such as carbon capture and storage, which will in the longer term deliver near-zero CO₂ emissions from the use of coal.

Policies will vary with countries' geographical and economic imperatives. However, there are common observations and principles that should be recognised in formulating energy and environmental policies throughout the world:

- Affordable energy is essential to the economic and social goals of developing countries and to continued growth and energy security in developed countries.
- Reconciling this with the need to limit CO₂ emissions from energy production and use is a major long-term challenge for the energy sector that requires a far-sighted, technologically focused approach.

- Coal's particular attributes - its availability, affordability and role in stabilising energy markets - will ensure that it continues to be a primary source of fuel for the economic generation of electricity. Therefore, viable means for substantially reducing specific CO₂ emissions from coal-fired power generation need to be developed and widely adopted.
- Proven cost-effective means for removing and sequestering most of the CO₂ emissions from coal-based power plants do not currently exist. However, the prospects for developing and commercialising such near-zero emission coal technologies (ZETs) over the next two decades are promising.
- Realising this potential will require co-ordinated international effort to develop and demonstrate ZETs, and to create the commercial environments in which they may be routinely deployed. In particular, mechanisms are needed to accelerate investment in new, first-of-a-kind demonstrations of advanced coal-fired power plants (such as IGCC with integrated CO₂ capture and storage) and to provide for their eventual deployment in both industrialised and developing countries.
- In the interim, improving the efficiency of existing and new coal-fired power plants is a cost-effective way to limit the growth of CO₂ emissions.
- The installation of best available commercial technology should be a focus of planners for the significant amount of new coal-fired capacity that must be built in the near term. Where practical, it is highly desirable that these power units are designed to enable cost-effective carbon-capture retrofitting when that technology becomes available for commercial application.
- Governments have a crucial role to play in establishing an appropriate and stable policy context for investment in state-of-the-art coal plants. National policies and international agreements need to take a long-term managed approach to energy sustainability that looks beyond the short-term dictates of energy markets and that:
 - recognises the role of coal in supporting economic growth and social development;
 - balances the need to limit CO₂ emissions in the short to medium term with the need to maintain the security of energy supplies and ensure continued economic growth;
 - strives to realise the potential of ZETs and other energy technologies, in power generation and also in other sectors which offer affordable greenhouse gas abatement, and to reconcile growth with climate protection over the long term.
- The scale of the emissions limitation challenge means that all potentially viable energy sources and technologies need to be developed to their practical and commercial potential.
- The transition to sustainable energy has a major role for coal, other fossil fuels, and nuclear as well as renewable technologies and energy conservation, with each contributing at a time and to an extent dictated by technical feasibility and affordability.

This report examines the potential for achieving greenhouse gas reductions in coal-based power generation and the types of technologies and policies required to realise that potential. It presents both a global perspective, and regional viewpoints based on observations and experiences in key coal-producing and consuming countries.

2. INTRODUCTION

Diverse, secure, affordable and environmentally acceptable supplies of energy are essential to sustainable development of world societies. The issues related to meeting the energy requirements of both developing and mature economies vary over time and between regions of the world.

Following the oil supply crises of the 1970s, fossil fuel supply security and curbing energy demand were primary considerations. More recently, over the last two decades, global climate issues have assumed prominence and the energy sector needs to take account of climate-related challenges. Societies are sufficiently concerned about the risks and potential effects of climate change to make greenhouse gas emissions reduction a core energy policy issue.

Sustainable development (meeting the needs of the present generation without undermining the capacity of future generations to meet their needs) demands a balance between social, economic and environmental considerations. The current challenge is to respond effectively to the risks of global climate change while continuing to meet the high energy demands of mature economies and the rapidly increasing energy demands of developing economies.

Energy projections made by the World Energy Council, the International Energy Agency and the US Energy Information Administration give similar pictures of future energy requirements.

For example, the Reference Scenario of the IEA *World Energy Outlook 2004* projects an increase of some 60% in global primary energy consumption from 2002 to 2030 to reach a level of 16.5 billion tonnes of oil equivalent (bn toe) in 2030. Over this period, coal consumption increases from 2.4 bn toe to 3.6 bn toe.¹ More than 60% of the increase in world primary energy demand will come from developing countries, especially in Asia.

The consumption of electrical energy is expected to increase to an even greater extent. World electricity demand is projected to grow at an annual rate of 2.5%, nearly doubling from 16.1 trillion kilowatt-hour (tn kWh) in 2002 to 31.7 tn kWh in 2030. Strong growth in electricity consumption is expected in countries of the developing world, where electricity demand increases by an average of 3.5% per year. The global power sector will need 4 800 GW of new capacity between now and 2030 to meet the projected rise in electricity demand and to replace ageing infrastructure. The total installed capacity is expected to increase from 3 500 GW to more than 8 000 GW. The exact mix of fuel input to this new generating capacity will depend on a number of factors including fuel diversity, indigenous and international availability, cost and environmental acceptability; and will vary between different regions of the world. Gas and renewable energy

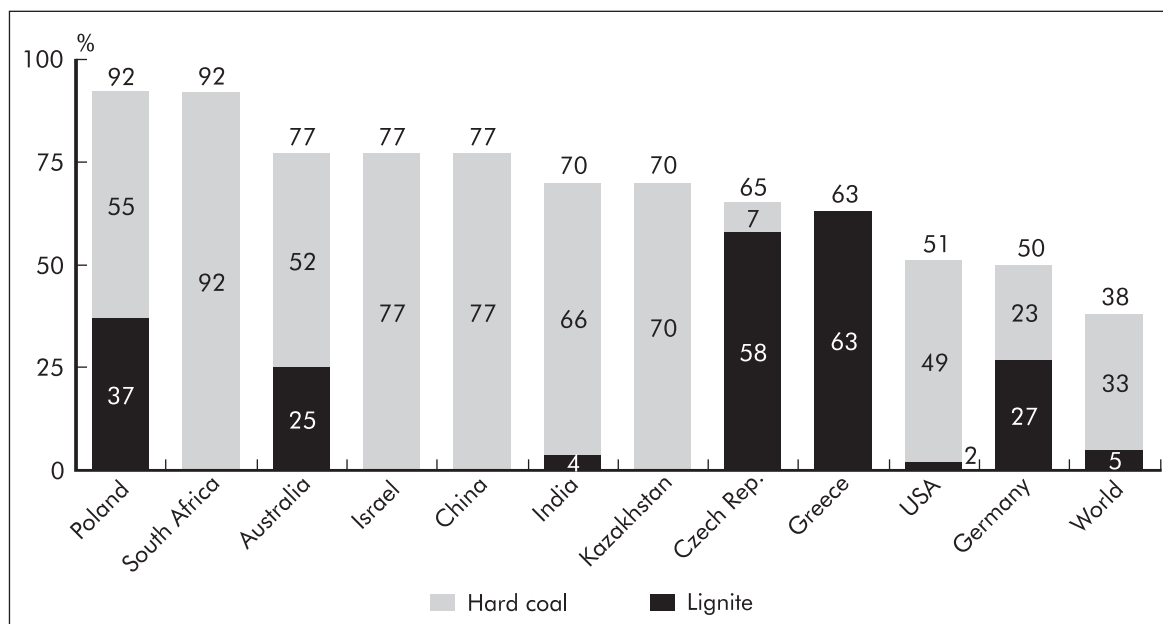
1. Even under the IEA *World Energy Outlook Alternative Scenario*, reflecting new measures to tackle climate change and energy security, coal use is expected to grow from 2.4 bn toe in 2002 to 2.7 bn toe in 2030.

sources will play increasing roles, particularly in the industrialised nations. However, coal's wide availability, supply security and competitiveness are recognised in the projections. They show coal retaining a very important position in fuelling this electricity generating capacity.

Currently, two-thirds of the coal consumed worldwide is used for electricity generation. In many large countries in the developed world as well as in the developing nations, coal occupies top slot as energy source in power generation. In almost every region, power generation accounts for most of the projected growth in coal consumption of some 1.5%/a. Coal-fired power plants provided 39% of global electricity needs in 2002. This share will fall only slightly, to 38% in 2030.

Figure 1

Share of Coal in Power Generation, 2002

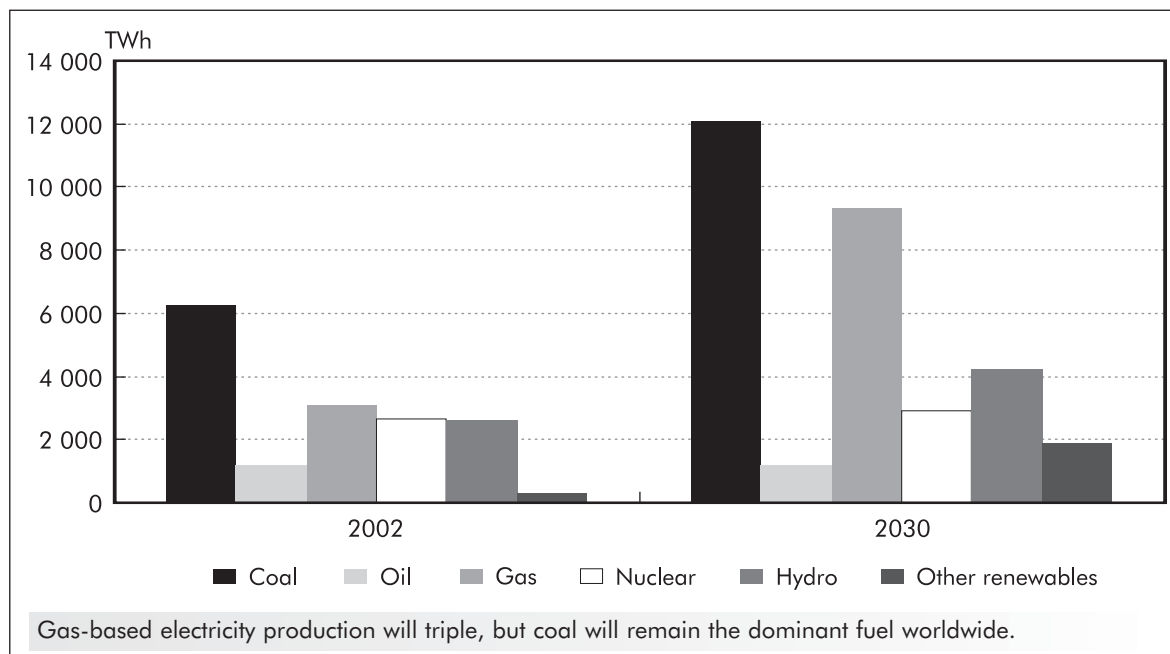


Source: IEA, *Electricity Information 2004* - Tables 6 and 7.

In view of this, continuing improvements in the environmental performance of coal use are essential. This report explores the worldwide potential for CO₂ emissions reduction through coal use, within the context of underlying political conditions in specific regions (Australia, Europe, Japan, the United States and South Africa). Key questions that have been addressed by CIAB members are:

- What is the potential to reduce greenhouse gas emissions through the use of clean coal technologies (advanced technologies and improved generating plant efficiencies)?
- What is the potential cost and benefit of carbon capture and storage technologies (near-zero emission technologies) to provide affordable CO₂ abatement options in the future?
- What are the possible barriers to the development of these technologies in specific countries and regions of the world?
- How do developments in different countries/regions differ in their support for development of the coal option?
- What guiding principles should be considered by policy-makers?

Figure 2

World Electricity Generation by Energy Sources

Source: IEA, *World Energy Outlook 2004*.

3. THE TECHNOLOGY POTENTIAL

Key Messages

- In the long term (>2020), CO₂ capture and storage offers the potential for near-zero CO₂ emissions from coal-based power plant. Delivery of this option requires co-ordinated research, development and demonstration (RD&D) now. (See: *Prospects for CO₂ capture and storage*, IEA, 2004)
- In the next decade, cost-effective CO₂ emissions reductions can result from increased coal combustion efficiencies achieved through the more widespread use of state-of-the-art coal-based power plant technology.
- These strategies are complementary: deployment of modern, efficient coal-fired electrical generation technologies in the short to medium term can enable carbon capture for less cost in the longer term, if those power units are designed to enable cost-effective carbon capture retrofitting when that technology becomes available for commercial application.
- Successful implementation demands that government and industry work together - commercial markets will not deliver without appropriate and stable policy frameworks.

Sulphur dioxide, nitrogen oxides and particulate emissions from power stations can be substantially reduced through the application of flue gas de-sulphurisation, selective catalytic reduction (SCR), and low NO_x burner and precipitator technologies. Furthermore, as these technologies have been deployed, costs have fallen and their commercial acceptability improved. In other words, the economic cost of addressing the environmental sustainability issue has reduced over time for these technologies.

The challenge to reduce CO₂ emissions from fossil fuel-based power generation is also capable of being addressed through various technology options. These have been described by several organisations and in several recent publications including *Clean coal technologies roadmaps*, IEA Clean Coal Centre, 2003 and *Clean Coal - Building a Future through Technology*, World Coal Institute, 2004. It is worth noting that clean coal technology encompasses both the ultimate goal of removing the majority of CO₂ emissions associated with using fossil fuels and the progressive reduction of emissions through improved combustion efficiency. The former will involve increasing costs to meet tighter environmental requirements. The latter will improve the economics of power generation and help to preserve scarce fossil fuel resources. Both will be needed to improve the environmental performance of coal to the necessary extent over an acceptable timeframe.

CO₂ Capture and Storage - The Long Term Vision for Clean Power Generation from Coal

Both fossil and non-fossil forms of energy will be needed in the foreseeable future to meet global energy requirements. Fossil fuels, in particular coal for power generation, are available on a long-term basis and their continued large-scale and widespread use is necessary in order to sustain economic growth. It is therefore important that technological solutions be commercialised which allow the use of fossil fuels with greatly reduced CO₂ emissions. CO₂ capture and storage (CCS) offers sound potential for the future; however, further work is required on:

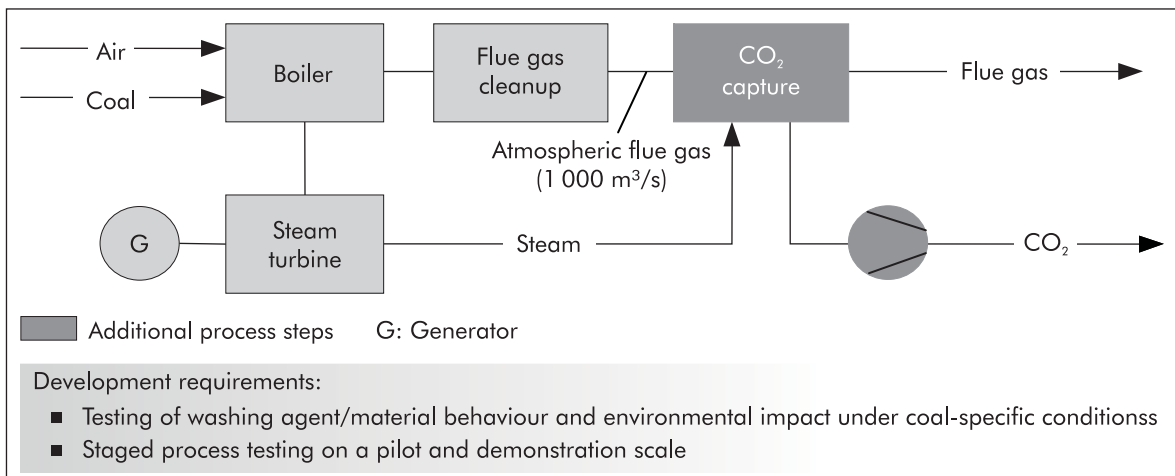
- Suitable power plant technology with CO₂ capture; and
- Environmentally acceptable and reliable CO₂ sequestration and use.

Possible technologies for CO₂ capture from coal-fired power plants can be categorised as:

- CO₂ capture after combustion (post-combustion);
- CO₂ capture after concentration in the flue gas (oxyfuel power plant); and
- CO₂ capture before combustion (pre-combustion).

Figure 3

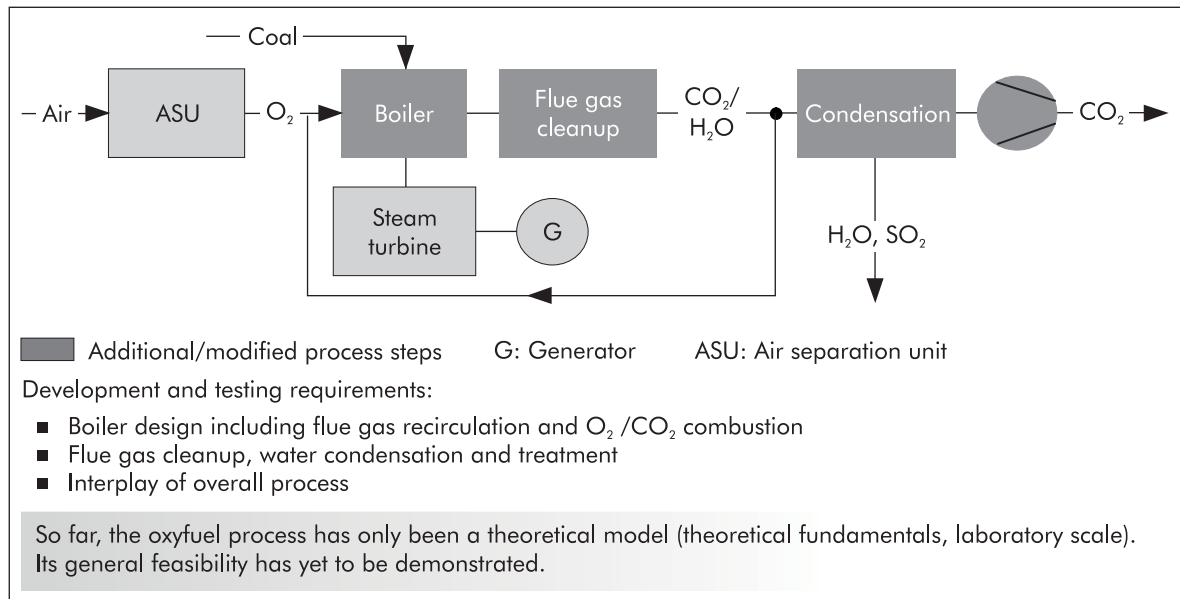
Post-combustion CO₂ Capture; Pulverised Coal-fired Steam Power Plant



Post-combustion CO₂ capture downstream of the conventional steam power plant is currently expensive and involves significant efficiency losses. Oxyfuel technology, which is based on a modified process configuration with an oxygen feed using recycled offgases, is the subject of a significant new research programme in Australia, and holds promise, but also still requires considerable research and development efforts.

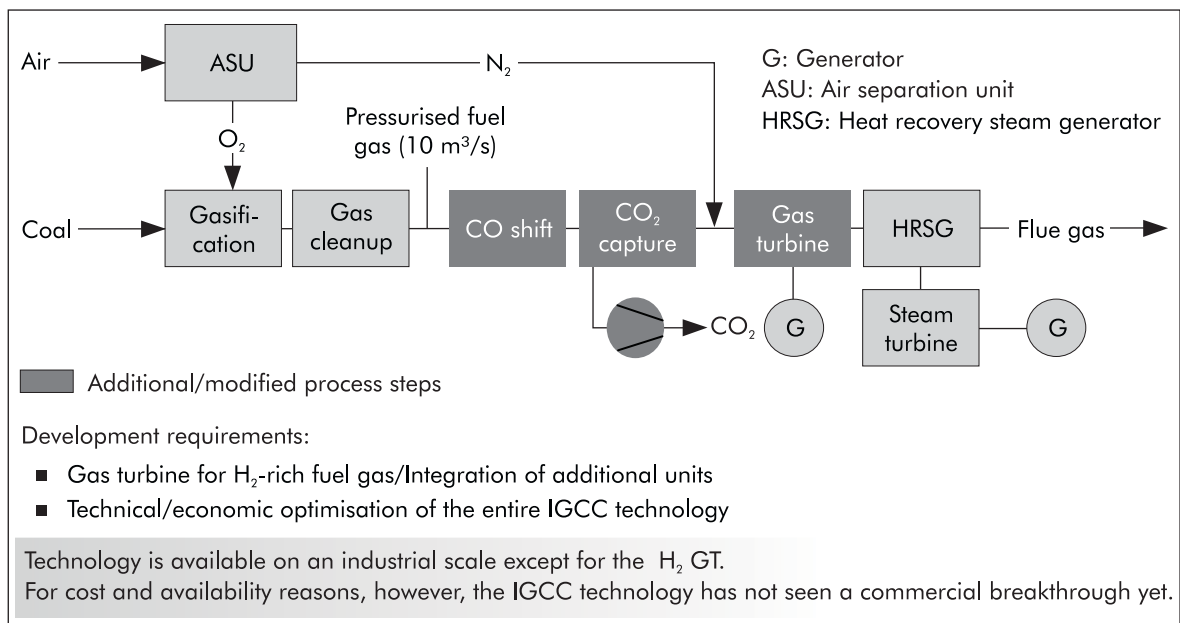
The pre-combustion technology which is closest to commercial deployment - the integrated gasification combined cycle (IGCC) with CO₂ capture, constitutes the CO₂ capture technology most favourable today in economic and technical terms for fossil-fired power plants. Compared with current power plant

Figure 4

Post-combustion CO₂ Capture; Oxyfuel Process

technology, however, it also involves additional costs and efficiency losses. Government-subsidised IGCC demonstration plants are operating today, and industrial-scale demonstration will clarify its potential for more widespread application.

Figure 5

Pre-combustion CO₂ Capture; Combined-cycle Process with Coal Gasification (IGCC)

International collaboration on the development of CCS is being assisted by the Carbon Sequestration Leadership Forum which has sixteen member nations bringing together their efforts and have announced to date a total of 10 major projects to advance the development of CCS.

The use of geologic formations for CO₂ sequestration is being investigated in many nations. Depleted gas fields, non-minable coal seams, if possible with simultaneous coal bed methane production, and saline aquifers, all offer CO₂ sequestration options. Options for CO₂ sequestration in deep-sea sediments are also being explored. Considerable research and development effort is still required to clarify and confirm these options.

The use of these newer technologies will be highly location-specific and driven by government policy in terms of the extent of GHG emissions reduction in the longer term. Regions with strong endowments of fossil fuels, existing pipeline infrastructure, and well-mapped geological structures, are expected to be able to offer lower-cost development options, and to provide a lead in demonstration of these technologies. As costs reduce over time and the imperative for comprehensive action is taken up, the deployment of these near-zero emission technologies can be expected to widen.

Efficient Preventive Climate Protection by Deployment of “State of the Art” Coal-based Power Plant Technology

There is considerable potential to reduce CO₂ emissions from coal use by applying existing state-of-the-art technology.

Under ideal conditions, modern coal-fired power plants are capable of achieving efficiency levels of more than 40% on a higher heating value basis. This is about a 30% improvement on plants built in the 1950s and 1960s, with equivalent reductions in CO₂ emissions. Furthermore, modern installations emit less dust, sulphur and NO_x than older plants, and their reduced fuel usage contributes to management of increasingly scarce energy resources.

New power plants illustrate the current status of power plant technology. In Germany, the 965 MW BoA² lignite-fired power plant with supercritical steam conditions went fully on stream in 2003 at Niederaussem/Rhineland with an efficiency of more than 43 % on a lower heating value basis. In Australia, the recently completed 860 MW Millmerran black coal power station has an efficiency of around 40% on a higher heating value basis, and in Japan, the 1050 MW Tachibanawan-2 black coal power station has an efficiency of around 42 % (HHV).

Hard coal and lignite combustion efficiencies will continue to improve through the use of coal drying and higher power plant steam cycle temperatures, as illustrated below.

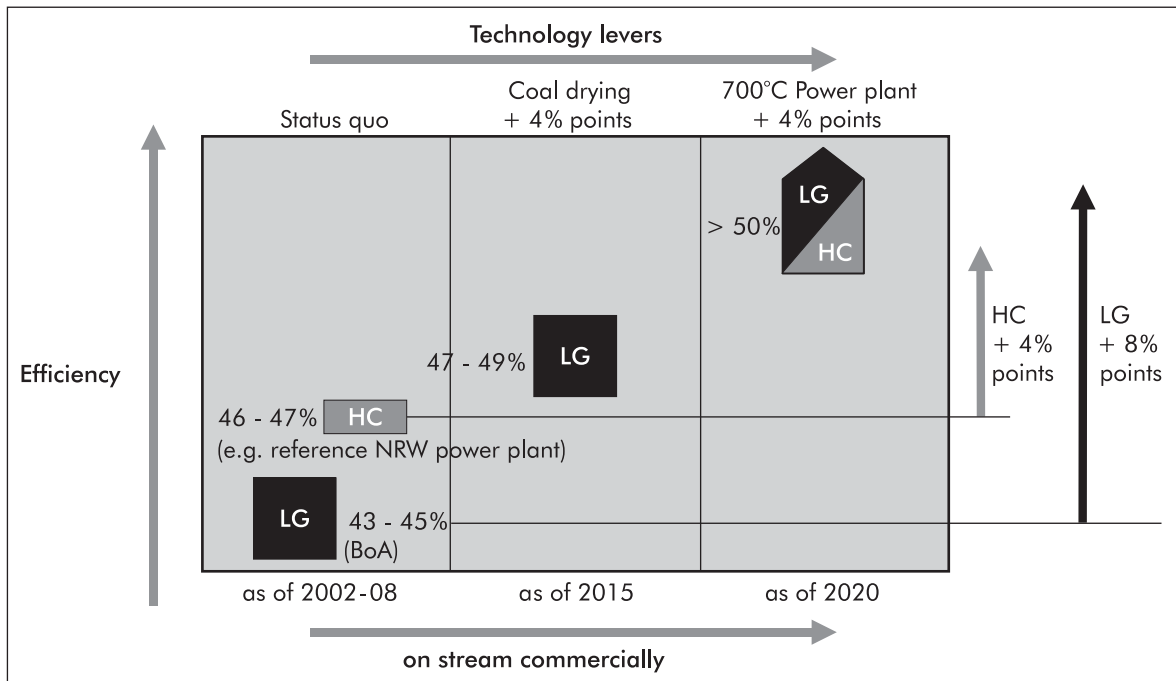
Coal-fired generating capacity of about 1 000 GW is installed worldwide. Almost two-thirds of the international coal-fired power plant portfolios are older than 20 years and have an efficiency of 29%. These power plants emit some 3.9 bn t CO₂ per year.

If the normal life of these plants is assumed to be 40 years, and they are replaced when they reach this age with modern, ultra-supercritical (USC) plant with efficiencies typically around 45%, the total

2. German abbreviation: BoA standing for “Braunkohlenkraftwerk mit optimierter Anlagentechnik” (lignite-fired power plant with optimised plant technology)

Figure 6

Development Horizons of Lignite and Hard Coal-fired Power Plants
(LG= lignite; HC = hard coal; "700°C Power Plant")



greenhouse gas (GHG) emissions from this 1 000 GW of capacity will be reduced by 1.4 bn tonnes CO₂ per year, reflecting a 36% reduction in GHG emissions.

This corresponds to some 6% of the 23.4 bn t of global energy-related CO₂ emissions which are reported by the IEA for 2002 and is more than the targeted reductions under the Kyoto Protocol in 2008-2012. This is an important contribution, albeit it is recognised that even greater reductions are required.

In many developing countries, the efficiency of coal use is much lower than in OECD countries. As stated in the *World Energy Outlook 2004*, the average efficiency of coal-fired generation in the OECD was 36% in

Table 1

CO₂ Reduction through Efficiency Increase
Potential of Coal-based Power Generation in China, India and Russia that Account for
Some 40% of Global Coal-fired Power Plant Capacity

	Unit	China	India	Russia	Total
Coal-based power generation	TWh/year	1 139	435.8	544.6	2 119.4
Average efficiency	%	30	30	27.9	29.5
Average CO ₂ emissions	† CO ₂ /MWh	1 202	1 120	1 325	1 216
CO ₂ emissions for efficiency of 33%	† CO ₂ /MWh	1 090	1 020	1 120	1 083
CO ₂ emissions reduction	mill.t/year	127.6	43.6	111.6	282.8

Source: Paper presented by R. K. Boyd (Australia) at the 2004 World Energy Conference (WEC).

2002, compared with 30% in developing countries. This means that one unit of electricity produced in developing countries emits 20% more carbon dioxide than does a unit of electricity produced in an average OECD coal plant.

Raising the efficiency in China's, India's and Russia's coal-fired power plants *e.g.* by only a few percentage points (as shown in Table 1) would allow CO₂ emissions to be cut by 283 million tonnes per year. This is equivalent to one-third of total CO₂ emissions in Germany.

In a long-term view, after 2020, coal-fired generation technologies featuring efficiencies of some 50% can be available. A modern plant with an efficiency of 50% implies a 28% cut in CO₂ emissions compared to a typical plant of around 36% efficiency.

The replacement of older power generating plants with modern equipment would also yield numerous ancillary benefits, including greater coal-use efficiency, substantial reductions in conventional pollutant (SO₂, NO_x, particulate) emissions, a reduced cost to implement any new air-emission controls that may be required by future national legislation such as in the US, and the potential to construct these plants to enable retrofitting with CO₂ capture technology, when it becomes commercially available.

Electricity generating companies are constantly making plant investment decisions, whether to meet new capacity requirements, to improve environmental performance of existing plant, or to reduce overall costs. It is essential that these decisions are made within policy frameworks that recognise the CO₂ reduction potential of increasing the efficiency of coal-fired electricity generation.

Technology Development and Deployment - the Policy Challenge

Fossil fuels will continue to be part of the energy mix for many decades to come. In developing countries, the prime driver is to increase the economic well-being of the population and, where possible, to use indigenous energy resources. In more mature economies, the focus is increasingly on environmental improvement and global climate issues. In both cases coal-fired electricity generation will be an important part of the picture, giving the world access to a cost-efficient supply of energy and having the technological potential to make a significant contribution to reducing CO₂ emissions over the short and longer term.

Effective research, development and demonstration of potential CCS technologies is essential for the longer-term "clean" use of fossil fuels, including coal. Progress needs to be made now to ensure the timely availability of these technologies. The coal industry is doing much to promote the development of these technologies, and a number of the RD&D programmes in which the industry is involved are mentioned in the regional sections of this report and in the World Coal Institute (WCI) publication *Clean Coal - Building a Future through Technology*.

At an international level, the formation of the Carbon Sequestration Leadership Forum (CSLF) in June 2003 was an important initiative. The CSLF comprises 16 member countries and the European Commission, and is dedicated to international co-operation on facilitating development of cost-effective techniques for CO₂ capture and safe long-term storage. It will seek to:

- Identify key obstacles to achieving improved technological capacity.
- Identify potential areas of multilateral collaboration on carbon separation, capture, transport and storage technologies.
- Foster collaborative RD&D projects reflecting members' priorities.
- Identify potential issues relating to the treatment of intellectual property.
- Establish guidelines for the collaborations and reporting of their results.

- Assess regularly the progress of collaborative R&D projects and make recommendations on the direction of such projects.
- Establish and regularly assess an inventory of the potential areas of needed research.
- Organise collaboration with all sectors of the international research community, including industry, academia, government and non-government organisations.
- Develop strategies to address issues of public perception.
- Conduct such other activities to advance achievement of the CSLF's purpose as the members may determine.

Successful RD&D has a long time horizon and depends on stable energy policy frameworks. Market deregulation of energy and electricity markets in some mature economies has brought many benefits, but it has also had undesirable consequences for new technology development. Energy security is not adequately valued in energy markets and deregulation has lowered the returns to and increased the risk aversion of the major utilities, making the financing of new technology more difficult – especially when that technology requires large investments of capital and relatively long capital-recovery periods.

In Europe and the USA, uncertainties around the future direction of environmental and global climate policies have stalled investment in coal-fired electricity generating plant, except where the use of indigenous resources has been an important consideration. Commercial markets and financial institutions have not had the confidence to invest in newer technologies, which would reduce CO₂ emissions but which have long payback periods. Instead, investment has tended to favour gas-fired electricity generating capacity with its shorter and less risky payback horizon. However, gas alone will not be able to fill the demand for new generating capacity, particularly in developing countries, and excessive reliance upon it will drive prices higher and decrease energy security.

The development of near-zero emission technologies for coal may be centred in developed nations, which have the means and political will to apply resources to the development of these technologies. However, most new coal-fired generating capacity will be installed in developing countries. National and international policies supportive of advanced coal technologies and zero-emission technology transfer to developing nations is essential, including recognition of such projects in the Joint Implementation and Clean Development Mechanism accounting frameworks under the Kyoto Protocol.

Governments also should seek to agree on the domestic and international incentives and rules that might encourage the application of modern technology to improve efficiency when older power stations are being refurbished. In particular, these activities should also qualify for government support and be admissible under the Joint Implementation and Clean Development Mechanism rules.

More fundamentally, governments should seek to balance the social, economic and environmental needs of society by maintaining the energy security, including continued coal use, needed to support growth. Government policies need to provide long-term strategic solutions for achieving sustainable energy use and economic growth. In this context, government support for the demonstration of first-of-a-kind technologies may be appropriate, allowing these to compete on even terms with mature, commercialised technologies and thereby accelerating their deployment.

The co-ordination of technology development efforts by energy market regulators and participants is also important – lack of co-ordination, rivalry and duplication among research and development programmes will waste resources and delay new technologies.

The following sections explore developments and differences in energy policies and industry/government co-operation initiatives in several regions of the world.

4. EUROPE

Key Messages

- There is need for new power plant capacity in the EU-25 of about 500 GW by 2030.
- In view of a projected increase in reliance on imported energy which rises to 69% by 2030, a broadly diversified energy mix is indispensable for energy supply security reasons.
- Stabilising coal input to power generation can make a substantial contribution to securing the energy supply.
- With continued efficiency enhancements in the power plant field and the development of near-zero emission technologies, coal will contribute to meeting the requirements of preventive climate protection.
- In setting rules for emissions trading in each EU member State, the focus should be upon improving efficiency to achieve GHG reductions.

Energy Supply

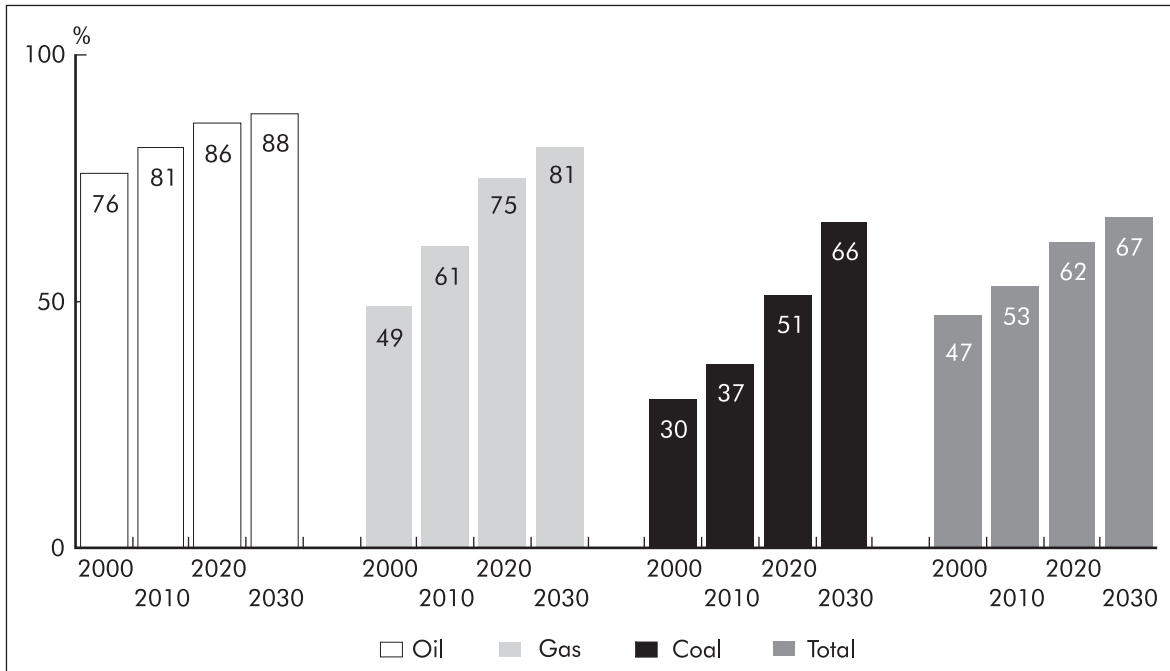
Since 1 May 2004, the European Union has had 25 member States with some 455 million inhabitants. Primary energy consumption in the EU-25 amounts to approximately 2.5 bn tonnes of coal equivalent (tce) or one-sixth of the 15 bn tce global energy consumption.

The EU-25 is heavily dependent on energy imports (>50% of energy requirements). The EU estimates that this will have grown to 62% by 2020, with gas consumption and imports rising dramatically in the medium term and consequent significant increases in electricity prices.

Coal holds an important place in the EU-25 energy supply mix, accounting for 32% of power supply. Coal is indispensable to primary steel production and other energy-intensive industries. Being the only significant indigenous energy source, it also guarantees a certain degree of independence in energy supply.

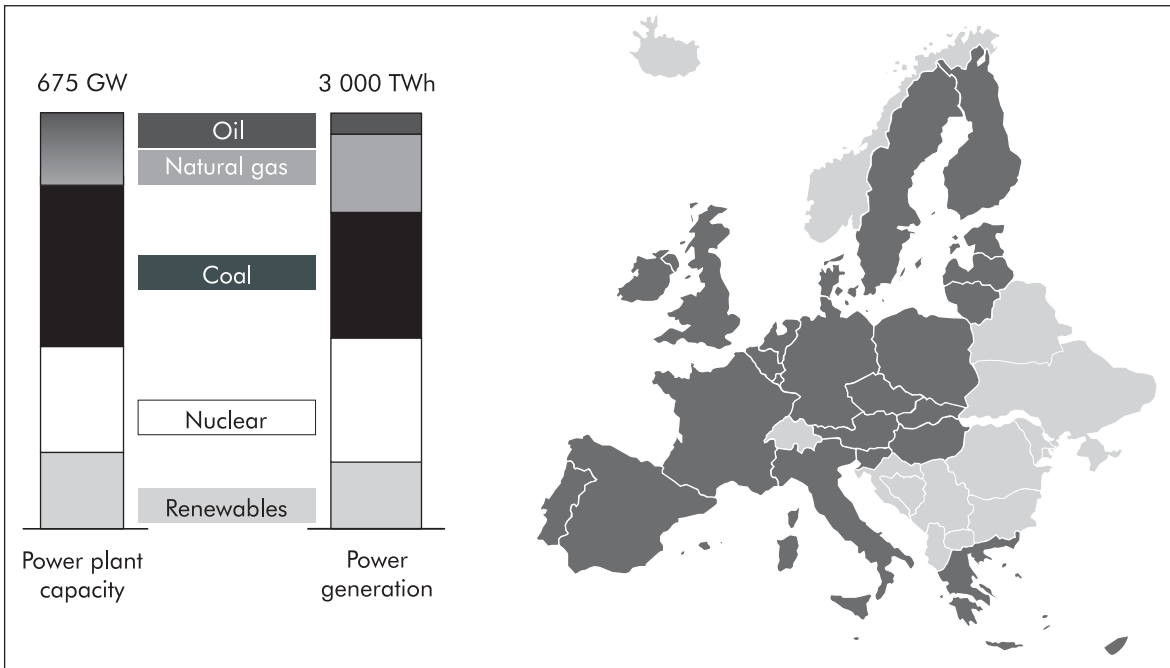
The EU-25 has some 675 GW of electricity generating capacity, expected to generate about 3 000 TWh of electricity in 2004. Of this, 30% is based on nuclear energy, 30% on coal, 19% on gas, 5% on oil and 16% on renewable energies. In the latter case, most of the total is generated by hydropower (some 12 percentage points). The EU-25 countries account for 19% of worldwide power consumption.

Figure 7
Dependence on Imported Energy, EU-25



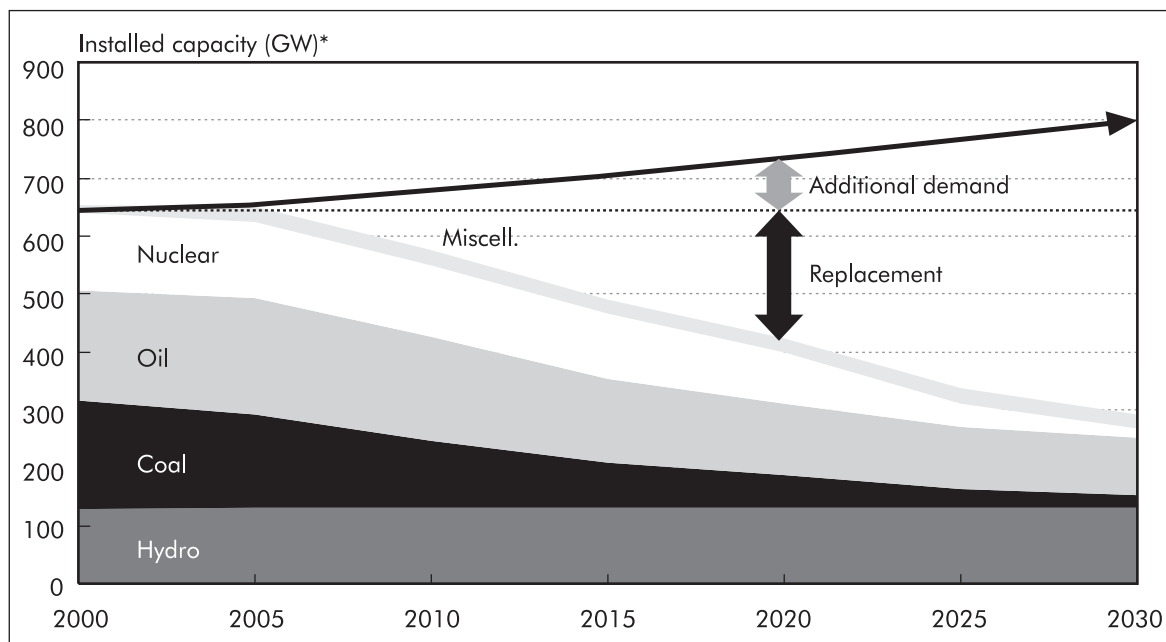
Source: European Commission.

Figure 8
Power Generation Structures in EU-25, 2004



Source: European Commission, *European Energy and Transport Trends to 2030*, Brussels 2003; Eurelectric 2004.

Figure 9

Power Capacity Renewal in EU-25

* Younger than 40 years.

Coal plays a very important role in European electricity generation, but 70% of coal-fired electricity is generated using plant that is over 20 years old.

Slight increases in power consumption and much of the existing power plant capacity reaching the end of its technical/economic life will create the need for about 350 GW of new electricity generating capacity by 2020 and about 500 GW by 2030. €300 bn will need to be invested in new power plant during the next 25 years to ensure continuing security of supply and reductions in emissions of greenhouse gas emissions.

Energy and Environmental Policy Context

At European level, recent years have seen a number of environment-related initiatives. In 1991, the EU Commission issued the first Community strategy to limit carbon dioxide emissions and improve energy efficiency. In 2001, an amendment to the European Large Combustion Directive was adopted. The most important climate protection initiatives affecting energy generation are in particular:

- Directive of 27 September 2001 on the promotion of electricity from renewable energy sources in the internal electricity market.
- Directive of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity.
- Directive of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community.
- Directive of 27 October 2004 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms.

Furthermore there are other EU directives towards energy efficiency improvement that have an impact on electricity generation. Besides the transposition of these directives into national law, the EU member States have taken additional measures to limit greenhouse gas emissions at national level.

Clean Air

A first European Large Combustion Directive was issued as early as 1988. It anchors limit values for various emissions associated with various fuels and power-generation processes to "state of the art" standards.

In 2001, this directive was amended and tightened up. Under the amendment, for example, new power plants with a furnace capacity upward of 100 MW_{th} may only emit up to 200mg/Nm³ SO₂ and NO_x. These limit values make flue-gas scrubbing systems mandatory and will affect the future for coal-fired electricity generating plants.

For example, electricity generation from coal will become more expensive when the EU Large Combustion Plant Directive is implemented in the UK because of the need to upgrade technologies for the control of SO_x, NO_x and dust. Plant that is opted out of the necessary improvements is likely to be retired over the period to 2015. So even if cost-effective ways can be found to reduce carbon dioxide emissions, there are other factors that could lead to coal-fired generation reducing in significance in the UK's fuel mix for energy in the second decade of the 21st century.

Climate Protection

Climate protection issues and the Kyoto Protocol of 12 December 1997 have profoundly affected European energy policy. The European Union signed the Protocol and has also ratified it. In accordance with the Protocol, the EU-15 has undertaken to reduce emissions of the six chief greenhouse gases by a total of 8% in the period from 1990 to 2008/12. In 1998, as part of the concluded burden-sharing agreement, this undertaking was divided very unevenly among the member States. Eight of the 10 States that acceded to the EU on 1 May 2004 have also given an undertaking to lower their GHG emissions in line with the Kyoto Protocol. The reduction commitments amount to 6% for two and 8% for six of these states, each relative to the base period.

While Germany, Finland, France, the UK, Luxembourg and Sweden are well on track to achieve their goals – the same is true of almost all accession countries – the same is not true for Belgium, Denmark, Italy, the Netherlands, Austria, Ireland, Greece, Portugal and Spain. By 2002, the EU-15 as a whole had only achieved a reduction of 2.9%.

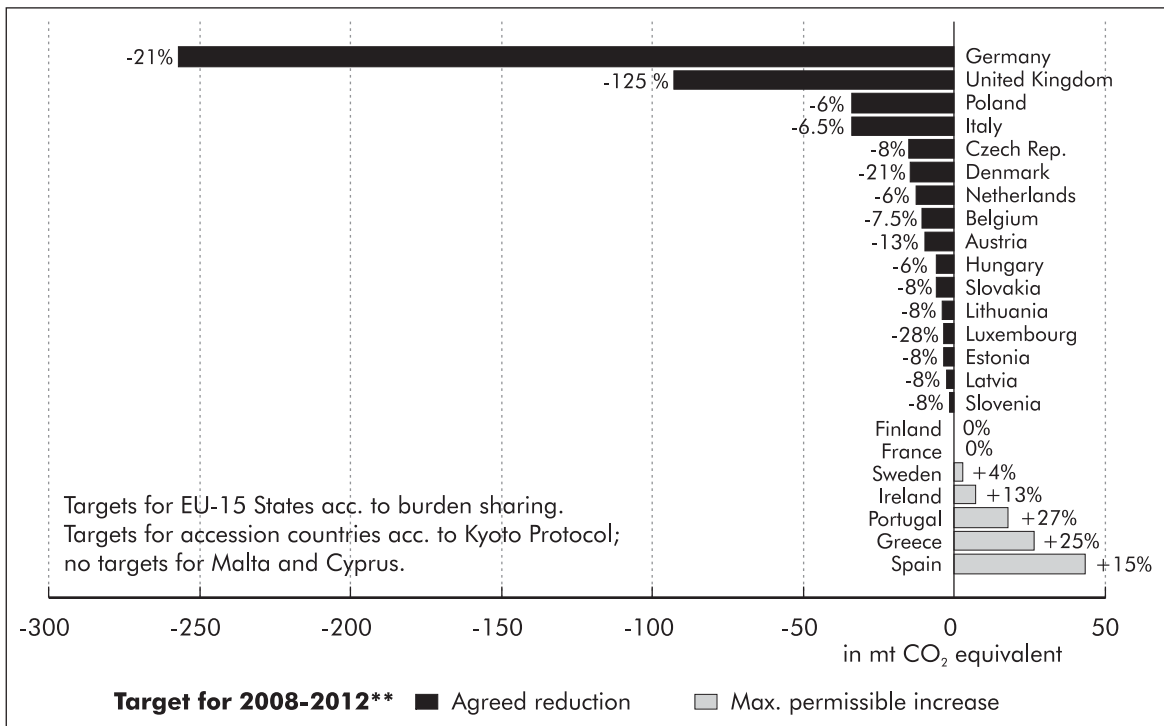
Investment in building new power plants with roughly half of today's total capacity must be made throughout Europe in the next 25 years. This could result in a profound change in the power generation portfolio, with options under consideration for new plant including nuclear energy, coal, natural gas and renewables.

The various EU States have widely different starting positions in terms of resource availability and energy policy stipulations. France and Finland, for example, are heavy backers of nuclear energy. The UK and the Netherlands have gas deposits, although output reductions are foreseeable. In Germany, lignite offers a competitive foundation for baseload power generation although hard coal from German deposits is not internationally competitive. In Austria, hydropower is the dominating energy source for generating power, though potentials for expansion are limited. The use of other renewable energy sources is often only feasible if subsidised.

UK government policy on energy was described in a 2003 White Paper. It set four goals, of which two pertained to the reliability of energy supplies and the aim to cut CO₂ emissions by 60% by 2050, using 1990 as the baseline. Based on the UK policies in existence before the White Paper, UK CO₂ emissions were expected to be 135 Mt of carbon by 2020. The government is now signalling further cuts of 15-25 Mt of carbon by 2020, which it believes to be consistent with the long-term target of 65 Mt of carbon by 2050. The White Paper comments that the future for coal must lie in cost-competitive cleaner coal technologies which can increase the efficiency of coal-fired plant and/or use carbon capture and storage.

Figure 10

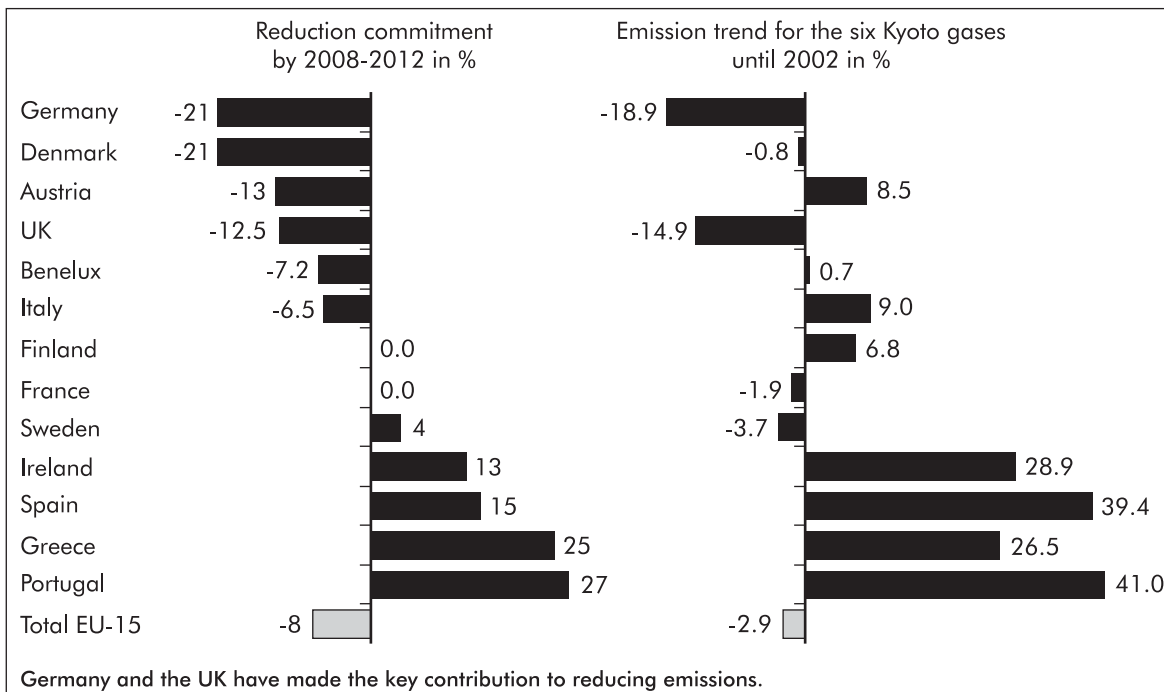
Targets for Limiting Emissions of Climate-relevant Gases* in the EU-25



* CO₂ methane, N₂O, two groups of hydrocarbons HFC and PFC, as well as sulphur hexafluoride SF₆.
** Compared with base year, base year for most States/greenhouse gases in 1990.

Figure 11

EU-15 Burden Sharing



The UK government is using an Emissions Trading Scheme as an additional mechanism to achieve its challenging targets on CO₂ reduction. The scheme has been operational in the UK for a few years, but covering only a limited range of industrial sectors. With the particular focus on power generation for significant reductions in CO₂ in the early phases of the Kyoto compliance period, the scheme will extend to this sector from the beginning of 2005.

In the Netherlands all owners of coal-fired power stations have concluded a voluntary agreement with the government to achieve an annual CO₂ reduction of 6 million tonnes (Mt) of CO₂ during the Kyoto period (2008-2012). About half of this reduction will be achieved by keeping the generation efficiency of all installations (both coal and gas) at world class level as determined by benchmarking Dutch efficiencies with the rest of the world. These global benchmarks cover all power stations larger than 50 MW which deliver electricity to the market. In these benchmarks the trend for world class performance is set by the generating efficiency of new investments. This implies an ambitious challenge for existing Dutch power stations in order to achieve and follow the world class benchmark.

Renewable Energy

EU Directive 2001/77/EC, 27 September 2001, aims to raise the share of electricity produced from renewable energy sources in the Community's total power consumption to 22.1% by the year 2010.

In Germany, renewables are promoted through a system of guaranteed supply prices which are well above market prices. This has made Germany the "world champion" in wind energy, with installed capacity in 2004 amounting to some 15 000 MW and producing over 20 TWh electricity/year, or approximately 4% of total power generation in Germany.

The amended Renewable Energies Act that entered into force on 1 August 2004 provides mechanisms to promote electricity production from water, wind, biomass and the sun, the aim being to increase the share of all renewables in German power generation to at least 12.5% by 2010 and to 20% by 2020. The costs of power generation based on renewables are and will be much higher than those of production from conventional fuels. Therefore subsidies, that already exceed €2 bn per year in Germany, are expected to increase further in volume, even if they will decrease on a per kWh basis, for wind.

Other EU member countries have introduced promotional mechanisms in favour of renewable energies in the electricity sector, such as the UK has introduced a "market mechanism" with Renewable Obligation Certificates.

Energy Taxation

With the Directive of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity, the system of minimum taxation that was previously limited to mineral oil products was extended to all products including coal, natural gas and electricity. The directive sets minimum rates of taxation for motor and heating fuels. Moreover, the member States are required to tax electricity at the minimum rate defined in the directive as a function of its use. Energy products used to produce electricity are exempt from taxation. However, the member States are free to charge energy products used for electricity generation not only with the mandatory output tax but also, for environmental reasons, with an input tax.

European Greenhouse Gas Emissions Trading

Since the EU-15 is likely to miss its pledged reduction target without the inclusion of additional tools, the European Parliament and the Council enacted a system for trading GHG emission allowances in the Community under the terms of Directive 2003/87/EC dated 13 October 2003. Pursuant to this directive, which became effective on 25 October 2003, CO₂ emissions trading is to start on 1 January 2005.

In addition to the trade in emission allowances, the Kyoto Protocol provides for Joint Implementation (JI) and a Clean Development Mechanism (CDM) as further mechanisms to help meet given commitments. JI

enables an offset of emissions reductions obtained by projects between two industrialised nations. Here, one industrialised country entity participates in a project (*e.g.* to increase the efficiency of a power plant) in another State that has a duty to limit emissions under the Protocol. The emissions reductions obtained are credited to the country in which the project was launched and may be transferred to the investor. The CDM concerns projects in which investors from industrialised countries lower GHG emissions in developing countries. Suitable underlying conditions permitting, JI and CDM can offer a cost-effective alternative to expensive emissions reduction measures taken at home.

In 2004, the EU Parliament and the Council issued a supplementary directive to the emissions-trading directive, giving companies investing in appropriate projects tradable allowances for the reductions in CO₂ emissions achieved by such projects. As a result, this will increase the diversity of low-cost compliance options within the Community scheme leading to a reduction of the overall costs of compliance with the Kyoto Protocol while improving the liquidity of the Community market in greenhouse gas emission allowances. This Directive 2004/101/EG (JI/CDM directive) was adopted with legally binding effect, irrespective of the entry into force of the Kyoto Protocol.

- Recognition of CDM projects within the scope of the emissions trading system applies at national level from 2005 on. JI projects are included by analogy starting in 2008. However, only part of the commitments assumed on limiting emissions can be met with such project-related measures; corresponding caps are to be harmonised and will apply EU-wide.
- In addition to the above, national projects are allowed. These refer to the inclusion of plants, sectors or gases that are not originally subject to the CO₂ trading system. These could involve, for example, emission reductions in <20 MW_{th} combustion installations and in plants outside industry or the energy sector, or include climate-relevant trace gases other than CO₂ (*e.g.* pit gases).
- Inclusion of nuclear power plant projects is ruled out until 2012.
- Sinks (afforestation measures) cannot be included until 2007.
- Hydropower projects can be recognised wherever they comply with the relevant guidelines of the World Commission of Dams.

The directive amending the directive establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms, took effect on 13 November 2004.

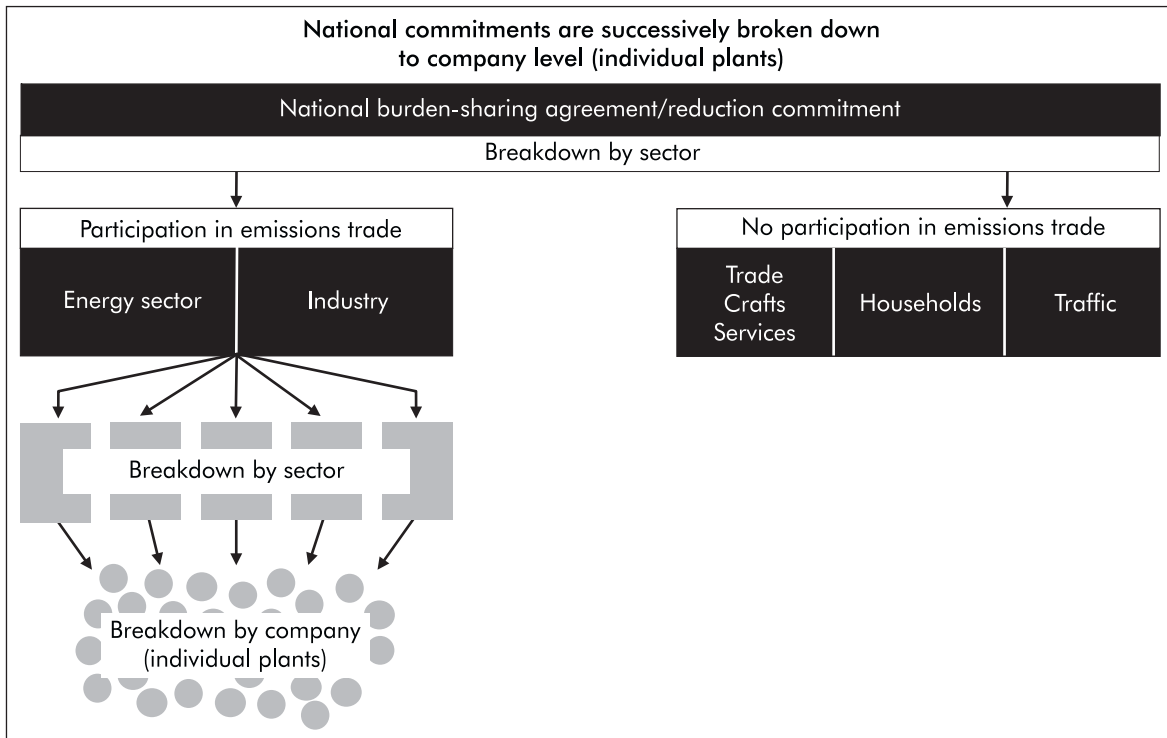
This allows European industry, at an early stage, to use the option of project-based schemes to lower the cost burden generated by reducing GHGs. In this way, an adverse impact on growth and jobs in EU countries could be contained, while making a contribution towards technology transfer.

The EU's trade in allowances is a plant-based system at company level. It affects power producers (combustion installations >20 MW_{th}, refineries, coking plants), the iron and steel sector, the mineral-processing industry (cement, glass, ceramics) and pulp, paper and cardboard makers. Throughout the EU, for example, some 12 000 plants in total will be affected. The transport, households and trade/crafts/services are exempt from emissions trading. Of the six Kyoto Protocol greenhouse gases, only carbon dioxide (CO₂) is included in the first trading period from 2005 to 2007.

In order to trade CO₂ emission allowances, initial allocations must be made. The directive imposed a duty on member States to publish national allocation plans (NAPs) by 31 March 2004 and to submit these to the EU Commission and to the other member States. Each NAP must state the total emission allowances that a member State proposes to issue in the three-year period 2005 to 2007 and how these allowances are to be distributed between the affected plants. The directive prescribes that member States must issue at least 95% of emission allowances free of charge for the period 2005 to 2007 and at least 90% for the period 2008 to 2012.

Figure 12

National Allocation Plan Process



The set-up of National Allocation Plans is a complex process and the detailed allocations will affect the commercial position of production plants and companies, as demonstrated by the following example of Germany.

The 2005-2007 NAP which each member State had to submit to the EU Commission in 2004 is divided into a macro-plan and a micro-plan. The macro-plan indicates the total number of allowances to be allocated as well as their breakdown by sector, while the micro-plan outlines the methods, rules and criteria for allocations, as well as the number of allowances for specific plants.

The predominant allocation method throughout the EU is grandfathering. Partial auctioning (maximum 5%) is only used in few countries.

The allocation of emission allowances to existing plants is usually based on historical emissions (in Germany *e.g.* on the emissions of the years 2000 to 2002) and emission projections for the years 2005 to 2007. New plants are subject to allocation on the basis of benchmarks. These benchmarks measured in gram CO₂/kWh are defined differently by the various member States. Some countries specify fuel-independent benchmarks, while others differentiate between feedstocks and technologies. In addition to the rules for existing and new plants, some countries offer the possibility to transfer allowances that were allocated to existing plants to newly erected substitute plants. Free allocation to new and substitute plants in Germany, for example, is as follows:

- Where old systems are shut down and substitute plants built, the emission allowances of legacy systems can be transferred to the substitute plants for four years (the transition rule). Thereafter, the substitute plants are given free allowances on the basis of fuel-specific benchmarks according to the state of the art for a further period of 14 years subject to a compliance factor of 1.

- For new power plants not built to replace existing plants, such as those operated by new market players, an emission value of 750 grams CO₂/kWh is made. This "benchmark" value is the weighted average of the emission values for modern lignite, hard coal or gas-fired power plants, and is equivalent to a hard coal-fired power plant with an electrical efficiency of 44%. For power stations having a specific fuel-related emission value lower than 750 grams CO₂/kWh, allocations will not be higher than actual needs, although they will be at least 365 grams CO₂/kWh. This minimum level is equivalent to a modern gas-fired power plant. Allocations are guaranteed for 14 years, subject to a compliance factor of 1.

Where the total emission allowances applied for by all plant operators exceed the emission budget, cutbacks in allocation will be made that in Germany, for example, can total up to 7.5% of the emission allowances requested by existing plants.

Research Initiatives

In the currently launched 6th European Framework Programme, numerous operators, suppliers as well as institutes from the field of energy technology are participating in several European research projects (*e.g.* ENCAP, CASTOR) dealing with the development of CO₂-free power stations. The ENCAP project investigates the zero-CO₂ integrated gasification combined cycle (IGCC) coal-fired power plant and investigates/further develops the oxyfuel process. The CASTOR project deals with the development of zero-CO₂ power plant technology based on the conventional steam power plant – an option involving integration of an additional CO₂ scrubbing stage downstream of the flue gas desulphurisation (FGD) system. The comparatively high energy demand of this process results from the regeneration of the required chemically acting scrubbing agent (amines) with steam extracted from the steam turbine.

At German level, too, the zero-CO₂ power plant is planned to be dealt with in the context of the COORETEC research project established by the Federal Ministry of Economics and Technology. The ongoing projects cover the period 2004-2008.

In the 6th European Framework Programme, CO₂ storage is also being investigated in integrated projects (*e.g.* CO2SINK). In the context of the CO2SINK project, CO₂ storage in so-called aquifers (porous, water-bearing rock layers) at a depth of approximately 600 m is planned to be experimentally tested at a location in Brandenburg.

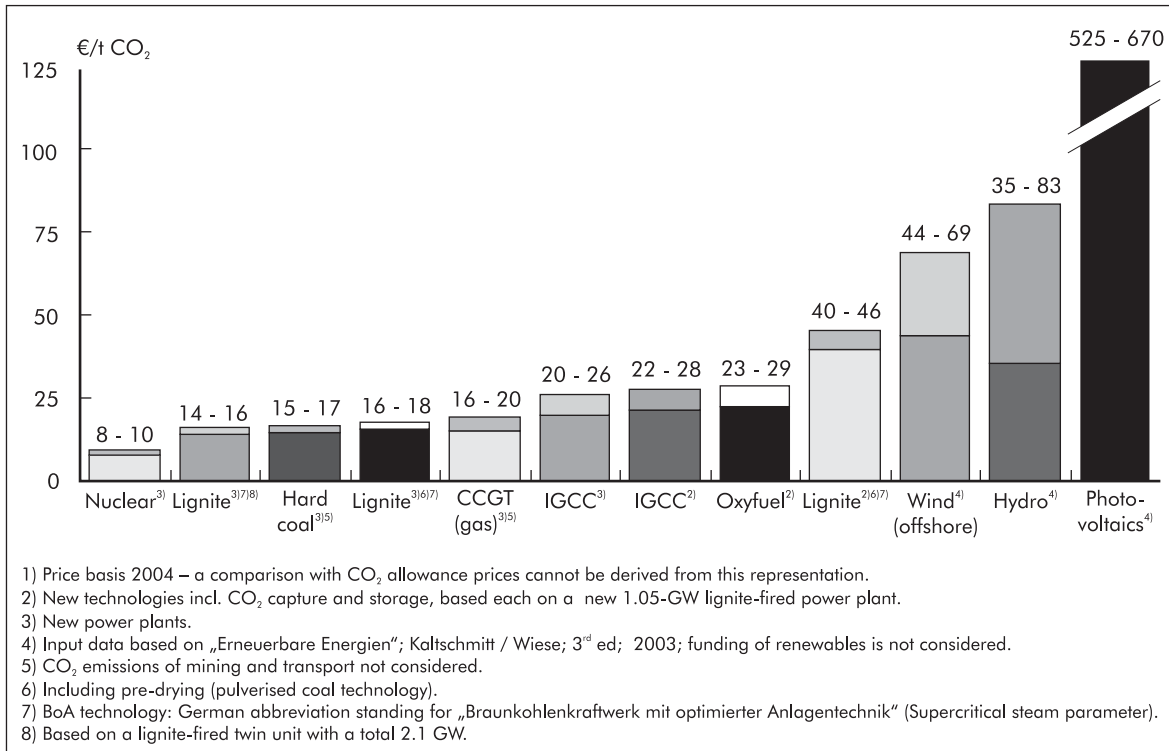
Policy Insights

The primary target of the European climate policy is the fulfilment of its Kyoto Protocol commitments. However, industry and energy trading partners expect energy supplies to be secure and favourably priced as well as environmentally compatible. Therefore security of supply, economic efficiency and environmental compatibility goals have to be pursued with equal priority within the scope of a sustainable energy policy. In order to achieve these goals, domestic energy resources need to be given appropriate consideration within a well-balanced energy mix, requiring that efficient, environmentally compatible coal-based power plant technology be further developed and replace old coal-fired plants.

The specific CO₂ avoidance costs are indicated in comparison with an old 150 MW lignite-fired power plant (reference plant). For the calculation, the average electricity generation cost comprising capital costs and operating costs of the respective comparative plant was determined first.

The CO₂ avoidance costs are the result of the difference between specific electricity generation cost divided by the difference between specific CO₂ emissions. Variations in relative prices of coal and gas would of course affect the above picture.

Figure 13

Specific CO₂ Avoidance Costs of German Power Generation¹⁾

Source: RWE.

The cost margins shown reflect the uncertainties with regard to fuel prices and costs of new technologies. For renewables, plant sizes and locations are additional factors determining the cost margin. As the costs of the reference plant, only the reducible costs were used (*i.e.* fuel costs and costs for inspections). In the case of hydropower stations and, also, for the construction of new installations including nuclear and fossil power plants (with and without CO₂ capture technologies), variable and fixed costs of the reference plant are reducible costs since no reserve capacity is required. Wind and solar energy, however, may temporarily not be available, so that there must be a fossil-fired plant as a reserve. Here, only the short-term variable costs (*i.e.* costs that only account for a fraction of total lignite-specific variable costs) of the reference plant are reducible.

If we take a hard coal power plant based on imported coal as a reference power plant, the fuel costs, unlike lignite which is mined by the operator, are completely variable costs. This means that the CO₂ avoidance costs would be different.

This comparison of the specific CO₂ avoidance costs shows that the most cost-efficient means of CO₂ mitigation are the use of nuclear energy and the renewal of power plants based on fossil energy sources. Investing in new power plants with higher efficiencies enables us to tap considerable CO₂ reduction potentials. For example, the construction of a new 1 000 MW state-of-the-art lignite-fired power plant that replaces existing units yields an annual CO₂ reduction of some 3 million tonnes.

The expansion of renewables with massive financial aid increases the costs of the power supply because it is not the most cost-effective means of reducing CO₂ emissions.

5. JAPAN

Key Messages

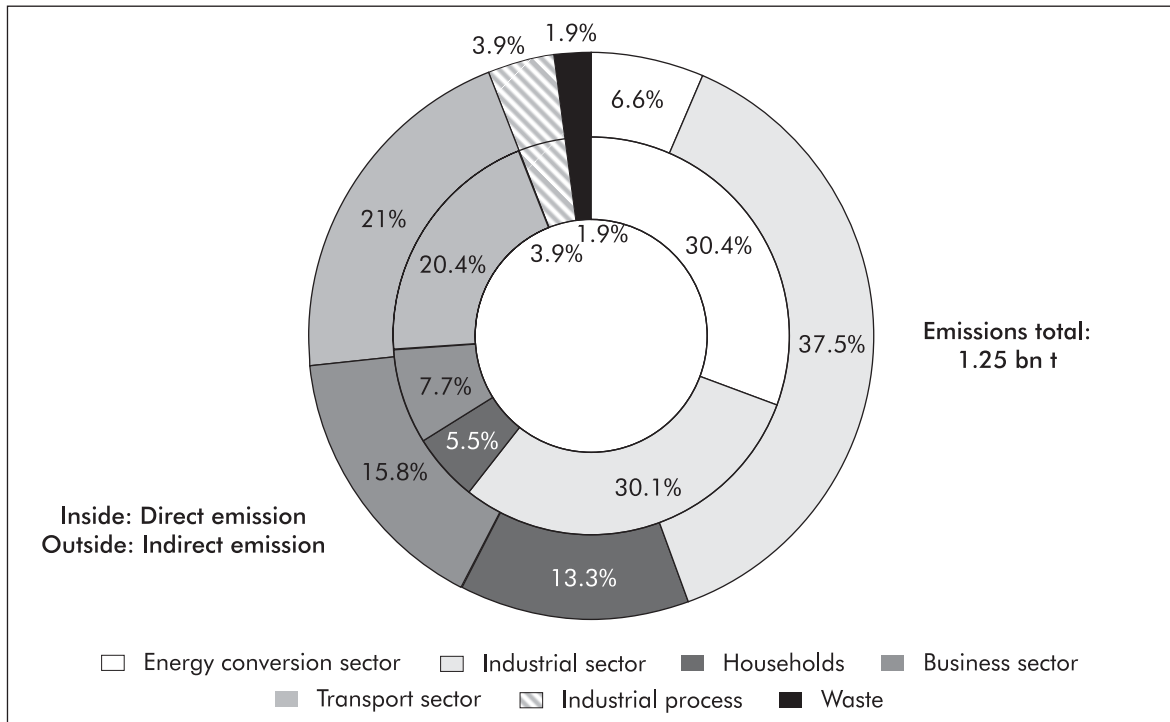
- Although the use of natural gas in power generation will grow, coal will retain an important position in Japan's energy mix.
- The commercial implementation of renewable wind and photovoltaic electricity generation is limited by geographical factors.
- Much progress has already been made on increasing the efficiency of coal-fired electricity generation through the use of advanced technology, so the potential for further increases in Japan is limited.
- One of the keys to Japan's compliance with its emission objectives under the Kyoto Protocol is the greater use of Kyoto JI/CDM mechanisms.
- Development of Clean Coal Technologies in the longer term requires government support and regulatory stability.

Energy Supply

In 2003, Japan was the fourth-largest energy consumer in the world and the second-largest energy importer. Fossil fuels accounted for a significant majority of this energy consumption: some 50% came from oil; 17% from coal; and 14% from natural gas. Nuclear energy was by far the most prominent non-carbon energy source; it contributed some 14% of Japan's total energy consumption. Although Japan is a world leader in renewable energy technologies, non-hydroelectric renewables account for less than 1% of total energy consumption. Japan's share of the world's total energy-related carbon emissions is some 5%.

For a variety of geographic, economic, political, and cultural reasons, Japan is one of the least energy- and carbon-intensive countries in the developed world. In part, this is due to the fact that Japanese energy costs are among the highest in the world, largely as a result of its very limited fossil energy resources. This has led the country's heavy industry, formerly a major energy consumer, to streamline its energy use. In addition, Japan has continued to shift away from energy-intensive industries and has developed extensive energy efficiency programmes.

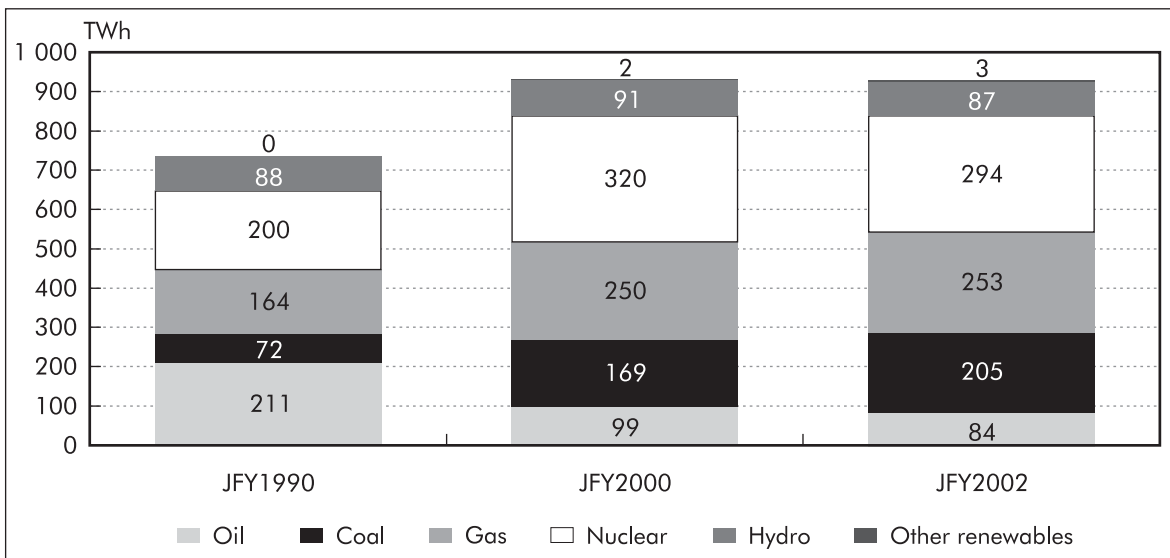
Figure 14
CO₂ Emissions in Japan According to Sectors



Source: Electric Power Development Company (EPDC).

Japan generated over 920 TWh of electricity on some 230 GW of capacity in 2002. Some 32% of electricity was generated from nuclear reactors, more than 27% from natural gas (LNG) and some 22% from coal (see Figure 15). These energy sources replaced oil, with its share declining to 9% in 2002.

Figure 15
Power Generation in Japan by Fuel



Source: Electric Power Development Company (EPDC)

Due to the country's desire to enhance its energy security and to reduce its carbon dioxide emissions, Japan has increased its reliance on nuclear power generation, which nearly doubled between 1985 and 2003.

Despite its relatively high cost, natural gas, mainly imported as liquified natural gas (LNG), is likely to experience considerable growth as a fuel for electricity generation. Renewables, chiefly hydropower and geothermal energy, also are expected to grow. An accelerating decline is projected for oil-fired generation, which is still more significant in Japan than in most other developed countries.

Japan, which is the third-largest coal user in Asia (behind China and India) and the seventh-largest globally, is by far the world's largest importer of steam coal, mainly for power generation, and of coking coal for its steel industry (22% of total world coal imports). The importance of coal will grow. Japanese power companies plan to construct an additional 13 GW of new coal-fired generating capacity by 2011.

It is accepted that the environmental performance of coal has to be further improved. Several coal-fired power plants using pressurised fluidised bed combustion and ultra-supercritical technologies have been operating for many years. Some of them have been developed by Electric Power Development Company (EPDC) with investment support from the government. Table 2 summarises the new coal-fired power plants with lowest emission factors commissioned between 1999 and 2005.

Table 2

Coal-fired Power Plants with Lowest Emission Factor in Japan
(placed in service between 1999 and 2005)

Plant ID	Plant type	Thermal efficiency (HHV)	Environmental control equipment and performance			Construction cost
			DeSO _x (emission at stack outlet)	DeNO _x (emission at stack outlet)	PM control (emission at stack outlet)	
A	USC*	42.8%	Wet scrubber: limestone-gypsum (24 ppm)	SCR** (24 ppm)	Electric precipitator (13 mg/m ³ N)	1 600 USD/kW
B	USC* (2 units)	42%	Wet scrubber: lime-gypsum (25 ppm)	SCR** (15 ppm)	Electric precipitator (16 x 2 mg/m ³ N)	1 630 USD/kW
C	USC*	43.6%	Wet scrubber: limestone-gypsum (50 ppm)	SCR** (50 ppm)	Electric precipitator (10 mg/m ³ N)	1 500 USD/kW
D	USC*	42.1%	Wet scrubber: limestone-gypsum (50 ppm)	SCR** (45 ppm)	Electric precipitator (10 mg/m ³ N)	2 000 USD/kW

*USC: Ultra-supercritical technology

**SCR: Selective catalytic reduction

Source: Electric Power Development Company (EPDC).

The average thermal efficiency in thermal power plants increased from 38.9% in 1995 to 41.0% by 2002. The major reasons for this have been the increased use of natural gas in combined cycle gas turbines with efficiencies above 50% and the installation of new ultra-supercritical (USC) coal-fired power plants with efficiencies above 40%. Figure 16 illustrates the increases achieved in coal-fired plant efficiency.

Coal is seen to contribute to the diversification of the Japanese energy mix. Since there is some uncertainty over the extent to which generation from nuclear power can be increased, the role of other fuels in power

generation is more likely to grow. The high cost of LNG and the uncertainties with respect to pipeline supply of gas may further expand the use of coal in the liberalised Japanese power market. Japan is also introducing ambitious energy efficiency programmes that will eventually lower overall electricity demand.

Figure 16

Gross Thermal Efficiencies of Coal-fired Power Plants



Source: Electric Power Development Company (EPDC).

CO₂ Emissions Reduction Potential

Wind Power

The Japanese government has announced its target for the installation of 3 000 MW of wind power generation capacity by FY2010, which is a challenging target. Based on current implementation promotion measures, it is forecasting the installation of 780 MW.

Table 3

Cost of CO₂ Reduction

(Illustrative only. Does not imply full feasibility of wind power)

	Capacity (MW)	Capacity factor (%)	Power generation (GWh/year)	Construction unit cost (USD/kW)	Construction cost (million USD)	Gross thermal efficiency (%)	CO ₂ emissions (kt-CO ₂ /year)	Reduction of CO ₂ emissions (kt-CO ₂ /year)
Coal (old)	1 000	70%				37%	5 370	
Coal (new)	1 000	70%	6 132	1 600	1 600	43%	4 620	749
Renewable (wind)	3 500	20%		1 667	5 833	-	0	5 370

Reasons for this include:

- Without both backup generating capacity and power quality control facilities, wind power plants are not able to provide the stable and high-quality power required by consumers.
- For mainly geographical reasons, potential sites with market-acceptable generation and transmission construction costs are very limited in Japan.

Table 3 shows the theoretical potential and cost of reducing CO₂ emissions using wind power. In practice, as discussed above, this potential will be significantly restricted.

Replacement of Old Coal-fired Power Plants with New Ones

Domestic reduction potentials appear limited in the short to medium term. The majority of new coal-fired power plants in Japan already employ Ultra-Supercritical steam conditions and the majority are too young to warrant renewal in the short or medium term. Further, the level of coal prices is not sufficiently high to encourage power companies to invest in further advanced technologies for fuel-cost saving reasons.

Replacement of old coal-fired power plants with renewable sources

Although they are very important and need to be developed as domestic and CO₂-neutral energy sources, photovoltaic and wind electricity generation are not considered alternatives to power generation from coal-fired power plants. The goal of introducing photovoltaic and wind power generation by FY2010 is 8 GW in total, on condition of implementing promotion measures currently in progress. In the same period, power companies' coal-fired power generating capacity is expected to increase to 44 GW.

The main reason for this limited growth is that photovoltaic and wind energies are naturally unstable and their power output fluctuations are unforeseeable, requiring backup generating capacity and power quality control facilities.

It is difficult to estimate the potential for cost reductions in these technologies. Discussions are still under way in Japan among renewable power generators, power companies that own and operate transmission and distribution facilities, and electricity consumers on the cost-sharing rules for the construction and/or reinforcement of transmission facilities.

Energy and Environmental Policy Context

Japan has been a strong supporter of efforts to avoid global warming and played host to the conference that led to the Kyoto Protocol, which was finalised in December 1997. In June 2002 Japan ratified the Protocol, with an undertaking to achieve a 6% GHG emissions reduction during the first commitment period. But Japan's energy-related CO₂ emissions actually rose by 11.2% between 1990 and 2002. Although CO₂ emissions per capita and per unit of GDP are lower than the IEA average, rising GHG emissions are one of the most important energy policy challenges in Japan.

The path towards the target has been laid down in the government's "New Guideline for Measures to Prevent Global Warming" published in March 2002. The government has developed a wide range of policies to address rising CO₂ emissions from energy use: energy efficiency standards over a range of equipment, voluntary building codes, labelling, growing support for renewable energy and conservation policies, as well as subsidies to encourage fuel switching. At present, no measures such as emissions trading exist in Japan, although the Japanese government monitors the development of such instruments in other countries. A simulation was organised by the Ministry of Environment (MOE) in early 2003, mostly as a learning tool for industry and government. MOE and METI (Ministry of Economy, Trade and Industry)

are studying the introduction of an Emissions Trading System or a Carbon Tax, but the direction of policy-making is yet to be decided.

Japan has an Energy Conservation Law that sets energy efficiency standards on a broad range of products, including everything from automobiles to home and office appliances. The law establishes a "Top Runner Program" that sets targets and timelines for energy saving improvements. Japan's Advisory Committee for Natural Resources and Energy plans to draw up a long-term plan for energy conservation in early 2004. This committee published an interim report in July 2004. The blueprint especially focuses on curbing consumption in the private and transportation sectors.

Since the late 1980s, Japan has become a world leader in the development and implementation of innovative and energy-efficient technologies. It is now one of the pre-eminent international disseminators of environmental technology. It has also improved in the monitoring and control of pollution and carbon emissions.

The government is trying to reduce energy consumption while at the same time encouraging the use of renewable, non-polluting energy sources. It is also attempting to curb energy consumption through economic incentives that affect both energy demand and supply, and is now emphasising environmentally sustainable development technologies in its foreign aid programmes, especially to other Asian countries.

An environmental impact assessment is legally required in Japan in the case of construction of new plant and repowering or modification of existing plant that increases capacity. The average duration of an environmental impact assessment process, including an initial survey of existing circumstances, various impact simulations, meetings for stakeholders' comments, and final reporting to the Ministry of Environment, is 4 years.

As of September 2004, the electric power generation companies are not legally obliged to reduce CO₂ emissions. The Federation of Electric Power Companies has announced a voluntary target: "Efforts will be made to reduce in 2010 the CO₂ emissions per generated power (t CO₂/kWh) in the electric power industry as a whole by about 20% as compared to the 1990 actual emissions. As a result, although the electric power output in 2010 is expected to increase 1.5 times over 1990, the absolute CO₂ emissions will be kept down to an increase of about 1.2 times."

New electricity generating plant construction decisions are influenced by several energy policy instruments:

Nuclear Power

In 2001, Japan released a "Revised Long-Term Energy Supply and Demand Outlook" which emphasises the development of nuclear power plants as effective means of reducing CO₂ emissions. It is planned to increase nuclear power generating capacity by 37% in the ten years to 2010, involving the expected construction of between 10 and 13 new nuclear power plants.

Renewable Energy

The Green Power Fund was established in 2000 to promote the use of wind power. Renewable energy also benefited from the Special Measures Law Concerning Promotion of the Use of New Energy by Electricity Utilities, which introduced a renewables portfolio standard (RPS) system.

The RPS system mandates that a certain percentage of power must come from renewable sources and is intended to force major power providers to generate or purchase renewable energy. Here, Japanese power utilities are legally obliged to purchase or produce the power generated from renewable energy, *e.g.* photovoltaic power, wind power, small hydropower, biomass power, and geothermal power.

Natural Gas

As of 2002, 70% of Japan's natural gas utilisation was for power generation. The government has introduced a subsidy to promote the use of natural gas, for example by replacing old coal-fired power plants by state-of-the-art natural gas-fired ones. Under this system, the government would subsidise 10% of the construction cost of a natural gas plant if a coal plant of more than 35 years of age were closed.

Coal

Japan has been promoting clean coal technologies because, while the country needs to continue using coal to ensure a balanced generation mix, it has ambitious emissions reduction targets under the Kyoto Protocol and improved efficiency in coal use would reduce emissions. The key technologies are:

- Ultra-supercritical (USC) steam conditions: In the last decade, most of the new coal-fired power plants have been installed with USC steam conditions in Japan.
- Integrated gasification combined cycle (IGCC): Major power companies in Japan have jointly established a research institute on IGCC which finalised the pilot-scale test and now constructs a 250 MW demonstration plant. It is expected that it will take some time before it reaches commercial maturity and comes into nationwide use. This is due partly to the fact that power demand growth in Japan is expected to be limited.

Recognising the progress already made in increasing the efficiency of domestic energy use, the Japanese government also has a near-term goal of supporting Kyoto mechanisms. Through offset projects certified under the international rules of the Kyoto Protocol, developed countries such as Japan are able to transfer high-efficiency and clean coal technologies to developing countries and then to receive emission credits to encourage them to promote further R&D. These mechanisms and actions are indispensable for sustainable coal development, and the government supports the establishment of a fund to facilitate their use. The fund will be operated mainly by the private sector but in co-operation with government-affiliated financial institutions such as the Development Bank of Japan and the Japan Bank for International Cooperation.

Currently a number of private Japanese companies are actively engaged in the Kyoto mechanism.

Policy Insights

A sizeable portion of Japan's energy needs until well beyond 2010 will be met by coal. Therefore, the widespread introduction of clean coal technologies is necessary to achieve energy efficiency savings, to limit emissions and to contribute to the GHG emissions targets laid down in the Kyoto Protocol. Japan has been in the forefront of the development of these technologies over the past decade and should be well placed to implement their commercial introduction.

But measures are needed to encourage the market deployment of clean coal technologies. This could be addressed through market-based incentives similar to those given to the development and commercialisation of renewable energy technologies, *i.e.* accelerated depreciation or tax discounts.

Long-term investment in clean coal technologies also requires stability in the environmental and other regulatory frameworks.

6. AUSTRALIA

Key Messages

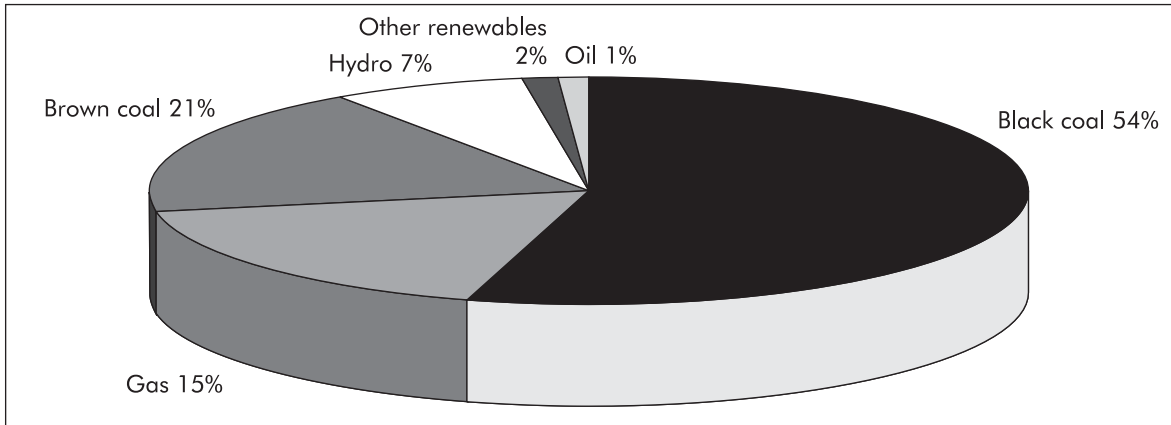
- Coal is essential to Australia's economic development and will retain a major role in domestic electricity generation despite the increased use of other fossil fuels.
- The COAL21 programme aims to define an integrated strategy for reducing CO₂ emissions in the medium term by deploying existing, efficient, coal-fired electricity technology and in the long term by developing CO₂ capture and storage technology. Australia has large CO₂ storage potential.
- Research, development and deployment of priority clean coal technologies require the further development of private/public partnerships and international co-operation. The recent announcement of a federal government fund to support the demonstration of low-emissions energy technologies is an important development in this respect.

Energy Supply

Australia has more than thirty coal-fired power stations, with a combined capacity of about 30 000 MW and accounting for approximately three-quarters of national electricity production (Figure 17). Almost all of them are sub-critical pulverised fuel (PF) plants, although there are three supercritical plants located in the State of Queensland with a combined capacity of more than 2 200 MW.

Australia derives enormous benefits from the cost-competitiveness and reliability of its coal-based electricity supply sector. Coal is the lowest-cost source of baseload power in Australia (Figure 18) and Australian electricity prices are amongst the lowest in the world (Figure 19). This has attracted major energy-intensive industries such as minerals mining and processing and pulp and paper that contribute greatly to exports and import substitution. However, it has also contributed to Australia having one of the highest per capita greenhouse footprints in the world, although its contribution to global emissions is small, at 1.4%, largely in line with its share of the world economy.

Figure 17
Australian Electricity Generation 2003-04

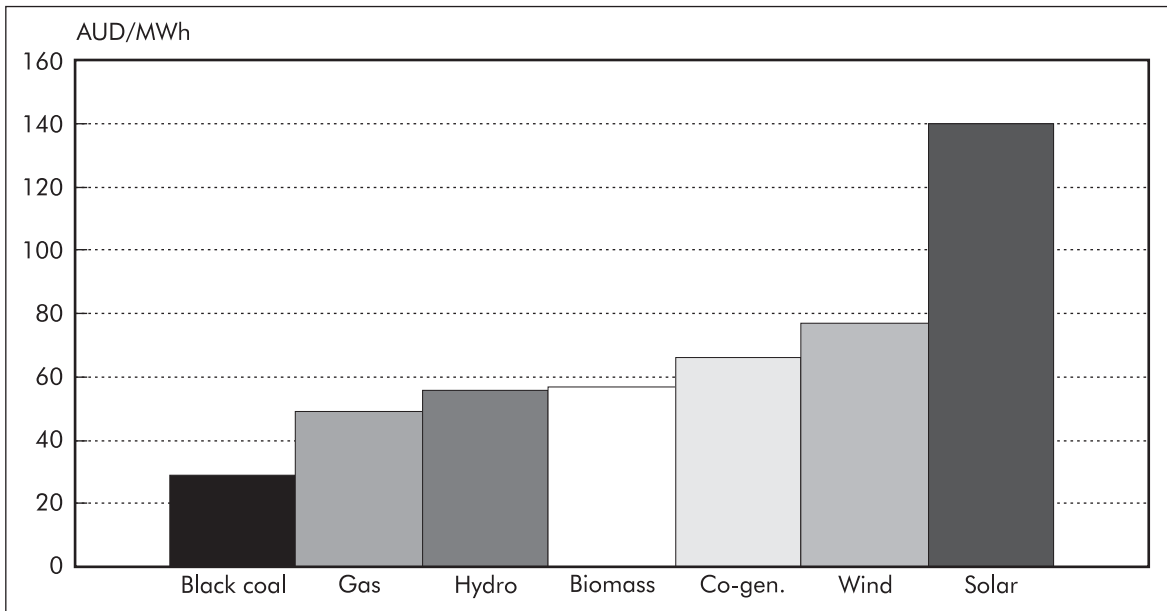


Source: ABARE, August 2004.

Currently about half of Australia's total greenhouse gas emissions are from stationary energy, and of this about two-thirds is from electricity generation. Coal-based power generation accounts for about 30% of Australia's total emissions.

Electricity use in Australia has risen strongly over the last decade, and will continue to do so. The Australian Bureau of Agricultural and Resource Economics forecasts electricity demand to increase by 2.4% per annum to 2020. Over this period, coal's share of generation is expected to decline to 71%, replaced mainly by gas and some non-hydro renewables, although black coal consumption for generation will nevertheless increase by an expected 2.2% per annum and brown coal by 1.2% per annum.

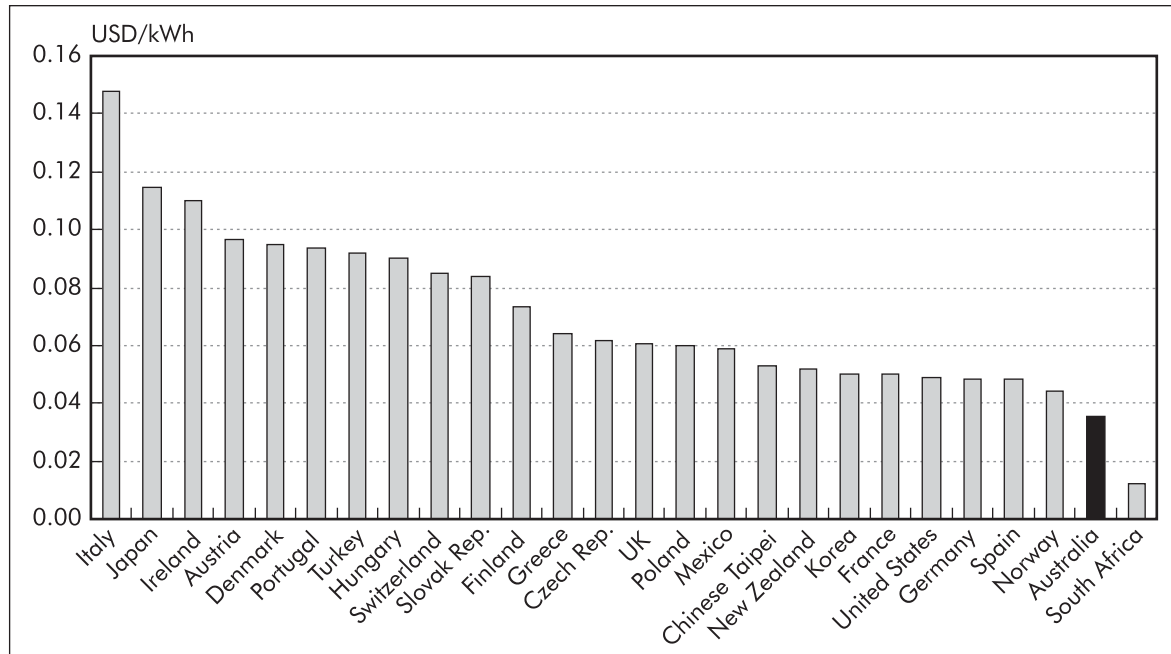
Figure 18
Australian Electricity Generation Costs (AUD/MWh)



Source: Prime Minister's Science, Engineering and Innovation Council, 2002.

In the absence of measures to significantly reduce the average greenhouse intensity of coal-based power generation, emissions from Australian energy use will continue to increase solidly for the foreseeable future. It is the policy challenge posed by this situation – that is, to reconcile Australia’s continuing dependence on coal and other fossil fuels with the need to achieve major emissions reductions over a realistic timeframe and in a cost-effective manner – which the coal industry and government are seeking to co-operatively address through the COAL21 programme.

Figure 19
International Electricity Prices (Industrial)



Source: IEA, 2004.

CO₂ Emissions Reduction Potential

COAL21 (see below) looked at the potential for abatement of greenhouse gas emissions from Australian coal-based electricity by 2030, in the context of strong forecast growth in electricity demand and coal-fired generation. It found that a reduction in the average emissions intensity of coal-based generation from the current level of 1 020 kg CO₂/MWh, to 650 kg CO₂/MWh in 2030 was possible, provided certain key assumptions were met. These included the retirement of all existing generating capacity at 40 years of age and steady increases in the thermal efficiency of new and replacement plant.

A reduction in emissions intensity of this magnitude would result in annual emissions from coal-fired power being lower than they are currently, despite an assumed 35% (10 000 MW) increase in installed coal-based generating capacity over the period.

Some of this reduction in emissions intensity (to about 880 kg CO₂/MWh) would occur under a business-as-usual scenario through the installation of reasonably efficient (41% HHV) supercritical PF plant in place of retired sub-critical capacity to meet new demand. Reductions below this (to about 760 kg CO₂/MWh) would require best available technology to be employed, *i.e.* increasingly efficient supercritical and ultimately

ultra-supercritical plant (52%). Achievement of 650 kg CO₂/MWh emissions intensity of coal-based generation by 2030 would require moderate deployment of CO₂ capture and storage commencing around the middle of the next decade.

Each of these reduction scenarios could be augmented by additional measures, where technically and commercially practical, such as the utilisation of power station fly ash and coal mine methane, retrofit of existing generating capacity and the application of lignite drying to brown coal-based generation.

The current potential of these options is summarised in the following table.

Table 4

Some Options for Reducing GHG Emissions from Coal-fired Power in Australia and their Potential to Abate Emissions (based on COAL21)

Option	Description	Abatement potential
Increased energy efficiency in mining operations	Reducing the energy intensity of coal extraction, handling and delivery to power stations.	Low – Australian coal mining operations are already highly efficient.
Improved coal preparation	Coal washing and beneficiation to reduce ash and other impurities and, in the case of lignite, moisture content.	Low for black coal – preparation has little effect on emissions. Moderate to high for brown coal – provided the moisture can be removed in an energy-efficient manner.
Use of process wastes	Utilisation of coal bed methane (CBM) for gas supply/power generation. Power generation from coal washery rejects (CWR). Use of power station fly ash in cement/concrete making.	Low – Australian power stations are supplied by open cut and non-gassy underground mines. Low – CWR use is very site-specific. Low to moderate – only 10% of fly ash is currently re-used, compared to 40-60% in some countries.
Synergies with renewable energy	Co-firing coal with biomass (5%). Linking coal thermal with solar thermal.	Low to moderate – companion systems can improve the efficiencies of biomass/solar conversion and therefore their economics; however, practical factors limit the suitability of these options for established power stations.
Power station efficiency improvements	Plant upgrades, retrofits and repowering to increase plant efficiency.	Low to moderate for black coal plants – cost-effectiveness is a major constraint.
Advanced generation systems	Ultra-supercritical (USC); integrated gasification combined cycle (IGCC); formative concepts such as fuel cells powered by hydrogen from coal.	Moderate to high - depending on the efficiency improvement, e.g. displacement of a sub-critical PF plant (36% HHV) by a USC plant (45%) would reduce emissions from that load by 20%.
CO ₂ capture and storage (CCS)	Pre/post capture of CO ₂ from power station gas streams and its permanent storage in underground reservoirs.	Very high – CCS is the key to radically reducing and possibly eliminating emissions from coal-based power generation.

This ranking of options has two main implications:

- There is a range of measures available to coal mines and electricity generators to effect incremental reductions in greenhouse gas intensity. The extent to which these are employed will depend on their practicality and viability. They tend to be highly site-specific and measures will be taken if and when they support improved mine/plant economics.
- The achievement of major reductions in emissions intensity is dependent on the application of CO₂ capture and storage (CCS) and of the advanced coal combustion/treatment techniques that support CCS.

In the context of rapidly growing fossil fuel-based electricity generation, as in Australia, the second point takes on even greater significance; and the development and deployment of these low and near-zero emissions technologies becomes essential to the long-term sustainability of the nation's energy system.

Energy and Environmental Policy Context

For Australia to contribute meaningfully to the international goal of stabilising greenhouse gas concentrations in the atmosphere will require the widespread adoption of low-emissions energy technologies and, given Australia's resource base and economic structure, the application of zero-emission coal-based power generation must be a major element of any such technological response. Also, progress towards this long-term goal needs to be marked by incremental reductions in the greenhouse intensity of the Australian energy sector, and coal production and use have a role to play in this regard as well.

Australia's objective is therefore to make steady progress on the reduction of GHG emission intensity over the short to medium term on the way to substantial emissions reductions in the longer term. How best to achieve these objectives is the subject of debate within Australia by governments, industry, interest groups and the community generally.

While Australia is a signatory to the United Nations Framework Convention on Climate Change, current federal government policy is not to ratify the Kyoto Protocol or introduce measures such as emissions limits, emissions trading or carbon taxes, on the basis that to do so would not be in Australia's interests. These national interests include the importance of low-cost and reliable fossil fuel-based energy to Australia's international competitiveness and living standards, and the contribution to national income from the production and export of fossil fuel-based energy commodities.

There is a range of measures that have been introduced by the federal and state governments in Australia to reduce greenhouse gas emissions from energy supply and use. These include both voluntary and mandatory measures relating to emissions, energy efficiency, demand management and fuel choice, and support for research and development of lower emissions energy technologies. Coal use and coal-based low emissions technologies feature prominently in the national research effort through the Commonwealth Science and Industrial Research Organisation's (CSIRO) "Energy Transformed" Research Flagship Program and a number of co-operative (industry/government/research sector) programmes investigating black and brown coal-based power generation technologies and CO₂ capture and storage.

Most recently, the federal government recognised the importance of encouraging the demonstration of low emissions fossil fuel-based energy technologies by announcing the creation of a fund to facilitate such projects. The Low Emissions Technology Demonstration Fund will provide funding of up to one-third of the cost of industry-led projects for large-scale demonstration of low emissions technologies with significant long-term abatement potential. Total outlays are expected to be AUD 500 million to June 2008, with at least an additional AUD 1 000 million from industry proponents, focusing on technologies that are capable of lowering Australia's GHG emissions by at least 2% and have potential to be commercially available between 2020 and 2030.

The LET Demonstration Fund was one of a suite of GHG reduction measures – including mandatory energy efficiency improvement assessments by large-scale energy consumers, and extended renewable power subsidies – announced by the government in its June 2004 Energy White Paper entitled *Securing Australia's Energy Future*. It represents a major opportunity for the Australian coal industry to realise significant public funding support for the demonstration of a black coal-based ZET facility – most likely an IGCC plant with integrated CO₂ capture and geological storage. The need for such a demonstration under Australian conditions, and in partnership with government, was one of the main conclusions from the assessment of coal technology development requirements carried out under the auspices of the industry's COAL21 programme.

COAL21

COAL21 is a partnership between coal producers, electricity generators, research institutions, and federal and state governments. It aims to:

- Create a national plan to scope, develop, demonstrate and implement near zero emissions coal-based electricity generation that will achieve major reductions in greenhouse gas emissions over time and maintain Australia's low-cost electricity advantage.
- Facilitate the demonstration, commercialisation and early uptake of technologies identified in the plan.
- Promote relevant Australian RD&D and provide a mechanism for effective interaction and integration with other international zero-emission coal initiatives.

The first major instalment of this programme occurred in March 2004, when COAL21 released a National Plan of Action for Reducing Greenhouse Gas Emissions Arising from the Use of Coal in Electricity Generation (www.australiancoal.com.au). This followed twelve months of consultation among the coal and electricity industries, governments, the Australian research community and interest groups.

The action plan examines the range of current and emerging technologies for reducing emissions from coal-fired generation and identifies those that are particularly promising for Australia in terms of their ability to facilitate near zero-emissions, increase energy efficiency and facilitate hydrogen production. It also reviews the developmental status of each of the technologies and makes recommendations on actions, including government policies, which are required to accelerate their commercialisation and adoption in Australia. Finally, the plan looks at the extent of greenhouse gas emissions abatement that, conceivably, could be achieved from a concerted programme of support and application of these key technologies.

Table 5 describes these priority technologies and their development status and needs.

Among the COAL21 priority technologies, geological storage is pivotal in that it will enable the CO₂ released from the coal, whether via combustion or gasification, to be prevented from entering the atmosphere. Geological storage of CO₂ is a viable option for Australia where underground storage potential is immense, there being enough reservoir capacity to contain in excess of 1 600 years of Australia's current total annual net emissions (stationary emissions at current rate of emissions).

How this translates into realistic storage potential, however, depends on a range of technical and economic factors relevant to the matching of stationary CO₂ emission sources and geological sinks. A detailed assessment of these factors has led to an estimate that about one-quarter of Australia's current annual emissions – that is, more than 100 Mt CO₂/year – could be geologically sequestered.³ Of this, a significant proportion would be emissions from coal-fired power generation.

3. *Australia's Geological Storage Potential and Matching of Emission Sources to Potential Sinks*, J Bradshaw, G Allinson, G Bradshaw, V Nguyen, A Rigg, L Spencer and P Wilson, 2004.

The extent and rate of potential abatement of emissions from coal-based generation will depend on how actively certain technological advances are pursued. The COAL21 Action Plan separates the period to 2030 into two phases with different emphases on technological development.

The first phase is from now until around 2015, during which the main focus should be on the RD&D required to develop priority technologies to the stage that they are commercially deployable by Australian industry. Also during this time, commercially sensible opportunities to incrementally improve upstream and downstream greenhouse performance (*e.g.* ash/methane use, plant retrofits) should be taken, and any new baseload coal-fired capacity should be the most efficient available technology that is competitive in the Australian generation market.

Phase two from around 2015 would be a deployment phase in which the newly commercialised priority technologies, particularly CO₂ capture and storage, are introduced progressively and at an increasing rate. During this phase, “sequestration ready” technologies, such as IGCC and oxyfuel combustion, should be preferred for new capacity as these configurations become competitive, even if CO₂ capture and storage is not applied to the plants immediately.

Table 5

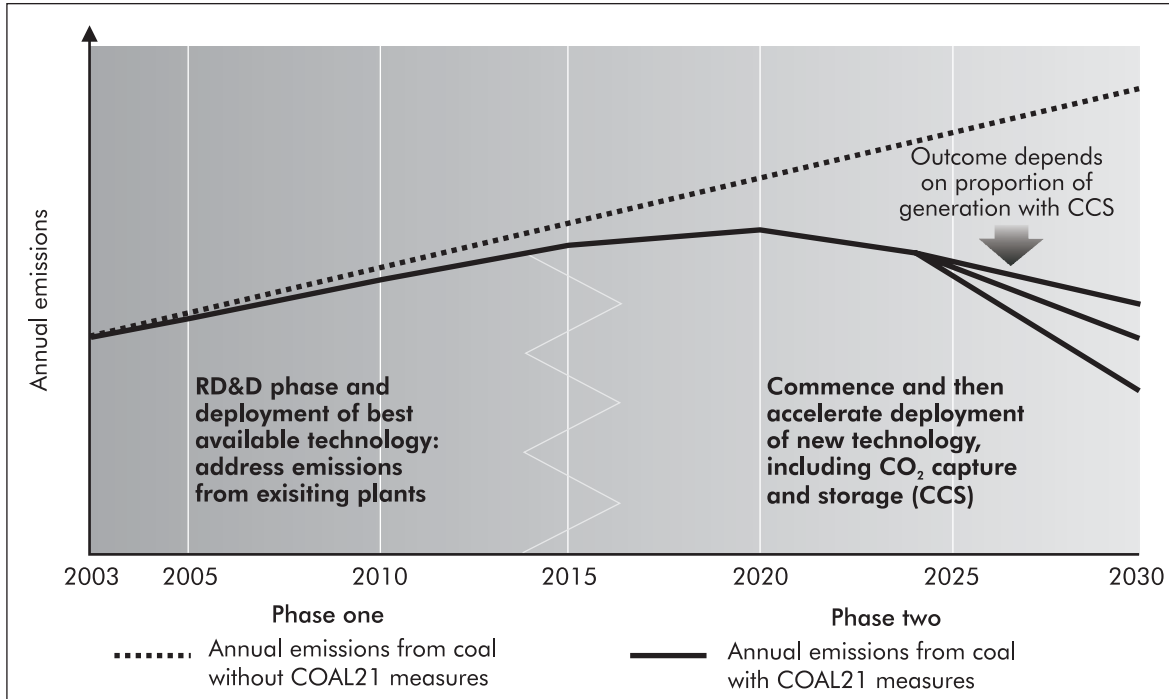
Technologies for Australia and their Development Status and Needs

Technology	Role	Development	
		Status	Needs
CO ₂ capture and geological storage	Key enabling technology for achieving major emissions reductions, and ultimately zero emissions, for Australian coal-based electricity.	Capture is feasible but uneconomic, requiring more cost-effective techniques for low CO ₂ exhaust streams and/or achieving higher concentration streams via oxy-firing and coal gasification.	Site demonstration under Australian conditions, focusing on long-term storage integrity, safety and environmental effects.
Integrated gasification combined cycle	Enable higher efficiency, lower-cost CO ₂ capture and hydrogen production.	Black coal – commercially proven in the USA and Europe, but not yet demonstrated in Australia. Lignite – locally developed brown coal drying, gasification trialled at small scale.	Australian demonstration of black coal IGCC plant. Requires commercial scale demonstration.
Oxyfuel combustion	Enable post-combustion CO ₂ capture, and possible retrofit option for existing PF plant.	Early developmental stage.	Pilot-scale furnace and oxygen separation trials; retrofit to existing coal boiler; commercial-scale demonstration.
Lignite dewatering and drying	Enable higher efficiency lignite-based generation and the use of brown coals in IGCC.	A number of promising technologies have been developed in Australia.	Further pilot and demonstration-scale plants are required.

The two phases are represented in Figure 20. A summary of the COAL21 Action Plan for Australia is reproduced in Table 6.

Figure 20

COAL21 - Advanced and Low Emissions Technology Development Phases



Policy Insights

COAL21's conclusion that the next ten to fifteen years is a period of research and demonstration of priority technologies has important implications for Australian energy policy and the respective roles of government and industry. The need to support the further development and commercialisation of these technologies points to a public-private partnership approach (a “push together” model) rather than a market-based or regulated approach (or “pull through” model) that seeks to change behaviour in respect of established practices and technologies.

The partnership approach is a familiar one. It recognises that stimulating the development of new, low-emissions energy technology is in the public interest, and therefore that governments should share the costs. It also recognises that this activity cannot be left solely to markets, whose perspectives tend to be shorter term than is required to achieve socially desirable levels of investment in these technologies.

In Australia, most RD&D of coal use technologies already involves cost-sharing by industry and governments – this includes the Co-operative Research Centres for “Coal and Sustainable Development”, “Clean Power from Lignite” and “Greenhouse Gas Technologies”, and the newly formed Centre for Low Emission Technologies (CLET). The Commonwealth Science and Industrial Research Organisation’s (CSIRO) “Energy Transformed” research programme also focuses on obtaining private sector partners.

However, the further development of the priority coal technologies identified by COAL21 would require a significantly greater level of commitment on the part of industry and government than in the past.

Demonstration-scale plants will involve substantial uneconomic elements – activities such as CO₂ capture and storage and oxy-firing that will involve higher costs and risks than competitive energy markets will tolerate, and for which industry will need government assistance if it is to consider investing in these first-of-a-kind integrated facilities. The level and nature of such assistance would be project-specific – there is a range of direct and indirect instruments available to government, and projects will differ in scale, risk profile and market circumstances.

There is also an onus on industry and government to ensure that expenditure is carefully targeted, given the potential sums involved and the need to avoid duplication of effort in an area where unnecessary delays will have global environmental consequences. For a relatively small country like Australia, this means focusing on areas of technology development where it has emerging expertise (such as geological storage of CO₂) or for which local circumstances require a local solution (such as the gasification of Australian black and brown coals).

It also requires close collaboration with international RD&D in order to assist the progress of priority technologies and learn how to adapt them to Australian conditions. In so doing, Australia needs to match its research and demonstration efforts to its capabilities, seeking out projects that may be modest in scale but nonetheless complementary to larger overseas programmes. The aim should be to contribute meaningfully to the larger, global RD&D effort while equipping Australia to be a fast-follower as key technologies become commercialised.

It is the potential for the Australian government's recently announced Low Emissions Technology Demonstration Fund (see earlier) to accommodate the above requirements that make this initiative particularly significant, and to present the coal industry with the opportunity to realise a key goal in the form of a visible and successful coal-based, near-zero emissions power project.

Table 6

Australia's COAL21 Action Plan Summary

Reduce non-power station emissions	Reduce emissions from existing generating capacity	Deployment of new and replacement generating capacity	Australian RD&D priorities	Role for government	Role for industry
PHASE 1: RD&D Phase					
<ul style="list-style-type: none"> Minimise fugitive emissions of methane from mining operations where practical 	<ul style="list-style-type: none"> Improve existing generating units through refurbishments, retrofits or repowering where appropriate and cost-effective 	<ul style="list-style-type: none"> Deploy most efficient conventional PF units economically available at the time of construction 	<ul style="list-style-type: none"> Complete techno-economic assessments of CO₂ abatement options 	<ul style="list-style-type: none"> Support and facilitate RD&D into priority technologies 	<ul style="list-style-type: none"> Support RD&D into CCTs and ZETs
<ul style="list-style-type: none"> Maximise reuse of flyash 	<ul style="list-style-type: none"> Apply lignite dewatering technology when proven and economically viable 	<ul style="list-style-type: none"> Prefer deployment of "sequestration ready" technology where feasible 	<ul style="list-style-type: none"> Improve CO₂ capture technologies to lower costs 	<ul style="list-style-type: none"> Support Australian pilots and/or demonstrations of CCTs and ZETs in partnership with industry 	<ul style="list-style-type: none"> Support pilot and/or demonstration projects in partnership with government
<ul style="list-style-type: none"> Continuously improve energy efficiency of mining operations 	<ul style="list-style-type: none"> Deploy oxyfuel retrofits when proven and cost-effective 		<ul style="list-style-type: none"> Complete assessment of Australia's geosequestration potential 	<ul style="list-style-type: none"> Ensure that policy encourages RD&D into longer-term solutions 	<ul style="list-style-type: none"> Foster greater community awareness and acceptance of CCTs, ZETs and related issues
			<ul style="list-style-type: none"> Prove CO₂ injection and storage 	<ul style="list-style-type: none"> Facilitate international collaboration through bilateral and multilateral forums 	
			<ul style="list-style-type: none"> Adapt IGCC for Australian conditions and demonstrate IGCC and IDGCC 	<ul style="list-style-type: none"> Foster greater community awareness and understanding of CCTs, ZETs and related issues 	
			<ul style="list-style-type: none"> Assess and develop oxyfuel combustion 		
			<ul style="list-style-type: none"> Develop and commercialise lignite dewatering and drying 		
			<ul style="list-style-type: none"> Further develop and commercialise UCC 		
			<ul style="list-style-type: none"> Increase international collaboration 		

Table 6 (continued)
Australia's COAL21 Action Plan Summary

Reduce non-power station emissions	Reduce emissions from existing generating capacity	Deployment of new and replacement generating capacity	Australian RD&D priorities	Role for government	Role for industry
PHASE 2: Deployment Phase					
<ul style="list-style-type: none"> Continue methane abatement 	<ul style="list-style-type: none"> Retire less efficient plants and replace with best available technology, preferably ZETs when economically viable 	<ul style="list-style-type: none"> Commence deployment of ZETs for new and replacement capacity 	<ul style="list-style-type: none"> Continue RD&D of priority technologies where required 	<ul style="list-style-type: none"> Continue targeted support for identified RD&D gaps 	<ul style="list-style-type: none"> Continue support for priority RD&D
<ul style="list-style-type: none"> Continue and increase flyash reuse 		<ul style="list-style-type: none"> Accelerate deployment as costs reduce 	<ul style="list-style-type: none"> Respond to new RD&D priorities, including for novel technologies 	<ul style="list-style-type: none"> Ensure that policy encourages deployment and does not discriminate against ZETs 	<ul style="list-style-type: none"> Work with government to ensure policy frameworks and regulation preserve economic competitiveness while reducing emissions
<ul style="list-style-type: none"> Continuously improve energy efficiency of mining 			<ul style="list-style-type: none"> Continue high level of international collaboration 	<ul style="list-style-type: none"> Ensure that policy encourages abatement while maintaining competitiveness 	<ul style="list-style-type: none"> Continue to foster greater community awareness and understanding of CCTs and ZETs
				<ul style="list-style-type: none"> Continue to foster international collaboration 	
				<ul style="list-style-type: none"> Continue to foster greater community awareness and understanding of CCTs and ZETs 	

7. UNITED STATES

Key Messages

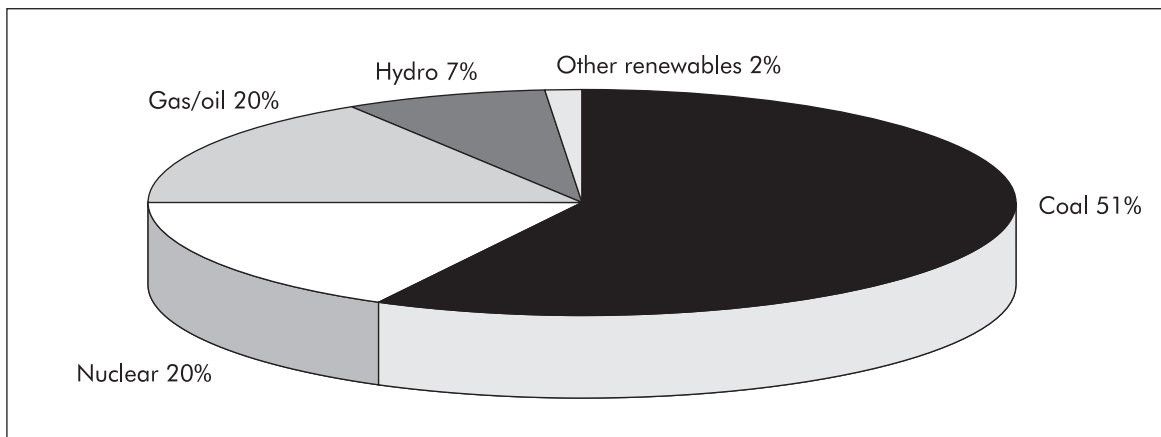
- The US will remain dependent on coal for the majority of its electricity production for at least the next two decades.
- The key to long-term, sustainable reductions in CO₂ emissions is the development and deployment of ultra-low emissions generating technologies, including carbon capture and storage technologies. The proposed FutureGen project is one example of the sort of technology required to address this challenge.
- US climate protection policy emphasises the role of voluntary public/private initiatives.

Energy Supply

In the United States, the primary consumption of energy by all users (*i.e.* residential, commercial, industrial, transportation and electricity production) comprises predominantly oil and gas, which accounted for 61% of total use in 2003. Most primary energy use for users other than the electric sector comes from the direct use of liquid and gaseous fuels for heating, industrial and transportation uses. With the large amount of liquid and gaseous fuel usage in the US, over 30% of total US primary energy use is covered by imports and more than half of oil consumed in the US has to be supplied by foreign producers.

However, the majority of electricity in the US is produced by coal (51%), with approximately 20% from nuclear, 20% from natural gas and oil, and most of the balance from hydro, with relatively small amounts from renewable resources such as wind. EIA projections, as well as others, indicate that coal will continue to produce the majority of electricity in the US economy for at least the next two decades. In fact, with no new nuclear construction in the US currently planned, tight supplies of natural gas to the US and declining domestic production, and limitations on how rapidly other sources such as renewable power can grow to meet growing US demand for electricity, coal will likely end up meeting an increasing share of US power needs in the coming decades.

Figure 21
Electricity Generation by Fuel - 3 852 TWh in 2003



Source: EIA

CO₂ Emissions Reduction Potential

While the implementation of existing electricity generation efficiency improvement technologies and mechanisms can provide useful reductions in CO₂ emissions in the short to medium term, in the longer term CO₂ emissions reductions will crucially depend on the development and deployment of ultra-low emissions technologies, including carbon capture and storage (CCS) technology developments. In the US several initiatives have already begun that focus on carbon capture and storage.

Carbon Capture and Sequestration Research

A number of US entities are engaged in research intended to develop carbon sequestration technologies and options. A variety of government agencies and other entities are involved. Research programmes address sequestration of atmospheric carbon by terrestrial systems (agriculture and forestry), and use of geologic and oceanic reservoirs for use in association with a CCS approach. Much of this research is being conducted co-operatively, with industry and academic involvement.

The Department of Energy (DOE) carbon sequestration research activities encompass all aspects of carbon sequestration with core R&D efforts aimed at developing a portfolio of technologies to cost-efficiently capture and permanently store CO₂. The DOE programme consists of a number of key elements including FutureGen, the Carbon Sequestration Leadership Forum (CSLF), a core R&D programme and the Regional Sequestration Partnerships.

FutureGen

FutureGen, the "Integrated Sequestration and Hydrogen Research Initiative", is a USD 1 billion government-industry partnership to design, build and operate a practically emission-free, coal-fired electric and hydrogen production plant in the United States. The 275 MW prototype plant will serve as a large-scale engineering laboratory for testing new clean power, carbon capture, and coal-to-hydrogen technologies. Virtually every aspect of the prototype plant will employ cutting-edge technology. As regards capture technologies, CO₂ will be separated from the hydrogen possibly by novel membranes currently under development. It would then be permanently sequestered in a geological formation. Candidate reservoir(s) could include depleted oil and gas reservoirs, unminable coal seams, deep saline aquifers, and basalt formations. A number of major US coal and utility companies are involved in the FutureGen project.

The Carbon Sequestration Leadership Forum

The United States hosted the first meeting of the Carbon Sequestration Leadership Forum in June 2003. This international partnership co-ordinates data gathering, R&D and joint projects to advance the development and deployment of carbon sequestration technologies worldwide. The Forum, which now includes 15 countries and the EU, held its second Ministerial meeting in September 2004 where ministers approved 10 capture and storage projects as well as a Technology Roadmap to provide future directions for international co-operation.

Multi-agency Core Carbon Sequestration Research

The US government's core sequestration R&D emphasises technologies that directly capture CO₂ from large point sources and store the emissions in geologic formations. Reducing net CO₂ emissions from these facilities with CO₂ capture technology represents an opportunity to achieve substantial emissions reductions. Storing CO₂ in geologic formations is considered an attractive option for a number of reasons. In the case of depleted oil reservoirs or deep coal seams, CO₂ can be used to enhance oil recovery or produce methane thus providing economic incentive to store carbon. Furthermore, saline reservoirs are geographically located throughout the world and have the capacity to store vast amounts of CO₂.

The DOE also supports a multi-laboratory consortium for Carbon Sequestration in Terrestrial Ecosystems (CSiTE) to perform fundamental research on mechanisms that can enhance terrestrial carbon sequestration as one component of a more comprehensive carbon management strategy.

The Department of Agriculture's global change research programme is also strengthening efforts to determine the significance of terrestrial systems in the global carbon cycle and to identify agricultural and forestry activities that can contribute to GHG reductions in the atmosphere.

Regional Carbon Sequestration Partnerships

The regional sequestration partnerships consist of state agencies, universities, and private companies that form the core of a nationwide network designed to determine the best approaches for capturing and permanently storing GHGs. Collectively, the partnerships include more than 140 organisations spanning 33 states, three Indian nations, and two Canadian provinces.

The partnerships will develop a framework to validate and potentially deploy carbon sequestration technologies with a focus on determining which sequestration approaches are best suited for each geographic region. They will also study regional regulations, safety and environmental concerns, and the infrastructure that would be required if sequestration technologies were to be deployed. At the end of the first two-year phase, the partnerships will recommend technologies for small-scale validation testing in a Phase II competition expected to begin in 2005.

Energy and Environmental Policy Context

In the US, electricity markets have been restructured though not fully deregulated. Restructuring efforts vary significantly from state to state. Wholesale electricity markets were partially deregulated (for independent power producers) during the late 1970s and 1980s, and for all wholesale participants during the mid-1990s. These actions, as well as relatively plentiful supplies and low prices of natural gas and the relative uncertainty with respect to emissions policies, led to the boom in construction in new gas-fired combined cycle plants and combustion turbines during the 1990s. By the late 1990s, many developers were seeking to become major participants in the emerging deregulated generation market. These participants were spurred by high wholesale power prices and rosy economic and electricity growth projections to add very large amounts of new generating capacity.

However, the pace of retail deregulation that was expected by many to accelerate across many states in the US was dealt a major blow by the 2000-2002 power crisis in California. In addition, the economic downturn in 2001-2002 plus a more than doubling of natural gas prices led to vast amounts of uneconomic over-capacity in many parts of the US. It is against this uneasy backdrop of financial difficulties for merchant power and a patchwork of regulated/deregulated electricity industry that future power requirements in the US will need to be met.

In addition to the end or even reversal of retail electricity deregulation at the state level, comprehensive energy policy legislation failed to pass in the Congress in 2004. The legislation, which was designed to spur future domestic supplies of oil and gas, coal and renewable energy, promote conservation and demand-side management, as well as provide the appropriate framework and incentives for investing in US electricity infrastructure, has foundered on election year politics. Although it is expected that a similar energy package will be considered again in 2005, the delay will mean that the US's growing dependence on foreign sources for energy (primarily oil and natural gas or LNG) will likely continue to grow. It also highlights the important role of coal-fired power as the only large domestic source of power in the US.

Finally, the US Environmental Protection Agency (EPA) is in the process of finalising rules that would require substantial further reductions in sulphur dioxide, nitrogen oxides and mercury for US coal-fired power plants. With most US coal-fired power plants already more than 30-40 years old, such regulations increase the likelihood that new replacement coal-fired capacity will be needed over the next decade, not only to meet new demand but to replace retired capacity. This makes development of new clean coal technologies even more important.

US Greenhouse Gas Policy

Although the United States has announced that it will not participate in the Kyoto Protocol, the federal government has introduced a series of alternative measures to reduce greenhouse gas emissions. In 2001, President Bush committed the US government to the pursuit of a broad range of strategies to address the issues of global climate change, launching three initiatives:

- The Climate Change Research Initiative to accelerate science-based climate change policy development.
- The National Climate Change Technology Initiative to advance energy and sequestration technology development.
- Increased international co-operation to engage and support other nations on climate change research and clean technologies.

On 14 February 2002, President Bush announced the Administration's Global Climate Change Initiative, which calls the United States to reduce greenhouse gas intensity (total greenhouse gas emissions per unit of GDP) by 18% between 2002 and 2012, primarily through voluntary measures. Under the Global Climate Change Initiative, the President directed improvements in the Voluntary Reporting of Greenhouse Gases Program (through the Department of Energy), to enhance the accuracy, reliability, and verifiability of emissions reduction measurements reported to the programme. President Bush's 2005 budget proposes \$5.8 billion for climate change programmes and energy tax incentives, which is over USD 700 million (13.9 %) more than 2004, as enacted.

President Bush has created an interagency, cabinet-level committee, co-chaired by the Secretaries of Commerce and Energy, to co-ordinate and prioritise federal research on global climate science and advanced energy technologies. This committee develops policy recommendations for the President and oversees the sub-cabinet interagency programmes on climate science and technology.

On 12 February 2003, the US Department of Energy launched the President's "Climate VISION" programme. Climate VISION is a voluntary, public-private partnership to pursue cost-effective initiatives to reduce the projected growth in US GHG emissions. The programme is intended to help meet the President's

goal of reducing US greenhouse gas intensity by 18% between 2002 and 2012. It involves federal agencies working with industrial partners to reduce GHG emissions voluntarily over the next decade.

Several industry sectors are participating in Climate Vision. The electric power industry has done so through its Electric Power Industry Climate Initiative (EPICI). The coal and mining industry has developed a separate initiative, the Mining Action Climate Plan (MICAP). Both are described below. Other industry groups with voluntary reduction goals or other voluntary climate initiatives include the petroleum, chemical, automotive, forest and paper, iron and steel, semiconductor, railroad, aluminium, and cement industries.

In addition, the Business Roundtable (BRT), an association of CEOs of leading US and international corporations have developed a Climate RESOLVE (Responsible Environmental Steps, Opportunities to Lead by Voluntary Efforts) initiative, which is designed to motivate member companies to seek innovative ways for practical cost-effective opportunities to reduce the GHG intensity of the US economy. A unique aspect of the programme was that the commitment to mitigate or reduce GHG emissions was made by ALL members of the association, with the focus on energy efficiency improvements from demand-side applications.

In addition to the voluntary industry activities, there have been several notable private-public-NGO coalition activities including the Chicago Climate Exchange, EPA's Climate Leaders, Environmental Defense's Partnership for Climate Action, and World Wildlife Fund's Power Switch and Climate Savers Programs. The largest programme, the Chicago Climate Exchange (CCX) has over 40 member companies with greenhouse gas emissions totalling about 5% of US total emissions. Participation in CCX for member companies requires a cumulative reduction of 10% in greenhouse gas emissions (1% in 2003, 2% in 2004, 3% in 2005 and 4% in 2006). Members are from all industrial sectors (*e.g.* Ford, IBM, AEP, Dupont, etc.) as well as non-governmental organisations and governmental entities (*e.g.* World Resources Institute, City of Chicago).

There are also resources being focused on hydrogen technology. The President's Hydrogen Fuel Initiative and the FreedomCAR Partnership launched in 2002 will provide funding through 2008 to develop hydrogen-powered fuel cells, hydrogen infrastructure, and advanced automobile technologies, allowing for commercialisation of fuel-cell vehicles by 2020.

Electric Power Industry Climate Initiative

The Edison Electric Institute (EEI) together with six other power sector groups, representing 100% of U.S. electricity generation, formed the Electric Power Industry Climate Initiative (or EPICI) to reduce the sector's carbon intensity. Other EPICI members include the National Rural Electric Cooperative Association, the Nuclear Energy Institute, the American Public Power Association, the Large Public Power Council, the Electric Power Supply Association, and the Tennessee Valley Authority.

A formal memorandum of understanding between EPICI and DOE will likely pledge the industry to reduce the power sector's carbon impact in this decade by the equivalent of 3% to 5%, through increased natural gas and clean coal technology, increased nuclear generation, offsets, and expanded investment in wind and biomass projects. The MOU is still pending but could become final soon. Initiatives include reforestation in the lower Mississippi River valley (PowerTree), increased use of coal combustion by-products (C2P2), and expanded use of wind and biomass (Harvesting the Wind, etc.). The Edison Electric Institute is also working with DOE to develop the Power Partners Resource Guide, a Web-based tool to help companies reduce greenhouse gas emissions intensity.

The Nuclear Energy Institute (NEI) has identified the potential to expand nuclear power generation to displace growth in sources that emit greenhouse gases. Capacity of 6-8 GW can be added by power uprating, in addition to those uprates already identified by the Nuclear Regulatory Commission. Productivity of existing plants can be improved to add the equivalent of another 3-5 GW of capacity. Re-starting nuclear power plants, such as the TVA Brown's Ferry plant, could add more than 1 GW. Full use of existing facilities could increase nuclear power capacity by 10 GW, or 10% of existing nuclear capacity, and would avoid the emissions of approximately 22 million metric tons of carbon equivalent in 2012.

National Rural Electric Cooperative Association (NRECA) represents operators serving 36 million people in 47 states, and participates in Power Partners to develop renewable sources, landfill and agricultural methane uses, and biofuels. NRECA is also participating in the effort to find “near-zero emissions” technologies. Other efforts include improved load management to cut peak demands and line-loss research to increase distribution efficiency over the members’ extended distribution lines.

American Public Power Association (APPA) and Large Public Power Council (LPPC) members provide electric power to more than 40 million Americans, and pledge their efforts to expand generation from renewable sources. Specifically, members will increase utilisation of existing hydroelectric capacity to meet western power needs, will increase generation from wind projects and landfill gas, and implement “green pricing” to increase incentives for production by low-emission technologies. Where coal generation is used, APPA members pledge to increase generation efficiencies by 4 to 8% under enabling revisions to the Clean Air Act.

Electric Power Supply Association (EPSA) members supply electricity to competitive markets and provide a large share of new, low-emission electricity capacity. EPSA members pledge to increase their average capacity factor from the current 40% projected in 2012 to 44%.

Coal Production Climate Policy Initiatives - the Mining Industry Climate Action Plan

The members of the National Mining Association (NMA), an association representing producers of 70% of the nation’s primary electricity fuels (coal and uranium) agreed on a voluntary climate action plan with five major elements. These include:

- The Allied Partnership Program, an industry-government partnership to increase efficiency in mining operations using DOE developed optimisation techniques.
- The Mining Industry of the Future Program, a research programme emphasising co-operative research and then commercialisation of technologies to increase efficiency at mining and processing operations.
- The Coal Mine Methane Program to continue and increase methane recovery wherever possible.
- The Reclamation and Carbon Sequestration Program to look at ways to improve reclamation techniques in order to sequester additional carbon.
- The Inventory and Reporting Program that will result in a method to inventory and report on greenhouse gas emissions in the mining sector on a comparable basis.

The mining sector is also active in other Administration initiatives such as the Carbon Sequestration Leadership Forum and the newly announced Methane to Markets Initiative. The mining industry is committed to achieving a 10% increase in systems efficiency wherever possible. Additional technology developed through DOE partnerships is projected to further reduce greenhouse gas emissions by one million metric tons annually by 2012.

Policy Insights

While the climate change initiatives in the US are important in utilising of variety of greenhouse gas mitigation measures, improving the efficiency of the US energy and power system and increasing the use of non-fossil resources, the long-term solution must involve major technology development and breakthroughs. In particular, with the increasing needs for power in the US and the important role that coal will continue to play in that future, new clean coal technologies, with carbon capture and sequestration, are expected to provide the future option to move to ultra-low or near-zero emissions power generation as part of long-term climate policy.

Major successes in compliance with power generation air-pollution control over the past decade have been achieved through application of the market-oriented “cap and trade” approach, which utilises marketable emission allowances. US observers expect that, should CO₂ control policies advance beyond the current voluntary approach at some future time, a market-based approach would be an essential component of such policy. Cap and trade has been a fundamental component of SO₂ emissions control by power generators since 1995, and has been implemented more recently in controlling NO_x. The SO₂ emissions-control programme is widely viewed within the US as a compliance success, because the emissions reduction goals for the programme's first five years were achieved more rapidly, and at less cost, than had been anticipated before implementation. This success has had a major influence on views of potential mechanisms for achieving CO₂ reductions in the USA although industry has consistently opposed a congressionally mandated cap and trade programme for CO₂. However, action is being taken on a voluntary basis by some states and a number of corporations, including major coal-burning power generators who are members of the Chicago Climate Exchange's greenhouse gas emissions reduction and trading pilot. The exchange is a self-regulatory, voluntary organisation that began continuous electronic trading of greenhouse gas emission allowances in December 2003.

An analysis report produced by the US Department of Energy's Energy Information Administration (EIA) in June 2004 indicates that a substantial reduction in US greenhouse gas emissions can be achieved, but would most likely result in a considerable shift away from coal-fired generating capacity and generation. This report provided analyses of S.139, the Climate Stewardship Act of 2003, and an amended version of this bill, Senate Amendment 2028. The original S.139 bill, sponsored by Senators McCain and Lieberman and introduced on 9 January 2003, proposed to establish caps on greenhouse gas emissions that would eventually reduce overall US emissions to approximately the 2000 level by 2025. An amendment to S.139, introduced on 29 October 2003, removed language pertaining to the more restrictive phase of emission caps that were to come into force in the original bill, resulting in a smaller reduction in the projected levels of annual greenhouse gas emissions.

In EIA's June 2004 report entitled “Analysis of Senate Amendment 2028, the Climate Stewardship Act of 2003”, US emissions of greenhouse gases are projected to rise from 1 928 million metric tons of carbon equivalent in 2001 (15% above the 1990 level) to 2 806 million metric tons of carbon equivalent by 2025 (67% above 1990). Under S.139, EIA estimated that US coal production (in physical units) would be 79% less in 2025 than in the report's reference case forecast. Under SA.2028, where emissions of greenhouse gases are less severely curtailed, US coal production in 2025 is projected to be 56% below the reference case forecast.

Under both greenhouse gas analysis scenarios, the electric power sector is projected to account for 88% of the projected reductions in energy-related carbon dioxide emissions by 2025. Larger reductions of carbon dioxide emissions are projected to result in the electric power than in other energy end-use and conversion sectors, as the cost of reducing emissions in this sector are projected to be lower. In the S.139 forecast scenario, coal-fired generating capacity is projected to decline from 315 GW in 2001 to 147 GW in 2025, the net result of 38 GW of projected new integrated gasification combined cycle coal plants (with carbon capture and sequestration equipment) less 206 GW of retirements. In the SA.2028 forecast scenario, coal-fired generating capacity is projected to decline to 229 GW in 2025, the net result of 2 GW of projected new integrated gasification combined cycle coal plants (with carbon capture and sequestration equipment) less 90 GW of retirements.

Security of supply has become the major concern facing future generation decisions in the United States. Coal is clearly the best solution to addressing the security of supply concern.

The country is committed to the development of clean coal technology applications to mitigate climate impacts in a way that is consistent with sustainable development.

8. SOUTH AFRICA

Key Messages

- Coal is essential to South Africa's economic development and will retain a major role in domestic electricity generation.
- The Kyoto Protocol does not require South Africa to reduce its greenhouse gas emissions. In fact, it is generally recognised that South Africa's emissions will continue to increase as development is realised. However, a clean development path and encouragement of Clean Development Mechanism (CDM) projects has benefits for the country's other development priorities.
- South African climate change policies must recognise the potential vulnerability of the country to climate change on the one hand, and developed countries' mitigation policies on the other hand.

Energy Supply

Coal plays a major role in South African energy supply, accounting for about 80% of primary energy use. Excluding the electricity sector, coal accounts for nearly one-third of the national energy mix. Electricity contributes a further 22%, with 90% of the electricity generated by Eskom coming from coal. Expansion of the country's electricity supply grid remains a major priority, reflected in the breakdown of Eskom's research effort.

CO₂ Emissions Reduction Potential

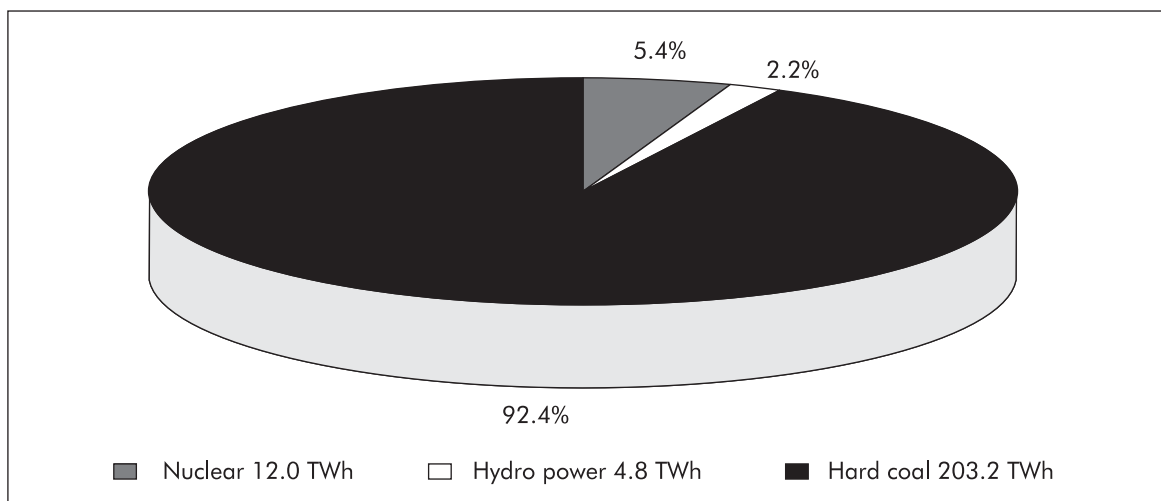
South Africa, as a non-Annex I (developing) country, is not required to reduce its emissions of greenhouse gases in terms of the Kyoto Protocol. However, as the South African economy is highly dependent on fossil fuels, including coal, there could be benefits to be derived from adopting a future strategy that is designed to move the economy towards a cleaner development path.

There is a definite potential for the CDM, carbon emission offset funding and carbon trading in general in South Africa. This will require the rapid implementation of the South African National Climate Change Response Strategy to access investment through the CDM, technology transfer and donor funding

opportunities. Further, even given this scenario of moving towards a cleaner production path, emissions can still be expected to increase with economic development, albeit at a smaller pace than would have happened without intervention, reinforcing the desirability of developing the market for carbon emissions trading.

Figure 22

Electricity Production of South Africa - 220 TWh in 2002



Source: IEA, *Electricity Information* 2004.

The Department of Minerals and Energy (DME) has developed a white paper on renewable energy and clean energy development as well as an energy efficiency programme to support the sustainable energy programmes proposed therein. Early CDM projects will almost certainly focus on low-cost credits while working through existing investment routes and, given these factors, the energy sector can provide several potential opportunities for CDM projects. However, as a word of caution, some interventions may be necessary to ensure that small capital value projects, bringing benefits at a community level, are given a fair chance to get CDM funding alongside large-scale capital-intensive projects. There appear to be several attractive possibilities for projects involving carbon emission offset funding in South and Southern Africa, providing there is a sustainable market for credits. Some of the larger projects could be viable with lower carbon trading values, although it is difficult to estimate the bottom end range for viability. Such projects include:

- New projects using gas as the primary fuel, including coal bed methane and coal mine methane
- Clean coal power generation
- Repowering
- On and off-grid electrification
- *In situ* coal gasification
- Carbon capture and storage
- Industrial energy efficiency
- Commercial and domestic energy efficiency
- Renewable energy projects, including solar and wind power between 1 and 100 MW in size (namely, concentrating solar tower project of 15 to 100 MW)
- Off-grid projects, including micro-hydro, solar, wind and micro-geothermal energy, which promote community development

This list is not exhaustive but does give an idea as to what could usefully be investigated. In addition, focused research, development and demonstration projects and pilot studies are needed to adapt or develop suitable technologies for the South African situation. This could include projects such as underground coal gasification.

Energy and Environmental Policy Context

The South African government's national priorities include, *inter alia*, the creation of employment, the alleviation of poverty and the provision of housing, which implies a commitment to the process of sustainable development and advancement. Thus, projects such as energisation through comprehensive electrification schemes, both grid and non-grid, can continue to be important catalysts in this process.

South Africa's position is to view climate change response, including carbon emissions trading, as offering just one specific avenue of opportunity for achieving the sustainable development objectives of those national policies and legislation that are concerned simultaneously with both development and environmental issues.

At the same time, international action on climate change can be viewed as a significant vehicle to redress the historical, inequitable and unsustainable North/South divide of the world's economy and prosperity. In support of this objective, the South African National Climate Change Response Strategy strongly supports the New Partnership for African Development (NEPAD).

The South African government ratified the United Nations Framework Convention on Climate Change (UNFCCC) in August 1997 and acceded to the Kyoto Protocol in July 2002. In order to fulfil the requirements of the UNFCCC, South Africa has prepared an Initial National Communication to the UNFCCC, in accordance with Article 12 of the convention, and detailed South Africa Country Studies reports have been compiled on a sectoral basis. Using the results of this work, together with information from the Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report (TAR), the Department of Environmental Affairs and Tourism (DEAT) has developed a National Climate Change Response Strategy, which was accepted by Cabinet in October 2004.

The objective of this strategy is to support the policies and principles laid out in the government White Paper on Integrated Pollution and Waste Management, as well as other national policies including those relating to energy, agriculture and water.

Policy Insights

According to the IPCC's Third Assessment Report, not only is climate change already happening, it will continue to happen even if global greenhouse gas emissions are curtailed significantly. There is now more confidence that global climate change is a threat to sustainable development, especially in developing countries, and this could undermine global poverty alleviation efforts and have severe implications for food security, clean water, energy supply, environmental health and human settlements.

South Africa must thus be considered vulnerable to climate change impacts and it will be necessary to carry out adaptation measures. The most vulnerable sectors have been identified as health, maize production, plant and animal biodiversity, water resources and rangelands, and these are the areas that need to be targeted initially for adaptation measures. Further, the South African economy is vulnerable to the possible response measures that may be implemented by Annex 1 (developed) countries, since the economy is highly dependent on income generated from the production, processing, export and consumption of coal.

National climate change response strategies have been designed to address issues that have been identified as

priorities to deal with climate change, specifically in South and Southern Africa. Whereas any national strategy must recognise international realities, including the growing pressure for quantified commitments of some kind by developing countries, they must be seen within the context of the present economic realities of the country and the inequitable distribution of global wealth. Thus, the point of departure reflected in an effective national response strategy must be to achieve national and sustainable development objectives, whilst simultaneously responding to climate change to avoid negative impacts in areas of specific vulnerability. There are many benefits to be derived in integrating climate change response programmes across national and regional boundaries, to serve common areas of interest and to maximise the utility of available resources, and carbon emissions trading could play a useful role in this process.

A key element is to promote sustainable development utilising various mechanisms and, in particular, it is recognised that the CDM of the Kyoto Protocol could play an important role. Climate change research needs to be properly co-ordinated and the benefits optimised to meet the needs of policy-makers in South and Southern Africa. Attention needs to be focused on such projects that will assist with the mitigation of, and adaptation to, climate change and address specific areas of vulnerability, whilst providing for the capacity building and skills transfer needed to operate and maintain such projects. Development and demonstration projects may be required to show the advantages and acceptability of a variety of specific technologies related to climate change to avoid South Africa taking on unproven and unworkable technologies to its detriment and the CDM could be used advantageously for this purpose.

South Africa needs to accelerate its national climate change response programme to avail itself of the potential advantages that could stem from international action on climate change, whilst at the same time minimising its vulnerability to such events. The following list contains a number of suggested priority interventions that cut across the entire spectrum of possibilities for climate change response actions for South Africa:

- Enhancing the capacity of national government to facilitate CDM projects through the Designated National Authority (DNA).
- Ensuring co-operation, co-ordination and the buy-in of all stakeholders to the climate change programme.
- Using climate change response to support sustainable development objectives.
- Supporting the DME in the implementation of its national sustainable energy strategy.
- Screening projects and proposals to ensure that they promote national development objectives, even though they may also serve foreign and international interests as well, and noting that the objectives of other environmental conventions and protocols, including the United Nations Convention on Biodiversity (UNCBD), the United Nations Convention to Combat Desertification (UNCCD), the Vienna Convention for the Protection of the Ozone Layer and the Ramsar Convention also need to be considered when evaluating projects and proposals.
- Exploring the potential for carbon capture and storage.
- Raising awareness of climate change and its likely impacts so that actions can be initiated at all levels that will modify behaviour and foster a sense of responsibility at all levels of society.
- Promoting the use of donor funding to address vulnerability and adaptation issues.

Primarily, the country's main developmental needs will have to be met by domestic savings and investment, foreign direct investment, donor agency and UN funding. However, the CDM could make important contributions to both development and environmental issues. The South Africa National Climate Change Response Strategy essentially consists of a proposed broad framework for action and, as such, represents a starting point for such action. It does not, and cannot, contain detailed action plans with defined time scales. These can only be formulated meaningfully on a case-by-case basis, given the ever-changing political

backdrop to climate change, technological progress and the robustness of the assumptions about what can be expected to transpire from the international negotiation process, together with the relevant commitments that are likely to flow from them. While it is extremely important to understand the reality and constraints of the South African economy, no door is closed to any action based on sound economic principles, which can bring tangible benefits to the country and its people. To this end, there is no need to embrace an overly conservative approach to climate change response, even though both the physical and economic vulnerability of the country needs to be duly acknowledged.

There is no doubt that the next few decades will see major changes, not the least of which will be technological progress. History teaches us that what is far-fetched today will be common practice tomorrow. Thus, the developed nations of the world, with their immense capital reserves, need to be encouraged to develop appropriate technologies to mitigate global climate change. South Africa, as an integral part of the developing world, should always be willing to accept new developments, as they become appropriate to achieving its national goals and objectives. There is therefore a large potential for organisations and institutions from developed countries to undertake climate change-related ventures in South Africa. This is particularly true given the fossil fuel base of the South African economy and the relatively developed industrial infrastructure on the one hand, and the overwhelming need for development on the other to eliminate intrinsic poverty. Concrete engagements in this regard, including projects that involve carbon emission offset funding, are thus to be encouraged. There is significant potential for such projects in South Africa.

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