Delta
Energy and Environment
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Spark Spreads for Combined Heat and Power

Delta Research Brief

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New Delta Spark Spread analysis in Europe suggests that the competitive position of gas-fired CHP (combined heat and power) projects relative to CCGT plants is improving as gas prices rise.

Spark spread trends, based on the difference between fuel and power prices, is one commonly used indicator that assesses the economics of different types of power generation for investors and developers.

Spark spreads are typically only published for power-only combined cycle gas turbine (CCGT) plants. This Research Brief, based on a newly developed Delta CHP Spark Spread, presents data for three types of gas-fired CHP plant and compares it with spark spreads for a CCGT plant.

Delta's analysis of European wholesale power and gas prices shows that:

> CHP plants have suffered less than CCGT plants from the rise in European gas prices since 2004, although the overall competitive position of gas-fired generation has suffered.

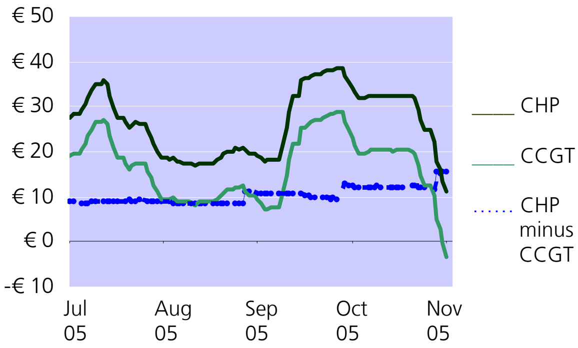
> The greater the gas price for any given power price, the greater the benefit of CHP over gas-fired power only plants.

> The main reason for this relative benefit of CHP is its marginal electrical efficiency of 70 – 95%. Power-only CCGT plants have typical operational efficiencies of around 53%.

Recent spark spread data for a CCGT and typical 10-MW CHP plant is shown in *Figure 1* below.

Figure 1: Recent CCGT and CHP Spark Spread Trends in Europe.

The CHP spark spread advantage has increased with rising gas prices.



Note that CHP plants will typically pay higher gas prices than CCGT plants, but nonetheless retain their competitive spark spread edge. The electricity they produce also has a higher value than the wholesale price when used on-site.

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The Spark Spread: an Important Indicator - with Limitations

The spark spread is the difference between the price received by a generator for selling a unit of electricity and the cost of the fuel required to generate this unit. Thus the efficiency of the generating plant is a key factor in spark spread calculations (this issue is addressed in the following section).

Spark spread data does not present the full picture, however. Taxes, transport costs and fixed expenses (staff, maintenance etc.) are not included in the figure; these all change from plant to plant and country to country.

In addition, since January 2005 power generators in the European Union (EU) have had to hold sufficient carbon allowances (known as EUAs) as part of the EU's emissions trading scheme (ETS). A 'clean spark' provides an indication of the profit a generator can make from selling power, having bought both the fuel and the required number of EUAs. This Brief, which looks at the relative competitive positions of CCGT and CHP, does not address this specific aspect.

Finally, Delta is not aware of any previous spark spread calculations that include the recovery and use of the heat from CHP generation. This is important in order to assess more accurately the financial viability of CHP plants in relation to other gas-fired generation.

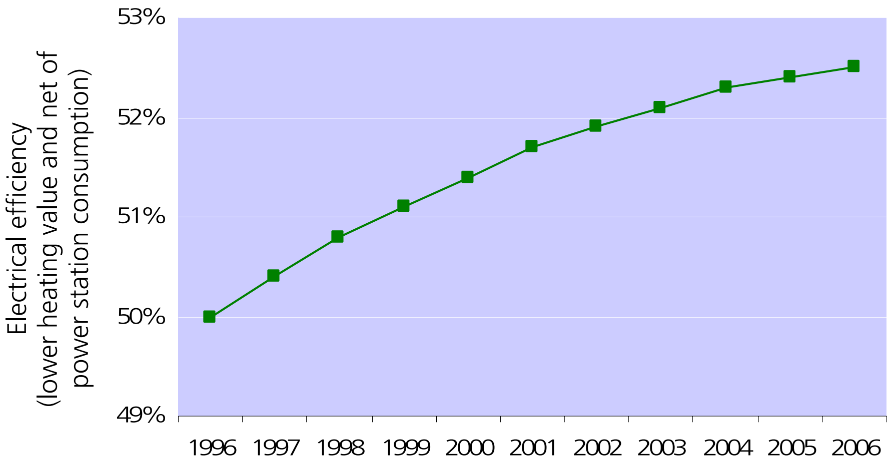
The Fuel Cost of Generating Electricity

To calculate the fuel cost of generating a unit of electricity, both the efficiency of the plant and the fuel price need to be known.

The Efficiency of CCGT plants

The spark spread calculation must assume a certain efficiency for the power plant. For modern power-only CCGT plants, spark spread analysis often uses efficiencies in the range 50 - 60%. A good deal of recent work has been done in Europe on the operational efficiency of CCGT in order to provide data for reference plants for the EU CHP Directive. Many data sources have been drawn upon and, although individual plant data is confidential, aggregated data of the operating efficiencies of modern CCGT plants is available and shown in *Figure 2* below.

Figure 2: Operating Efficiencies of CCGT plants.



Source: ECN and Cogen Europe

The Efficiency of CHP Plants

The overall efficiency of CHP plants varies widely according to several factors. These include the technologies used, the size of the plants, the sector in which they are installed and the operating requirements for each application. Three example CHP schemes have been considered for this paper:

> An 80 MWe CCGT CHP plant on a chemical site with a steam output of 80 MWt and an overall annual efficiency of 82%.

> A 10 MWe CHP plant in a food factory using a gas turbine with a waste heat boiler and producing 15 MWt of steam with an overall efficiency of 81%.

> A 1.2 MWe CHP plant in a hospital using a gas engine with hot water heat recovery of 1.4 MWt and an overall efficiency of 86%.

Calculating a CHP spark spread requires that the heat output of the plant is recognised. The method Delta has chosen for this, one used widely in Europe to assess CHP performance, is the *marginal electrical efficiency*.

In this method, the heat output of the CHP plant is used to calculate the fuel used by a heat-only-boiler to generate the same amount of heat. This quantity of fuel is deducted from that used by the CHP plant and the amount of remaining fuel is used to assess the efficiency of the CHP electricity generation.

Again referring to the EU CHP Directive reference plants, modern boilers are assumed to have annual operating efficiencies of 90% for hot water and 85% for steam.

Thus for the three example CHP schemes considered in this Brief, the marginal electrical efficiencies are shown in Table 1.

Table 1: CHP Marginal Electrical Efficiencies

CHP Scheme	Marginal Electrical Efficiency
80 MWe	79.2%
10 MWe	75.7%
1.2 MWe	81.8%

Gas Prices

European gas prices have seen substantial rises in the past couple of years. In early November, the Zeebrugge Hub price reached €28/MWh. In the year to September 2005 (before Hurricane Katrina) the price averaged just over €15/MWh and in 2004 it was around €11/MWh.

In the US, prices at the Henry Hub reached $14.50/mmBtu (€42/MWh) in October 2005. Prior to the hurricane season the prices were in the range $6-$8/ mmBtu (€17-€23/MWh). Thus gas prices in the US were roughly 50% higher than European prices at the end of October 2005.

The Fuel Cost of Generation

Because of the greater efficiency of CHP, the fuel cost of generation will be lower than that for CCGT, and this is reflected in Delta's spark spread calculations. An important issue here is the relative prices of gas paid by CCGT plants and those paid by smaller CHP plants. While CHP plants will not normally be able to buy gas at the same prices as large CCGT plants, this is partially compensated for through the higher value of the electricity generated by CHP plants embedded into electricity networks.

Electricity Prices

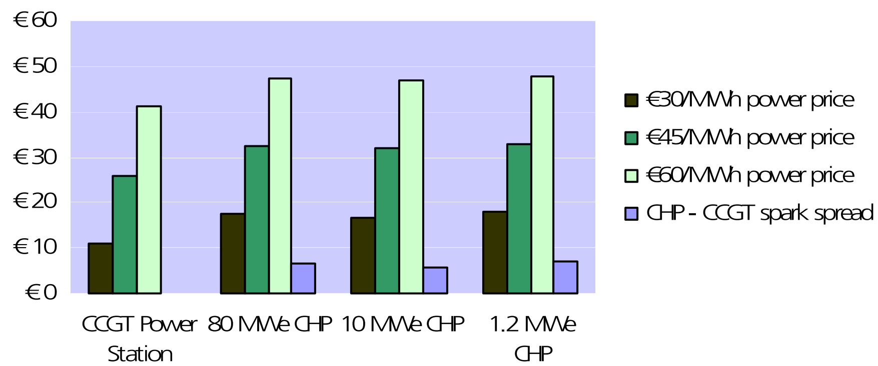
Wholesale electricity prices in Europe have also increased in 2005. The average wholesale electricity price was €32/MWh in 2004 and has been €50/MWh in the second half of 2005. There is considerable variation in these prices on a daily basis. The increase in prices is attributable to several factors, including higher fuel prices and the EU ETS. Prices have also risen in the US, though by a much smaller margin. In parts of US, the average industrial user price for electricity has been $54 (€46)/MWh in 2005 and was $51 (€44)/MWh in 2004. Californian and north-eastern wholesale exchanges show similar average monthly prices.

Spark Spread Comparison – Some Examples

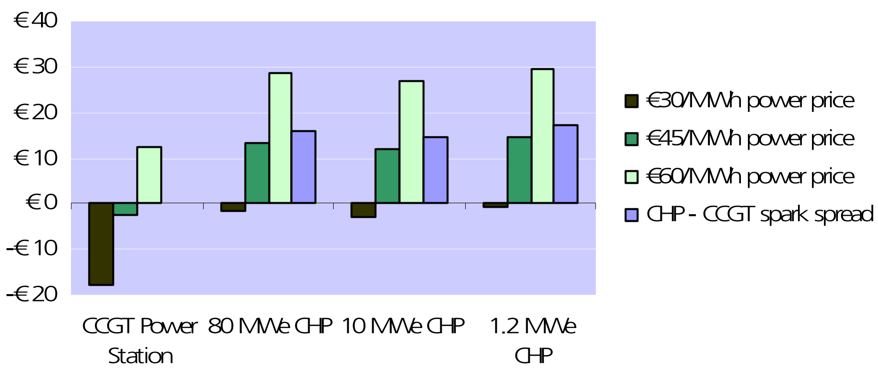
Using a set of three wholesale power prices (€30, €45 and €60/MWh) and three gas prices (€10, €25 and €40/MWh), the Delta CHP Spark Spread can be calculated for the three CHP plants described above and a CCGT power plant. This is shown in *Figure 3.*

Figures 3a-c: Spark Spreads for CHP and CCGT Plants for Different Power and Gas Prices

3a: Spark Spreads for €10/MWh gas price.



3b: Spark Spreads for €25/MWh gas price.



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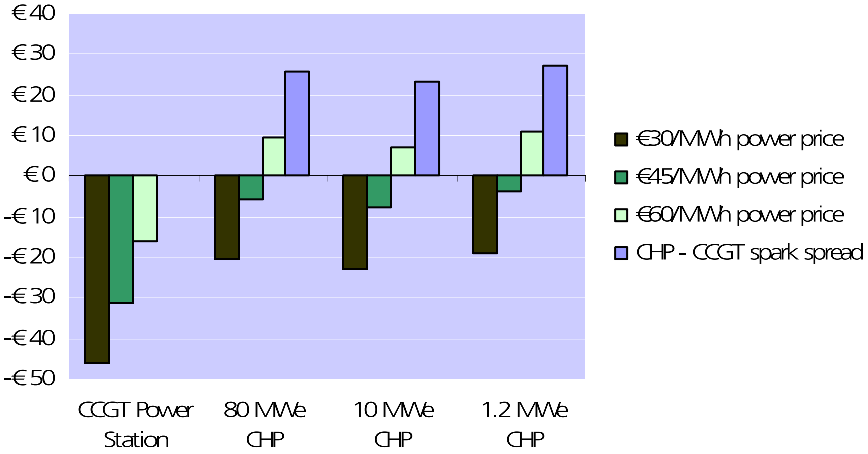
3c: Spark Spreads for €40/MWh gas price.

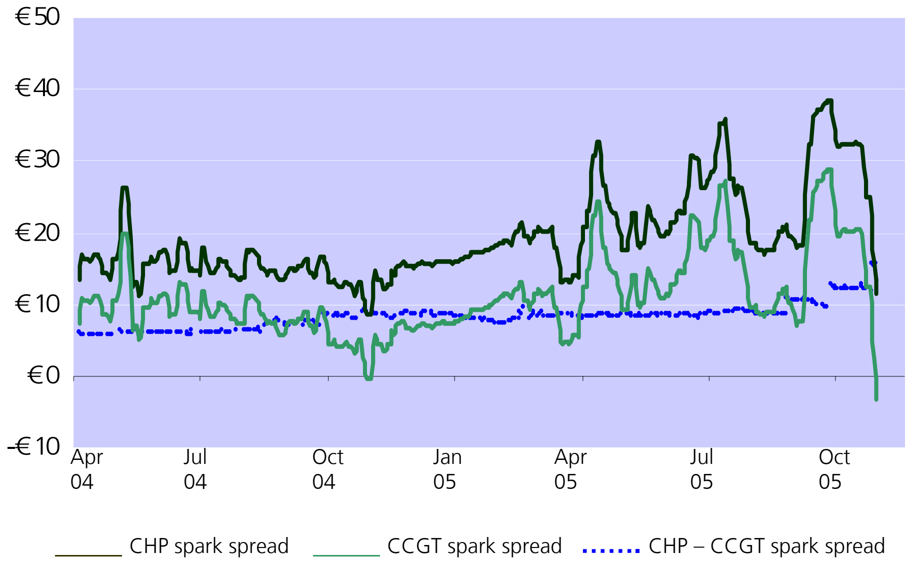


These figures show that, given the same gas price, CHP has higher spark spreads than the CCGT power-only plants. More significantly, the graphs also confirm that the spark spread margin between these two plant types increases as the gas price rises against any given electricity price. (While a higher gas price for CHP will diminish the margin, the relative trend remains: as gas prices rise, the relative competitive position of CHP improves).

Spark Spread Trends in Europe

Delta has also calculated European spark spreads based on actual gas and power prices. Figure 4 shows these spark spreads for a CCGT and gas-fired CHP (10 MW industrial plant) using the price of gas at the Zeebrugge Hub and the Conti Power Index for European electricity.

Figure 4: European Spark Spreads for a 10-MW CHP plant and a CCGT power plant



Based on this analysis, the margin between the power station spark spread and that for CHP has varied from around €6 to over €15 in November 2005. This margin is proportional to the change in gas prices, which have generally risen over the time period shown in Figure 4, substantially so in recent months.

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Conclusion

Based on the spark spread comparison therefore, gas-fired CHP is becoming a more attractive investment proposition relative to power-only CCGT plants as gas prices rise. Clearly, there are several additional important factors that will also influence such choices. For example, account will need to be taken of the higher plant costs for CHP, location factors, grid connection costs - and other issues. Equally, higher gas prices will incentivise developers to consider alternatives, such as renewables and coal, although the higher carbon emissions from the latter (and so the higher cost of emissions allowances) suggest that gas is likely to continue to be the fuel of choice for a significant proportion of new power generation plants.

As price trends change, Delta will update and publish the CHP Spark Spread on its website. Further Research Briefs will consider the impact of other factors that will shape future investment in the decentralised power generation sector, including an analysis of electricity production costs.

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Delta Energy & Environment provides independent, commercially oriented research and analysis in the decentralised power generation, cogeneration and renewable sectors. Services include consultancy and a growing range of research products. Delta is based in the UK and Belgium, serving a diverse range of clients from around the world. For further information visit www.delta-ee.com.