COAL 2007

Options for the Future

Annual Report

2007

German Hard Coal Association

V.2

Foreword

'Options for the future' is the title of this year's Annual Report and the key theme for the 2007 annual convention of the German Hard Coal Association. The historic course that has been set this year for the German coal industry and for the companies that have emerged from it will create new potential and generate new opportunities for the future.

This year has seen a broad-based political understanding reached on the domestic coal mining industry. This will guarantee the legal and contractual basis needed for funding the socially acceptable restructuring of the industry until the year 2018. Subsidised coal mining in Germany will then cease and the last colliery will have to close – unless there objectives are amended as part of the parliamentary review process scheduled for 2012. From the current viewpoint all focus is on planning for the run-down, and especially workforce downsizing. We should not be speculating about the nature of the economic, energy and environment situation in 2012 and that is not exactly the object of the review clause for 2012. By then it may well be that we have to look at things from a different perspective. The most important aspect of the understanding that has been reached is that there will be no compulsory redundancies for our mineworkers. Moreover, the newly established RAG Foundation will provide the coverage needed to meet the ongoing liabilities inherited from the mining industry. This Foundation will at the same time promote education and training, science and culture in the coalfield regions insofar as these activities are linked to the German mining industry. The Foundation's assets will be generated from the sale of shares in the 'white part' of the former RAG Group (chemicals, energy and real estate), which will develop a momentum of its own as a new integrated company that is now also trading under a new name.

In September this year we saw a new arrival – Evonik Industries AG. This means that the Ruhr Area will soon have a new listed contestant in the German share index (DAX). The company will take-on additional regional responsibility for property and real estate operations and will provide homes for more than one hundred and fifty thousand people, while at the same time acting as a creative and politics-free industrial group with a remit to provide cutting-edge products designed to meet global mega-trends in the chemicals and energy markets. In addition to being global market leaders in certain speciality chemicals the company also provides energy efficiency solutions and innovative technologies for the renewables sector. Evonik Industries is now the fifth-largest electricity producer in Germany and market leader in the field of biomass power plant; it also builds and operates state-of-the-art coal fired power stations and installations designed for mine gas-based power generation. Here too we see coal forging the link between progress and tradition – and in all-new purple-coloured livery. But the really important thing is that we now have a framework that finally allows us to put lots of new ideas into practice and to exploit our opportunities for growth with renewed vigour.

Essen, October 2007
Dr Werner Müller
Chairman of the Management Board of
the German Hard Coal Association

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Options for the future

"The Federal government, North Rhine-Westphalia (NRW) and Saarland reached an understanding on terminating subsidised coal production in Germany until the end of 2018 in a socially acceptable manner.… In 2012 the German parliament will review this understanding on the termination of subsidised coal production whether or not the German coal industry will continue to be financially supported under consideration of the aspects of economic viability, energy-supply security and the other energy-policy objectives."

Extract from the 'Coal-policy understanding' of 7 February 2007

"In this form the foundation will be a winner for everyone"
Homepage of the RAG Foundation, September 2007

"Germany competing for natural resources"
Handelsblatt, March 2007

"Scientists sounding the alarm: thirteen years to the climate turning point"
Rheinische Post, 22 February 2007

"You can prescribe any CO2 reduction you want for Germany and you will eventually achieve your target – even if it means industry packing its bags. Then of course you will also need fewer power stations."
Werner Müller interviewed in 'manager magazin', April 2007

"Coal? Yes, coal – Never mind global warming"
Business Week, May 2007

"Everyone's talking about the weather – except us!" This advertising slogan from Deutsche Bahn was on everyone's lips in the early 1970s. Change it around slightly and it could be the leitmotiv for the political debate now under way in 2007: "Everyone's talking about the climate – and they are talking about nothing else." No other topic has so preoccupied the public debate this year than that of the climate, in all its various forms. It has now become the main challenge facing the coal industry and the German Hard Coal Association (GVSt) too – and in Europe the future of the world's most important fuel will be determined to a large degree by environmental and climate policy decisions taken in Berlin and, more significantly, in Brussels. GVSt's stance is clear and unambiguous: a precautionary climate and environment policy is essential for Europe, but this has to be agreed at an international level and must be developed within an economic framework so as to permit a balanced energy mix. And coal – the number-one fuel for electricity production – must be part of this.

Of course another topic has been dominating the energy agenda in Germany this year – and this is still the key issue affecting the German coal industry: the understanding that has been reached between all the parties concerned – namely the Federal Government, the coalfield regions of North Rhine-Westphalia and Saarland, the mining companies and the IG BCE union – as to the future of the German coal industry. This contract, which was laid down in the 'Key Points Paper' of 7 February 2007, has been labelled as the "termination of subsidised coal production in Germany". And in fact the course that has been set now for the first time allows a general consensus to be reached on how to solve problem of inherited liabilities.

These two critical issues – climate and environment policies and the future of the German mining industry – have dominated the activities of the German Hard Coal Association throughout the year. They also feature largely in this year's Annual Report. The line of argument adopted by

GVSt and in the Report therefore takes account of the various viewpoints that under the Coal Industry Financing Act should serve as a guide for reviewing the 'termination decision' in 2012: these relate to competitiveness, energy supply security and other objective of energy policy.

Let us recall what has taken place: after months of discussion, and much media-hyped attention, the Federal Government, the Länder Governments of North Rhine-Westphalia and Saarland, RAG Aktiengesellschaft and the IG BCE reached an understanding on 7 February 2007 to accept the 'key points of a coal-policy understanding. This essentially provides for the socially acceptable phasing-out of the German coal industry until the end of 2018, with this decision to be reviewed by the Bundestag in 2012 (the 'review clause'), and for the setting-up of the RAG Foundation to take care of inherited liabilities – including creating the conditions needed for the 'white part' of the former RAG Beteiligungs-AG, acting under its new name of Evonik Industries AG since 12 September, to be listed on the stock exchange. The Federal Government and the Länder Governments of North Rhine-Westphalia and Saarland will be providing a joint package of aid to finance the entire phasing-out process – apart from the various charges taken over by the RAG Foundation. The principle of social compatibility has been recognised by all parties.

The current act of parliament is one of three pillars of the agreed provisions that are laid down and detailed in the coal-policy understanding. The other two pillars are the 'Framework Agreement' and the 'Inherited Liabilities Contract'. From 2009 these will assume responsibility for the total financing package, which is to comprise:
- aid provided by the Federal Government that is managed throughy the Coal Industry Financing Act (up to € 15.6 bn),
- aid approved by the two coalfield regions under the terms of the Framework Agreement between the Federal Government, North Rhine-Westphalia, Saarland and RAG AG, along with the co-payment that will be made by RAG AG, and
- the funding of 'inherited liabilities' after the closure of the coal industry, which is to be the responsibility of the RAG Foundation under the terms of the Inherited Liabilities Contract between the Foundation and the coalfield regions.

These three regulatory instruments are closely synchronised and extremely complex and are also dependent on each other. For example, the Framework Agreement is conditional on the Coal Industry Financing Act, the Inherited Liabilities Contract is coordinated by the Federal Government and the Coal Industry Financing Act and the aid provisions contained therein are subject to approval from the European Commission. The Federal Government is to notify the Commission of the details of the entire financial framework. Here account has to be taken of the fact that the current EU Regulation on aid to the coal industry expires in 2010 and that no decision has yet been taken on a follow-up regime and on its structure.

This means that some really big wheels will be turning for the coal industry over the next few years. For one thing it means – after months of uncertainty – long-term social security for the mining industry and its workforce: the funding has now been secured for the period to 2018 and beyond. And we will find out in 2012 whether Germany will have any collieries after this date that can continue to produce German coal with the help of state aid. In June 2012 the German Bundestag will take the final decision on whether 2018 really spells the end for the subsidised German coal industry, or whether mining will still have a future that will at the very least ensure continued access to the coal reserves at the highest technical level. This decision will be taken in the light of the global energy and raw-materials situation prevailing at the time and in consideration of the price trends on the world coal markets and will also be based on independent scientific reports and after consultation with the coal industry and the IG BCE. It is evident that key parties involved in the coal-policy understnding of February 2007 tend to see the reversal of the termination decision as no more than a theoretical possibility. Furthermore, the entire instrument is based on the phasing-out of the industry. But we need to be clear about one thing: the review takes place in 2012 – not today.

If we look at current developments in the raw-materials and energy markets there is no disputing that coal is the world's number-one fuel and that the world coal trade is seeing increasing demand-driven competition and at the same time a growing concentration of supply.

Above all China has now become a net importer of coal. Some supplier countries – and even those serving the Atlantic market – are exposed to considerable risk. When planning new mining projects investors are no longer taking the 'whatever the cost' approach of just a few years ago because those involved are predominantly acting purely out of business considerations and the infrastructure available for coal loading and transport in the main exporting countries is already overstretched. Add to this the fact that the high global demand for raw materials has created a general shortfall in freight capacity for seaborne coal, while the shipyards have order-books that are likely to remain full for years to come. The world coal market is witnessing structural change on a scale that is likely to create increasing shortage problems, with the result that at the very least we should not be ruling out the option of exploiting our own indigenous deposits.

The German coal industry therefore has a real option for a longer-term future. Exploiting this potential will also be of benefit to the mining suppliers who have succeeded in establishing themselves as global market leaders thanks to the tough working conditions encountered in German collieries. If this position is to be safeguarded there is no alternative to the domestic 'test bed' industry, as has been confirmed by independent experts. And the know-how – both in terms of technology and workplace safety – that the German coal industry has acquired from working at deep levels is now used all over the world. Measures to prevent the kind of events that are almost reported on a daily basis by large producers like China, including rockbursts of the type experienced this summer in the USA, are part of the daily working routine of the German miner and have been developed to a high level of refinement.

The future of coal mining in Europe and its regional significance for the Ruhr area have been the subject of two in-depth studies that were published by Prognos AG in the latter half of the year. The Europe-wide analysis was commissioned by Euracoal, the European Association for Coal and Lignite, while the regional report was commissioned by GVSt.

According to the study 'The future role of coal in Europe', which was produced by Prognos in the summer of 2007 and published by Euracoal, coal has excellent long-term prospects – seen purely in economic terms – as a power generation feedstock in the EU-27. This assessment applies equally to coal and to lignite. The Brussels-based Association, which represents the European coal and lignite industry, commissioned the report in 2005 – in collaboration with many European member companies and associations (including GVSt) representing the European mining and power supply sectors – in order to evaluate the opportunities and risks for coal-based electricity generation in the EU in the light of current climate and energy related requirements and challenges. As part of its remit Prognos also investigated the role that coal plays as a power generation fuel in the EU-27 and analysed potential developments and trends leading to the target date 2030 against the background of various scenarios.

The positive conclusions drawn by the study initially seem to contradict the widely-held view that coal is in conflict with the climate protection targets that have been set for Europe and, more particularly, for Germany, and for this reason coal will in future decline in importance and will only play a limited role in the long term. There is now growing opposition to the building of coal fired power stations. And yet the findings only appear to be surprising. If sufficient and affordable CO_2 allowances are made available in an efficiently functioning market, based on the fact that the most cost-effective possibilities for reducing emissions are exploited first – especially in the developing countries – then coal will have potential. The criticism generally directed at coal-based power generation in Germany undervalues the technical possibilities that exist for bringing coal into line with the growing environmental requirements. Furthermore, it overlooks the very important role that coal-fired electricity generation currently plays in many EU member states (and in Germany too) and the enormous benefits that it provides in respect of competitiveness

and security of supply in a deregulated European electricity market. Of real significance is the fact that in the power generation sector coal has real competitive advantages over its main rival, gas.

This year's Annual Report will be reporting on the findings of the study and on the conclusions drawn by Prognos in another survey that was commissioned by the German Hard Coal Association in 2006. This latter study, which is entitled 'Regional and economic impact of coal mining in North Rhine-Westphalia', follows-on from an earlier Prognos report commissioned by the ZAK ('Coalfield Communities Action Group') in 1999 and entitled 'Interdependence between coal mining and economic structure in the Ruhr coalfield', but takes account of the latest industry figures and developments and has also been methodically revised. It contains a series of future scenarios based on the coal-policy understanding of early 2007. The termination scenario of 2018 is hypothetically contrasted with the continuation of the German coal industry at its 2006 level and in some respects with the immediate shut-down of the industry in 2006. The main findings of the study can be summed-up as follows:

- The persistently high average unemployment rate in the Ruhr area – which is worse than in other regions of North Rhine-Westphalia, especially in the manufacturing sector – can largely be attributed to the structural decline in mining jobs.

- It has been calculated that the indirect and induced employment impact of the mining industry means that for every job that exists in coal mining there are 1.3 additional jobs created in other sectors nationwide. In the Ruhr coalfield for every mineworker there is another employee working somewhere in the wider economy.

- Without coal mining unemployment in the Ruhr area would be about two percentage points higher on average; in some individual communities the unemployment figure would even rise by up to 50%. On the basis of these employment relationships the shut-down of the mining industry in 2018 would mean over forty thousand job losses in North Rhine-Westphalia. According to Prognos, the autonomous growth in employment anticipated in other sectors will by then only be sufficient to offset about half of these losses.

- - The closure of the coal mining industry will clearly result in financial savings by way of the subsidies paid-out from the public budget, which in some cases are fairly considerable. However, its loss as an economic and employment factor will at the same time mean a decrease in income for the public purse (by way of income, business and corporate taxes) and an increase in expenditure (type I and type II unemployment benefits). Based on the termination scenario for 2018 the disappearance of mining from the Ruhr area alone will produce fiscal on-costs of nearly € 1.3 bn nationwide.

- As far as the public authorities are concerned the withdrawal scenario up to 2018 and beyond will not, on balance, result in financial savings. According to the Prognos study the aid saved has to be set against additional (non-recurrent) expenditure required to cover the cost of colliery closures along with (long term) fiscal on-costs "of a similar or higher magnitude". The tables would only be turned when replacement jobs are being created at a rate of 9% a year. However this seems illusory, since even the UK has only managed to achieve a rate of 4.5% a year. The decision to shape the withdrawal process in as socially-acceptable a manner as possible and to stretch it out over time was therefore absolutely correct.

Coal, climate, future – irreconcilable? Certainly not – coal utilisation, environmental protection and future opportunities do not have to be mutually exclusive. The decisive thing is to take an unbiased view and to think in every direction. In the many-sided and multi-voiced political and public debate that has surrounded the decisions and declarations of intent on climate policy at national and at EU level one thing has recently become quite clear: CO_2 reduction and avoidance is now inextricably linked to power station technology. In 2007 Berlin and Brussels adopted a whole series of climate-policy decisions – including the ambitious CO_2 reduction targets set by the Federal Government and by the EU – which impose huge challenges on industry in general, and

especially the manufacturing and energy supply sectors, and in future will also impact on the car industry and private households. The key principle is that the lowest fruit are to be harvested first, in other words emission reduction measures are to be employed where they can do most good – a policy that does not conflict with the promotion of new technology.

The power generation system of the future therefore stands at a critical crossroads: the political guidelines that are now to be set will determine whether solid fuel – that is to say coal and lignite – will in future have a level playing ground on which to demonstrate its advantages and merits for electricity generation. For it would seem that as far as solid fuel is concerned everything depends on being able to employ CCS technology (carbon dioxide capture and storage) at power stations in order to capture and store CO_2. The Federal Government is also banking on the development and implementation of CCS technologies for climate and energy-policy reasons: only this could give coal-fired power stations a medium and long-term future – even faced with increasingly stringent CO_2 reduction targets. However, it has to be said that there are still knowledge gaps to be filled in the overall CCS programme and experts believe that it will be 2020 at least before this technology is commercially available. It is still too early to predict which particular system will prove to be most effective, especially in terms of longer-term international competitiveness. As well as the economic aspects various problems of a technical and legal nature still have to be resolved as quickly as possible before a realistic CCS system is available for use. We must not put the cart before the horse by opting for a technology that has not been properly tried and tested.

GVSt and its member company Evonik Steag GmbH – now the energy division of Evonik Industries AG – have overtly stressed this point in 2007. The technical achievements of German power station technology – particularly in respect of new materials, scrubber systems and improved efficiency – have already resulted in significant CO_2 reductions and there is more to come. Under the heading 'Clean Coal Technology' (CCT) we now have an eco-friendly, economically efficient and viable system for coal-fired electricity generation that is not only currently available but also competitive. CCT is now accepted practice in Germany, and the same cannot be said for many other countries – including leading coal consumers like China. Even the USA and the UK have still not achieved the same level of development as Germany when it comes to Clean Coal Technology. Greater use of German CCT technology worldwide would result in a significant reduction in CO_2 emissions – and not in 2020 but right now.

From an energy policy point of view it is to balance up the pros and the cons: on one hand CCS may provide an opportunity to increase coal's general acceptance as a power station fuel. We therefore need to develop the technical and legal framework as a matter of some urgency. On the other hand CCS risks being seen as a cure-all that at the end of the day could not live up to expectations. CCT, by comparison, is now available for use, while in view of the many unresolved issues involved it would be irresponsible at the present time to prescribe CCS as the only mandatory standard for new power stations. This year's Annual Report will examine this theme in some detail against the general issue of climate and climate protection.

Coal, climate, future – these three issues are all linked. The coal industry in Germany – and elsewhere around the world – has a whole series of new questions and challenges to face both now and for the foreseeable future. And these may well determine its long-term role and its image as an acceptable fuel. It is at this point that we need to mention the whole range of sciences associated with coal processing and upgrading – a subject that is also examined in the Annual Report. The German Hard Coal Association – which was founded in December 1968 as the Gesamtverband des deutschen Steinkohlenbergbaus – is committed to tackling these challenges and making the most of the opportunities arising, and intends to participate proactively in all the relevant public debates. In view of the depth and scale of these discussions the Association took the decision this year to change its name to 'Gesamtverband Steinkohle'.

The German coal industry – on its way out or still an option for the future?

Restructuring – the story so far and the current state of the mining industry

In 2007 the German coal industry is expected to produce some 22 million tce from its three production areas, which are the Ruhr, Saar and Ibbenbüren coalfields, which means little or no change from the previous year's output. Most of this production is destined for power stations, while about 4 million t will be delivered as coking coal and coke to the steel industry and the remainder will be purchased by the heat generating sector.

The year 2007 therefore constitutes a brief period of stabilisation in a long process of restructuring that has lasted many years, and one that in the years ahead will see further downsizing until, in 2018, the industry finally ceases production completely according to the current perspective.

Figures for 2006 show that annual coal production has declined by 86% since the industry's heyday after the Second World War when, in 1956, Germany recorded a peak output of some 151 million t. And here are some other figures: in 1980 annual production was 87 million t, while in 1990 – the year of German reunification – it was still nearly 70 million. Even in the year 2000 Germany was still producing around 33 million t of coal. The German coal industry once numbered more than 170 mines. Pit closures and a number of colliery mergers have reduced this to eight.

Manpower downsizing has been even more dramatic when viewed over the years. By the end of 2007 the coal industry will have some 33,000 men on books – a 94% reduction on the 1956 figure. Back then coal mining employed more than 600,000 people in Germany. Even in 1990 the workforce still numbered 130,000, and in 2000 some 58,000.

This restructuring process, which is unmatched anywhere in west-German industry, has been achieved in a socially-acceptable way thanks largely to political backing. This has meant no compulsory redundancies to date – an achievement that has called for and will call for the application of all available instruments.

The various coal companies have also been subjected to a root-and-branch reorganisation. The entire German coal mining industry, except for the small Saar-based Merchweiler mining company (which will cease production in 2008), has for a number of years been managed by Deutsche Steinkohle AG (DSK) and as a result it has been possible to restructure the entire industry 'under one roof' as it were.

DSK is a subsidiary of RAG AG, formerly Ruhrkohle AG, which has long since outgrown the status of a mining company through the development of its investment division – which is referred to as the 'white part' of the business (as opposed to the 'black part', which involves the mining operations). The main emphasis of the RAG Group, both in terms of its employee base and its share of turnover, is now on the more profitable 'white' activities – which means chemicals (formerly Degussa), energy (formerly STEAG) and property. In 2007, as part of the new coal policy understanding, an agreement was reached with the Government to make the white part of RAG an independent company and to float it on the capital market as a new integrated group trading under the name Evonik Industries. This is all due to happen during the first six months of 2008. At the same time RAG will again become a 'black' company with the focus on coal mining and as a result will have a big say in the future restructuring of the industry.

The coalfield regions too have undergone profound structural change that has now seen a complete transformation of the mining industry and its deep-rooted historical potential. While at

one time every one worker in five in the Ruhr area was a coal-miner, the figure now has dwindled to one in fifty. The coal industry has long since stopped being the most important structural factor in the coal producing regions, but neither has it been an obstacle to structural change. Several tens of thousand of jobs in the general business community still depend on mining and these tend to be regionally concentrated in much the same way as the coal industry itself.

The compelling reasons for coal industry restructuring are widely known. While historically coal mining was Germany's most important branch of industry and the nation's number-one source of primary energy, operating costs have long since deprived it of its ability to compete with imported coal and other rival forms of energy – apart from in the fairly small heat market – with the result that it has become reliant on state subsidy for its continued existence and in order to cushion the impact of restructuring. Nevertheless, the level of aid provided has been reduced significantly in recent years. In 2006 the coal industry was granted € 2.5 bn in public aid – ten years previously the figure was more than twice this. The subsidy cut-backs introduced since the 'coal compromise' of 1997 are unprecedented in German history.

Over the next few years coal-industry subsidies are to be methodically scaled-back – initially to a figure of just under € 1.8 bn by 2012, which represents a two-thirds reduction from the level of aid allocated in 1996. Aid to the coal industry is to be phased-out completely after 2012, unless there is a policy reversal for the period thereafter. For the time being, therefore, the indigenous coal industry is in a sense Germany's champion 'subsidy buster'.

Here it should be remembered that aid to the coal industry, unlike the quasi subsidies paid out to renewable energies under the Renewable Energies Act, is annually limited to a fixed ceiling and comprises not only aid for disposals and current production but also has to cover expenditure on colliery closures and the financial liabilities incurred from mining activities that ceased many years ago. The so-called per-capita subsidies paid out to mineworkers – figures that are much quoted in the press and media – are therefore nothing more than typically naïve miscalculations.

The ongoing subsidy cut-backs that are proposed will require the coal industry to undergo a further round of major restructuring by 2012. Of the eight remaining collieries, four will have to close and annual production will initially be reduced to 12 million t.

In spite of major capacity restructuring and the huge efforts that have been made to modernise and streamline the industry, which has brought German coal mining to the status of global technology leadership in a number of areas, the coal industry has still not been able close, on a sustained basis, the considerable gap that exists between its production costs and the prices being paid for imported coal – and hence to reduce the amount of aid required per tonne produced. In recent years production costs have been at least twice as high as the world market prices for steam coal. While the cost-price difference has been less for coking coal, the gap here too is still considerable – the exception being the coking-coal crisis of 2004/2005 when international coking-coal and coke prices went through the roof. After a temporary easing-off the world prices for coking coal have in fact shown a significant upturn again this year, whereas international prices for steam coal have been moving steadily upwards since 2006. It is still too early to predict what will happen next, especially as price trends on the global markets are being determined not by the respective production costs but rather by availability of supply. As the international coal markets become tighter so imported coal also becomes in increasingly short supply and import prices can rise considerably as a result.

The relatively high production cost of indigenous coal can primarily be attributed to the difficult geological conditions prevailing in Germany. Our collieries are now working at an average depth of nearly 1,100 metres. Add to this the higher wage costs and the higher social-welfare, environmental and safety standards that have been put in place. For example the German coal industry's unmatched health and safety standards – which have helped eliminate the kind of mining disasters that were all to frequent in the past and are still part and parcel of mining operations in other coal producing countries – come at a price that is reflected in the higher

production costs of our coal. Another cost factor to be taken into account involves the inherited liabilities and perpetual costs associated with inactive mines (water management, rehabilitation measures, etc.), which in Germany, unlike in many other countries, have to be included in the costs for current production. Even the cost of mine closures has to be factored into the general operating costs. Moreover, the restructuring process often generates special economic conditions of its own, such as the 'cost lag' effect and various idle-capacity costs, which reduce the potential for making carry-over payments and can relatively quickly lead to temporary cost increases – especially in an industry where production levels are in permanent decline. And all this makes the coal industry absolutely reliant on a high degree of planning predictability.

The coal policy decisions of February 2007 – socially acceptable withdrawal by 2018 with a review clause to take effect in 2012

On 7 February 2007, and in accordance with a previous understanding reached by the Berlin coalition partners and involving the Federal Government, the regional Governments of North Rhine-Westphalia and Saarland, RAG AG and the IG BCE union, a coal-policy understanding was reached on "terminating subsidised coal production in Germany until the end of 2018". All parties involved committed themselves to ensuring that there would be "no compulsory redundancies until the termination of the subsidised industry".

The Federal Government and the Länder Governments of North Rhine-Westphalia and Saarland will jointly provide the funding that is required up to 2018. Under the terms of the understanding RAG AG will apply its entire investment assets towards the financing of the coal industry's 'perpetual liabilities', which in practical terms means that the proceeds from the proposed stock-market flotation of the 'white part' of the former RAG Group are to be transferred to the newly established RAG Foundation that will in future be responsible for financing the perpetual liabilities and for undertaking certain additional activities (promotion of projects in the field of education, science and culture, provided that these are linked to coal mining). This understanding in principle is to be made legally binding in a 'framework agreement' between the Federal Government, the coalfield states and RAG. Aid to the industry will also be regulated under a Coal Industry Financing Act to be enacted by the Government.

The new coal-policy understanding also contains the provision that North Rhine-Westphalia – historically the country's largest coalfield region and one that has always been involved, and fairly intensively during some periods, in the financing of aid to the coal industry – will not be required to provide financial support for current production after 2014, while the Federal Government will not be providing structural funding for the area. This special regulation will also take effect "provided the German Parliament revises this agreement in 2012 to terminate subsidsed German coal production"

The new agreement contains a review clause that is anchored in the Coal Industry Financing Act. According to this provision the German Parliament will in 2012 "on the basis of a joint report of the Federal government with the Länder governments of NRW and Saarland whether or not the German coal industry will continue to be financially supported under consideration of the aspects of economic viability, energy-supply security and the other energy-policy objectives". This report is to be submitted by June 2012 and the coal industry and the IG BCE will be heard as part of the process.

The review clause still keeps the option open that after 2012, instead of phasing-out the industry, Germany could retain a subsidised minimum coal production base for years to come. The final decision will be taken by the Bundestag on the basis of the criteria outlined below. The coal industry must and will accept this political decision and has already re-aligned its plans to take account of the new targets: socially compatible scaling-down until 2018 with the possibility of a review of the withdrawal decision in 2012.

Key points of a coal-policy understanding of the German Federal Government, North Rhine-Westphalia (NRW) and Saarland, RAG AG and IGBCE

1. The Federal government, North Rhine-Westphalia (NRW) and Saarland reached an understanding on terminating subsidised coal production in Germany until the end of 2018 in a socially acceptable manner. NRW will no longer contribute to the sales aid (for current production) after 2014. As a result the Federal government is exempted from providing funds for structural aid.[1] RAG AG and IGBCE (German Mining, Chemical and Energy Industrial Union) accepted this on the basis of the provisions agreed upon in this understanding.

   In 2012 the German parliament will review this understanding on the termination of subsidised coal production on the basis of a joint report of the Federal government with the Länder governments of NRW and Saarland whether or not the German coal industry will continue to be financially supported under consideration of the aspects of economic viability, energy-supply security and the other energy-policy objectives. The report of the Federal government has to be submitted to the German parliament and the Länder parliaments of NRW and Saarland by 30 June 2012 at the latest. The coal industry and the IGBCE will be heard. The report has to be based on expert opinions of acknowledged economic research institutes, which have to be attached. Provided the German parliament revises this agreement in 2012 to terminate subsidised coal production the contribution of the coal-mining Länder to coal aid will be limited to their share in case of a phasing-out until the end of 2014 (on the basis of the model calculation existing for a phasing-out until 2018).

   Until 2018 the Federal government, North Rhine-Westphalia and Saarland together will make available the funds required for the financing according to the provisions of paragraphs 1 and 2. This is also the prerequisite for the complete contribution of RAG's shareholdings to the financing of the perpetual costs. The model calculation existing for this phase-out version and the findings of the expert opinion on the costs for closure / inherited liabilities and perpetual burden form the basis for the ultimate specification of the financial volume. The aid is to be governed by an agreement between the Federal government, NRW and Saarland and by law.

2. According to the understanding in section 1 subsidised coal production will be phased out in a socially acceptable manner. All parties involved co-operate to prevent compulsory redundancies until the termination of the subsidised coal industry.[2]

3. The Federal government, North Rhine-Westphalia and Saarland will secure the above financing of the phase-out only under the condition that all current RAG shareholders sell their indirect and direct holdings in RAG AG – without conditions burdening the parties to this key-point understanding – for 1€ each.

4. To acquire all shares of RAG AG for a total of 4 € and to restructure the RAG group a private-public law foundation will be established by a company of the RAG group which will receive the overall assets of RAG AG ("black" and "white" divisions). The statutes and the act of the foundation are agreed upon by common consent with the Federal

[1] RAG AG and Saarland agree that structural aid amounting to 100 m€ is made available by RAG AG.

[2] To this end the early-retirement schemes for employees in the coal industry already supporting the ongoing adaptation process will be continued until the termination of the coal industry, as assumed in the above calculations.

government, NRW and Saarland. The joint and several liability scheme between the "black" and the "white" divisions is maintained until the decision pursuant to section 7. The purpose of the foundation shall be limited to the winding-up of the coal-mining activities of RAG AG, the use of the overall shareholdings of RAG AG pursuant to the provisions of section 7 and the support of education, science and culture in the mining regions in the Ruhr and Saar areas as long as there is a relation to the German coal industry. The Federal government, NRW, Saarland and IGBCE will be adequately represented as members of the foundation's board of trustees. The majority ratios in the board of trustees shall be designed to reflect the respective financial commitments.

5. The Federal government, NRW and Saarland will immediately enter into negotiations on details of the financing of the closure process as well as the inherited liabilities and perpetual burden of the coal-mining activities of RAG AG and on the complete inclusion of the shareholdings of RAG AG in the financing scheme:

   The distribution of the financing burden, including the inherited liabilities, will be governed by a framework agreement between the Federal government, NRW and Saarland.
   To finance the perpetual burden NRW and Saarland will create a separate regime by means of an inherited liability contract with the foundation to be established. According to RAG's assessment and present knowledge the shareholdings of RAG AG are sufficient to this end. The inherited liability contract will be underwritten by the Länder. The Federal government will contribute one third.

6. On the basis of an understanding on the overall financial framework pursuant to section 5 the Federal government will submit a bill on coal financing to the German parliament specifying the annual aid volumes to be granted as from 2009 until the termination of the coal industry. On this basis RAG AG is to receive an administrative decision in 2007 on the allotment of aid for sales and closure aid to be granted as from 2009 up to and including 2012.[3] On the basis of this administrative decision RAG AG will adapt its mine planning to a production capacity of presumably 12 million tonnes in 2012.

7. A decision on the release of the joint and several liability scheme between the "black" and the "white" divisions, the specification of details for the use, with priority given to an IPO, of RAG Beteiligungs-AG and the issue of maintaining a minimum share of the foundation in the shareholdings of RAG AG will be taken as soon as the result of the expert opinion on the assessment of the RAG holding sector and on the options for use commissioned by the Federal Ministry of Economics and Technology is available.

Berlin, 07 February 2007

Dr Jürgen Rüttgers, Minister President of North Rhine-Westphalia

Dr Peter Müller, Minister President of Saarland

Michael Glos, Federal Minister of Economics and Technology

Peer Steinbrück, Federal Finance Minister

Dr Thomas de Maizière, Head of the Federal Chancellery and Federal Minister with Special Responsibilities

Dr Werner Müller, Chief Executive of RAG Aktiengesellschaft

Hubertus Schmoldt, Chairman of the IG BCE (the Mining, Chemical and Energy Industrial Union)

[3] The ceiling regime oriented at the development of the world market price of coal and the official statement to avoid insufficient financing continue to be valid.

A review would be dependent on the willingness of a majority of the members of the German Bundestag to provide aid to coal mining for the period beyond 2018. At the present time no such majority exists. Opinion polls conducted up to the spring of 2007, however, indicate that the public at large is broadly and solidly against any total abandonment of coal mining. The coal industry's view is that when the determining factors are examined there are, from the current perspective, objective arguments to be made in support of this position.

Indigenous coal from the perspective of security of supply, climate protection and economics

a) Indigenous coal and security of supply

The argument that indigenous coal plays an important role in safeguarding energy and raw-materials supplies in Germany is frequently countered by claims that it currently only accounts for 4% of primary energy consumption and that this figure is on the decline. It is said that the few remaining collieries can no longer act as a bulwark against potential energy crises. Moreover, coal can be imported relatively easily from any part of the world. But this is a very superficial expectation and such an assessment does not constitute a serious analysis of the recognisable and potential risks that would arise for coal supplies following a complete loss of the indigenous coal industry and the onset of 100% dependence on imports. A fact especially worth noting here is that the bulk of the steam coal supplied to Germany now comes not from North America or Australia but – apart from some supplies from Poland that are set to decline considerably in the years ahead – for the most part from South Africa, Colombia and Russia.

In the heat sector, where oil and gas dominate, coal – and even indigenous coal that is still competitive in this market – is now only regarded as a niche product, while in the transport sector coal plays no role whatsoever, and this despite the fact that liquefaction technologies have been available for many years (and indeed were first developed in Germany) for producing oil and petrol from coal feedstock. Coal liquefaction is still practised in a number of countries and large-scale liquefaction projects are now being planned in the USA and China. However, coal's real significance for the German energy and raw-materials market lies in the contribution it can make towards electricity generation and steel production.

In Germany coal currently accounts for about 13% of total primary energy consumption, which means that imported coal has a 9% share of the primary energy market. But what does this ratio say about those sectors in which coal is still indispensable?

The German energy and raw-materials market is heavily reliant on imports and this is set to increase further as the indigenous mining industry is downsized. In the primary-energy sector the import quota now totals 74% (as at 2006); even if we leave out 'quasi indigenous' nuclear power the figure is still 62%. Add to this the fact that any remaining indigenous reserves of oil and gas will be used up in 15 to 20 years time. By law nuclear power will be phased-out by 2021. The planned expansion of the renewables sector, even if it were to achieve the extremely ambitious targets that have been set, will never be enough to offset the increased level of imports that are anticipated. Lignite production capacity in Germany is practically fully exploited and is coming under serious pressure from the environmental lobby. Further reductions in indigenous coal production, including the possible closure of the industry, will only increase our reliance on energy imports, and this will be for the long term.

In 2006 indigenous coal accounted for 16% of domestic primary-energy production. After lignite coal has long been the most important of all the national energy resources – which means that it plays a greater role than indigenous gas, oil and biomass and also surpasses hydro and wind power. German coal's contribution is therefore anything but insignificant.

The decline in indigenous coal production in recent years has clearly given imported coal an excessively dominant share of the German coal market. Nevertheless, German-mined coal currently accounts for 33% of the domestic coal market and even by 2012 it will still be making a significant contribution of about 20%. Along with imported coal it provides an energy mix that has a balancing and diversifying role to play for national coal supplies.

However, when it comes to long-term security of energy and raw-materials supply, maintaining access to our indigenous deposits is much more important that the actual figures for current production capacity and market share. For whatever happens, these coal deposits will still constitute by far and away our largest indigenous fuel reserve.

Germany's coal measures constitute almost two thirds of the nation's technically recoverable energy reserves. And a living coal industry is the gateway to these deposits. It is precisely for this reason that one of the stated aims of the current European Regulation on aid to the coal industry is to allow member states to use mining subsidies to maintain a minimum level of coal production and, as a precautionary measure, to guarantee access to indigenous reserves.

The review clause that forms part of the new coal-policy understanding at least keeps open the option of not nailing this access shut. Whether or not we take-up this option will depend on the political decision makers, who will in turn be influenced by future developments in the global energy and coal markets. Over the years the world coal market has without doubt been more stable than that of either oil or gas, even though – apart from the potential risks associated with imported coal – there have been isolated disruptions to supply, including the coking-coal and coke crisis of two years ago, which are to some extent linked with shortages in the freight sector.

More-recent studies conducted by the German utility industry and various independent European experts, which were published in 2007, point to significant medium and long-term risks in respect of shortages in the international coal markets.

An in-depth analysis of supply and demand trends in the global coal market (see the ZfE energy-industry magazine, issue 1/2007) has already corroborated the warning given last year that since about 2002 the long-prevailing 'buyers' market' for steam coal is now threatening to develop "an unstable equilibrium" that will steer the market towards a "medium-term state of shortage and undersupply". In concrete terms the study in question comes to the conclusion that in the boiler-fuel sector – which is the benchmark for steam coal – supply bottlenecks are anticipated in the seaborne trade market after 2010 because the available supply capacity will no longer be able to meet the rapid growth in international demand after that date. And the supply situation here could well become critical already by 2009. Unless substantial countermeasures are taken in the near future and projects launched to develop additional export capacity in order to relieve the strain we shall "soon be threatened by a perceptible gap in supply that will have painful consequences for the movement of prices".

Steam-coal prices on the international market have already been rising steadily since 2005 because the available export resources are currently and persistently stretched to 90% of capacity, much more than ever before. For coal importers this will mean, among other things, that any return to the relatively low import-coal prices of the 1990s will have to remain a "mere dream" for the foreseeable future. If current trends continue "the growing supply shortfall and resulting bottlenecks will (become) increasingly visible".

The main reason for this development, which is especially alarming for those countries whose coal supplies are based increasingly or even entirely on imports, is identified as follows in the aforementioned study:

- Since the turn of the millennium the global growth in demand on the international coal market has really picked-up. And this trend is set to continue. Until now the available supply capacity has been sufficient to cover the growth in demand, while rising prices always provide motivation for

extending production capacity. However, these market cycles have now become much shorter in recent years and the surges in demand are leading ever more quickly to the exhaustion of existing and newly-accruing export capacity.

- Add to this the fact that the world's largest coal producing nations, namely China and the USA, are now becoming net importers and are therefore absorbing part of the available export capacity, which in turn further heightens the international competition for demand.

- From a European perspective it is also possible to detect dynamic developments in steam-coal demand on the Pacific market (in 2006: 336 million tonnes) and this sector is now taking a larger share than the Atlantic market, which is the important one from Europe's point of view (in 2006: 220 million tonnes). According to all prognoses the balance of power in the international coal trading sector is set to shift increasingly towards the Pacific market.

- Within the EU there is real concern that production from the Community's largest coal producer, Poland, is being directed primarily at the homeland market and that exports – especially of steam coal – are being cut back significantly. Further reductions in Polish coal exports are anticipated in the years ahead, which could mean a further growth in demand from the EU for steam coal sourced in third countries.

- In addition to demand factors the analysis considers it critical that the supply side on the international steam-coal market has clearly "underinvested" since 2000. There has been a worldwide decline in the level of investment on export mines and the associated infrastructure, with only half as many such projects currently are being planned as compared with the 1990s. These ventures still tend to be relatively moderate in scale, even though specific investment costs have certainly not increased.

"For more than two years producers have not been prepared to invest in good time in order to ensure sufficient and uninterrupted supplies. The market is already leading a hand-to-mouth existence when it comes to fuel supply."

- It is still unclear whether this trend is "the result of the financial strategy being pursued primarily by the so-called 'Big Four' coal producers and exporters". These four giants of the international coal market (BHP Billiton, XStrata/Glencore, Anglo Coal and Rio Tinto), which together control about 40% of global coal exports, have also acquired a strong position in the steam-coal sector – although at just under 30% this cannot yet be considered as a dominant one. Nevertheless, they have recently been directing their investments increasingly towards the coking-coal sector, which for them represents a more lucrative market (and one that has for the moment calmed down again after the turmoil of 2004/2005). They have now acquired an even stronger position with 44% of this market (where it is claimed they are exerting considerable influence on price developments on a level similar to that seen in the iron-ore sector).

- Investment in new mining developments and infrastructure (road, rail and port facilities, water supply) is also relative expensive and large capital market-driven companies like the Big Four always have to consider the 'shareholder value' when weighing-up whether they should divert their funds to new investments in the coal sector or pay out higher dividends and thereby raise their stock-market value and enhance their credit rating. Operating profits can occasionally benefit from supply shortages and in any case the Big Four can only profit from a tightening seller's market. It would appear that this financial strategy is beginning to pan out – and here there are recognisable parallels with the global oil market.

- The supplier countries are also relatively highly concentrated. The available export capacity for steam coal is now in the hands of a limited number of countries, even though at its peak the degree of concentration is not as pronounced as in the coking-coal sector. Here Australia now

has a 67% market share – thereby making the world's steel industry globally dependent on just one supplier country. Indonesia, with a 26% market share (but no coking coal to offer), has now come to dominate the international steam-coal trade, just ahead of Australia which supplies 20% of the market. In overall terms, therefore, 81% of global exports of steam coal is sourced from a mere handful of countries, while the entire world supply comes from just eight different countries.

- On the Atlantic steam-coal market, which is relevant for western Europe, supplies are even more highly concentrated, for Indonesia and Australia have very little input. In 2006 this market was dominated by South Africa (32%), Russia (28%) and Colombia (27%), which together accounted for 87% of all exports to the Atlantic sector.

- This purely economic analysis of the global coal market does not take account of the political aspect, which is so important for security of supplies. However, this factor can be derived from the statistics: about three quarters of global steam-coal supplies are sourced from countries whose political stability, according to the World Bank classification, is rated as precarious or very precarious.

The two scientific studies 'The future of coal' and 'Coal of the future', which were published in early 2007 by the Energy Institute of the Joint Research Centre (JRC) of the European Commission, also predict serious risks, from a European perspective, for future coal supplies on the world market. These studies emphatically contradict the widely held view that for Europe coal imports constitute a readily available, reliable and price-predictable source of energy. They consider this assessment to be much too general and simplistic. Increasing the supply base in line with demand would involve considerably higher production costs and prices in the years ahead and such a venture would be fraught with unanswered question. The supply prospects for coal on the world market are not nearly as secure as is often assumed. The traditional experience of a stable international coal trade cannot necessarily be projected forward, especially since Europe is steadily downsizing its own coal supply capacity. The JRC, which is based in Petten in the Netherlands, is a joint scientific service set up by the various Directorates-General of the European Commission. While the findings of the JRC clearly do not represent the official position of the Commission, they do constitute scientific expertise that is recognised and supported by Brussels. The studies produced some remarkable conclusions that are of great significance for the ongoing coal-policy debate. This includes an important observation about the European coal industry, namely that a more extensive and efficient exploitation of indigenous coal reserves would reduce the EU's reliance on energy imports and would also have a beneficial synergy effect, including the generation of additional jobs.

The basic aim of these JRC studies was to provide an assessment of the global supply conditions in the future steam-coal market up to the year 2030 – with special relevance to possible implications for the European Union – and of the main figures and trends that will dictate the future availability of this fuel. The studies ultimately produced the following general findings and conclusions:

- It is probable that the clear defining lines between the various forms and uses of fossil fuels will gradually become blurred and that part of the energy market of the future will develop into an integrated marketplace for hydrocarbons in which coal will assume increasing importance by way of coal gas and coal oil.

- As far as competing energy forms are concerned it is suggested that the EU's high consumption of oil and gas, of which Europe has low levels of indigenous reserves, exposes the European Community to a high degree of vulnerability – a fact that is admittedly to coal's advantage when it comes to security of supply. The EU should also takes steps to prevent its electricity generation sector becoming excessively reliant on gas. In spite of some success in diversification the EU is still dependent on Russia for at least one third of its gas supplies – a figure that may well grow in the years ahead – and in addition to the political risks and express concerns about the potential creation of an OPEC-like natural gas cartel this could also have further economic repercussions

associated with Gazprom's ability to deliver its product in sufficient quantities as and when required. For this reason alone we need to ensure an adequate balance between coal fired and gas fired generation.

- Current background conditions combined with the need to expand global coal supplies to meet growing international demand will probably lead to a further rise in global production costs, with the result that international coal prices seem set to rise significantly in the years ahead.

- The current supply capacity of the world coal market is being gradually depleted as economically recoverable coal reserves quickly become exhausted. Because of the huge rise in global demand and the more-restrictive quantitative assessment used for the period 2000 to 2006 the static life-span of the world's coal reserves, as based on the 'reserves to production ratio', has now been reduced from 277 to about 150 years. This projection is further corroborated by the fact that international predictions for coal production indicate a level of expansion far greater than in any other fuel sector. Given the relatively poor quality of the indigenous coal reserves of China and India, the spectacular economic growth of these two countries is likely to drive the international demand for coal even further upwards with the result that existing supplies will be depleted at an even faster pace. Those countries that have the largest coal reserves also tend to be the biggest coal consumers, a fact that helps stabilise this trend. Moreover, for reasons of cost and competition the reserves that have already been accessed cannot in many cases be fully exploited using the 'room and pillar' method that tends to be common practice around the world.

- However, any rapid exhaustion of the world's coal reserves is only hypothetical – as the JRC studies themselves point out – inasmuch as in addition to the economically accessible 'proven reserves' there are also significant quantities of technically accessible reserves, and this includes European coal measures, as well as large amounts of geologically estimated resources that are still not technically accessible at the present time. These deposits are likely to be much larger in size than the conventional oil and gas reserves and changing technical and economic conditions could transform the world's coal resources relatively quickly into 'proven reserves'. But before this happens there needs to be a huge improvement in the investment climate prevailing in the coal industry and in the associated logistics sector, and this will require a political and regulatory framework with real long-term stability. Steps also have to be taken to iron-out the uncertainty surrounding the emission-reduction targets that will apply after 2012. Over the years investment in existing mines and in developing new production fields has been inhibited by low prices and inadequate profit margins as well as by industry fragmentation. Even coal-based R&D has been on the decline. If prices continue to remain (too) low there could well be physical shortages in supply – in spite of a sufficiency of reserves – as a result of 'psychological exhaustion'.

- From a purely technological point of view world coal supplies could be increased dramatically by developing and implementing new exploration methods for coal reserves and resources, by introducing better deep-mining technology and by increasing research and development into new mining practices, including the exploitation of 'non conventional deposits' by way of underground coal gasification and methane usage. The studies therefore explicitly call on the EU to intensify its R&D efforts in this area, which implies a continuation of the European deep mining industry.

- The JRC studies also highlight the fact that there is considerable concentration in the international coal market when it comes to the supplier companies. The 'Big Four' handle almost 40% of the world trade in steam coal and, more significantly, control the entire supply from the largest exporter country Australia. While the reports do not consider that a 'coal OPEC' is likely to develop, this concentration of market power could certainly impact on world market prices in the coal sector.

- It is also conceivable that there will be an even greater tendency towards concentration in the exporting countries. China and the USA, once net exporters on the coal market, are now gradually developing into net importers. India made this switch some years ago, while China too swapped roles in 2007.

- Exports from other potentially significant suppliers (Russia, Kazakhstan and Colombia) are fraught with major logistical problems. Australia is now gradually developing into the ultimate global coal supplier, while other traditional exporters of note, such as Indonesia and – even more importantly for the EU – South Africa, are experiencing serious problems in developing their coal reserves and export capacity.

- Most of the world's coal production and exports are therefore concentrated in the hands of a few countries and market players, a situation that could well lead to a risk of 'market imperfections'. More significant from a long-term perspective is the fact that the lion's share of the world's coal *reserves* is also highly concentrated: 55% of the planet's coal reserves are owned by just three countries, while a massive 85% is controlled by six supplier nations (the USA, China, India, Russia, South Africa and Australia), which also have nearly 80% of the world's reserves of lignite. It is therefore 'misleading' to refer to the geostrategic diversity of the world's coal reserves, simply because this fuel is distributed over every Continent. While reserves are certainly present in every part of the world, high-quality tradable coal tends to be regionally concentrated in one or in just a few countries, a fact that actually creates an extremely high level of supplier concentration.

Against this background there is real reason to fear that Germany's security of coal supplies would be seriously compromised in the event of total dependence on imported fuel, a scenario that would moreover be permanent if the country were to phase-out coal production completely. The risks involved could never be effectively countered by diversifying coal imports, signing long-term supply contracts or stockpiling. The energy-industry expert Frank Umbach of the DGAP (German Council on Foreign Relations) considers phasing-out the mining industry to be a strategic mistake for national security of energy and raw-materials supply that is similar to, or in some respects even more serious than, the decision that German companies have been taking for the last twenty years – for short-term economic reasons – to withdraw from ownership or even participation in overseas mining projects.

Neither does the state-managed stockpiling of imported coal, a measure repeatedly advocated by various economists, offer a real alternative solution to this problem. Here there is certainly no easy answer to the question of how large such a reserve stockpile should be – one proposal suggesting that it should represent one full year's indigenous production, which at current levels comes to 20 million tonnes or more. Would it not be more sensible to use total consumption, including imports, as the yardstick for such a strategic reserve? Finding the solution to such a problem assumes prior knowledge of the extent and duration of any possible disruptions to supplies – something that cannot easily be established even in the oil and gas markets. Moreover there are real practical difficulties to be overcome (ranging from the preparation of suitably large storage areas and the additional logistical problems this would pose, to the provision of enclosed facilities capable of storing such huge quantities of coal in an environmentally acceptable way and without causing undue fuel degradation), along with the question of financing not only the ongoing storage costs but also the initial investment (20 million tonnes would require a single payment of around € 1.5 bn) and the measures needed to top-up the stockpile on a regular basis, in spite of occasional sales and the provision of emergency aid. While this funding requirement may well be lower than that needed to maintain indigenous production – though this would also depend on the scale of the project – the stockpile option would generate many fewer employment opportunities and would provide no reference base whatsoever for German mining technology. From an energy policy point of view the basic assessment that was made back in 1990 by the then Coal Commission, which was set up by the Federal Government and headed by Professor Mikat, continues to apply to this day: coal stockpiles merely provide "reaction time" and "buy the possibility of a smooth transition to a different situation". By exploiting indigenous deposits, on the other hand, we retain "the option of continuing to use these reserves, on a more intensive basis if necessary, as a diversification alternative and in this way effecting a long-term structural change to the energy mix".

b) Indigenous coal and climate protection

The Federal Government's climate-protection programme set a target of a 25% reduction in CO_2 emissions by 2005 and an overall 21% reduction on 1990 levels of the six greenhouse gases listed in the Kyoto Protocol (CO_2, CH_4, N_2O, SF_6, HFCs and FCs), in conjunction with the EU burden sharing agreement. With a view to meeting the targets laid down in the Kyoto Protocol German industry has given firm commitments to the effect that under the terms of the agreement it will, by 2012, reduce specific emissions of all greenhouse gases by 35% compared with 1990 levels. In this context German industry also agreed to make further efforts up to 2005 to achieve a specific 28% reduction in CO_2 emissions measured against the reference year 1990.

On 30 May 2002 GVSt, acting on behalf of the German coal industry, acceded to the climate agreement that had been concluded by German industry. As part of a series of voluntary commitments, and in spite of the difficult restructuring process under way at the time, the Association set itself some challenging objectives for reducing production-related CO_2 and CH_4 emissions with a view to helping Germany achieve its environmental targets. In a statement issued to this effect GVSt declared that the German coal industry intended to reduce CO_2 emissions from production-related energy consumption (coal winning, conveying, preparation and processing) by 70% by the year 2005 and by a figure of 75% by the year 2012 (both related to 1990 emission levels). It also stated that by 2012 methane emissions vented to atmosphere from both active and inactive mines would be reduced by 70%. Methane's impact on the environment means that it is listed as a greenhouse gas in the Kyoto Protocol. Cutting methane emissions therefore figures large in the coal industry's environmental commitments. The setting-up of two methane marketing companies in 2000/2001, under the control of the (then) RAG, was an important step in the process for reducing methane emissions. (These colliery-based mine gas activities are now managed by Mingas-Power GmbH, Minegas GmbH and Evonik New Energies GmbH.)

By reorganising and developing its operations the coal industry succeeded in reducing mining-related CO_2 emissions by 73% during the period 1990 to 2004 and CH_4 emissions by 71% between 1990 and 2005. The planned reduction targets of 70% originally set for the year 2005 have therefore been achieved and maintained well ahead of schedule and easily surpass the overall reduction targets that have been set for the German business sector in general.

The German coal industry will continue to focus on measures for reducing specific trace-gas emissions. Between 1990 and 2004 specific CO_2 emissions were cut by 25.2% from 132 kg CO_2/t to 99 kg CO_2/t. This has to be seen in the light of the unique conditions prevailing in the German coal industry, as unlike other branches of industry the special efforts made to ensure rational energy usage are partially offset by countervailing developments such as increasing working depth/temperature and an extending roadway network. However, the dramatic reduction in CO_2 emissions can be attributed mainly to the programme for closing collieries and other facilities associated with coal production, although the decline in specific energy consumption has also played a part. CO_2 emissions have been falling much faster than production levels. Technical innovations introduced in recent years have meant that the once-separate tasks of coal winning, transport and cavity support can now be combined into a fully-mechanised system. A whole range of innovative developments have been put in place for increasing efficiency and boosting performance in all areas, including cutting and stripping winning, face and belt conveying, materials transport, mine ventilation and workplace environment. For many years mine gas was regarded primarily as a source of danger and an environmental pollutant – especially when it came to inactive collieries. Now its positive aspects as a fuel are becoming increasingly apparent. Apart from the Saar coalfield, few collieries ever considered using their gas for profitable ends. This situation changed fundamentally in 2000 with the Renewable Energies Act (EEG) and the possibility of reducing emissions from this source. The mine-gas sector – which is responsible for the installation of plant and equipment for exploiting the energy potential of this fuel, thereby preventing uncontrolled and diffuse methane emissions – owes its development to the energy-policy framework created by the EEG.

Since then a new branch of industry, small in scale but dynamic, has sprung up – especially in the Ruhr coalfield – and is creating job opportunities in the environmental sector. The first mine-gas extraction systems were connected-up to existing gas-drainage equipment installed at filled-in mine shafts. It quickly became apparent, however, that the gas was escaping not just from the open cavities and workings. Methane is lighter than air and therefore takes the most direct route to the surface via any available cleavages and fissures. After an examination of all existing charts, maps and general data, holes were drilled into inactive mine workings at various sites where there was the greatest likelihood of gas being present. The practical reasons for extracting mine gas via holes drilled into old mine workings are many and varied: inadequate technical rating of the gas extraction plant, site-location benefits for the processing equipment of having a single drilling site, and so on. In 2004 a total of 196 million m³ of mine gas were extracted and marketed from inactive mines. The NRW Energy Agency acts as an umbrella organisation in bringing together plant operators, manufacturers, statutory-authority representatives, motor manufacturers, drilling companies and others, who now have a public forum in which they can regularly exchange information and experience. The Ruhr coal industry, which formerly used to market about 20% of its gas yield, now extracts around 70% of the gas released from collieries in active production, thereby just about achieving the maximum standard already set in the Ibbenbüren and Saar coalfields. In 2006 approximately 93% of all the gas extracted was sent for further processing and marketing.

c) Indigenous coal and economics

When it comes to economics the coal industry is still amazed to note how much it is criticised for its lack of competitiveness and its reliance on subsidies, while much larger sums are set aside as state aid to the renewables sector without generating any comparable critical debate. Even if the comparison is restricted merely to payments associated with the Renewable Energies Act this fact applies in terms of both absolute volume and aid per kWh of electricity. According to Government figures the 'differential costs' of the feed-in tariffs payments effected under the provisions of the Renewable Energies Act, as compared with conventional forms of energy, currently total more than € 3 bn, which is about double the amount paid to the coal industry as aid to electricity generation. As regards the rate of subsidy per kWh, scientific calculations have shown that the cost of generating power from indigenous coal as opposed to imported fuel implies an additional expenditure/subsidy requirement of about 2.5 cents/kWh, whereas the average payment for renewable energies under the terms of the EEG is about 7 cents/kWh – in other words almost three times higher. Neither does the argument that renewables are ultimately 'CO_2 free' hold water, since CO_2 avoidance through the power-station renewal programme is a 'real alternative'. Add to this the extra cost of 'balancing energy' and back-up capacity that has to be incurred due to the inherent instability of renewables-based electricity supplies, along with the additional expenditure on transmission-network extension and adaptation measures. Clearly a case of double standards being applied by the energy-policy makers.

Even the subsidy debate continues to focus a disproportionate amount of attention on the aid that is given to the coal industry. Mining receives less than 2% of the total national subsidy allocation, which means that more than 98% of the state aid being paid-out is destined for other sectors, companies and purposes – and this does not even include the 'subsidy equivalent' feed-in tariffs payments for renewable energies that are compulsorily financed through electricity prices.

The suggestion that after the initial phase of start-up funding – which has lasted twenty years already – renewables will reach their feasibility threshold at some point in the foreseeable future also fails to convince as a discrimination criterion for indigenous coal. The relevant scenarios that predict a decline in the differential cost of renewable energies are based on the assumption not only of a decreasing cost trend for renewables themselves but also of an ongoing and significant increase in the world market price of oil, gas and coal. Under such a premise, however, the cost-price difference of indigenous coal would also be put into a quite different perspective. In the

latter case the gap would close even faster than for many of the renewables, especially with the abolition of special financial liabilities. And even the fact that many supplier countries will for the foreseeable future be able to produce coal more cheaply than here in Germany does not exclude the effects of price competition. For production costs are only partly responsible for price movements. World market prices in fact tend to follow shortfalls in supply and levels of demand, as demonstrated by the international oil market – the world's largest energy trading place – where for years prices have been many times higher than production costs.

The assumption that indigenous coal can never again be competitive is therefore no less speculative than the expectation of an all-round competitive supply of renewables-based energy. However, the future prospects for competitive coal mining in Germany will only be safeguarded by retaining a minimum production capability. The Donar Project, which is being planned by DSK, highlights the fact that world market prices only have to stabilise at a certain level, for example, for indigenous coking coal and coke to be produced competitively and therefore without the need for subsidy.

The Donar deposits, which lie close to the town of Hamm and not far from the existing Ost colliery, contain about 100 million tonnes of high-quality coking coal that can be extracted at a cost that is fairly similar to current world market prices. The significance of these carboniferous measures, which could provide a supply of low-cost coal for many years to come, has been known for quite a while. The Donar deposits were fully surveyed in the 1980s by a programme of exploratory drilling combined with surface and line seismics. The measures cover a wide area and are largely free from geological faults. The coal seams are well formed and would be suitable for high-performance, continuous extraction using the latest underground layouts and mining technology. The basic rudiments of the underground infrastructure are already in place, while the surface conditions would allow mining to take place with minimal environmental impact. Germany therefore has a real opportunity to develop a new, ultra-modern and subsidy-free colliery that would not only help ensure security of supply for German industry but would also create up to 3,000 jobs in the region – and this could be achieved relatively quickly in just a few years time. DSK has already set the planning and approval procedure in motion. All that is required is an investor. DSK still lacks the investment capital needed and other potential investors are waiting for the security that can only be provided by a regulatory framework. Neither of these situations can be changed as long as the political signals are still pointing towards the phasing-out of coal mining in Germany.

Without a living coal industry Germany would also lose the sales market, development facilities and reference base that are so vital for the mining technology industry. Even though the German mining-machinery sector now generates most of its revenue from exports, and has developed into an internationally competitive and strong-selling brand, the German coal industry – with its highly developed know-how and geological challenges – continues to play a vital 'test bed' role. The closure of the German mining industry would also shut down the domestic sales market on which so many small and medium-sized suppliers are dependent and moreover would spell the end for local research and development activities. As a result, most of the added-value and employment potential currently generated by this sector would probably be driven out of Germany for ever.

From an economic viewpoint the consequences for the regional employment markets have to be examined, too. The coalfield regions are in any case beset by structural problems and suffer above-average unemployment rates. In the Ruhr, for example, unemployment was still running at 13% in the summer of 2007, in spite of the fact that the local labour market was benefiting from the general economic upturn. The experience acquired by other mining regions affected by similarly severe restructuring programmes, such as the coalfields of Britain and the lignite mining areas of eastern Germany, suggests that coal-industry downsizing not only has an immediate impact on the job market but in fact leads to decades of increased regional unemployment.

As well as causing huge social problems, pit closures and job losses in the coalfield regions have a huge financial impact in the form of reduced revenue for the Treasury and social security

department from taxes and national insurance contributions as well as additional expenditure to cover the cost of higher unemployment levels and possibly also structural measures. Whether or when these fiscal follow-on costs will be offset by the Treasury savings on reduced subsidy levels is a purely empirical question that cannot yet be answered in either economic or ideological terms, as purported by various politicians, opinion shapers and even economists. What is certain, however, is that the savings to the Treasury will not be anything like 100% and that coal-industry aid cannot therefore be re-allocated on a one-to-one basis.

In order to examine these relationships on an empiric-scientific basis GVSt commissioned the well-known economic research institute Prognos to produce a study of the 'Regional and economic impact of coal mining in North Rhine-Westphalia' that would also examine the question of financial follow-on costs. Prognos set about in exemplary fashion to examine the economic and fiscal relationships associated with the Ruhr mining industry. While DSK is not synonymous with the entire German mining industry, its Ruhr-based operations do account for about 75% of the national coal industry's production and workforce. The current report was therefore able to follow-on directly from the accredited study on the 'Interdependence between coal mining and economic structure in the Ruhr coalfield', which was carried out in 1999 on behalf of the ZAK (Coalfield Communities Action Group) and has now been updated to take account of recent developments. In the new study, which has now been published, Prognos also reached some very interesting conclusions on the economic impact of the 2018 phase-out scenario, which has meanwhile been decided.

Regional, fiscal and other impacts of the 2018 withdrawal scenario (Prognos study based on the Ruhr mining industry)

The Prognos study 'Regional and economic impact of coal mining in North Rhine-Westphalia', as commissioned by GVSt in 2006 and completed in September 2007, sought to employ empiric-scientific methods in analysing the regional and economic implications – and hence the associated fiscal and other effects – of the mining industry of North Rhine-Westphalia. The work is therefore to be regarded as an objective contribution to the regional-economic debate that is part of the contentious issue of German coal and the future of the industry and should help provide a resilient and factual rationale. (The energy-policy aspects of the debate have not been considered.)

The study duly focussed exclusively on the regional and economic impact of the Ruhr mining industry of North Rhine-Westphalia. The Saar and DSK Ibbenbüren operations were not therefore included in the survey or in its findings. In qualitative terms, however, the relationships established for the Ruhr coal industry – which represents three-quarters of the German mining sector – can also be said to apply to these other coalfields too.

a) Current significance for the regional economy and labour market

The study confirms that in spite of significant downsizing the coal industry 'continues to be of major significance for the Ruhr area and for the regional job market'. Coal mining is still one of the Ruhr's biggest employers, at least as far as the coalfield communities are concerned, and still ranks alongside the other important industries of the region. As well as the direct effect of mineworkers' salaries and mining jobs the coal industry has an indirect and induced impact on regional businesses and on the supplier sector in the form of added value, income generation and job opportunities. It has been calculated that every single mining job is linked to 1.3 dependent jobs in the general economy nationwide (one of which – or to be exact 0.98 – is in the Ruhr); long-recognised for many years, the 1.3 multiplier effect of the mining industry has therefore now been confirmed.

In practical terms this means that the Ruhr coal industry not only provides employment for some 27,100 mineworkers in North Rhine-Westphalia (2006 figures) but that a further 36,000 or so jobs are dependent on it in the wider industrial sector – which comes to just about 63,000 jobs in all. On the basis of this estimate the study comes to the following conclusion: "While coal mining as an economic factor is naturally of benefit particularly to North Rhine-Westphalia, the entire country in fact profits from it."

And further evidence is provided of the significance of the Ruhr coal industry as it is today:

- The regional-economic impact of the German mining industry lies not only in the employment opportunities it creates but also in the taxes and social contributions paid by the workforce, which currently total some € 1 bn a year.

- With a purchasing and procurement capacity of some € 2.0 bn in 2006 (orders worth € 1.6 bn, plus expenditure on energy, transport, insurance, etc.) the Ruhr mining industry alone generated an overall production value of € 2.6 bn in the upstream industries sector, which equates to an added value of € 1.1 bn for North Rhine-Westphalia. While the mining machinery manufacturers and mining suppliers naturally benefit most from this business, construction companies, haulage firms, maintenance and servicing engineers, assembly companies, steel manufacturers and various other service providers also generate valuable revenue from it.

- Because of the multiplier factor coal-industry employees – who have a total annual income of € 1.1 bn – produce a collective income effect of € 1.6 bn. For the region this means additional consumer spending worth about € 500 million, which safeguards nearly 6,000 jobs in the Ruhr area. While if the coal industry were to close social welfare benefits would still allow some general consumer spending (about 60% would remain), at least 2,000 non-mining jobs would be threatened simply as a result of the loss of purchasing power in the Ruhr area.

- The Prognos study also produces another finding: the massive programme of coal-industry restructuring has triggered job losses and a general decline in demand in both manufacturing and services throughout the Ruhr coalfield area and this has been a contributory cause of the above-average unemployment now affecting the region. What the report actually says is: "While mining now only accounts for a relatively small 2% of all employment in the Ruhr area, because of the indirect effects (declining demand for services from SMEs based in the Ruhr coalfield, demand shortfall caused by irremediable employee downsizing) the negative impact on the Ruhr labour market has been greater than might have been supposed merely on the basis of coal industry restructuring."

- The investigation also shows something else: namely that a rapid run-down of the coal industry, and with all other conditions remaining unchanged, would drive-up unemployment in the Ruhr coalfield area as a whole (which at 13% is now higher than both the national and the regional average) by about two percentage points, while in some communities the rise in the number of jobless would be even more considerable: in places like Alpen, Bergkamen, Dinslaken, Moers, Neukirchen-Vluyn and Voerde, for example, the increase could be as much as 25 to 38%, while in towns such as Hünxe und Kamp-Lintfort it could well reach a peak of 50%. Even if a proportion of the former mineworkers were to find new employment this would only squeeze other job-seekers out of the labour market.

- The end of coal mining would also be a serious blow for professional training in the region, as DSK – which has at least 1,800 apprentices on its books – is currently one of the Ruhr's biggest training providers and its training ratio of 7.1% is higher than the average for Germany's major listed companies (5.6%).

- Any further reduction in coal output will also mean job losses in the engineering sector and will place additional strain on the regional labour market in other peripheral sectors with links to the mining industry, unless ongoing employment gains are made in other areas (such as modern

services, etc.). Prognos already predicted this in its 'Germany Report 2030' and has also factored it into the new study. As far as the Ruhr is concerned, according to Prognos: "If coal mining were maintained at the current level, on the other hand, the number of gainfully employed would increase by 1.2%, or some 28,300 persons, by the year 2020." The various run-down scenarios, and therefore the ultimate 2018 closure scenario itself, would on the other hand result in ongoing regional (net) losses of at least 20.000 jobs. As the 'autonomous' job gains associated with other sectors would also be sustained if coal mining were to be kept at a steady level, the 2018 withdrawal scenario would essentially be responsible for more than 40,000 job losses.

The Prognos study also analyses the importance of the Ruhr coal industry, both financially and in other respects, for North Rhine-Westphalia and the country as a whole and examines what the impact of the industry's closure would be.

b) Fiscal impact of phasing-out the coal industry

Not only maintaining coal production means having to pay subsidies, the complete cessation of coal mining would also have serious financial consequences for the state and social-security budgets. This would take the form of a decline in revenue from taxes and social contributions and additional expenditure on unemployment benefits and other costs. Prognos therefore calculated the fiscal effects of a hypothetical shut-down of the coal industry in 2006, and the impact of a '2018 withdrawal', as measured against the current status quo.

In the initial stage of the investigation the study set out to establish the fiscal costs incurred for each unemployed person, for the further downsizing and eventual closure of the coal industry will mean the loss not only of mining jobs in North Rhine-Westphalia but also of ten thousands of workplaces in the peripheral economy (multiplier effect of 1.31), as outlined in the first part of the study. Even given average employment growth in other sectors a '2018 withdrawal' would lead to more than 20,000 job losses in North Rhine-Westphalia, while if no such growth is forthcoming (the 'ceteris paribus' case) the figure could top 40,000. This would mean an increase in regional unemployment even if the mineworkers were not made redundant or were to find employment elsewhere, for it would reduce the regional employment potential or would squeeze other job-seekers out of the labour market.

Official figures on the cost of unemployment have been produced by the IAB (Institute for Employment and Vocational Research), though these only cover the period to 2004 and so do not take account of labour market reforms after 2005 or, more importantly, the new 'Hartz IV' regulations on unemployment benefits. Prognos was therefore only able to produce estimates that followed-on from the IAB figures, though efforts were made to incorporate as far as possible the system changes introduced post-2005. (According to Prognos the total cost of unemployment nationwide in 2005 can be put at about € 97 bn.)

It should be noted that because of the change in the allocation of employment responsibilities between the Federal Government, on one hand, and the regions and local authorities on the other, the German 'Länder' now pay a reduced share of the unemployment costs – though without any change in the overall level. The deficit for the social security budget cannot be reassigned to the individual Länder as a cost factor, even though – from a regional viewpoint – it originated there. This also has to be taken into account when examining the NRW-specific cost of unemployment generated by the closure of the coal industry, which is therefore now somewhat lower than it was. Moreover it should not be forgotten that jobs in the coal industry and in the mining supplier sector are industrial posts that attract higher wage levels than is average for the economy in general (which includes the low-pay sector, especially the service industry), with the result that the loss of the associated revenue in the form of income tax, VAT and social security contributions, along with specific labour-market charges, also contributes towards higher fiscal costs.

Prognos has calculated that the average financial cost incurred by the loss of each coal-industry job (as at 2006) would be nearly € 35,400, of which at least € 5,100 would fall to the state coffers of North Rhine-Westphalia.

Using as a reference the calculated cost of each lost coal-industry job Prognos has analysed the financial impact of a hypothetical abandonment of coal mining in the Ruhr in 2006. Implicit in this is not the sudden shut-down of the coal industry but rather a gradual phasing-out over ten years. This is also done in a realistic way, whereby it is assumed that the coal industry does not shed all its jobs but rather retains a residual workforce of some 800 (about 2% of the actual labour force in 2006) for dismantling and run-down operations; furthermore, the analysis also factors-in the creation of new jobs in the Ruhr coalfield and so allows for the normal pace of structural change that has been experienced in other comparable coalfield communities, such as in the UK. When taken overall the study estimates that prior to 2006 this would have resulted in an additional loss of nearly 48,000 jobs (in both mining and in the economy at large).

In addition to the financial follow-on costs of unemployment referred-to above there would at the same time be a decline in the revenue from earnings-related tax (corporate tax and business tax) in the supplier sector. All in all, for the 2006 scenario, this would mean fiscal costs of € 242 million for North Rhine-Westphalia and some € 1.76 bn for Germany as a whole (Federal Government, Länder, local communities, Ministry of Employment and Social Security Institutions).

The Prognos study also comes to the following conclusion: the fiscal cost alone of the sudden shutdown of the Ruhr mining industry would exceed any hypothetical savings made on the financial aid paid out to the coal industry in 2006 (€ 1.93 bn, of which a calculated 75% – or about € 1.45 bn – went to the Ruhr). But even this does not tell the whole picture, as Prognos goes on to stress. Taking into account the additional aid required to meet the cost of the closure programme and the remaining 'perpetual costs' that would have to be met by the state in the event that the coal industry were shut down, it was found that "the savings made by the state on aid to disposals ….. would be largely offset by the fiscal shortfall and job market-related costs resulting from the abandonment of coal mining and the indirect impact this would have".

What this means is this: contrary to what has often been assumed, the state would not have saved anything had the coal industry been closed down at any time in the past and in fact on balance would have had to pay out more. This only confirms the findings that the previous Prognos study reached in 1999 when comparing the 'crash-landing scenario' with the 'gentle landing' provided for by the 1997 coal agreement.

This conclusion also brings home another important point: a 1:1 reallocation of coal-industry aid for other economic ends, such as structural development, is economically impossible. The widely-held political belief that coal-industry funding should have been stopped and the money put to better use elsewhere is therefore no more than an untenable generalisation. In overall financial terms such a calculation would not have added up – and neither will it in the future.

Prognos estimated the fiscal on-costs of a 2018 shutdown, with its progressive rundown of coal production and the resulting loss of jobs in mining and in the supplier sector, and compared these with the 'status quo scenario' (constant manpower levels in the mining industry). The previously determined parameters for fiscal shortfall were also applied to the job losses. A 'ceteris paribus' analysis was also employed here too, in other words no allowance was made for autonomous employment gains and losses in other sectors. (This approach seems justified, as these would remain the same in both cases.) The study also assumes socially-acceptable downsizing of the coal industry, which means that the scenario follows the actual political commitment that there will be no compulsory redundancies in the mining industry. Nevertheless, the loss of these jobs has a knock-on effect for the regional labour market and there are further job losses in upstream industries. According to the 2018 withdrawal scenario Prognos calculates that North Rhine-Westphalia will suffer a total of 43,726 job losses (of which nearly 21,000 will be 'other employees' outside the mining industry), while the losses nationwide are put at 50,777.

This in turn means annually increasing on-costs for the Treasury. This revenue shortfall has been estimated by Prognos using a conservative approach based on real net costs, as no rates of increase are assigned either for wages and social insurance contributions or for average levels of expenditure on unemployment. (Neither is the politically agreed extension of the adaptation benefits settlement for mineworkers taking early retirement factored into the equation.) By 2018 the resulting revenue shortfall for the Treasury nationwide would total nearly € 1.3 bn, while for North Rhine-Westphalia the loss to the state budget would amount to some € 200 million. Seen in cumulative terms for the period 2007 to 2018 the total fiscal cost of phasing-out the Ruhr coal industry therefore comes to approximately € 9.5 bn for all Government and Länder authorities, of which € 1.4 bn would fall on NRW.

Expenditure on inherited and perpetual liabilities (mine drainage etc.) – costs that for the most part are associated with mines already closed and which would still arise even if coal production were to cease completely – has to be seen to a large extent as something quite separate from the coal production sector.

The study also undertakes another calculation: if coal mining were to be continued at 2006 production levels and with no change in the annual amount of state subsidy, which as already mentioned totals € 1.93 bn a year, the financial aid paid out by 2018 would come to about € 23.2 bn. In the '2018 withdrawal' scenario, on the other hand, the cumulative aid would be reduced to € 14 bn in proportion to the decline in coal production, which represents a maximum saving of some € 9.2 bn in subsidies. At the same time, however, additional aid would be needed to cover the planned cost of colliery closures (technical measures such as demolition, shaft filling and site restoration, additional expenditure on workforce downsizing and depreciation charges for plant and equipment being de-commissioned), which would come to a cumulative € 3.2 bn or so by the year 2018. According to this calculation, the net saving to the subsidy payer would be around € 6 bn, and this with more than € 9 bn alone in follow-on costs from the phasing-out of the Ruhr coal industry.

Prognos therefore states quite clearly that "up to the year 2018 at least the savings made by way of aid (to disposals) will be offset by a financial shortfall of a higher order of magnitude". Here there is a certain problem with transparency: "While the savings on expenditure can clearly be entered on a budget, the revenue shortfall cannot directly be accounted for in anything like the same way." In general fiscal terms the findings clearly state "that the financial contributions for the coal industry can on no account be reallocated on a one-to-one basis for other structural programmes or public projects but will up to 2018 at least be offset either fully or (if the revenue shortfall can be reduced by way of special measures) at least to a large degree by the deficit in revenue".

At first glance NRW would seem to benefit most from the easing of the financial burden. (By way of comparison: in 2006 the NRW contribution to coal industry aid was € 564 million, which is initially to be reduced to € 516 million by 2008.) But Prognos states quite explicitly in this respect that the NRW authorities not only benefit from the financial output of the coal industry and are saved from suffering a reduction in tax revenue but also profit in a more direct way from the economic output and monetary payments of the mining industry, which mainly flow back into the coalfield regions – and in this case to the Ruhr coalfield specifically – in the form of mineworkers' wages and the purchasing power of the Ruhr coal industry. According to Prognos it is therefore "perfectly clear that North Rhine-Westphalia's involvement in aid to the coal industry pays-off many times over (an estimated five to six-fold) when set against the financial returns and economic performance". From this it can be inferred that while the phasing-out of the coal industry will clearly have less of an impact on the NRW budget than on the national Treasury, this will be offset by significant losses to the economy and labour market of the regions concerned.

These conclusions will continue to apply for many years after 2018, provided that there is no change to the situation of general underemployment and above-average unemployment in the Ruhr area. This state of affairs would be different if economic growth, structural change and

employment were to develop more dynamically than assumed and the region were to move back towards full employment. For this reason Prognos also used model calculations to determine the fiscal effects that would be generated by an accelerated pace of structural change and a higher rate of compensation for the job losses in the coal industry. Three optional scenarios were used for the calculation: one possible evolution is based on a 'job replacement rate' of 4.5% a year, which corresponds with the level experienced over the years in the UK coalfield regions (where about 60% of the job losses from the mining industry have been made good within twenty years); a second evolution assumes a much smaller job replacement rate of 2.25% a year (as the German labour market is less flexible than that in Britain), while a third uses a much higher job replacement rate of 9% a year (with the Ruhr, lying as it does at the heart of a densely-populated European conurbation, possibly experiencing an acceleration in structural change, though such a scenario seems less than realistic).

Under such very optimistic assumptions about structural and employment-related developments, job losses in NRW caused by the phasing-out of the Ruhr coal industry would be reduced from 44,000 to between 25,000 and 38.000 along with a proportional reduction in the fiscal follow-on costs. However, only in the extreme scenario of a job replacement rate of 9% a year is the loss in tax revenue suffered by the public purse reduced to a level that roughly corresponds in its total volume with the amount of state subsidy saved, to the extent that phasing-out the mining industry could be regarded as "financially neutral". For this to happen to the pace of structural change leading to the creation of new employment opportunities would have to be accelerated to a degree never seen before either in the coalfields or indeed anywhere else – and the framework would have to be created to allow this to happen.

Whatever the case it appears that in purely financial terms, and disregarding the social, regional and energy-supply aspects, the phasing-out of the coal mining industry would only not be a loss-making decision for the Treasury if the pace of structural change and the creation of new jobs in the coalfield areas can be stepped-up significantly. But because this does not happen automatically and as the signs of such structural developments have so far not been forthcoming – and in any case structural change takes time – Prognos recommends that the regional and economic impact of the ongoing coal-industry restructuring process should be continuously monitored, especially since the coal policy objectives are to be reviewed anyway in 2012. Such a monitoring programme should also provide for the contingency of being able to slow down the pace of restructuring in the Ruhr coalfield in the event that substitute jobs are not being created in sufficient numbers. While the financial relationships warrant such a facility, there are also other economic interdependences of the mining industry that would justify the use of such an option.

c) Other interdependencies of the mining industry

Elsewhere in the study Prognos investigates various other areas in which the coal industry has an impact, and examines what a withdrawal would mean here. While this factor is often referred-to in the public debate, its actual significance has never been clearly understood. This means that the clearly negative structural consequences of phasing-out the industry contrast sharply with the very confusing and at best sketchy information on how closure will impact on regional job opportunities.

- Significance of the coal industry for the supplier sector

It is evident that the coal industry is important for the supplier sector, especially for those firms manufacturing mining machinery. Germany has now become the global front-runner and international technology leader in the export of mining equipment, especially in the area of health and safety. This achievement can be attributed to the cutting-edge technology employed by the German mining industry and to the fact that the geological conditions here are among the most demanding in the world.

Prognos states that aid to the coal industry has helped develop “a competitive and successful technology sector” and that in this respect has not in any way been “out of line with market requirements”. The links that have been forged between the mining industry, the machinery manufacturers and the various technical colleges and research establishments have created an exemplary set of “spatial benefits whose positive regional and economic effects have recently become the subject of the ‘cluster policy’ debate taking place in scientific and regional circles”.

With 50 to 80% of production now destined for export it is calculated that of the 16,000 jobs currently provided by the mining equipment manufacturers in North Rhine-Westphalia between 4,000 and 8,000 are directly dependent on the German coal industry. Without access to German collieries as a test bed and reference base many of the suppliers would be forced to relocate production elsewhere or simply close down completely. Without the German coal industry most of the 16,000 jobs in this particular manufacturing sector in NRW would therefore be threatened. There could also be an exodus of mining R&D, which would rob Germany of an important added value factor.

Prognos believes that if the mining industry is shut down we risk not necessarily a national migration of industry but at the very least a regional exodus that will also threaten the downstream value chain, for example power station operations may be relocated away from the Ruhr and out of North Rhine-Westphalia to coastal locations.

- Social impact of industry closure on mining communities and regions

The well above-average unemployment figures still seen in the Ruhr area, which are a consequence of decades of major downsizing in the coal industry, are evidence of the fact that the problems associated with structural change have still not been effectively resolved in spite of the efforts made to cushion the effects of restructuring. Were the coal industry to be closed down with immediate effect the regional jobless rate would soar overnight to 17%, putting it on a par with the structurally-weak regions of eastern Germany.

Too hasty a withdrawal from coal mining could well have a negative impact on the regional labour market and on the social fabric. In line with demographic trends this could lead to greater population migration and so further restrict the municipalities’ potential for action within the Ruhr region.

The experience of other traditional mining regions, such as the Lausitz lignite basin and the coalfield communities of Great Britain, shows that the unemployment problem created as a result of large-scale pit closures and the huge gaps left in the regional economic structure cannot be solved even after many years. Prognos therefore supports the idea of a socially acceptable and very gradual phasing-out of the coal industry along regional and economic lines, while at the same time keeping a continuous watch on events (monitoring process) so that the pace of the rundown can be slowed if necessary.

- Social involvement by the coal industry

Closing the mining industry would also rob the community of the extensive social commitment that this sector has built up over the years – a factor that would have fairly major consequences given the deep roots that mining has developed throughout the region. As well as being an important regional employer DSK is a major training provider, organises own job finding services, helps former employees start-up new companies, contributes to cultural, educational and sporting projects and even has traditional ties with the local churches.

Mining as an institution therefore performs a social function by helping to maintain the internal cohesion of the region and this would have to be replaced by some government agency or other with responsibility for social infrastructure and project promotion.

- Closure of the coal industry as a stimulus for new businesses and structural change?

Prognos does not share the view that a rapid rundown of the mining industry could provide a huge stimulus for the development of a different set of structures based on new commercial projects. The development of new business ventures on the basis of rising unemployment and industrial closures, and in an environment that is still structurally weak, is said to be "extremely unlikely". Practical experience from the new German Länder and from other mining regions, and indeed from the 'Ich-AG' scheme (one-person government-funded start-ups), clearly refutes this suggestion.

- Will additional exports of German products to coal exporting nations generate jobs at home or drive-down regional wage levels?

If German coal is to be increasingly – and possibly completely – replaced by imported fuel the supplier countries will benefit from an increase in revenue and this in turn could boost the demand for German-made products and also generate additional employment in Germany.

While this knock-on effect is possible, it would be of minor significance. Using existing international trading structures and the value of potential coal imports Prognos has empirically assessed the impact of such a factor and has established that it would at most be fairly modest. The additional demand for German-made exports resulting from such a development would be about € 100 million at most and in the Ruhr specifically this would only amount to one hundred or so new jobs.

Given the empirical facts, any positive effects on employment or potential relief for the region's labour market generated by the curbing effect of phasing-out the coal industry on regional wage levels would, according to Prognos, be "extremely small".

- (Alternative) employment opportunities through promotion of future technologies?

Prognos is very sceptical about the view that the increased promotion of future technologies as a way of supporting structural change in the local region would be a viable alternative and could compensate for the decline of the coal mining industry.

While the regionally focussed development of future technologies is right and proper in principle, it would be more than difficult to achieve. The success of R&D projects is inherently uncertain; then there is the political risk associated with the use of public funds to promote technologies that ultimately prove to be ill-founded. What is more, it is very hard to predict the direction that technical progress will take and the level of interest generated as a result. And then again process innovation can also lead to regional job cuts. Another problem is the lead time required to develop a future technology into a marketable product, which can vary enormously from sector to sector. An effective regional development policy first has to identify or generate suitable investment projects. Empirical experience has shown that increased spending on R&D (in successful cases) only has a positive effect on productivity after a period of two or three years; there is therefore a delayed impact on the labour market, with the new employment opportunities created mainly being for higher-qualified posts rather than across the entire skills spectrum. For the Government it would therefore be difficult to forecast whether and when employment gains would be made that could replace the job losses. Managing the pace of structural change required from a labour-policy perspective will therefore always be risky. This is one of the reasons why the study advises against too fast a rundown of the coal industry.

Sufficient funding would also have to be put in place for the Ruhr area. However, elsewhere in the study it is stated that financing such development aid by saving on and reallocating coal subsidies

is on balance not economically possible – and certainly not in the short or medium term – simply because of the fiscal follow-on costs of phasing-out the mining industry.

In addition to various individual findings the overall conclusion that the Prognos study draws from a regional and economic perspective is that the strategy of a progressive restructuring of the coal industry should be retained and the speed of the rundown should not be overdone. In fact it is suggested that the pace of change be controlled and monitored in an appropriate manner and even reviewed if necessary. Clearly the communities affected are facing a major challenge that they cannot shoulder alone. For this reason, as Prognos explicitly stresses, regional development policy has to assume special responsibility for the future of the coalfield communities and their employment situation.

What still remains unanswered, as can also be derived from the study, is whether this development support (for which no specific plans have yet been laid) can ultimately prove successful and where the funding required is to come from. A phasing-out of the mining industry until 2018, combined with a proportional phasing-out of coal subsidies, would on balance produce little or no financial saving for the public purse, out of which additional regional development grants could be funded. The savings in departmental budgets in one place would be offset by the additional burden of the fiscal on-costs imposed elsewhere, not to mention the various charges in the social security system that would have to be compensated for.

Mining technology

Growing demand for energy and raw materials, combined with the continuous global boom in steelmaking, means that mining worldwide is expanding at a rate currently matched by very few industrial sectors. The coal industry is no exception here and there is much to suggest that this trend is set to continue. “I think the coming decades will be very strong indeed”, says Chip Goodyear, retiring Chief Executive of the global mining corporation BHP Billiton, when presenting his company’s latest annual report in August 2007. His colleague Sam Walsh of Rio Tinto, another representative of the so-called ‘Big Four’ – as energy-industry watchers have dubbed the four largest global resources corporations because of their market dominance – even expects Africa to develop into the next growth region in the course of the next twenty years, thereby further fuelling the raw-materials boom. These assessments are borne out by the IEA, which is predicting an average rise in primary energy consumption of 1.6% a year up to 2030. And in spite of the extended use of renewables it is the fossil fuels that will have to meet 83% of this growth between now and 2030. In 2006 coal accounted for 30% of world energy consumption, coming in second place just behind oil (35%) and well ahead of gas (23%).

These projections also seem to offer good prospects for the German mining equipment industry, which has established itself as global leader in this market. But a domestic reference industry is essential if these manufacturers are to consolidate their position. Mining know-how – both technical and safety related – that the German coal industry has built up over years of working at deep levels is now being used in every corner of the globe. Measures to prevent the kind of events that are reported on almost a daily basis by large producer nations like China, including rockbursts of the type experienced this summer at a mine in Utah in the USA, are now part of the daily working routine of the German miner. Our industry is now recognised around the world for the high standards it has set in respect of safe working practices, mineworkers’ health and safety and environmental sustainability in natural-resources extraction.

Most of the mining suppliers, along with the added value and employment potential they bring, are based in the coalfield areas. For example 80% of all German mining equipment manufacturers are registered in North Rhine-Westphalia. Some 120 small and medium-sized companies – and workforce numbers are growing, with more than 16,500 people now employed in this sector – currently supply all the deep-mining and opencast machinery and equipment

required by the various branches of the mining industry. And this sector has seen its turnover grow year on year. As sales decline on the home market the shortfall is now being made-up by a 34% rise in exports.

Yet the Mining Machinery Association, which is affiliated to the VDMA (Association of German Plant and Machinery Manufacturers), believes that this position as global market leaders will be threatened if the Government goes ahead with its plan to phase out the industry. According to the VDMA Mining Machinery Association an active German mining industry is essential if German mining technology is to maintain its high global standards, as the innovative products needed have to be tested out and refined under the harsh working conditions encountered in the domestic coal industry. Year after year real progress is made in a whole range of fields – and as a result coal winning at deep levels is made more competitive and more efficient, workplace safety is enhanced and productivity improved. This not only benefits the domestic mining industry but also helps drive exports of innovative mining technology – bearing the label 'made in Germany' – all over the world.

Ongoing automation of underground operating processes is at the forefront of development efforts. While the first automation systems focussed primarily on increasing production levels and reducing production costs, this technology is now used increasingly to improve workplace safety and reduce the health risks for mineworkers. Recent guidelines introduced in major coal producing countries like Australia and the USA support this drive and miners there, for example, are now not allowed to work in dust-laden environments, or are subject to working restrictions under such conditions. Automatic systems are now being employed as a means of protecting operating equipment. This results in less wear and tear and extends servicing intervasl.

Putting this technology into operation requires an advanced communications infrastructure that can reliably transmit vast quantities of data from individual machine parts through the machine interface to an external management centre. At present this is done through a combination of modems, glass-fibre cables and WLAN network systems. All kinds of sensors, infrared cameras and radar units are used to generate the data. Video cameras help support the monitoring process and PCs with commercial user interfaces ensure that large quantities of data are rapidly processed and transferred and that online communication is established with control consoles, servicing units and machine manufacturers. The result is a massive reduction in machine downtime and an increase in productivity.

This technology has already produced the 'manless coal face' for coal-plough operations and a similar development – based on the latest generation of German-made drum shearer loaders – is now not far off for shearer faces. These winning machines are equipped with various systems, such as infrared detection, solid-borne noise analysis, natural gamma radiation, geo-electrics and radar sensors that can identify the coal-stone boundary layer and detect other types of obstacle lying in the machine travel path. Oscillation sensors are used to provide dynamic monitoring of gearboxes, motors and machine bearings. These give early warning of developing faults and help make machine servicing much more effective. With its rugged design specification and increased power reserve this new generation of shearer loader is capable of achieving a high availability factor.

The latest type of drill jumbo represents another development of the so-called 'intelligent machine'. Equipped with electrohydraulic proportional valves and an industrial-grade PC these twin-boom machines are designed for use in roadway drivage operations. Cable-linked controls, a display with clear-text messages showing status parameters and machine faults and the provision of a data connection to the surface control room are all steps along the way to the development of an automatic and 'intelligent' machine that can rationalise the link between electronically acquired status parameters, independently communicate machine defects, optimise servicing intervals and drill holes without the need for an operator.

High-efficiency coal mining means smooth-functioning logistics. This requires an uninterrupted flow of information to ensure the seamless IT-supported tracking of an order for plant or materials up to the point of delivery. The key component of this wireless communication system is the WLAN access point, which is used for the transfer of information (fed-in by mini-computers with barcode scanners) over large distances and ultimately up to the central database. In the field of mine transport the prototype of an unmanned diesel trolley has successfully completed underground trials and is now ready to go into series production. Equipped with two radar sensors and a laser scanner the machine has 'electronic eyes' and can stop automatically when an obstacle is detected. The route taken is controlled by the 'driver' from the surface control room, who guides the vehicle's progress via video cameras with infrared projectors.

The list of examples of modern, cutting-edge technology in use in the German coal industry seems unending. But to be competitive on the global market the industry needs something just as valuable as technical development – and that is knowledge of strata behaviour and how to cope with it. The problem has always been that this know-how was fragmented and lacked synergy. A self-instructive database on strata control in in-seam roadways, which reflects the knowledge developed over more than a hundred years of coal mining in Germany, has now been built up using the latest IT systems and structures. In fact over the last twenty-five years in particular the German coal industry has acquired a pool of know-how and experience that is unique in the mining world.

These selected examples show that despite the decline in production levels German mining technology continues to develop year on year. Much of this can be attributed to the fact that German collieries are working the deepest coal deposits in the world and this calls for technical performance of the highest level. Anything that works under these conditions can certainly be deployed in confidence elsewhere. In most coal producing countries the trend is now increasingly away from opencast mining and towards underground production. This is partly due to the increasingly stringent ecological standards being applied in many countries, as opencast mining is much more intrusive for the natural environment. However the main reason is to be found in the depletion of coal deposits that are economically suitable for extraction by opencast methods. What is more, in countries where coal is already being deep-mined the tendency now is to penetrate even deeper into the earth's crust; this in turn brings a greater awareness and greater knowledge of problems such as increasing rock pressure, stricter requirements in respect of mine ventilation and air-conditioning and such like.

Potential customers of the mining equipment companies therefore use German-based collieries to demonstrate the operating characteristics and reliability of locally-developed technology. The difficult working conditions and the possibility of using the indigenous coal industry as a test-bed for new machines and equipment are a major success factor. Without this reference base quite a few supplier firms would sooner or later relocate their development and production facilities overseas, or would lose their technology leadership and competitiveness altogether. This will apply most of all to the small and medium-sized companies operating in this sector. In both cases the outcome will be significant job shedding at home and the loss of a significant value-added potential against the background of a strongly developing global market. At the same time Germany would be deprived of having any say in determining international health and safety and environmental standards. An indigenous coal industry therefore remains indispensable as a development platform and reference base. This has also been confirmed by independent expert reports, including one study published earlier this year that was carried out for the European Commission under the leadership of Europe Economics, a UK consultancy.

CLIMATE AND ENERGY

German climate policy under the Kyoto protocol

Since the early 1990s climate policy has defined both the international and national environmental debate. In 1990 Germany established itself as a pioneer in international climate policy by announcing its intention to cut CO_2 emissions by 25% by the year 2005. At an international level emission reduction efforts were set in motion with the agreement of the Framework Convention on Climate Change in Rio de Janeiro in May 1992. In December 1997 the Kyoto Climate Conference subsequently ratified what became known as the Kyoto Protocol, in which the industrialised states undertook to achieve a 5% reduction in greenhouse-gas emissions by the year 2012. Within the context of these arrangements, and on the basis of the Europe-wide 'burden sharing agreement' of June 1998, Germany is committed to reducing its CO_2 emissions by 21% from the 1990 levels. These commitments are to be implemented by way of various climate-policy measures that at a European level are centred around the EU emissions trading system. The scheme's pilot phase began on 1 January 2005 and the provisions will be applied on a more rigid basis from 2008 on, so that the European Union can achieve its climate target of an 8% reduction in greenhouse-gas emissions by 2012.

These reduction commitments are to be fulfilled at member-state level by way of 'National Allocation Plans' (NAPs). The Federal Government's NAP II for the allocation period 2008 to 2012 was submitted to the European Commission within the set deadline. The proposed plan fully complied with the targets laid down in the EU Burden Sharing Agreement and in the Kyoto Protocol. The 'carbon budget' upper limit of 453.1 million tonnes of CO_2 subsequently prescribed by the Commission represents a further reduction of some 50 million tonnes – just over 10% – on the actual CO_2 emission figures achieved by German industry in 2005. Moreover, this reduction burden, which goes beyond the Kyoto target, is to be applied exclusively to the power supply industry.

The allocation rules for the power generation industry have also been completely revised. The previous model of allocation according to demand and based on certain reduction factors has been replaced by a system of allocation according to a benchmark with the additional application of a reduction factor if and when the power industry's overall budget is exceeded.

These rules have now been included in the 2012 Allocation Act that will be used to achieve transposition of NAP II in Germany. An auctioning process for about 9% of the total budget of 453.1 million tonnes of CO_2, which will in turn be taken from the amount to be assigned to the power supply industry, was also established to this effect by parliamentary action. Compared with the 2005 to 2007 period the total power-industry budget has therefore now been much reduced – and this will have predictable consequences for the price of emission trading permits.

The current climate debate for the post-Kyoto phase

The Kyoto Protocol agreements only run until 2012 and the Protocol requires that a follow-up agreement be established by 2009. Over the last few years the environmental debate has been characterised by calls for much stricter Kyoto targets to be introduced after 2012, the reference being that a really efficient climate protection programme needs a much more rigorous set of global reduction measures than those provided for under the original Protocol. Within Europe the call is for any rise in climate temperature by 2100 to be restricted to a figure of 2°C above the levels prevailing in the pre-industrial age. The European Union is therefore essentially submitting to the demands of the environmental lobby without any agreement having been reached on such a target within the international scientific and environmental community.

By late 2006/early 2007 the debate on climate change had taken on a new intensity both at national and at international level. A number of events that attracted huge media attention were instrumental in shaping public opinion at that time: perhaps the most significant of these in terms of public perception were the Al Gore film 'An inconvenient truth', the publication of the 'Stern review' about the impact of climate change on the global economy, and the publication of the Fourth Interim Report by the International Panel on Climate Change (IPCC). While the IPCC report of February 2007 does not really contain anything that goes beyond what was set out in the 2001 or even in the 1996 documents, the media debate and public discussion of the subject suggested that some fundamentally new findings had been announced and this gave the impression that we were facing an imminent environmental catastrophe. In the actual IPCC reports, for example, previous projections for sea-level rises due to global warming have been moderated continuously since 1990.

Neither can the global temperature rise of the last thirty years be attributed simply to the conclusion that a temperature increase of 3 - 6°C (0.3 – 0.6°C per decade) can be expected over the next hundred years. The temperature rise observed by NASA and the University of Alabama over the last thirty years has in fact been a relatively constant 0.15°C a decade or thereabouts, and this is not gathering pace, despite frequent assertions to the contrary.

With environment issues constantly hitting the headlines various plans have now been developed by both the European Commission and the German Government to introduce a much stricter set of climate targets after 2012, the date when the Kyoto Protocol is due to expire. The 'climate package' presented by the European Commission on 10 January 2007, the associated EU climate targets that are based on these proposals – as presented at the European Summit of 9 March 2007– and more especially the announcement of a national climate protection programme by Environment Minister Sigmar Gabriel on 26 April 2007, all call for a radical reorganisation of industrial society so as to avert the impending "environmental catastrophe".

The current environmental strategy of the European Union and that of the Federal Government both essentially reject the previous balanced weighting that was given to the key energy-policy objectives of security of supply, price competitiveness and environmental compatibility. Henceforth all relevant policy areas, including energy supply, trade and industry, transport and urban development, will be subordinate to the primacy of climate policy. The priority objective of European and German energy policy is now to cut CO_2 emissions and thereby to avert the threat of a "climate catastrophe". Security of energy supply is therefore to be seen as secondary to efforts aimed at reducing CO_2 emissions: fossil-based energy use is to be reduced along with imports of fossil fuels. The Commission believes that security of energy supply can be improved by setting two targets for the year 2020, namely an extension of renewables' input to 20% of primary energy consumption along with a 20% increase in energy efficiency.

As part of the international climate debate the EU wants to underline its eco-leadership by announcing a unilateral, EU-wide CO_2 reduction target of 20% by 2020, the intention being that this will be extended to 30% if the other industrialised states are prepared to commit to similar emission reduction targets. Certainly the post-Kyoto debate is still in its early stages. In spite of the EU's determination to play a leading role in climate protection, there is a distinct sense that the other industrialised nations that are bound-up in the international climate-policy process (essentially the USA, Japan, Canada and Australia) are less prepared to draft more-rigorous targets for the post-2012 era than was the case for those who signed up to the Kyoto Protocol for the pre-2012 period. In any case the USA and Australia have opted out of the Kyoto Protocol and for this reason alone will not be meeting the commitments given in Kyoto for the period to 2012. The same can be said for Japan and Canada, for while these countries have clearly ratified the Kyoto Protocol it is at present not possible to predict or determine whether and how they intend to comply with the Kyoto guidelines up until 2012. At the G8 Summit held in Heiligendamm in June 2007 Chancellor Merkel, with the support of US President George Bush, was able to make some progress towards agreeing longer-term CO_2 reduction targets for the year 2050, while at the same

time continuing the climate-change debate at an international level on the basis of the Kyoto Protocol – although this still does not commit the USA to any firm emission reduction targets.

If climate protection really is to be effective after 2012 there will be no ignoring major developing nations like China and India. China is now overtaking the USA as the world's largest producer of CO_2 emissions and if the country maintains a 10% growth rate in respect of economic development and CO_2 emissions it will very soon become the dominant global generator of CO_2 – and no international environmental policy will work without its involvement. China's importance in any international climate policy is illustrated by the fact that its environmental emissions are increasing by some 500 million tonnes of CO_2 a year. This is twice the amount of emissions that the European Union will be saving between 1990 and 2012 under its Kyoto obligations (approx. 270 million tonnes of CO_2).

China's annual growth in CO_2 emissions is equivalent to about two-and-a-half times the volume of German CO_2 emissions that have to be eliminated by 2012 under the terms of the Kyoto Protocol. This means that the total reduction in emissions that Germany has to achieve within the Protocol is cancelled out every six months by the rate of at which China is producing additional emissions of its own. For this reason alone it is obvious that an effective climate policy can only come into being if it is implemented as part of an international set of agreements – and not by a national go-it-alone approach.

However, the 'climate agenda' that was announced by the Federal Government on 26 April 2007, the details of which were laid out in the Meseberg climate policy resolutions of 23 August, seems to be going down this road. The main objective of the integrated energy and climate framework, with its twenty-nine individual stages, is to reduce CO_2 emissions by at least 35% on 1990 levels by 2020, whereby the reorganisation of the industrial society that is the intended purpose of this programme is to cover all social groups.

But more than this Meseberg demonstrates that the Federal Government has decided to subordinate the aims of an integrated energy policy – which were to be laid down in agreement with the energy supply industry at the Energy Summits of 2006 and 2007 – to those climate-policy demands that it considers most judicious. The third Energy Summit of early July 2007 has now been steamrollered by the climate debate and as a result its real significance has been curtailed. The Meseberg climate policy resolutions are now also determining the national energy policy framework. It now seems as if the future energy policy of Germany and of Europe too is to be reduced essentially to the implementation of climate-policy targets, whereby the decision makers believe they can control the risks that this will present for energy supply security and the international competitiveness of German industry.

But this gains nothing for the world's climate. Germany only contributes about 3.2% of global emissions and any further reduction between now and 2020 will have no measurable effect on world climate trends. The emissions generated by the rapidly expanding economies of the threshold countries and third-world nations will more than make-up for Germany's contribution to emission reduction within a few months. Current German climate policy does not in fact constitute real climate protection but is more of a moral response to a political problem. Proper solutions to the global climate problem can only be found by way of global strategies based on instruments supported by extensive international agreement. National trailblazing generally just involves risk for the trailblazer and at best brings some technology rewards. Failing this installations that generate significant CO_2 emissions were simply relocate abroad.

Climate change and CO_2 avoidance costs

In late summer 2007 McKinsey & Company Inc., commissioned by BDI, produced a study whose aim was to assess more than three hundred start-off points (instruments) for avoiding greenhouse gases in Germany as part of an objective and comprehensive analysis for the period up to 2020 and 2030. Some seventy companies and associations representing all relevant sectors of the German economy participated in the study, together with a large number of independent experts.

In order to reach an overall assessment of the quantitative savings that can be made to 2020, for example, the study produced a 'state-of-the-art' projection for 2020 in which the entire capital stock for that year achieves the current technology as standard by the ongoing reinvestment. The additional quantities saved according to the assessment were then compared with this volume of emissions totalling 1,048 million tonnes of CO_2e (CO_2 equivalent).

The study differentiates between the different sectors – energy, industry, building construction, transport, waste disposal and agriculture – in assessing the respective instruments with their specific avoidance costs in €/t CO_2e in conjunction with the volumetric savings potential and then classifies these instruments according to their cost intensity. This serves to demonstrate the economic connection, namely that additional potential savings can only be realised by incurring an increasing level of marginal avoidance costs – which in some cases will be quite significant.

Overall the study comes to the some astonishing conclusions. Many of the evaluated instruments can be introduced at no extra cost, as the investment required brings a pay-off for the decision-maker – in today's terms – within the relevant service life of the asset. These significant economic instruments, which include heating insulation in buildings, improvements of electrical drive systems in industry and various measures for improving drive-train efficiency in motor cars, are already capable of achieving a high potential saving of 127 million tonnes of CO_2e in relation to the state-of-the-art projection; by 2020 these measures will lead to an emission volume of 921 million tonnes of CO_2e, which represents a saving of 25% on the 1990 levels. The bulk of this potential saving comes from sectors other than the power supply industry.

Those instruments that are linked to avoidance costs of 0 – 20 €/t, which overall bring a potential saving of only 14 million tonnes of CO_2, include not only industrial measures but also efficiency improvements at lignite power stations and the increased use of combined heat and power systems. These additional instruments, along with various economic measures, would lead to an overall reduction of 26% in greenhouse-gas emissions compared with 1990 levels.

On the premise that nuclear power is phased-out according to plan, the restructuring of Germany's energy mix – greater use of renewables in electricity generation (-34 million tonnes CO_2e), increased use of biofuels (-14 million tonnes CO_2e) and the first CCS pilot projects (-6 million tonnes CO_2e) – will cut CO_2e emissions by a further 54 million tonnes. According to the study, these actions – combined with the measures listed above – will bring a saving of 31% on 1990 levels. While the average avoidance costs, namely 32 €/t CO_2e (power generation) and 175 €/t CO_2e (biofuels), are relatively high, the current political mood would seem to suggest that these measures will be introduced.

Further potential for saving an additional 58 million tonnes of CO_2e will cost significantly more, and in some cases as much as several thousand €/t CO_2e. These individual avoidance measures could only be implemented by incurring a massive escalation in the emission reduction costs. Even progressing from a 31% reduction to a 32% reduction on 1990 levels will generate avoidance costs of more than € 450 million a year. Together with the aforementioned measures this potential saving of 58 million tonnes of CO_2e would bring a total saving of 35% on1990 levels.

After 2020, according to the McKinsey study, further economically tolerable avoidance instruments and other measures involving avoidance costs of up to 20 €/t CO_2e would be available, with the result that by 2030 – in conjunction with a further restructuring of the energy

mix after the phasing-out of nuclear energy with average avoidance costs of 45 €/t CO_2e – it would be possible to reduce emissions by 36% on 1990 levels. In addition to this, CCS actions (carbon-dioxide capture and storage) by the power generators and steel makers will save 104 million tonnes CO_2 a year up to 2030, with avoidance costs of 30 - 55 €/t CO_2e, though as well as posing technical problems and acceptability risks these measures will mean substantial locational risks for energy-intensive industries because of electricity-price rises of 15 - 25 €/MWh.

Renewable energies: huge cost differential

Germany's adoption of the Electricity In-feed Act in 1991 marked the start of a massive programme to promote renewable energies. By 1999 the input from this source had risen eightfold to 7.9 TWh. When the Electricity In-feed Act was replaced by the Renewable Energies Act (EEG) in 2000 a new target was adopted calling for renewables' contribution to power generation to be doubled by the year 2012. The 2004 amendment of the EEG introduced a revised set of targets and specified a 12.5% renewables contribution by 2010 and a minimum contribution of 20% by 2020. The current policy goals of the European Commission and German Government are that renewable energies should account for 20% of primary energy consumption by the year 2020.

The programme to promote renewable energies has led to a rapid expansion in the use of renewables for electricity generation. In 2006 about 50 TWh of electricity was generated from renewable sources, this representing a total of € 5.2 bn in revenue under the EEG arrangements. And this figure is expected to grow significantly in 2007. Power generated under the EEG system is likely to amount to 70 TWh, representing some € 7.7 bn in revenue, and the VDN (Association of Network Operators) predicts that payments will break the € 10 bn threshold by 2010.

At the end of February the Federal Environment Ministry presented a pilot study on the expansion of renewable energies, which had been carried out on its behalf by the DLR (German Aerospace Centre). The targets laid down by the coalition agreement for 2010 have already been exceeded, or are about to be met, in that renewables accounted for about 6% of primary energy consumption in 2006 and provided around 10% of the electricity generated. According to the study, if further efforts are made to boost efficiency levels renewables might contribute as much as 50% to primary energy consumption by 2050 and could account for 77% of total electricity production.

It is interesting to note that the 'cost differential' for renewables in 2006, and hence the need for subsidies in this sector, is estimated at some € 3 bn. This is not only more than the total subsidy package paid to the German coal industry but also exceeds the amount of aid to disposals that is allocated for coal-based power generation. According to separate calculations based on VDN estimates, and given generation costs of approximately 5 cents/kWh (= wholesale prices) for conventional electricity in Germany and an anticipated EEG average payment of 10.9 cents/kWh, the additional charge for 2007 would be nearly 6 cents/kWh or € 4.2 bn. The DLR has calculated that under the given assumptions these additional investment costs, which will cumulate to some € 117 bn by 2025, would have paid back by 2040 as a result of subsequent cost savings to the economy as a whole.

Apart from the fact that cumulative additional costs of € 117 bn by 2025 could only be paid off in a mere 15 years under very favourable hypothetical conditions, this analysis also shows that even assuming a favourable set of premises future generations will still have to bear the burden resulting from the massive promotion of renewable energies, and moreover in the likely scenario that this contribution will have had no detectable beneficial impact on global climate.

Other environmental factors also come into play. A large-scale extension of wind-based power generation would take-up huge amounts of space, which means looking at the option of offshore

wind-parks that would also offer better wind availability, which, in turn, will lead to escalating avoidance costs. Moreover, when seen against an EU-wide programme of optimised wind-generation sites based on wind availability, any national strategy to extend wind power generation would also prove to be less than ideal. Add to this the fact that climate-related interventions into the natural environment can also produce undesirable side-effects. To cite one example: in 2006 German consumers suffered the effects of competition for land use between biomass for energy generation and foodstuff production in the form of a marked increase in price of some basic foods.

Climate protection and future energy supply in Germany

By driving-through the national climate-protection targets towards a 40% saving in greenhouse-gas emissions, measured against the reference year 1990, the Federal Government is already pursuing a policy that is likely to prove effective in the medium term at achieving a sustainable change in the level and structure of German energy consumption.

A number of studies have been published during 2007 in connection with the energy-supply debate and with particular reference to emission reduction targets.

The first results of the 'VDEW 2030' study were published in May 2007. This investigation was commissioned by the VDEW (German Electricity Association) in conjunction with other organisations such as the BDI, DEBRIV, GVSt, VDN, VGB PowerTech and VRE and was entrusted to the Energy Institute of Cologne University (EWI) and to Münster-based Environment Forecast Analysis GmbH (EEFA). The study uses scenario calculations to examine the impact of various energy policies on the German energy-supply situation, as embedded in the European market, up to 2030. As the study focuses on the cause-and-effect relationship between different energy and environmental instruments its findings cannot be interpreted as constituting a set of energy-related predictions.

VDEW 2030 presents four policy scenarios (I, II, IIa, III), each with two optional fuel-price pathways, whereby climate scenario III has as its premise a 40% saving in greenhouse-gas emissions by 2020 and a 50% saving by 2030 (in relation to 1990 levels) along with the phasing-out of nuclear power by 2022 and a full auctioning of CO_2 allowances. This scenario indicates that for both price pathways, and measured against the reference year 2005, German primary energy consumption will fall by one fifth by 2020 and by as much as one third by 2030. As far as CO_2 reduction targets are concerned the main burden will be borne by the coal and lignite industries, which will suffer a decline in consumption from 2005 levels of 40 - 55% by 2020 and 60 - 80% by 2030, depending on the price pathway, and this in spite of the assumed introduction of CO_2 sequestration at coal-fired power stations from 2020. By comparison, the low-price scenario for gas – which is strategically a much more sensitive fuel – predicts a growth in consumption of 12% by the year 2030.

And it is not just structural changes in the energy sector that can be triggered by an ambitious climate policy, for the impact on our industrial society would be even more far-reaching. Accepting the most favourable environment scenario, for example, the VDEW study points to a long-term loss of growth in GDP of as much as half a percentage point a year, as a result of the high cost of emission trading permits (full instead of partial auctioning), leading to job losses of as much as 500,000 by 2030. According to the study, a national or EU-wide 'go-it-alone' approach to climate policy would only harm the international competitiveness of German industry and force carbon-intensive production processes – such as oxygen-steel and cement production – overseas.

As part of the preparations for the German Government's Energy Summit 2007 Prognos AG and the EWI were commissioned by the Federal Environment Ministry to examine three different scenarios for the development of energy consumption, power generation structures and

greenhouse-gas emissions between now and 2020. The basic scenario 'coalition agreement' (scenario CA) centres on the target of a doubling of energy productivity during the period 1990 to 2020, which is equivalent to an annual increase of 3% after 2005. In contrast to the CA scenario the environmental scenario is based on an increased use of renewable energies (scenario RE), while 'scenario NPS' assumes that the lifespan of nuclear power stations will be extended by twenty years on the basic scenario.

All three scenarios are at least capable of achieving the 40% reduction target set for greenhouse-gas emissions. Primary energy consumption would fall by as much as 17% during the period 2005 to 2020, while power generation would decline by up to 13% – with serious consequences for the electricity generating sector. Solid fuel destined for the power generators would be faced with significant losses in all scenarios up to the year 2020, with coal suffering more seriously than lignite.

A comparison of the VDEW 2030 and Prognos/EWI studies for the years leading up to 2020 shows that the findings differ to some extent as a result of different premise settings and model mechanisms, but the studies exhibit similarities too.

In addition to the marked expansion of renewables, nuclear-energy policy and energy-price trends will lead to an increased use of gas for electricity generation, with Prognos/EWI indicating a growth of up to 75% and VDEW 2030 even suggesting that the increase could be as much as 175%. This has to be seen in a critical light given the risks that it would pose for energy security.

As renewables make further inroads into the power generation market they will certainly help to achieve the quantitative climate protection targets. But there is a downside too, for while the renewables' component regarded as indigenous power generation is free from any geostrategic risk, questions still have to be asked as to the physical reliability of renewables given the daily and seasonal fluctuations that affect this energy source.

The degree to which the model results from these studies depend on the premise settings is illustrated in a variant calculation undertaken in the Prognos/EWI study. Given the way in which energy productivity has developed in the past, the assumption of an annual increase in energy efficiency of 3% for the period 2005 to 2020 is highly debatable and for this reason Prognos/EWI developed a 2% variation on the CA scenario. While in the 3% basic scenario gross electricity generation falls by nearly 13% during the period 2005 to 2020, the 2% variant actually produces a slight increase of almost 4%. And whereas in the 3% variant coal's share of gross electricity generation falls from just under 22% to about 17% by 2020, the 2% variant actually suggests that coal-based generation will remain fairly stable along with a slight volume growth.

A more recent study published in the summer of 2007 by Prognos AG, which was commissioned in 2005 by EURACOAL – the Brussels-based European Association for Coal and Lignite – in cooperation with various other companies and organisations representing the European coal and power supply sector, comes to a quite different set of conclusions. This report suggests that from a purely economic viewpoint coal has excellent long-term prospects as a power generating fuel in the EU-27.

The study uses a detailed economic model of the EU's total power plant capacity to play through a broad based scenario mix with numerous variables and framework settings in order to show what the consequences would be for the energy mix and for electricity production costs. The study abstracts restrictive national emission budgets and assumes that emission reduction targets are met by way of the emissions trading scheme and the flexible instruments. The CO_2 cost is preset in each of the respective scenarios. The Prognos study sets up four different scenarios with varying CO_2 costs, with the European Commission's prognosis for the EU-27 'EU energy and transport trends to 2030' (update 2005) serving as a reference throughout.

In the 'basic scenario' the fundamental data and the assumptions made on energy consumption and price trends (relatively high fuel prices are assumed) coincide fully with the 'EU trends to 2030', whereby the CO_2 cost is taken to be constant at 5 €/t.

In the 'policy 15/30/45 scenario' three different levels of increasingly stringent climate policy are assumed for the same fuel price pathway, along with a corresponding rise in CO_2 costs, including lower fuel prices (especially in the case of gas) for two levels in the 'low price 15/30 scenario'.

The 'Tech 30/45 scenario' assumes an accelerated pace of technological development as a result of an increasingly strict climate policy, and possibly even through regulatory measures, leading towards CCS, whereby 'Tech45' is based on an extension of nuclear energy usage for climate-protection reasons.

All the scenarios outlined in the EURACOAL study indicate that between now and 2020 the prospects for coal in the German power generation market are quite favourable. In each of the scenarios coal-based electricity makes an increasing contribution towards German power generation – and the same also applies to the EU as a whole. Some of the scenarios even suggest that coal's share of the electricity generating market will continue to grow until 2030.

However, the EURACOAL study also points out that the optimistic predictions being made as far as coal for power generation in Europe is concerned also depend on certain prevailing conditions that will be laid down by the political decision makers. High CO_2 prices in conjunction with low gas prices – a somewhat less probable price combination – will tend to damage coal's future prospects. When gas prices are elevated coal-based electricity will be competitive even if CO_2 costs are relatively high. CCS technology, provided it is available, will make a breakthrough after 2020, market-driven by high gas prices and very high CO_2 costs as outlined in the VDEW 2030 study.

The VDEW 2030, Prognos/EWI and Euracoal studies, which vary from pessimistic to optimistic assessments of the possible ways in which coal-based power generation could develop in Germany, present a very wide range of scenarios that – and this is something common to all three studies – depend to a large degree on the prevailing energy and environmental policy conditions. The bewildering climate debate under way in Germany and the country's stated intention of taking the international lead in environmental emissions reduction, combined with the uncertainty surrounding aspirations for climate-change targets and the manner in which CO_2-allowances are to be allocated (free of charge, partial auction or full auction) – factors that will affect CO_2 costs – are already causing uneasiness among investors as they try to develop their long-term investment decisions.

At the same time the German power generation industry is in real need of substantial investment and modernisation in the medium and long term. According to a status report presented at the first Energy Summit in April 2006 much of the current power station capacity will have to be replaced even before 2020. Many of today's fossil fuel-fired power stations are more than 25 years old, and some are even 50 years old and more. The phasing-out of nuclear power, as prescribed in the Atomic Energy Act, will only increase the amount of investment required for replacement capacity to be provided in good time. New conventionally-fired power station capacity totalling some 20,000 MW is now being planned just for the period to 2012, while more than half of the existing power plant capacity will have to be replaced by 2030.

Climate protection and low-CO_2 coal-fired generation

CCS technology for coal-fired power generation is now commanding public attention and the European Commission in its January 2007 energy proposal 'An Energy Policy for Europe' is proposing to equip all new coal-fired power stations with this system after 2020, while existing

installations are also to be converted as part of a gradual retrofit programme. New plant built prior to 2020 are to be designed for 'capture readiness', so that they can subsequently be fitted with CCS technology. On the basis of recommendations from the ZEP technology platform (zero emission fossil fuel power plants) the Commission has also proposed that as many as twelve full-scale CCS demonstration power stations will be constructed and funded by 2015. The European Commission is seeking to use these proposals as a mean of accelerating development and innovation in the energy supply sector. Climate and energy-policy considerations are also behind Federal Government efforts to develop and implement CCS technology: this is the only way in which coal-fired power stations could have a medium to long-term future, even if tougher CO_2 reduction targets are introduced.

Large-scale CO_2 capture is still at the development stage. From a technical point of view CO_2 can be captured after combustion by means of flue-gas scrubbing (the 'post-combustion' method). This system has already been employed on a limited scale at smaller power stations and in industrial plants. However, introducing it on a full industrial scale means huge investment costs and a very high energy requirement.

RWE Power, BASF and Linde are currently working on new processes whereby innovative technologies and solvents developed by BASF are used for CO_2 capture – the so-called 'CO_2 emissions scrubber'. Research is now under way to find a suitable solvent capable of achieving efficient CO_2 separation and plans are now being laid to construct and operate a pilot plant at the RWE Power AG-operated lignite power station in Niederaussem.

The possibility also exists of feeding the combustion process with pure oxygen so as to obtain a waste gas that is almost exclusively composed of CO_2 and is relatively easy to liquefy (the so-called 'oxyfuel process'). However such a combustion system would involve significantly higher temperatures, which would place greater stresses on the boiler-plant materials. According to published estimates both these systems would generate efficiency losses of up to 15%. This would mean burning 40% more coal to obtain the same quantity of electricity, which would be a retrograde step as far as resource management and security of supply are concerned.

The third possible method involves separating the CO_2 prior to combustion, whereby a synthesis gas is first produced as part of a chemical process and the CO_2 is then isolated from this in a subsequent step ('pre-combustion capture'). This technique could be employed in future IGCC power stations (integrated gasification combined cycle), though efficiency losses and increasing costs would also be unavoidable here too.

As well as for CO_2 capture during coal-fired generation solutions also have to be found to the problems of transporting and storing the resulting gas. The Federal Institute for Geosciences and Natural Resources is currently drawing up an inventory of potential geological deposits. Investigations are also to be carried out to determine the extent to which CO_2 not destined for subsequent application could be temporarily stored, as opposed to permanently deposited and disposed of. CO_2-free manufactured hydrogen, for example, could be used for producing fuels, so that our reliance on oil could be reduced and CO_2 disposal rendered superfluous. A cross-sector interdisciplinary discussion group for 'CO_2/H_2 coupling' has now been set up with GVSt involvement to look into this working hypothesis.

The science and technology of carbon dioxide capture and storage is still far from complete and many experts in this field believe that CCS will not be commercially viable until 2020 at the earliest. As well as resolving various economic issues quick answers to problems of a technical and legal nature have do be found and steps have also to be taken to ensure that large-scale CO_2 capture and storage, and gas transport, becomes socially acceptable to the public at large.

As already stated, the EU is currently politically advocating technical trials under its framework research programme through the construction of twelve full-scale demonstration facilities for coal and gas-fired power stations. Europe is now considering whether all new power stations should

be fitted with CCS technology after 2020. Existing installations would be retrofitted stage by stage. The legal framework needed for the CCS planning and approval procedures is currently being put into place.

But it would be premature to set out various legal obligations that would apply to various periods in the future, and which could impact on investment decisions that have to be taken today, when some of the fundamental issues connected with the technology in question still have to be resolved. As things stand at present CCS is only one of several possible options.

When it comes to achieving rapid and effective results in terms of CO_2 reduction, and doing so competitively, then current efforts towards improving efficiency levels at coal-fired power stations have to be continued. Even if the indigenous coal-fired plants are pilloried in the current climate debate, these installations still rank among the most environmentally compatible generators in the world. 'Clean' coal utilisation – whereby pollutants such as nitrous oxides, sulphur dioxide and dust are filtered out of the flue gases – is now yielding much higher efficiency rates at Germany's coal-fired power stations, and this in turn means a reduction in CO_2 emissions.

While average efficiency levels worldwide are around 30%, modern and efficient coal-fired installations in Germany are already achieving 45% efficiency and are proving economically competitive for investors. Industry experts are already suggesting that Clean Coal Technology (CCT) could be developed to achieve efficiency rates of 50% and more.

A comparative analysis of the two systems (CCT and CCS) indicates that Clean Coal Technology presents significant economic advantages. Electricity generating costs for CCS technology would probably be much higher than those of CCT, while efficiency would also be significantly down. This also shows that CCS would not be competitive at international level and could only become so if uniform environmental standards could be introduced on a global scale. Otherwise the cost of German or EU-generated CCS electricity would be far higher than that of conventional coal-based electricity everywhere else in the world. The unilateral and exclusive introduction of CCS technology could therefore put German and European industry at a self-imposed disadvantage. However, if the world's coal-fired power stations could only be improved from their current 30% average efficiency to the state-of-the-art level of 45% this would produce a 30% reduction in global CO_2 emissions. As well as examining various CCS options therefore the current efforts aimed at achieving further improvements in CCT for coal-fired power stations should be intensified.

Climate protection with coal: favourable prospects worldwide

In view of the fact that the climate problem is a global concern, and not a regional or national issue, German climate-protection efforts must not be allowed to obscure the international prospects for global energy supplies.

In May 2007 the US-based Energy Information Administration (EIA), which comes under the Department of Energy (DOE), submitted its latest assessment of world energy consumption to the year 2030. The reference case – as based on current conditions and unaltered policy targets – predicts that global primary-energy consumption will increase by 57% from 16 bn tce in 2004 to 25 bn tce in 2030. Of this growth in consumption of 9 bn tce some 7 bn tce will be accredited to non-OECD countries and only 2 bn tce to the OECD nations. In the course of this 26-year period energy consumption in Europe is expected to grow merely by 10% (0.3 bn tce).

The reference scenario to 2030 also indicates that coal's contribution to world energy supply will grow from 25.6% in 2004 to 28.4% by the end of the reference period, during which time coal consumption is expected to rise in absolute terms by 3 bn tce to a figure of 7 bn tce. It is predicted that China alone will account for about 78% of this growth in consumption. In spite of a

rise in consumption of 2.5 bn tc by 2030 oil's share of the global energy market is expected to decline by about 2%, while gas is set to improve its position by at least 1%. In absolute terms coal consumption is therefore expected to surpass that of gas.

According to US forecasts for the period to 2030 coal will improve on its current dominant position in the world power generating market, increasing its share from 41% in 2004 to 45% in 2030, with electricity production set to grow twofold to 13,650 TWh. Only gas-fired power generation is expected to increase at an even faster pace during the same period, with a predicted growth rate of nearly 130%. However, with a 24% share of the generating market in 2030 gas will still be lagging far behind coal as a power generating fuel.

The reference scenario and the two case variants with alternative estimates for economic growth and energy price trends also examine the development of CO_2 emissions, which as a consequence of an anticipated global population growth of some two billion are expected to be 43 - 77% above the 2004 emission levels of 26.9 bn t CO_2, or 81 - 125% above 1990 levels. Without a globally coordinated climate strategy these figures put Germany's individual attempts at cutting back on CO_2 emissions into a certain perspective.

On 14 March the prestigious Massachusetts Institute of Technology (MIT) published a widely-reported study on the future of coal as a global fuel. Assuming a 'business as usual' scenario it is projected that coal consumption will more than quadruple between 2000 and 2050. Coal's contribution to global CO_2 emissions, which is expected to be in the region of 62 bn t CO_2 by 2050, would therefore increase from 38% in 2000 to 50% by the end of the period. Recognising that action is needed to contain greenhouse-gas emissions in the long term the MIT study uses a highly-complex model with two alternative assumptions for nuclear energy use (limited application and expansive application) in order to investigate the long-term hypothetical development pathways for coal consumption under the technological premises of CCT with CCS and without CCS. It is shown that global CO_2 emissions to 2050 can be stabilised at a level of 26 – 32 million t CO_2, whereby global coal consumption in the very long term would still be above the levels recorded for the year 2000, barring an expansive development of nuclear power and the renunciation of CCS technology. Yet even then world coal consumption in 2050 would still be 78% of its 2000 level.

The study considers that CCS would be a very practical technological option for reducing greenhouse gases in the very long term, adding that much research and development work still remains to be done before such a technology can be put in place. It also recognises the need for a legal framework that would include insurance arrangements to cover the risk of possible leakage during the CO_2 storage operation, this to be backed as far as possible by government guarantees.

The study shows that emissions reduction and global coal utilisation are not mutually exclusive. On the contrary: even while recognising the need for effective climate protection measures there is no alternative to large-scale coal utilisation if the world is to embrace sustainable development. Climate protection therefore should and must be practised in partnership with coal and not in conflict with it.

RAW MATERIALS AND SECURITY OF SUPPLY

German industry is calling for a security of supply strategy for raw materials

German industry and Government politicians are increasingly recognising that security of supply is vital if industry is to stay competitive in the global marketplace, and that Germany and other industrialised nations currently risk falling behind the international competition. Security in the provision of raw materials is increasingly becoming one of the most important political and economic themes of our age.

At the first Raw-Materials Summit in the spring of 2005 the Federal Government and Federation of German Industries (BDI) agreed to work closely together to develop an appropriate raw-materials strategy for Germany that could be followed by both the political and the business communities. Following-on from this Chancellor Merkel used the second BDI Raw-Materials Conference of 20 March 2007 to announce the setting-up of a raw-materials security strategy for Germany. The focus of this conference was on mineral and metallurgical resources, since these materials had previously not been afforded the same status as security of energy resources – but were equally indispensable. Yet the boundaries between energy resources and raw materials can sometimes be blurred. For example, coke is a raw material for the German steel industry, but then so is iron ore. What is indisputable is that action is urgently required in the natural-resources sector in general.

During the raw-materials crisis of 2004/2005 warnings were already being sounded of the economic risks of an excessive reliance on imports of both energy resources and minerals. In 2005, following the shortages and price hikes that had just driven coking coal and coke into previously uncharted territory for purchasers, the German Hard Coal Association commissioned the prestigious EEFA Institute to produce a study on the use of raw materials as a structural factor for industry. This investigation set out to examine the sectoral cost effects and job losses that would be incurred throughout Germany as a result of a twofold increase in the price of raw materials. This premise was then rapidly overtaken by real events, as some international commodity prices recorded a sixfold increase on the base-year figure.

German production has fallen by 0.6% and GDP by 0.4%, because of the price and cost impact of an increase in commodity prices since 2001. According to the latest figures from the BDI this has already cost the country nearly 140,000 jobs and has pushed unemployment up by 0.4%. Moreover, without security of raw-materials supply the entire industrial capacity of Germany could be threatened. This would affect not only industrial production for the domestic market but also the export position of German industry.

In all likelihood Germany will have to cede the title of 'export world champion' to China sometime this year. And if the country is to continue to play in the premier league it is essential to ensure a competitive and reliable supply of raw materials and resources to the German export sector and to the sub-contractors and suppliers that are associated with it. It has to be remembered in this context that according to general estimates from various expert bodies the current movement of raw-material prices is not just a passing phenomenon. Temporary market flutters will do nothing to alter the upward trend and structural problems affecting energy and commodity supplies as the market attempts to keep pace with the rapid growth in demand.

Growing world population – rising demand for raw materials and energy

As the International Energy Agency (IEA) reports in its World Energy Outlook 2006, global population growth correlates with the rise in primary energy consumption. According to the United Nations' Report 'World Population Prospects: The 2006 Revision' (UNPD, 2007) the world's

population is growing by an average of 1% a year and is expected to increase from an estimated 6.4 billion in mid-2004 to over 8 billion by the year 2030. At the same time the annual growth rates of the industrialised countries (OECD) will be halved from 0.8% per year for the 1990 to 2004 period to 0.4% per year by 2030. The annual growth rate will also fall in the developing nations, and China and India are included in this group, but here annual growth to 2030 will still be in the region of 1.2% per year – which is still three times more than that of the industrialised world. According to the IEA reference scenario global energy consumption will increase 1.6% year on year to 2030, which is slightly above the rate of population growth. More than 70% of this predicted rise in consumption will take place in the developing nations, with China alone accounting for 30% of it.

According to estimates by the US Department of Energy (DOE) the industrialised countries will still be responsible for more than half of global primary energy consumption (57%) in 2030. In 1990, by comparison, this group accounted for nearly 70% of all the energy consumed on the planet. When set against the reference year 1990 we are already beginning to see a gradual reversal of roles between the industrialised and the developing nations in respect of primary energy consumption.

Raw materials and energy – vital resources for combating hunger and poverty

Although some emerging nations are beginning to bring their living standards and levels of prosperity into line with that of the industrialised world, the goods and commodities of this world are still as unequally distributed as ever. A large part of the world's population still has no access to clean drinking water, to adequate food supplies or to electricity. According to an assessment by the Federal Ministry for Economic Cooperation and Development (BMZ) more than 20% of the world's population is living on less than one dollar a day and more than half (52.8%) has to survive on less than two dollars a day. According to the twelfth BMZ report on the Federal Government's development policy nearly 20% of the world's citizens have no access to better sources of water supply. The IEA's World Energy Outlook 2006 shows that the global rate of electrification – currently standing at 75% or more – is primarily focussed on urban areas. This means that in 2005 about two billion people still had no or very limited access to electrical power.

Access to energy is and will remain an essential factor in combating hunger and poverty. A reliable supply of competitively-priced energy is essential for productive activity to be carried out on an industrial scale in order to ensure the sustainable provision of basic needs and to create employment opportunities along with adequate economic growth. Great efforts have already been made to contain global poverty, but the problem has still to be fully resolved. If the world's population is to be provided with sufficient food, water and energy there must be adequate capacity for production and a commensurate level of global economic growth.

The global economy grew by about 5.3% in 2004, this representing the highest rate of economic expansion since 1973. The IEA has estimated that the annual rate of global economic growth during the period 2004 to 2030 will be +3.4%. The most dynamic rate of growth during this reference period, put at some 5.5% a year, will be recorded by the Chinese economy. According to this projection China will take over from the United States sometime around 2015 as the country with the world's strongest economy. During the same period the annual rate of economic growth in the developing nations will generally be in the region of +4.7% per year, which is about twice the average rate of expansion of the industrialised countries (OECD: +2.2%/a).

BRIC countries and developing nations want to be part of the affluent society

The industrialised countries will increasingly have to adjust to the fact that the depleting resources that over the years have helped secure their economic prosperity now have to be shared with the aspiring and emerging nations, and particularly Brazil, Russia, India and China, and that at some point in the future this will also apply to an increasing degree to many of today's developing countries whose economic catch-up is just commencing. And it is what the US investment bank Goldman Sachs has referred to as the 'BRIC countries' that will be at the head of the queue in demanding a slice of the prosperity cake. These states have a huge backlog demand combined with an enormous appetite for consumer goods and raw materials. At the same time they have vast natural resources of their own and are now major suppliers on the international commodities markets: Brazil is the world's most important producer of iron ore, while Russia has huge oil and gas reserves that has made it a much sought-after business partner for western Europe and increasingly for Asia too. China and India have the world's largest coal deposits and are already in the throes of massive economic expansion. China also provides about 60% of all the coking coal currently available on the international export market.

The often very favourable conditions that exist in these countries for the establishment of industry – namely reliable and favourable supplies of energy and raw materials, low taxation, a high level of state funding, good transport links and a huge sales market with massive future potential – have meant that international companies are increasingly relocating production to these regions. This in turn generates an even higher demand for raw materials in the countries concerned. Unlike many of the industrialised nations the BRIC countries, and especially China, began taking steps well ahead of the raw-materials crisis to devise basic strategies aimed at ensuring security of supply in energy and raw materials.

The BRIC countries are now challenging the economic dominance of the industrialised world to an increasing degree. For example, while the USA – in terms of its share of total global revenue in 2006 – was still well ahead of China in respect of oil consumption and CO_2 emissions, it has already been overtaken by the latter in many other areas, including raw steel production, coal consumption and coal output.

China: now the number-one absorber of raw materials

Many international statistics still portray China as a developing nation, even though the country currently has the largest foreign exchange reserves in the world of about 1.3 trillion US dollars. Many industrialised nations have already stopped sending development aid to China (including Sweden) or are currently discussing such an action. Even Germany is debating whether the aid sent to China each year should be discontinued.

The Government of the People's Republic of China bases its economic policy on a series of ten- and five-year plans and therefore is able to think well ahead of events. While centrally planned economies have certainly had their pitfalls in the past, this approach also delivers benefits – and will continue to do so – for those countries with this form of economic system. China anticipated energy and raw-materials shortages at home and consequently on the international commodities markets too, and laid plans to deal with the problem. Since the mid-1990s China has been busy securing itself long-term access to key raw materials all over the world. It has been estimated that the country invested more than a trillion (one thousand billion) US dollars in projects of this kind prior to 2006. While China effectively has abundant natural resources of its own, the country's rapid and massive economic expansion has meant that even this can no longer satisfy its huge appetite for raw materials.

China is therefore switching from being a net exporter to a net importer in many commodity sectors. With economic growth targeted at 8% a year the Beijing Government has estimated that China's gas production, for example, is no longer sufficient to meet domestic demand. And with the other two fossil fuels oil and coal too we are witnessing a dramatic surge in the excess demand that has been building up around the world. China is now reliant on imports for one third of its energy needs. The Chinese Central Government has therefore declared that global security of resources is now a strategic priority and no effort is being spared in achieving this target. This includes strategic resource partnerships, direct investments and joint ventures with and in certain countries that the industrialised nations have tended to avoid due to human-rights issues and other (moral) reservations.

China is therefore involved in mining and drilling projects in every corner of the globe, including South Sudan, Venezuela, Ecuador, Nigeria and forty other African countries. Bilateral agreements on raw-material deliveries have also been signed with the Russian Federation and Iran. Large-scale projects are also under way to develop and expand raw-materials projects at home. According to IEA predictions, by 2030 China will have invested about 120 billion dollars in developing its oil industry. And the country is increasingly placing its energy supply industry on a broader footing. As well as global diversification in the procurement of fossil fuels China is slowly developing a civil nuclear energy programme, investing in coal liquefaction plant and planning nine coastal sites to serve as landing terminals for liquefied natural gas (LNG) that will provide a combined annual capacity of over 26 million tonnes.

Price trends in key global resources markets

The concentrated surge in demand from China and other emerging nations like India is increasingly generating excess demand and capacity shortages on the international energy and commodity markets. Alongside other factors, including speculation and politically motivated situations, the appetite for raw materials being displayed by the newly emergent nations is repeatedly cited as the main reason behind the dynamic price movements in the energy-resource markets. This is also reflected in the prices of Brent Crude (North Sea oil), which is traded on the London International Petroleum Exchange (IPE).

Price trends for internationally traded fossil fuels were for the most part fairly unspectacular for many years up to the price turnaround of 2004, interrupted only by several oil-price shocks. OPEC long contemplated a new basket price of first 60 and then later 70 dollars a barrel (one barrel is equivalent to 159 litres). However, given current price movements this now seems to have been overtaken by events, with some crude oils having already overshot the 80-dollar mark.

A similar trend can also be observed in steam-coal prices. In the middle of this year, for example, the price for steam coal delivered to North West European ports broke through the record that had been set at the end of 2004. While current market imbalances – especially as far as high prices are concerned – will obviously be evened-out again as part of the cyclical process, the price of this commodity, like that of other energy resources, will continue to see-saw upwards in the long term.

International freight charges have now developed to a degree that has made them a significant factor in CIF coal prices. The global resources boom is now being accompanied by cyclical shortages of seaborne freight capacity. Temporary full-capacity usage of port facilities combined with disruptions to loading due to strikes and technical problems can affect ship turnaround times both in and outside the ports and this in turn quickly impacts on freight charges because of the international interdependence between freight markets.

Internationally active mining corporations like BHP Billiton and Rio Tinto are now making huge profits. However, while 'the raw-materials boom' is also increasingly acting as an incentive for venture capitalists to invest in this highly speculative business, for consumers it means ever greater uncertainty about supply bottlenecks and price hikes.

Growing tensions in the raw materials and energy supply markets

The concerns of consumer countries about the future reliability of affordable energy and raw materials combined with the economic and power-policy interests of the supplier nations are now causing growing tensions between the states concerned. Market observers and political analysts are already talking of a new 'Cold War'. In retrospect it is now clear that the raw-materials crisis that developed in early- and mid-2004 was already smouldering for some time beneath the surface of political and economic events. Emerging market countries like China and Russia understood well before the industrialised nations that security of supply in energy and raw materials is a strategic responsibility and at the same time discovered that their abundance of raw materials could be used as a political lever against those that were dependent on such supplies.

The risks associated with such a high reliance on one supplier were demonstrated by last year's stand-off over high gas prices between Ukraine and Russia, which resulted in the latter temporarily suspending gas deliveries to its neighbour. And a short time later Russia behaved in a similar fashion to Belarus, also in an attempt to enforce higher prices. Both these countries had agreed short-term supply contracts with Russia at prices well below the market level, but had few gas storage facilities of their own and no fallback options. Legally speaking Russia was clearly justified in raising its prices, but the manner in which it set about this raised quite a number of questions in the EU. The Community's own oil and gas reserves will soon run out and its current high level of dependence on imports will increase to 70 - 80% in about twenty years time and will continue to grow thereafter. Coal is in fact the only resource that Europe has in abundant supply.

Russia now meets about 50% of the EU's demand for imported gas and about 30% of its oil requirements. The EU's response to this has mainly taken the form of increased renewables usage and improved energy-efficiency and energy-saving measures, while there are also some initial signs of a gradual return to indigenous resources. And Europe is looking towards other energy suppliers too. In order to increase the diversification of gas supply sources the EU is proposing to build a 3,000 km-long Nabucco pipeline to connect to the gas deposits of the Caspian region and the Middle East. Russia, concerned at the possible loss of its supply monopoly on Turkmen and Uzbek gas, is opposed to these plans. Several pipeline projects are currently being developed in order to make the Nabucco operation obsolete. And the row has now been joined by Turkey, which is planning to construct a pipeline to the Iranian South Pars field – one of the world's largest gas deposits. The Turkish pipeline could eventually link up with the Nabucco pipeline. However, the USA is strongly opposed to this project, as it wants to keep Iran politically and economically isolated because of the latter's nuclear programme. This particular example demonstrates one thing: attitudes are hardening; the 'competition for raw materials' and the 'battle for resources' – as some journals, including *Der Spiegel* and *DIE ZEIT*, reported earlier in 2007 – are now becoming more predatory and there are no holds barred.

Energy reserves and consumption: oil, gas and coal

In their current projections for the year 2030 many internationally active institutions, including the International Energy Agency (IEA), the World Energy Council (WEC) and the US Department of Energy (DOE), calculate that fossil fuels – namely coal, lignite, gas and oil – will be responsible for meeting as much as 90% of the world's energy needs, and this in spite of the massive budgets allocated for the development of renewables and other alternative forms of energy. This

raises the question as to the lifespan of these key energy resources. If world energy consumption were to remain unchanged at 2006 levels it is estimated that coal reserves, that is to say those deposits that are economically recoverable under current conditions, would have a static lifespan of some 150 years. Current estimates give gas reserves a life expectancy of about 60 years and oil about 40 years. However these lifespan calculations will vary over time as a function of current market-price trends and consumption patterns and according to worldwide exploration activities. As prices rise these reserves will then also include various deposits that were previously known to exist but had not been economically recoverable at earlier price levels – such as the Canadian oil sands that can be used as a source of heavy oil. While the factor of static lifespan is of great psychological significance, it says nothing about the actual and temporary availability of a particular energy resource.

Geostrategic risks for oil and gas supplies

The geostrategic distribution of these resources is of very great significance, especially as far as the temporary availability of oil and gas is concerned. There is now a growing tendency around the world for oil and gas companies to be nationalised, a development that has a direct impact on their productivity. This has recently happened in Russia, Bolivia, Venezuela, Argentina and Algeria. Add to this the fact that the available deposits are now increasingly being concentrated in a few countries where the political situation is anything but stable. The consumer countries' own reserves of oil and gas are gradually becoming depleted. Germany's indigenous deposits, which currently account for about 15% of national gas consumption and almost 3% of oil usage, will only last for a few more decades. This compares with the situation in the UK, which has already become a net importer of oil and gas. In Norway the gas supply companies are now embarking on a costly venture to develop the Arctic region, which is thought to contain about one quarter of the world's as-yet undiscovered oil and gas deposits.

The world's oil reserves are already largely located in politically unstable regions. More than 70% of the planet's oil reserves and about 40% of the world gas reserves are to be found in the so-called 'strategic ellipse' – a zone stretching from the Persian Gulf to the Caspian Sea. More than 70% of the fourteen leading oil-exporting states are now classified as politically unstable. Political crises and conflicts in these countries very quickly result in major supply shortages and dramatic price hikes on the different world markets. In spite of their immense oil deposits OPEC only contributed about 38% of global oil production in 2006. As alternative sources of supply – for example in the EU and in the United States – gradually near depletion, OPEC's share of the market will rise considerably in the years ahead.

While global coal reserves are much more widely distributed across the Continents, this resource too is largely controlled by just a few countries. Two thirds of the world's solid fuel reserves are to be found beneath the soil of four major powers: the USA, China, Russia and India.

Alternative uses for raw materials: coal hydrogenation

From the current perspective it would seem that future supplies of oil and gas will come under increasing threat. Coal hydrogenation is now enjoying a global revival as countries seek possible alternatives to oil in the transport sector. One year ago, aware of the growing importance of coal liquefaction, the IEA organised a 'coal to liquids' workshop that turned out to be a very popular event indeed.

In spite of an increase in OPEC production levels US oil prices climbed above the historic 80 $/b mark in September 2007. This record high hit Germany and other countries especially hard, as the German economy is not only dependent on crude-oil imports from Russia and the OPEC states but also has to import processed crude along with fuel oil, petrol and diesel. As there is

every likelihood of long-term shortages of oil, alternative fuels now need to be developed before it is too late. The current focus is on coal liquefaction. This technique was first developed in Germany in the 1930s and was then revived by the Federal Government in the 1970s, after the first oil crisis, when several pilot plants were built. However, the oil-price collapse of the mid-1980s meant that in Germany this process never developed into industrial-scale coal refining. The last of the pilot plants operated by Deutsche Montan Technologie GmbH (DMT) were dismantled and sold to China in 2004.

The Chinese energy group Shenhua is now planning to build a coal liquefaction plant in Inner Mongolia that will be set-up to produce about 5 million tonnes of petrol, kerosene, diesel and other fuels from a 9.7 million-tonne coal feedstock. It is claimed that this operation will be competitive when crude-oil prices reach 20 US $/b and that other plants will follow. The Chinese Government believes that this industrial project – which represents about € 2.45 bn in investment capital and is the first direct coal hydrogenation plant (Bergius process) ever to be built – will make a significant contribution to China's domestic energy structure. Incidentally, the contract to supply high-performance pumps for the new plant was awarded to the Swabian-based company URACA in June 2005. The coal liquefaction process, which has been the subject of many years of research, is capable of yielding various liquid hydrocarbons - such as petrol and diesel fuels, methanol (as an admixture to petrol) and coal-oil for heating – and this technique could help Germany and the EU reduce its reliance on crude oil on a permanent basis. Coal is the most abundantly available of the world's fossil fuels and while Europe has very little oil of its own Germany and the EU in general have access to huge indigenous coal reserves. Of course producing motor fuels from oil is at present more cost-effective and generates fewer CO_2 emissions than when using coal. Yet the question of whether Europe will again invest in coal liquefaction and gasification is not merely a matter of economics. If the infrastructure is not there and the technical know-how migrates elsewhere additional incentives will be needed to make up the lost ground. It is therefore all the more important to reactivate German research and development in this field if we are not to completely squander the 'coal-oil' option that is provided by our most important natural energy resource – coal.

The great white hope: underground coal gasification

Underground coal gasification (UCG, also known as in-situ gasification) is another possible option. The origins of this technique, which have always generated a certain amount of interest at times of energy shortage, can be traced right back to the nineteenth century. The first experimental bases were laid in 1912, while the former USSR developed the process from 1934 to 1940 and even used it to some degree in some smaller deposits right up to the 1950s.

The system disappeared almost completely with the oil surplus of the 1960s, but was revived after the first oil crisis of 1972 and was developed to commercial status in the USA in the 1980s, based on experience acquired in the USSR and elsewhere. However the sudden easy availability of natural gas meant that industrial-scale UCG was again blocked.

High and volatile energy prices, combined with the continuing debate as to whether oil and gas have reached or even gone beyond their 'mid depletion point', now again seem to have focussed attention on UCG – a 'new' technology that was developed to commercial viability many years ago. Put in simple terms, this technique allows coal to be converted underground, and in a controlled manner, into synthesis (natural) gas.

A number of boreholes are drilled to access the underground coal deposits. Reagents such as water and oxygen are then injected into the target zone and the gasification process initiated by means of a trigger ignition under high pressure. The resulting product, which is referred-to as 'syngas', is delivered to the surface preparation plant via a vertical producer and is then refined for use as a power-station fuel, as a feedstock for the chemicals industry or as a constituent in the 'coal to liquids' process.

Part of the CO_2 gas produced during UCG can be re-injected into the cavities left by the gasification process. Some of the CCS projects being carried out under the EU's Sixth Framework Research Programme are also investigating CO_2 storage possibilities of this kind.

The highly-advanced drilling technology that has been developed by the oil and gas industry, and the extensive experience acquired by the deep-mined coal industry with its wealth of know-how, provide ideal foundations for an underground coal gasification industry – which is reliable, economically viable and ecologically sustainable – to be developed on a large-scale industrial basis.

In recent years the United States, the former USSR and a number of western European countries have been carrying out research and development into underground coal gasification. The technology has now been developed to full commercial status and the coal deposits of these countries are most likely to be the target for full-scale UCG.

Since 1974 the European Union, for example, has funded research projects aimed at the gasification of deep-lying deposits of high-grade coal that are not accessible for conventional mining. The ultimate objective is to produce a high-quality gas for use in industry. Trials carried out in an anthracite deposit at Thulin (Belgium) – using both guided lateral drilling and deviated drilling – succeeded in producing high-grade gas from a depth of 860 metres. After ignition the gasification process traversed the UCG cavity at a pressure of 20 to 30 bar; this test gasified about 340 tonnes of coal. Bituminous coal has also been gasified in the USA (Pricetown) and in the Russian Federation (Lisichansk).

Lignitic coals have proved to be the most reactive, while anthracite coals tend to react more slowly. Research has shown that because of volumetric increase coals with high coking, caking and swelling capacity are unsuitable for underground gasification.

There are several reasons why UCG has still not been developed on a full commercial scale. Two of the main obstacles at present are that very precise information is needed on each individual area of deposits and on the adjacent strata, while initiating and controlling the underground gasification process itself is still a lengthy and extremely complex chemical and physical operation. Another problem concerns the permeability (pore space and fissuring) of the deposits and the need to keep these pathways open so that the synthesis gas can be extracted. Add to this the need to prevent undesirable gas emissions and to avoid ground-water contamination, all of which requires a highly-developed mining know-how.

Up until now the easy availability and affordability of other fuels have rendered UCG unnecessary. But all this could change fundamentally at some point in the future.

Underground coal gasification is now essentially based on the use of directional wells, which provides better control of the deposits and allows gas quality to be regulated.

A number of projects at various stages of experimentation and production are currently under way around the world. In addition to those already mentioned in the USA and the Russian Federation China too is actively engaged in this area and at present has five such projects up and running, some producing process steam and some fuel gas and electricity. An Australian pilot plant is now capable of generating about 90,000 m^3 of gas an hour with a calorific value of 5.23 MJ/m^3. It is planned to use the gas as fuel for a 40-megawatt downstream power station that will generate about 280 MWh of electricity a year. In a second development phase the UCG gas is to be converted into diesel fuel using the Fischer-Tropsch process; the cost of this operation has been estimated at 17 - 18 US$/t. A plant of this type has been in operation at Angren in Uzbekistan since 1959, where the synthesis gas is used as power-station fuel.

It has been estimated that there are about 240 billion tonnes of solid-fuel reserves that cannot be extracted by conventional means, of which some 210 billion tonnes are coal. About 30% of these

reserves (70 billion tonnes) are thought suitable for the UCG process. It is assumed that each tonne of coal could yield 2,700 m^3 of gas with a calorific value of 3 to 5 MJ, which in turn would produce about twenty times 10^{12} m^3 of product with the quality of natural gas.

UCG could provide a whole new energy reserve by accessing vast deposits that would not be recoverable by conventional means. The World Energy Council has put the theoretical life expectancy of this resource at some 3,000 years, while conventional gas reserves – by comparison – at present have an estimated lifespan of about 60 years.