CHP and Electrification

confederation of paper industries

DISCUSSION PAPER

Papermaking is an energy intensive process which uses electricity to drive the paper machine and heat to dry the paper from 99% water content to 6-7% in a few seconds. Since 1990, UK papermakers have already halved the amount of fossil carbon emitted per tonne of production. Ongoing investment is delivering yet more savings.

Combined heat & power technology (CHP) is a good fit for the sector; in the UK, 77% of paper is made at sites using either gas or biomass fuelled CHP, which delivers significant energy and cost savings compared to the alternative of grid-supplied electricity and stand-alone boilers used by smaller sites. Removing CHP from the sector would increase carbon emissions by around 28%. We're also starting to see policy proposals where the use of gas to generate process heat could be replaced by electrification. This paper discusses the implications and problems associated with policies to drive UK-based energy intensive sites to increase their use of grid supplied electricity.

The UK paper sector has an aggregate annual turnover of £12 billion, with 62,000 direct and a further 100,000 indirect employees. Notwithstanding the existing 46 paper mills, the UK imports more than half of the paper it uses, and exports more than half of the paper collected for recycling to other countries where the jobs and economic benefits are delivered. If the Government is serious about rebalancing the economy and delivering green jobs in left-behind parts of the UK, then adding value to the 5m tonnes of unrecycled paper by increasing UK papermaking would make a significant contribution to this agenda.

But such investment in new and existing sites can only be secured if the UK ensures that companies can access competitively priced energy during the transition to a net-zero economy.

The joint BEIS/Paper Sector 2050 Decarbonisation Plan identifies CHP as one of the key technologies to help deliver the plan, either powered by gas or biomass, and it was expected that Government support would be offered to further roll-out CHP across the sector and support the replacement of older CHP plant reaching the end of its operational life.

The two UK mills making virgin pulp already use UK sourced forest residues and wood-based wastes to power modern biomass fired CHP; with these low-grade and otherwise waste materials generally acknowledged to be eminently suitable for high-efficiency energy use in CHP. Such use should continue to be supported where suitable feedstock is available.

For other sites (where the feedstock is predominantly recycled fibre and biomass-based materials are not readily available) gas-fired CHP is acknowledged as Best Available Technology (BAT) by the UK regulatory agencies and in the sector technical BREF.

In this discussion paper we highlight that electrifying the existing paper industry through the national grid would be hugely expensive and add extra inflexible baseload demand to a network already struggling with managing fluctuating supplies of renewable electricity and increasing demand.

We also argue that energy intensive paper mills with modern CHP powered by decarbonised gas or sustainable biomass have an important role in ensuring security of supply by providing the back-up required by intermittent renewables. Sites with CHP can increase their take from the grid in times of renewable excess by turning their generation plant down; while reducing their demand and even supplying into the grid in times of shortage by ramping up the operation of their CHP plant.

A continued role for industrial CHP

CPI believes that industrial CHP fired by natural gas has a role to play in decarbonising the UK in the short to medium term by **supporting and decarbonising industrial production** and **reinforcing the national grid** to cover the gap before

alternative technologies develop and become cost effective. Such plant already plays an important role in supporting the grid and not adding to overall demand necessitated if industrial operators were to be driven to swap away from auto-generation and gas.

A new, state-of-the art gas-fired CHP delivers significant carbon savings versus electricity from gas CCGT and heat from boilers (and even more versus gas OCGT which is expected be the marginal generation technology for some years to come). It follows that, until gas is phased out of the generating mix completely, the use of high-efficiency gas-fired CHP at an industrial site will save carbon compared with the alternative of installing heat-only boilers and purchasing electricity from the grid.

The Government decision not to provide further incentives to invest in such plant, and indeed to withdraw some of those policies that have benefited existing plant in recent years, is misguided and should be reviewed.
CHP technology is BAT and economic alternatives are not currently available for many sites. The UK already has the most expensive grid supplied industrial electricity in Europe – so companies risk being forced away from affordable CHP to unaffordable grid supply.

There is a risk that papermaking company decision makers – nearly all of whom are headquartered outside the UK – decide to stop investing in their UK assets and reduce or cease their participation in the UK market because of the high costs of energy in this country. CHP is the obvious way to reduce this risk.

The role of CHP in the national grid

Government assumes that the electricity transmission and distribution system in the UK will continue on its rapid decarbonisation pathway. Now that coal has been essentially removed from the generation mix, natural gas is the major fossil fuel used to produce electricity. The Committee on Climate Change (CCC) assumes that unabated gas generation will no longer be needed after 2035. At some point before this, depending on how quickly natural gas generation is phased out, co-generating heat and electricity from natural gas will no longer produce electricity with a lower carbon content than that sourced from the grid.

The expectation is that, provided appropriate policies that increase the price of higher carbon fuels are put in place, sites currently using gas-CHP will find it economic to swap from auto-generation to grid-supplied electricity and separate heat boilers.

Some obvious issues arise from this assumption:

- CHP delivers overall efficiency by combining the generation of heat and power – it follows that CHP cannot be simply viewed from an electricity generation perspective.
- Can the UK generate and distribute the large quantities of low-carbon electricity required (just as other sectors such as transport and domestic heating are also being driven to electrify)?
- The existing supply network and local connection into mills cannot cope with full electrification of energy demand. A huge investment would be required to upgrade.
- CHP attached to a mill allows for flexibility of operation to match site demand for both heat and power so overall efficiency is optimised.
- A dispersed network of local generation helps ensure stability in the nations supply of electricity in times of stress.

The important issues to consider are:

- How rapid will grid decarbonisation be? Even if the average grid carbon factor reduces quickly, what is the marginal generation technology going to be? Can dependable gas generation be put on one-side as quickly as suggested by the CCC?
- Increasing dependence on renewable generation (especially off-shore wind) will make supplies less stable – increasing the need for guaranteed back-up. Are there realistic (and cost effective) alternatives to this back-up being provided by gas?
- If bio-methane and renewable hydrogen are blended into natural gas (say at up to 20%) in the near and medium future, this will reduce the carbon intensity of natural gas in direct proportion and will push back the point in time at which average CHP generation becomes less carbon-efficient than average grid supply. New CHP plant should be designed to be fuel-flexible, with retrofit to existing plant as required.
- Can a UK paper mill move from CHP to grid electricity without reducing competitiveness to such a low level that future investment in the site is curtailed or stopped altogether? This is a particular risk if supply and distribution costs are allocated on a simple usage basis.
- Is it sensible to increase the overall UK demand for grid supplied electricity by driving industry away from generating its own electricity? CHP provides a huge benefit to the electricity network in that the system does not need to invest in the capacity that would otherwise be needed if CHP did not exist. If industrial CHP is removed earlier than necessary, electricity network capacity will have to be enhanced at huge cost.
- CHP provides a further significant benefit in that excess electricity can be spilled into the grid locally, so both reducing the total requirement for power generated at distance and also further reducing the required capacity of the network.

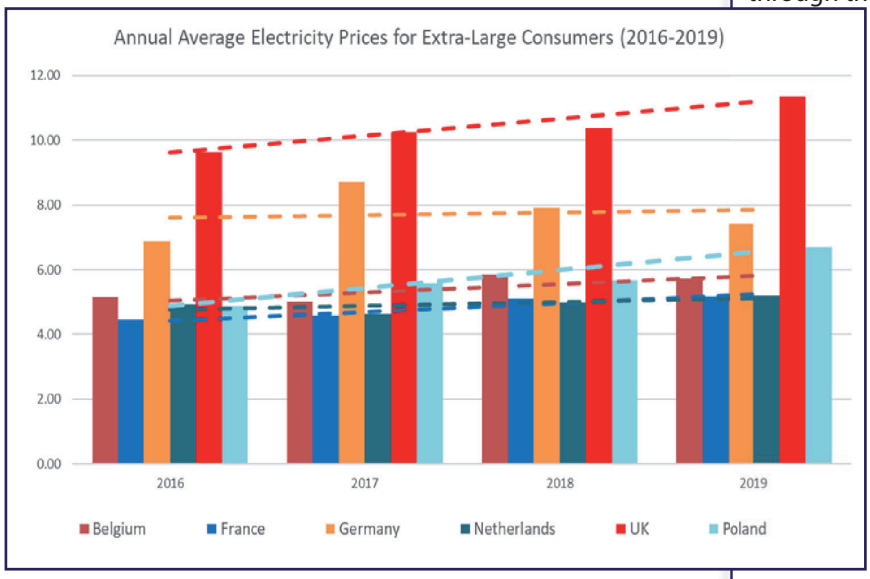
Affordability

One of the decarbonation strategies proposed during 2050 Roadmap discussions was to electrify production – but this was largely put to one side as uneconomic. However the CCC has now highlighted potential to substitute gas boilers for electric ones. Specifically, the CCC focuses on the falling cost of off-shore wind generated power, indicating this will lead to lower electricity prices.

This thinking is flawed for a number of reasons:

- The actual cost of grid delivered electricity at the point of use differs greatly from the cost at the point of generation. Non-generation costs (supply, distribution taxation etc) now make up more than half of a bill.
- Focusing on generation costs misses the costs of distribution and supply – and from off-shore locations these costs are huge.
- The cost to provide reliable back-up power when intermittent renewables (such as wind and solar) are discounted.
- The cost of historic policies to support the historic development of low-carbon generation are being carried by present day bill payers in honouring generous long-term supply contracts.
- Electric boilers don't exist at a scale needed by large sites.

In summary, UK industry pays the highest costs for grid supplied electricity of any major industrial nation – and there's no sign of this changing. Forcing companies to switch from gas the electricity would simply make UK sites uneconomic.



Energy Intensive Users' Group (EIUG)

Source for high UK electricity costs – BEIS Consultation into the operation of the Green Gas Levy (page 13) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/919901/consultation-green-gas-levy.pdf

CHP Carbon Savings

CHP is a proven way of increasing energy efficiency at a consumer site which uses both heat and electricity. Because of this (plus avoided transmission losses), it will always deliver carbon savings compared with use of the same input fuel to generate electricity centrally and distribute it to the site.

CPI holds data sourced from the CHPQA on the CHP installations at UK paper mills. A simple spreadsheet calculation (available on request) shows the carbon savings that electricity generation by gas-fired CHP plant delivers versus that produced by CCGT power stations.

1. Current paper sector average gas-fired CHP fleet:

- We know the natural gas fuel input to the fleet, the heat output and the electricity output. Assuming the heat is delivered at 81% gross efficiency allows us to calculate how much of the fuel is associated with electricity generation. Knowing the carbon content of natural gas allows us to assign a specific CO2 emission to each kWh of electricity generated.
    - o Carbon content of CHP electricity = 284 gCO2e/kWh
- Assuming a CCGT efficiency of 55% (fleet average) we can similarly assign a specific CO2 emission to each kWh generated.
    - o Carbon content of CCGT electricity = 335 gCO2e/kWh

Allowing 15% for transmission losses (in delivering the electricity through the network to the industrial site), the CCGT number increases to 394 gCO2e/kWh. This results in the CHP delivering a 28% carbon saving.

In 2019, gas-fired CHP in the paper sector generated 1,250 GWh of electricity. This saved 137,500 tCO2e compared with sourcing this electricity from the grid and assuming that it had been generated in a CCGT. In fact, there was 120,000 GWh of gas-generated electricity produced in 2019 and since gas is currently the effective marginal generation fuel, this carbon saving can be regarded as genuine.

2. Newest paper sector gas-fired CHP plant:

- We repeated the calculation for the newest CHP sets in the paper sector. On the same basis, the results are:

o Carbon content of CHP electricity = 219 gCO2e/kWh

o Carbon content of CCGT electricity = 335 gCO2e/kWh

Allowing 15% for transmission losses, the CCGT number increases to 394 gCO2e/kWh. The result is a 44% carbon saving.

A brand new, state-of-the art, gas-fired CHP can deliver significant savings versus gas CCGT (and even more versus gas OCGT which will be the marginal generation technology for some years to come). Until gas is phased out of the generating mix completely, high-efficiency gas-fired CHP will still save carbon.

And even then, there may be a role for low-carbon gas in providing support for industry and reliable back-up for the grid.

Adding demand to the grid

Some analysis to illustrate the impact of electrifying the 46 UK paper mills by switching from on-site CHP and boilers to grid supplied electricity (based on 2019 figures):

Sector use of fuel in CHP is around 9TWh pa (5.5TWh gas, 3.5TWh biomass), providing 1.6TWh of onsite electricity (from 4.2TWh of the input fuel) and 4.8TWh of heat. An additional 3.2TWh of gas is used in non-CHP mills.

To convert to grid supplied electricity then an additional supply of 1.6TWh would be needed to replace CHP generated electricity; an additional supply of 4.8TWh to replace the CHP heat; and an additional supply of 3.2TWh to replace gas boilers. Plus, the 1.6TWh of existing grid supplied electricity that could be reduced by additional investment into on-site generation would still need to be supplied from the grid.

So, to supply an electrified UK papermaking industry, the grid would be required to supply 11.2TWh of low carbon electricity – or a seven-fold increase on current imports. Assuming new generation operating at 100% load factor, this would require 1,278MW of new capacity.

Assuming this new generation would be supplied by off-shore wind (currently the preferred technology) and a load factor of 38% (source DUKES) then an installed capacity of around 3,200MW would be required. While the installations costs for new offshore wind farms has fallen, the estimate cost for the proposed Hornsea 3 array (2,400MW) is still quoted as £5B to £8B (source – funding statement by developer in the application documents for the Development Consent Order) – indicating an investment cost in the region of £7.5B to £12B to provide one and a half such sites to supply an electrified paper industry.

As well as this direct investment cost, off-shore wind cannot guarantee to supply electricity when needed - critical for continuous process manufacturing such as papermaking. Power cuts, and increasingly fluctuating voltage cause crash-shuts on machines that result in costly and time-consuming incidents.

This requirement for guaranteed power supply when needed, means either expensive storage or conventional back-up generation is required. The cost of this storage and back-up is additional to the capital investment cost.

The existing CHP fleet already provides this role, while modernised and new plant on industrial sites can provide a larger pool of support – required as intermittent renewable increase their generation role, so replacing traditional baseload fossil-fired plant.

Reinforcing and support the grid

An increasing component of electricity bills is the cost of the distribution and supply system. As well as the costs for national distribution, few if any of the existing supply links into paper mills are currently sized to be able to cope with a switch to 100% electricity use. Upgrading these links would be hugely expensive at site level.

A dispersed network of local generation plant

An additional benefit of having a significant number of industrial generators around the country is that they connect to the distribution networks at local level. This means they feed into the local distribution network when required by local conditions, so reducing the quantity of electricity required to be supplied by the transmission system to that local network. This also has the benefit that less physical reinforcement of the transmission system (to supply that local network) is required, with associated investment and operating cost savings for the system operator.

During the COVID-19 crisis with depressed electricity demand, sector CHP plant has operated flexibly – indeed a UK paper mill was the largest responder to one of the emergency response schemes with a 30MW swing offering based on flexible operation of the CHP.

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