



EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR ENERGY AND TRANSPORT
DIRECTORATE C - Conventional Energies
Coal and oil

E U R A C O A L

European Association for Coal and Lignite



COAL IN EUROPE

24TH JANUARY 2005
IN BRUSSELS



FOREWORD

“Coal in Europe” was the focus of the conference EURACOAL organised after its Executive Committee Meeting on 24 January 2005. In his opening speech, EURACOAL's newly elected President, Nigel YAXLEY (UK COAL), highlighted the increasing importance of coal after EU Enlargement. Coal is produced in 9 Member States, and is also widely available across the world, with reserves forecast to last for over 200 years. Coal is traded internationally in a very competitive world market, with major producers and exporters in each continent. The supply chain for coal is flexible and it is safe to transport coal, in contrast to other fossil fuels. Coal is relatively cheap and contributes as an important stabilising factor to the world and European energy mix.

Nevertheless, according to guest speaker Commissioner for Energy Andris PIEBALGS, until now, coal has not received the attention it deserves. Coal still suffers from a negative image, as being a dirty fuel causing environmental damage, whilst its advantages and its role to secure the European energy supply are often overlooked. These advantages are particularly important in times of high and volatile oil prices. However, it is clear that the environmental challenges associated with coal need to be overcome.

The European coal industry has backed a consistent application of the Clean Coal concept in order to further optimise coal utilisation consistent with environmental goals. This Clean Coal concept comprises all currently available technologies and strategies as well as a longer-term vision, designed to ensure a continuing reliable supply of low-cost energy by means of efficient coal utilisation while at the same time minimising the impact on climate and environment.

The Clean Coal concept is built around a three-stage programme for future coal utilisation:

- reducing emissions from existing power stations;
- facilitating the development and market penetration of new, highly efficient, coal-fired power stations,
- promoting new technologies for CO₂ capture and storage.

Phase One seeks to reduce emission levels from existing installations, while Phase Two aims to increase the efficiency of operational and future plant. Many of Europe's coal-fired power stations are already equipped with new “Phase One” technology. Phase Three covers the long-term objectives for electricity generation from coal, including the introduction of CO₂ capture and sequestration as part of the process. This phase takes Clean Coal well into the future with the visionary prospect of the near-zero CO₂ power station together with the efficient production of hydrogen for the transport sector. The know-how currently available means that there are no insurmountable obstacles to achieving this objective, although a number of technical and regulatory issues have to be resolved. Developing commercially viable solutions to these issues is one of the major challenges facing both governments and industry in the years ahead. Energy is and will remain one of life's most basic essentials.

In order to achieve these objectives, the European Commission, the European Parliament, Member States and industry need to collaborate to develop a coherent and ambitious European Clean Coal Partnership striving towards a viable competitive European industry, which is recognised for its contribution to environmental sustainability.



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THE COMMISSION'S APPROACH TO FUTURE ENERGY POLICY

COMMISSIONER
ANDRIS PIEBALGS





Andris PIEBALGS

Ladies and gentlemen

During my Hearing before the Parliament I identified six key energy priorities for the new Commission, namely:

1. Energy efficiency
2. Ensuring a proper functioning internal energy market
3. Promoting renewable energy sources
4. Security of energy supplies, and in this context, developing external energy policy relations.
5. Creating a better linkage between energy, environment and research policies, and
6. Strengthening nuclear safety and security.

Underlying these priorities are the three key objectives of a coherent energy policy for Europe – balancing competitiveness, sustainable development and security of supply.

In developing the new Commission's approach to energy policy it is my intention to look again at the action that has until now been taken in each of these six priority areas. On this basis, we need to rethink existing approaches and determine what can additionally be done to ensure that our approach makes the maximum possible contribution to these three core objectives of energy policy.

The contribution that an effective energy policy can make to Europe's overall welfare cannot be underestimated. Energy is one of the key sectors of the European economy, vital to competitiveness and thus to the achievement of the Lisbon agenda, essential to meeting our Kyoto obligations, and a major factor in terms of security.

I believe that the next five years will be a "watershed period" for energy policy. It seems clear that we are going to see continued higher oil and gas prices at least in the medium term, and the same can probably be said for coal. Europe must continue to support the Kyoto process, maintaining its world leadership in terms of environmental responsibility. China and India will continue to grow explosively, and the EU will become increasingly dependent on external energy suppliers. These factors mean that energy policy will be at the heart of the new Commission's efforts to address the Lisbon agenda, to achieve Kyoto, and to guarantee security for its citizens. We have the opportunity over the next five years to further develop an energy policy that addresses these issues in a coherent way, making a real and visible contribution to Europe's welfare.

Before considering how these priorities will impact on the coal industry, I would like to discuss my key priority for 2005, **energy efficiency**. An effective energy efficiency policy can make a

very major contribution to our Kyoto objectives. At the same time, it can make an immediate and appreciable contribution to Community competitiveness, and should thus play a major role regarding the Lisbon agenda. In addition, reducing EU energy demand is the most obvious method of tackling our external energy supply dependency.

Considerable work in this respect has been done in the past, but I am absolutely convinced that much more can be achieved with determined action at Community, national, regional, local and international level. I intend that the Commission should lead a new major European Energy Efficiency Initiative, combining action at all of these levels.

I believe that the Commission – indeed Europe as a whole - should therefore set an ambitious but realistic and achievable target to save, by 2010, the equivalent of 70 million tonnes of oil that would otherwise be consumed. This represents a saving of 15 billion Euros per annum, a very significant reduction of CO₂ and a reduction of 4% in terms of external supply dependence. Furthermore, a successful energy efficiency policy means more jobs in Europe.

It is therefore necessary to create a momentum for action across Europe. I have already identified some actions that might be taken:

- A European wide co-ordinated publicity drive
- New standards for public procurement throughout Europe to kick-start new energy efficiency technologies, for example on IT equipment and cars.
- The revision of the buildings and labelling Directives, and
- Extending and expanding the Energy Star agreement.

These are just first examples. A major effort will be made to identify a whole series of measures to be taken at all layers of society, creating an EU-wide partnership. Over the next two months it is my intention to initiate a widespread discussion to ensure real input into the preparation of the concrete measures that will make up the Initiative. This will be a key element in the preparation of a Commission Green Paper proposing a first concrete plan of action in late spring. This must lead Europe to real conclusions at the end of the year, demonstrating how to achieve the 70 million barrels of oil reduction, and committing to take the action to do so.

All the five other energy priorities that I identified before Parliament are equally capable of contributing to the three core objectives of energy policy. As I mentioned above, it is my intention to re-examine our approach for each of them to determine how to improve the present balance.

Before considering coal in particular, I would like to express my sincere interest in a close co-operation with you from the very beginning. In developing a clearer, more coherent long-term vision on the role of coal in the E.U., consultation and collaboration between the Commission and industry is essential. With this in mind I have decided to create a Hydrocarbons Forum, based on the successful Madrid and Florence Forums, to promote discussion and

develop consensus on all issues related to Hydrocarbons. EURACOAL will, of course, be invited to play a prominent role in the Forum.

I have the impression that in the past coal has not received the attention it deserves. It is true that coal suffers a number of disadvantages in environmental terms. However, it is equally true that it offers important advantages in terms of security of supply and I have no doubt that – if we take a pro-active approach to addressing the environmental challenges – my great grandchildren will also be using electricity produced by coal.

Coal is widely available across the world, with reserves forecast to last for more than 200 years. It is traded internationally in a very competitive world market, with important producers and exporters in each continent. It has a flexible supply chain and minimum safety risks are involved in its transportation compared to other fossil fuels. These are the advantages of coal, and they are often neglected. They are particularly important in times of high and volatile oil prices.

However, it is clear that the environmental challenges associated with coal need to be addressed. If we do not invest in the necessary technologies, reduce their costs and promote their effective penetration into the market, there is a risk that coal-fired generation will decline in Europe as old power plants are decommissioned.

Therefore, while coal is an important element of our overall policy of security of energy supply, its future use is closely linked to effectively addressing the environmental challenges it poses. That is why I have established the following three objectives for our coal policy:

- reducing the emissions from existing power stations;
- facilitating the development and market penetration of new, highly efficient, coal-fired power stations, and
- promoting new technologies for CO₂ capture and storage.

I know that these three objectives for European coal policy are rather similar to EURACOAL's Clean Coal concept and we have much to gain by working together to achieve it.

I would therefore like to propose that during this Commission, we work together to develop a coherent and ambitious **European Clean Coal Partnership**, between the Commission, Member States and industry. We need to set clear and ambitious targets for taking a real leap forwards towards a viable competitive industry, recognised for its contribution to environmental sustainability.

Such a partnership will need to focus on the three priorities I have outlined.

Firstly, reducing emissions from existing power stations

Reducing so-called “conventional” emissions such as for SO₂, NO_x, as well as dust and heavy metals, from existing power plants is covered by the Large Combustion Plant Directive which sets limits for each of these pollutants. Progress in implementing this directive is encouraging.

In 2005, the Commission plans to review the Large Combustion Plant Directive. This could lead to limit values being defined for additional substances such as mercury. As many of you are doubtless aware, the Commission's so-called “Mercury Strategy” is expected to be approved later this year and shall underpin the United Nations' action plan on tackling global mercury emissions. I look to a constructive and supportive role from EURACOAL on this. Part of securing a real future for coal in the EU is the public perception or - indeed realisation - that the coal industry is playing a determined and important role in promoting positive environmental change.

Furthermore, by developing and applying new environmental techniques in Europe, for instance for the reduction of mercury, our domestic technology base will be strengthened and innovative products as well as services will find their way onto global markets.

The second priority, facilitating the development and market penetration of new, highly efficient, coal-fired power stations also requires a pro-active approach.

Across the EU, there are a wide variety of coal-fired power plants, both in terms of the technologies used and their age. Whilst the construction of some of these power plants dates back to the 1950s, thermal efficiency ranges between 27% and 43%. Current calculations indicate that between 200 and 300 Gig watts of capacity will need to be replaced over the next decade.

I am fully supportive of EURACOAL's mid-term objective of boosting energy efficiency in coal-fired installations beyond 50% by 2020. The Commission's track record in R&D spending for this long-term goal is consistent and goes back to the early framework programmes for Community research. My services are now striving to ensure that more attention is given in the 7th RTD framework programme to improving the efficiencies of fossil power plants, alongside the development of renewable energy. Current ideas being developed include a demonstration plant to be co-funded by the industry and I count upon your support to make this installation a real European “lighthouse project”. Initiatives such as this need to form the core of any **European Clean Coal Partnership**.

The third priority for coal concerns the need to take a European lead in developing new technologies for CO₂ capture and storage.

The need to achieve emission reduction targets in the context of Kyoto should be an underlying criterion regarding the structuring of the 7th R&D framework programme. My Services are in close contact with DG Research to include energy efficiency (and renewable energy) as mid-term objectives, together with the development of commercially viable technologies for CO₂ capture and storage as a long-term goal.

To take a real European lead in this technology, however, will not just result from funding under the 7th Framework Programme. It will require a real European partnership for change, between the Commission, Member States and industry, similar to that described by President Chirac at the launch of the new Airbus. This will be at the core of the **European Clean Coal Partnership**, and I count on your support in developing this during the coming months. It will be one of the first issues to discuss at the new Hydrocarbons Forum.

Our basic objective must be to develop a European “zero-emission” coal-fired demonstration power plant with CO₂ capture. Such a prestigious project would not only serve as a show case for excellence in science and technology in the EU, it would also demonstrate how cutting-edge technology can create future revenues for the European technology base.

This objective is far from simple. Its success will in fact depend on the ability of this audience to convince their governments, and their companies, to really support such an initiative, and not just in words. The next five years will be vital for the long term future of coal in Europe. If we work together, and be ambitious, it can be a bright one.

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COAL IN EUROPE

NIGEL YAXLEY,
PRESIDENT OF EURACOAL



Coal powered the industrial revolution. With the ECSC, Coal was a key part of the beginning of European unification. But not long ago most people talked about the glorious past of King Coal – Green Paper title also “unloved”.

Growing realism about chances and risks in the energy sector, enlargement and discussion about Clean Coal turn out to be positive for coal – indeed at the first Coal Dialogue the Commission referred to a renaissance for coal. More and more people believe coal will remain part of the story. EURACOAL works for this on behalf of producers, importers and other interested parties in Europe.

Coal in Europe

- Secure energy for Europe
- Economic energy for Europe
- Clean Coal – three stages in a long-term vision
- Working together for the right policies

There is a need for balanced energy and environmental policies

Brussels, 24th January 2005

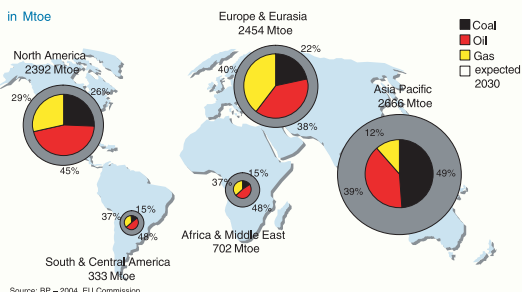
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1. The following issues should be taken into consideration:

- Secure energy
- Economic energy
- Clean coal

Working together – the best future for coal and for Europe cannot be achieved without the right policies. There is need for a balanced energy and environmental policy.

Coal is a key part of the world's energy mix – and growing



Primary Energy Consumption of Fossil Fuels – 2003 to 2030

Brussels, 24th January 2005

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2. Energy is one of life's most basic essentials. It is also a major political issue – in the future we can be sure more shortages, price shocks, conflicts and crises will have to be overcome. What are the sources we can rely - I believe there is no single solution. Coal is a major part of the energy mix in the world around 40% of world's electricity. Coal is an abundant, secure and competitive source. Demand in the developing world is rising rapidly – coal is a major means for providing electricity for those millions who do not already have it.

Europe is the world's third largest consumer of coal behind China and the US



About 490 mill. t/a hard coal and 550 mill. t/a lignite in Europe

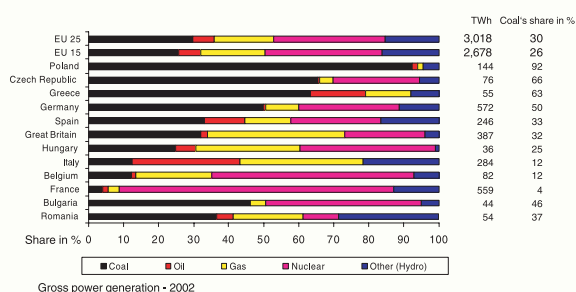
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3. Europe, in its wider geographic context, is the third largest coal consuming region in the world. Europe has access to enormous coal and lignite deposits. The new Member States are of key importance in this respect. Indigenous production is complemented by imports from a wide spread of countries across the world from where coal can be safely shipped. The EU has an efficient infrastructure of ports, waterways and railways at its disposal - It is cheap and safe to transport and stock coal.

4. The diversity of the generation mix across the European Union varies from one Member State to the other. Many states have significant reliance on coal. Poland over 90%, Greece over 60%, Germany around 50%, UK close to the EU average at around one third. We cannot underestimate the importance of coal in the EU now – but what of the future? Utilisation depends on environmental policy. In the longer term investments will determine capacity. Energy and environmental policies, particularly with respect to CO₂ will strongly influence investments and utilisation, and therefore security of supply and prices for consumers. This in turn affects the competitiveness of the EU.

Coal is key to power generation in states across Europe

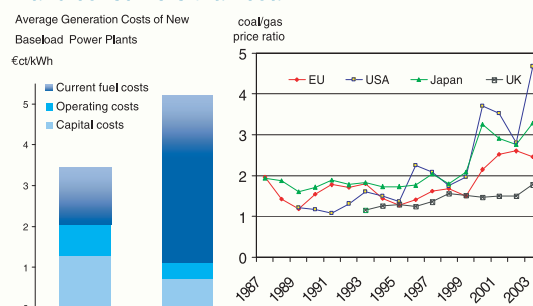


Brussels, 24th January 2005

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5. Interfuel competition is an important requirement if Europe wants to achieve reasonable priced electricity supply for industry and private consumers. Even though international coal prices have risen significantly over the last year, indigenous production provides a valuable hedge. Oil and gas prices have shown much more volatility, and by contrast EU's import dependency will increase dramatically. A further "dash for gas" such as we saw in the UK last decade would therefore prove a high risk strategy. Coal and Nuclear constitute furthermore an important counterbalance especially as far as the gas producers are concerned. Such a strategy has served Europe well to date, and indeed the US, China, India, Japan apply a similar model.

Rising gas prices are higher risk for generators and consumers than coal

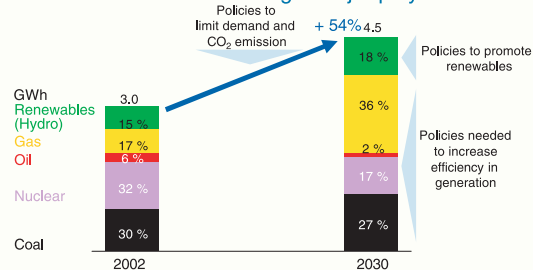


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6. The EU's predicted trend to 2030: all EU States want to develop the generation of electricity from renewables and many policies are in place to achieve this. The share of approximately 15 % renewables in 2003 relies for more than 80 % on large hydro. Targets to increase the share of renewables are therefore extremely ambitious and can only provide part of the answer. Policies to reduce demand will also not be sufficient. Policies are also needed to enable fossil fuels to contribute to the solutions for climate change. Simply achieving this by switching from coal to gas is an illusion – it reduces security, cannot achieve "deep cuts" as gas is also a hydrocarbon, and many instruments such as emissions trading ignore the overall supply chain – e.g. loss of gas from pipelines.

Power requirements of the enlarged Europe will increase with coal remaining a major player



Policies are needed to enable all fossil fuels to contribute to the solutions for climate change

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Clean coal can balance energy security and economic needs with environmental needs

- Coal is inexpensive, secure and has no transport risks
- The environmental impact of coal use can be minimised by clean coal technologies
- Clean coal is the basis for long-term acceptance of coal and is a flexible concept which can be used by all countries
- Euracoal defines clean coal in three stages
 - I Reduction in SO₂, NO_x, dust
 - II Improved energy efficiency
 - III The long-term vision of CO₂ capture and storage

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7. How can coal continue to contribute in a way which is consistent with environmental objectives? Regarding the Clean Coal Concept, already many good examples of Phase I can be observed around Europe – available techniques should continue to be implemented according to community guidelines.

Niederaußem's lignite-fuelled power plant illustrates step-by-step efficiency enhancement

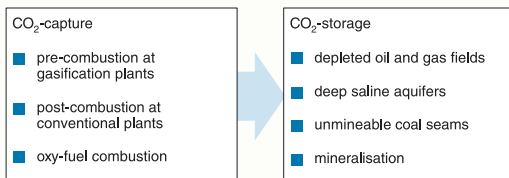


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8. Clean Coal II: The construction of highly efficient new power plants is a further step when replacement is needed or increased demand for electricity must be covered. This process of modernisation should be pursued without interruption. The regulatory framework should give security and attract investors. Efficient use of scarce resources and fewer emissions of pollutants can be achieved in line with a market economy.

In the longer term there is a route to near -zero CO₂ emission power stations



Some technologies are well-proven, others need significant R&D. All require demonstration with monitoring & verification of storage sites.

EU Framework Programme VII offers the opportunity to move ahead with demonstration projects and targeted R&D

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9. The capture and storage of carbon dioxide is an option for the future that provides a longer term vision for coal, together with the efficient production of hydrogen - the most economic basis for the hydrogen economy. A technical option therefore exists for the electricity sector in addition to nuclear and renewables, to use gas and coal in the long-term with dramatically reduced CO₂ emissions. Europe should take measures to develop this option by creating a technology platform in the 7th R&D Framework Program. Members of EURACOAL are engaged in this field and the mining industry is able to contribute to solve the storage question.

10. It is clearly premature to evaluate Emissions Trading, and Phase I was always envisaged as a trial with less challenging targets. There is no experience of what happens on a liberalised electricity market when power generation cannot follow because of a shortage of emissions rights. EURACOAL believes that Europe needs an open debate aiming to minimise unwanted side effects and to provide the system with the necessary investments – we need to start planning Phase II now. It is EURACOAL's opinion that a long time approach - i.e. the need oriented, free allocation of certificates over several trading periods - is vital for the power plant sector.

12. Coal is more than only a fuel for power generation. The demand of coal for European coke-oven plants is about 60 mill. t/a. They have an output of more than 45 mill. t/a of coking coal as an elementary raw material for the iron and steel sector in Europe. We also need about 30 mill. t/a coal and coal products for district-heating and in households. A large number of energy intensive industry like cement and building materials rely on coal. Coal is an inherent part of the European value-added chain.

13. We know from our own history that structural changes impose huge challenges. This is still relevant in a number of coal mining regions. Inherited liabilities often cannot be solved by the enterprise in question, with the result that the companies affected would simply go out of business. This is where state assistance is required. Investing in the modernisation and construction of new power generation plants and mines means making long-term commitments. Those willing to provide the funds have to be supported by a reliable legal framework. The regulation of the electricity market has a major influence on the behaviour of investors. Producers and consumers need clear price signals from the competitive market to stimulate.

Implementation of emissions trading policies is of key importance for coal and for Europe

- Emissions trading will inevitably lead to fuel switching from coal to gas
- Increased gas burn within the EU will have an adverse impact on competitiveness and energy security
- Coal can provide low carbon solutions
 - needs right political and investment climate

Implementation of Phase I has been rushed – We need to start planning Phase II now

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Coal is More Than a Fuel in the Power Sector

- Coking Coal is needed for the steel industry
- District heating, small business and households still consume a lot of coal
- Energy intensive industry like cement, building materials rely on coal

Coal is an inherent part of the European value-added chain

Brussels, 24th January 2005

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Euracoal welcomes continued dialogue with the European Institutions

- Europe needs an economical, environmentally sound energy supply based on an appropriate energy mix
- Coal's role in this context is crucial
- Technology and continuous modernisation have the potential to preserve resources and reduce CO₂
- Coal and coal-based power generation need stable planning
- With the right policies, coal is capable of continuing to provide secure, economical power for Europe, as well as meeting the environmental challenges

Let us work together to make coal part of the solution

Brussels, 24th January 2005

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RAW MATERIAL AVAILABILITY –
WITH A FOCUS ON FOSSIL
ENERGY RESOURCES

PROF. DR.-ING. DR. H.C. MULT.
FRIEDRICH-WILHELM WELLMER

INTRODUCTION

Ever since the oil crises in the 1970s, people have become increasingly aware of the fact that non-renewable raw materials like oil, natural gas, coal and nuclear fuel are finite resources. In 1972, a group of scientists from the Massachusetts Institute of Technology drew up a report, "The Limits to Growth", for the Club of Rome. On the basis of a computer simulation then used for the first time, the group, headed by Dennis Meadows, came to the conclusion that the world, with continued exponential growth, would use up all the world's raw materials in the near future.

Why were the authors wrong at the time? One main reason that must be mentioned is that the coupling of industrial growth and the consumption of resources presumed by the model has failed to materialize. In other words: Meadows' system did not factor in any ability to learn. Aside from this, the study seriously underestimated the available reserves. These were viewed statically and not as dynamic variables that constantly change thanks to human creativity and learning successes. Still, this study did raise an awareness of the growing scarcity of raw materials.

As we speak, the availability of oil has re-emerged in the public debate, driven, among other things, by the barrel price, which peaked at over US\$ 42 in New York last May, for example. Although it does appear that Europe has been able to benefit from a relatively wide spectrum of energies since the 1980s, with domestic oil and coal, nuclear energy programmes in certain countries, and the advances made by natural gas on the heating and electricity markets, the future certainly looks less rosy. In its Green Paper, the EU describes, e.g., future changes on the oil market in a Europe of 30: The decline in domestic production – specifically in the North Sea – must be juxtaposed with a continuously growing demand to more than 900 million tonnes (mt), so that dependence on imports will increase to nearly 80 % in 2030. Quite apart from this specific scarcity of domestic raw materials, we also have to consider the phase-out of nuclear energy in some EU states and the extra consumption of fossil energy sources due to climate policy (keyword: lower efficiency as a result of emission-free power generation).

Comparable scenarios can be produced both for other raw materials and for other regions on the world market. The resulting question of the availability of raw materials can be broken down – with account taken of an uneven global distribution – to an availability chain with the following elements:

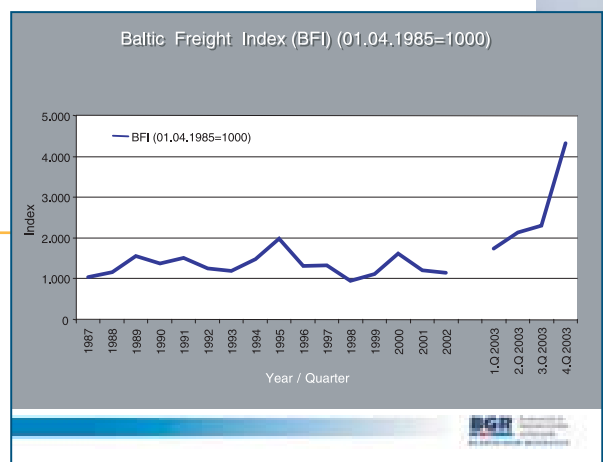
- geological availability,
- technical availability,
- availability of transportation.
-

These specific links in the chain are discussed in the following remarks – in reverse order – focusing on selected aspects.

AVAILABILITY OF TRANSPORTATION

As we are aware, there are long distances involved in our global raw-material world between raw-material deposits and consumer centres, e.g., Western Europe or Japan and Korea. This being so, the "transport" element is a necessary component in the provision of raw materials. Wherever the transportation of raw materials is possible without regard to quantities and distances, this may even lead to a complete elimination of regional markets. This phenomenon was observed between 1960 and 1995, "textbook-style", in the example of growing imports of higher-quality iron ores in ever bigger ships to Germany, all the way to a total ousting of domestic iron production.

Besides vessel size, freight rates are an indicator of the market for carriers. The Baltic Freight Index (BFI), between 1987 and 2002, varied only slightly between the values of 1,000 and 2,000, though it rose in 2003 to more than 4,000.



This reflects, on the one hand, the recovery in the world-wide business cycle and the tremendous appetite for raw materials in population-rich countries like China and India, and, on the other, the currently limited global transport capacities in the maritime area. In other words: freight rates, just like the raw materials themselves, are subject to similar market conditions and can morph from being a seller's to a buyer's market with corresponding price fluctuations and, possibly, supply bottlenecks.

Some raw materials have transport costs that are fairly high relative to their market prices. This is true, e.g., of natural gas on account of the low energy density.

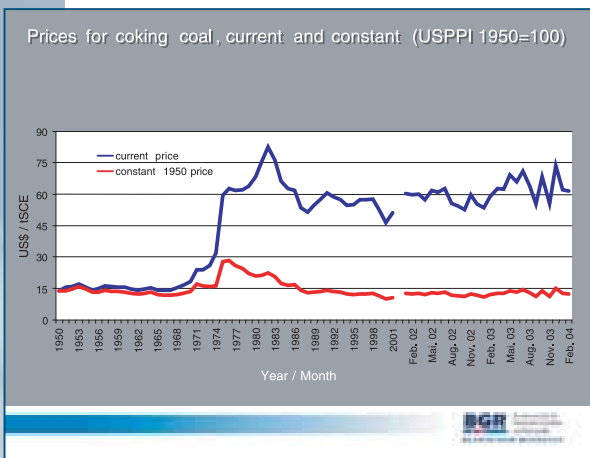
Due to strong growth in demand going beyond the previous market boundaries – boosted in the years to come by the US in particular – a rapidly growing world market for liquefied natural gas (LNG) has been developing for some years now. During the next three decades, experts are reckoning with a quintupling of trade, also beyond previous market boundaries – starting with the construction of 18 new LNG plants and expansion of the world gas tanker fleet to exceed 200 ships in the next five years. Still: bottlenecks in infrastructure and logistics, as well as a lack of availability of LNG are, for the time being, preventing the formation of a transparent, global spot market for LNG. To this must be added differences in the energy content of LNG of different provenances and the fact that LNG terminals are unable to handle varying quantities. If market shortages can be overcome, however, the development of a worldwide LNG market could lead to an atrophying of regional natural-gas markets and, possibly, even culminate in a natural-gas cartel similar to OPEC.

TECHNICAL AVAILABILITY

As for technical availability, the question to the fore is whether sufficient mining capacities can be provided at the right time and at all times – but also processing capacities. What matters here is not merely that we find replacements for depleted deposits – this can be predicted with relative ease – but two further aspects:

- Owing to a long-term trend toward often falling prices in real terms, some deposits are ousted from the market. How large are the capacities that vanish?
- How is demand developing?

Consequences of competition



The nominal world-market price of coking coal has risen dramatically only twice since 1950, namely in 1973/74 (from US\$ 15/t to approx. US\$ 60/t), when the first oil price crisis broke out, and in 1980/81 (to approx. US\$ 80/t), when the Gulf war between Iraq and Iran massively changed the price of oil for the second time.

Following a drop, the price fluctuated between 1986 and 2001 around a bandwidth of US\$ 40 to US\$ 50/t, with a falling trend along the time axis. Since then, the price has recovered and has been moving above US\$ 60/t since

2003; meanwhile, in spring 2004, the spot-market price reached the US\$ 80/t mark. German coal production – whether steam or coking coal – has been unable to hold this price level ever since the 1960s. Due to structural considerations, production has been propped up by digressive state subsidies. As a consequence, German mines have been successively removed from the market, with the result that the country since 2001 has been using more imported than domestic coal for consumption by the steel and power generation sectors: trend rising.

The process of ousting high-priced producers from the market outlined in the above example is similar, in principle, for all raw materials: a new deposit is only developed for the market if total production cost is in the bottom third of the scale (lower-third rule). In this way – in view of the life of a deposit – even falling raw-material prices can be cushioned without investment collapsing. Logically, this lowers the mean value worldwide, with the result of a fall in real prices for as long as there is a buyer's market. A further consequence: these new raw-material deposits exclude competitors producing at high prices, unless the market is booming in an extreme fashion. Still, there are also exceptions to this rule: the development of an oil field in the North Sea, for example, depends not only on the price of oil, but also on the availability of a

production infrastructure, so that it is included in production even if the costs of production are higher. Otherwise, a situation would occur where this deposit would no longer be exploited at a later point in time.

Demand trends

The demand for raw materials in the world economy is at the start of a new growth curve – this is indicated by the growing presence of population-rich emerging countries like China, India, but also Brazil. Growth curves usually take an S-shape – similar to learning curves. Due to an intensification of demand, growth curves can become steeper. This trend was forecast, for example, for the raw-material needs of big demand countries like China, India and Brazil. Here, a huge raw-material appetite clashes with an infrastructure that is not growing in step (mines, processing plants, transportation systems), although such structural imbalances are normally dismantled again by the usual market mechanisms.

The crucial factor in the current raw-material boom, therefore, is a brisk demand with which supply is unable to keep up, as the example of coke shows. In steel production, coke is an indispensable input material whose world market price (spot market) has virtually exploded since 2002. The reason is that the main exporter, China, needs its coke output primarily for domestic steel production, thanks to economic growth which has been racing away for years now.

GEOLOGICAL AVAILABILITY

Static range

Static ranges are defined as the ratio of currently known reserves divided by the most recent annual consumption. This ratio is often understood as the range of the reserves – usually an inadmissible interpretation, since both reserves (from new discoveries, technological innovation, changes in the price structure, changes in underlying political conditions) and consumption (due to changes in the business cycle, demographics and motorization, substitution, etc.) are subject to continuous change. In fact, this is a snapshot view of things in an inherently dynamic system. Hence, the static ranges of raw materials must be understood as an indicator of the need for exploration efforts, rather than a sign of the range or lifetime of a raw material. Only where this quotient is applied to a specific deposit – where consumption is substituted for annual output – is it possible to directly deduce the range.

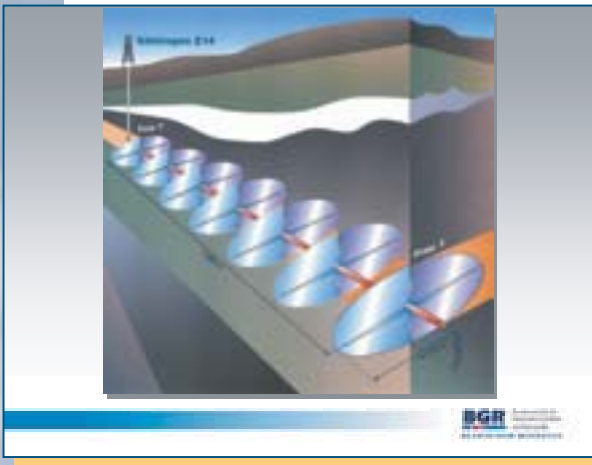
potassium	302	uranium	50
chromite	220	tungsten	32
lignite	197	fluorspar	50
vanadium	147	oil	45
bauxite	158	nickel	45
PGM	175	molybdenum	46
hardcoal	178	tin	29
cobalt	65	copper	32
niobium	155	baryte	30
iron ore	122	graphite	108
rutile	121	zinc	26
tantalum	39	lead	29
phosphate	130	gold	16
manganese	82	antimony	14
ilmenite	81	silver	12
natural gas	67		

Dynamizing factors in the availability of raw materials

Listed below are the chief parameters that have a dynamic effect on the reserve figures for raw materials:

- type of deposit,
- size-distribution of deposits,
- exploration efforts by companies,
- price level,
- technological developments,
- other factors, like the infrastructure situation, tax regimes, stock exchange rules, etc.

By way of example, we may look at the factors "technological developments" and "type of deposit".



In Germany, so-called "tight gas", i.e. natural gas encapsulated in hardly permeable sandstone at a depth of some 5,000 m, is extracted, e.g., at the Söhlingen field in Lower Saxony. The field was discovered as early as 1980 by what is today ExxonMobil. At the time, economic extraction was not yet possible. Economic gas extraction had to wait for new technologies, namely a combination of horizontal drilling and multiple frac treatment, later even using the so-called coil rig method.

According to LIERMANN & JENTSCH, use of these ultra-modern exploration technologies in Germany can economically extract an additional 100-150 Gm_o. In other words, technological advances have allowed resources to be converted into reserves.

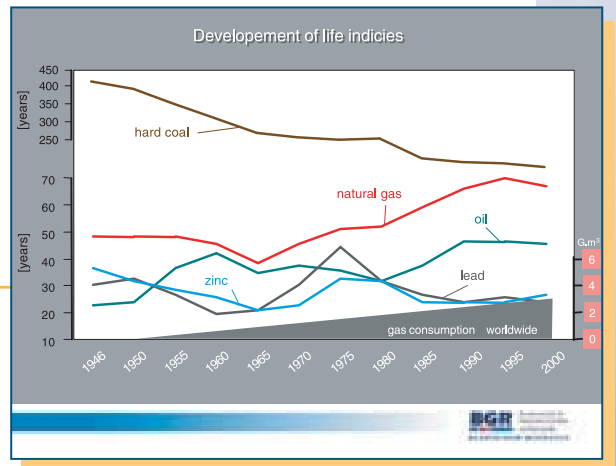
The type of deposit has a very crucial impact: stratiform deposits, like coal, potassium and chromite, but also weathered mantles, like bauxite, are easy to calculate and are widespread, so that their lifetime is high. By contrast, lenticular or nest-shaped deposits or alluvial deposits (e.g. uranium and tin) usually require a much finer conceptual model and, what is more, they are limited in spatial terms.

Equilibrium lines

Each raw material has its own equilibrium line – in the form of a time series of static ranges. The uniqueness of each is a function of the different implications of the above factors for the

dynamism of the ranges. It must be the aim of any exploration efforts to underpin this equilibrium between raw-material supply and demand.

Does this equilibrium also apply to the fossil energy sources oil, natural gas and coal? In principle, the answer is in the affirmative, at least for as long as additions to reserves, fed by exploration, technological developments and a rising price structure – when resources are transferred into reserves – are higher than annual consumption.



The figure shows developments over the last 50 years for the non-renewable raw materials oil, natural gas and coal. As can be seen, oil (approx. 40-45 years) and natural gas (65-70 years) appear to have stabilized for some 15 years, while the equilibrium line for coal has fallen from roughly 400 years to approx. 200 years in the last 50 years. Presumably, this is the result of higher consumption – which rose from 1.7 Gt (1945), to 2.7 Gt (1980), to some 3.8 Gt (2003) – as well as unnecessary exploration efforts and a successively improved, economically steered classification of reserves and resources.

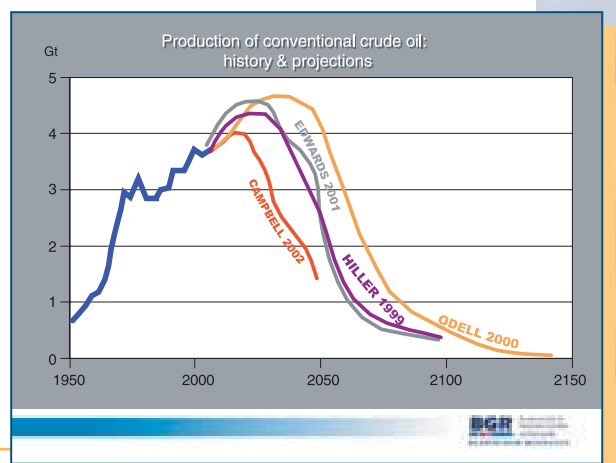
Put another way: lifetime ratios are not the main issue, since they indicate a need for exploration, but allow no inferences to be drawn on the availability of raw materials. If the lifetime of a raw material is to be assessed properly, a different instrument must be used.

The lifecycle curve

In principle, the bell-shaped curve reflects the ideal type of the production or consumption of a finite, non-renewable raw material. The area below the curve shows the volume of the raw material; the course of the curve, with an exponential rise and fall, is interrupted by a "plateau phase", the maximum output.

In an ideal case, the maximum output coincides with a 50% raw-material depletion, the so-called "depletion mid-point". This concept, developed by HUBBERT in 1956 for oil production in the US, at that time correctly predicted the depletion mid-point for the year 1968.

Now, the course taken by the production of a deposit or a region, exposed as it is to the market, differs considerably from the ideal curve, as can be shown using oil production in West Germany.



The EOR measures in particular (hot steam and polymer flooding) in the 1980s, as well as the specific conditions for developing the Mittelplate oil field (limited exploration and extraction options in Germany's mud-flats nature reserve; later the development of the extended-reach drilling technology) have modified the course of the falling flank.

UPSHOT

"Forecasting is a difficult business, especially with regard to the future". This Mark Twain quote also applies, without qualification, to any statements on the availability of raw materials. The availability chain of raw materials moving towards us, the buyers, depends on many factors. The basic prerequisite is geological availability. However, the raw material must also be made available to the market. And that requires the timely and sufficient availability of mining, processing and transportation capacities. These elements are rather structural in nature, so that they can usually be handled by taking technical measures. Geological availability, by contrast, is subject to market mechanisms and control loops steered by human creativity.

Although all raw materials are generally subject to the same market rules, the "fork in the road" toward recycling and substitution is blocked, or only passable with some qualifications, for non-renewable energy raw materials.

The example of the availability of the oil that is so important for our economies may explain a few necessities for improving transparency and for easier quantifying reserves and resources in future:

- What matters is that all authors of reserve data use "binding" rules for the classification and quantification of reserves and resources. On this road, the UN-ECE – by agreement with the organizations WEC/SPE/AAPG, IAEA/NEA and CMMI/CRIRSCO – only recently proposed a classification system that applies to the energy raw materials oil, natural gas, coal and uranium. Here, in a three-dimensional approach, the parameters "geological knowledge", "field project status and feasibility" and "economic and commercial viability" apply simultaneously.
- All publications on oil reserves and resources should contain mandatory and specific information on the assessed regions and oil types. Example: when the Association for the Study of Peak Oil and Gas (ASPO) publishes its ideas on the availability of oil, it must be made transparent for the reader that this assessment does not include reserves from deep water (>500 m) and Arctic regions or even the condensate occurring in the processing of natural gas. This is where such an assessment differs from statements made by other authors, e.g., the BGR, not only owing to the different evaluations of specific countries and regions, but also due to the exclusions mentioned.
- Finally, more communication is needed between experts on the raw-material supply side – usually geoscientists and engineers – and those on the demand side – normally economists in national or international organizations. Both groups have widely diverging views on the future availability of energy raw materials.



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