



Kolets framtid

NOG-seminarium den 14 juni 2007

Ellenor Grundfelt
Stefan Grönkvist
2007-07-24

Förord

Sett ur ett globalt perspektiv har kol varit det primärenergislag där användningen ökat mest under de senaste åren och det är i Asien som ökningen varit störst. Kol är det icke förnybara energislag med de överlägset största kända reserverna och stora resurser återfinns dessutom i andra regioner än där de kända oljereserverna finns.

NOG-seminariet den 14 juni behandlade kolets utveckling sett från flera perspektiv, bland annat: Tillväxttakten för användningen av kol i olika delar av världen. I vilka tillämpningar kol kan ersätta olja på kort och lång sikt. Framsteg inom olika tekniker för renare kolkraftverk. Möjligheterna att använda kol mer hållbart genom avskiljning och deponering av koldioxid. Hur och när avskiljning och deponering av koldioxid kan tänkas slå igenom på bred front.

En av talarna beskrev utvecklingen i Indien där den ekonomiska utvecklingen går mycket snabbt just nu. Indiens stora och ökande kolanvändning har bland annat genererat en teknikutveckling som kan innebära att teknik för kraftproduktion med kol kan blir en indisk exportvara. Talare var:

Milton Catelin

Direktör, World Coal Institute

Göran Lindgren

Chef för forskning och utveckling av kraftverk och processteknik, Vattenfall

Gordon Couch

Seniorkonsult och författare, International Energy Agency – Clean Coal Centre

Referatet är en sammanställning baserad på presentationerna vid seminariet.

Milton Catelin has since January 2005 been the Chief Executive of the World Coal Institute. Prior to that, he worked with the United Nations Environment Programme (UNEP) in Geneva, where, as Chief of Partnerships & Public Affairs, he created a public-private partnership programme for the Basel Convention on Hazardous Wastes. Milton Catelin has worked at the executive level in the Australian Department of the Prime Minister & Cabinet, the Department of Finance & Administration, and the Department of the Environment & Heritage. He was a chief negotiator for Australia on both the Kyoto Protocol on Climate Change and the Montreal Protocol on Substances that Deplete the Ozone Layer and has a Masters in Public Policy. He received an Australian Public Service Award for “significant and sustained contribution to the achievements of Environment Australia” in 2003 and the USA EPA Stratospheric Protection Award in 2003.

The Cleaner Future - coal for power & transport

Catelin’s presentation aimed to give a global perspective on coal. Accordingly, Catelin began his speech by pointing out the importance of coal in world primary energy use and, primarily, the importance for the world electricity and steel production. He particularly stressed that, even though coal has almost no influence on the Swedish energy balance, it represents one of the most widely used fuels in the world.

After a short introduction on World Coal Institute (WCI), Catelin presented statistics on coal production and trading, showing that coal is the fastest growing fuel and has been so for the last 10 years. Catelin referred to coal as abundant in 70 countries and mined in 50, for example, China, USA, India, Australia, and South Africa. At current rates of consumption, coal lasts more than three times as long as oil and more than two times as long as gas, according to recently published BP statistics. Catelin also explained that coal plays an important role in poverty alleviation. He illustrated this by referring to China, India and South Africa. In these countries power production from coal has enabled very high electrification rates, whereas the electrification rate is only 10 percent in some African countries where people rely on biomass for energy.

Catelin concluded that coal is an essential component of present and future global energy supply and use, along with energy efficiency improvements, nuclear power, and renewable fuels. This conclusion led him further on to the subject of carbon capture and storage (CCS). Catelin referred to the UN Intergovernmental Panel on Climate Change (IPCC) and their Special Report on CCS. The authors of the report claim that power plants with CCS could emit 80-90 percent less CO₂ net, and that the costs of stabilising CO₂ emissions can be reduced by 30 percent or more by including CCS in mitigation portfolios. The report further suggests that it is very likely that the potential leakage is less than 1 percent over 100 years and likely so for over 1 000 years. The storage capacity in geological formations is estimated to be huge, with deep saline formations corresponding to most of the storage potential. However, Catelin added that CO₂ transport will be necessary in many cases.

Catelin continued by suggesting that coal-to-liquids (CTL) production is particularly suited to carbon capture and storage. The CTL process involves gasifying coal which will give high concentration of CO₂ emissions. Moreover, significant local air quality improvements – i.e. lower emissions of nitrogen oxide, particulate matters, hydrocarbons and carbon monoxide –

can be achieved by exchanging conventional diesel with synthetic diesel. If the CO₂ emissions from the gasifying process were to be captured and stored, the overall environmental gain would be significant. Catelin added that commercial scale CTL technology already has been used for over 50 years in South Africa. Furthermore, the “break even crude oil price” for CTL production, including CCS, is no more than \$27-\$45/barrel (according to Princeton University studies). However, Catelin added, the technology may require governmental support due to capital costs exceeding those of conventional oil refinery – and full commercialisation of CCS and CTL will definitely not happen without government-industry partnerships.

Catelin summarized his speech by quoting the Executive Director of the International Energy Agency: *“The only possible overarching solution to a long-term sustainable future is to develop a global mix that uses all options simultaneously – to combine greater energy efficiency improvements with more renewables, more nuclear energy and more fossil fuels with CCS.”*

Göran Lindgren has since 2006 been the manager for the Power and Process Technology Department at Vattenfall. He has a background as a consultant in thermal combined heat and power, forest industrial energy, and nuclear power plant engineering. In 2004, Göran Lindgren joined Vattenfall Research & Development as a project manager within Vattenfall's CO₂ free Power Plant Project of Capture Technology in general and with a special focus on oxyfuel development, test and verification.

CCS Technology Implementation

Lindgren began his speech by presenting a few facts about the Vattenfall Group, being one of the major Energy companies in Europe. Vattenfall sells almost 200 TWh electricity on an annual basis, the main part being produced by hydropower, nuclear power, coal and natural gas. In addition, about 40 TWh heat is produced by biofuels, coal, and gas in cogeneration plants. Vattenfall has also been a major player in the environmental field and, for instance, developed high efficiency coal fired plants with extensive cleaning. However, Lindgren added, the CO₂ emissions are still to be taken care of. He explained that Vattenfall is responsible for a considerable part of the CO₂ emissions in Europe, emitting about 90 million tons of CO₂ per annum.

Lindgren continued by explaining some issues on carbon capture and storage (CCS). He mentioned that, presently, the three major pathways CO₂ capture are capture from the flue gases, called post-combustion or tail-end capture, by decarbonizing the fuel before combustion, called pre-combustion capture, or by the oxyfuel combustion, which might be described as a combination of the previous pathways. The oxyfuel combustion has thus far been the preferred method for Vattenfall. After capture, the CO₂ must usually be cleaned before compression, transportation and storage. The compressed CO₂ may, for example, be permanently stored in porous rock formations containing water called aquifers. According to Lindgren's presentation, three capture technologies can be commercial by 2020. All three technologies contain known technology and components, however, all three technologies also need optimisation, scale up and process integration.

The post-combustion capture technology is already commercially available in large scale and currently also the most expensive technology. When using post-combustion capture technology the carbon dioxide is separated from the flue gas by absorption or adsorption, whereupon the CO₂ is stripped from the absorbent/adsorbent, commonly utilising steam or pressure differences. Unfortunately, the net efficiency of a power plant is usually heavily decreased by this method. Another technology, which will also give severely decreased net efficiency, is the pre-combustion capture technology. The fuel will here be put into a gasifier, producing a so called syngas that mainly consists of carbon monoxide and hydrogen. The syngas may then react catalytically with steam in a shift reactor, producing CO₂ and more hydrogen. As the concentration of CO₂ is relatively high after the water-shift reaction, the CO₂ is easily separated from the hydrogen by adsorption or absorption. If the hydrogen produced through this gasification process subsequently is utilised in a combined cycle consisting of a gas turbine, a heat recovery steam generator and a steam turbine, it is a modified integrated gasification combined cycle (IGCC). The IGCC concept without capture already exists in several demo plants and IGCC with CCS might become a competitive technology. Nevertheless, Lindgren added, an optimised gas turbine still has to be developed.

The third technology that Lindgren mentioned was the oxyfuel combustion. At present, it is the most competitive and preferred technology for coal. At first, nitrogen will be separated from the combustion air. The flue gas will consequently mainly contain CO₂, water and unseparated nitrogen, together with some sulphur dioxide. The sulphur dioxide will be removed and, after cooling and condensation, the water can be separated from the CO₂. Vattenfall is trying to introduce this technology step by step. The company is now building a 30 MW oxyfuel combustion pilot plant right next to the Schwarze Pumpe power station in Germany. However, Lindgren was very careful to stress that, even though Vattenfall has taken the lead in oxyfuel combustion, they are also involved in developing other technologies for carbon capture.

During his presentation, Lindgren showed the audience graphs on specific investments with and without CO₂ capture as well as CO₂ avoidance cost. In the best case, the CO₂ avoidance cost is about € 20-30 per ton CO₂, when coal is used as fuel. The cost for storage and transport is not included here, but storage and transport is far less costly than CO₂ capture, Lindgren explained. The storage costs strongly depend on the depth of subsurface layers used for storage. However, compared to a capture cost of € 20-30 per ton CO₂, the storage cost is generally considerably lower, ranging from € 1-7 per ton CO₂ for aquifer onshore storage. The oxyfuel combustion test facility that is being built by the Schwarze Pumpe power station will produce CO₂ of a very high quality, Lindgren explained. The CO₂ can be stored anywhere or sold as a commercial product. Lindgren pointed out that the CO₂ is not a waste, but a product. However, several pilot storage options are examined at present, and Vattenfall anticipate to have a pilot storage ready when considerable amounts of CO₂ is being produced.

Lindgren brought his speech to an end by pointing out the importance of economic incentives and a proper legal framework to facilitate CCS initiatives. He also cleared up some difficulties concerning myths and realities about greenhouse gas abatement. For example, he said it is a myth that addressing GHG emissions will severely strain the global economy. On the contrary, Lindgren explained, reaching 450 ppm could cost as little as 0.6 percent of GDP if all low-cost opportunities are addressed. He concluded that cleaning coal-fired power plants from CO₂ will cost no more than cleaning cars with catalysts.

Gordon Couch is presently a Senior Consultant and Technical Author at the International Energy Agency - Clean Coal Centre (IEA CCC), a position he has had since 1985. His published reports during this period cover a wide range of topics from coal mining to different applications of coal including characteristics of coal, coal upgrading techniques, coal market studies, coal-fired power generation, metallurgical use of coal, coal cleaning technologies, etc. Gordon Couch's academic background is as a chemical engineer and he started his career in 1959 as a technical assistant at the British Ministry of Supply by working in a project to commission a light isotope plant. Gordon Couch subsequently was involved in heat transfer research at the BICC Research Centre and he has also had a number of positions at Berk Chemicals, Thomas Ness Ltd and the National Coal Board Mining Department between 1965 and 1985.

Clean coal technology developments in India

Couch was invited to the NOG seminar to talk about clean coal technology developments in India. He began his speech by presenting some facts about India. For example, he mentioned that the Indian land area is as large as one third of the European land area. Furthermore, more than one billion people live in India, compared to 730 million inhabitants in Europe. Couch pointed out that several millions of Indians live on less than one American dollar per day, and that India's GDP per capita ratio is \$700, compared to \$40,000 in Sweden.

Couch then presented figures on Indian fossil fuel reserves showing that 10 percent of the world coal reserves can be found in India. Most of the major Indian coalfields are situated in the north eastern and middle parts of the country. Couch explained that the mineral matter here is finely divided, making the coals difficult to clean. Indian coals are of extremely low grade and high ash content – and, consequently, none is exported. However, Indian coal demand projections show that coal demand in India will amount to 1 390 Mt/year in year 2021-2022, i.e. the current demand is predicted to increase three times in 15 years. Power generation already accounts for 72 percent of the total Indian coal consumption, and there are plans for large-scale capacity expansion. In fact, India is today already the third largest producer of coal-generated electricity. New supercritical units are now being built, with the first to be commissioned in 2009. The design efficiencies of these units will be more than 40 percent, which is a significant improvement in comparison to existing plants. Low-NO_x formation measures are taken in some plants, but flue gas desulphurization (FGD) is not yet perceived as necessary as the coal is low in sulphur content.

Couch pointed out that a considerable contribution could be made to increasing the efficiency of coal use by washing the coals and using the cleaner coal in large supercritical units and using the lower grade product in CFBC (circulating fluidized bed combustion) units. According to Couch, there are differences of view about the overall cost of cleaning, but the major boiler manufacturer BHEL says that it can build cheaper, smaller boilers with high efficiency and PLF (plant load factor), if the coal is washed. Couch added that there are discussions about setting up a National Clean Technology research centre, possibly based on BHEL's facilities at Tiruchirapalli in Tamil Nadu. A lot of good research and development work is undertaken there and elsewhere in India. An interested speculation, Couch said, is that in 20 years time, the flow of technical information on coal-related issues may be from India and China back into the OECD countries rather than the other way around.

According to Couch, India is unlikely to move far on reducing CO₂ emissions until it is required to do so by international agreement. The Indians have more pressing priorities in terms of reducing poverty through economic growth. Efficiency improvements will reduce the CO₂ per MWe of power produced, but CO₂ emissions will still grow as fossil fuel use grows. By 2030, the power sector emissions from India and China are likely to exceed those from all the OECD countries, according to the International Energy Agencies World Energy Outlook (IEAWEO) 2006 projections.

A national Cleaner Coal Technology programme is being formulated in India to plan strategically for the development, demonstration and commercial deployment of new and more efficient technologies. However, Couch added, while there is a considerable urgency to implement such a programme, decision making in India tends to proceed quite slowly. Couch explained that in the longer term, consideration will undoubtedly be given to the use of alternative fuels. However, oil will continue to be the main source of transport fuels. Furthermore, the most obvious source of natural gas is Iran with a pipeline coming across Pakistan, and, taking into consideration the political situation, this is very unlikely to happen in the short term. There will be opportunities for renewables, including solar, tidal and wind power – and hydro power is already well exploited. Even so, Couch summarized, coal is likely to remain a major energy source in India, and its clean and efficient use is of vital interest.