Steve Mihalchick

From: John & Mandy [neshfamily@bigfork.net]
Sent: Monday, November 30, 2009 9:05 PM
To: Steve.Mihalchick@state.mn.us
Subject: DOE/EIS-0382 - MN PUC Docket #E6472/GS-06-668
Importance: High
Attachments: Final EIS comments.pdf; EWG_Report_Coal_10-07-2007ms.pdf

Dear Judge Mihalchick:
Please find attached two pdf documents. One containing my comments for the Final Environmental Statement of the Mesaba Energy Project and the other a report written by Energy Watch Group, which I refer to in my comments.

Thank you for your consideration in examining these comments,
Amanda Nesheim

Public Comment on FEIS 12

November 30, 2009
DOE/EIS-0382, MN PUC Docket # E6472/GS-06-668

Steve M. Mihalchick
Administrative Law Judge
Minnesota Office of Administrative Hearings
P.O. Box 64620
St. Paul, MN 55164-0620

Regarding comments on Adequacy and Impact of the Final Environmental Impact Statement for the proposed Mesaba Energy Project.

To Judge Mihalchick:

The below comments are being submitted regarding the adequacy and impact of the Final Environmental Impact Statement (EIS) for the proposed Mesaba Energy Project (MEP). I have made an attempt to identify page and section numbers for easier reference, please note page numbers are not used in Volume II, Appendix.

Pg. S-3 DOE Purpose and Need

The purpose of an environmental impact statement is to determine what impacts a proposed project would have on the environment. The discourse by the Department of Energy (DOE) throughout the EIS readily promotes the demonstrational E-Gas technology under a legislative Clean Coal Power Initiative (CCPI) program. This politically biased approach has lead to an inadequate assessment of the environmental impacts of the proposed project. This inadequacy comes out in several comments submitted by the United States Department of Agriculture Forest Service, the Environmental Protection Agency and the United States Army Corps of Engineers in Volume II, Appendix E.

Pg. S-3 Alternatives Determined to be Reasonable by DOE

Nowhere in this section is it mentioned impacts on the environment. It is a significant push "to accelerate commercial deployment of advanced coal-based technologies" supported by congress through congress through the CCPI program.

Pg. S-63 Conclusions

The DOE displays threatening language if a "No-Action" alternative is selected. Language such as; "delays in commercialization of the E-Gas IGCC technology" and "widespread commercialization would likewise be delayed or jeopardized" reflect the DOE's biased approach to the EIS. The DOE acknowledges that there are issues unresolved even after federal governing agencies submitted concerns during the Draft EIS, which have not been adequately addressed in the final EIS.

Pg. 1-3, 1.2.1 Clean Coal Power Initiative

The DOE states coal as an "abundant" energy resource. I submitted comments in the draft EIS (75-08 of Vol. III) pertaining to the DOE's claimed 240-year supply of coal. My comments were dismissed with this response: "DOE estimated the number of years of available coal". How did they determine their 240-year supply? No background information was given, yet studies, (most notably the Energy Watch Group report - enclosed), indicate that that figure is grossly overstated. In addition there have been reports by the Wall Street Journal that reflect the disparity of a 240-year coal supply.

The DOE is promoting this "demonstration" project to further advance commercialization of Integrated Gasification Combined Cycle (IGCC) projects. There are several IGCC projects in the process of deployment, too many to list here, the most notable being Conoco-Phillips 700 MW IGCC E-Gas project in Sweeny, Texas. This project is IGCC and utilizes Conoco-Phillips E-Gas technology. Other comparable projects ranging in 400 MW to 750 MW facilities are: Summit Power, Penwell, TX (has applied for CCPI Round III funding); Great Lakes Energy, Alma, MI; Cash Creek Project, Owensboro, KY; Mississippi Power, Kemper County, MS; Duke Energy, Edwardsport, IN; Taylorville Energy Center, Taylorville, IL (is advancing in loan guarantee program from DOE).

The DOE mentions long-term ideology of Carbon Capture and Sequestration (CCS), yet openly admits the MEP is not economically feasible for CCS.

The DOE heavily explains CCPI funding "to reduce project risks associated with project financing and technical challenges for emerging clean coal technologies..." As described in more depth in these comments coal is not clean and should not be referred to in such terms.

Pg. 1-4 Bullet points

There are several areas in the bulleted points that Excelsior Energy has not shown their ability as project managers. The last two should be of particular concern as Excelsior Energy has already shown that their management of financing the MEP is highly questionable. They have been unable to pay just the interest payments on IRRR loans and successful procurement of a power purchase agreement or investors has eluded them.

Pg. 1-6, 1.2.2 State Legislative Incentives

The MEP is being contested as an "innovative energy project" in the Minnesota Appellate Court system at the time of submitting these comments.

Pg. 1-7, 1.2.2 State Legislative Incentives continued

The MN PUC has dismissed the Power Purchase Agreement for Docket Number E6472/GS-051993. The proposed project has no buyer for the electricity. This is a significant problem. Why build an expensive technologically unproven power plant if there is no one to purchase the electricity.

Pg. 1-25, 1.6.4 Connected Actions

It should be noted that the proposed pipeline to Essar Steel MN has been downgraded in size and Essar may be able to utilize an existing pipeline. Nashwauk PUC was unable to solicit other potential customers.

Pg. 5.1-1, 5.1.2 Impact of Commercial Operation

Referring to the first sentence, the MN PUC has determined that the cost of electricity of the MEP is not in the public interest and is not the least cost resource and in May of 2009 dismissed the power purchase agreement for Docket E6472/GS-051993. To date there is no buyer for the electricity generated by the proposed facility. How can the project be economically viable if the proposed project managers cannot find buyers for the generated electricity?

It should be noted that the proposed project cost was submitted in 2005 at $2.16 Billion and is out of date. The ACoE has determined cost increases to large construction projects at 10% per year since the above cost figure was submitted. Therefore cost adjustments (4 ½ years or 40.5 %) should be applied to the proposed MEP to help aid in determining economic feasibility of the project. Considering the ACoE's determinations the proposed project cost should be adjusted to reflect the increase with a projected cost closer to $3.1 Billion.

There has been repeated reference to a 20-year life expectancy of the proposed project. It is not credible to state that a project of this magnitude would expire in so short of time. History shows that power-generating facilities are heavily invested in and are made operational well beyond a "commercial life" of 20 years. Any environmental and economic feasibility projections should be based on a 50-year operational life expectancy at a minimum.

Regarding comments on Maximum CO_2 emissions – This addition of CO_2 is not conducive to Minnesota's long-term goals of reducing Greenhouse Gas (GHG) emissions by 20% by 2012 and 30% by 2018. There are no plans to retire any current power-generating facilities in the short or long-term projections in the state.

Pg. 5.1-2, 5.1.2.1 Carbon Dioxide Capture and Geological Storage

There is no new information submitted by Excelsior Energy or DOE. The DOE has already acknowledged in the Draft EIS Appendix A2, which is repeated verbatim in the Final EIS. Since the DOE has previously determined that CCS is not economically feasible for this project, why has the DOE made exaggerated assumptions as to the viability of CCS for the MEP?

Using calculations provided by the DOE in this document I wish to address issues that the DOE has not considered or possibly ignored with CCS technology. It should be noted that comments similar to these were submitted in Vol. III (19-03 and 75-13). Using the DOE's CO_2 emission number of 212 million tons (10,600,000 x 20 years) over a 20-year period and theoretically capturing 30% (63,600,000 million tons of CO2) with a 93% storage rate, (Vol. III 19-03 adjusted in FEIS from 33-60%), would equate to 59,148,000 tons of CO2 theoretically being sequestered over a 20-year period. There are no studies available to quantify the implications of sequestering these quantities of CO2 into the earth's crust for just this one project alone. Sequestration is known to cause fracturing (earthquakes). Small sequestration projects are being planned or implemented, but nowhere near the scale of this theoretical CCS plan. There are no studies available to determine groundwater contamination possibilities on a large-scale sequestration endeavor such as is described by the DOE. The DOE needs to closely examine CCS of large-scale proposals and potential rapid or incremental releases of CO2 back into the atmosphere and potential groundwater contamination to a dwindling potable water supply due to earth fracturing. We need to be asking ourselves if we are creating a bigger problem trying to solve GHG emission reductions by CCS. I do not believe the DOE has adequately addressed these troubling issues and is diverting large sums of resources for short-term gain. This country would be better served by using its limited resources for rigorous energy efficiency and renewable energy options.

Pg. 5.2-7 Class I Visibility/Regional Haze Analysis

Regarding the first paragraph, it should be noted that the USDA Forest Service has submitted comments in Appendix E of Volume II that have not been addressed since submitting information for the draft EIS. *"Our concerns with this project have not changed since our last comment letter sent to you on December 17, 2007"* and *"We would like to make it clear that we feel the impacts modeled to visibility at EITHER site require mitigation"* are two statements made by the Forest Service noting that their concerns have been ignored by the DOE. There are several other serious issues the Forest Service has concerning DOE's "forward thinking advancing IGCC" language directed at the project instead of factual analysis of the environmental impacts the proposed project would have if the project were built.

Pg.5.2-42, 5.2.8.5 Climate Change Greenhouse Gases, and the Mesaba Project

"...it cannot be assumed that, if the Mesaba Generating Station were not built, these additional emissions would be avoided – other fossil fuel power plants might be constructed in its stead, or existing plants might produce more power, thereby increasing their CO2 emissions."

The above comment defines a thought process that does not encourage reduction of GHGs. This mentality is prohibitive language that only signifies the deep-rooted political agenda of fossil fuel based industries. It is this mentality that has gotten us in the situation we are in and should be curtailed. If the DOE continues to entertain such thought processes, climate change will escalate beyond our ability to stabilize GHG emissions. It is imperative, and our moral obligation, to reduce and reverse the adverse affects that our industrialized society has created. The United States is responsible for the industrial revolution – therefore the United States is responsible for reducing GHG emissions.

<u>Pg. 5.2-43, 5.2.8.6 Potential Mitigation through Carbon Capture and Sequestration</u>

To build a power-generating facility utilizing coal that the DOE acknowledges is not economically feasible for CCS, is equal to committing additional significant amounts of GHGs for decades to come.

It is highly unlikely that Excelsior Energy could find other funding resources for their project. Financial institutions are extremely wary of funding these high-risk ventures. Several projects have been proposed, but no financiers have come forward. If the coal and oil industries actually believed IGCC and CCS are viable economic technologies, they would be investing and building such projects themselves.

<u>Pg. 5.2-44, 5.2.8.7 Climate Change, Greenhouse Gases, and the Clean Coal Power Initiative</u>

"The IPCC report ../ /.. identifies carbon capture and sequestration for coal-fired power plants as one of the 'key mitigation technologies' for development before 2030."

Since it is not economically feasible for the MEP to develop CCS, then it should not be considered in the CCPI program.

Pg. 5.5-1, 5.5 Relationship Between Short-term Uses of the Environment and the Maintenance and Enhancement of Long-term Productivity

"The Proposed Action would support the DOE objective of demonstrating and promoting innovative coal power technologies that can provide the United States with clean, reliable, and affordable energy using abundant domestic sources of coal."

Coal is not "clean", from the moment it's dug out of the ground to end combustion. The cost of electricity has been determined by the MN PUC to not be in the public interest and not the least cost resource. We have all seen significant electricity cost increases in MN, which will continue to escalate with any carbon management plan that Congress determines to enact. These findings are not considered "affordable". Coal is not as "abundant" as the DOE insists. The DOE's response to 75-08 of Vol. III of the EIS; *"In its capacity as the Federal agency responsible for the nation's energy resources, DOE estimated the number of years of available coal reserves in the U.S."* is a non-statement and does not acknowledge "attainable" coal reserves (please see attached Energy Watch Group report enclosed) which are now being recognized even in the coal industry. Other studies exist that come to similar conclusions. This irresponsible denial of the true amount of coal reserves is dishonest to the American people. It is counter-productive to continue to support a fossil fuel based industry in light of these findings. The MEP is acknowledged as a "demonstration" project by the DOE so it can hardly be described as "reliable" since the proposed project may very well not be successful in its demonstration.

Regarding the second paragraph: How can the proposed project be seen as minimizing emissions when it would be an additive and cumulative source of emissions that is currently not there?

Regarding this statement in the third paragraph; *"Local officials, business leaders, and many residents consider the potential environmental impact that* *would occur during construction and operation of the IGCC generating station to be acceptable tradeoffs for the long-term productivity of Iron Range communities."* Nowhere is it acknowledged in the EIS of the many business leaders, local and state officials, and approximately 1000 signatures gathered in opposition to the proposed project. To consider the long-term impacts of the project as "acceptable tradeoffs" reflects an attitude proposed by the project managers that have not fully disclosed the basic economic and environmental impacts of the proposed project. A cost-benefit analysis (which was requested by several commentors) was not conducted. As a result the true economic impact is unknown.

Throughout the EIS document the DOE repeatedly expresses their need to satisfy the CCPI requirement to accelerate the commercialization of clean coal technologies. A determination by a political body should not supersede the importance of a true analysis of impacts to the environment for this project.

Thank you for your consideration in comments regarding the Final Environmental Impact Statement for the Mesaba Energy Project.

Respectfully submitted,
Amanda Nesheim

Coal: Resources and Future Production

Final-Version 28032007

Background paper prepared by the

Energy Watch Group

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About the Energy Watch Group

This is the second of a series of papers by the Energy Watch Group which are addressed to investigate future energy supply and demand patterns.

The Energy Watch Group consists of independent scientists and experts who investigate sustainable concepts for global energy supply. The group was initiated by the German Member of Parliament, Hans-Josef Fell.

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Stefan Peter, Institute for Sustainable Solutions and Innovations
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Ottobrunn, 28th March 2007

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Contents

EXECUTIVE SUMMARY

When discussing the future availability of fossil energy resources, conventional knowledge has it that globally there is an abundance of coal which allows for increasing coal consumption far into the future. This is either regarded as being a good thing as coal can be a possible substitute for the declining crude oil and natural gas supplies or it is seen as a horror scenario leading to catastrophic consequences for the world's climate. But the discussion rarely focuses on the premise: how much coal is there really?

This paper attempts to give a comprehensive view of global coal resources and past and current coal production based on a critical analysis of available statistics. This analysis is then used to provide an outlook on the possible coal production in the coming decades. The result of the analysis is that there is probably much less coal left to be burnt than most people think.

Data are of poor quality

The first and foremost conclusion from this investigation is that data quality of coal reserves and resources is poor, both on global and national levels. But there is no objective way to determine how reliable the available data actually are.

The timeline analyses of data given here suggest that on a global level the statistics overestimate the reserves and the resources. In the global sum both reserves and resources have been downgraded over the past two decades, in some cases drastically.

The most dramatic example of unexplained changes in data is the downgrading of the proven German hard coal reserves by 99 percent (!) from 23 billion tons to 0.183 billion tons in 2004. The responsible German administration[1] did not publish any explanation, and thus the downgrading went unnoticed in spite of the intensive public debate of the future of coal production in Germany. The World Energy Council briefly notes in its "2004 Survey of Energy Resources": "Earlier assessments of German coal reserves (e.g. end-1996 and end-1999) contained large amounts of speculative resources which are no longer taken into account". Thus, large reserves formerly seen as *proven* have been reassessed as being *speculative.*

Also the German lignite reserves have been downgraded drastically, which is remarkable as Germany is the largest lignite producer world-wide.

Poland has downgraded its hard coal reserves by 50 percent compared to 1997 and has downgraded its lignite and subbituminous coal reserves in two steps to zero since 1997.

[1] Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)

For some countries such as Vietnam proven reserves have not been updated for up to 40 years. The data for China were last updated in 1992, in spite of the fact that about 20 percent of their then stated reserves have been produced since then, and another 1-2 percent has been consumed in uncontrolled coal fires.

Even though the quality of reserve data is poor, an analysis based on these data is deemed meaningful. According to past experience, it is very likely that the available statistics are biased on the high side and therefore projections based on these data will give an upper boundary of the possible future development.

Only **reserve** *data are of practical relevance, not* **resource** *data*

The logic of distinguishing between *reserves*, which are defined as being proved and recoverable, and *resources*, which include additional discovered and undiscovered inferred/ assumed/ speculative quantities, is that over time production and exploration activities allow to reclassify some of the resources into reserves. It should be noted that resources are regarded as quantities in situ, 50 percent of which at most can eventually be recovered. In practice, such a reclassification has only occurred in two cases over the past two decades: in India and Australia.

Indian hard coal reserves have been upgraded over time from 12.6 Mt in 1987 to 90 Mt in 2005. Australian hard coal reserves have been upgraded from 29 Mt in 1987 to 38.6 Mt in 2005. All other countries have individually downgraded their hard coal reserves by a combined 35 percent over the same period. In the global sum, hard coal reserves have been downgraded by 15 percent. Adding all coal qualities from anthracite to lignite reveals the same general picture of global downgradings. The cumulative coal production over this period is small compared to the overall downgrading and is thus no explanation for it.

For global resource assessments, the trend is even more severe: World coal resource assessments have been downgraded continuously from 1980 to 2005 by an overall 50 percent.

Thus in practice, resources have never been reclassified into reserves over the past more than two decades despite increasing coal prices.

Six countries dominate coal globally

85 percent of global coal reserves are concentrated in six countries (in descending order of reserves): USA, Russia, India, China, Australia, and South Africa. The USA alone holds 30% of all reserves and is the second largest producer. China is by far the largest producer but possesses only half the reserves of the USA. Therefore, the outlook for coal production in these two countries will dominate the future of global coal production (see below).

Largest coal producers in descending order are: China, USA (half of Chinese production), Australia (less than half of US production), India, South Africa, and Russia. These countries account for over 80 percent of global coal production.

Coal consumption mainly takes place in the country of origin. Only 15 percent of production is exported, 85 percent of produced coal is consumed domestically.

Largest net coal exporters in descending order are: Australia, Indonesia (40 percent of Australian export), South Africa, Colombia, China, and Russia. These countries account for 85 percent of all exports with Australia providing almost 40 percent of all exports.

	Largest	**2nd largest**	**3rd largest**	**4th largest**
Reserves 2005	USA 120 Btoe	Russia 69 Btoe	India 61 Btoe	China 59 Btoe
Production 2005	China 1,108 Mtoe/a	USA 576 Mtoe/a	Australia 202 Mtoe/a	India 200 Mtoe/a
net Export 2005	Australia 150 Mtoe/a	Indonesia 60 Mtoe/a	South Africa 47 Mtoe/a	Colombia 36 Mtoe/a

Fastest reserve depletion in China, USA beyond peak production

The fastest reserves depletion worldwide is taking place in China with 1.9 percent of reserves produced annually.

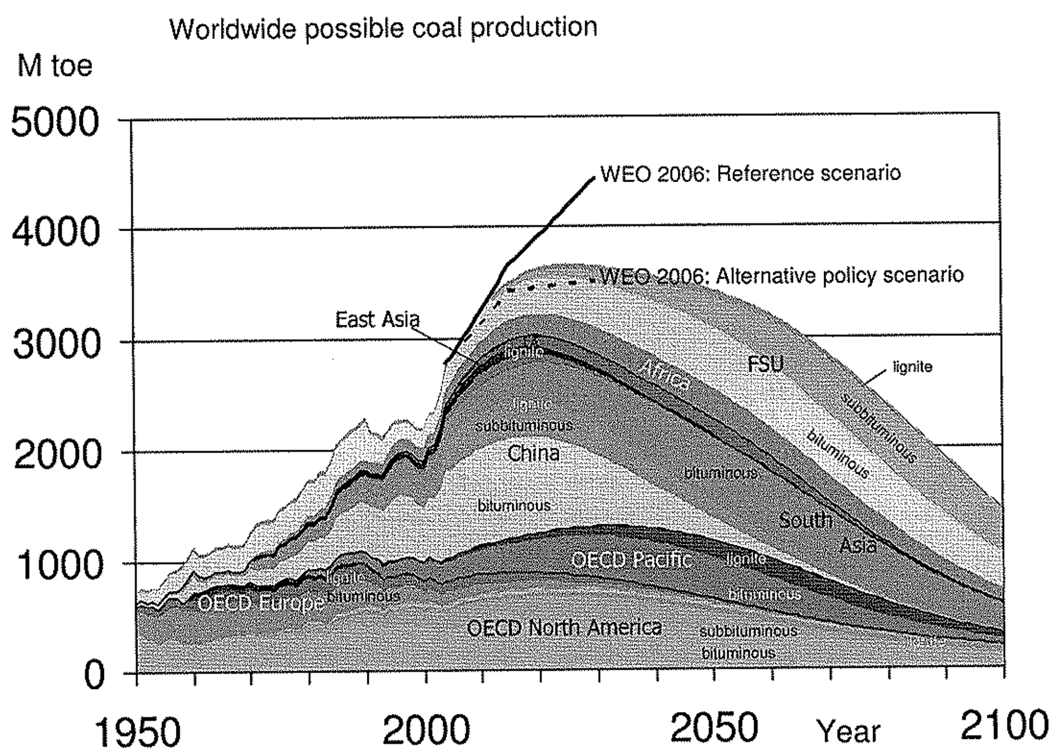
The USA, being the second largest producer, already passed peak production of high quality coal in 1990 in the Appalachian and the Illinois basin. Production of subbituminous coal in Wyoming more than compensated for this decline in terms of *volume* and – according to its stated reserves – this trend can continue for another 10 to 15 years. However, due to the lower energy content of subbituminous coal, US coal production in terms of *energy* already peaked 5 years ago – it is unclear whether this trend can be reversed. Also specific productivity per miner has been declining since about 2000.

About 60 percent of US reserves are located in the three states of Illinois, Wyoming and Montana. Illinois and Montana show no signs of expanding their production which has remained at low levels or even declined for two decades. There are a number of possible reasons for this: low quality coal, political opposition because of competing land use and environmental issues, overestimated coal reserves because of poor geological data or a weaker definition of "proven".

Global coal production to peak around 2025 at 30 percent above present production in the best case

Based on the assessment that reserve data may be taken as an upper limit for practical relevant coal quantities to be produced in the future, production profiles have been developed.

The following figure provides a summary of past and future world coal production in energy terms based on a detailed country-by-country analysis. This analysis reveals that global coal production may still increase over the next 10 to 15 years by about 30 percent, mainly driven by Australia, China, the Former Soviet Union countries (Russia, Ukraine, Kazakhstan) and South Africa. Production will then reach a plateau and will eventually decline thereafter. The possible production growth until about 2020 according to this analysis is in line with the two demand scenarios of the International Energy Agency (IEA) in the 2006 edition of the *World Energy Outlook*. However, the projected development beyond 2020 is only compatible with the *IEA alternative policy scenario* in which coal production is constrained by climate policy measures while the *IEA reference scenario* assumes further increasing coal consumption (and production) until at least 2030. According to our analysis, this will not be possible due to limited reserves.



Again, it needs to be emphasized that this projection represents an upper limit of future coal production according to the authors' best estimate. Climate policy or other restrictions have not been taken into account.

Conclusion and recommendation

Global coal reserve data are of poor quality, but seem to be biased towards the high side. Production profile projections suggest the global peak of coal production to occur around 2025 at 30 percent above current production in the best case.

There should be a wide discussion on this subject leading to better data in order to provide a reliable and transparent basis for long term decisions regarding the future structure of our energy system. Also the repercussions for the climate models on global warming are an important issue.

Coal Reserves and Supply

Reserves and Resources

Classification of **reserves** according to the scheme of the *World Energy Council (WEC)*:

- **Proved amount in place** is the resource remaining in known deposits that has been carefully measured and assessed as exploitable under present and expected local economic conditions with existing available technology.

- **Proved recoverable reserves** are the tonnage within the proved amount in place that can be recovered in the future under present and expected local economic conditions with existing available technology.

Classification of **resources** according to the scheme of the *World Energy Council (WEC)*:

- **Estimated additional amount in place** is the indicated and inferred tonnage additional to the proved amount in place that is of foreseeable interest. It includes estimates of amounts that could exist in unexplored extensions of known deposits or in undiscovered deposits in known coal-bearing areas, as well as amounts inferred through knowledge of favourable geological conditions. Speculative amounts are not included.

- **Estimated additional reserves recoverable** is the tonnage within the estimated additional amount in place that geological and engineering information indicates with reasonable certainty might be recovered in the future.

The *International Energy Agency (IEA)* but also BP Statistics and most others use the term

- **Proved reserve** which is equivalent to proved recoverable reserve as defined by WEC.

The US *Energy Information Agency (EIA)* uses the following nomenclature:

- **Demonstrated reserve base** covers publicly available data on coal mapped to measured and indicated degrees of accuracy and found at depths and in coalbed thicknesses considered technologically minable at the time of determinations.

- **Estimated recoverable reserves** (this category corresponds to the proved recoverable reserves according to WEC and to proved reserves according to BP statistics) cover the coal in the demonstrated reserve base considered recoverable after excluding the coal estimated to be unavailable due to land use restrictions or currently economically unattractive for mining, and after applying assumed mining recovery rates.

- **Recoverable reserves at producing mines** represent the quantity of coal that can be recovered (i.e. mined) from existing coal reserves at reporting mines.

Other national geological agencies use different definitions, e.g. Germany's *Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)* uses the terms

- **Reserves:** These are equivalent to proved recoverable reserves according to WEC
- **Resources:** These include discovered but not yet economically producible amounts and undiscovered but estimated accumulations of coal. This includes the resources as defined by WEC, but includes also any other possible coal deposits.

In the *BP Statistical Review of World Energy* proved reserves are published together with production data. Each year a new edition is published with a listing of "proved reserves at year end", the latest in June 2006 with data for the end of the year 2005 (BP 2006). However, the BP report just reproduces the data which are collected by the World Energy Council. The WEC collects these data from time to time from its member countries. The latest WEC *Survey of Energy Resources* was published in 2004 with data as of the end of the year 2002 (WEC 2004). Therefore the published "proved reserves at year end 2005" in the *BP Statistical Review of World Energy* are in reality those which were reported for the year 2002.

Different classes of coal are also reflected in the statistics. Each coal class has a different range of energy content. Most common is the following classification (IEA 2007):

Anthracite:	30 MJ/kg
Bituminous coal:	18.8–29.3 MJ/kg
Subbituminous coal:	8.3–25 MJ/kg
Lignite:	5.5–14.3 MJ/kg

A closer look at the historical reserve assessments raises doubts regarding the quality of reserve assessments:

- For instance the reported proved reserves of China have not changed since 1992, those of some other countries not even since 1965.
- Proved recoverable reserves (as reported by the WEC) for other countries – e.g. Botswana, Germany and the UK – have been downgraded over the last years by more than 90%. Even the reserves of Poland are 50% smaller now than 20 years ago. This downgrading cannot be explained by volumes produced in this period. The revisions are probably due to better data.

- Since 1987 the proved recoverable reserves (as reported by WEC) of India were continuously revised upward from about 21 billion tons to more than 90 billion tons in 2002. However, India is the only country with such huge upward revisions.

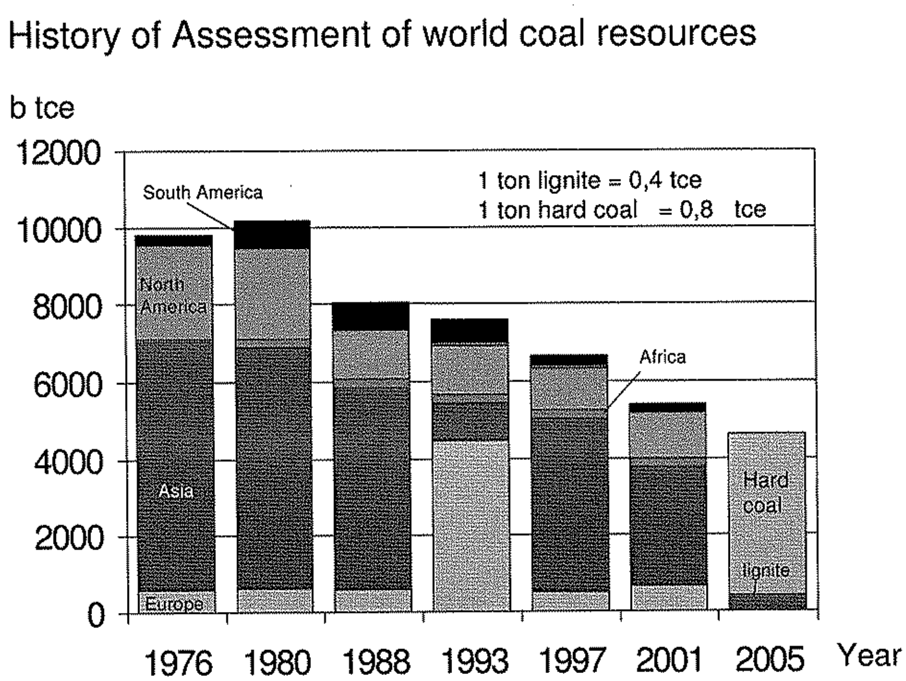
- According to the latest assessment by the WEC total proved recoverable world reserves at the end of 2002 mount up to 479 billion tons of bituminous coal and anthracite, 272 billion tons of subbituminous coal and 158 billion tons of lignite.

The history of reserve revisions and adjustments is analysed in more detail in Annex C-1. The conclusion drawn is that the data quality is very poor and the reported data cannot be regarded as a realistic assessment of "proved recoverable coal reserves".

Normally it is argued that reserves are part of the resources. Over time and with coal prices increasing more and more resources will be converted into recoverable reserves. This suggests the analogy to an iceberg of which only the tip is visible whereas 90% are under water. However, as detailed in Annex 1, the present and past practice of reserve reporting does not support that view. Many countries have not reassessed their reserves for a long time, and if so, revisions have been mostly downward instead of upward, contrary to what should be expected.

The estimated resource base should be regarded as a final limit for the amount which ultimately can be recovered. But in addition to the concerns raised above, the historical assessment of global resources has also revealed substantial downgradings over the last decades. The following figure shows that estimated coal resources have declined from 10 billion tons coal equivalent (~8300 Mtoe) to about 4.5 billion tons coal equivalent (~3750 Mtoe), a decline of 55% within the last 25 years. Moreover, this downgrading of estimated coal resources shows a trend supported by each new assessment. Therefore it is possible that resource estimates will be further reduced in future. One could interpret that better understanding and improved information have led to a continuous downgrading. In figure 1 the discrepancy of data for Europe and Asia for 1993 is due to the fact that the former Soviet Union was attributed to Europe in 1993 and to Asia in all the other years.

Figure 1: Reported resource assessments by the BGR since 1976. The physical tons of coal are converted into btce (billion tons of coal equivalent) for reasons of comparison. For comparison, 1 btce = 833 Mtoe.



Source: BGR, 1995/1998/2002/2006
Analysis: LBST 2006

Production

Even though the above discussed reserve data cause severe concern with regard to data quality, the most recent reported reserves are used to assess future coal production (for lack of better data). It is very unlikely that recoverable reserves eventually turn out to be higher than reported. The reasons for this assessment are as follows:

- As shown above, the resources have been downscaled several times since 1980. The most recent reassessment resulted in coal resources which are 55% less than in 1976.
- Reserve data have often remained unchanged for many years. When updated this has resulted in downward revisions instead of upward revisions in most cases.

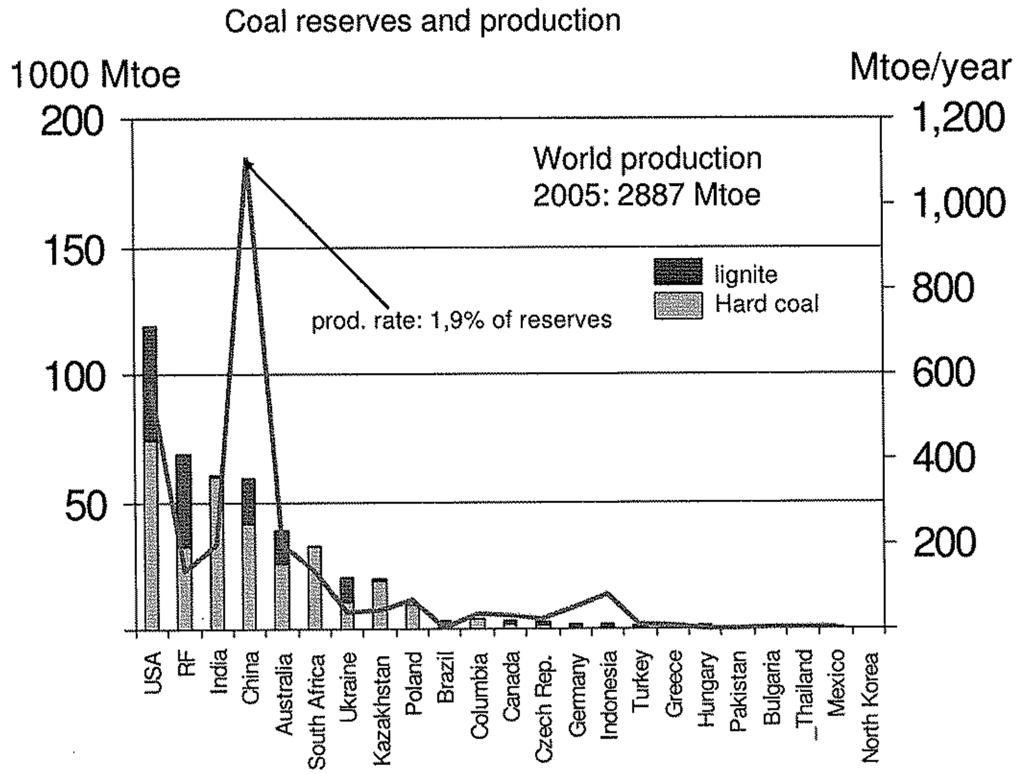
If these reserve data turn out to be too optimistic also the derived production profiles will be too optimistic. Nonetheless, this is the starting point for further considerations.

The following figure shows the coal reserves for the main countries. Reserves of hard coal and lignite are converted into energy units by means of the rough conversion factors as used in BP Statistics: 1 ton of oil equivalent (toe) corresponds to 1.5 tons of hard coal (anthracite and bituminous coal) and to 3 tons of subbituminous coal and lignite.

Six countries own about 90% of the world's coal reserves. Therefore, future world production is determined by the production profiles of these countries: USA, Russia, India, China, Australia and South Africa.

The figure also shows the coal production in 2005. The six countries with the largest reserve base are also the largest coal producers. However, their ranking differs. China – which is only number four in reported reserves – is by far the top producer, almost twice as big as the USA which has twice as much reported reserves. China depletes its reserves at an annual rate of almost 2%. Therefore, at the present production rate, China's reserves will be depleted in about 50 years, if its resources will not turn up as reserves. But a conversion of resources to reserves has not been observed in the past for almost 30 years (for more details see Annex 1 and 2). Besides the special role of China and the production of the "big six", also Germany and Indonesia merit some attention as they deplete their reserves at an even faster rate. Germany is the world's largest lignite producer with a share of about 20 percent of the world production.

Figure 2: Distribution of world coal reserves and annual production



Source: BP Statistical Review of World Energy 2006
Analysis LBST 2006

Future coal production profiles are estimated by fitting the reported proved reserves to the present and historical production pattern. In Annex 2 the estimate for China is discussed in more detail. Provided present trends continue and due to the huge coal depletion rate of China and its absolute dominance of the world-wide production (being the largest producer by a factor of two), the eventual peak of Chinese coal production will determine the peak of the world-wide coal production.

Second to China, the United States of America are the next important producer, surpassing the production volume of the next important producer states (India and Australia) almost by a factor of three. The reported proved reserves would allow production for more than 200 years at the present level. However, probably not all these reserves will be converted into production volumes, as most of them are of low quality with high sulfur content or have other restrictions. Early signs in the USA for possible restrictions of future coal production can be concluded from the facts, that

(1) The productivity of mines in terms of produced tons per miner was steadily increasing until 2000, but has declined since then, and that

(2) The bituminous coal production had already peaked around 1990 and is in decline now.

(3) An indication of imminent problems with future coal production is that the USA has recently switched from a net exporting to a net importing country of steam coal (Kalavov 2007).

Though total production volumes are still increasing due to the expanding production of subbituminous coal in Wyoming, coal production in terms of energy had already peaked in 1998 at 598 Mtoe compared to 576 Mtoe in 2005 (BP 2006). Based on future coal production profiles by the USGS, it is very likely that coal production in the Appalachean region and in the Illinois basin has already peaked and will decline in future. Therefore it is probable that a sizeable fraction of the reported reserves will never be converted into actual production volumes. A detailed state by state analysis for the USA is shown in Annex 3.

Comparable analyses have been made for each country. A bell shaped curve is fitted to the historical production data and to the available proved reserve for each country. These production profiles do not take account of possible restrictions such as coal quality with respect to pollutants and policy restrictions due to greenhouse warming. They represent a future scenario not restricted by political measures.

The results are summed up for each region and for each coal class. Germany and Canada provide illustrative examples which are also described in more detail in Annex 4 and Annex 5. The coal production in both countries shows signs of depletion (e.g. a decreasing coal to waste ratio).

The production data of the different regions are combined to arrive at the world production data in the following figures for bituminous and subbituminous coal and separately for lignite. The first figure (figure 3) provides a summary for bituminous and subbituminous coal. The lower quality subbituminous coal is always painted in a darker colour in order to demonstrate the different coal qualities.

According to this analysis it is very likely that global coal production will peak around 2020 at a production rate being about 30% higher than at present. However, it must be noted that the quality of coal will continuously decline.

The analysis shows that the strongly rising production of China will have a substantial influence on the peak of world coal production. Once China cannot increase its production any more global coal production will peak. But also the future production of the USA will have a substantial influence on the absolute size of peak production volumes. Other important coal regions are OECD Pacific (Australia), South Asia (India), FSU (Russia, Kazakhstan and Ukraine), and, to a smaller extent, Africa (South Africa). Australia and Russia have a large share of subbituminous coal and lignite which is not suitable for export. But nevertheless in Australia the absolute amount of coal with high heating value is still large which makes it by far the largest coal exporter. The following table lists the largest coal producing, consuming and exporting countries.

Table 1: The world's largest coal producing and consuming countries in 2005 according to BP Statistical Review of World Energy and their net export/import balance (BP 2006)

Country	Production Mtoe	Consumption Mtoe	Net Export / Import Mtoe
China	1,108	1,082	26
USA	576	575	1
Australia	202	52	150
India	200	213	-13
South Africa	139	92	47
Russia	137	117	20
Indonesia	83	23	60
Poland	69	57	12
Germany	53	82	-29
Kazakhstan	44	27	17
Ukraine	41	37	4
Colombia	38	2	36
Canada	34	32	2
Total (Share of world coal production/consumption)	2,683 (93%)	2,334 (80%)	

The decline rates of future production are reduced by the production of the Former Soviet Union countries in line with their reported subbituminous coal reserves - yet it is by no means certain that their reported reserves will ever translate into corresponding production volumes. Some doubts regarding the data quality of the coal reserve data for the former Soviet Union countries remain as the last update was carried out in 1998. Therefore, it is probably more realistic to expect the decline after peak to be steeper than shown in figure 3.

Figure 3: World production of hard coal (bituminous and subbituminous) disaggregated into the 10 world regions.

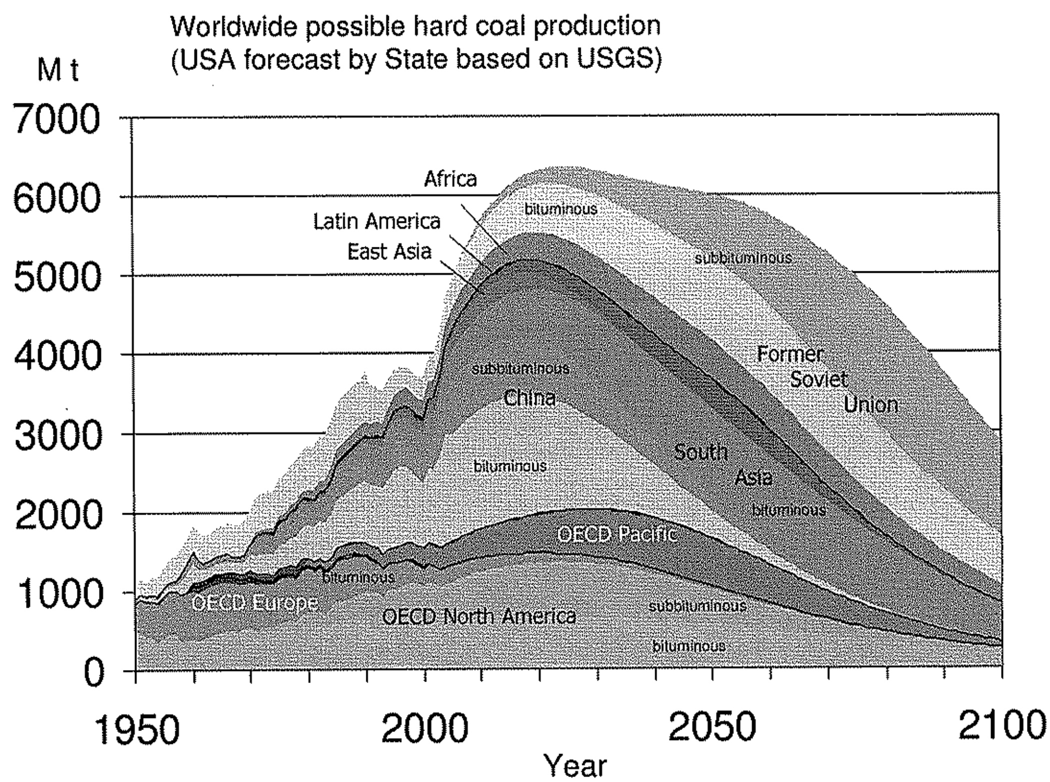
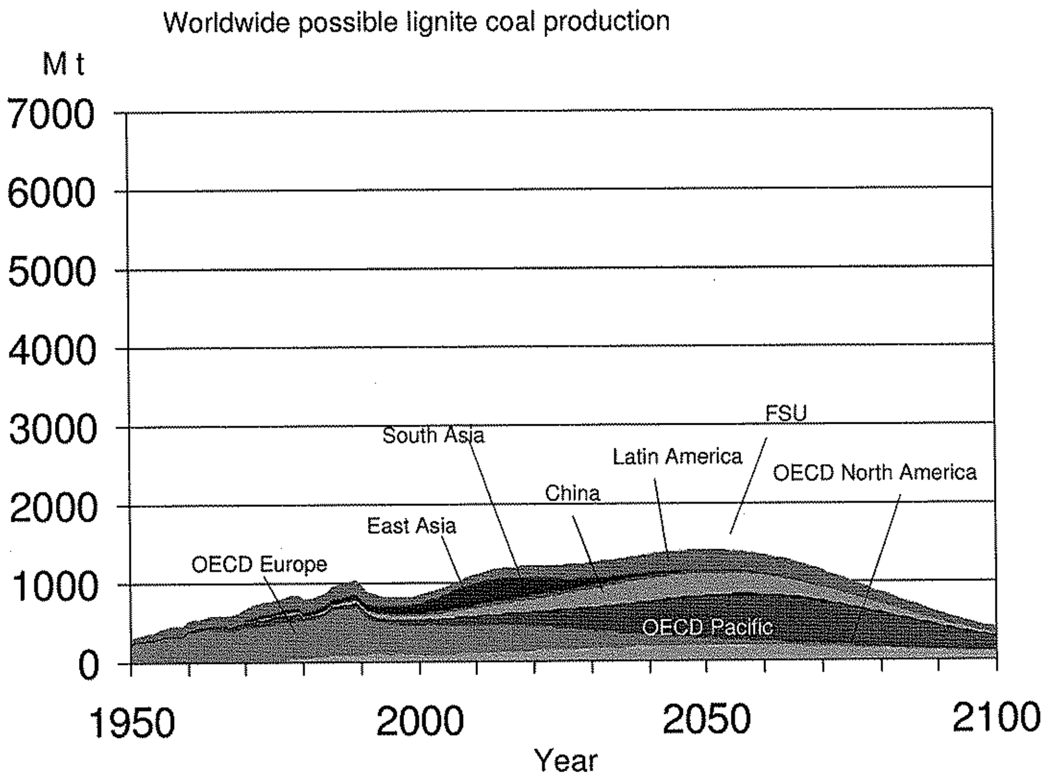


Figure 4 shows the world production of lignite. To facilitate comparison the same scale is used as in figure 3. However, the heating value of lignite is much lower than that of bituminous and even lower than that of subbituminous coal. Lignite is predominantly used for domestic heating and power production purposes and is not transported over large distances because of its low energy content.

Figure 4: World production of lignite (bituminous and subbituminous) in the 10 world regions.

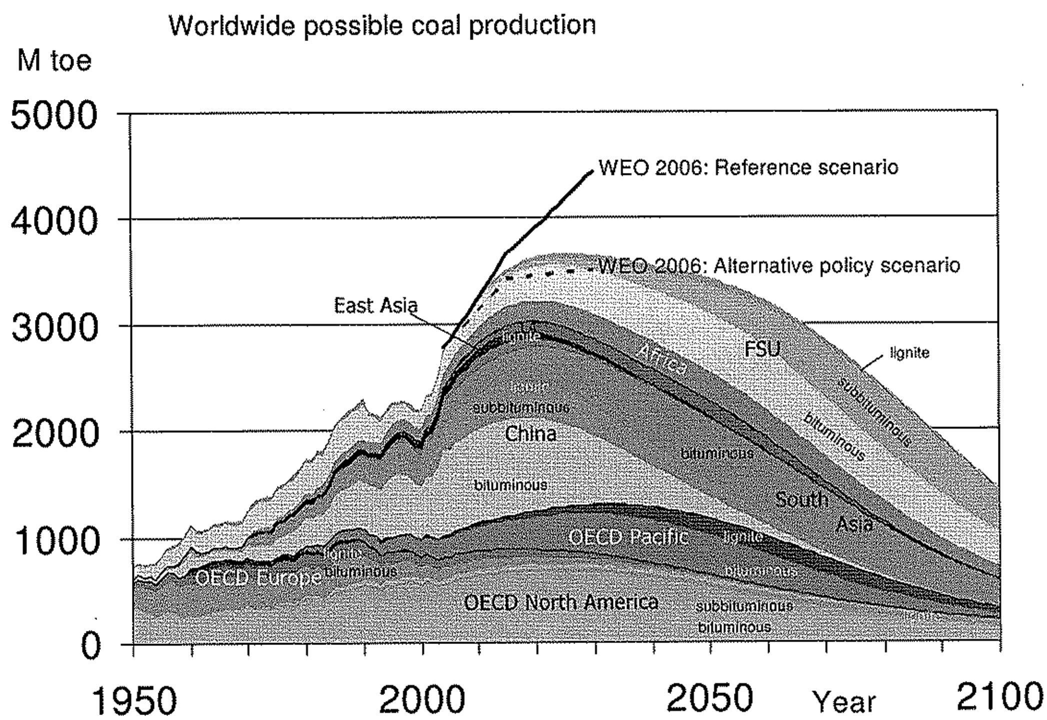


These projected production profiles are based on reported "proved" recoverable reserves (WEC), except for the USA. In the case of the USA an earlier production forecast by the USGS is used as a guide. For more details see Annex 3.

The final figure 5 combines the regional contributions to global hard coal and lignite production and converts them into energy terms. For the conversion the following factors are used: 1 toe bituminous coal = 1.5 t bituminous coal (For China, South Asia and Russia the relation "1 toe = 1.6 t" is used); 1 toe subbituminous coal = 2 tons subbituminous coal, and 1 toe lignite = 3 t lignite.

The figure includes the two scenario calculations from the World Energy Outlook 2006 of the IEA, the "reference scenario" and the "alternative policy scenario".

Figure 5: World coal production in the equivalent of a million tons of oil as calculated in this study based on proved recoverable reserves.



This analysis leads to some important conclusions:

- The production profile of the world's largest producer, China, determines the peak of global coal production.
- The production profiles of China, South Asia and the Former Soviet Union countries are based on resource data of probably low quality.
- Apart from the world production profile, regional production profiles are also important. In a world of shrinking supplies of oil (and later gas), coal will attract increasing attention again. It can be assumed that regional oil and gas supply gaps will first be closed by using domestic alternatives, probably even by producing fuels from coal. This will have significant consequences for the availability of coal on the world market (because of reduced amounts available for export). This is even more the case for lignite which is not transported over long distances due to its low energy content.
- The WEO 2006 scenarios ("reference scenario" and "alternative policy scenario") by the IEA are compatible with this supply scenario until about 2020. After that only the

demand of the "alternative policy scenario" will possibly be met as supply will flatten whereas demand in the "reference scenario" will not be met due to supply restrictions.

Annex

Annex 1: History of Reporting and Reassessing of Coal Reserves

The analysis of historical reserve assessments provides remarkable insight which casts doubt on the quality of these assessments. The following two figures show the changes of "proved" coal reserves between 1987 and 2005 (BP 2006).

Figure A-1 covers bituminous coal and anthracite, while figure A-2 covers subbituminous coal and lignite. This distinction is important because to some degree it reflects the different coal qualities. Anthracite is an almost hydrogen free coal with the highest energy content of about 30 MJ/kg. Bituminous coal contains small amounts of hydrogen and water which reduces its energy content to between 18.8–29.3 MJ/kg (lower heating value). Subbituminous coal has a still lower heating value of 8.3–25 MJ/kg and lignite of 5.5–14.3 MJ/kg. Therefore 1 kg of anthracite has the same energy content as 2–5 kg of lignite. Usually anthracite and bituminous coal are classified as hard coal while subbituminous coal and lignite are known as brown coal. However, these definitions sometimes overlap and the energy content of the specified coal is not always apparent and can vary within a broad range.

The first figure shows the data for the largest producers China, USA, Former Soviet Union (which since 1998 has been split into the Russian Federation, Ukraine and Kazakhstan), South Africa, Germany, Poland, India and Australia. These countries cover more than 95% of the world's hard coal reserves (anthracite and bituminous). Only India and Australia show increases of proved coal reserves in this period. All other countries report significant reductions of their proved reserves.

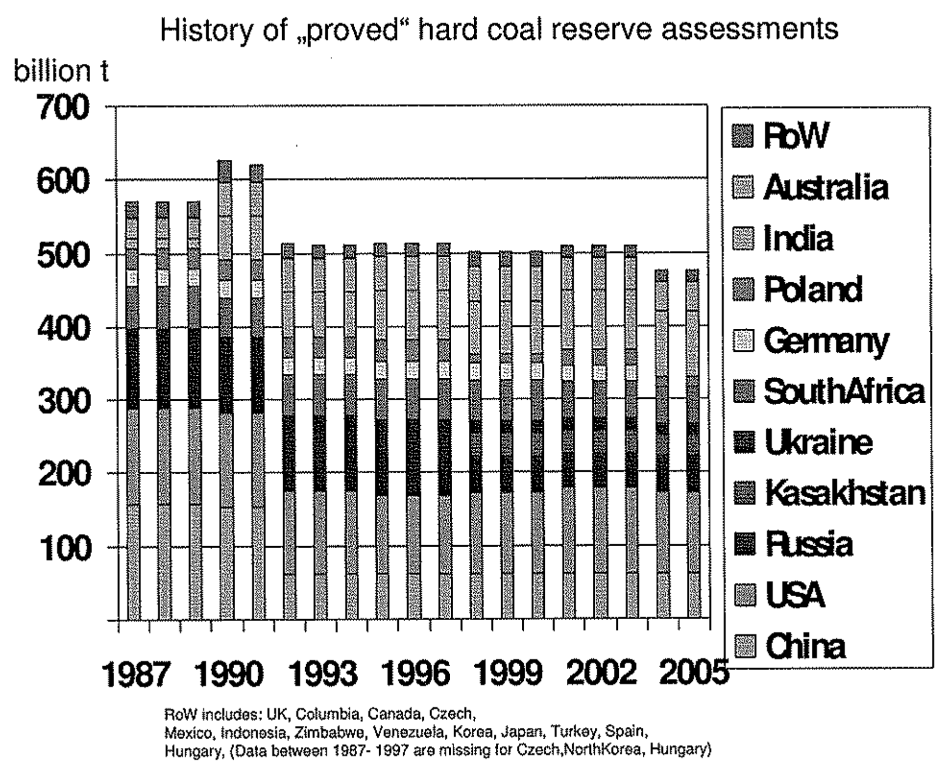
The reported reserves of China have been unchanged since 1992 without any reasons given. The comments in the WEC-Survey on China are : "It is interesting to note that the end-2002 reserves figures reported for China are the same as at end-1999", and "The level of proved recoverable reserves (as at the end of 1990), originally provided by the Chinese WEC Member Committee for the 1992 Survey, have been retained for each successive edition" and further "It is interesting to note that the same figure (114.5 billion tons) for total proved reserves was quoted at the 11th Session of the UN Committee on Sustainable Energy (Geneva, November 2001), in the context of an estimate of 988 billion tonnes for China's coal resources. This reference, in a paper co-authored by Professor Huang Shengchu, a vice-president of the China Coal Information Institute, indicates a degree of continuity in the official assessments of China's coal reserves and supports the retention of the level originally advised by the Chinese WEC Member Committee in 1991."

This reasoning by the authors of the World Energy Council Survey is strange. It ignores the fact that between 1992 and 2005 about 18 billion tons of coal was produced in China which should have reduced the original proved reserve figure of 62.2 billion tons by almost 30%. Before 1992 the Chinese bituminous coal reserves were reported with 152.8 billion tons in

1990 and with 156.4 billion tons in 1987 (according to older editions of the BP Statistical Review of World Energy). An even older assessment of the WEC in 1980 stated 99 billion tons as "proved" reserve. Therefore, Chinese coal reserves have been downgraded twice since 1987, before the data remained unchanged after 1992. Identical arguments hold for the lignite and subbituminous reserves.

The "proved" reserves for the USA and Canada were slightly revised between the last WEC reports but at present are exactly identical with the numbers given in 1998 for the USA and in 1986 for Canada.

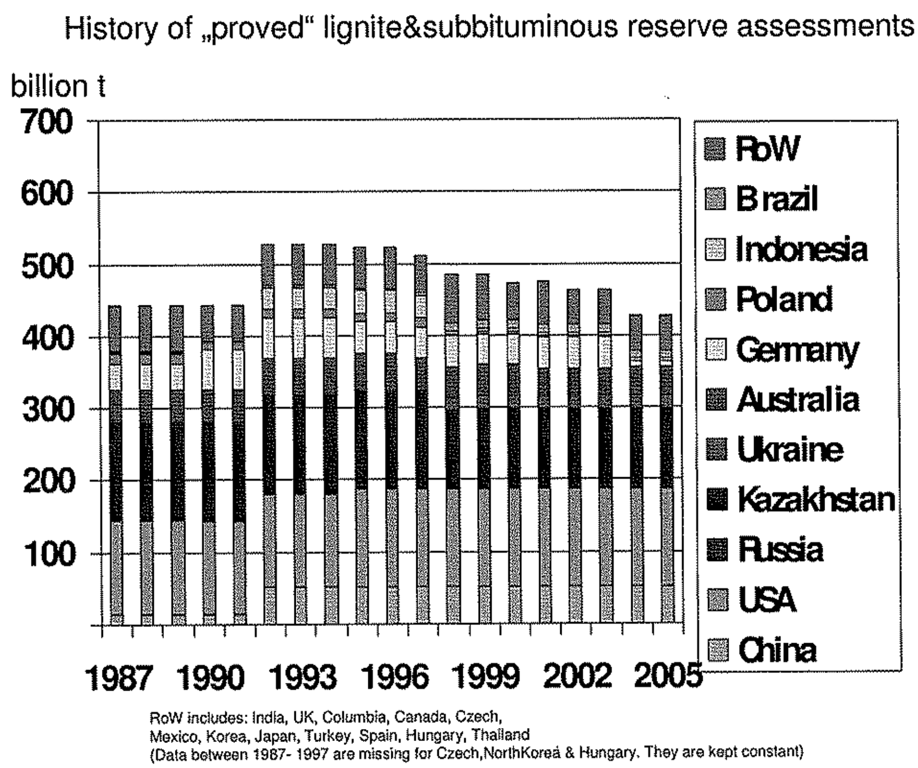
Figure A-1: History of reserve assessments for hard coal



Source BP Statistical Review of World Energy 2006/ WEC 2004

Though not important at the global level, the coal reserves of Vietnam and Afghanistan have never been changed since 1965. For Vietnam 150 Mt of proved recoverable reserves (200 Mt of reserves in place) are stated despite a production of about 15 Mt/yr. Proved reserves of Afghanistan are stated at 66 Mt. These reserves are probably underestimated, but more recent reserve estimates are not available.

Figure A-2: History of reserve assessments for lignite and subbituminous coal



Source BP Statistical Review of World Energy 2006 / WEC 2004

More significant are the huge downgradings of "proved" reserves for a number of African and European countries as will be detailed below.

For Botswana the WEC 1980 reported proved reserves in place of 7 billion tons of which 3.5 billions tons were classified as proved recoverable reserves and 100 billion tons were classified as estimated additional resource. In the WEC 2004 Survey the proved recoverable reserves were reduced to 40 million tons (a downgrading of 99%), while the amount in place was reduced by 50% to 3.34 billion tons. The cumulative production between these two reports is in the order of several million tons and therefore cannot be the reason for this downgrading.

Swasiland saw a downgrading of almost 90% from 1.82 billion tons in the 1980 report to 0.208 billion tons in WEC 2004.

The proved recoverable coal reserves of the United Kingdom were reported at 45 billion tons with estimated additional resources of 145 billion tons in WEC 1980. In the following years the "proved" recoverable reserves were downgraded several times: to 9 billion tons in 1987, to 8.6 billion tons in 1990, to 3.3 billion tons in 1992, to 2 billion tons in 1995, to 1 billion tons in 1998, and finally to 0.22 billion tons in the latest report in 2004. Accordingly the reported "proved" recoverable reserves have been downgraded by 97% within the last 20 years. Cumulative production in this period amounted to approx. 1.8 billion tons.

The "proved" recoverable hard coal reserves (bituminous + anthracite) for Germany were reported with 23.9 billion tons (and 44 billion tons "in place") with an additional estimated resource of 186.3 billion tons in WEC 1980. In later reports these reserves were restated with minimal modifications. It was only in the latest WEC report in 2004 that these "proved" recoverable reserves were downgraded from 23 billion tons in the previous edition to 183 million tons. The latest country report by the BGR sees the proved hard coal reserves at 161 million tons at the end of 2005. The WEC-report has some comments on this downgrading: "The new numbers comply with the recommendations of the UN-ECE, within the context of the definitions specified by the SER." and "Earlier assessments of German coal reserves (e.g. end-1996 and end-1999) contained large amounts of speculative resources which are no longer taken into account". German brown coal reserves were downgraded by 85% from 43 billion tons in WEC 2002 to 6.556 billion tons in WEC 2004. Cumulative production since 1980 amounted to approx. 1.5 billion tons.

Similar downgradings are reported for Poland which had "proved recoverable reserves" of 27 billion tons according to WEC 1980. After that recoverable reserves increased slightly until 1997 to 28 billion tons. However, since then recoverable reserves were downgraded to 14 billion tons in the latest WEC 2004 report.

Also the recoverable reserves of the United States of America have been downgraded several times: bituminous coal from 132 billion tons in 1987 to 111 billion tons in 1998 which is still the reported reserve figure in the WEC 2004 report. In contrast, the lignite and subbituminous reserves had been slightly revised upward from 132 billion tons in 1987 to 135 billion tons in 2004.

On the other hand, also significant upgradings of proved recoverable reserves have been reported, especially for India and Australia, e.g. the "proved recoverable bituminous coal reserves" of India increased from 12.61 billion tons (plus additional resources of 91.1 billion tons) in WEC 1980 to 90 billion tons in WEC 2004.

The observed reserve revisions are by no means systematic. Only South Africa reports continuously shrinking reserves which are roughly in line with cumulative production.

The overall conclusion is that the data quality in general is very poor and the reported data cannot be regarded as a realistic assessment of "proved recoverable coal reserves".

Table A-1: History of bituminous and anthracite reserve assessments as published in former editions of the BP statistical review of world energy. These statistics are based on assessments of the World Energy Council (WEC).

Year	USA Mt	China Mt	India Mt	FSU Mt	Australia Mt	S. Africa Mt	Germany Mt	Poland Mt	UK Mt
1987	131,971	156,400	12,610	108,800	29,138	58,404	23,919	28,300	9,000
1988	131,971	156,400	12,610	108,800	29,138	58,404	23,919	28,300	9,000
1989	131,971	156,400	12,610	108,800	29,138	58,404	23,919	28,300	9,000
1990	129,543	152,831	60,098	102,496	44,893	54,811	23,698	28,182	8,602
1991	129,543	152,831	60,098	102,496	44,893	54,811	23,698	28,182	8,602
1992	112,668	62,200	60,648	104,000	45,340	55,333	23,919	29,600	3,300
1993	112,668	62,200	60,648	104,000	45,340	55,333	23,919	29,600	3,300
1994	106,495	62,200	68,047	104,000	45,340	55,333	23,919	29,100	2,000
1995	106,495	62,200	68,047	104,000	45,340	55,333	24,000	29,100	2,000
1996	106,495	62,200	68,047	104,000	45,340	55,333	24,000	29,100	2,000
1997	106,495	62,200	68,047	104,000	45,340	55,333	24,000	29,100	2,000
1998	111,338	62,200	72,733	96,476	47,300	55,333	24,000	12,113	1,000
1999	111,338	62,200	72,733	96,476	47,300	55,333	24,000	12,113	1,000
2000	111,338	62,200	72,733	96,476	47,300	55,333	24,000	12,113	1,000
2001	115,891	62,200	82,396	96,362	42,550	49,520	23,000	20,300	1,000
2002	115,891	62,200	82,396	96,362	42,550	49,520	23,000	20,300	1,000
2003	115,891	62,200	82,396	96,362	42,550	49,520	23,000	20,300	1,000
2004	111,338	62,200	90,085	93,513	38,600	48,750	183	14,000	220
2005	111,338	62,200	90,085	93,513	38,600	48,750	183	14,000	220

The FSU (Former Soviet Union) countries include Russia, Kazakhstan and Ukraine.

Table A-2: History of subbituminous and lignite reserve assessments as published in former editions of the BP statistical review of world energy. These statistics are based on assessments of the World Energy Council (WEC).

Year	USA Mt	China Mt	FSU Mt	Australia Mt	Germany Mt	Poland Mt	UK Mt	Indonesia Mt
1987	131,872	13,600	135,900	45,300	35,150	14,400	500	2,000
1988	131,872	13,600	135,900	45,300	35,150	14,400	500	2,000
1989	131,872	13,600	135,900	45,300	35,150	14,400	500	2,000
1990	130,752	13,292	136,520	45,461	54,964	11,487	500	2,000
1991	130,752	13,292	136,520	45,461	54,964	11,487	500	2,000
1992	127,892	52,300	137,000	52,300	56,150	11,600	500	31,101
1993	127,892	52,300	137,000	45,600	56,150	11,600	500	31,101
1994	106,495	52,300	137,000	45,600	56,150	13,000	500	31,101
1995	134,063	52,300	137,000	45,600	43,300	13,000	500	31,101
1996	134,063	52,300	137,000	45,600	43,300	13,000	500	31,101
1997	134,063	52,300	137,000	45,600	43,300	13,000	500	31,101
1998	135,305	52,300	128,890	43,100	43,000	2,196	500	4,450
1999	135,303	52,300	128,890	43,100	43,000	2,196	500	4,450
2000	135,305	52,300	128,890	43,100	43,000	2,196	500	4,450
2001	134,103	52,300	128,801	39,540	43,000	1,860	500	4,580
2002	134,103	52,300	128,801	39,540	43,000	1,860	500	4,580
2003	134,103	52,300	128,801	39,540	43,000	1,860	500	4,580
2004	135,305	52,300	128,929	39,900	6,556	0	0	4,228
2005	135,305	52,300	128,929	39,900	6,556	0	0	4,228

The FSU (Former Soviet Union) countries include Russia, Kazakhstan and Ukraine. Germany includes the former German Democratic Republic for data after 1989.

Annex 2: China

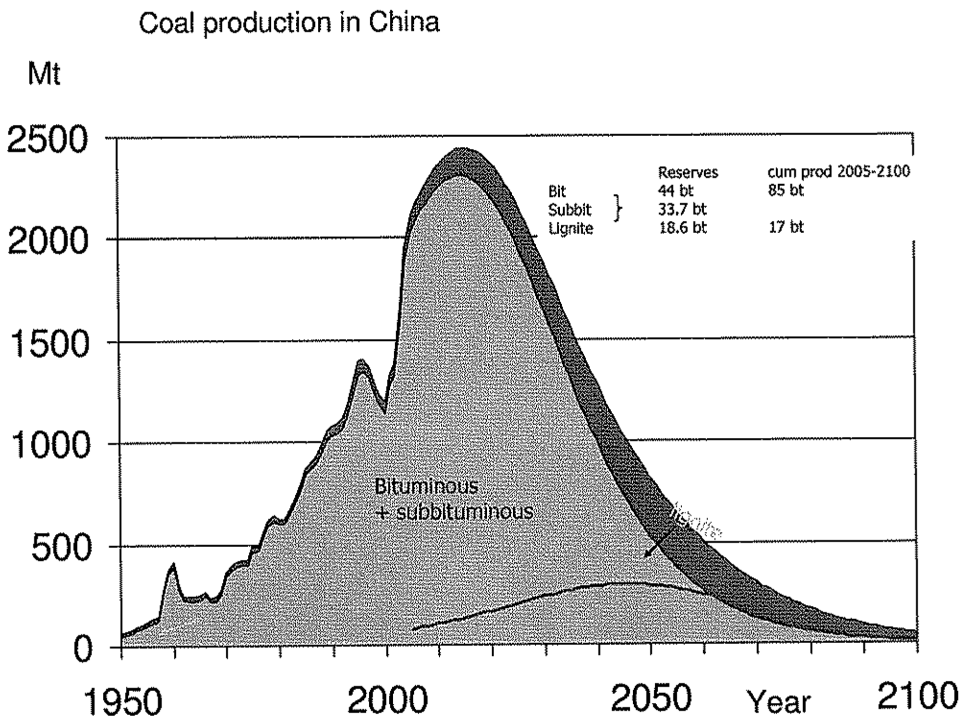
China's reported coal reserves are 62.2 billion tons of bituminous coal, 33.7 billion tons of subbituminous coal and 18.6 billion tons of lignite. Subtracting the produced quantities since 1992 (the latest data update) results in remaining reserves of about 44 billion tons of bituminous coal, 33.7 billion tons of subbituminous coal and 17.8 billion tons of lignite.

A possible future production profile is projected. For projection a logistic growth concept is assumed which is fitted to the available coal reserves.

This scenario demonstrates that the high growth rates of the last few years must decrease over the next few years and that China will reach maximum production within the next 5–15 years, probably around 2015. The already produced quantities of about 35 billion tons will rise to 113 billion tons (+ 11 billion tons of lignite) until 2050 and finally end at about 120 billion tons (+ 19 billion tons of lignite) around 2100. The steep rise in production of the past few years must be followed by a steep decline after 2020.

Even if lignite production – which at present covers about 5% of the production – is expanded, lignite reserves are far too small to have a significant influence on total production. The possible profile of lignite production is shown separately in the figure.

Figure A-3: Coal Production in China – scenario based on present reserve estimates



Historical data: US-EIA: 1980-2004; Lefohn et al. 1999

One should also note that projected produced quantities of coal will show a steadily declining energy content which for lignite is only about ¼ of high quality bituminous coal.

This scenario is based on presently reported reserve figures, but backdated to the latest assessment. It has not yet taken care of uncontrolled coal fires which according to satellite image based estimates additionally consume between 5–10% of the regular coal production (ITC 2007). But a much larger fraction of unburned coal might be distorted through these fires.

The conclusions derived from these calculations are that

- either the reported coal reserves are highly unreliable and much larger in reality than reported
- or the Chinese coal production will reach its peak very soon and start to decline rapidly.

Taking into account that (1) reserves have not changed for many years, and (2) earlier reassessments resulted in downward reserve and even resource revisions rather than in upward revisions, and also that (3) effects of coal fires have not been subtracted from coal reserve estimates, one should not be surprised if the peak of China's coal production is not far away.

At present there are many plans to extend Chinese coal production for the production of liquid fuels. The plans suggest an additional coal consumption of up to several 100 million tons per year to supply coal-to-liquids plants. It seems that this will push production rates to its limits very quickly.

Annex 3: USA

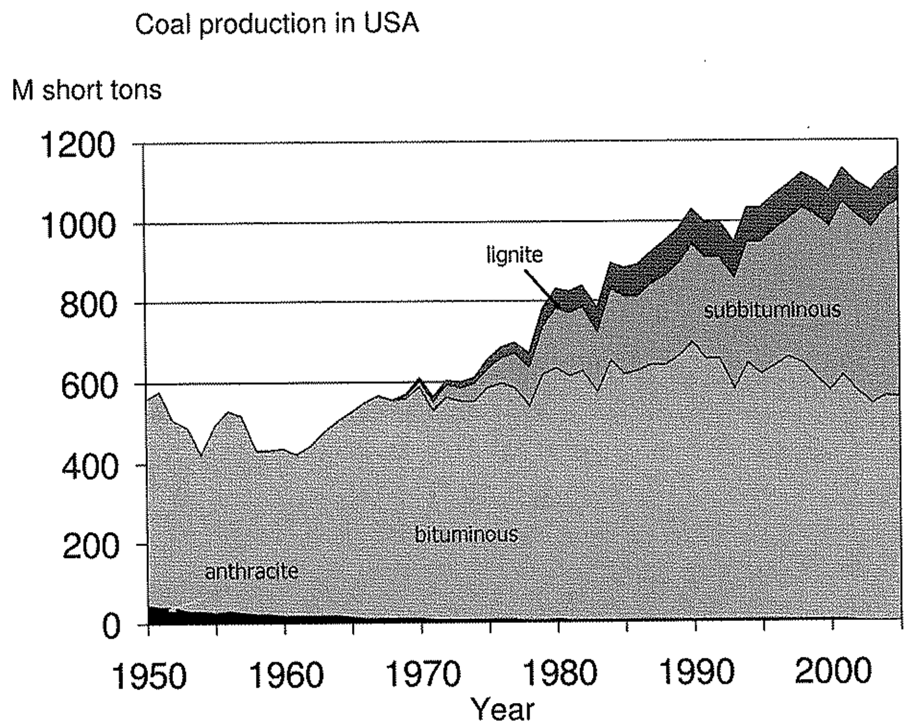
The country with the largest reported coal reserves is the United States of America. However, as already discussed above, these reserves were also revised downward several times in the past. Nevertheless, the present R/P-ratio allows the continuation of present production rates for more than 200 years.

First it has to be noted that the current proved reserve figures as stated in the BP statistics – which correspond to the WEC definition of proved recoverable reserve – are identical with the estimated recoverable reserve according to EIA. The EIA definition seems to be somewhat weaker than the BP and WEC definitions. Here we observe that the same values have mysteriously changed from estimated to proven. Our understanding is that only the EIA definition of "recoverable reserves at producing mines" can be regarded as "proved reserves", whereas the EIA category "estimated recoverable reserves" in analogy to the definitions used for mineral oil would not be regarded as "proved reserves" but as "proved + probable reserves".

A more detailed analysis reveals that in the USA the era of high quality coal is nearing its end and the efforts to produce the coal are steadily increasing. The following figure A-4 shows coal production rates since 1950, distinguishing between anthracite, bituminous, subbituminous and lignite. Anthracite production has been steadily declining since 1950, from 5.5 million tons in 1950 to 1.5 million tons in 2005. Bituminous coal production has also been declining since about 1990. But total coal production has still been rising by about 20 million tons per year since 1960. This increase seems to have flattened out somewhat since 1998 but is still rising reaching its maximum in 2005.

Since 1970 lower quality subbituminous and low qualitiy lignite have been contributing with rising volumes. The growing share of lower quality coal is the reason why total coal production in terms of energy content peaked in 1998 at 598.4 Mtoe and has since declined to 576.2 Mtoe in 2005 in spite of the continuous rise in produced volumes (BP 2006).

Figure A-4: Coal production in the USA (Source EIA)

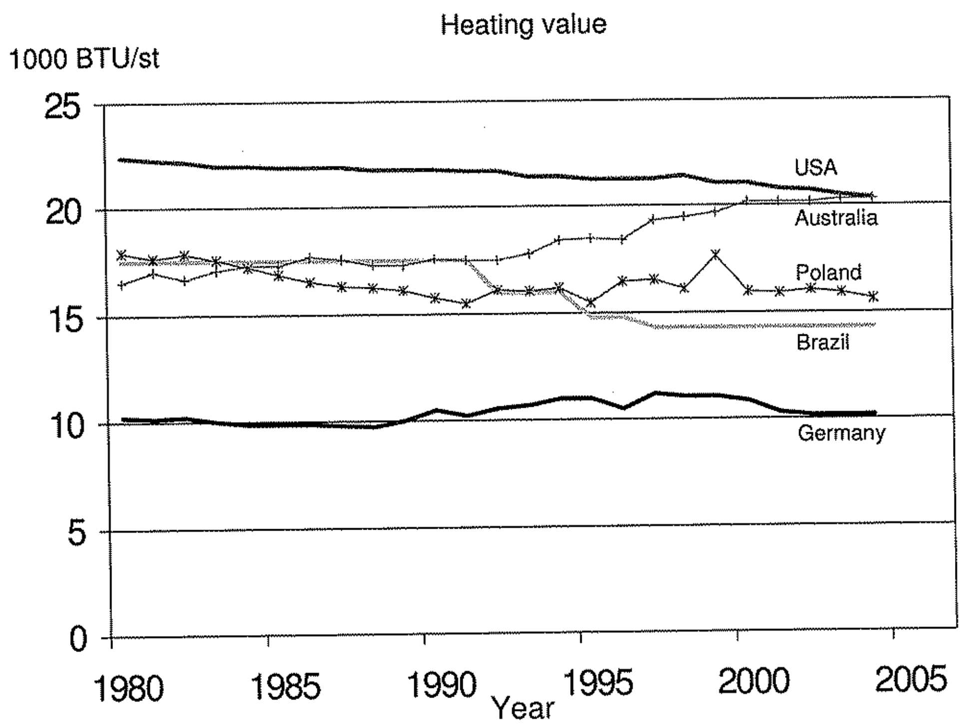


Source: EIA 2006

Ffigure A-5 also demonstrates this aspect of declining coal quality (in terms of energy content) for several other countries. Although the overall data quality might be rather poor, general trends are obvious for the USA (probably with highest data quality), Brazil and Poland. Australia is the only investigated country where the coal quality is still increasing. The slight decline of German coal quality, interrupted by an increase during the 1990s, is a result of the German reunification in 1990 when coal production in the eastern states was restructured and inefficient coal mines were closed.

The observed steady decline of coal quality is due to the steadily rising share of lower quality coal shifting from anthracite and bituminous to subbituminous and to lignite.

Figure A-5: Heating value of produced coal in USA, Australia, Poland, Brazil and Germany (Source: EIA 2006)

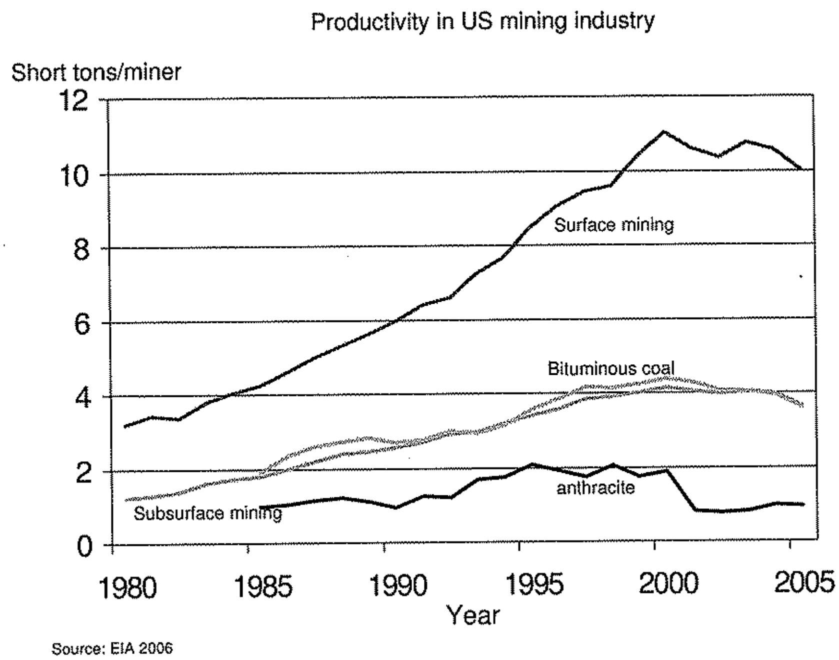


Source: EIA 2006

The declining coal quality is not only due to a steady shift towards subbituminous and lignite. Also within each class, the quality is declining.

Another aspect is the productivity of the US coal industry in terms of produced tons per miner. Until the year 2000, productivity steadily increased for all types of coal produced covering surface and subsurface mining. But since then productivity has declined by about 10% (see the figure below). The decline in productivity can only be explained by the necessity of rising efforts in production. This might be due to deeper digging and/or to a higher level of waste production. Are these already indications for the era of "easy coal" drawing to a close?

Figure A-6: Coal mining productivity (Source: EIA 2006)



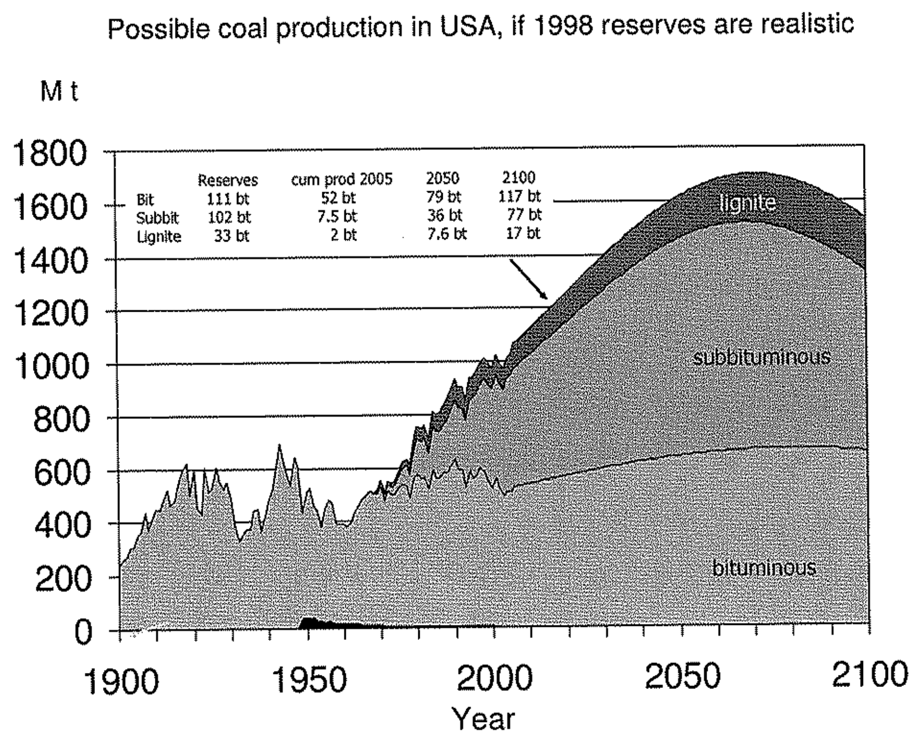
The rising effort for coal mining has also been reflected in rising coal prices since about the year 2000 but the price rise certainly also has other causes. These price rises are summarised in the following table.

Table A-3: Coal spot prices for various coal qualities in the U.S. (Source EIA 2006)

	Northern Appalachian	Central Appalachian	Illinois Basin	Powder River Basin	Uinta Basin
Spot prices 2000	20-21 $/st	20-22 $/st	19-20 $/st	4-5 $/st	12-13 $/st
Spot prices 2001	20-25 $/st	22-33 $/st	20-26 $/st	5-6 $/st	13-18 $/st
Spot prices 2002	23-25 $/st	26-32 $/st	23-26 $/st	6-7 $/st	14-18 $/st
Spot prices 2003	25-33 $/st	32-38 $/st	25-26 $/st	6-7 $/st	18-20 $/st
Spot prices 2004	33-63 $/st	38-66 $/st	26-35 $/st	6-7 $/st	20-30 $/st
Spot prices 2005	44-63 $/st	58-65 $/st	35-40 $/st	6-17 $/st	30-37 $/st
Spot prices 2006	38-45 $/st	47-64 $/st	36-38 $/st	10-15 $/st	36-38 $/st

Based on the reported proved reserves (BP definition) a future production scenario can be built. This scenario is shown in the following figure A-7. The reported reserves of bituminous coal are large enough to allow for growing production volumes for the next 80–90 years, followed by a decline phase lasting another 100 years.

Figure A-7: Production forecast based on proved reserve (BP-definition), proved recoverable reserves (WEC-definition) and estimated recoverable reserve (EIA-definition)



Historical data: EIA 2006

In the above figure anthracite production is only shown since 1950 because prior data were not available.

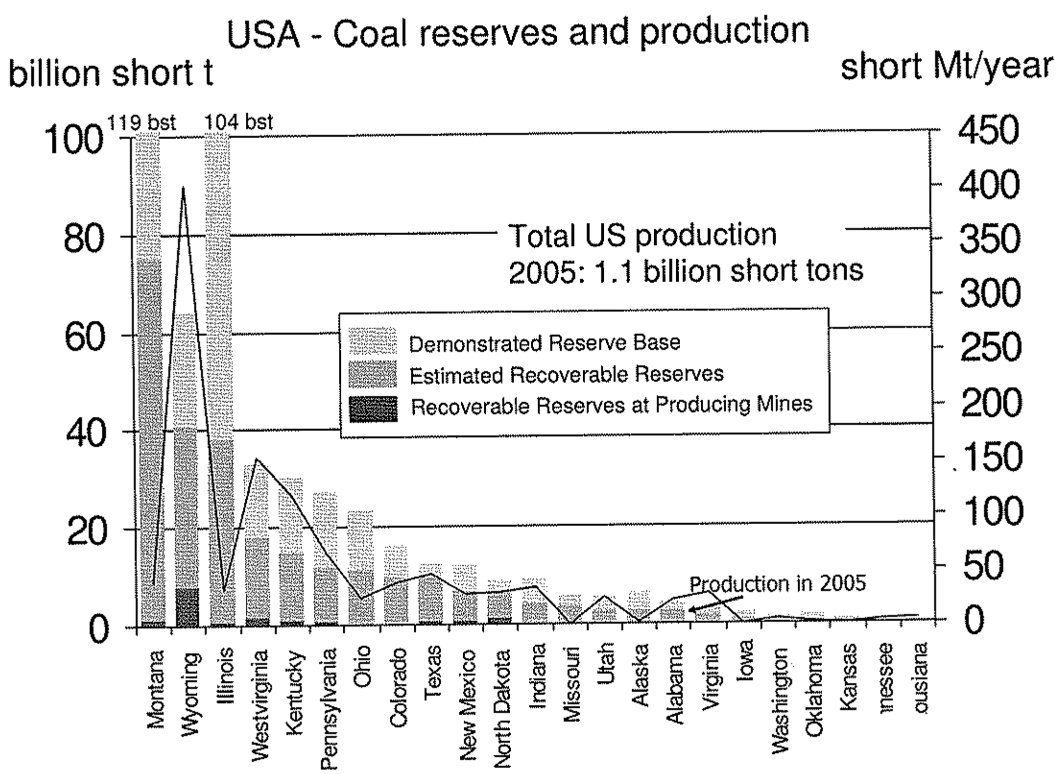
However, this scenario does not adequately reflect the aspects discussed above. Even if volumetric production rates can be increased by about 60% until 2070-2080 before decline sets in, the corresponding energy production will increase only by about 45-50% due to the increased share of subbituminous coal and lignite.

A look at coal production data for the USA on a regional level helps to gain more insight. It turns out that the vast coal reserves are concentrated in only a few federal states, some of which belong to the largest producers, but others do not. The scenario based on reserve data sketched above implies that federal states with huge coal reserves on paper but modest or already declining production over the last 10–20 years would have to shoulder the largest production increases in the coming decades. It is very likely that in these cases either the reserve estimates are highly exaggerated or some other reasons prevented the growth of their coal production. For instance high sulfur content (e.g. in Illinois) or content of other pollutants, or high extraction costs could be a reason.

The following figure A-8 shows the ranking of the federal states regarding their coal reserves. These reserve data are provided according to the EIA classification scheme which distinguishes between recoverable reserves at producing mines, estimated recoverable reserves and demonstrated reserve base.

One should note the big differences in the values for the three reserve categories. About 60% of the remaining estimated recoverable coal reserves are concentrated in three federal states. Only one state, Wyoming, is a high volume producer at present. Wyoming produces about 90% of subbituminous coal and also showed the largest growth rates. Its reserves would allow for a further growth within the next 20 to 30 years.

Figure A-8: Ranking of US federal states according to their coal reserves and production volumes in 2005

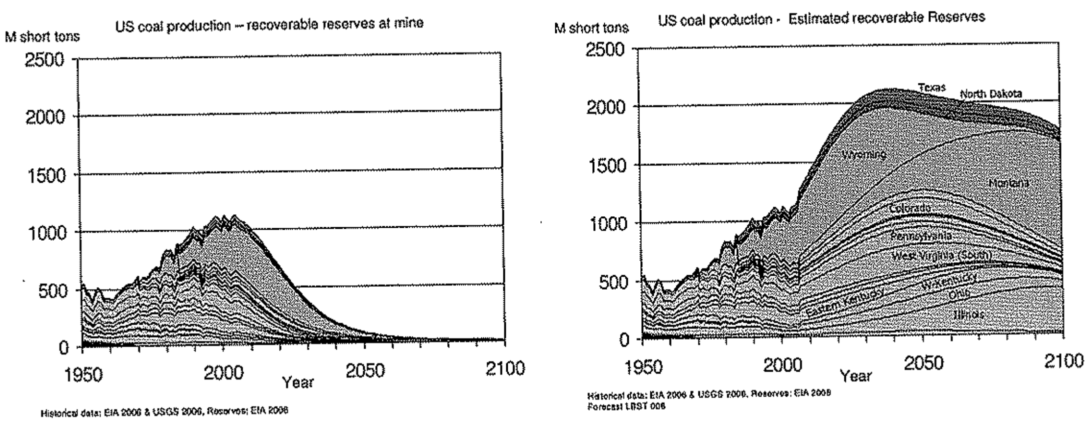


Source: DoE-EIA 2006
Analysis LBST 2006

However, the other two federal states with large resources, Montana and Illinois, show declining or almost constant production rates at very low levels in relation to their reported estimated resource base. The reserves contain contributions from recoverable reserves at producing coal mines and estimated additional recoverable resources. The first category has a very high probability of being produced, while the estimated additional recoverable coal has a lower probability of being produced. Both categories together constitute the "proved recoverable reserves" as reported by the WEC.

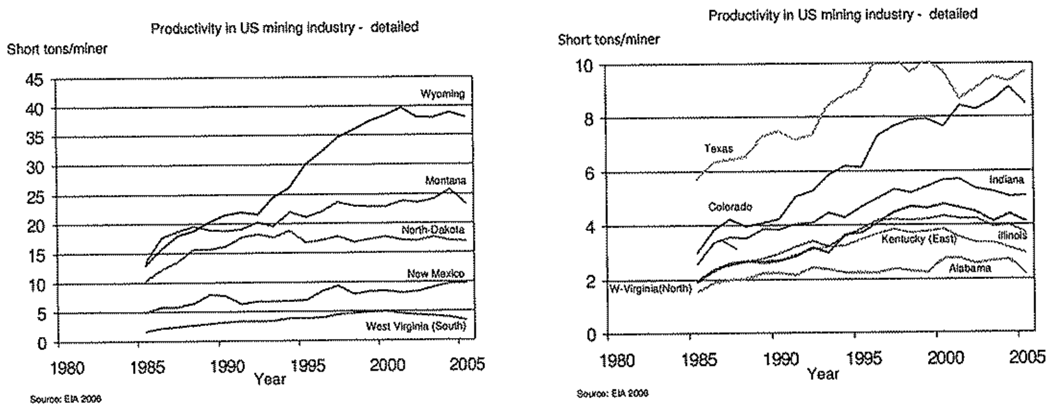
The following figure A-9 shows how coal production would develop if only the recoverable reserves at producing mines were used (left figure), and if all estimated additional recoverable reserves were produced (right figure) according to a bell shaped profile. In the first case, coal production would decline rapidly. Therefore, any future increase of US coal production requires huge investments into new mines, especially in Montana and Illinois. A realistic production profile will have to be somewhere between the two extremes outlined here. In this context it should be noted that the USA has switched from being a net exporter to being a net importer of steam coal (Kalavov 2007).

Figure A-9: US coal production if only recoverable reserves at mines are producible (left) and if all reported estimated recoverable reserves are producible (right). The real profile will be somewhere between these two extremes.



With about 2–2.5 short tons per miner Alabama's coal production has by far the lowest productivity. This compares for instance with the 38 short tons per miner in Wyoming which might be the main reason for the huge production growth in Wyoming over the last 20 years.

Figure A-10: Productivity in short tons per miner for some federal states



Other federal states with low production rates relative to their reported reserves and resources are Illinois, Ohio, West Kentucky and Montana. It is very likely that their production will further decline continuing the trend of the last 20 years. The production in Illinois has steadily declined by 50% and in West Kentucky by 40% over the last 20 years and it seems unlikely that these trends will reverse.

Also the production of Montana will probably decline or at best grow only slightly – over the last 20 years it has more or less remained at around 40 Kt/yr. This would be in line with the small reserves at producing mines. But why are the huge estimated recoverable reserves in non-producing areas not used? Possible reasons are as follows. Open pit coal mining in Montana is already causing severe environmental burdens. The subbituminous coal is of poor quality because of its high sodium content. Mining causes severe contamination of soils and groundwater. Only 2% of the exististing mines have been reclaimed as yet. Therefore the approval of new mines is politically very controversial (no new surface mines have been approved in the last 20 years) and is in direct conflict with farming interests (the Montana economy relies heavily on cattle farming) and environmental goals. In the decade between 1978 and 1988 more than 40 new surface mines were approved. But since then no further permit for a surface mine has been given. The last permits for new underground mines were given in 2003, 1994 and 1979. However, underground mines are considerably smaller than surface mines (EIA 1998-2006), (Montana 1998).

There is also the problem of finding customers for a significant increase in coal production. Either the coal would have to be transported over long distances to the urban centers in the east of the US (and also existing power stations would have to be adapted to the poor coal quality) or electricity would have to be generated locally and then transported to the locations of demand. In both cases huge and expensive new infrastructures (either railways or local power stations in combination with long distance power lines) would have to be built. It is not obvious how this is going to happen any time soon. Another reason for the small contribution of Montana might be the low productivity compared with Wyoming.

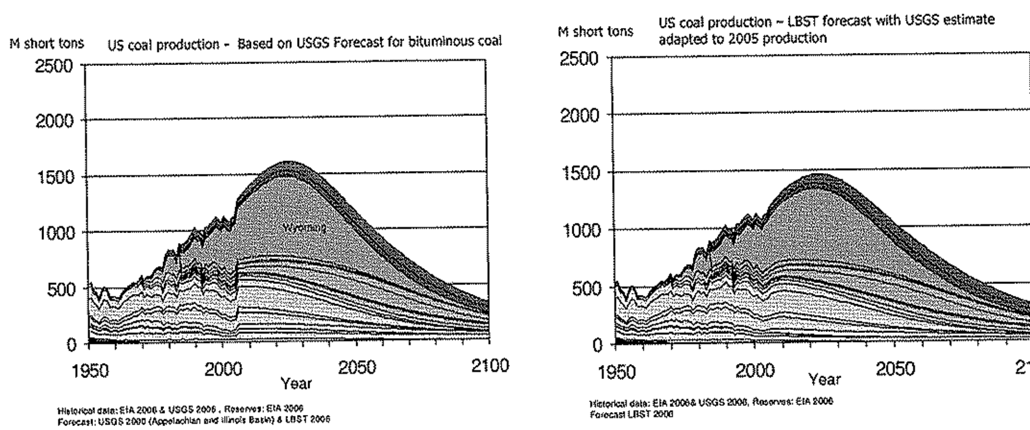
However, these federal states with a low relative production own by far the largest reported reserves.

It is not probable that the huge reserves in Montana, Illinois, Western Kentucky and Ohio will be converted into production. This results in a future production profile as shown in the following figure A-11. In this figure the production profiles for the Appalachian region states and the Illinois basin are based on production forecasts by the USGS in 2000 based on 1995 data (in fact this forecast for these regions covers most of the bituminous coal production in the US).

The left part of the figure is based on this USGS estimate for the Appalachian states and the Illinois basin (yellow area). The USGS forecast indicated no further production increases for bituminous coal. In addition, this 10-year old forecast turns out to have been too optimistic by about 20% in 2005. In addition to the USGS forecasts, the reserve estimate with recoverable reserves at producing mines for Montana is added. Wyoming is also included in the figure. The future production profile is chosen in compliance with past production trends and a possible production growth taking account of the estimated resources.

The right part of the figure corrects the USGS forecast in line with actual data. The other assumptions remain unchanged.

Figure A-11: LBST forecast of future US coal production based on USGS forecast of bituminous coal production

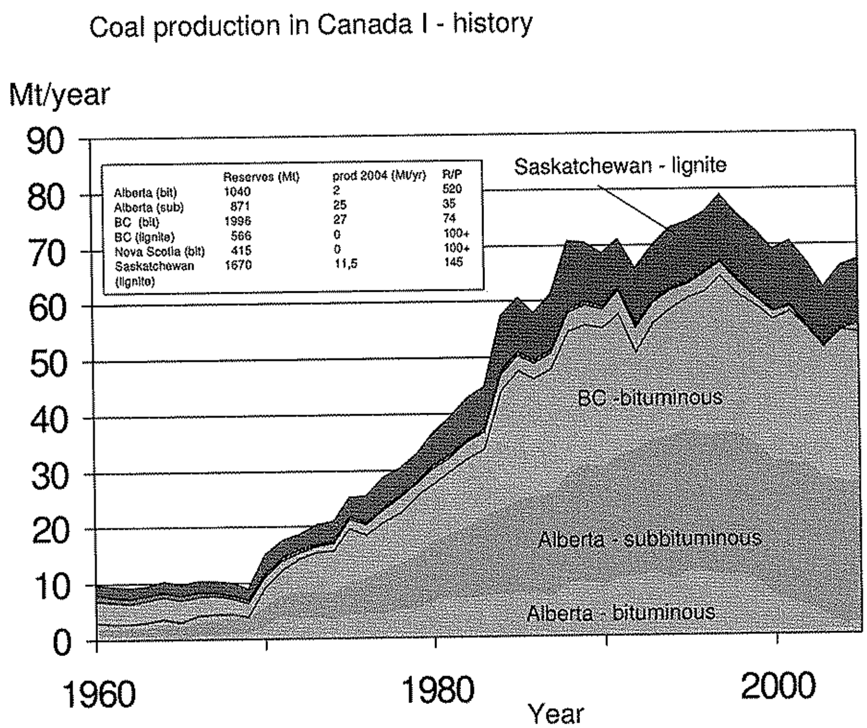


To summarize the analysis: Three federal states (Montana, Illinois, and Wyoming) own more than 60% of the US coal reserves. Over the last 20 years two of these three states (Montana and Illinois) have been producing at remarkably low levels in relation to their reported reserves. Moreover, the production in Montana has remained constant for the last 10 years and the production in Illinois has steadily declined by 50% since 1986. This casts severe doubts on the significance of their reported reserves. Even if these estimated recoverable reserves (according to EIA) or proved reserves (according to BP) do exist, there must be other reasons which have prevented their extraction. In Illinois the reason might be the high sulphur content of the coal. The possible reasons relating to Montana have been discussed above. Therefore it is very uncertain whether these reserves will ever be converted into produced volumes. Considering the insights of the regional analysis it is very likely that bituminous coal production in the US has already peaked, and that total (volumetric) coal production will peak between 2020 and 2030. The possible growth to arrive at peak measured in energy terms will be lower, only about 20% above today's level.

Annex 4: Canada

The reported proved recoverable reserves of Canada in WEC 2004 are identical to those already reported in 1986 by the Canadian Geological Survey (CGS). In the period between 1992 and 2000 there were upward revisions which have not been upheld in the latest report. This leaves some room for speculations about the real size of reserves. The following figure A-12 shows production volumes between 1960 and 2005. From this profile it seems that production had already peaked in 1997, despite the fact that reserves of 3.47 billion tons of bituminous coal, 0.87 billion tons of subbituminous coal and 2.2 billion tons of lignite are reported. This peak can be solely attributed to the declining production volumes of bituminous coal in Alberta which fell by more than 90% within 6 years. The production of subbituminous coal in Alberta increased until 1995 but has remained constant since then.

Figure A-12: Production history



Data: Natural Resources Canada 2006

However, the reported reserve data do not indicate shrinking reserves. In Alberta bituminous coal has still an R/P-ratio of more than 500 years, while subbituminous coal has a 25 year range.

The two following scenario calculations project the future production profile based on two alternative assumptions:

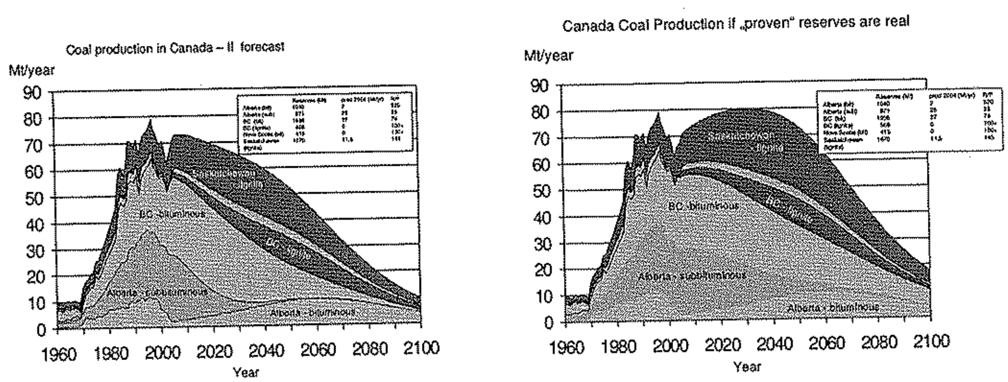
(1) Reported reserves are adjusted to 1986 (the first reporting of the reserve data by CGS) – "low" case.

(2) Reported reserves are valid for the end of the year 2005 (as reported in BP 2006) – "high" case.

In the "low" case, production already peaked in 1998. In the "high" case, production can still grow slightly with a peak around 2030 – 2040. But due to the lower energy content of lignite, this peak would not translate into corresponding increases of available energy.

If this analysis is correct, then the next few years should show further limitations for future coal production in contrast to other observers who foresee growing coal reserves and growing production for Alberta. But based on current data - because of their poor quality - this question cannot be answered at present.

Figure A-13: Production forecast "low" and "high"



Annex 5: Germany

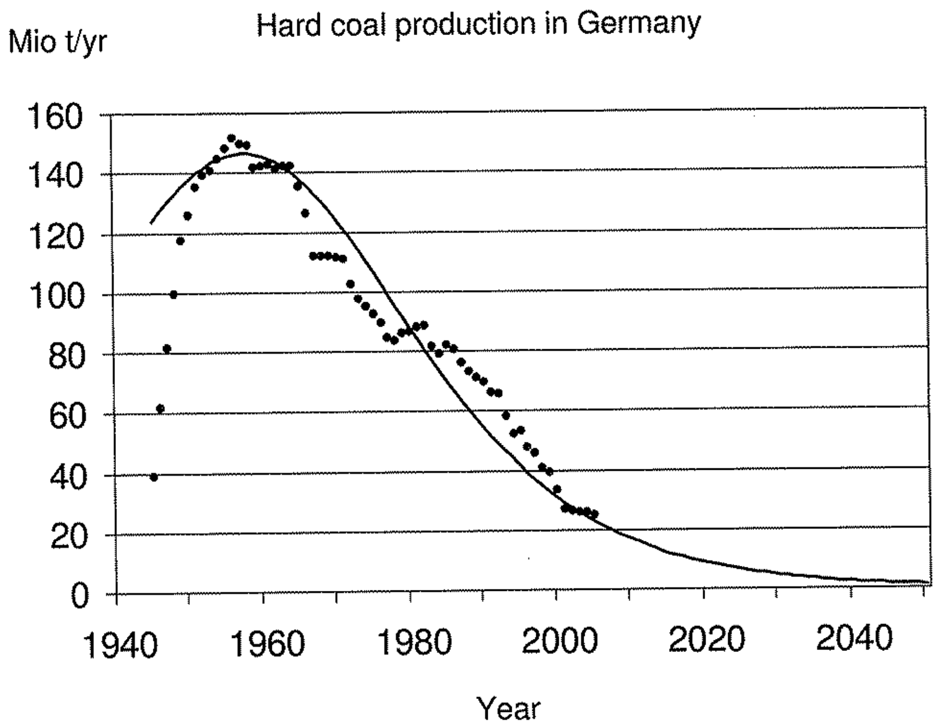
Coal production in Germany has a long tradition. After the Second World War coal was the energy basis for the economic revival of Germany. Coal production was mainly linked to electricity production and to steel production which was the basis for the rise of the car industry which again was the backbone of economic growth. Hard coal production after WW II started at about 40 million tons per year, but grew quickly during the middle of the 1950s. Peak production was reached in 1958 at 150 million tons which thereafter was followed by a steady decline. In 2005 hard coal production was around 25 million tons. The high costs of hard coal production in Germany, Italy, France and the Benelux countries were the reason for the first initiative to create a protected market within Europe. These efforts culminated in the European Coal and Steel Community (ECSC) founded in 1952 which formed the nucleus of the later European Union.

The rising costs of European coal production compared with cheaper imported coal from overseas are often seen as the cause for the decline of the European (and especially German) hard coal production. But even with the support of subsidies German coal production continued to decline at an almost constant rate.

The "proved recoverable coal reserves" were stated as being 23 billion tons for many years before 2004, when the WEC 2004 report reclassified 99% of these proved reserves as speculative and downgraded proved reserves to 183 million tons. In line with this downgrading, the most recent data published by the German BGR at the end of 2005 state proved reserves of 161 million tons. These downgraded reserves roughly fit the future production profile sketched in the following figure A-14.

The dramatic downgrading of German hard coal reserves has not been explained and there has been no public debate of this fact. This is surprising again especially against the background of the recent debate in Germany regarding the future of hard coal mining. One of the proposed political options was to continue production at a minimal level in order to uphold the option for a future revival of coal mining if required. But looking at the reserve base, this option does not make sense.

Figure A-14: Hard coal production in Germany and theoretical model for extrapolation



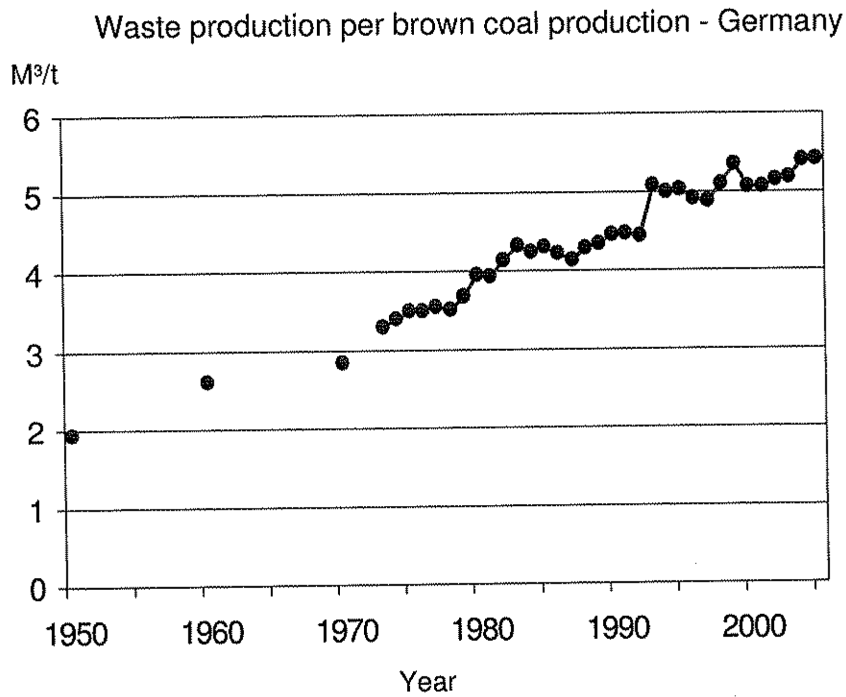
Source: Statistik der Kohlenwirtschaft 1988 & 2006

Another indication that the supply base is shrinking (independent of the question of subsidies) is the fact that the waste production per ton of coal has increased substantially over the last few years: from 1.02 ton waste per ton hard coal in 2001 to 1.206 t waste per t hard coal in 2005 (i.e. an annual increase of 4-5%).

The unexplained and far reaching downgradings of German hard coal reserves (and also resources) should be investigated and rediscussed in public because of their political implications.

Germany has vast reserves of lignite. In fact, Germany is the world's largest producer of lignite, contributing about one third to world lignite production. But similar to hard coal production, the extraction effort rises continuously. This can be seen best by looking at the waste production which has steadily increased from 2 $m^3/t_{lignite}$ in 1950 to 5.5 $m^3/t_{lignite}$ in 2005. A more detailed analysis reveals that this trend can be observed in almost all producing regions with the only exception of the Rhineland.

Figure A-15: Waste production increase by 250% since 1950

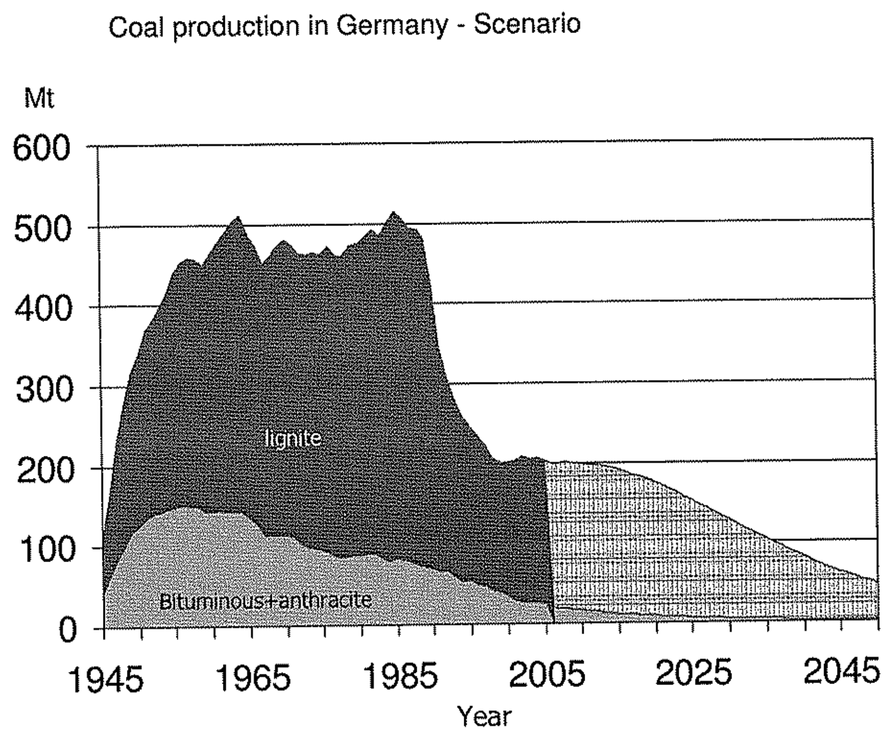


Source: Statistik der Kohlenwirtschaft 1988 & 2006

Lignite reserves have also been downgraded in the last few years from 55 billion tons in 1990 to 43 billion tons in 2002 and recently to 6.6 billion tons in WEC 2004.

The development of German coal production since 1945 is shown in the following figure. Data between 1945 and 1950 are correct for hard coal but estimated for lignite since production data for Eastern Germany were not available for this period. Around 1990 the Eastern German coal production was restructured. This resulted in a substantial decline of total production. Since Germany is the largest lignite producer in the world, this decline of production had a significant influence on the volume of world-wide lignite production. The future production profile of lignite is compatible with the proved recoverable reserves (WEC) as reported in 2004.

Figure A-16: German coal production, history and forecast based on proved reserves



Source: Statistik der Kohlenwirtschaft 1988 & 2006

LITERATURE

Historical data for USA, France, UK: National Bureau of Economic Research (www.nberg.org)

BGS 2005 Coal – Mineral Profile, British Geological Survey, November 2005

BP 2006 Statistical Review of World Energy various editions

Canadian Minerals Yearbook, 1960-2005, Mineral Resources Division, Department of Mines and Technical Survey, Ottawa, see http://mmsd1.mms.nrcan.gc.ca

EIA 2006 annual coal statistics from 1994-2006

EIA 2005 Coal News and Markets, week of July 17, 2005, http://tonto.eia.doe.gov/FTPROOT/coal

EIA Energy Information Administration, Annual Coal Reports, 1994-2005

GSC 1989 Canada's Coal Resources, Geological Survey of Canada, EMR/GSC Paper 89-4, 1989

IEA 2007 Energy Content of coal www.coalonline.info

ITC 2007 The burning problem – a short introduction, ITC's coal fire homepage, Netherlands, www.itc.nl/personal/coalfire/problem/china_coalfire.html

Kalavov 2007 The Future of Coal, B. Kalavov, S.D. Peteves, DG JRC, Institute for Energy, Petten, to be published 2007

Kohle 2005 Statistik der Kohlewirtschaft e.V.

Lefohn 1999 Estimating historical anthropogenic global sulfur emission patterns for the period 1850-1990, A. Lefohn, J. Husar, R.B. Husar, Atmospheric Environment 33(1999) , pp. 3435-3444

Lixin 2006 Fueling the Nation's Growth, Wan Lixin, China International Business, March 2006, pp 31-34

Montana 1998 Montana – the state with the second largest quantity of coal reserves

NRC 2000 Canada's Energy Markets, Sources, Transformation, Infrastructure, Natural Resources Canada, siehe http://www2.nrcan.gc.ca/es/ener2000/online/html

NRC 2005 Canada's Minerals and Metals Industry, An economic Overview, Natural Resources Canada, 2005

R.C. Milici	Coal Resources of Appalachian and Illinois Basins, USGS, undated power point lecture
Robert C. Milici	Depletion of Appalachian coal reserves – how soon? International Journal of Coal Geology, vol. 44, no.3/4, September 2000, pp 251-266
Sinton 2001	Accuracy and Reliability of China's Energy Statistics, J. Sinton, Lawrence Bercely National Laboratory, LBNL-4819, 18 September 2001
WEC 1980	Survey of Energy Resources, prepared by Bundesanstalt für Geowissenschaften und Rohstoffe, ed. by World Energy Conference, München, 8-12th September 1980
WEC 2002	Survey of Energy Resources, World Energy Council, 2002
WEC 2004	Survey of Energy Resources, World Energy Council, published by Elsevier Ltd, 2004