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Industry View
Cautious

Capital Goods

Clean Coal: Opportunities Alstom, GE and Siemens

Coal will remain the dominant fuel source for electrical power generation. Coal accounts for 39% of global electricity supply, a figure set to increase given growth rates in China and India. In the US, coal is responsible for 83% of the total CO_2 emitted from the power generation sector.

1,400 GW of coal capacity to be added over next 25 years. The IEA expects 1,400 GW of new coal capacity to be built over the next 25 years — second only to gas in terms of capacity additions. Retrofitting existing plants can cut SO_2 by 90% and NO_X by 50%, but new, more efficient plants are needed to cut CO_2.

We examine three clean-coal technologies: CO_2 is emitted in proportion to plant efficiency. Coal plants in China have an average efficiency of 27%; in developed countries the average is still only 35%. We examine three technologies that can reduce CO_2 by up to 30%, and SO_2 and NO_X by up to 99%.

No silver bullet — a portfolio of technologies likely to win: The three technologies we consider are coal gasification, supercritical pulverized coal, and pressurized fluidized bed combustion. Each has its own distinct advantages and presents electrical utilities with a portfolio of options.

Major suppliers — Alstom, GE and Siemens: High natural gas prices, the abundance of coal and environmental legislation have increased interest in clean coal technologies. While GE is leading the effort in coal gasification, Alstom is leader in supercritical boilers and desulphurization technology.

Please see analyst certification and other important disclosures starting on page 15.

This report follows a request from a group of asset managers working with the United Nations to analyse the environmental, social and governance issues that may be material for company performance and to then identify potential impact on company valuations.

The United Nations Environment Programme Finance Initiative (UNEP FI) works closely with 160 financial institutions worldwide, to develop and promote linkages between the environment, sustainability and financial performance.

UNEP FI Asset Management Working Group (AMWG) explores the association between environmental, social, and governance considerations and investment decision-making. Asset Managers that have participated in this project have combined mandates of 1.7 trillion USD.

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Key Conclusions

Coal will remain a major fuel source: Coal drives 39% of electricity production, a figure set to increase given growth from China and India.

Clean coal technologies can significantly reduce emissions: CO_2 by up to 30%, and SO_2 and NO_X by 80% to 99%.

No single technology will win outright: Utilities will likely select a variety of options depending on fuel grade and required flexibility.

Three Clean-Coal Technologies

Supercritical pulverized coal: The most proven technology of the three, with lower capital costs and higher operational flexibility.

Coal gasification: Offers the largest potential reduction in SO_2 and NO_X emissions, and is the most suited to potential carbon sequestration.

Pressurized fluidized bed combustion: Most suited for low-grade coal, with the ability to mix biomass fuels with coal.

Key Equipment Suppliers

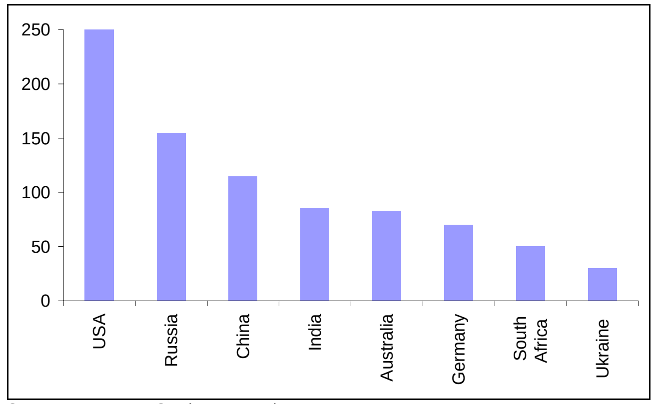
Alstom is a major supplier of supercritical boilers for supercritical PCC plants, and is leader in flue-gas desulphurisation systems.

GE is leading the commercialisation of IGCC (coal gasification plants), both in turbines and the gasification technology.

Siemens is the leading supplier of turbines to gasification plants in Europe, and supplier to a recently-announced supercritical plant in China.

Exhibit 1

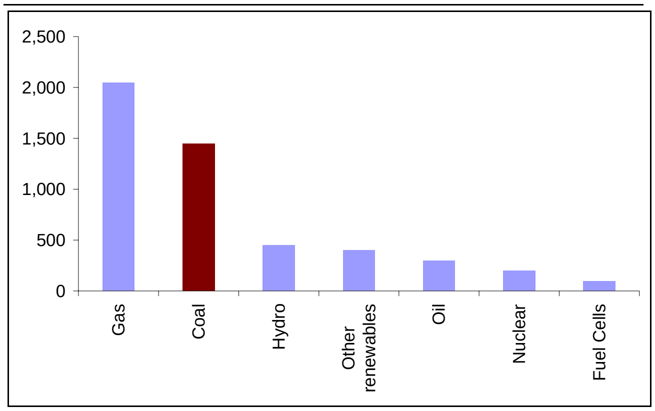
Coal Reserves Remain Substantial for the Fastest- Growing Electricity Consumers (billion tonnes, 2004)



Source: BP, Morgan Stanley Research

Exhibit 2

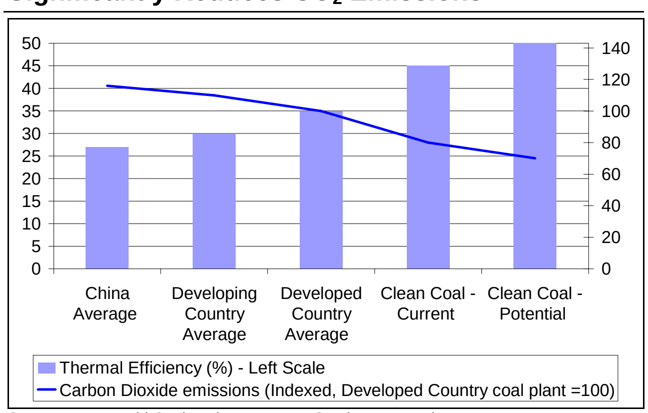
Opportunity Size: Coal Will Account for 1,400 GW of Capacity Additions over Next 25 Years



IEA forecast of global generation capacity additions (GW) 2000-30
Source: IEA, Morgan Stanley Research

Exhibit 3

Increasing the Thermal Efficiency of Coal Plants Significantly Reduces CO_2 Emissions



Source: IEA, World Coal Institute, Morgan Stanley Research

Investment Case

Coal set to remain a major fuel source
Electricity-generation is highly dependent on coal — it drives 39% of global electricity supply, as compared with 19% for natural gas, 17% for nuclear and 16% for hydro. Coal's share is likely to grow owing to disproportionate economic growth in Asia. In China and India, coal is the main electricity feedstock, with 78% and 76% penetration rates. The IEA estimates that coal's share of electricity generation will be largely unchanged by 2030, driven by growth in China and India, suggesting 1,400 GW of coal-fired power generation will be added over the next 25 years.

Increasing coal-plant efficiency is key
In the US, coal-fired generation accounts for 83% of CO_2 emissions from the power generation sector. Traditional coal plants in developed economies have relatively low thermal efficiencies of 35-36%, and plants in China are even less efficient, averaging 27%. In coal plants, CO_2 is emitted in proportion to thermal efficiency — increasing efficiency by one percentage point reduces emissions by around 2%. (Thermal efficiency is the ratio of heat absorbed to total heat output). In addition to increasing efficiency, clean coal technologies can reduce SO_2 and NO_X emissions by between 80% and 99%.

Exploring three clean coal technologies
In this report, we explore three technologies that currently offer efficiency levels of 40-45%, with the possibility of efficiencies up to 50-55%. Existing technology for new plants can reduce CO_2 emission by 10-20%, with the possibility of up to 30% reductions with further technology developments. Sulphur dioxide (SO_2) and nitrous oxide (NO_X) emissions are also substantially reduced using clean coal technologies.

No silver bullet — all three have advantages
With each technology offering similar thermal efficiencies (and therefore similar CO_2 emission reductions), there is no 'outright winner' in clean coal. Each technology has its own distinct advantages, as we outline in the table on page 8. For supercritical PCC the advantage is its reliability and low cost, for IGCC it is SO_2 and NO_X emission reduction, and for PFBC it is the ability to burn low-grade fuels. While no one technology will win, in our view, the backing from the suppliers is key to uptake of the technologies — GE in the case of coal gasification and Alstom in the case of supercritical PCC.

Exhibit 4
Coal-fire Power Generation as % Total Electricity Consumption (2004)

Country	%
Poland	94.8
South Africa	93.0
India	**78.3**
Australia	76.9
China	**76.2**
Czech Republic	66.7
Greece	62.3
Germany	52.0
USA	**49.9**

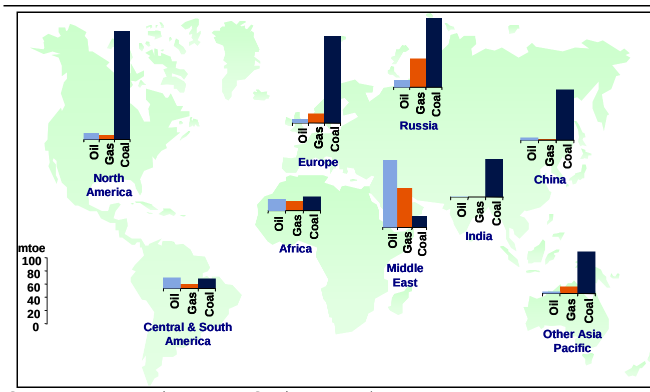
Source: IEA, World Coal Institute, Morgan Stanley Research

Exhibit 5
Clean Coal: No Outright Winner

	Emission Reduction					Proven
	CO2	NOX	SO2	Dust	Cost	Reliability
Supercritical PCC	✓	✓	✓	✓	✓	✓
IGCC (Coal Gasification)	✓	✓	✓	✓	✗	✗
PFBC	✓	✓	✓	✓	✓	✗

Source: Morgan Stanley Research

Exhibit 6
Proven Reserves: Coal Abundant in Most Regions



Source: BP, Datamonitor, Morgan Stanley Research

Relative abundance of coal compared to oil and gas

Coal currently accounts for 39% of global electricity supply, although this figure is much higher in coal-rich nations. The US has the largest coal reserves globally, at 250 billion tonnes, although the next three largest coal-rich nations are countries where the power generation market is less developed — Russia, China and India. While the World Coal Institute estimates that there are coal reserves for 190 years of consumption, oil (less than 50 years) and gas (60 years) reserves are significantly lower. This abundance of coal, particularly in China and India, means that the IEA expects coal-fired power generation to be the second-largest type of capacity addition over the next 25 years, after natural gas.

Existing technology, new applications

Clean-coal technologies are not new in a technological sense, although most have yet to be used on a widespread basis in power generation; many of the technologies have been under development for 30 years or more. Supercritical variants of pulverized coal technology were developed in the 1960s, and coal gasification has its roots in a technology that is over 50 years old — what is new is its application in the power industry.

Higher thermal efficiency = lower $C0_2$ emissions

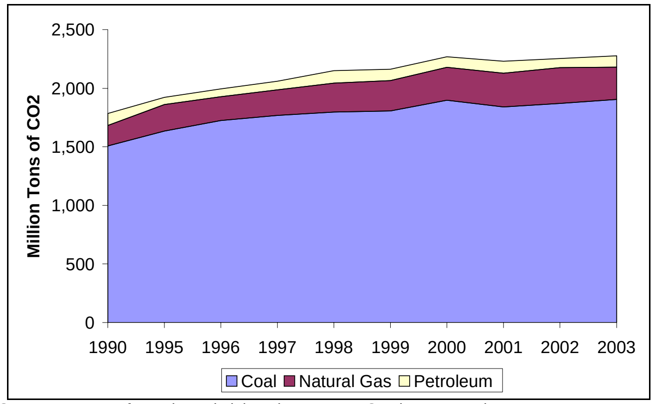
All coal-fuelled technologies emit CO_2 in proportion to efficiency levels — essentially for the same amount of electricity produced an IGCC, FBC, or supercritical PCC coal plant (each with 40-45% efficiency) will produce 10-20% less CO_2 than an existing coal plant (with 35% thermal efficiency). Next generation IGCCs and ultra-supercritical PC plants will likely reduce CO_2 emissions by 20-30% over a traditional plant owing to increased thermal efficiency.

Cleaning up existing plants can also reduce SO_2, NO_X

Although significant reductions in SO_2 and NO_X emissions can be achieved by retrofitting equipment on existing plants, the same is not true for CO_2. Existing plants can be fitted with 'low-NO_X' combustion systems, which reduce NO_X emissions by up to 50%, and flue-gas desulphurisation (FGD) systems can also be fitted, cutting SO_2 emissions by up to 90%. Unfortunately, thermal efficiency levels, the largest determinant of CO_2 emissions cannot be significantly increased on existing coal plants. Similarly, if carbon sequestration were to become a reality — whereby CO_2 is captured and permanently stored — it is unlikely that existing plants could be easily converted.

Exhibit 7

In the US, 83% of CO_2 Emitted from Power Generation Is from Coal



Source: Energy Information Administration, Morgan Stanley Research

High-sulphur coal drives demand for coal scrubbing

In the US, eastern coal has the highest energy content — power plants need to burn approximately 50% more western coal to match their power output from eastern coal, but it also has greater sulphur content. Sulphur emissions are covered by the Clear Skies regulations in the US, meaning 'scrubbing' the coal to remove sulphur is an attractive option for utilities relying on coal for base-load generation. The abundance of high-sulphur coal in China, which has the largest coal reserves after the US, has also meant significant interest in clean coal technologies from China. Alstom is the market leader in desulphurization, competing primarily with Babcock & Wilcox. Depending on the size of the plant, SO_2 control capital costs — such as FGD or Scrubbers — are US$275-150/kW for a 300MW-1,000+MW plant, and SCR costs (NO_X control) are US$150-75/kW for a 300MW -1,000+MW plant.

Legislative drive on noxious emissions

In the US, Clear Skies legislation calls for a 70% reduction in nitrogen oxides, sulphur dioxide and mercury by 2018. The measure provides for a market-based approach that would allow dischargers to buy and sell emission allowances. The EU Large Combustion Plant Directive (LCPD) aims to control emissions of SO_2 and NO_X from large combustion plants, including power stations. While the exact implementation of the directive, to be effective from January 2008, has not been finalised (whether a trading scheme similar to that in place for CO_2, or simply an emissions cap per plant), demand for desulphurisation technology will likely be boosted by the directive, particularly in the UK.

Exhibit 8
Scrubbing Opportunity Still Exists in US

Coal Capacity (MW)	East	Central	West	Total US
Current				
Scrubbed	48,836	23,411	25,260	97,507
Unscrubbed	147,725	60,287	7,016	215,028
Total	**196,561**	**83,698**	**32,276**	**312,535**
Scrubbed (%)	25	28	78	31
Unscrubbed (%)	75	72	22	69
Total (%)	**100**	**100**	**100**	**100**
Planned Scrubbed Capacity				
2005	1,828			1,828
2006	5,737	618	800	7,155
2007	5,623	612	1,245	7,480
2008	8,708		790	9,498
2009	1,775			1,775
2010	5,740			5,740
2011	768			768
2012	2,098	445		2,543
2013	410	830		1,240
Total Planned	**32,687**	**2,505**	**2,835**	**38,027**
as % of Unscrubbed	**22.1**	**4.2**	**40.4**	**17.7**

Source: Company data, Morgan Stanley Research US Utilities Team

Evidence of commitment in China

The Chinese government has committed to "popularize clean coal technology", a commitment underlined by the ultra-supercritical PCC plant being constructed at Huaneng, the pilot PFBC plant at Xuzhou, and the IGCC demonstration plant at Shangdong. China has also prohibited the opening of new coal mines with sulphur content in excess of 3.0% (coal sulphur content can vary from 0.5% to over 10%), and an SO_2 emission charge of 1.2 yuan/Kg now exists in some cities.

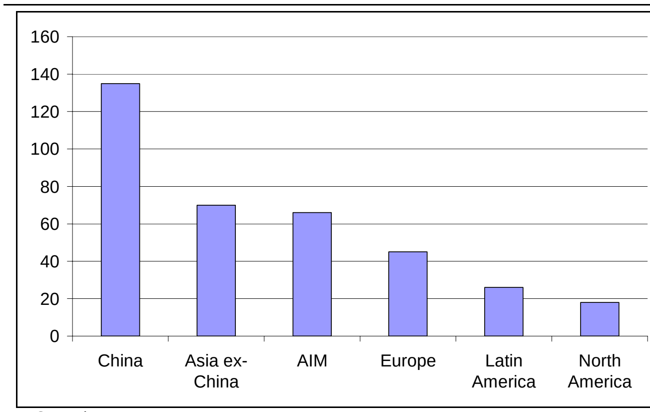
Opportunities in India

India has 202 billion tonnes of coal reserves (although recoverable reserves are about half of this level), 73% of which is inferior grade non-coking coals with ash content as high as 45-50%. Unlike coal in China, the sulphur content of Indian coal is generally low, typically below 0.5%. Given current consumption and mining forecasts, there is a projected shortage of 87 million tonnes of coal by 2011-12, which has given rise to an increased sense of urgency to improve the efficiency of coal technologies. Atmospheric Circulating Fluidized Bed Combustion (ACFB) plants have been set up in the capacity range of 30-60 MW, in addition to clearance given to several 125-250MW projects by the Central Electricity Authority. Coal gasification plants are commercially operational in the country, and further, investments in pilot IGCC plants have been made by engineering firm Bharat Heavy Electricals (BHEL) in Trichy.

Carbon sequestration — unlikely in short term

Carbon sequestration is the long-term storage of CO_2 to prevent release into the atmosphere, thus reducing emissions of greenhouse gases. Possibilities being considered include long-term storage in underground reservoirs, such as depleted oil fields. CO_2-capture technology could be fitted to all types of coal plant, although most experts, including the IEA, estimate that the cost would likely be lower for an IGCC plant than for other types (although the subsequent sequestration costs would be identical). Given the unknown long-term impact of carbon sequestration, we believe it is unlikely that sequestration will be a commercial scale technology over the next decade.

Exhibit 9
China to Represent 135 out of 360 GW of Power Generation Orders 2004-2007e



e = GE estimates
Source: GE, Morgan Stanley Research

European Industrials Industry view — Cautious

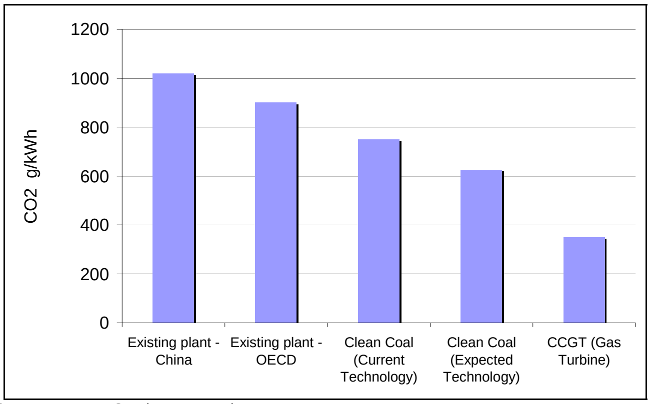
Valuations are already pricing in strong prospects in many instances. We are typically interested in late-cycle end-markets where companies have not yet reached their full margin potential.

US Industrials Industry view — Attractive

This is based on what Morgan Stanley considers solid fundamentals, pricing power, appropriate cycle timing, high cash generation, healthy balance sheets, high relative dividend yields, and reasonable valuations.

Exhibit 10

Clean Coal: Significant Reduction in CO_2, But Not As Clean as Natural Gas



Source: Morgan Stanley Research, IEA

Clean Coal Opportunities: Examining Three Technologies

Name	Capital Cost (US/kW)	Thermal Efficiency (%)	Emission Reduction (%)			Advantages	Disadvantages	Key Suppliers
			SO_2	NO_X	CO_2			
Supercritical Pulverized Coal Combustion **(Supercritical PCC and Ultra-supercritical PCC)**	1,200	40-45	Up to 99	80-90	10-20	• Lowest capital cost • Offers highest levels of availability • Most proven of the three technologies	• Not appropriate for coal with high ash content	• Alstom • Siemens • Hitachi • Mitsubishi • Babcock & Wilcox
Integrated Gasification Combined Cycle **(IGCC)**	1,600	40-45	95-99	95-99	10-20	• Largest reduction in SO_2 and NO_X emissions • Can also be used for hydrogen generation • Most suited to potential carbon sequestration	• Less efficient on low-grade fuel • Highest capital cost • Demonstrated reliability / availability not as high as Supercritical PCC	• GE (Gasifiers and Turbines) • Siemens (Turbines) • Shell, Prenflow • (Gasifiers)
Pressurized Fluid Bed Combustion **(PFBC)**	1,300	40-45	90+	90+	10-20	• Can be used with low-grade coal • Coal can be mixed with other combustible fuel (e.g. biomass) • Lower NOX emissions than PCC	• Efficiency levels not yet proven in operational plants • Interest from utilities receding, favouring instead IGCC and Supercritical PCC	• Alstom • Siemens • Hitachi • Foster-Wheeler • Babcock & Wilcox

Emission reductions are compared to a sub-critical PCC plant without SO_X and NO_X emission reduction technology. Sub-critical PCC plants in developed economies have thermal efficiencies of 35-36%
Source: Morgan Stanley Research

Supercritical Pulverized Coal Combustion (PCC)

The Proven and Cheapest Option

Supercritical PCC can achieve efficiencies at least as high as coal gasification.

Reliability is proven — 400 supercritical units are already in operation.

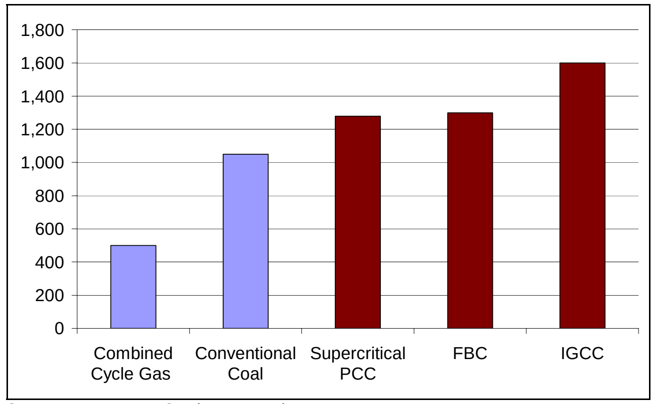
Capital costs are the lowest of the three clean coal options currently available.

What is supercritical PCC?
In traditional (sub-critical) PCC plants, the coal is ground to a fine powder before being blown with air into the boiler plant; steam is then generated, driving a steam generator and turbine. In a supercritical PCC plant, the supercritical boiler has higher pressure (3,600 psi versus 2,400 psi) and higher operating temperature (600 degrees centigrade rather than 538) than a standard sub-critical boiler. The higher temperature and pressure increase thermal efficiency — Babcock & Wilcox estimate that a supercritical boiler can add 5 to 6 percentage points to a PCC plant efficiency — as well as lowering fuel costs; this lowers CO_2 emissions by 10-12%. While supercritical technology has already established itself as a technology, ultra-supercritical technologies — with temperatures of 700 degrees centigrade promising efficiencies of up to 55% — are now being developed.

The most established technology
Over 90% of coal-fired plants operational globally are sub-critical PCC, and there are now over 400 supercritical coal units in operation — this compares with less than ten each of PFBC and IGCC plants, all of which have been demonstrators and government-subsidised to some extent. Supercritical PCC has effectively become the technology of choice for new coal capacity since 1997.

Efficiencies over 45% are proven
A unit at the North Jutland station at Limfjorden near Aalnorg, Denmark, is the most advanced supercritical PCC plant in operation. The unit, constructed in 1998, has a thermal efficiency of 47%, a 96.0% SO_2 removal rate and 80% NO_X reduction rate. The Danish plant does benefit from sea-water cooling, but the same plant inland would still have an efficiency of 44-45%. This level of efficiency is at least in line with that promised by IGCC (coal gasification) plants.

Exhibit 11
Supercritical PCC Has the Lowest Capital Cost of the Three Contenders (US$/kW)



Source: IEA, Morgan Stanley Research

'Ultra-supercritical' offers even higher efficiency levels
Both the European Commission and US Department of energy have provided funding for research into 'ultra-supercritical' technology. This involves developing components that can withstand temperatures of up to 700 degrees centigrade, and promises efficiency levels of up to 55%.

Ultra-supercritical under construction in China
The Huaneng Yuhuan plant, in the Zhejiang province, will be the first ultra-supercritical plant to be constructed in China, and is due for completion in 2007. The plant will also be China's first 1,000-MW-per-unit power plant. Mitsubishi Heavy Industries (MHI) is supplying the ultra-supercritical components to local supplier Harbin Boiler, while Emerson is supplying the plant automation technology. In June of this year, Siemens also won a contract with Shanghai Municipal Electric Power Company to supply the ultra-supercritical coal-fired power plant, Waigaoqiao III; Siemens will supply the main components for two steam turbines and one electric generator.

Who are the key players?
Alstom, Hitachi, Mitsubishi, and Babcock & Wilcox are leaders in the high-pressure and high temperature boilers used in supercritical and ultra-supercritical plants. Alstom and Siemens have also been successful in developing the steam turbines for super-critical and ultra-supercritical plants.

Exhibit 12

Supercritical PCC: Larger Capacity Possible with High Availability Proven

Technology	Capacity Range (MW)	Availability (%)
Supercritical PCC	**300-1,000**	**90-95**
PFBC	<400	60-90
IGCC	<500	70-85

Source: Alstom, Morgan Stanley Research

Coal Gasification (IGCC)

Coal Gasification (IGCC)

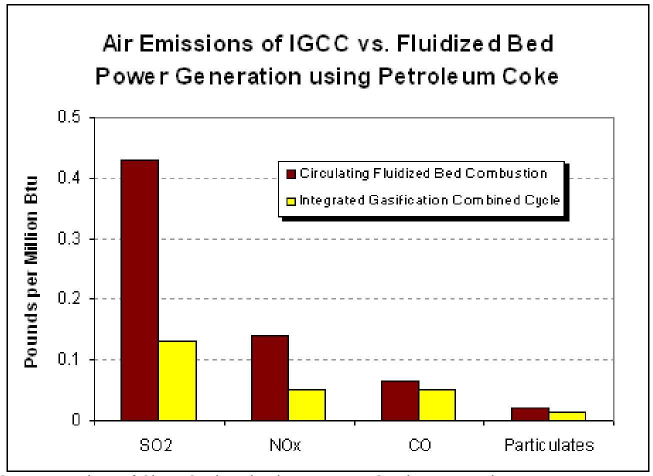
Gasification involves crushing coal to create a ‘syngas’ to feed a gas turbine.

Efficiency is high, at 40-45%, but capital costs also remain high at US$1,600/kW.

IGCC is the most suited technology to potential carbon sequestration programmes.

Exhibit 13

Coal Gasification: Significantly Lower Emissions than Conventional Technologies



Source: Institute of Clean Coal Technology, Morgan Stanley Research

What is coal gasification?

The gasification process converts any carbon-containing material into a synthetic gas composed primarily of carbon monoxide and hydrogen, which can be used as a fuel to generate electricity or steam (or used as a basic chemical building block for a large number of uses in the petrochemical and refining industries). Gasification adds value to low or negative value feedstocks by converting them into marketable fuels and products. The key benefits of gasification are environmental.

During the gasification process, virtually all of the carbon in the feedstock is converted to so-called ‘syngas’. Sulphur is then removed from the syngas and captured either in elemental form or as sulphuric acid, both of which are marketable items. The high temperature of the gasification process converts ash and other inert materials into a granular solid, thereby greatly reducing the volume of waste remaining after processing. This material is typically non-hazardous and can be used in building and construction.

Coal gasification reduces emissions — dramatically

Conventional competing power generation technologies, such as circulating fluidized bed combustion (CFBC) and pulverized coal boilers with flue gas desulphurisation (FGD), typically generate large amounts of waste by-products as a result of sulphur removal from the combustion flue gases. By contrast, coal gasification can readily remove more than 98% of the sulphur while generating from one-sixth to less than one-eighth the amount of solid wastes.

Outlining the process

In the gasification process, coal is funnelled into a gasifier and steam and oxygen are pumped in at high temperatures, decomposing the coal and giving off carbon monoxide and hydrogen. This initial process is known as pyrolysis. In the next stage, combustion, oxygen is fed into the gasifier and the carbon monoxide and hydrogen are thus converted into hydrogen dioxide (water) and carbon dioxide. In the final phase, gasification, the water, CO2 and coal byproducts react again to form the syngas, containing carbon monoxide and hydrogen.

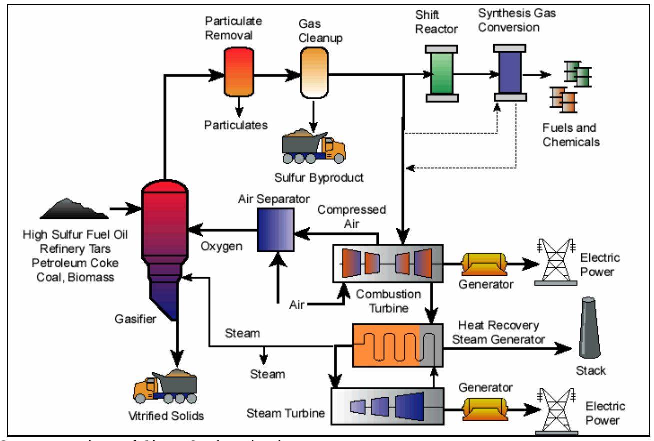
Capital costs of IGCC plants remain high

Although the environmental benefits of coal gasification are considerable, there are currently two key drawbacks: (i) the capital cost of building an IGCC (Integrated Gasification Combined Cycle) plant is high, at around US$1,600/KW compared with US$1,250/KW for a standard pulverized coal facility; and (ii) the gasifier is often unreliable and subject to stoppages and breakdown. Although the technology has not yet been widely adopted, the installed base of IGCC plants is believed to be in the order of 350 GW worldwide, still a significant number. In the US, the capital cost of a conventional CCGT (using natural gas) is only about US$550/KW, thus it has been the prevalent technology over the last several years, contributing to the so-called ‘gas bubble’ of the late 1990s. However, the future market for coal gasification is likely to be given further impetus from both sustained higher natural gas prices; and, increasingly, demanding emissions standards.

Who are the key players in this technology?
The coal gasification industry has remained in its infancy for economic and environmental reasons, despite the technology having been available for more than 50 years now. The key players in the industry come from the petrochemical segment and only recently the power equipment sector. These include Conoco Phillips, Shell Oil and, up until 2004, ChevronTexaco. In June 2004, GE acquired ChevronTexaco's operations for an undisclosed sum and we believe GE may now be the leading participant in this industry; however, its revenues from 65 acquired facilities is likely to be below US$50 million, in our opinion. We note that there are only two commercial-scale IGCC power plants in the US at this time.

Siemens is IGCC leader in Europe
Siemens is the leader in Europe for IGCC turbines, having supplied the first coal gasification plant in the world in 1972, and now having developed the V94.2K turbine, specifically designed for the IGCC market. Siemens has supplied three IGCC demonstration plants in Buggenum (the Netherlands), Puertollano (Spain) and Priolo Gargallo (Italy), with the gasifiers supplied by Shell, Prenflo and Texaco, respectively. Although these plants were built as demonstrators, all now run to operational standards. The Buggenum plant, built in 1994, has being supplying electricity to the Dutch grid on a commercial basis since 1998. The first commercial IGCC plant in Europe, planned for construction by 2007 by Valleys Energy in south Wales, will likely use a GE 9FA turbine.

Exhibit 14
Coal Gasification: Explaining the Technology and the Production Process



Source: Institute of Clean Coal Technology

Exhibit 15
IGCC: Existing Plants

Location	Country	Year	MW	Turbine	Gasifier
Buggenum	Holland	1994	253	Siemens	Shell
Wabash River	USA	1995	262	GE	Destec
Tampa	USA	1996	250	GE	Texaco
Puertollano	Spain	1997	300	Siemens	Prenflow
Pinon Pine	USA	1998	100	GE	KRW
Priolo Gargallo	Italy	1999	521	Siemens	Texaco

Source: Company data, Morgan Stanley Research

Pressurized Fluidized Bed Combustion (PFBC)

Least Favoured; Still Offers Potential

PFBC is the most suited of the three technologies for low-grade coal.

Technology has fallen out of favour versus coal gasification and supercritical PCC.

A pilot-scale plant has been constructed in China for trial use.

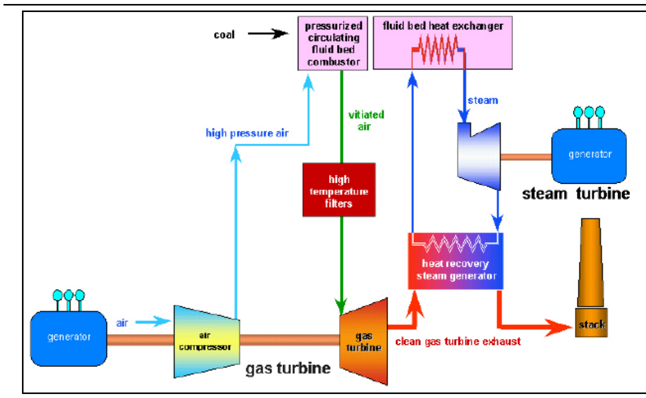
What is pressurized fluidized bed combustion?
In fluidized bed combustion, coal is burnt on a rapidly- flowing bed of moving air; this 'fluidising' action allows complete coal combustion at relatively low temperatures, and also allows virtually any combustible fuel to be used. PFBC plants can be used to burn a mix of low grade coal, coal waste, and biomass. In the PFBC plant steam is generated in a pressurized boiler; the pressurized coal combustion system heats steam for use in a steam turbine, and produces a hot gas supplied to a gas turbine — although PFBC uses both gas and steam turbines, the gas turbine in a PFBC plant accounts for only 20% of the power output, compared with 60-70% of the output in an IGCC plant.

Technology take-up has been muted
Traditional fluidized bed combustion plants were developed in the 1980s, and had the advantage of being able to remove sulphur at the time of combustion, plus lower NO_X emissions compared with a traditional plant owing to lower operating temperatures. Major drawbacks included small plant sizes, typically less than 200 MW, and a thermal efficiency no greater than a sub-critical PCC plant. Pressurized fluidized bed combustion addresses both these problems, although only seven plants are operational today, most of which were supported by government subsidies.

Pilot plant in operation in China
Since these plants were built largely as demonstration projects, reliability has been variable. Further uptake of plants has arguably been held back since no supplier has been pushing the technology — ABB, the largest supplier of PFBC plants, sold its power business to Alstom in 2001; Alstom favours supercritical PCC. Although a PFBC plant had been planned in Florida under the US Federal Clean Coal Programme, these plans have since been shelved. A pilot-scale 15 MW PFBC power plant in China has, however, been put into trial operation, at the Wangjia Power Plant in Xuzhou.

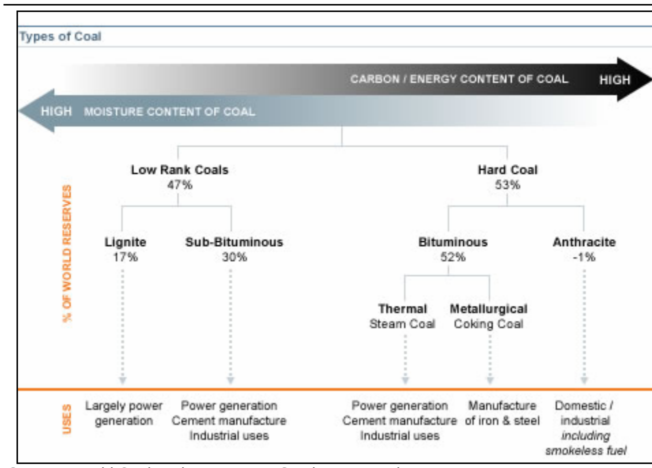
SO_2 emission reduction better than supercritical PCC
SO_2 emissions are largely dependent on the sulphur content of the coal, although sulphur can be removed at the time of combustion, with an additive such as limestone or dolomite. This method is more effective at removing sulphur compared with a post-combustion method such as flue-gas desulphurization. NO_X emissions are also lower than PCC owing to the lower operating temperatures.

Exhibit 16
Pressurized Fluidized Bed Combustion



Source: US Department of Energy, Morgan Stanley Research

Exhibit 17
47% of Global Coal Reserves Are Low Grade



Source: World Coal Institute, Morgan Stanley Research

Who are the key players?

The world's largest PFBC power plant began commercial operations in July 2001. The 350MW plant at Karita, Japan, was commissioned in 2000, with ABB (before it sold its power business to Alstom) supplying the gas turbine and Toshiba supplying the steam turbine. All but one of the existing PFBC plants were constructed by ABB, with a single plant also being built by Hitachi. Although interest in this technology has receded, both Alstom and Siemens are capable of constructing PFBC plants.

Exhibit 18

PFBC: Take-up Has Been Limited

Location	Country	Year	Capacity (MW)	Supplier
Vartan	Sweden	1991	135	ABB
Tidd	USA	1991	70	ABB
Escatron	Spain	1992	80	ABB
Wakamatsu	Japan	1994	71	ABB
Cottbus	Germany	1999	80	ABB
Osaki	Japan	2000	250	Hitachi
Karita	Japan	2001	350	ABB

ABB sold its power generation business to Alstom in 2001
Source: Sussex Energy Group, Morgan Stanley Research

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(as of December 31, 2005)

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Overweight/Buy	**753**	**36%**	**272**	**40%**	**36%**
Equal-weight/Hold	**943**	**45%**	**320**	**47%**	**34%**
Underweight/Sell	**382**	**18%**	**88**	**13%**	**23%**
Total	**2,078**		**680**		

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Industry Coverage: Capital Goods

Company (Ticker)	Rating (as of)	Price (01/20/2006)
Alex J Toms		
Bodycote (BOY.L)	O (06/13/2005)	226p
Cookson (CKSN.L)	E (07/12/2005)	468p
FKI (FKI.L)	U (06/13/2005)	125p
IMI (UK) (IMI.L)	E (07/12/2005)	485p
Rotork (ROR.L)	O (12/01/2005)	664p
Spirax Sarco (SPX.L)	O (11/22/2005)	880p
Tomkins (TOMK.L)	E (07/12/2004)	304p
Ben E Uglow		
ABB (ABBN.VX)	E (05/13/2004)	SFr 13.75
Alstom (ALSO.PA)	O-V (01/18/2006)	€56.25
Assa Abloy (ASSAb.ST)	O (06/10/2004)	SKr 123.00
Schneider Electric (SCHN.PA)	E (03/11/2005)	€78.40
Siemens (SIEGn.DE)	O (08/31/2004)	€70.00
Diego Lopez Martinez		
Heidelberg (HDDG.DE)	U (07/12/2005)	€34.85
MAN (MANG.DE)	E (05/15/2003)	€45.08
Gustaf Lindskog		
Atlas Copco (ATCOa.ST)	U (01/18/2006)	SKr 170.00
Sandvik (SAND.ST)	U (10/20/2004)	SKr 370.50
SKF (SKFb.ST)	O (11/15/2005)	SKr 111.50
Paloma Sanjuan		
Electrolux (ELUXb.ST)	E (05/18/2005)	SKr 193.50
Invensys (ISYS.L)	E-V (01/18/2006)	21p

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