Position Paper

UK Paper Sector Decarbonisation Roadmap – Technical Update February 2022

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, so 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 Energy Transition (from a fossil-based economy to a renewable-based economy) is clear. With UK manufacturing sites directly competing with overseas manufacturing sites, then policy cannot simply be to load additional costs onto UK sites on the assumption they will decarbonise if 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, in favour of broad top-down targets and generic policy setting 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 remains willing 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 sector 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, industry suppliers, academics, and experts on particular topics who jointly identified opportunities to decarbonise and make production more energy efficient, whist also addressing the barriers preventing these opportunities 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 and 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 welcomed (and continue to welcome) government promises to support industry to decarbonise 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

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that while the UK has developed 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 – and 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 operating location 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 as against a 68% UK target. As long as UK progress continues to be measured in terms of domestic emissions (and not consumption emissions) there is a real danger that UK decarbonisation is delivered by closing industry and offshoring emissions. This issue negates the point of the UK's decarbonisation strategy by setting back progress on global carbon emissions. If UK progress in reducing domestic reductions is re-tracked against consumption emissions, much of the reported progress proves to be illusionary.

Background to Net Zero

In 2019, the UK Government committed to deliver a net zero economy by 2050, so underpinning UK leadership of COP 26 in Glasgow. Net zero means that total fossil GHG emissions are zero but that 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. 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 domestic emissions were 48% below 1990 levels in 2020, though COVID-19 linked disruption likely distorts this figure. The fall in emissions between 2019 and 1990 was 40% (but note these figure omit the emissions associated with the import of manufactured goods).

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 recycling. 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. All other mills either use paper for recycling or imported virgin pulp as feedstock. 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 into 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. At this stage, the continuous paper sheet is self-supporting and is lifted from the mesh with further drying by physical pressing. After this, heat is used to dry the sheet to a typical moisture content of 6%; heat being applied either using steam-heated rollers (over which the paper web passes at speed) or by direct heating.

In 2019, the UK consumed around 8.2 million tonnes of paper and manufactured 3.8 Mt with around 0.8 Mt being exported. These are the lowest UK manufacturing figures since 1984.

Of paper used in the UK, 3.0 Mt was made here (in 46 paper mills) and 5.2 Mt was imported, mostly from EU countries but increasingly from further afield. With increasing levels of recycling, 4.3 Mt of used paper and card were exported for recycling outside the UK – material that could and should be recycled in the UK. High energy costs in the UK are one of the biggest barriers to winning new investments to close this loop.

Papermaking & Energy

Papermaking is an energy intensive process, with electricity used to drive machinery and heat to dry the paper from an initial water content of greater than 99% down to around 6% within a few seconds. 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 generally 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 (impingement burners). 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 both electricity and heat are required, combined heat & power technology (CHP) is often a good fit for papermaking 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 via CHP plant.

Current Energy Statistics

Ignoring 2020 as a non-representative year because of COVID-19, sector energy imports in 2019 comprised:

- 8.7 TWh of natural gas (used in CHP or boilers)
- 3.6 TWh of solid biomass (used in CHP)
- This "gas + biomass" provided 1.9 TWh of electricity and 8.2 TWh of heat
- 1.6 TWh of electricity (imported from the grid)

CHP plant can also be operated to support the national grid, with the sector exporting 0.4 TWh of electricity.

Sector Carbon Reductions since 1990

For 2019, using Defra national carbon factors, and assuming a credit for electricity exported, the sector's fossil GHG emissions were:

- 1.64 MtCO2 direct emissions - with a specific figure of 0.41 tCO2/t
- 0.31 MtCO2 indirect emissions

Compared with a base year of 1990:

- Direct fuel CO2 emissions are 60% lower
- Specific fuel CO2 emissions from direct fuel use are 50% 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 and indirect fuel CO2 emissions were in total 70% lower in 2019 than in 1990
- CO2 emissions from direct & indirect fuel use were 62% 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-based recycled fibre based manufacturing displacing imports of virgin fibre based product. Additionally paper-based product are increasingly being used in the packaging sector to replace fossil-based plastics. In other words, (for the purpose of this report) it is assumed that total sector energy demand remains constant over time.
2. The sector continues to actively progress new opportunities with a Europe-wide Energy Solutions Forum bringing together industry, academia, researchers and equipment suppliers to identify and progress new and innovative ideas to drive efficiency and carbon savings.
3. 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 3.6 TWh of fuel which is used to produce 0.93 TWh of heat and 0.55 TWh of electricity (plus electricity for export).
4. Removing the biomass mills from the a sector leaves an annual heat requirement of 7.3 TWh and an electricity requirement of 2.5 TWh.
5. Electricity from the grid is steadily decarbonised such that by 2050 it represents a zero carbon energy source.
6. Gas-fired CHP is progressively swapped to zero carbon gas or hydrogen or replaced by grid supplied zero carbon electricity.

Therefore, taking its 2019 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 the 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.

Energy Solutions Forum – key ideas

- Lean manufacturing and operational excellence
- Use of Best Practices & Industry 4.0
- Paper production without water
- Products with lower grammage / lightweight products
- Improved mechanical dewatering / better presses
- Reduction of water in the size press
- Cascading of residual heat internal / external
- In-line water cleaning for water reuse
- Redesign entire drying system – drying with optimal heat recovery
- Heat recovery with heat pumps or solar thermal
- Power Purchase Agreements

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 sustainable solid biomass to replace natural gas (without subsidy) and there has not been a biomass conversion in our 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 three site currently with biomass-CHP with existing links into their local forest sectors that already 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 biogas produced either injected into the national gas grid or fed to a CHP 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 relying 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 biogas is claimed by a specific user (via a tradable certificate system) or benefits all grid users by simply 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 "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 COMAH-style hazardous chemical processes.

Current technology means that hydrogen is likely to be expensive (without subsidy) and probably available 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.

Additionally a number of industrial sites are technically difficult to electrify due to local grid capacity constraints (see below) so hydrogen could be the only feasible option to decarbonise.

Electrification

Electrification is a good fit for papermaking heat supply. We expect that electric boilers will shortly be available in a range at relevant voltages and steam production rates; electric IR dryers are already available and these could replace gas impingement dryers. Currently it is uneconomic to electrify heat and 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 – an increasingly important issue as growing amounts of intermittent renewables are developed that need a more proactive approach to balance grid supply and demand. Flexible industrial use has a key role in supporting grid operation.

Additional to uneconomic operational costs, the cost of new replacement electric equipment for mills (boilers, buildings, cabling, sub-stations, control systems) is high but could be supported though capital grants. However, the provision of increased grid capacity is likely to be hugely expensive and require exceptionally long duration to provide.

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 1.6 TWh. ***This is a greater than six-fold increase in import capacity!***

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 (e.g. South Wales, NW England). In the past 15 years, 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 to building a completely new site and associated infrastructure.

Possible approach

The analysis above leads to some interesting conclusions.

- It would be possible to completely electrify sector fossil heat but at considerable expense (mainly incurred for grid reinforcement and connection to site). Furthermore, from an OPEX perspective, electricity is not currently an affordable option.
- 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 may become a key technology, but is better addressed as a generic issue and not sector specific. 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 energy 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 energy efficiency progress will be cancelled out, but we can still assume that resource and energy efficiency can provide around 15% of the solution. For the balance we might have the following split:

Fossil heat: 7.3 TWh requirement less 15% = 6.2 TWh.

- 15% of heat from biogas = 0.93 TWh
- 15% from hydrogen = 0.93 TWh
- 65% by electrification = 4.0 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 1.6 TWh, will have to increase to 6.5 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 will be at least 4 times what we have now – and more like 5 to 6 times.**

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 higher than elsewhere can only damage the competitive position of UK-based installations giving imports from lower cost locations an 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 nowhere to go but seek to pass high costs to consumers with a risk of losing market share.

We continue 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. Without being too specific 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 industry, as well as employment, carbon sequestration and biodiversity services.
- Biomass carbon neutrality enables additional support for biomass CHP, linked to growing UK SFM 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.
- A policy to support the flexible operation of industrial power generation and use to provide support to the operation of the national grid.

Further Information

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