

# Clean Coal

## 2005

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## Clean Coal - A Strategy in Review

- ▶▶ Coal will remain an indispensable resource as global energy demand rises dramatically.
- ▶▶ The energy mix provides for price and supply stability in the international power generation sector.
- ▶▶ Eco-friendly coal utilisation is essential for the long-term acceptance of the world's most abundantly available fossil fuel.
- ▶▶ Coal can help cushion our growing dependency on imported fuels and reduce the price risks associated with energy supply.
- ▶▶ The Clean Coal Concept provides a comprehensive technical and socio-political instrument for sustainable coal utilisation worldwide.
- ▶▶ Clean Coal is a multi-stage concept whose timetable and technical implementation can be organised flexibly on a region by region basis.
- ▶▶ As global leaders in emission reduction technology, Europe must consolidate its position by breaking down the current disparity between conversion rates and by exporting its know-how abroad.
- ▶▶ The efficiency improvements that can be achieved by modernising existing power stations and building new installations will make a significant contribution towards the conservation of resources and climate protection. Each year two to three percent of the installed power-station capacity can be replaced by modern technology. This process of modernisation must be pursued without interruption as any discontinuity only blocks successful actions in the field.
- ▶▶ Clean Coal also contains the vision of the zero-CO<sub>2</sub> power station. The increasingly intensive research and development effort being put into European and international research programmes can help develop commercially viable and cost effective technologies for the capture and sequestration of carbon dioxide up to the year 2020. These actions would have a built-in safety factor so that in the event of any further dramatic reduction in CO<sub>2</sub> appropriate measures could be taken that do not compromise the reliability of coal as a fuel. ◀

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## Foreword by Dr Böcker, President of EURACOAL

EURACOAL – the umbrella organisation of the European coal industry – works to preserve coal's broad-based market and to extend the contribution that solid fuel makes to the energy supply sector. In concert with the coal-fired power station operators the Association is pursuing a „Clean Coal“ policy that seeks to promote the progressive introduction of a series of technologies designed to reduce CO<sub>2</sub> emissions from electricity generating plant. Clean Coal is therefore part of a long-term strategy that will provide the economic and ecological basis needed to safeguard future coal utilisation.

The first phase of the Clean Coal concept seeks to promote the introduction of state-of-the-art technology for the eco-friendly combustion of coal and lignite on a Europe-wide basis; this means reducing emissions of dust, NO<sub>x</sub> and CO<sub>2</sub> as well as increasing power station performance levels.

The second phase provides for a series of pragmatic developments based on the continuous improvement of power-station efficiency levels. There is real global potential for further increasing the efficiency of the power generation process – in other words more electricity for each tonne of coal burnt. The resulting capacity for CO<sub>2</sub> reduction would be sufficient to realize a large percentage of the CO<sub>2</sub> savings that have been agreed or are considered necessary at international level. What makes Clean Coal special is that it allows us to tap into this potential in a series of stages using the technology that is currently available and this in turn will increase the reliability and efficiency of the power supply system.

Phase three of the concept takes Clean Coal well into the future with the visionary concept of the low-CO<sub>2</sub> power station. The know-how currently available means that there are no insurmountable technical obstacles to achieving the concept of CO<sub>2</sub> capture and sequestration.



The technical and economic challenges that have to be overcome include the key question of how CO<sub>2</sub> can be safely stored in suitable underground deposits. Finding solutions to this problem is one of the major tasks facing both government and industry in the years ahead.

EURACOAL will do all it can to ensure that the technical and economic options available for CO<sub>2</sub> capture and sequestration will be the subject of proper assessment under the 7th EU Research Programme.

A specific timetable and plan of operations have to be drawn up for the development of effective CO<sub>2</sub>

separation and storage processes. In the coal industry's view feasibility and pilot studies should enable us, by the beginning of the next decade, to identify the most suitable and the most economically promising of these technologies. Demonstration plant could then be built during the course of the decade thereafter. Government's role is to provide financial support for the research and development work and to lay down the legal bases and framework conditions needed for the pilot plant and demonstration facilities. The first industrial installations, along with a reliable storage concept, could be in operation by 2020 – if by this time it has become absolutely clear that radical measures are needed to reduce CO<sub>2</sub> emission levels.

As a primary energy resource, coal is set to play a decisive long-term role in providing Europe with a cost-effective, environmentally friendly and reliable energy supply. With the introduction of new, high-performance technologies for the power station sector and the potential for further improvements in energy efficiency coal already has a solid foundation on which to bring all its existing advantages to bear – namely security of supply, long-term availability and price competitiveness. EURACOAL is convinced that in a competitive European market coal will continue to have an important contribution to make. ◀



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## Clean Coal is more than an avenue for technology

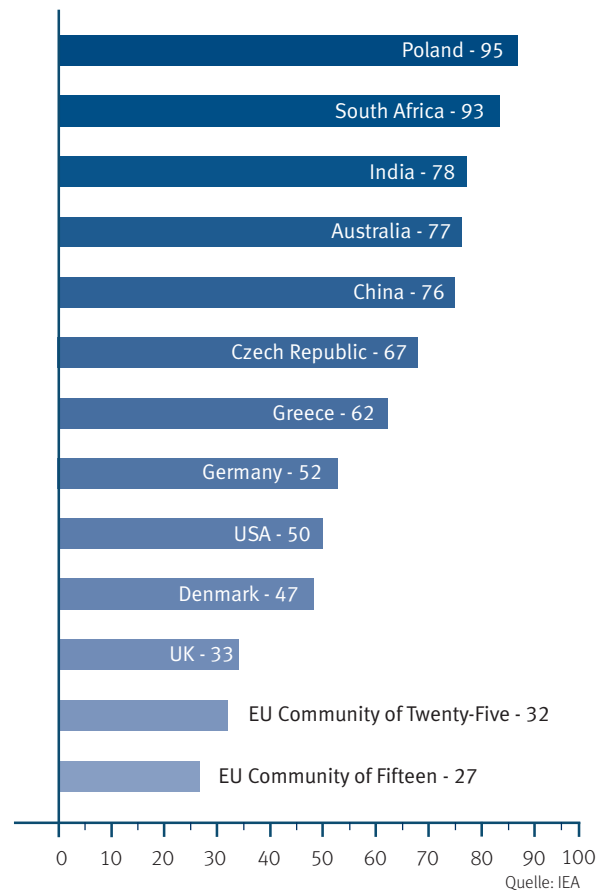
Many countries around the world depend on coal as a means to achieve their growth objectives and raise living standards. Coal not only makes a key contribution to the energy balance of emerging macro-economies such as those of China and India but is also fundamental to high-technology countries like Germany and the USA. In this respect coal usage is based on quite different energy-policy considerations. While in one country local availability of resources may be the crucial factor, in another the key consideration may be to ensure the best possible price and supply stability for the consumer.

In Europe coal is one of the central pillars that support the balanced energy mix. This mix has to develop in accordance with the economic criteria prevailing in the marketplace. Furthermore, the energy-policy framework has to be kept open to all types of fuel and energy systems.

Coal has lost none of its importance in the key economic areas: it is an essential feedstock fuel for iron and steel making, while in the electricity sector it remains a fuel of choice by reason of its security of supply and competitiveness. If coal is to continue to make a vital contribution to energy supply in the years ahead the industry must learn not to count on its economic advantages alone, for environmental considerations are becoming increasingly relevant.

The concept of Clean Coal embraces all currently available technologies and strategies designed to minimize the negative impact of coal utilisation on our climate and environment. Clean Coal is a dynamic process that continuously assimilates and develops new technologies, but it also allows coal industries to follow different objectives for environmentally-friendly coal utilisation, according to their situational framework.

Coals's share of the power market in selected countries in 2000 - in percent





# Clean Coal

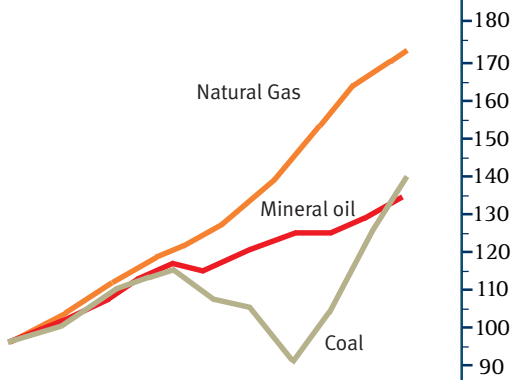
Clean Coal is not restricted to technological development alone, but also constitutes a socio-political response to the changing demands that are imposed on the way we use fossil-based energies. Clean Coal can make a key contribution to the sustainable and long-term acceptance

of coal as a mainstream fuel. The building-block structure of the Clean Coal Concept means that it can be phased-in gradually as the technology becomes available.

Clean Coal is being introduced on a world-wide scale, but in a manner that takes account of the needs and opportunities presented by the local environment. The flexibility of the Clean Coal Concept therefore also contributes towards social equity in the sense of sustainable development.

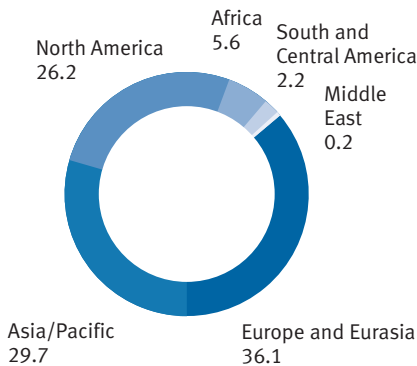
The European coal industry supports the active promotion of the Clean Coal Concept and calls for it to be part of the energy and environmental strategy that underpins Europe's policy for a reliable, cost-effective and eco-friendly energy supply.

Consumption of primary resources in the Asian and Pacific region 1993 - 2003  
1993 = 100



Source: BP 2004

Regional distribution of world coal deposits as percentage of total



Source: BP 2004

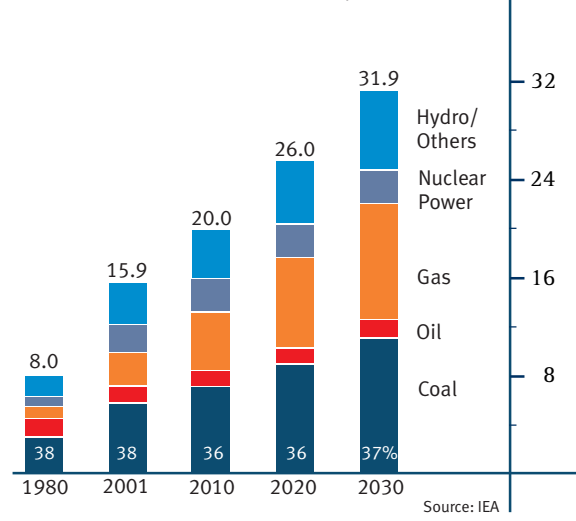


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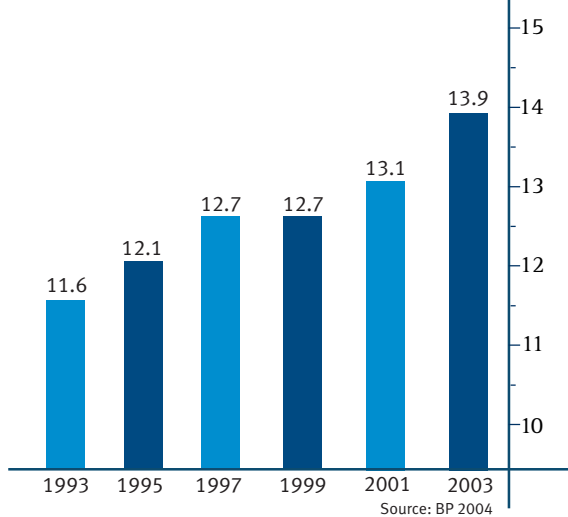
## No substitute for coal

If world energy consumption increases by seventy percent over the next thirty years, as has been predicted by the International Energy Agency (IEA), there is likely to be some serious conflict over the distribution of energy resources. The dynamic economic growth under way in the Asian and Pacific region is absorbing raw materials and logistics on such a scale that dramatic price rises and shortages are even now beginning to affect certain products worldwide. It is a fundamental social and political requirement that each country should be able to fulfil its energy and raw-material needs as effectively and as economically as possible. Such a demand cannot be met without using all available natural resources. This means that coal - which is abundantly available and geographically well distributed - has a key role to play. As a result of national emission controls, public health concerns and global climate constraints there is now real pressure on all coal users to introduce Clean Coal Technologies - and to do so in a manner that is tailored to meet their particular conditions and requirements.

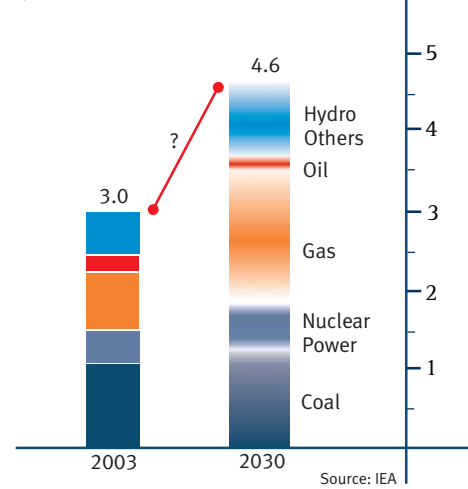
Global electricity consumption trends 1980 - 2030 in petawatt-hours



Increase in world energy consumption 1995 - 2003 in billion tce



Electricity consumption and power generating structure in the Community of Twenty-Five in the years 2003 and 2030 in gigawatt-hours





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## Coal has a central role to play

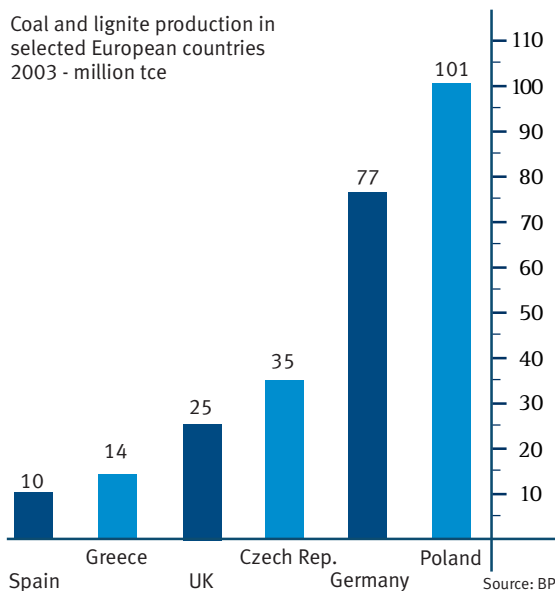
The Lisbon Strategy, which the European Union adopted in the year 2000, has set ambitious growth objectives. Economic performance in the EU is to be increased by three percent a year until 2020, making Europe the world's most competitive region. One of the essential conditions for achieving this objective is an optimal supply of energy. The demand for electricity is set to grow significantly and greater promotion of energy efficiency in power utilisation can only help slow down this trend.

Part of the growth in demand is to be met by making greater use of renewable energies. According to the European Union, renewables' contribution to EU power generation is to be increased to 21 percent by 2010 – an extremely ambitious target that is not without risk. The extensive depletion of our natural hydro-electric power capacity has compelled us to push ahead with new and as yet uncompetitive energy engineering systems that are expensive and offer limited security of supply. Irrespective of the actual contribution that renewable energies are able to make to Europe's power supply industry, most electrical energy will still have to be generated from fossil and

nuclear fuels. As western Europe is relatively deficient in natural resources the current high level of dependence on imported energy is bound to increase. In such a situation it is imperative that we make use of all our existing fuels and focus on the efficient utilisation of indigenous resources. These strategic goals have imposed a number of requirements on European energy policy. For one thing, the existing energy mix must not be constricted, for all fuels are needed and must be used in line with the various regional distinctions. Market forces, and not political directives, create the best balance between the different energy sources. There needs to be greater security of supply in the oil and gas industries. Investment in the energy sector must remain predictable over the long term. A standard approach has to be adopted for environmentally-friendly energy utilisation. Any interference in the structure of the energy supply sector with a view to providing climate protection has to be justified on strictly scientific lines and must be assessed in a global context.

Europe can take a leading role in the development of Clean Coal technology. The life-cycle of fossil fuel-fired power stations requires between two and three percent of the installed generation capacity to be replaced on an annual basis. This has to be part of a continuous operation, so that the best commercial technology is always made available. Delays to the construction work must never be allowed to interrupt the process, as this is not only bad for competition but also has a negative impact on the actual contribution that can be made towards climate protection and the conservation of resources.

Coal and lignite production in selected European countries 2003 - million tce





# Clean Coal

## Still significant potential for modernisation

Europe leads the field when it comes to emission reduction technology. Processes developed back in the 1980s are capable of achieving substantial reductions in the emission of dust, sulphur dioxide and nitrous oxides. The first European regulation dated from 1988 and was replaced by a more stringent version in 2001. The Commission has announced that a status report will be published at the end of 2004 detailing the achievements of the clean-air

scheme to date and setting out additional measures.

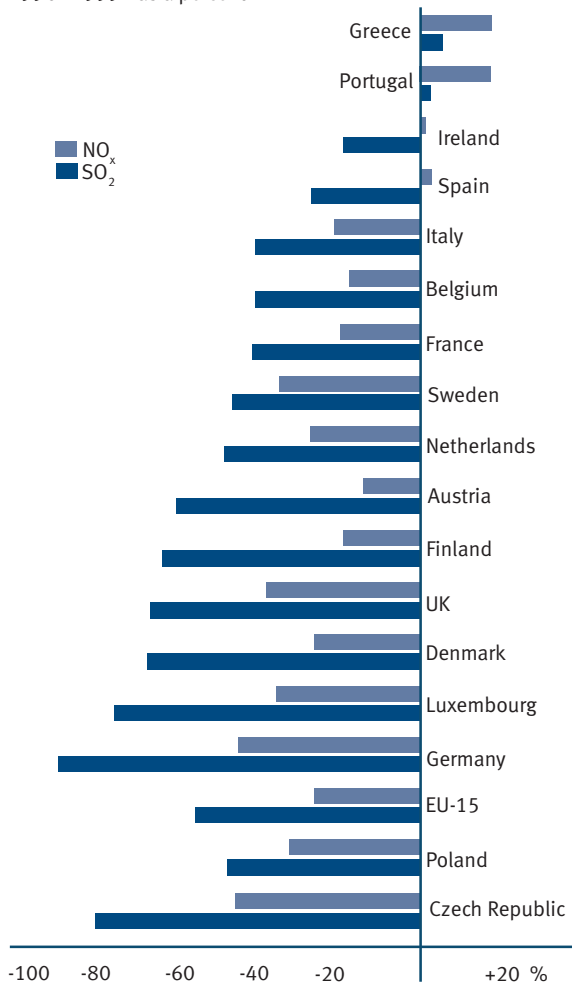
In adopting their own clean-air strategies EU Member States are able to choose between fixing emission thresholds for individual installations and setting emission budgets for specific sectors.

The quantity of sulphur dioxide emitted by coal-fired power stations depends on the type and quality of the coal being used. It has now been established that sulphur-dioxide emissions are harmful to plants and soil. The technology currently available allows more than 90 percent of the SO<sub>2</sub> to be removed from the flue gases of coal-fired power stations. Almost all of the waste products obtained from flue-gas desulphurisation can be used in the building industry. Europe has taken a leading role in this area.

Electro-filters can now separate practically all the fly-ash from the flue gases of coal-fired power stations. This technology is now in standard use. Large-scale fly-ash recycling is now well established in the concrete and cement industry. The „high-dust process“, whereby the flue gases are catalytically cleaned as soon as they emerge from the boiler plant, has established itself as the most economically efficient method of nitrogen removal for new coal-fired power stations. Certain combustion strategies can also be used to reduce the emission of nitrogen oxides from coal-fired power stations.

Although flue-gas cleaning technology has been available for many years for removing sulphur dioxide, nitrogen oxides and dust, there is great disparity in the application of such systems within the various EU member states. With the recent phase of EU enlargement complete it would seem that now is the most propitious moment to implement the first stage of the Clean Coal Process in full. Countries outside the EU zone generally observe the guidelines laid down by the World Bank, although many are already failing to comply fully with these standards. ◀

Energy-related emission trends  
1990 - 1999 - as a percent



Source: EEA

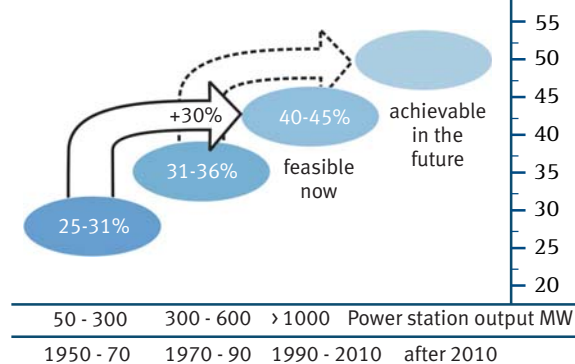


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## The economic response to climate policy demands

The environmental debate of the mid-1990s opened up a new phase in the Clean Coal Strategy. Environmental opinion became convinced that additional man-made emissions of the trace gas carbon dioxide were primarily responsible for the observed phenomenon of global warming. National and international efforts to limit or reduce carbon-dioxide output focussed mainly on energy-related emissions. However, with fossil fuels in general, and coal in particular, being of fundamental importance for the world's energy supply, any drastic curtailment in the use of fossil-based fuels would seem to be ruled out. For Clean Coal the preferred option is to increase the efficiency of existing and newly-constructed installations. Coal-fired power stations have already benefited from a one-third improvement in efficiency over the last thirty years. Modern installations are now capable of running at 40 to 45 percent efficiency and plant availability has also been increased. The ongoing and large-scale replacement of Europe's power station capacity has already opened up the perspective of dramatic gains in efficiency and significant savings in CO<sub>2</sub>.

Continuous technological improvement increases the efficiency of power generation plant - in percent



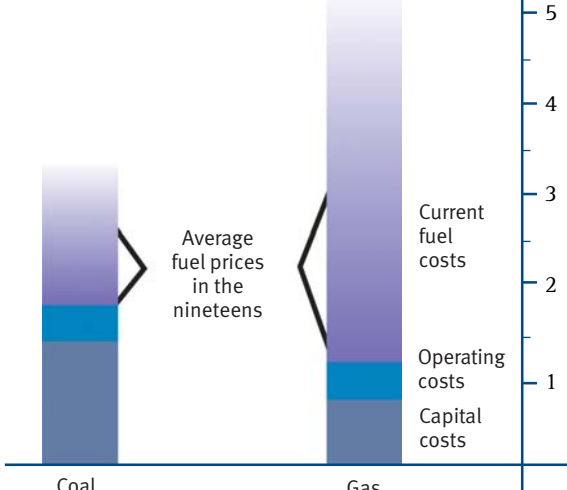
Source: DEBRIV

The modernisation of existing installations, combined with the replacement of outdated plant, essentially means that any single percentage-point improvement in efficiency results in a two-percent reduction in CO<sub>2</sub> output.

The Clean Coal Strategy opens up two routes to greater efficiency. Firstly, outdated plant can be brought up to standard as part of a continuous process of modernisation. This is the approach that German power-station operators have been taking for the past ten years as part of a comprehensive programme for the modernisation of lignite-fired installations. The second route can, for example, involve the construction of new generating plant. These new installations have set international standards for efficiency and CO<sub>2</sub> output and have done much to make Germany a frontrunner when it comes to the reduction of power-industry CO<sub>2</sub> emissions in Europe.

Yet there is still plenty of scope for further development in the area of efficiency improvement too. New materials are being tested that will permit higher boiler temperatures and steam pressures. The concept of the „700 degree power station“ promises to bring another dramatic improvement in power-station efficiency within the next decade.

Average generation costs of different new base-load power plants - in cents per kilowatt hours



Source: DEBRIV





# Clean Coal

In the European coal industry's view, it is extremely important for the European Commission to keep efficient coal utilisation at the centre of its next Research Framework Programme and to send a clear signal when it comes to reducing CO<sub>2</sub> output in the short term.

When examining the production of costs of a coal-fired or nuclear power plant, on the hand, and those of a gas-fired power plant, on the other, we see, that coal-fired and nuclear installations are expensive to construct but their operating costs and primary-energy and generation costs are low.

In the case of gas-fired plants the picture is exactly the reverse: the investment and operating costs are fairly low,

but the fuel prices have a substantial impact on the installation's competitiveness. A logical consequence of this technology-based difference would therefore be a rational division of generation: coal and nuclear power for the base load, coal for the mid-range loads and gas mainly for peak or for combined heat and power generation. Coal and nuclear energy often act as price indicators for competitive energies in the power sector. In this way they constitute an important counterbalance, especially as far as the gas producers are concerned.

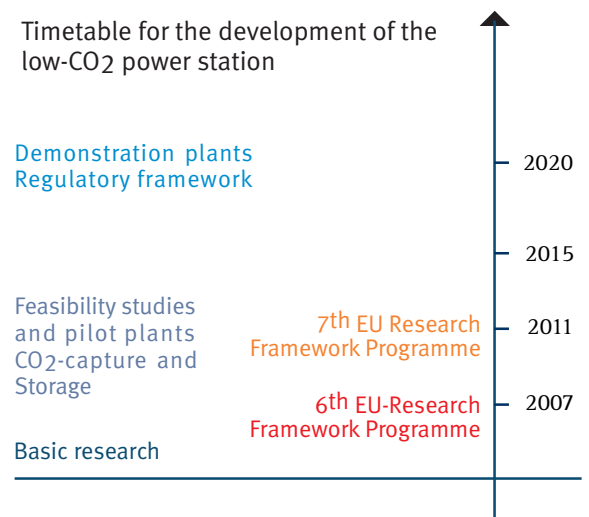
Such a strategy has served Europe well to date, and indeed the USA, Japan and China all apply a similar model for their power generation industry. ◀

## Visions for the future

Clean Coal has a clear vision for the future, namely the zero-CO<sub>2</sub> power station. As well as continuously improving plant efficiency and environmental compatibility as part of the cyclical plant modernisation programme, Clean Coal also embraces future technologies. Preventive climate protection demands the timely development of processes for the technically and economically rational separation of environmentally-relevant trace gases from power-station emissions with a view to preventing the release of CO<sub>2</sub> into the atmosphere. It is here that the preventive impact of the Clean Coal Concept is most effective. The introduction of these advanced technologies can only be triggered by radical changes in climate policy based on secure scientific findings.

From today's perspective the development of CO<sub>2</sub> separation technologies appears to be simpler to achieve than the reliable and long-term storage of the carbon dioxide after separation. The Carbon Sequestration

Timetable for the development of the low-CO<sub>2</sub> power station





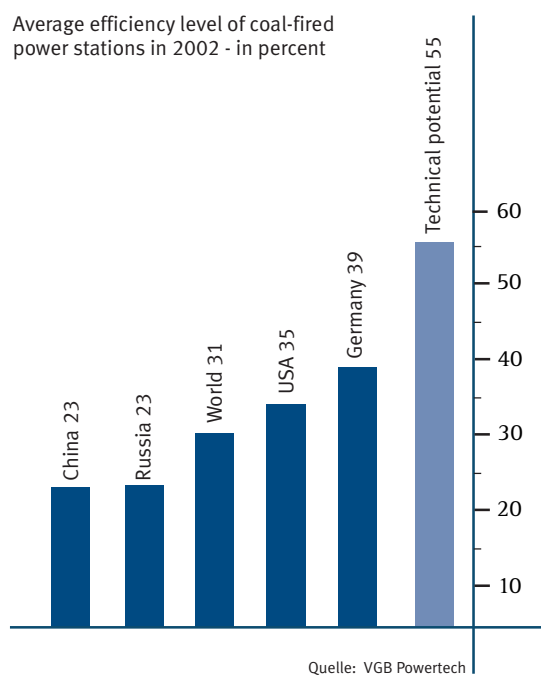
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Leadership Forum (CSLF) brought together fifteen countries and the European Union with the aim of identifying technical, cost-effective and eco-friendly solutions for CO<sub>2</sub> capture and sequestration. This major multi-national effort illustrates that there is a substantial need for research, especially in the area of CO<sub>2</sub> storage. There is, for example, very little known about the long-term behaviour of large quantities of CO<sub>2</sub> in enclosed storage chambers. At the present time the debate is focussing mainly on sequestration in depleted oil and gas measures or in deep salt aquifers. Such an undertaking will require substantial logistical investment. One of the most promising techniques for CO<sub>2</sub> separation is coal gasification and intensive R&D effort has already produced tried and tested commercial-scale plants of this type.

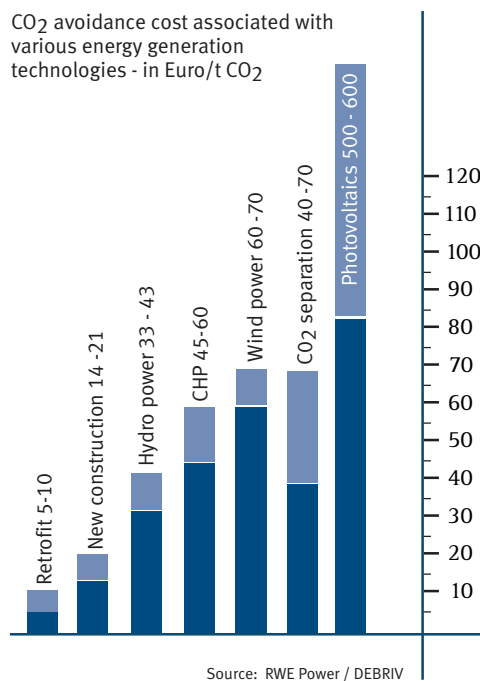
The European coal industry has pointed out, however, that the capture and storage of carbon dioxide holds significant risks for the economic efficiency of the electricity generation process.

The installation of the equipment needed to separate carbon dioxide in a zero-CO<sub>2</sub> power station produces a detectable loss in plant efficiency and this in turn increases the cost of the end product. Reliable estimates for the cost of CO<sub>2</sub> storage are not yet available. ◀

Average efficiency level of coal-fired power stations in 2002 - in percent



CO<sub>2</sub> avoidance cost associated with various energy generation technologies - in Euro/t CO<sub>2</sub>





# Clean Coal

## The strategy of comprehensive responsibility

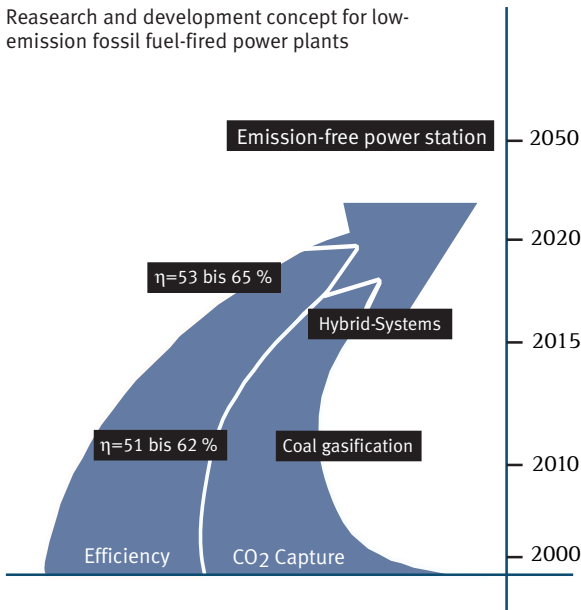
The multi-stage Clean Coal Concept is part of a long-term strategy designed to provide economic and ecological safeguards for coal utilisation. Clean Coal's ongoing contribution is helping to balance out national differences between eco-friendly coal utilisation processes. At the same time Clean Coal includes pragmatic future developments based on continuous efficiency improvements. The global potential for CO<sub>2</sub> reduction that can be harnessed through efficiency gains at coal-fired power stations is sufficient to achieve a large part of the CO<sub>2</sub> savings that have been agreed, or are considered necessary, at international level.

What is special about the Clean Coal Concept is that its potential can be fully exploited without jeopardising the reliable and efficient supply of electricity. The zero-CO<sub>2</sub> power station is Clean Coal's visionary concept for the future. According to current expertise there is no insurmountable technical obstacle to such a development, though the concept is fraught with considerable economic

R+D efforts leading to the zero-CO<sub>2</sub> power station

Power station technology	CO <sub>2</sub> -sequestration
<ul style="list-style-type: none"> <li>▶ Process selection and assessment</li> <li>▶ CO<sub>2</sub> capture before combustion</li> <li>▶ CO<sub>2</sub> capture after combustion</li> <li>▶ Gasification</li> </ul>	<ul style="list-style-type: none"> <li>▶ Search for suitable storage facilities</li> <li>▶ Depleted gas fields</li> <li>▶ Reservoir rock</li> <li>▶ Deep-sea storage</li> </ul>
Technical and economic assessment	Long term security for CO <sub>2</sub> sequestration
<p>The future of the zero-CO<sub>2</sub> power station depends on having a reliable and ecologically acceptable long-term CO<sub>2</sub> storage facility</p>	

Research and development concept for low-emission fossil fuel-fired power plants



and ecological risk. Minimising this risk is one of the major tasks facing both industry and government in the years ahead.

The European coal industry is determined to do everything it can to ensure that the 7<sup>th</sup> Research Framework Programme contains concrete proposals for the timetable and measures needed to develop CO<sub>2</sub> capture and sequestration technology. The coal industry believes that by 2010 feasibility and pilot studies will have identified the most suitable and most economically promising of these new technologies. The legal bases and framework conditions will then have to be laid down in the course of the following decade. The first of the new installations, along with a reliable storage concept, could be in operation by 2020, if by this time it has become absolutely clear that drastic measures are needed to further reduce CO<sub>2</sub> emission levels.



# Clean Coal

## EURACOAL – Members and Activities

The European Association for Coal and Lignite is the umbrella organisation of the European coal industry. The associations and companies representing the coal industries of Belgium, France, Germany, Great Britain, Greece and Spain, the relevant organisations of the New Member States Poland, the Czech Republic and Hungary, Slovakia and Slovenia as well as Romania, Bulgaria, and Serbia work together in EURACOAL, where they have equal rights. Importers, dealers and consumers have a seat and vote in EURACOAL. By integrating these countries, EURACOAL has anticipated an important political development for the European Union as a whole. The new Association, which evolved from CECSO (the European Solid Fuels' Association) after the expiry of the Treaty establishing the European Coal and Steel Community (ECSC Treaty) now, has a much broader remit.

EURACOAL's task is to highlight the importance of coal's contribution to security of energy supply within the enlarged EU, to price stability, to added value and to environmental protection. EURACOAL seeks to be an active communicator, doing all that is necessary in order to create an appropriate framework within which the European coal industry and coal consumers can operate. Almost 25 % of the power generated in the former EU-15 and nearly 50 % in the New Member States are coal-based. Steel producers and other energy-intensive industries all need large quantities of energy. Coal has therefore established itself as a permanent and reliable source of energy in its own right and will remain a vital source of EU energy supply for the years to come. The importance of coal

for the European power supply defines EURACOAL as an active player in the future energy policy of the whole EU.

EURACOAL's work is entirely geared to the interests of its Members. This includes the entire process chain beginning with coal extraction, marketing and transportation rights through to its utilisation at power plants, in the steel industry and in other industrial and private sectors. Coal research plays an important role here.

EURACOAL is the voice of the coal industry in Brussels. It is actively involved in balancing the political requirements for a secure and cost-effective supply of fuel on the one hand with the objectives of environmental policies on the other. The EU has to create and to maintain adequate framework conditions for coal utilisation, as this fuel is vital if we are to achieve a balanced European energy mix. ◀

### Members Association/Enterprise Country

Status: January 2005		
Euriscoal	European Association of Coal Importers	BEL
ISSEP	Institut Scientifique de Service Publique	BEL
Mini	Maritsa Iztok EAD Bulgarian Lignite Producer	BUL
ZSDNP	Czech Confederation of the Coal and Oil Producers	CZR
CARBUNION	Federation of Spanish Coal Producers	ESP
CdF	Charbonnages de France	FRA
DEBRIV	Deutscher Braunkohlen-Industrie-Verein	GER
GVST	Gesamtverband des deutschen Steinkohlenbergbaus	GER
VDKI	Verein der Kohlenimporteure	GER
VDMA	Mining Equipment	GER
PPC	Public Power Corporation	GR
MATRA	Mátra Erőmű Rt	HUN
PPWB	Confederation of the Polish Lignite Industry	POL
ZPGWK	Polish Hard Coal Employer's Association	POL
PATROMIN	Federation of the Romanian Mining Industry	RUM
EPS	Electric Power Industry of Serbia	SER
HBP	Hornonitrianske Bane Prievidza	SK
	Premogovnik Velenje	SLO
COALPRO	Confederation of the UK Coal Producers	UK
Coaltrans	Conferences Ltd. Conference Organiser	UK
	Int. Mining Consultants Ltd	UK
	University of Nottingham	UK