International Energy Agency: Focus on Asia Pacific

FOCUS ON CLEAN COAL

Paper

November 2006

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INTERNATIONAL ENERGY AGENCY

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It carries out a comprehensive programme of energy co-operation among twenty-six of the OECD's thirty member countries. The basic aims of the IEA are:

- To maintain and improve systems for coping with oil supply disruptions.
- To promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations.
- To operate a permanent information system on the international oil market.
- To improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use.
- To assist in the integration of environmental and energy policies.

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The OECD is a unique forum where the governments of thirty democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

The OECD member countries are: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission takes part in the work of the OECD.

FOCUS ON CLEAN COAL

A briefing note prepared in June 2006 with November 2006 updates

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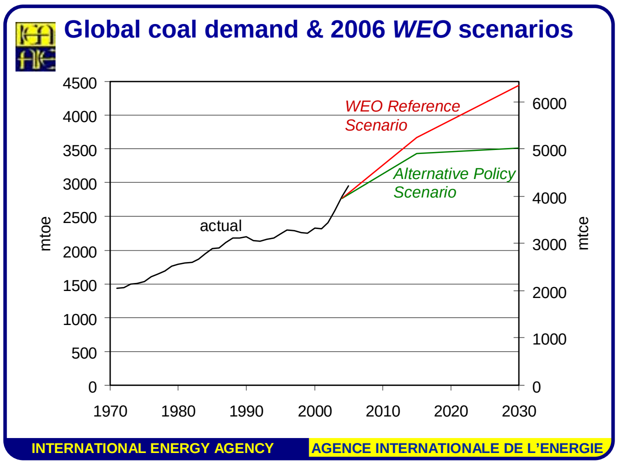
Introduction

1. This note provides an update on growth in global coal demand, the potential for efficiency improvements through the application of best practices at coal-fired power stations, and recent developments in the field of clean coal technologies incorporating carbon dioxide capture and storage.

Background

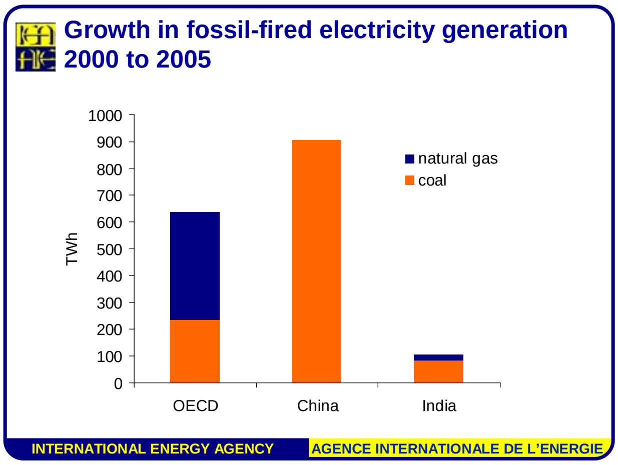


2. Coal use is rising in all regions – policies assumed in the IEA's 2004 edition of *World Energy Outlook* (*WEO*) *Alternative Policy Scenario* have not been adopted, whilst the major developing countries are following energy-intensive growth paths. In fact, current global coal demand already lies above earlier forecasts for 2030, with no signs that the growth trend will reverse. It is also notable that the rate of growth is significant in almost all regions and countries, except North America and Europe.

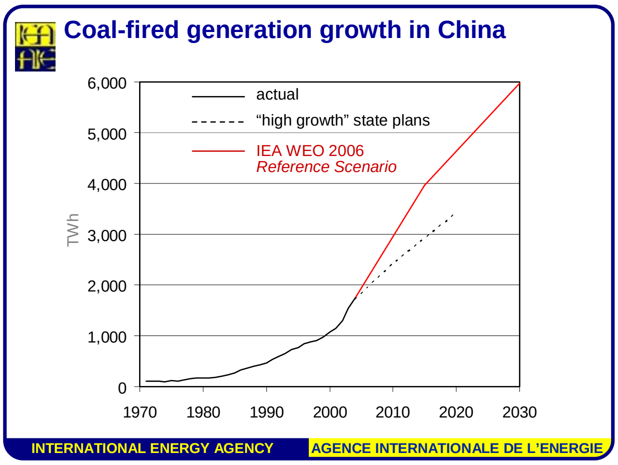
Coal demand (and growth) in selected regions and countries in 2005

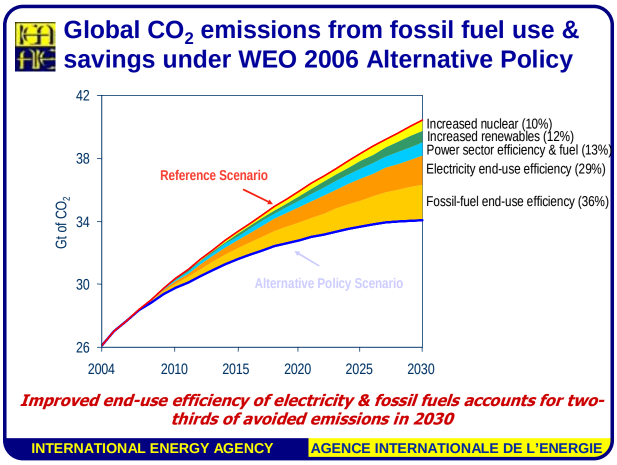
	Actual	
	mtoe in 2005 (annual % growth 2000-05)	
World	2998	(5.5%)
OECD N America	588	(0.3%)
EU-25	300	(-0.4%)
OECD Pacific	221	(3.5%)
China	1203	(13.4%)
India	209	(5.0%)

3. High oil and gas prices are driving demand for coal, but economics is not the only driver. For example, energy security concerns have led to a renewed interest in coal-to-liquids (CTL) as an alternative source of transport fuels. China is proceeding with large CTL projects and aims to produce 50 mtoe by 2020 from 200 million tonnes of coal. Whilst CTL raises its own issues, not least its potentially high CO_2 intensity, it remains a niche market for coal. Of the 5.9 billion tonnes of coal produced in 2005, two thirds was destined for power generation – the focus of this note.



4. Between 2000 and 2005, electricity generation grew by 1.5% per annum across OECD member countries. Although dominated by the growth in output from gas-fired plant (+402 TWh), output from coal-fired plant grew by 234 TWh. Over the same 2000-05 period, output from thermal power plants in China grew by 905 TWh (12.6%/yr) and by 106 TWh (4.5%/yr) in India, predominantly coal-fired.





5. Capacity additions in the generation sector are a leading indicator of future coal consumption. China and India are adding significant coal-fired capacity to meet projected demand: 27.5 GW per annum in China (2000-05) and 1.6 GW per annum in India over the same period. According to China's National Development and Reform Commission, over 50 GW of new coal-fired capacity should come on-line in 2006. India is likely to fall short of its 3.5 GW target for 2006.

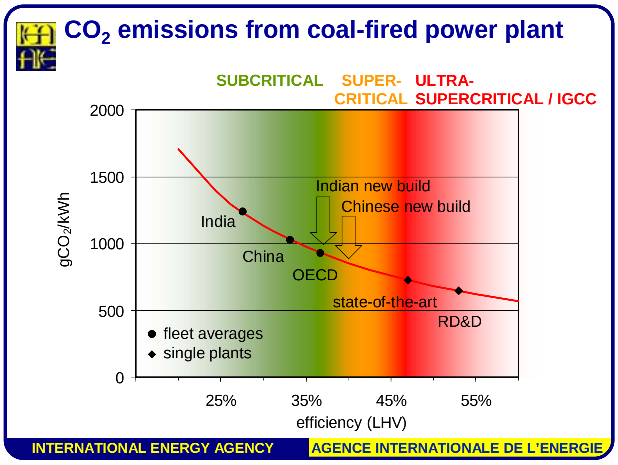
Coal-fired generation capacity (and output) in China and India: actual and state-planned growth

	China		India	
	actual & planned GW (TWh/yr)		actual & planned GW (TWh/yr)	
2004	302	(1720)	73	(450)
2010	469	(2420)	95	(595)
2020	661	(3420)	160	(1027)
2030			290	(1912)

6. In the 2006 *WEO Reference Scenario*, energy-related CO_2 emissions rise 98% above 1990 levels by 2030 (*c.f.* a 67% rise in the *Alternative Policy Scenario*). If China and India continue to follow the high economic growth paths that predicate the above capacity additions, global CO_2 emissions could easily rise to double 1990 levels by 2030.

7. Available, conventional, coal combustion technologies have the potential to reduce future CO_2 emissions from power generation in all countries, technologies such as those based on supercritical steam conditions. For example, an older coal-fired power plant with subcritical steam conditions operating at 35% efficiency might be replaced by a new one operating at 45%, reducing fuel use and CO_2 emissions by 22%. When planning a new power plant, selecting state-of-the-art technology might yield a reduction of up to 10% in emissions, compared with today's standard supercritical technology.

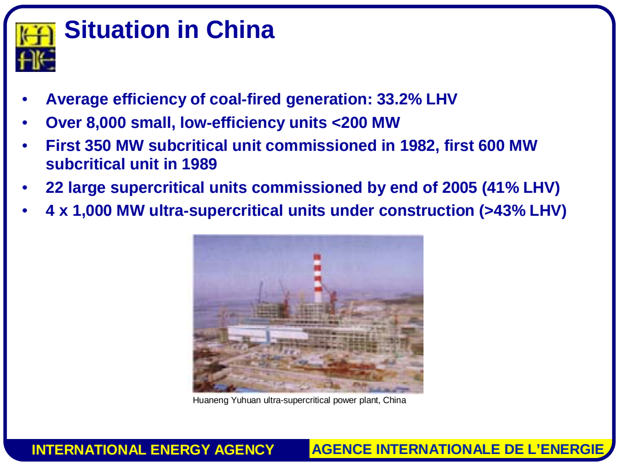
8. The strategy and choice of technology adopted are largely economic decisions. Extending the life of old, inefficient plant is very often more economic than replacing with new, and the additional cost of high-efficiency, supercritical plant can be difficult to justify, particularly in regions with access to low-cost coal.

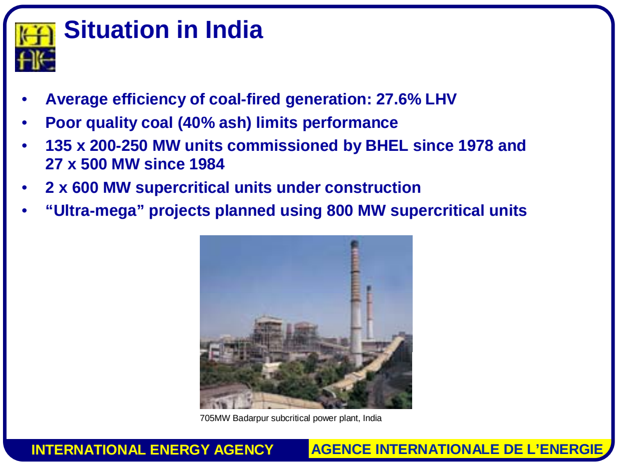


9. In 2003, the average efficiency of coal-fired power generation in China was 33.2% and, in India, it was 27.6%, compared with an average in OECD member countries of 36.7% – all calculated using IEA gross generation data (at generator terminals) for 2003 and the fuel's net calorific value (NCV) *i.e.* lower heating value (LHV). Average efficiencies are lowest in those countries where large numbers of small units <200 MWe continue to operate, often well beyond their design lives.

10. Whilst Chinese coal can be, and sometime is, prepared to a high quality with a calorific value (CV) equal to the 6,000 kcal/kg typical of internationally-traded coals, it is generally left unwashed for use in power generation, with an ash content of up to 25% and a CV below 5,200 kcal/kg. Indian coal is now rather poor with a low CV, typically 3,600 kcal/kg, and high ash content, typically 40%, that is difficult to wash below 30%. Older Indian power stations were designed for better coal and operate inefficiently with the coal now supplied. With renovation and modernisation, design performance can be restored or surpassed, as demonstrated in 2003 when the upgrading of four 60 MWe units dating from 1967/68 at Talcher power station was completed. Properly preparing a greater proportion of the coal supplied to power stations in China and India would also improve performance.

11. The bulk of coal-fired plants constructed in China and India have been subcritical: mainly 350 MWe and 600 MWe units in China, commissioned since 1982 and 1989 respectively; and, in India, BHEL has commissioned a total of 135 × 200-250 MWe units since 1978 and 27 × 500 MWe units since 1984. Although never state-of-the-art, the efficiency of these large units is respectable enough by OECD standards.





12. In China, the latest technologies are now being adopted – half of all coal-fired plant orders in 2004 were for supercritical units. China has commissioned supercritical units of 300 MWe, 500 MWe, 600 MWe and 800 MWe with an average efficiency of 41% (LHV). In 2004, the first, locally designed and built 600 MWe supercritical unit was commissioned at Qinbei, and, by the end of 2005, the total number of large supercritical units was twenty-two, with plans to build one hundred more. The first of four 1,000 MWe ultra-supercritical units, using Siemens technology, is under construction at Yuhuan with a scheduled commissioning date of 2007. The unit is state-of-the-art at this size, with an efficiency of >43% (LHV).

13. In India, the first two 660 MWe supercritical units are under construction by Doosan at Sipat and the country plans a series of >4,000 MWe "ultra-mega" projects totalling 17.6 GWe based on 800 MWe supercritical units, possibly supplied locally by BHEL. However, past performance suggests that India may not achieve this ambitious plan, even though it forms a part of the government's "100,000 MW thermal initiative" to add 100 GWe of coal- and gas-fired plants by 2012.

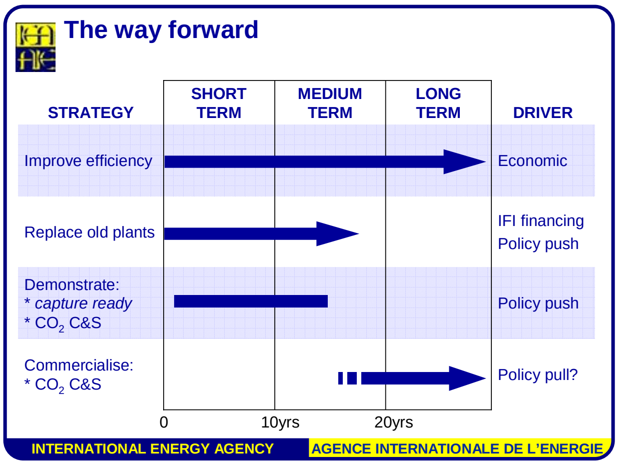
14. Whilst it might be argued that China and India could move more swiftly to adopt the latest, most efficient generation technologies at all new plant, the potential gains would have a relatively small impact on the general trend of rising emissions. In the case of India, further liberalisation of the mainly state-owned and state-managed coal and electricity sectors would speed progress by encouraging more rational decision making within a competitive market.

15. The situation with old plant is more complex. Ageing plant that should ideally be replaced exists almost everywhere, for example in the USA, Europe, South Africa, China and India. The average age of coal-fired plant in the USA is over 30 years on a capacity-weighted basis, whilst in India, it is 18 years. To reduce emissions, replacement of the oldest plant should be a high priority, but it is rarely economic and electricity demand growth dictates that these plants often remain open.

16. In theory, under the Kyoto Protocol, the Clean Development Mechanism (CDM) should provide an incentive for owners of inefficient plant in non-Annex I countries, such as China and India, to invest in upgrades or replacements that reduce emissions. In practice, demonstrating additionality and agreeing baselines with the CDM Executive Board has proven impossible, such that no projects have proceeded at coal-fired plant.

17. Advanced clean coal technologies incorporating CO_2 capture and storage (CCS) offer the prospect of containing emissions from coal use. It is not yet clear whether coal combustion in a conventional boiler with steam turbines, or coal gasification with gas and steam turbines will be the preferred route forward. However, the ability to retrofit CCS during plant upgrades and build new plants that are "capture ready" would have clear advantages. The IEA's G8 work programme explores these issues.

18. Annex I lists selected projects to illustrate that whilst the technologies to capture and store CO_2 exist and can be demonstrated, they are, in the case of coal, at least ten years from commercial deployment. In any case, there are no economic drivers for them to be adopted.



19. The projects listed show governments and industry taking some early, tentative steps with a technology that must be adopted quickly if the CO_2 emissions' trajectory of the next 25 years is to be radically altered.

IEA Activity

20. In November 2005, the CIAB organised a workshop, *"Meeting Our Energy Needs – driving forward coal's role in a clean, clever and competitive energy future"*. The workshop concluded that improving coal-fired plant efficiency, through the application of best practices, was an essential first step that could, and should, be taken around the world to stem the rise in global emissions. There was a divided view on the timing of advanced technologies, some believing that commercialisation of CCS before 2020 was impossible, with others calling for earlier deployment. All agreed that, with the strong and active support of governments and industry, the timing could be accelerated to show more quickly that coal can have a sustainable role in the future global energy mix.

21. At the March 2006 Governing Board meeting, the CIAB Chair, Preston Chiaro of Rio Tinto plc, reviewed the situation of coal, beginning with its abundance and its contribution to energy security. The CIAB called for greater industry/government co-operation to ensure low-emission coal technologies are deployed quickly, within a predictable policy framework.

22. In May 2006, the IEA and the World Coal Institute co-hosted a workshop, *"Coal for Sustainable Energy: Clean Development and Climate Change"* in New Delhi, India. The agenda covered issues faced by the coal industry and national responses, including the potential for emissions improvement at Indian power stations using conventional, best-practice technology and methods to stimulate deployment of these technologies. Coupled with the workshop, the Secretariat led site visits to two older coal-fired power stations in India. Similar activities are envisaged for China in 2007.

23. In November 2006, a workshop, *"Coal-to-Liquids – an alternative oil supply?"*, was held bringing together coal industry leaders from IEA member countries and their counterparts from South Africa, China, Russia and Poland. Coal-to-liquids (CTL) has a long history in South Africa and Sasol now converts 40 million tonnes of coal per year to produce 160,000 barrels per day (bpd) of crude oil equivalent using the commercially-proven indirect liquefaction process. In the USA, companies are moving ahead with projects that seek to reduce the country's dependence on imported oil, encouraged by a variety of Federal and state government incentives. However, it is in China where new projects are being developed in earnest, with a major construction project underway in Inner Mongolia. This plant, using newly-developed direct liquefaction technology and scheduled for commissioning in

2008, will produce one million tonnes of oil products each year (20,000 bpd) with a planned expansion to 100,000 bpd. Dr Yuzhuo ZHANG, Chairman of China Shenhua Coal Liquefaction Corporation, explained that this project formed one component of a strategy that would limit oil imports to below 50% of China's demand by 2020 when direct and indirect coal liquefaction plants are expected to meet 10-15% of the forecast 450 million tonnes (9 million bpd) annual oil demand. The global abundance of coal means that CTL could play an important future role, especially if greater experience leads to improved economics. However, as in other energy sectors, the scarcity of capital and skills was considered to be a major hurdle. NGOs, industrialists and policy advisors were all agreed that using coal as an alternative to oil for producing transport fuels will require CCS, if significant increases in carbon dioxide emissions are to be avoided. In OECD countries, the need for CCS was taken as a given by project developers. In China, it is not a priority, but participants at the workshop heard a clear willingness to apply the technology if some way could be found to cover the economic cost.

24. The Secretariat, the Working Party on Fossil Fuels (WPFF), the Carbon Sequestration Leadership Forum (CSLF) and certain IEA Member governments have been active in addressing national and international legal issues associated with the geological storage of CO_2. Significant progress has been made with the necessary amendments to international treaties. Greater public awareness of CO_2 storage must be achieved before it can be viewed as an acceptable mitigation option.

25. The Implementing Agreement for an IEA Greenhouse Gas R&D Programme (GHG IA) is actively supporting CCS. GHG IA co-sponsored the 8th International Conference on Greenhouse Gas Control Technologies in Trondheim, Norway, 19-22 June 2006. It is also undertaking an engineering and cost study on "capture ready" plants that will inform the Secretariat's policy work on this concept.

26. The Implementing Agreement for the IEA Clean Coal Centre is extending its global database of existing coal-fired power plants to assist with the IEA's G8 work and bring greater precision to the analysis of plant performance. The Centre is also preparing a series of case studies on recently constructed power plants that, together with a study of best practices at existing plants, will help the Secretariat quantify the overall benefits of plant upgrading, including the potential for CCS retrofit.

27. Also forming part of the IEA's G8 work programme, a joint IEA/CSLF workshop was held during August 2006 in San Francisco, covering near-term opportunities for CCS that are technically viable for demonstration or economically viable for commercialisation. Further events are planned in Norway and Canada in 2007.

28. The new IEA publication, *Energy Technology Perspectives to 2050*, launched in June 2006, shows that CO_2 capture and storage is critical to obtaining a long-term decrease in CO_2 emissions. In one scenario, 4 Gt/yr of CO_2 would be captured from coal-fired power plants by 2050 (equivalent to 20% of the emissions from fossil fuel use in 1990).

Key Findings

29. There is a consensus that the way forward is with the more rapid adoption of best practices at new and existing plants, and with the large-scale demonstration and deployment of CCS. The former is often economic with little need for new policy incentives and can deliver benefits in the short-term, especially in the larger, developing countries where fuel purchasing strategies, plant renovation and modernisation, and choice of technology for new build all play a role. In contrast, the latter is expensive with benefits accruing only in the medium to long term and will require policy incentives, but is essential to have any hope of reversing the trend of rising CO_2 emissions.

30. In all countries, replacement of small, old and inefficient generating plants would have the greatest impact on emissions; new policies and financing schemes are needed to encourage this.

31. In the case of CCS, the IEA recommends 10-15 demonstration projects are needed to prove the various technology options with different fossil fuels. Greater international co-operation and collaboration is needed between national programmes to establish these projects. New IEA Implementing Agreements could play a role here.

32. Given the scale of new plant build without CCS, technology options that can be retrofitted are urgently required to give credibility to the "capture ready" concept.

33. Technology costs will fall and the trend towards CO_2 pricing in some regions could provide the right financial incentive for the adoption of CCS, whether though emissions trading schemes, tax-based incentives or other market-based mechanisms, but potential investors need political, policy and regulatory certainty over the 25-year investment periods typical for coal-fired plant.

34. The reality is one of policy uncertainty. Only when CO_2 emissions have a universally recognised cost will markets operate to allocate capital efficiently to reduce global emissions. Until then, progress will be sporadic, but can be influenced and informed by the IEA's G8 programme of work. Also in response to the G8 request, the World Bank's *Investment Framework for Clean Energy and Development* is a recognition by the international financial institutions that significant abatement opportunities exist in the fossil fuel sector, providing existing resources are reallocated and new financing instruments designed.

ANNEX 1

Selected technology demonstration projects incorporating carbon dioxide capture and storage (CCS)

Company / project name	Fuel	Plant output and (cost)	Technology	Start date
BP / SSE DF1, Peterhead / Miller, Scotland	natural gas	350 MW ($600M)	autothermal reformer + pre-combustion, storage in oilfield – EOR	2010
BP DF2, Carson, USA	petcoke	500 MW ($1bn)	IGCC + shift + pre-combustion, storage in oilfield – EOR	2011
China Huaneng Group (CHNG), GreenGen, China	coal	100 MW	IGCC + shift + pre-combustion	2015
E.ON, Killingholme, Lincolnshire coast, UK	coal	450 MW (£1bn)	IGCC + shift + pre-combustion? (may be capture ready)	2011
Ferrybridge, Scottish & Southern Energy, UK	coal	500 MW (£250m)	PC (supercritical retrofit) + post-combustion capture (£100m)	2011
FutureGen, USA	coal	275 MW ($1bn)	IGCC + shift + pre-combustion	2012
GE / Polish utility	coal	1000 MW	IGCC + shift + pre-combustion	
Karstø, Norway	natural gas	430 MW	NGCC + post-combustion amine, potential storage in oilfield – EOR	2009
Mongstad, Norway	natural gas	see footnote[1]	CHP with post-combustion CCS	Phase 1: 2010[2] Phase 2: 2014[3]
Nuon, Eemshaven, Netherlands	coal / biomass / natural gas	1200 MW	IGCC with option to capture	2011
Powerfuel, Hatfield Colliery, UK	coal	~900 MW	IGCC + shift + pre-combustion	2010
Centrica / Progressive Energy, Teesside, UK	coal (petcoke)	800 MW ($1.5bn)	IGCC + shift + pre-combustion (+ H_2 to grid)	2009
SaskPower, Saskatchewan, Canada	lignite	300 MW	PC + post-combustion or oxyfuel, storage in oilfield – EOR	2011
Siemens, Germany	coal	1000 MW €1.7bn	IGCC + shift + pre-combustion	2011
Stanwell, Queensland, Australia	coal	100 MW	IGCC + shift + pre-combustion, storage in saline reservoir	2012
Statoil/Shell, Draugen, Norway	natural gas	860 MW	NGCC + post-combustion amine, storage in oilfield – EOR	2011
RWE, Germany	coal	450 MW (€1bn)	IGCC + shift + pre-combustion, storage in saline reservoir	2014
RWE, Tilbury, UK	coal	1000 MW (£800m)	PC (supercriticial retrofit) + post-combustion, may be capture ready	2016

[1] The plant has an electricity output of 280 MW and 350 MW of heat.
[2] Includes testing of capture facility (100,000 tonnes of CO_2, storage site to be determined).
[3] Full scale CCS.

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