WORLD COAL PERSPECTIVES TO 2030

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Abstract

In Summer 2004, the World Energy Council published a Study on "Sustainable Global Energy Development: the Case of Coal". The Study aims at developing an internationally consistent reply to the question whether and to what extent coal use could be economic <u>and</u> sustainable in meeting global energy demand to 2030 and beyond. It covers markets, trade and demand, mining and combustion technologies, restructuring and international policies, and perspectives. It considers both, the contribution that coal could make to economic development as well as the need for coal to adapt to the exigencies of security of supply, local environmental protection and mitigation of climate change.

The conclusion suggests that coal will continue to be an expanding, cheap foundation for economic and social development. Backed by its vast and well-distributed resource base, coal will make a significant contribution to eradicating energy poverty. And: coal can be and will be increasingly clean, - at a bearable cost in terms of technological sophistication, and at little cost in terms of international technology transfer and RD&D in CO_2 sequestration. For this to happen, even-handed energy and environmental policies are needed, not ideologies. Moreover, a more pro-active involvement of the coal and power industries is needed in "globalising" best technical and managerial practices and advocating coal's credentials.

1 Sustainable Global Energy Development And Coal: Overview

WEC holds [1], that sustainable energy development can be appraised against three benchmarks:

- the continued availability of energy, in sufficient quality and quantity, adapted to the changing needs of customers
- the growing accessibility of energy, it being understood that the costs of supply and further energy development are covered. WEC recalls that at the beginning of the 21st century, **two billion people had no access to commercial energy**, while another two billion had access to unreliable and often unaffordable supplies [2].
- the acceptability of energy, i. e. its compatibility with societal concerns, be they developmental, environmental or social.

Against these benchmarks, the Study concludes that coal is

- available to meet the steeply rising demand for steam coal, while adapting the supply of coking coal to reduced demand. Despite the drain on reserves, those would remain huge in absolute terms and compared to oil and gas reserves [3]

- accessible, mostly in the form of electricity, to a growing number of people. Thanks to significant productivity gains [4], international coal prices would remain stable or increase much less than the prices of its competitors. Thus, coal would contribute notably to cutting by half, till 2030, the number of people with no or unreliable access to energy [5]. Beyond its use in electricity generation, gasification and liquefaction of coal emerge as long-term options
- acceptable in so far as by 2030, 72 % of coal-based power generation in the world would use clean coal technologies [6], and as methane drainage[7] and carbon sequestration would have been increasingly practiced

However, the present Study also notes deficits and advocates remedial measures. Coal's global image does not reflect the realities of the industry. A worldwide commitment of the coal and associated industries is needed to improve the public perception of coal's real performance.

International policies appear to discourage the contribution to sustainable development, which coal offers in terms of availability, accessibility and affordability, and acceptability. Hence a need to re-equilibrate international policies which should

- place emissions from coal into a more balanced perspective. If life cycle analysis was used and other greenhouse gases were taken into account, electricity generation from fuels other than coal would show similar or even higher GHG emissions [8]
- acknowledge that the projected increase in annual emissions of carbon dioxide from coal between 2001 and 2025 of 1.1 billion metric tons of carbon equivalent will be less than the increased amount projected for either natural gas (1.3 billion tons) or oil (1.5 billion tons) [9]
- acknowledge the contribution which coal can make to social and economic development and energy security
- avoid instruments which discriminate coal; rather encourage a more efficient and clean use of coal in power generation, including through Joint Implementation, Clean Development Mechanisms and emission trading [10]
- supplement ongoing information exchanges on carbon sequestration by related funding of R and D initiatives
- assist developing countries in acquiring clean coal technologies [11]; an expanded contribution of the Global Environmental Facility and of the World Bank's Prototype Carbon Fund under preferential conditions is recommended
- encourage the worldwide application of more effective SO_2, NO_x and dust emission standards for new power plants; this would also reduce the regulatory uncertainty affecting the design of clean coal technologies
- encourage a transparent and representative reporting system on health and safety practices in coal mining, as a basis for the broad deployment of good practices [12],
- ratify ILO Convention Nr. 176 on Safety and Health in Mines
- include coal services (consulting, engineering, management) in the attempts underway in WTO-GATS to liberalise access to markets [13].

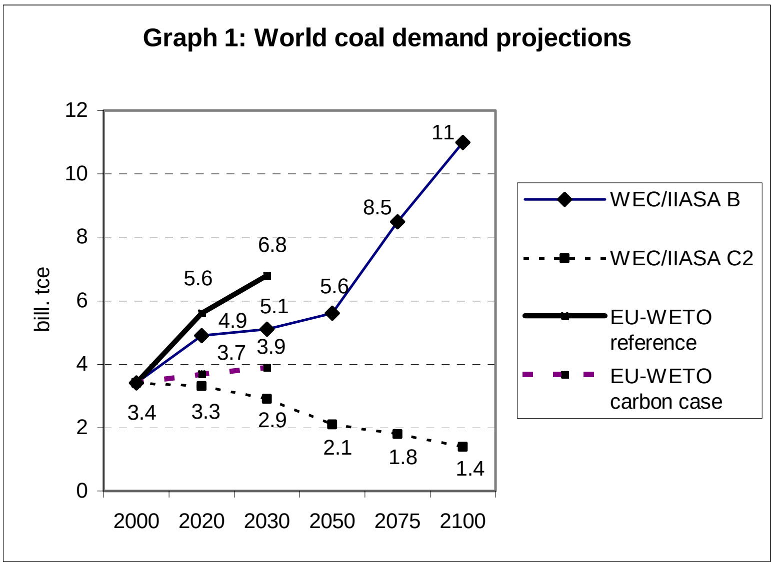
The projected growth of energy demand particularly in developing countries will prompt a significant increase of CO_2 emissions. The coal industry and power equipment manufacturers are making every effort to deploy technologies with higher efficiencies in the short and medium term and to develop carbon sequestration to technical and commercial maturity in the next 15 to 20 years.

2 Availability Of Energy: Coal's Lasting Asset

2.1 World coal demand on the rise

Demand for coal (hard coal, brown coal, lignite) has grown by 62 % over the past thirty years [14]. IEA, in its reference scenario, expects coal demand to grow by another 53 % up to 2030 and EU-WETO by 100 %. WEC/IIASA market-driven scenarios [15] project a continued growth during the remainder of the century. By contrast, carbon constraining policies would lead to a decline of coal demand as of 2030 or slightly before (see Graph 1[16]); this begs the question how relevant such policies could be in addressing the issue of "energy poverty eradication and the role of affordable universal energy access as the principal issues of sustainable development" (World Summit on Sustainable Development).

In market-driven scenarios, the share of coal will decline slowly from 26 % in 2000 to 24 % in 2020 and 22 % in 2050. Carbon constraints would reduce the share of coal to 11 % in 2050, which (nevertheless) corresponds to 2.1 bill. tce (2000: 3.4 bill. tce).



2.2 The main driver: power generation

Most of the increase of coal demand will be from power plants, which will absorb in 2030 some 74 % of coal supplies, against 66 % in 2000 [17]. Three decades from now, coal would cover 45 % [18]of world power needs, compared with 38 % in 2000[19].

2.3 New regional demand and production patterns

Under the impact of demand, during the last 30 years, production rose steeply in China (with a temporary adjustment recently), India, United States, South Africa, Australia, Canada, Colombia and Indonesia, but declined in Europe with its high-cost deposits [20]. This pattern is expected to continue [21].

2.4 Towards globalisation: international coal trade

The coal mining and power generation industry becomes ever more global. Whereas international sea-borne hard coal trade accounted for only 7.5 % of world hard coal production in 1970, by 2000 already 16 % of production was internationally traded [22]. At 637 mill t in 2000, international coal shipments are expected to grow to 1051mill t in 2030 [23], corresponding to 15 % of world coal production.

Trading practices change: short-term contracts and tenders prevail over long-term contracts as a result of strong competition. Mergers, acquisitions and horizontal and vertical integration gain ground. Consolidation allows economies of scale and reduces overheads, hence enables competitive pricing. While in 2001, the five largest private coal companies accounted for 40 % of international hard coal trade [24], competition continued as new suppliers entered the market [25]. Sear-borne shipping accounts for about 30 % of the delivered cost of coal [24]. A reduction of these costs would contribute to enhancing coal's markets.

2.5 Coal reserves: the benefit of size

Economically recoverable coal reserves are huge [26]. Despite increased production during the next thirty years, only 25 % of presently known coal reserves will be depleted, compared with 84 % of oil reserves and 64 % of gas reserves [27]. Moreover, depletion ratios will slow due to the anticipated increase in coal combustion efficiency and related fuel savings of as much as 35 % [28]. Nevertheless, the industry should remain active in exploration, be it alone to enhance coal's contribution to energy security.

3 Accessibility Of Energy: Coal's Growing Strength

3.1 Income growth versus growth of energy prices

IEA [29] and EU-WETO [30] anticipate world per capita GDP to rise by about 2 % per year until 2030. Income growth would be faster in developing (2.8 %) and transition economies (3.4 %) than in OECD countries (1.6 %). Access to commercial energy would be eased if income growth exceeds the rise of energy prices. International fossil fuel prices would rise less fast than income, thereby opening access to commercial energy to a growing number of people. IEA estimates that by 2030, this differential and other factors would allow 2 bill people to have access to electricity and other modern fuels. However, another one billion people would remain stranded in energy poverty [31].

3.2 Coal's growing price competitiveness

After a significant decline of international coal prices during the 1990s [32], coal prices are expected to be stable or to rise only slightly in comparison with oil and gas prices [33]. As a result, coal will lead in terms of price competitiveness and accessibility.

3.3 Behind coal's performance: productivity and efficiency gains

Coal's price performance is in last instance caused by productivity gains in mining and improved efficiency in combustion.

Productivity per man and year rose between 5 and 10 % in the 1980s and by between 10 and 15 % in the 1990s [34]. This growth was not only due to increased labour productivity, but also to the closing of uneconomic or small (and often illegal) mines, the liberalisation and restructuring of coal industries, the transfer of know-how and technology to newcomers and the expansion of opencast mining versus underground mining. Productivity growth is expected to continue.

At present, average world coal combustion efficiency in power stations approximates 32 %, while state of the art is 42 to 45 %. Advanced clean coal combustion technologies promise efficiencies of 50 to 53 % [35]. As new plants penetrate the market, efficiencies will rise. EU-WETO estimates that by 2030, 72 % of world coal-based power plants use advanced technologies with efficiency at 49 to 50 %. EU-WETO also estimates that these plants could displace gas-fired combined cycles down to 4500 h/year even in regions with access to reasonable priced gas[36].

3.4 Investments in coal mining and combustion

Coal mining is less capital-intensive than the extraction of oil and gas. The mining of a ton of coal (in toe equivalent) requires less than $5, compared with $22 for the extraction of oil and almost $25 for gas. However, coal combustion associated with a higher environmental policy risk than its main competitor – gas, unless matched by clean coal technologies. Gas, by contrast, seems to face a risk of higher prices, affecting its competitiveness.

IEA[37] estimates the cumulative investment requirements for coal mining and shipping (including port facilities) during 2001-2030 at $398 billion. These would support an increase of world coal production from 4595 million t in 2000 to 6954 million t (reference scenario).

Cumulative global coal investments needs are shared equally by developed and developing nations, with China requiring 34 %, the United States and Canada 19 %, Australia and New Zealand 9 %, the transition economies 8 %, OECD Europe 7 % and India 6 %.

If investments for coal-based power stations were added, the total cumulative investment needs would amount to $1900 billion. This is 12 % of the investments required by the world energy supply industries as a whole ($ 16000 billion).

4. Accessibility Of Energy: Coal's Technological Agenda

The anticipated growth of coal demand (see Graph 1) will also be driven, and increasingly so, by coal's capability to accommodate societal concerns: economic growth, environmental protection, mitigation of climate change, improved labour safety and health standards, and community development. In the absence of response, these concerns will become the limiting factor to coal's growth.

4.1 Facilitating technology and knowledge transfer to developing countries

Coal demand is expected to increase during the next three decades everywhere in the world, except in western Europe. The increase would be strongest in the developing countries: China, India, South-East Asia, sub-Saharan Africa and Latin America. Coal demand by developing nations would actually double from 1.5 bill t in 2000 to 3.1 bill t in 2030. By that year, 60 % of world coal demand would be generated in developing countries, against 45 % in 2000 [38].

If the developing countries are the growth engine behind global coal demand, coal remains an important, indeed indispensable, growth engine for developing countries. Despite competition from natural gas, coal would account for 33 % of total primary energy supplies in 2030 (against 39 % in 2000). More importantly, in developing countries coal would secure 53 % of electricity generation in 2030, against 56 % in 2000. Coal-based power generation would more than triple [39].

Enabling a prospering coal industry of the size and dynamics suggested above, requires continued efforts on the part of governments, industry and the international community with regard to:

- **technology transfer:** financing technology transfer to developing countries meets serious difficulties, unless the macro-economic and policy frameworks encourage investors. Cumulative investment needs of developing countries for coal mining and shipping during 2001-2030 amount to $261 billion [40] IEA notes that the risk of a shortfall of foreign investments is greatest in developing countries, where ownership remains in government hands. Neither domestic capital markets nor government budgets have been and will be able to provide such funding. International financial assistance in demonstration projects (mining, liquefaction, washeries, methane drainage, waste handling, IGCC, coal slurry pipeline), have proven their value, if coupled with a legal regime attracting foreign investors. The number of such projects needs to be multiplied, until such time that the costs of modern technologies have been brought down.
- **restructuring:** recent policies of developing countries aim at a greater degree of private sector involvement in mining and power generation, including privatisation. At the basis of success are a reduced role of governments in operations, the gradual phase-out of price controls, import tariffs and subsidies, and the removal of restrictions such as on the use of coal production in captive power plants [41]. The main issue is to supply cheap energy to the poor, i. e. to change the system of producer subsidies to a system of consumer subsidies.
- **management:** the transfer of efficient management practices, through internationally operating companies or otherwise, enables significant productivity gains. The tools are company-supported education, training and community relations.
- **standards:** in developing countries, the setting of health, safety, environmental or quality standards has to obey the triple objectives of economic, social and ecological development. This demands a gradual, fine-tuned move from minimum to more

constraining standards rather than the application of first-world standards. International financial institutions should recognize such a step-wise strategy as valid, when determining the conditions for loans [42].

4.2 Abating local/regional pollution: a matter of worldwide deployment of proven technologies

Proven technologies exist to reduce the emission of dust, SO_2, and NO_x from coal-based power generation [43], to recycle toxic effluents, by-products and coal bed methane [44], to mitigate subsidence or to reclaim opencasts [45]. The issue is one of the worldwide deployment of best practice. Stricter national and transboundary emission standards and leadership of global players would pave the road.

4.3 Mitigating climate change: clean coal combustion and carbon sequestration

As pointed out in section 3.3 above, rising efficiencies of coal combustion in power stations reduce fuel use and, hence, CO_2 emissions.

There exist several technological options (with variants) with high and growing efficiencies. For hard coal, supercritical pulverised coal combustion presently operates at efficiencies of 45 % and offers prospects for an increase to 48 %; this technology remains the preferred option for large units and for up to 2020. For lignite, supercritical pulverized firing attains more than 43 % (in the so-called BoA unit of the German plant of Niederaussem), with a target of 50 % and more if pre-drying and new materials were used (time frame 2020). Fluidised bed combustion, suitable for smaller capacities and high ash coals, presently operates at 40 % efficiency with prospects for up to 44 %. Integrated gasification combined cycles (IGCC) – at demonstration stage – achieve 43 %, but may attain 51 to 53 % [46].

However, efficiency is only one parameter. The choice of the technology depends on many site-specific criteria such as the size of the unit, the load regime, the fuel used, the marketing or recycling of by-products and environmental legislation.
Be that as it may: the worldwide application of these advanced technologies would theoretically avoid 1.8 bill t of CO_2 per year, equivalent to 7.5 % of present world CO_2 emissions [47].

Coal does have every interest to develop carbon capture and disposal technologies to technical and commercial maturity in the next 15 to 20 years. International research is underway, such as the “Zero Emission Coal to Hydrogen Alliance” (ZECA), the US DOE "Vision 21” or President Bush’s “FutureGen” Programme. The EU Framework Programmes for Research and Technological Development for 2002-2006 include a chapter on capture and sequestration of CO_2. A Charter on carbon dioxide (CO_2) was signed in June 2003, creating the Carbon Sequestration Leadership Forum; 13 countries and the EU participate. The IEA Clean Coal Centre is since long active in CO_2 emission analysis and control [48].

Cleaner coal, indeed fossil fuel, technologies appear to be a major possible and feasible long-term means to seriously address the two interrelated issues of reducing energy-related GHG emissions <u>and</u> of enabling universal access to energy. However, related costs have to be brought down and least cost carbon mitigation technologies of all sorts need to be judged in a competitive market context. By contrast, alternative policies to wean the world of its dependence on fossil fuels require comparatively higher price increases which would be at least equivalent to the two oil shocks of the 1970s every 10 years. This would engender corresponding losses of economic growth, prolong the use of traditional fuels by poor people in developing countries and exacerbate the global level of GHG emissions [49].

Coal needs to care more for its markets other than electricity generation in power plants. Apart from the gasification of coal prior to its combustion in IGCC processes mentioned under section 4.3.1 above, the perspective of comparatively low coal prices aroused renewed interest in its liquefaction. In China, the construction of a coal liquefaction plant has begun in Majiata, Inner Mongolia. In the US, the Gilberton coal-to-power-and-clean-fuel demonstration plant is at its final stage, awaiting a favourable environmental impact statement, tax breaks and a government loan for May 2004. In Australia, a letter of intent has been signed for a large integrated power-and-liquids plant in Victoria [50]. Regarding underground gasification, a project has started in the United Kingdom with the ambition to tap coal reserves from beneath the North Sea with minimal environmental impact. Ultimately, synfuels and hydrogen emerge as vectors for coal use [51].

Evidently, these projects are forerunners, driven by a comparatively high price environment and tensions in the Middle East. Also, they benefit from specific favourable conditions. But it is telling, that they see the light of the day at a time when oil and gas reserves are plentiful.

Ultimately, synfuels and hydrogen emerge as vectors for coal use [52] . The longer-term perspectives of synfuels from coal are clearly related to the depletion of cheap conventional oil reserves: presently too expensive, synfuels from coal may contribute about 100 Mtoe (or 4 % of world liquid fuel demand) in 2020 and up to 660 Mtoe (14 %) by 2050.

4.4 Coal's road to public acceptance

There is still a striking cleavage between coal's perceived image and coal's real performance. Regrettably, there has not been so far an industry effort to address this deficit at the global level. Coal clearly has key attributes, however. It is incumbent upon the global industry to take action now to market them to the public and policymakers alike so as to ensure that coal provides a sustainable bridge to the future.

5. Epilogue

This Epilogue ventures an – informed – speculation of how the situation and prospects of world energy demand and supply, particularly of coal, might be seen in 2030. This is, of course, not a forecast of what would have happened by then, but a vision of what could have happened if all stakeholders had combined their efforts at rendering coal sustainable in a global economic growth and energy context.

5.1 2000-2030: a retrospective

Should the WEC launch in 2030 a mid-century revue of "Energy for the World of 2050", it will certainly applaud the role of coal in social and economic development and the spirit of societal responsibility of the industry. But concerns remain, although earlier concerns about sustainability of coal use might well be topped by concerns about the implications of dwindling low-cost oil and gas reserves.

Concerning sustainability, the carbon intensity of world energy use (tC/toe) during 2000-2030 had declined by about 25 % [53], due to the deployment of efficient and clean fossil fuel combustion technologies, CO_2 sequestration, penetration of gas and (less) renewables. Indeed, by 2030, 72 % of coal-based power generation uses advanced technologies [54]. But energy-related emissions of CO_2 had almost doubled, due to the growth of population and related energy demand in the developing countries. This is why policies to mitigate climate change remained important also in 2030. However, rather than enhancing global and comprehensive action, policies now focus on the fine-tuning of regional and special measures particularly with regard to emissions from transportation and in urban areas. Prospects, as seen in 2030, are that the disadvantages and advantages of global climate change might reach a satisfactory global balance in a not too distant future.

The burning issue in 2030 is the dwindling of low-cost oil and gas reserves. During 2000-2030, the economically recoverable reserves [55] of conventional oil, gas [56] and (less) coal had diminished, despite new discoveries. Supplies of oil and gas had since long peaked. This had lead to a general rise of energy prices, with beneficial effects on efficiency. Also, the structure of energy prices had improved, thanks to the internalisation of environmental and societal cost and the elimination of subsidies and restrictions. Now, in 2030, the energy price differentials between competing fuels tended to better reflect the life cycle costs of energy provision. As a result, least cost planning no longer referred to isolated plants or projects, but to entire energy systems. A case in point was progress in optimising local energy systems: in 2030, half [57] of the world population are urban dwellers, which require heat, warm water, electricity, air conditioning and transportation in an acceptable environment and at an affordable cost.

Higher prices and efficiencies had resulted in a slowdown of world primary energy demand growth to 1.6 %/year during 2020-2030. As however, during the same period, GDP growth stood at 2.6 %/year [58], even in 2030 a full decoupling of world economic and energy demand growth had not materialised. Neither did expectations that new renewables would cover a notable share of supplies. In 2030, fossil energy covered still 88 % of world energy demand, with coal covering 22 %, compared with 24 % in 2000.

5.2 2030 – 2050: a perspective

In 2030, the issue is one of resource constraint and opportunity. The concern is not so much the related rise of energy prices (which, as was pointed out above, had a beneficial impact on efficiency), or their impact on customers (average world income had doubled between 2000 and 2030 [59]), or a physical scarcity (unconventional fossil fuel resources are plentiful in 2030). Rather, the concern is the inefficient and unprofitable use, i. e. combustion, of the valuable organic components of fossil fuels.

Experience since the 2020s had shown that chemical processing, particularly into clean transportation fuels, enabled a fuller and more profitable exploitation of the energy raw material.

The discussion in 2030 centres on what would be the scope, dynamics and implications of such a change of long lasting attitudes towards fossil fuel use. Two such implications are immediately perceived:

- A renaissance of nuclear power as a substitute for base-load electricity generation from fossil fuels. New nuclear could replace precious natural gas and coal in the traditional power generation market.
- An upspring of numerous chemical processing plants using fossil fuels to produce electricity, synthetic gas and oil substitutes, hydrogen, fertilizers and chemical products. Thanks to synergy effects, these plants operate at high conversion efficiencies, reduce cost and minimize effluents and emissions (including carbon removal and storage).

Coal's comparatively favourable resource base and its price competitiveness could make chemical processing into synfuels and gas a growth market for coal. Under market conditions, coal-based synfuels could cover by 2050 some 14 % of world transportation fuel consumption. At a price: the coal industry would have to change: hitherto separate enterprises in coal mining, gasification, liquefaction and coal bed methane drainage, would have to integrate into necessarily globally operating oil and gas refining, product transportation and distribution businesses; the business strategy of coal companies would have to be subdued to the strategies of the processing and delivery conglomerates.

Whether servicing the traditional power generation market or the clean transportation fuel market, coal no longer reaches the end user as "coal". The term "coal" itself is replaced by brand names, which highlight the service rendered (power, mobility) without identifying the raw material (coal). Ironically, concerns expressed at the beginning of the century that the lack of public acceptance might be an obstacle to the growth of coal demand, proved unfounded: there is no direct interface any more between "coal" and the end user except in very rare cases of its direct use as a fuel or … as a piece of art [60].

The message: a study undertaken by the WEC in 2030 on "Energy for the World of 2050" would confirm the important societal role of coal in meeting the aspirations of nations for development <u>and</u> sustainability. It would point to a significant but challenged role of coal in traditional power generation. And it would appraise its comeback, as a derivate, in markets, which it had lost with the advent of cheap oil and gas, - hundred years ago.

References

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