IGCC AND INTERNATIONAL POWER INVESTMENT

John Bryant BSc MSc CEng FIMechE FEWI

VOCAT
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International Consultancy
& Expert Witness Services

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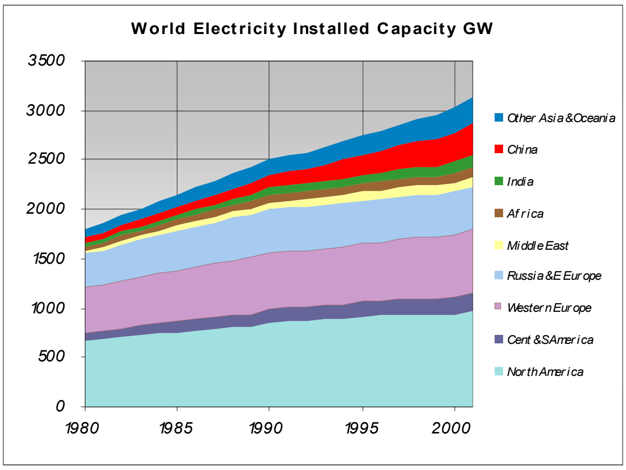
Introduction

Recently, the British government approved a £350 million project to build a 430MW power station at Hatfield colliery at Stainforth, Yorkshire, using Integrated Gasification Combined Cycle (IGCC) technology to provide electrical energy from syngas[1] produced by gasification of coal. This follows a growing trend in the world towards investment in more complex technology to generate electricity, heat or saleable products, while reducing significantly pollution of the environment both in the atmosphere and on the ground.

Using a variety of fuels, such as coal, heavy oil and wastes, IGCC technology can produce electricity and products such as hydrogen, ammonia and methanol, while at the same time removing by-products such as sulphur. This paper sets out to provide some background to the world power and related markets, their potential for IGCC investment and some of the financial implications of the technology.

World Electricity Installed Capacity

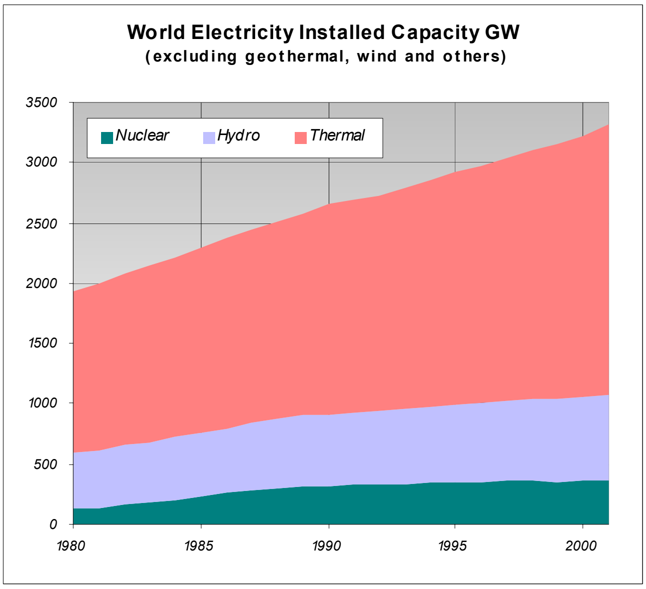
Since the 1980's there has been a significant increase in electricity capacity on the back of increased demand, and at a compound rate of about 2.5% p.a. Particular high growth countries include China, India & Pakistan, Japan, Korea, Australia & N Zealand, Saudi Arabia, Iran, Israel, Mexico, Brazil, Argentina and Venezuela, but growth continues inexorably also in Western Europe and North America.



International Energy Agency

Electricity, not being a storable commodity, has to be produced fairly locally, and its source of energy depends upon availability of natural resources not involving large power line losses, those imported and upon the strategies of relative dependence adopted by individual countries.

Countries that are very dependent upon coal include China, India, Poland, Czech Republic, Germany and South Africa. However it should be noted that both USA and Korea have a significant dependence upon coal for electricity generation.



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Many countries have developed some dependence upon nuclear fuel for electricity, but none more so than France, Belgium and Slovak Republic. Growth in nuclear generating capacity has however significantly reduced to almost zero, reflecting fears of future terrorism and high costs of building and decommissioning.

While Russia and the Netherlands have been dependent upon natural gas for a long time, this has also more recently gained increasing importance in Italy (at the expense of oil) and in the UK (at the expense of coal, and using Combined Cycle Gas Turbine CCGT technology).

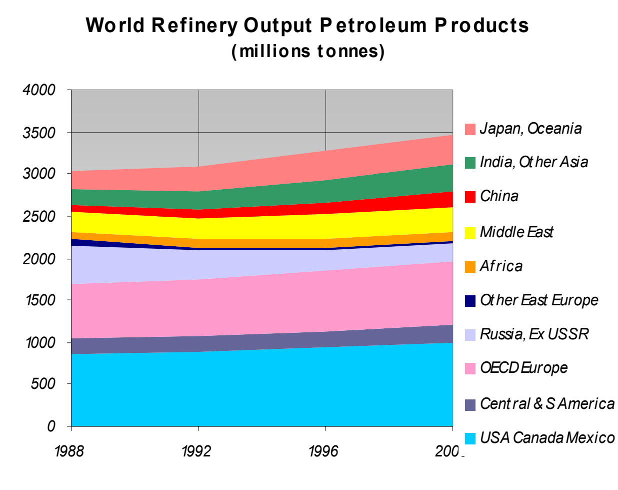
Outside oil producing countries, oil is losing ground to other forms of energy for electricity production. Hydro-electric power is of course restricted to countries with height potential.

Renewable sources such as wind power have as yet to make a significant impact worldwide on electricity production.

1 Syngas is a mixture of carbon monoxide and hydrogen.

Petroleum Products

Compared to electricity, growth in the production of petroleum products has been quite sedate at about 1% per annum, with some countries, notably Russia and Eastern Europe, experiencing a decline. Countries with particular strong growth in output include China, India, Iran and Brazil, and inward investment in product capacity in these countries is likely to continue.



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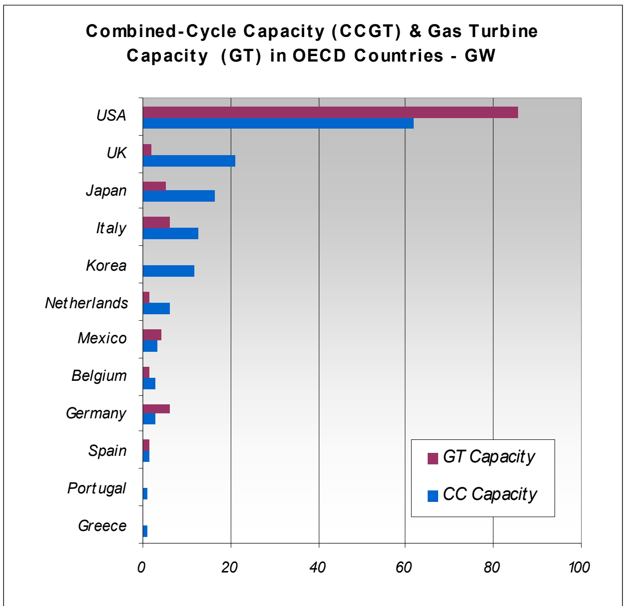
Combined-Cycle Technology

Gas and steam turbines running in combination is not a new technology. Gases leaving a gas turbine are still very hot 600—800ºC, and this potential can be utilised via an appropriately designed heat-exchanger to provide steam to drive a steam turbine. Additional increments of efficiency and heat output can be gained through adding various combinations of pre-heaters, economisers and superheaters connected to the high and low pressure sections of the steam turbine, depending upon requirements. Factors that affect the choice of cycle include the choice of gas turbine, the relative requirement for electrical energy versus heat/products, ambient conditions, environmental legislation, sites resources and finance/capital cost.

The chart below summarises Combined-Cycle (CCGT) capacity in key OECD countries, alongside the Gas Turbine only (GT) capacity.



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In the USA, the dominant country in this technology, gas turbines have been used significantly on their own to generate electricity, because of the easy availability of gas supplies. This may change in favour of IGCC if gas prices continue to rise apace in the US as they have been doing.

In the UK, since privatisation of the electricity market, there has been significant investment in Combined-Cycle capacity burning gas to produce electricity, with no other end product in view.

In the space of the 10-year period to 2000 CCGT capacity in OECD countries has grown from 29 GW to 145 GW, most of it for power generation.

Outside the OECD region, countries that are investing in CCGT capacity include China, Saudi Arabia, Brazil, and Far East countries such as the Philippines.

Combined-Cycle technology can be used for a variety of purposes including:

- ***Power*** — producing power for consumption through the grid or by local industry. It is possible also to convert existing steam power plants into Combined-Cycle plants by adding gas turbine capacity—ideal where steam turbines still have service life left in them but the boilers need replacing.

- ***Cogeneration*** — simultaneous production of electrical and thermal energy (usually in the form of steam or hot water). Examples of this include industrial power stations supplying a process requirement, district heating power plants, and seawater desalination plants.

- ***Integrated Gasification Combined-Cycle*** — useful where no natural gas is available and use of alternative fuels such as coal, heavy oil or wastes is required that cannot be fired in a gas turbine. Outputs can include electricity, heat, and saleable products such as ammonia, methanol and hydrogen, with the particular selection depending upon the circumstances. The technology is complex.

IGCC Market

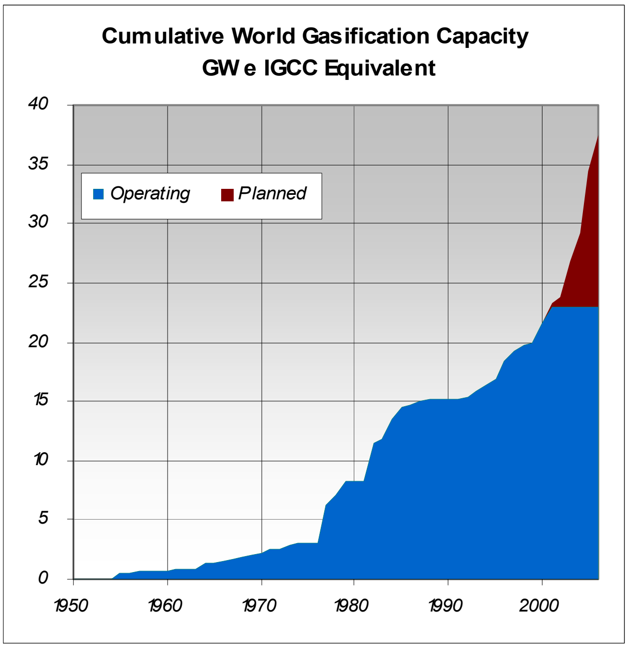
Figures of the Department of Energy, United States, indicate that currently (2001) there are 126 active commercial scale plants in operation with a combined capacity of 22.9 MW e equivalent, 41.7 MW th Syngas.

In addition to those in operation there are further plants planned (under construction, at the engineering stage or being developed), including the Hatfield UK IGCC. These plants are more

World IGCC Capacity

	No of Plants	No of Gasifiers	MW e Equivalent	MW th Syngas
Operating	126	401	22916	41723
Construction	5	8	851	1543
Engineering	6	15	4553	8338
Development	26	44	9065	15498
Total	**163**	**468**	**37385**	**67102**

DOE USA, SFA Pacific Inc



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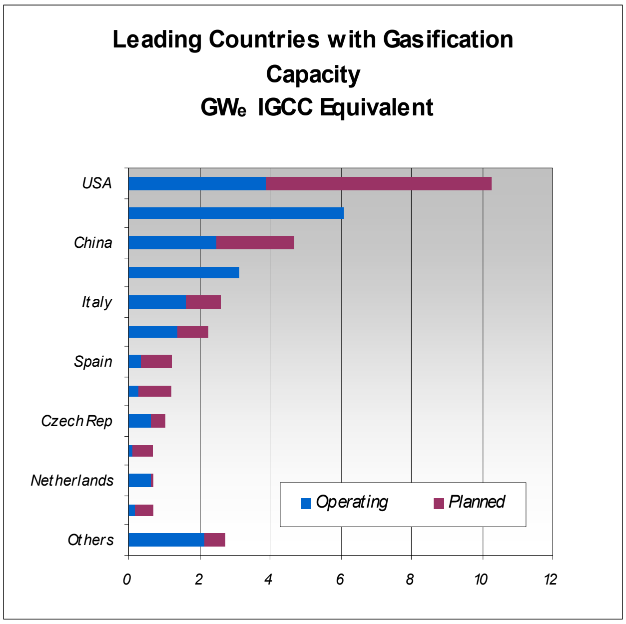
The chart below summarises total gasification plant by leading countries:



DOE USA, SFA Pacific Inc

The second place of South Africa in the chart is primarily owing to two large SASOL plants, built in 1977 and 1982.

Approximately 30% of IGCC plants are situated outside the OECD area, in countries such as China and India.

Currently IGCC likely forms 10-11% of the total CCGT market, but this is likely to grow in the future as the technology gains increased maturity.

Historically most IGCC plants have been designed with product manufacture in mind, such as ammonia and methanol, and this is still likely to be the case in developing countries such as China. However, about a third of IGCC installations now under development are planned with a primary objective of producing electricity and this represents therefore a new trend — reflected in the large scale of plant now being developed.

Power Cost Comparisons

Figures of the IEA Greenhouse Gas R & D Programme, a collaborative activity open to government and industry, indicate that current specific investment costs of IGCC technology are in the region of \$1.56-1.65 million per MW, compared to \$1.09-1.30 million for coal systems using pulverised fuel and flue-gas desulphurisation, and \$0.52-0.77 million per MW for CCGT. Clearly IGCC technology is expensive, although not as much as nuclear energy.

With further maturity the cost of IGCC might be expected to come down. A paper on the future of IGCC [2] indicates that this might in time come down to \$1.2 million per MW EPC level for larger plants, which would be of the same order as current coal-fired power stations. With about 30% of its coal-fired plant being over 30 years old, and with rising gas prices, it might be expected that the US would extend its IGCC capacity, particularly in plant for power only, above the planned level indicated in the chart above. Plants with total capacity in excess of 1000 MW_e might be expected in the future.

IGCC Technology

The introduction of IGCC has been made possible by the development of a number of IGCC technology processes, to meet a wide variety of fuel inputs, including fuel oil, refinery residues, petroleum coke, and coal. Since 1998 the main processes have included:

Plants Operational or Planned since 1998			
	Process	No.	%
ChevronTexaco	Entrained Flow	30	56
Shell	Entrained Flow	9	17
British Gas/Lurgi	Moving Bed	5	9
IGT U-Gas	Fluidised Bed	3	6
Foster Wheeler CFB	Fluidised Bed	3	6
Lurgi	Fluidised Bed	2	4
KRW	Fluidised Bed	1	2
Total		**53**	**100**

DOE USA, SFA Pacific Inc

Texaco clearly have a commanding share. Whatever the technology used, however, the build of IGCC plant is much more complex than just for a CCGT island. The following diagram shows a simplified general layout:

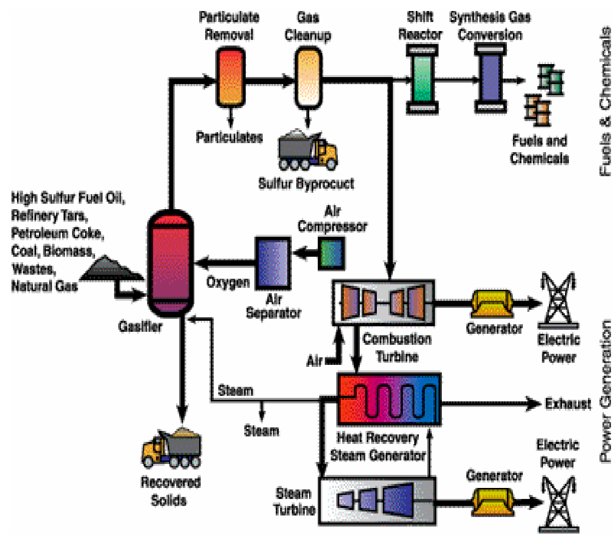


Diagram: Gasification Technology Council USA

2. *The Future of IGCC—Todd, Gasification 5, Netherlands October 2002*

IGCC technology requires that all parts have to run together for it to work and the parameters governing output and efficiency are many compared to conventional CCGT. They include:

- Plant size
- Plant heat rate
- Multiple fuel inputs and heat values
- Multiple product outages
- Guaranteed markets for multiple outputs
- Electrical consumption on site
- Multiple fuel prices
- Capital cost of additional complexity of design and construction
- Downtime and availability
- Interest rates
- Contractor performance and expertise.

Clearly analysis of these effects can be complex and, with the technology still maturing, there may be potential for disagreement among parties to EPC contracts to build IGCC plant.

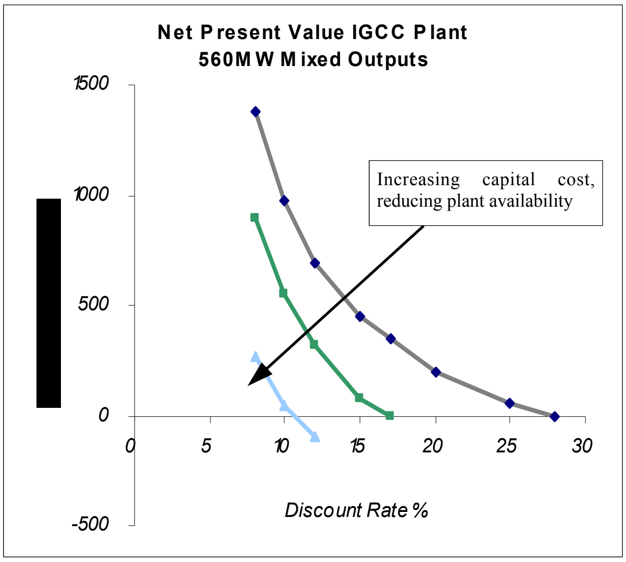
Financial Assessment

In order to clarify and reduce the potential areas of financial conflict, IGCC financial models, such as that developed for the US Department of Energy by Nextant, can be used to compute the relative effects of the main variables surrounding a particular plant.

A paper [3] utilising the DOE model has shown that variations in the cost of fuels consumed and the price of products can have a significant effect on the return on investment of an IGCC. The paper does not show, however, the effects of varying other parameters, such as reduced plant availability, EPC contract delays and additional costs, or lack of markets for products, though clearly scenarios to show these could be set up.

3. An Optimised Petroleum Coke IGCC Coproduction Plant - Amick, Geosits, Herbanek, Kramer, Rockey and Tam, Gasification Technologies Council Conference, October 2001.

By way of example, the following chart illustrates the effect on net present value and rate of return for an IGCC plant (with mixed electrical and product outputs), of increased capital cost and reduced plant availability:



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Over the long term, the real financial effects of changes in these other factors can only properly be investigated by reference to the actual figures of performance of specific IGCC plants. Experience of this will accumulate as the market matures.

VOCAT
INTERNATIONAL LTD
International Consultancy
& Expert Witness Services

Tavistock House
10 Falconers Field
Harpenden
Herts AL5 3ES

Tel: 01582 462015
Fax: 01582 767459
E-mail: john.bryant@vocat.co.uk
Web: www.vocat.co.uk

Managing Director: John Bryant BSc MSc CEng MIMechE FEWI
Fellow of the Expert Witness Institute