Cogeneration in a High Gas Price Era
A WADE Analysis

November 2004

About WADE

WADE is a non-profit research and advocacy organisation that was established in June 2002 to accelerate the worldwide deployment of decentralised energy (DE) systems. WADE is now backed by national cogeneration and DE organisations, DE companies and providers, as well as a range of national governments. In total, WADE's direct and indirect membership support includes over 200 corporations around the world.

DE technologies consist of the following forms of power generation systems that *produce electricity at or close to the point of consumption*:

- High efficiency cogeneration / CHP
- On-site renewable energy systems
- Energy recycling systems, including the use of waste gases, waste heat and pressure drops to generate electricity on-site.

WADE classifies such systems as DE regardless of project size, fuel or technology, or whether the system is on-grid or off-grid.

WADE believes that the wider use of DE holds the key to bringing about the cost-effective modernisation and development of the world's electricity systems. With inefficient central power systems holding a 93% share of the world's electricity generation, and with the DE share at only 7%, WADE's overall mission is to bring about the doubling of this share to 14% by 2012. A more cost-effective, sustainable and robust electricity system will emerge as the share of DE increases.

To ensure that its goal can be achieved, WADE undertakes a growing range of research and other actions on behalf of its supporters and members:

- WADE carries out promotional activities and research to document all aspects of DE, including policy, regulatory, economic and environmental aspects in key countries and regions.
- WADE works to extend the international network of national DE and cogeneration organisations. Current WADE network members represent Europe, the USA, India, China and Brazil.
- WADE provides a forum for DE companies and organisations to convene and communicate.
- WADE jointly produces an industry journal – "Cogeneration and On-Site Power" (published by James and James in association with WADE).

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Cogeneration in a High Gas Price Era

Introduction

The traditional indicator of the market viability of cogeneration plants is the price of electricity. Since electricity is the highest value product of a cogeneration system, a market that prices it highly will increase project returns. However, another part of the commercial equation is the cost of system inputs, the fuel. Natural gas is continuing to grow in importance as a fuel for cogeneration; indeed in many countries it is the fuel of choice. Yet gas price trajectories are upward, in some cases steeply upward.

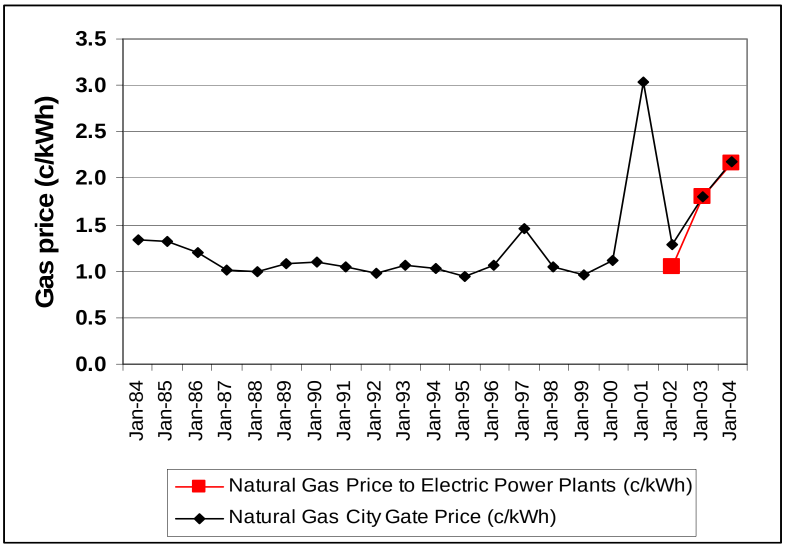
The purpose of this short analysis is to assess the impact of increasing gas prices on gas-fired cogeneration market development.

Gas Prices Are Increasing

Some of the most significant gas price rises have been seen in the USA, as Figure 1 shows. The trend of recent years has been dramatic.

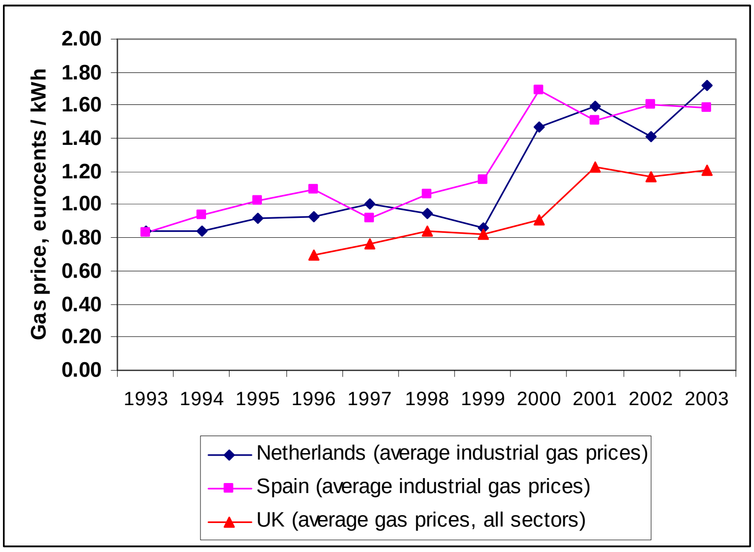
In Europe, trends are similarly upward, but not so severe. Here, there continues to be a strong link between the market prices for oil and gas and, with the price of the former more than doubling over the last five years or so, the impact on gas prices has been significant. Prices have continued to surge in 2004. The UK gas market operates in a slightly different way and the price rises there have, until 2004, been more subdued (though they have continued upward this year). Figure 2 shows typical European trends.

Figure 1. US natural gas prices, 1984-2004



US Department of Energy, 2004

Figure 2. European natural gas prices (ex-tax), 1993-2003



International Energy Agency, 2004; UK DTI, 2004

Alongside the oil price link, there lie the fundamentals of natural gas supply and demand, and growing import dependence. The International Energy Agency projects that the import share of total gas demand will increase to 26% in North America by 2030 (it was 1% in 2000) and will surge to 63% in Europe by the same time (36% in 2000). A permanent period of elevated gas prices may therefore have begun.

Expected Results

For the purposes of assessing the impact of these significant price changes, WADE has undertaken some new quantitative research. The aim of the analysis was to assess the extent to which current and future trends of increasing gas prices might be a challenge – or an opportunity – for gas-fired cogeneration. In qualitative terms, we might expect two main conclusions:

- Rising gas prices increase the average price of centrally generated power. If all price changes occur simultaneously and gas-fired generation is on the margin, then cogeneration with efficiencies greater than the delivered efficiency of grid generation should reduce costs to a greater extent than at lower gas prices. In reality, grid prices are averaged, even when the marginal generation is gas, and this makes central generation appear to be less sensitive to gas price increases.

- Those countries most dependent on gas, typically through the development of CCGT plants, will tend to suffer higher overall wholesale electricity prices when gas prices increase. Here, gas-fired cogeneration would be expected to suffer less, in competitive terms, than in countries where the share of gas in generation is low.

The main purpose of WADE's modelling was to quantify these responses.

Gas, Oil and Electricity Prices

The relationship between gas and electricity prices is not straightforward. Retail electricity prices depend on four main factors: the cost of generation, transport, administration and profit margins. Of these, only the generation cost is affected directly by the gas price. An increase in generation costs can, to a certain extent, be absorbed by other cost items and not passed through to the customer, at least in the short-term. Nonetheless, in countries where gas plays a significant role in electricity generation, electricity prices tend to be linked to gas prices – often with a lag period – and are likely to continue to do so. This may be a seasonal impact with, for example, the gas price directly affecting the electricity price during winter months.

It is not only the absolute gas price that is important, but also the stability of that price. Both Europe and North America are major gas consumers. OECD North American gas consumption has been rising steadily since the mid-1980s, with around 70% of the increase in US demand being met by Canadian production. The lack of spare production capacity since 2002 has led US markets to be vulnerable to significant levels of price volatility and spikes, caused by pronounced demand seasonality that cannot be fully balanced, even by extensive underground storage capacity.

Similarly, European demand has grown rapidly, as gas is seen in many countries as the fuel of choice for the replacement of old coal-fired capacity (for example in Denmark and the UK) and for new capacity growth (for example in Spain). Most European gas is sourced from the North Sea (where production is likely to peak around 2010), Algeria and Russia, as well as increasingly in the form of liquefied natural gas (LNG) from North Africa, Nigeria and the Middle East.

Since gas prices in continental Europe have traditionally been linked to oil prices and dominated by long-term contracts, there has been reasonable price stability. However, with the advent of gas market liberalization, smaller market players are not able to trade long-term contracts (because they have smaller trading volumes) but instead must rely on short-term contracts, tending to increase price volatility. Gas price volatility therefore appears to be on the increase and cogenerators in Europe have to face this challenge as well as that of historically increasing prices.

Economic Analyses

Two sets of economic modelling were undertaken to assess the effects of changing gas prices on electricity prices: the WADE Economic Model and a 'levelized cost model' developed by Delta Energy & Environment.

THE WADE ECONOMIC MODEL

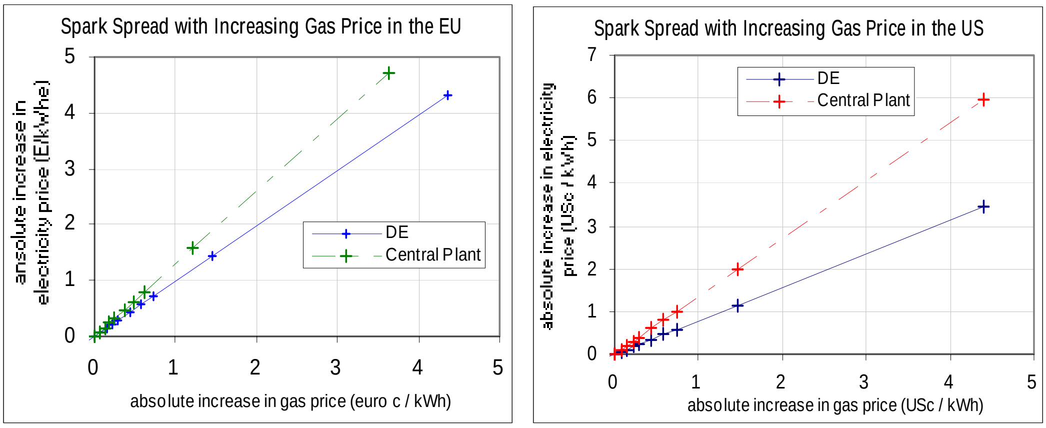
The WADE Economic Model calculates the cost of meeting new demand requirements over a 20 year period under scenarios that vary according to the relative shares of central plant and decentralized energy (DE) in the new generation plant mix. The model can be applied to any state, country or region in the world and provides a clear means of comparing the system costs of an investment strategy based on central power or DE, or any mix of the two.

The model asks for fuel price data inputs in order to calculate retail costs. Both current price and projected annual price change have to be input. The model therefore enables the user to vary the gas price in any way and to assess the impacts of these variations on the overall retail cost of electricity generation. Over the last two years, the model has been applied both to the EU-15 electricity system and to the US system. These two applications were selected for testing the impact of gas price rises.

In both the EU and US runs of the model, the net effect of rising gas prices on system unit costs (the full cost of generating a kWh of electricity) was smaller in a high DE growth scenario than in a high central power growth scenario (see Figure 3.). The difference between the impacts is not insignificant, as the charts make clear.

Since the high DE growth scenario is based heavily on gas-fired cogeneration and the high central power growth scenario is based heavily on CCGT plant, this suggests that, in competitive terms, cogeneration should suffer less from gas price increases than central gas-fired electricity generation in high gas penetration markets. This makes intuitive sense, since cogeneration derives more useful energy from gas than does a CCGT plant.

Figure 3. Impact of gas price increases on retail electricity costs under central and decentralized generation scenarios; EU and US



WADE, 2004

There are several reasons why the graphs are slightly different. Both have different input data (based on the national / regional energy circumstances) and projected technology mixes, as well as different capital and fuel cost assumptions. The main point for the purposes of this analysis, however, is that in both cases the costs of generating and supplying electricity rose less in a high DE scenario.

THE LEVELIZED COST MODEL

The levelized cost model applied by WADE assessed the impact of gas price changes on the internal rates of return (IRR) of a:

- A 500 kW reciprocating engine cogeneration project
- A 20 MW gas turbine cogeneration project
- A Central generation 300 MW CCGT plant.

The analysis also compared the impact on the cogeneration projects of gas price changes in a market with a high penetration of gas in the power generation sector (where gas price changes would affect the cost of electricity self-use) with a market where gas penetration was low. For convenience of analysis, inputs and assumptions were set such that the base case IRRs were 12% for each technology option. The results are summarized in Table 1.

Table 1. Impact of gas price changes on the IRR of selected generation projects

	500 kW reciprocating engine cogeneration plant	**20 MW gas turbine cogeneration plant**	**300 MW CCGT plant**
<u>Assumptions:</u>			
Hours of operation	5000	7500	8100
Gas price (base)	€2.5c/kWh	€2c/kWh	€1.2/kWh
Discount rate	6%	6%	6%
Price of self-use power (base case)	€9c/kWh	€6c/kWh	-
Power export price	€4.05c/kWh	€3.63c/kWh	€3.33c/kWh
% power self-use	75%	65%	-
Electrical efficiency	38%	35%	53%
Heat efficiency	43%	45%	-

	IRR		IRR		IRR
Gas price change	*High gas generation market*	*Low gas generation market*	*High gas generation market*	*Low gas generation market*	
-50%	20%	28%	22%	34%	47%
Base case	12%	12%	12%	12%	12%
20%	9%	6%	8%	3%	-2.6%
50%	4%	-5%	2%	-14%	(too low to calculate)

WADE, 2004

Two main observations can be made:

- As gas prices rise, both cogeneration projects fare better in a market with high gas penetration in power generation compared to a low gas penetration.
- Both cogeneration projects fare better, in both gas penetration scenarios, than the CCGT project as gas prices rise, though not as well when gas prices fall.

Again, in both cases, the scale of the impact is commercially significant.

Conclusions

The outputs of both models indicate that the competitive position of cogeneration should improve as gas prices increase, in comparison with CCGT plants with no heat recovery. This benefit for cogeneration will be more significant where overall gas generation is high. The results fit with what one would intuitively expect but demonstrate the scale of the advantage.

These findings are, in part, encouraging given that the gas share of power generation is increasing in most countries; however, as gas prices rise and the IRR of gas-fired cogeneration projects fall, alternatives to gas generation will also gain competitive advantage.

In addition, the commercial reality may be different to the economic theory, however persuasive. In markets with high gas-fuelled capacity, cogeneration may still remain vulnerable in circumstances where:

- Electricity utilities have high market power.
- Utilities, as large gas consumers, are able to purchase gas at a significantly lower rate than small consumers.

Nevertheless, WADE's analysis highlights the unarguable point that cogeneration should provide a better system price hedge than less efficient CCGT plants in an era of increasing gas prices, based on its superior efficiency. This is as it should be, given growing gas supply security concerns throughout the world.

Not only this, but cogeneration can protect its users against power supply interruptions caused by gas supply constraints to the power generation sector. Finally, cogeneration provides a benefit not only on the electricity side, but also through its heat generation: as gas prices increase, so will the cost of gas-fired boiler generation.

WADE Recommendations

How can policymakers respond to this evidence? The models' outputs are further confirmation of the benefits that arise from the overall high efficiency of cogeneration, yet these benefits may be hidden in a regulatory or fiscal environment that continues to incentivise less efficient central plant.

WADE therefore recommends that:

- The gas price differential between small and large consumers should not be excessive. It is reasonable, of course, that large consumers should benefit from a lower unit price, but not to the extent that it penalizes high efficiency.

- Policymakers respond to growing concerns about gas security of supply and price by introducing mechanisms that incentivise its use in high efficiency systems, primarily cogeneration. CCGT plants may be more efficient than conventional coal steam plants, but 50–55% gross efficiency is hardly impressive. There is a wealth of potential instruments at hand for policymakers, including fiscal mechanisms, regulatory intervention and the use of emissions trading that recognizes the net benefits of on-site cogeneration.

- As far as possible, policymakers should apply time-of-use pricing in order to send correct economic signals for efficient power generation.