Position Paper

UK Paper Sector Decarbonisation Roadmap

Introduction

The United Kingdom continues to provide global leadership in reducing greenhouse gas (GHG) emissions and encouraging other nations to develop similar policies, most recently hosting COP 26 in Glasgow. Mandatory targets have been tightened and the UK now has a legally binding target that the country reaches a net zero emissions position by 2050. New interim targets (a 68% reduction by 2030 and 78% by 2035 from levels in 1990) require much earlier action than the old target of an 80% decarbonised economy (by 2050) that was in place when the sector Roadmaps were originally developed.

The Decarbonisation Roadmaps were developed as a partnership between industrial sectors and Government with an aspiration to establish a joint vision of what can be achieved, and a shared evidence base on how the vision can be delivered. With a multi-decade time frame for action, the importance of policy stability and support through the so-called Energy Transition (from a fossil-based economy to a renewable-based economy) is clear. Because UK manufacturing sites directly compete with overseas manufacturing sites, the government's decarbonisation policy cannot simply load additional costs onto UK sites on the assumption they will decarbonise because their competitors don't face the same costs.

Since the original Sector Roadmaps were published, the Government has moved from sector deals and detailed planning in partnership with industry to a broad top-down setting of targets and policy as outlined in the publication of an overall industrial decarbonisation strategy:

https://www.gov.uk/government/publications/industrial-decarbonisation-strategy

Notwithstanding this changed approach, the paper industry sector continues to work with Government to deliver a decarbonised UK industry.

This paper explores how the papermaking sector might reduce its emissions and provides an update on the Pulp & Paper Decarbonisation Roadmap reflecting technological and policy changes and should be read alongside the original document.

https://www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-roadmaps-to-2050

Throughout this report we refer to the Paper Industry. This means a fully integrated value system based around fibres, paper and cardboard. Forestry and recycling providing raw materials for pulp; manufacturing sites making reeled paper and card; conversion operations making reels into paper-based products; and collection systems feeding clean used paper back for recycling.

The original 2050 Decarbonisation Roadmap

In 2014, eight heat-intensive sectors (pulp & paper, cement, ceramics, chemicals, food & drink, glass, iron & steel, and oil refining) worked in partnership with Government to explore the technical routes through which their sectors could decarbonise and support the 80% decarbonisation target then in place. The pulp & paper team was jointly led by CPI and the Paper Industry Technical Association (PITA). Discussions involved company representatives, suppliers to the industry, academics and experts on particular topics who jointly identified opportunities to decarbonise and make production more energy efficient, whilst also addressing the barriers preventing these outcomes being delivered.

Key issues from the original Roadmap

As well as sector-specific issues, a series of generic topics were also identified, including skills and training, access to finance, industrial heat recovery, biomass resources, industrial clustering and carbon storage & utilisation. These topics continue to be central challenges and need to be properly addressed through an overall UK Industrial Strategy and the wider levelling up agenda.

While CPI and papermakers continue to welcome government promises to support industry in its decarbonisation journey and become more energy

efficient, there was always a concern that strategic thinking had (and still has) a UK-only focus. It has also become clear that while the UK has developed some support schemes, their ambition and scale are lower than those developed by the European Union, further disadvantaging domestic industry.

Thinking by policymakers seems to discount the reality of an international operating environment where competing installations located overseas – critically not facing the same regulatory pressures and costs - have free access to the UK market. Ignoring this issue makes the UK a high cost location in which to operate and investment becomes much harder to justify for international investors who can choose to invest outside the UK or import manufactured product. This shifting of manufacturing outside the UK with no corresponding reduction in emissions is known as carbon leakage.

Since Brexit, this issue is now even starker with EU based competitors facing a 55% 2030 decarbonisation target verses a 68% UK target. As long as UK progress continues to be measured against domestic emissions (and not consumption emissions) there is a real danger that UK decarbonisation is delivered by closing industry and offshoring emissions. If UK progress in reducing domestic reductions is re-tracked against consumption emissions, much of the reported progress proves to be illusory.

Background to Net Zero

In 2019, the UK Government committed to deliver a net zero economy by 2050 which underpinned UK leadership of COP 26 in Glasgow. Net zero means that total fossil Greenhouse Gas emissions (GHG) are zero and this can be achieved by allowing some difficult-to-eliminate fossil emissions to be compensated for by technologies such as biomass energy carbon capture & storage (BECCS) and other carbon storage projects such as tree planting and land management changes which have the effect of introducing "negative" emissions. It is clear that reaching net zero will require extensive changes across the whole economy.

The Committee on Climate Change (CCC) believes the changes will encompass:

- resource and energy efficiency improvements to reduce energy demand across the economy;
- societal choices that lead to a lower demand for carbon-intensive activities;
- extensive electrification, particularly of transport and heating, supported by a major expansion of renewable and other low-carbon power generation;
- development of a hydrogen economy to service demands for some industrial processes, for energy-dense applications in long-distance HGVs and ships, and for electricity and heating in peak periods;
- carbon capture and storage (CCS) in industry, with bioenergy (for GHG removal from the atmosphere), and very likely also for hydrogen and electricity production.

Biobased, renewable and recyclable paper-based products are well suited to be part of this Net Zero economy but need support through the transition period to retain a strong domestic manufacturing base.

Progress to date

UK emissions were 48% below 1990 levels in 2020, though Covid-19 linked disruption has probably distorted this figure. For context, the fall in emissions between 1990 and 2019 was 40%.

The first (2008-12) and the second national carbon budgets (2013-17) have been met and the UK is on track to meet the third (2018-22) but is not on track to meet the fourth (2023-27) or the fifth (2028-32). The new Net Zero target (at least 100% reduction by 2050) plus the challenging interim targets for 2030 and 2035 mean that progress will need to dramatically accelerate. Additionally, the gas price crisis has illustrated the risk of an over-dependence on natural gas and focused attention onto alternatives ways to provide energy and drive forward energy efficiency. This cost crisis needs both short and long-term answers that support UK industry through the energy transition and don't result in the migration of UK manufacturing to locations with lower energy and carbon cost.

Reducing domestic emissions by closing UK industry and importing manufactured product is completely futile and achieves nothing in a global context.

Papermaking – a description

Paper is generally made from cellulose fibres mostly sourced from wood or by the recycling of used paper. For simplicity the Roadmap refers to "pulp & paper" but this covers different pulps and four general product sectors: packaging, print & writing, hygiene (tissue) and specialist products such as filtration papers and moulded fibre materials. Paper mills can use either (or both) primary (virgin) and secondary (recycled) fibre as feedstock. UK mills predominantly use recycled fibre which is sourced from paper collected for recycling.

Virgin fibre is sourced directly from wood and is either processed into paper in an integrated pulp & paper mill or delivered to a paper mill in the form of bales of pulp supplied by a remote pulp mill. The UK has two integrated virgin fibre mills receiving wood and processing it into paper on site; other mills using virgin fibre import in in bales. Smaller sources of cellulose fibre (for specialist use) come from plants such as cotton or abaca.

To form a continuous sheet of paper that can be produced in reels, the cellulose fibres are dispersed in water at a fibre concentration of less than 1%. This solution is sprayed onto a moving mesh and water immediately starts to drain through the mesh by gravity and then by vacuum. The continuous paper sheet becomes self-supporting and is lifted from the mesh to be fed into the press section where further drying is achieved by squeezing water from the sheet. Subsequently, heat is used to dry the sheet to a typical moisture content of between 3 and 8%; this heat being delivered by conduction through steam-heated rollers (over which the paper web passes at speed) or by direct radiative heating of the sheet.

In 2021, the UK consumed around 7.5 million tonnes of paper and manufactured 3.6 Mt (in 46 paper mills) with around 0.8 Mt being exported.

It can be seen that of the paper used in the UK, 2.8 Mt was made here, and 4.7 Mt was imported. These imports historically come from EU countries, but increasingly also from further afield. With the UK seeing growing levels of collection of materials for recycling, 4.3 Mt of used paper and card had to be exported for recycling outside the UK – material that could and should be recycled here. High energy costs in this country are one of the barriers to winning new investments which could close this loop.

Papermaking & Energy

Papermaking is an energy intensive process, with electricity used to drive machinery and heat used to dry the paper from an initial water content of greater than 99% down to around 6% in less than a minute. Almost all of the sector's GHG emissions arise from energy consumption and it is this consumption that needs to be addressed in order to reduce emissions.

Heat is mostly provided by the combustion of fuel; in the UK this fuel is currently a mixture of natural gas and solid biomass. 80% of sector heat is provided by steam of relatively low quality – saturated (or slightly superheated) steam at a few bars is required by the papermaking process. The remaining 20% of heat is supplied by direct drying (gas impingement burners or electrical radiative heating). This is unlike some other energy intensive sectors where high temperature heat is required, and the quality of the flame is important.

Electricity to power the paper machine drives, motors, vacuum systems and the like is imported from the local grid or generated on site. Because papermaking requires both electricity and heat, combined heat & power technology (CHP) is often a good fit for the sector and delivers energy savings compared to separate generation of power and heat. Almost 80% of all paper produced in the UK is manufactured at mills having on-site electricity generation using CHP plant.

Current Energy Statistics

Sector energy imports in 2021 comprised:

- 8.2 TWh of natural gas (used in CHP or boilers)
- 2.8 TWh of solid biomass (used in CHP)
- 0.2 TWh of other fuels
- (This "gas + biomass" provided 1.7 TWh of electricity and 7.1 TWh of heat)
- 1.5 TWh of electricity (imported from the grid)
- CHP plant also operate to support the national grid, and the sector exported 0.3 TWh of electricity in 2021.

Sector Carbon Reductions since 1990

For 2021, using Defra national carbon factors, and assuming a credit for electricity exported, the sector's fossil GHG emissions were:

- 1.53 MtCO2 direct emissions - with a specific figure of 0.42 tCO2/t
- 0.24 MtCO2 indirect emissions
- Compared with a base year of 1990:
- Direct fuel CO2 emissions were 63% lower
- Specific fuel CO2 emissions from direct fuel use were 49% lower

These reductions have been brought about by fuel switching (from coal & oil to natural gas & biomass), huge investment in CHP (both gas-fired and biomass-fired) and progressive energy efficiency improvements over the years.

Furthermore, reductions in the carbon content of grid electricity have helped reduce total CO2 emissions attributable to consumption of both direct fuel and electricity:

- Direct & indirect fuel CO2 emissions were in total 73% lower in 2021 than in 1990
- Specific CO2 emissions from direct & indirect fuel use were 63% lower.

Approach to Sector Decarbonisation

Assumptions

1. The effects of ongoing, business-as-usual, energy reduction investments in the sector (which may be expected to deliver an annual improvement of about 1% now but a steadily declining percentage as we move into the future) are counteracted by a small but regular increase in sector production tonnage as the sector slowly grows with UK recycled fibre-based manufacturing displacing imports of virgin fibre-based product. Additionally, paper products are increasingly being used in the packaging sector to replace fossil-based plastics. So for the purpose of this report it is assumed that total sector energy demand remains constant over time.
2. Assuming appropriate policy support, the three large mills currently using UK-sourced solid biomass as their primary energy supply continue to do so. This covers 2.8 TWh of fuel which is used to produce 0.74 TWh of heat and 0.33 TWh of electricity (plus electricity for export).
3. Removing these biomass mills from the sector leaves an annual sector heat requirement of 6.4 TWh and an electricity requirement of 2.5 TWh.
4. Electricity from the grid is steadily decarbonised such that by 2050 it represents a zero-carbon energy source. However it's worth noting that reducing auto-generation and increasing industrial grid electrical imports increases the challenge of decarbonising the electricity sector.
5. Gas-fired CHP is progressively swapped to zero-carbon gas or hydrogen or replaced by grid supplied zero carbon electricity.

Therefore, taking its 2021 energy demand and mix as a starting point, the sector needs to:

- Replace all the heat currently provided by natural gas with a zero carbon alternative.
- Replace all the electricity currently provided by gas-CHP with electricity from the grid or a zero carbon alternative.

Assuming that zero carbon grid electricity will be a fully available and cost-effective solution, this report assumes grid-supplied electricity will decarbonise without direct sector action (beyond paying for the transition through bills). This means that decarbonising the sector's heat requirement is the key challenge to achieving net zero.

Options to achieve zero carbon heat

Solid biomass

Solid biomass is a proven, reliable and sustainable source of energy for the paper industry. Historically, it is uneconomic to use solid biomass to replace natural gas (without subsidy) and there has not been a UK biomass conversion in the paper sector since 2012. Furthermore, supplies of sustainable biomass in the UK are relatively limited and there is insufficient material available at present to easily allow further large paper mills to utilise solid biomass as a primary fuel. Going forward, Government has stated that supplies of biomass will be prioritised for sectors having little alternative choice of fuel or to those sectors that need to mitigate process emissions. It follows that papermaking is not an obvious candidate sector (beyond the existing three biomass-CHP sites which have existing links into the local forest sectors that supply them with material for energy generation).

With no assumptions that UK site will utilise more domestic biomass or switch to imported biomass, we conclude that solid biomass is unlikely to make further meaningful inroads into our sector's fuel portfolio.

Biogas

Biogas can either be directly used by a site adjacent to the production plant, or blended into existing natural gas supplies. Indeed, there are already several anaerobic digestion (AD) plants at paper mills with the produced biogas either injected into the national gas grid or fed to a gas engine to generate electricity and useful heat. However, paper mill AD plants (using site process waste from processing recycled paper) are of a size that generally provide less than 10% of mill energy needs and most paper mills do not yet have AD facilities - they rely on aerobic digestion for secondary effluent treatment. Own-produced biogas is therefore likely to play a marginal role at best in decarbonisation of energy supplies.

Larger scale injection of biogas into the grid and its consequent use by paper mills on the gas grid will undoubtedly have some decarbonisation impact in the short-to-medium term; however the system of carbon accounting needs to be refined to confirm if the benefit

of the decarbonised bio-gas is claimed by a specific user (likely via a tradable certificate system) or benefits all grid users by helping decarbonise the general supply.

Assuming that at some stage the existing gas networks will switch to blended biogas and hydrogen, it is difficult to predict how much benefit could accrue to paper mills continuing to access grid supplied "gas" – indeed, will there be enough biogas and hydrogen (either as a mix or separately) to allow any paper mills to continue to use this "gas"?

We believe that mills are likely to be in a position to benefit from a decarbonised gas grid but that there will be insufficient decarbonised gas in the grid to allow all current mills to continue to use gas as their primary fuel.

Hydrogen

Hydrogen could replace natural gas in paper sector heat production. Hydrogen boilers and hydrogen impingement dryers are likely to be available in quantity in the not too distant future – provided the issues around hydrogen energy density, propensity to leak and flammability are addressed satisfactorily. On the other hand, hydrogen CHP seems to have limited applicability for the sector – why convert electricity to green hydrogen only to convert it back to electricity again? The energy losses and associated costs seem likely to mitigate against this approach, although the ability to convert green electricity unusable at time of generation into a fuel that can be used at a later time would be helpful. It should also be noted that paper mills are not generally of the scale where a hydrogen generation plant might be considered economic – and paper mills are not used to operating within COMAH-style hazardous process regulations that would apply to hydrogen generation facilities.

Current technology means that hydrogen is likely to be expensive (without subsidy) and probably available only in relatively limited quantities – meaning it will be reserved for applications for which there are few or no alternatives. Papermaking seems unlikely to be a candidate when compared with (for example) steel-making or HGV fuel. Furthermore, when natural gas is no longer available, and the existing gas networks are opened to biogas and hydrogen, it is difficult to predict how much benefit could accrue to paper mills continuing to access "gas" – indeed, will there be enough biogas and hydrogen (either as a mix or separately) to allow any paper mills to continue to use this fuel?

We believe that a handful of mills are likely to be in a position to benefit from a decarbonised gas grid but that there will be insufficient gas in the grid to allow all current mills to continue to use gas as their primary fuel. As for 100% hydrogen, there is a limited number of mills in the HyNet cluster (in NW England and N Wales) that could benefit from a direct supply of zero-carbon hydrogen provided by pipeline from Stanlow.

It should however be noted that a number of industrial sites are technically difficult to electrify due to local grid capacity constraints (see below) – in these instances, hydrogen could be the only feasible option to decarbonise.

Electrification

Electrification is a good fit for papermaking heat supply. Electric boilers are available in a range at relevant voltages and steam production rates (electrode boilers for larger requirements and resistive heating boilers for smaller ones); electric IR dryers are already available, and these could replace gas impingement dryers.

However, the biggest problem with electrification is that it is uneconomic to electrify heat because of the high cost of electricity in the UK. The only paper mill electric boilers installed in the world are in those countries where policies support their use in reinforcing grid operation by using electricity when the system is long and switching to gas when the system is short – this mode of operation is typically used to manage renewable intermittency.

The cost of new replacement electric equipment for mills (boilers, buildings, cabling, sub-stations, control systems) is high, but investment could be supported though capital grants and natural replacement cycles. However, the provision of increased grid capacity is likely to be hugely expensive and require years to deliver individual projects. This – together with the uneconomic operating cost issue mentioned above, are the two key blockers preventing the sector electrifying its heat use.

Total electrification of fossil heat in the sector would require 8 TWh of electricity to be supplied from the grid in addition to an electricity requirement of 2.5 TWh. This total of 10.5 TWh compares with a current import of 1.5 TWh. ***This is a greater than six-fold increase in import capacity!***

It is likely that within a few years, electric heat pumps that produce steam (rather than hot water) from paper mill waste heat (namely the warm moist air from the hoods and/or the warm cleaned effluent water) will become available. In this situation, because of their increased efficiency in producing heat when compared with an electric boiler, the widespread use of heat pumps could reduce the size of the required grid reinforcement. ***If we assume that steam-generating heat pumps are widely available by the mid-2030s and they can be successfully integrated into the flexible energy systems required by mills, then the required increase in grid capacity could be halved – say, to a three-fold increase – or even less.*** Grid capacity will still be a significant issue but will not be as problematic as it would be for straight-forward electrification.

Carbon Capture Utilisation and Storage (CCUS)

The investment to provide CCUS at scale is large and is well beyond the means of most paper companies in the UK whose sites are, on the whole, relatively small GHG emitters compared to the likes of steel, cement or chemical plants. We are not including CCUS as a site specific option in our decarbonisation roadmap (although see "Clustering" below).

Clustering

UK paper mills are in general not located in industrial clusters although there are a few mills that are in broadly the same geographic region as existing clusters (such as in South Wales and NW England). In the past 20 years, only three brownfield new paper mills have been commissioned in this country and although siting them in existing clusters was considered, in the end none were so located, and all have independent energy supplies as a result. We are not ruling out the construction of new mills in clusters in the future - especially where CCUS or hydrogen are available - but we believe clusters are not likely to play a major role in the decarbonisation of papermaking because moving existing sites to new locations is not practicable without huge support commensurate with building a completely new site and associated infrastructure.

Possible approach

Analysis of this information allows some conclusions to be drawn:

- It would be possible to completely electrify sector fossil heat but at considerable expense (mainly incurred for grid reinforcement and connection to site). Further development of heat pumps could halve the need for grid reinforcement. However from an OPEX perspective, electricity is not currently an affordable option, nor would it become so with current policy drivers.
- Biogas and hydrogen could supply a limited percentage of the sector heat requirement, but hydrogen is likely to be very expensive. It will be a viable fuel only at a few particular mills having particular characteristics.
- CCUS is not appropriate for the sector at site level.
- Clustering has limited applicability although this could be different for brand new sites.
- Therefore, we have to make some assumptions about the eventual mix of solutions that might transpire. The sector future fuel mix might comprise:
- Some limited biogas (from mill AD plants)
- Some limited biogas (blended via the existing gas grid)
- Some limited hydrogen (blended via the existing gas grid or from direct new supply)
- The balance is likely to be electrification

Potential pathway to 2050

Estimating the contributions likely to be made by each technology in a pathway is difficult depending on relative costs, policy support and deployment progress. As a starting point, the Committee on Climate Change (CCC) used the following approximate splits in its analysis of a paper sector decarbonisation pathway:

- Electrification 33%
- Energy efficiency 33%
- Resource efficiency 15%
- Hydrogen 8%
- Biofuels 8%
- Other 3%

Note this CCC analysis is for the whole paper sector including conversion and printing & publishing due to national statistical reporting that adds together a number of sub-sectors and is not exclusive to energy intensive papermaking. However, since these sub-sectors are mainly electro-intensive, the conclusions seem to be a not unreasonable possibility for the papermaking sub-sector (which is where most of the heat requirement is).

For the purpose of this report, we assume that progress on energy and resource efficiency will continue to be delivered and we welcome policy support (such a

capital grants via the Energy Efficiency Transformation Fund) and urge the level of support is increased to ensure that all UK mills have the most efficient technology installed.

With overall production expected to increase (more domestic use of recyclate and product substation to bio-based paper products) some of this benefit will be cancelled out, but we can still assume that resource and energy efficiency can provide 15% of the solution, we might have the following fuel split:

Fossil heat: 6.4 TWh requirement less 15% = 5.4 TWh.

- 15% of heat from biogas = 0.82 TWh
- 15% from hydrogen = 0.82 TWh
- 65% by electrification = 3.5 TWh
- 5% "other"

Electricity: all current electricity use (except that at the biomass mills) = 2.5 TWh and this must all come from the grid.

Note that one conclusion of this pathway is that electricity supply from the grid, which is currently 1.5 TWh, will have to increase to 6.0 TWh – a four-fold increase based on these annualised figures. In reality, peak heat demand is likely to be significantly greater than the annual average would suggest and therefore the increase in electrical connection capacity is likely to be about 6 times what we have now. However, if much of the electric steam-raising could be carried out using heat pumps instead of boilers, the required increase in connection capacity is likely to be – perhaps – only a two-fold increase (plus allowances for peak demand).

Required policy support

Decarbonising energy intensive manufacturing is a major global challenge, with products made at such sites often underpinning major supply chains, with trading certainly international and often global. It follows that driving up manufacturing costs so they are higher than elsewhere can only damage the competitive position of UK-based installations giving imports from lower cost locations ever greater share of the UK market and damaging exports.

The original roadmaps were developed in a spirit of co-operation between Government and industry, with an understanding that long-term policy stability is required to enable long-term investment decisions to be made.

However, current policy seems to assume that ever-increasing energy costs (specifically gas and carbon) will drive companies to reduce energy and switch to low-carbon alternatives. The above analysis explains that these alternatives are currently not technically feasible or not economic, meaning that companies have no-where to go but seek to pass high costs to consumers with a risk of losing market share.

CPI continues to remind policymakers that competitively priced energy is a pre-requisite for energy intensive manufacturing industries, and that without support through an Energy Transition, it will be difficult for UK installations to remain competitive and decarbonise.

The UK needs:

- A plan to reduce energy policy costs to levels competitive with competitor nations
- Reform of Ofgem to act as a better regulator to large energy users and drive lower costs
- A gas competitive decarbonisation strategy to fill the void between today's policy mix and the desired 2030+ position in which competitive alternatives to gas are available
- A reformed CAP to support sustainable forest management (SFM) and tree planting programmes to provide biomass and fibre resources for use by both manufacturing industry and energy demands, as well as recreation, carbon sequestration and bio-diversity services
- Continued biomass carbon neutrality to enable additional support for biomass CHP, linked to a growing UK sustainable forest resource
- A decarbonisation investment strategy that recognises the need for the UK to be an attractive location for both incoming investment from new investors and continuing investment from existing investors

Further Information

Further information is available from Steve Freeman, CPI Director of Environmental and Energy Affairs (sfreeman@paper.org.uk).

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