



# Energieia

## Coal in China

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### INTRODUCTION

China is a nation in transition from a centralized to a market economy, where increasing industrialization will need to be underpinned by increased energy usage. Coal, representing close to 70 percent of total primary energy consumption, will remain the major energy source in China even though alternative indigenous energy sources, such as oil, natural gas, hydro and nuclear power, are being exploited. The rate of energy growth is such that coal use is expected to increase significantly. Recent Government estimates suggest that by 2020 total coal consumption will exceed 2.4 billion tonnes compared to some 1.7 billion tonnes in 2003.

### COAL PRODUCTION ISSUES

The centers of coal production and utilization do not coincide and this creates certain logistical problems.

The need to maintain coal production during a period of growing domestic demand is a major challenge that raises issues of sustainability, particularly as there are flexibility limitations within the central planning function of the Chinese coal sector. Thus, coal can be produced from:

- ▶ State key mines that are large, generally modern units under provincial government control
- ▶ Local state mines that are smaller, only partially mechanized and administered by provincial governments
- ▶ TVE (Township and Village Enterprise) mines that are run by local TVE government and by private individuals. These are very small and use manual extraction techniques, which waste resources and also are dangerous in many cases.



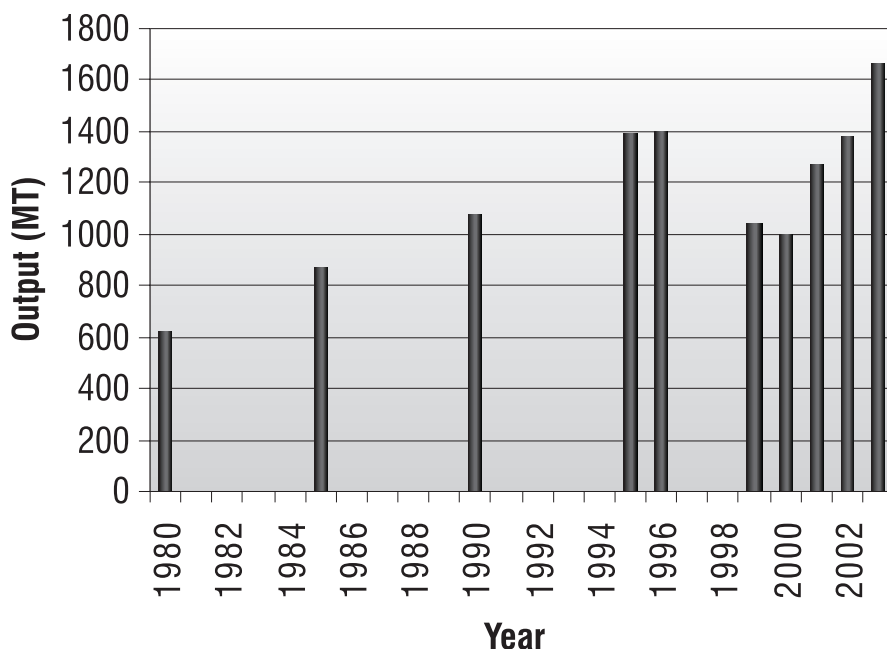
Figure 1. Map of China showing the various coal exporting and importing provinces.

During the 1990s there was a steady increase in production but at the same time supply was exceeding demand. In 1996, following the State Government intervention, there was a very significant downturn with production falling from a high of some 1.4 billion tonnes to about 1.0 billion tonnes four years later. This was achieved by closing many of the TVE mines, which had produced 46 percent of total production, while the coal stockpiles were run down. However, since then there has been a very significant upturn, mostly linked to the rapidly growing coal-fired power generation market. This caused a subsequent supply problem because the large State key mines could not rapidly increase production, nor could those mines in

the planning process be brought into production much ahead of schedule. Consequently, the shortfall had to be provided via the TVE mines. As such, there is a conflict between ensuring the longer-term optimization of resource utilization while at the same time dealing with shorter-term production needs.

Another factor to consider is the need to balance domestic supply and demand with international earning opportunities. The Government controls the levels of exports through export licenses and through the provision of financial support via tax credits to offset the adverse price differential between the domestic and international markets.

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**Figure 2. Trends in coal output in China.**

There had been a steady and continuing increase in coal exports from China, but from 2004 the government limited export licenses and reduced the tax credit with the aim of controlling exports at the 80 Mt level (compared to some 90 Mt in 2003) in order to alleviate domestic supply pressures. After May 2004, there was a further constraint on the export of coking coal, reflecting the Government's intention to ensure domestic demands are met first.

Alongside this, China has imported some 11Mt coal into South and East China, primarily for power plant use, but also for other markets such as coking. There are strong indications that imports will increase and that the import region will spread beyond the coastal regions.

## ENVIRONMENTAL ISSUES AND POLICIES

About 86 percent of the coal is burned directly with limited pollutant control undertaken, resulting in significant emissions of particulates, SO<sub>2</sub> and NO<sub>x</sub>. The magnitude and extent of the environmental problems vary, dependent upon the particular market sector. In addition, coal use is relatively inefficient compared to OECD (Organization for Economic Co-operation and Development) countries. It is estimated that if OECD standards could be achieved, then the 2003 annual coal utilization could be

reduced by some 300 million tonnes with associated reductions in emissions. From a global perspective, the significantly increased emissions of carbon dioxide are also a concern.

Clean Coal Technologies (CCTs), which offer improvements in coal utilization efficiency and enhanced environmental performance, thus have a pivotal role to play in reducing China's emissions of greenhouse gases and other atmospheric pollutants. Such CCTs can be made available, both from domestic and international sources, although progress in their introduction varies between the major industrial sectors for a variety of reasons. There are no Government policies that specifically encourage CCT introduction in any sector. However, there are drivers in some sectors that are resulting in some CCT introduction.

## COAL FIRED POWER GENERATION

As part of the ongoing reform of the energy sector, the State Power Corporation has been broken up

100 (MWe)	110-135 (MWe)	140-199 (MWe)	200-220 (MWe)	250-300 (MWe)	320-362.5 (MWe)	500-800 (MWe)
133	177	8	199	198	69	42

**Table 1. Number of coal fired units with varying capacities in 2002.**

into five-generation companies, two network companies and four service companies, with the intention that competition will be introduced into the power sector. However, the current situation is far from being market-based, in terms of setting electricity prices, the role of the network companies and the fact that demand remains in excess of supply. As such, the emphasis is on keeping all units on the grids without any opportunities to make improvements in performance.

The majority of power is and will continue to be produced from coal although in the near future some natural gas combined cycle units will be brought into operation. Coal use for power production in 2003 was 850 million tonnes, and was expected to reach 930 Mt by the end of 2004, continuing to rise after that. The Government recognizes that such increases cannot be maintained and there are some indications that demand-side energy efficiency measures will be introduced to attempt to limit the rate of increase.

The coal-fired capacity mix mostly comprises pulverised coal (pc) fired plants, the majority of which are 100 MWe and 200-300 MWe units with sub-critical steam cycles. There is a trend towards new, larger pc units, of higher efficiencies, together with the closure of the very small least-efficient units. Since the National Development and Reform Commission has approved supercritical and ultra-supercritical pc plants as the most appropriate way forward for large-scale power generation, it is likely that there will be a surge towards 1000 MWe power plants with advanced steam conditions. Along with this approach, and again in line with Government policy, there is a steady introduction of circulating fluidized bed combustors (CFBCs) to complement the pc applications, where the technology's capability of burning lower grade and variable-quality fuels is of particular benefit.

With the introduction of stricter and enforced emissions regulations, the generation companies are being pushed to introduce techniques to control gaseous emissions. In particular, better quality ESPs are needed to deal with dust emissions while for new plants, at least,

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Time period of construction for power project	Time-period I (Before January 1997)		Time-period II (January 1997 to end December 2003)		Time-period III (January 2004 onwards)
	Date set for compliance	January 2005	January 2010	January 2005	January 2010
Dust from a plant in or near a city (mg/m <sup>3</sup> )	300	200	200	50	50
SO <sub>2</sub> from a plant in or near a city (mg/m <sup>3</sup> )	2100	1200	2100	400	400

**Table 2. Dust and SO<sub>2</sub> emission standards for coal fired power plants.**

some level of NO<sub>x</sub> control is also required to meet the new NO<sub>x</sub> emission limits. With regard to SO<sub>2</sub> control, FGD is now becoming more commonplace. At present, some 6 GWe of capacity has FGD installed, almost all wet scrubbers. By 2008, FGD may be installed on 58-59 GWe of capacity. This represents 21 percent of the 2003 capacity and ~13 percent of the predicted 2010 capacity.

The development and application of CCTs need a significant amount of investment. Although China is an industrializing country with rapidly growing GDP, there are limited investment reserves. This in itself represents one of the major barriers for the development, introduction and use of CCTs. Thus, it is a major challenge for China to ensure that the very ambitious program to expand coal-fired power production, using large-scale advanced technology with higher efficiencies and better environmental performance, can be achieved. Alongside this there will also need to be significant investment to increase coal production and the associated infrastructure. It therefore seems likely that China will need access to international finance to supplement private and State investment from within. Consequently, it seems essential that further rationalization of the sector is achieved to resolve potential conflict between planned- and market-aspects of the economy such that external investors can be confident of an acceptable rate of return. For example, there appears to be a strong need for an integrated solution to price reform since electricity prices are currently set by the State, while coal prices are decided primarily, but not wholly, by market forces.

## NON-POWER SECTOR INDUSTRIAL COAL USE

Total non-power industrial coal use in 2003 was close to 800 Mt, which is similar to that in the power sector. However, the position is quite different, with each sub-sector being relatively small compared to the power sector and rather fragmented in scope and application. It includes:

- ▶ The use of coal for various applications by the coal industry (coal preparation; coal briquettes; heat/power generation from coal refuse and fines; utilization of fine coal water mixtures; utilization of coal bed/coal mine methane)
- ▶ Coke production and pulverized coal injection within the metallurgical industry
- ▶ Coal gasification for the production of chemicals and chemical fertilizer feedstock production
- ▶ The use of coal in kilns and furnaces for building-materials production, particularly cement
- ▶ Cross-sector systems, especially grate fired and fluidized bed boilers for heating and process applications.
- ▶ Coal liquefaction, which is a State Government-based strategic initiative, which is being undertaken by coal industry companies.

In contrast to the power sector, each sub-sector has differing needs, with large variations in regional demands and economic health, and with differing levels and types of technologies. Thus, although the overall potential market needs are very significant, each non-power sub-sector has been self-contained. This has been compounded by the fact that possible demonstration and commercial projects in these sub-sectors would be relatively small and more complex compared to competing power-sector projects, thereby limiting interest

from the multilateral donors. Consequently, Chinese technology development has been constrained with little involvement by OECD industrial enterprises. In addition, in most instances, the environmental drivers are neither strong enough nor robustly enforced such that technology dissemination will be effective after demonstrations.

There is considerable potential to introduce more advanced systems with economies of scale, higher efficiencies and better environmental performance. However, the issue of environmental drivers is crucial to the sustainable introduction of improved coal utilization techniques in this sector. There are many examples where the production capability for domestic technology (e.g. CWM and briquettes) has been established without sufficient attention being paid to the market conditions. Consequently, demand for cleaner-coal products has not materialized despite the various edicts from the State Government. There has been some encouraging introduction of international gasification technology from a number of vendors; however, the impact has been limited due to lack of reform in the appropriate sub-sectors. Similarly, there has been a program to introduce advanced industrial boiler designs from OECD countries in an attempt to counter the low efficiencies and major levels of local pollution arising from domestic units burning raw (i.e. unwashed and un-graded, poor and variable quality) coal. While there have been some technical improvements, the fundamental problems associated with the use of raw coal and the lack of strong emissions legislation remain, thereby limiting uptake of the technologies.

Finally, there is the development of coal liquefaction, which is a strategic initiative meant to provide a means for countering excessive oil imports and associated price vulnerability. Here an ambitious technology demonstration program is underway, covering both direct and indirect processes, with the intention of progressing to extensive commercial applications within China. It remains to be seen how such demonstrations will be both technically and economically, with consequent implications for

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commercial applications, bearing in mind the changing economic circumstances of China.

## THE WAY FORWARD

Overall, there is evidence of a market economy being established, but it is also evident that there is a need to resolve inconsistencies with the planned aspects of the economy (e.g. integrated solutions to price reform). For certain sectors and sub-sectors, the Government must carefully consider the need for additional policies, backed by further strong, robust environmental drivers, if sustainable improvements are to be achieved. Within such a scenario, the Government and its representatives will need to remain fully informed about policy-related choices as well as the CCT options, potential benefits and implications within the global context.

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Dr. Minchener's more detailed IEA report on this issue may be purchased from the US IEA Coal North American sales representative, CAER Librarian, Theresa Wiley at: [wiley@caer.uky.edu](mailto:wiley@caer.uky.edu) or (859) 257-0309.

## COMMENTARY

In place of the usual editorial that resides in this section of *Energieia*, you will find a few recent CAER achievements. More information on the Center's news can be found at our web site: [www.caer.uky.edu](http://www.caer.uky.edu).

### COMMONWEALTH COLLABORATIVE

A current US DOE-funded project that investigates advanced coal by-product processing has been selected as a UK Commonwealth Collaborative project. The CAER investigators are: Tom Robl and Jack Groppo.

The project was selected based on the application of research in addressing Kentucky's ongoing challenges and advancing its future. The investigators will be publicly recognized by UK President, Dr. Lee Todd, for distinguished scholarship, leadership, and commitment to university engagement.



CAER researchers 'scalping' the feed samples at the LG & E plant in Ghent, Kentucky.

### HOMELAND SECURITY AWARDS

Rodney Andrews and Darrell Taulbee recently received grants for Homeland Security Research and Development Projects. The announcement was made on August 8th by United States Congressman, Hal Rogers (R-5th District) at the Center for Rural Development in Somerset, Kentucky. The projects both strive to diminish problems related to explosions. Andrews' \$1M project is entitled, "**Carbon Materials for Blast-mitigating Wall Treatments**" and concerns the development of effective, low cost, modular wall panels to provide blast protection, electromagnetic shielding, radiological protection and chemical agent removal. The other project, "**Reduction of the Explosion Potential of Ammonium Nitrate by Coating with Low-Cost, Coal Combustion By-Products**" will use an ash-like, coal-combustion by-product to desensitize agricultural-grade ammonium nitrate with respect to detonation. It is funded for \$124K.

The University of Kentucky is part of The Kentucky Homeland Security University Consortium, which conducts research and development on ideas that might prove useful to the Department of Homeland Security. Eight universities and the Kentucky Community and Technical College System make up the consortium. Morehead State University will contribute to work on Andrews' project. Other collaborators are Drs. Mark Meier, John Selegue, and John Anthony, from UK's Department of Chemistry, and Mr. Robert Wombles, Vice President of Technology, Koppers Industries.

### AWARD TO REDUCE DIESEL ENGINE EMISSIONS

CAER researcher, Mark Crocker, recently received news that a proposal entitled, "**Investigation of Aging Mechanisms in Lean NOx Traps,**" will receive a total of \$1,079,314 in funding from the US DOE, including cost share, over the next three years. The project will work to reduce NOx emissions in lean exhaust gases (i.e., gases in which excess oxygen is present) such as those emitted by diesel engines. Improving catalyst durability will be a major goal of the project. This is important because environmental concerns are resulting in the adoption of stringent new NOx emission standards in the U.S. for diesel vehicles. Staff working on this project will spend a portion of their time at Oak Ridge National Laboratory and Ford Motor Company.



CAER Researcher, Mark Crocker.

## RECENT SHORT COURSE AT CAER

On September 21st, Kenneth Krupinski taught a course organized by the CAER's Rodney Andrews, entitled "**Coal and Petroleum Coke-Making.**" The 33 participants learned from Mr. Krupinski's 30 plus years in the industry. The half-day short course provided a fundamental knowledge of coke and coke making. Topics covered included production methods, uses, and properties of the two major coke types (metallurgical and petroleum cokes). Other topics included: a history of coking; types of coke ovens – recovery, non-recovery, pre-heat, and jumbo; coal-tar production and collection; and coal-tar pitch production.



**CAER Associate Director for the Carbon Group, Rodney Andrews (left) waits patiently for his photo alongside Ken Krupinski, who taught the half-day short course.**

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**Energieia** is published six times a year by the University of Kentucky's Center for Applied Energy Research (CAER). The publication features aspects of energy resource development and environmentally related topics. Subscriptions are free and may be requested as follows: Marybeth McAlister, Editor of **Energieia**, CAER, 2540 Research Park Drive, University of Kentucky, Lexington, KY 40511-8410, (859) 257-0224, FAX: (859)-257-0220, e-mail: [mcAlister@caer.uky.edu](mailto:mcAlister@caer.uky.edu). **Current and past issues of Energieia** may be viewed on the CAER Web Page at [www.caer.uky.edu](http://www.caer.uky.edu). Copyright © 2005, University of Kentucky.

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