Electrification – the cost and practicality of electrifying process heat

confederation of paper industries

DISCUSSION PAPER

Introduction

As part of the national strategy to transform the UK economy to Net Zero by 2050 (with challenging interim targets in 2030 and 2035 driving early action) policymakers are looking at decarbonisation strategies across the whole of the economy.

Amongst the sectors most affected by these proposed changes are the Foundation Industries – installations providing 75% of the materials that underpin manufacturing and construction supply chains, and where product shortages quickly translate into widespread economic problems.

These sectors (including chemicals, cement, ceramics, glass, metals and paper) are characterised by the energy intensive nature of their manufacturing processes and jointly they emit around 10% of total UK emissions of carbon dioxide, consume 12% of non-domestic electricity and 8% of non-domestic gas. With sites being mostly located in 'levelling up' areas, they already directly support 210,000 jobs, deliver £29 billion in value to the UK economy each year and their potential to help the levelling up agenda is recognised by Government. Indeed, Post-Brexit a number of policies are seeking to support these sites, securing jobs and attracting new investment to help deliver a re-balanced economy.

Additionally, the recent COVID-19 crisis has highlighted the importance of a domestic supply chain and the strategic risks of an over-reliance on imports. For paper-based products, packaging proved to be essential to keep supply chains moving, while the risk of tissue paper becoming unavailable was a trigger for panic buying.

With energy being one of the top three costs for energy intensive installations, decarbonisation polices that drive these costs higher in the UK than elsewhere inevitably make these sites less internationally competitive – and this comes from a base were the UK is already an expensive manufacturing location. Furthermore, driving up costs cascades through whole supply chains. With such sites being capital intensive, a progressive loss of competitiveness means losing out on new investment and eventually closure. If replacement plant is outside the UK, then domestic manufacturing is replaced by imports. Rather than delivering real carbon savings, closure of UK manufacturing results in 'carbon leakage' where emissions are simply moved to other countries – almost all with less ambitious climate change polices than the UK. If UK carbon accounting is adjusted to include imported manufactured goods, much of the reported progress in emissions reduction proves to be illusory.

A major part of the Government strategy is to support the decarbonisation of energy intensive sites by technological innovation and changing the energy sources to reduce their carbon intensity. The Committee on Climate Change (in evidence for the 6th Carbon budget) has examined these issues in some detail and identified a number of different approaches that could be taken, **including electrification, use of biogas, hydrogen and/or biomass, improving resource efficiency and of course improving energy efficiency.**

Decarbonising the Paper Sector

Papermaking uses electricity to drive machinery and heat to make and dry the product. The process transforms a dilute suspension of cellulose fibres in water into reels of paper, tissue and card ready for conversion into a wide range of paper-based products. The water content of the pulp at the start of the papermaking process is greater than 99% and this has to reduce to around 7% in the finished paper; this drying occurs in less than a minute.

Conversion into ready for use products happens either elsewhere on the same site, or at stand-alone conversions sites. In broad terms, mills processing wood into fibres (including those located in the UK), use biobased energy sources (process and forest residues); while sites utilising pulp made elsewhere (or paper collected for recycling) use natural gas. The UK sector has already moved away from coal, but it is still an

important energy source in some areas outside the UK. Most of the paper made in UK mills is produced at sites with their own Combined Heat & Power Plant (CHP), delivering energy saving when compared with using grid supplied electricity and separate heat boilers.

It follows that to decarbonise the UK paper sector – and deliver Net Zero – heat from natural gas needs to be replaced, either through technological breakthroughs or delivering low carbon heat.

Potential ideas and challenges are discussed in this paper: https://thecpi.org.uk/library/PDF/Public/Publications/Position%20Papers/PP_2050RoadmapFeb22.pdf

Energy Usage in UK Papermaking
In 2021, the UK industry made 3.7 Mt of paper and to do so it consumed the following fuels:

- *8.2 TWh of natural gas*
- *2.8 TWh of renewables (mainly solid sustainably-sourced biomass)*
- *0.1 TWh of other fossil fuels (oils & waste)*
- *1.5 TWh of grid supplied electricity*

The industry generates a large part of its electricity needs and in 2021 this amounted to 1.7 TWh (for internal use) and 0.26 TWh (for export to support the national grid). Therefore the total electricity requirement for papermaking was 3.2 TWh (1.5 imported + 1.7 self-generated).

Direct carbon emissions from fuels (so excluding those associated with the purchase of grid electricity) were 1.5 MtCO2. This represents 0.36% of the provisional 2021 UK figure of 424.5 MtCO2e.

Electrification

One of the most promising decarbonisation pathways is to switch heat production from natural gas to grid supplied electricity; this on the assumption that electricity delivered by the grid progressively decarbonises over time, as the proportion of low carbon generation supplied by the grid continues to increase. Indeed, the UK Government confirmed in October 2021 its intention that the grid be zero-carbon by 2035. Assuming this target is delivered, then by 2035, an industrial product made using 100% UK-supplied grid electricity would be zero carbon in its production.

Calculation of Electricity Needs:
In order to replace the use of natural gas with purchased electricity, based on 2021 performance, the sector needs to:

- *Replace heat from natural gas with heat from electricity. In 2021, the heat produced by natural gas was about 5.0 TWh. To replace this with electricity (at 95% efficiency) would require the purchase of an additional 5.3 TWh of electricity.*
- *Furthermore, to replace the electricity generated by existing natural gas-fired CHP plant would require the purchase of an additional 1.3 TWh of electricity.*

Therefore, whereas now the sector purchases 1.5 TWh of electricity from the grid, in an "electrification of heat" scenario the sector would require an additional 6.6 TWh of electricity – a 540% increase in quantity.

This grid decarbonisation presents a particular challenge for gas-fired CHP plant – major long-lived investments driven by regulatory policies. With high carbon grid supply, CHP delivers major carbon savings, but as grid supplied electricity continues to decarbonise, then at some stage carbon emissions become lower by replacing industrial use of gas with electricity – firstly in gas boilers, but also potentially also replacing heat and power from onsite gas-fired Combined Heat & Power plant.

The proposal to substantially increase the use of grid-supplied electricity by industry comes with a number of technical challenges, such as the additional total electrical demand, grid reinforcement needs, supply issues, new equipment and the loss of flexible industrial operation in balancing the grid.

As a contribution to this debate, CPI has commissioned two discussion papers to ask the question - can industry afford the investment and operating costs of swapping from gas to grid supplied power and stay competitive?:

The Economic Practicality of Electrification – this report is focused on grid supplied electricity being considerably more expensive than natural gas, and considers the economic OPEX case for electrification, exploring ideas to bridge the economic gap (in partnership with Cornwall Insight).

https://www.paper.org.uk/CPI/Content/News/Press-Releases/2022/Cornwall-Insight-and-CPI-publishes-analysis.aspx

The report concludes that making heat from electricity remains substantially more expensive than making heat from natural gas (even during the current energy crisis); and that the way UK industrial electricity is priced is far higher than in other major economies. To successfully electrify heat use by UK-based Energy Intensive Installations, both of these issues need to be resolved. The report goes on to suggest a number of strategies that policymakers could deploy – likely more than one would be needed to close the gap.

- Amending the supply rules so that market based solutions using the grid as a supply route (such as Corporate Power Purchase Agreements) result in lower delivered cost
- Amending the Network Charging rules to deliver less expensive industrial electricity

- Reallocating low-carbon generation support away from industry
- Rebalancing the relative policy costs between the electricity and gas markets
- Establishing new policy instruments such as Heat Contracts for Difference to deliver less expensive electricity to industry.

Grid Connection Assessment – this second report considers the technical and CAPEX issues for the upgraded electrical connection required if sites increase their electricity use (in partnership with Fichtner Consulting Engineers).

https://thecpi.org.uk/library/PDF/Public/Publications/Reports/UK%20Paper%20Mills%20Grid%20Connection%20Assessment.pdf

The report examines the process of electrifying the entire UK paper industry, specifically investigating the need to upgrade grid-electrical connections to sites to to allow the import of sufficient electricity to allow heat to be generated from electricity rather than gas.

In broad terms the report highlights that switching to 100% electricity is not realistic for all sites, and that major financial and technical investment will be required to provide grid connections to site boundaries ready for sites to electrify. While the report is focused on individual paper mills, it's likely that a number of other activities currently using fossil sourced energy will also be looking to electrify at the same time, so adding even further pressure to local supply grids.

The key conclusions were:

- **All site connections will need to be upgraded to allow a switch from gas use to grid supplied electricity.** None of the existing site connections are large enough to allow electrification.

- **Electrification will not be an option for all sites.** Even examination of a limited number of sites identified that such would be the increased requirement for electricity (especially at the largest sites) that the grid simply could not cope without reinforcement at all points of the regional supply network. It follows that grid supplied electricity is unlikely to be technically or economically realistic at the largest industrial sites. Notwithstanding this issue, the report assumes that additional electrical supply will be available at most sites, but noted that for the largest sites, alternative carbon mitigation measures such as switching to hydrogen may be a more feasible option. It is further assumed that the Distribution Network Operator will agree to provide electricity as required at sites being switched from gas to grid supplied electricity.

- **Substantial changes will also be required at site level.** The report takes no account of the extra site costs associated with utilising this additional electrical supply – the boundary for the study being the on-site sub-station, with no equipment requirements downstream of this being included. In reality, electrification will also require a new on-site electricity distribution network and the replacement of existing combustion equipment.

- **Constraints on grid capacity are likely to be a key limiting factor.** The analysis did not consider any allowance for increased electrical demand from other consumers in each area. However, it is certain that this will not be the case, as other non-domestic sites will also be seeking to electrify; as will domestic consumers as the roll-out of heat pumps and electric vehicles accelerates.

So, the reality is that when many of these sites actually try to electrify, then in addition to running cost issues, they will also face a constrained capacity grid, necessitating substantial grid reinforcement costs.

Role of CHP

The Paper Industry makes extensive use of gas-fired Combined Heat and Power Plant, as required under the existing technical documents that underpin the site operating permits issued by Government Regulators. Such plant currently delivers carbon savings when compared with stand-alone (grid supplied) electricity and (on-site) heat production – with the relative carbon balance changing over time as the grid decarbonises. As well as the fairness issue that these expensive investments have been driven by regulation, they also play an important role in supporting the operation of the grid. One of the growing challenges for grid management is the intermittent nature of some renewable generation, thus requiring expensive reliable back-up generation. Flexible use of industrial auto-generation (plus flexible industrial demand) could help support grid management.

CPI further considers this issue in a separate discussion paper: https://thecpi.org.uk/library/PDF/Public/Publications/Discussion%20Papers/DP_CHP_Aug2022.pdf

Other key issues

The on-site cost implications of replacing existing equipment with appropriate alternative equipment, is being considered directly by CPI in partnership with its members and equipment suppliers.

CPI August 2022