

Decarbonising the UK Paper Industry: Going beyond 80% to zero carbon – is it currently feasible to replace natural gas?



PRODUCED BY THE UK PAPER INDUSTRY TO INFORM THE ZERO-CARBON POLICY DEBATE

Executive Summary

As the global economy moves away from a dependence on high-carbon fossil fuels and finite resources, to a low-carbon, circular and bio-based economy, the UK is leading this transition with a net-zero 2050 target. Paper-based Industries, being based on renewable and recyclable forest fibres, have a key role to play.

However, the UK economy doesn't exist in isolation and it's critical that other countries follow this lead – without international action the estimated £1 trillion cost to the UK is simply a waste of money. With domestic emissions being such a small and declining proportion of world emissions (around 1%), a global response is essential. In this context, the UK must redouble attempts to secure international action, as well as drive change at home.

A decarbonised economy will mean major changes for Energy Intensive Industries (EIs) including papermaking. From an industrial perspective, measures to support and drive the transition to net-zero need to be realistic and ensure that domestic based manufacturing can be internationally competitive during the transition.

There's a particular issue in that revised UK targets bring forward actions to the 2030's – a much shorter timeframe for the new low-carbon technologies to mature and become internationally cost-competitive.

This paper addresses a particular set of issues around the use of natural gas as an energy source, highlighting that alternative technologies are either not yet proven, unrealistic or currently uneconomic. Until these alternatives are ready, natural gas, as the lowest carbon fossil fuel, has an important role to play as part of the energy transformation – a role that should not be lightly cast aside in a rush to decarbonise.

Why natural gas?

Natural gas is widely used for good reasons; it's easy to use with an existing distribution network and combustion equipment already installed; energy dense; efficient and clean with almost no sulfur dioxide emissions, low nitrogen oxide and particulates; and has 43% lower carbon emissions than coal and 30% less than oil. Global supplies are plentiful with a huge potential to further displace higher carbon fuels. There's no sign that countries outside the UK will stop using gas – something recently affirmed by the European Union.

It follows that simple policies that drive up the cost of natural gas in the UK risk making gas intensive domestic manufacturing uneconomic. In a fiercely competitive and price sensitive operating environment, uncompetitive UK gas costs will simply cost jobs and wealth creation as domestically made goods are swapped for imports.

We urge that the Treasury review into the cost impact of this new policy fully considers the impact on Energy Intensive Industries (EIs). Support and protection from low cost high-carbon imports should be delivered from day one and not rushed through in response to a crisis at a later date, as has been the case with a number of policies.

This paper considers the seven main options being proposed as alternatives to fossil gas in turn, (breakthroughs in energy and carbon efficiency; on-site renewable energy sources; replacing natural gas with low carbon gas; fuel switching to electricity; fuel switching to biomass; carbon capture and storage; and industrial clustering and recovering waste heat). At present none of these alternatives offer a commercially feasible alternative to natural gas. It's not just the capital investment cost that's an issue, it's also the ongoing running costs caused by switching to more expensive energy sources.

Natural gas is the sector's most important fuel and cannot easily or practically be replaced in the short term – the reasons are further explored in this paper. For the UK recycling industry - largely driven by gas – there's currently no realistic alternatives.

CPI urges policy makers to ensure that support is available to help UK industry transition to a low carbon future by working in partnership to understand issues and find solutions.

This paper is intended as a contribution to this debate.

UK Papermaking

Papermakers use both virgin and recycled fibre to deliver an ever-growing range of bio-based products. Most virgin fibre is made outside the UK in countries with huge and sustainable forest resources. The production sites use forest residues as their primary energy source and so produce carbon neutral paper and pulp.

Recycling has always been integral to the paper industry and a great example of the circular economy. For the UK, with relatively low forest cover, but a huge urban forest of paper to be recycled, recycling forms the basis of the industry. Around three quarters of paper made in the UK is produced from recycled fibres.

These mills use natural gas as their primary energy source to produce heat, and so unilaterally increasing the cost of gas would make their operation uneconomic. This is just at the point when policy makers are seeking to increase domestic recycling to reduce the reliance on exports of unrecycled materials to countries in the Far East, and also realising the opportunity for renewable paper-based products to replace oil-based single use plastics.

The UK Policy Context

The 2008 Climate Change Act set a legal target that, by 2050, direct UK emissions of greenhouse gases must be at least 80% lower than they were in 1990. In 2019, the Act was revised a target of net carbon neutral by 2050 – irrespective of what happens outside the UK. No detailed consideration was given to the huge cost on the UK economy to deliver this policy (estimated at £1 trillion by the then Chancellor). Post-Brexit, the Government has committed that UK climate change ambitions will be more ambitious than those of the European Union. The UK now has an interim 68% emissions target by 2030 versus an EU target of 55%.

The Committee on Climate Change (CCC) advises Government on the appropriate level for emissions

targets and how these can be met, reports to Parliament on progress, and identifies further measures required to meet future targets. For EEIs the work of the CCC is potentially challenging in two ways:

- The over-riding priority is to set and deliver the carbon budgets, and BEIS is required to develop policies to ensure the budgets are delivered. While cost is

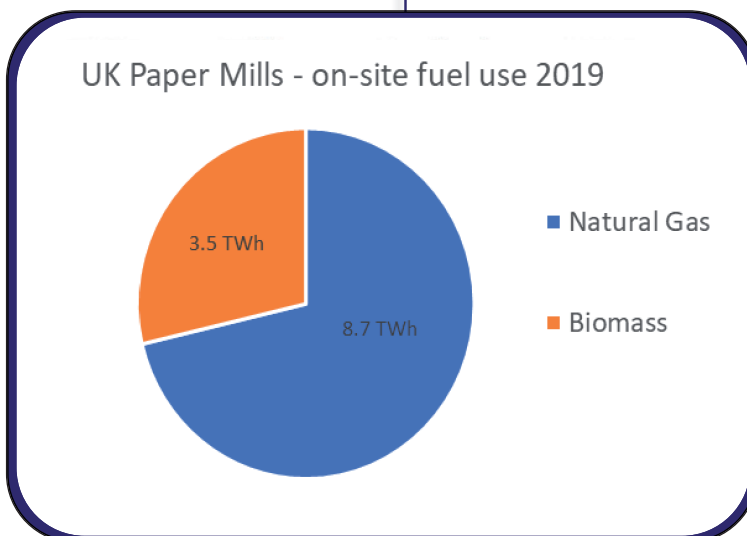
considered, it's ultimately a secondary issue and is considered over the whole of the economy. For EEIs this can be a huge problem as the cost of policies can drive up energy cost disproportionately in the UK.

- The focus is direct UK emissions only. Emissions in other countries linked to manufacturing of goods destined for use in the UK are not considered on the basis that this is a concern for individual countries and global negotiations. When the full impact of UK consumption on global emissions is considered, the reported progress with the reduction of direct UK emissions largely disappears. To drive to the ultimate, the UK could reduce direct emission to zero but still increase global emissions by importing power and goods manufactured outside the UK. The role of the CCC must be changed to also consider embedded carbon in imports.

2050 Decarbonisation Roadmaps

Papermaking is one of eight heat intensive sectors invited to work with Government in 2014 to explore the potential within the sector to decarbonise production (while remaining competitive) as the UK moves towards national decarbonisation targets. CPI and the Paper Industry Technical Association (PITA) jointly lead the interaction between Government and industry, resulting in the production of the original report and the subsequent action plan to progress specific topics. The published Roadmaps explore the technical potential for decarbonisation and progress actions to deliver energy efficiency and decarbonisation in each of the sectors.

For the purpose of this analysis the assumption is that national policies will have decarbonised the electricity grid by 2050 and likely much earlier – meaning that grid distributed power will be zero carbon. But note that UK electricity is already the



most expensive in European competitor nations and adding extra demand may increase this cost further, especially if natural gas can play no role.

As the sector has already moved away from coal and oil, this leaves natural gas as the only fossil fuel still being widely used in papermaking. The remainder of this paper considers if ending the use of natural gas is technically and commercially feasible, and the effect on papermaking if policy makers drive up the cost of gas to make use in the UK uneconomic compared to using gas elsewhere.

A continued focus on energy efficiency

Significant and strategic investment by papermakers over a number of years mean that around three quarters of UK made paper is produced at sites with high efficiency Combined Heat and Power plant, with major recent investment in new plant.

Papermaking carbon dioxide emissions from fuel combustion have reduced by 67% since 1990, the base year for the first Kyoto commitment period. Correcting for a shrinkage in the size of the sector, this means that carbon efficiency has improved by 58% over the same period. This is due to fuel switching (from coal and oil to natural gas and solid biomass), investment in CHP, investment in energy efficiency techniques and technologies and – in the last few years – by a reduction in the carbon content of UK grid electricity.

Papermaking energy efficiency has improved by 32% over the same period – in other words, each tonne of paper produced now requires the consumption of 32% less energy than it did in 1990.

CPI has produced a discussion paper focused on the role CHP plays in decarbonisation.

Why is gas so important in UK papermaking?

In general, countries with large forestry resources tend to have Paper-based Industries based on virgin fibres, while countries with smaller forestry resources (such as the UK) tend to have Paper-based Industries based on recycling fibres. Of course, the whole system comes together to deliver sustainable, renewable based products as part of the growing bio-based economy.

This split has major implications for energy use. Mills making and using virgin fibre are integrated into a local forest economy and have access to low grade forest residues and papermaking by-products used to make energy. Generally, these mills have heavily invested in green energy and are largely self-supplying, often provide energy to users outside the mill.

Conversely, mills making and using recycled fibres (or utilising virgin fibres made elsewhere) don't have direct access to forest-based green energy, with natural gas being the main source of energy. For larger mills often used in high efficiency gas-fired CHP plant; for smaller mills, used in gas-fired heat boilers with electricity drawn from the grid.

It follows that the industry is not suited to a simplistic energy use plan that covers all mills, especially if the physical recycling of paper collected in the UK is to be delivered in the UK as part of a circular economy.

Market economics demand that mills continue to focus on energy efficiency, with major improvements already delivered including huge investment in gas-fired CHP and modern boilers.

And of course there's a reason that natural gas is so popular – it's relatively cheap, abundant, energy dense with diverse supply routes, easy to use in conventional equipment, and benefiting from an existing distribution network. Critically, using natural gas produces lower emissions of fossil carbon than coal and oil, and so has been seen as a transition fuel to a zero-carbon economy, a role now being reassessed in the net-zero carbon discussion.

The rest of this paper explores the main options being proposed as alternatives to gas and explores ways that gas use could be reduced in the sector.

Alternatives to gas

The main options considered are: (1) Breakthroughs in energy and carbon efficiency; (2) On-site renewable energy sources; (3) Replacing natural gas with low carbon gas; (4) Fuel switch – electricity; (5) Fuel switch – biomass; (6) Carbon Capture and Storage; and (7) Industrial Clustering.

Some of these options can be realised within the paper sector. Others rely on the decarbonisation of the energy sector. To date, none of the options identified seems to deliver, on its own, a satisfactory alternative to natural gas that is both technologically and financially viable to meet the 2030 and 2050 challenges. However, combining different options can potentially lead to a progressive move towards ambitious carbon emission reductions. Solutions will inevitably be site-specific as they will depend on local, regional and national circumstances.

Option 1: Breakthroughs in energy and carbon efficiency

Several promising areas for innovation continue to be explored to assess their potential to help drive the decarbonisation, and energy efficiency of papermaking. The technology readiness levels (TRL) of these solutions vary. Some are still at their infancy (TRL levels 1-3), but others are making substantial progresses and are close to or at commercialisation (TRL levels 8-10).

Financing programmes are needed to bring these new technologies to the UK, such as the Innovation Fund promised under the UK ETS (matching the scheme benefiting sites in the EU), new financing programmes in the multiannual financial framework, and sustainable financing programmes such as the Industrial Energy Transformation Fund.

It's also worth highlighting again the role of Combined Heat & Power (CHP) plant in ensuring that gas (and other energy sources such as biomass) are used as efficiently as possible. CHP is intrinsically more energy efficient than stand-alone energy and heat production but is capital intensive and operationally more complex. Some types of papermaking have a power/heat requirement that matches to CHP better than others and indeed all larger UK mills where the balance is clear already have CHP. However some of this plant is close to the end of its operational life and there may be unrealised opportunities at smaller sites that could be delivered with the right support. Such projects would predominantly be gas-based but do offer efficiency savings as part of an energy transition.

In summary, ensuring that UK sites are operating in the most energy efficient manner will continue to drive carbon and energy savings, but (with current technologies) this will not fully decarbonise the industry.

Option 2: On-site renewable energy sources

The use of on-site renewable energies can reduce the need to import energy sources, such as natural gas or electricity. Several solutions could be envisaged:

1. Bioenergy from solid by-streams

Energy recovery from solid by-streams (sludge and rejects) accounts for about 1% of energy fuels used in the Paper Industry. It can take the form of conversion to energy carriers (such as gasification, pyrolysis, anaerobic digestion and secondary fuels production) or direct conversion to energy (incineration).

Moreover, several paper mills are already producing biogas from anaerobic waste-water treatments. In some cases, biogas accounts for 5% of a paper mill energy consumption. Potentially, this figure could go up to 10%.

In most of the cases, technology is mature and could be more widespread across the sector. More than 50% of solid by-

streams are composed of organic matter and, when used for energy purposes, this counts as renewable energy. In some cases, this has contributed in reducing carbon emissions in paper mills by a substantial amount.

However, energy recovery often faces strong local opposition, and a number of mills already use waste materials for different processes such as soil improvement or animal bedding.

Additionally, research continues to commercialise other ideas that could be alternatives to simple energy recovery.

2. Heat Pumps

Heat pumps are an interesting and developing technology to reduce external energy input and can be potentially deployed in paper mills. Developments are still needed for temperature above 180 °C, but some preliminary studies suggest that heat pumps could supply steam up to 160 °C, starting from ground water of 10 °C, or higher temperature waters where the heat is currently economically unrecoverable.

Pilot projects have already proved successful and plans for demonstration units in paper mills are ongoing in Europe. Research and development efforts are still needed to reduce capital expenses and increase the output temperatures. However, the huge issue is that this technology increases the use of electricity, which is often not an economic option.

3. Geothermal

Ultra-deep geothermal energy could also potentially deliver the necessary heat for papermaking. Projects could also be developed in partnership with local authorities or technology providers. The technology is currently being tested in other sectors, although it currently looks very expensive. Moreover, drilling underground for several kilometres would require quite specific geological conditions and societal acceptance, as well as solving technical challenges to ensure projects deliver long-term energy and a return on the high capital investment.

4. Solar & Wind

Deploying photovoltaic panels, solar heating or small wind turbines is theoretically possible, depending on the size and the geographic conditions of the paper mill. Examples of roof-top photovoltaic are already present in some paper mills, while a large-scale solar heating scheme is currently being installed in a first-of-a-kind project in Europe. However, considering the high volumes of energy currently needed for papermaking, energy produced by on-site solar and wind is unlikely to supply the full energy demand in a given paper mill.

In summary, all of these technologies offer opportunities but are very site specific.

Option 3: Replacing natural gas with low carbon alternatives

A seemingly simple solution would be replacing natural gas with “decarbonised” alternatives such as hydrogen or biogas, to be delivered to the point of consumption via existing infrastructure.

The gas industry has identified three options:

1. Blue Hydrogen from carbon capture and sequestration: carbon would be separated from natural gas, with the carbon being re-injected into depleted gas fields or stored elsewhere.
2. Green Hydrogen from power-to-gas: electricity would be used to generate hydrogen and/or synthetic gas.
3. Biogas: biomethane would be produced by gasification of energy crops or organic wastes.

In all these cases, the final product would be injected in the existing natural gas grid and/or part of local distribution networks.

The Paper Industry could potentially be a good enabler of these solutions, as it could use biogas, hydrogen, or a combination of the two, in combustion plants. However it's not clear how existing plant would cope with this changed fuel stream. For simple boilers, changes may be limited to new burners, but for more complex CHP plant, there would likely need to be substantial changes to the whole of the combustion section and operational controls.

This being said, there are several considerations to be made:

- In none of the studies commissioned by the gas industry would natural gas would be 100% carbon free and/or neutral by 2050 across the whole of the UK.
- The transition from natural gas to hydrogen requires careful planning in adjusting infrastructures and combustion equipment for end-users. To date, there is no plan for a national hydrogen network, though some regional initiatives are under consideration.
- The practical on-site implications of switching from gas to hydrogen are not well understood. Major work will be required to pipe networks to safely handle the smaller molecules of hydrogen and mitigate increased explosive risk.
- If volumes remain small, hydrogen would be better used in products delivering higher added value (such as fuel cells) rather than as a combustion fuel.
- Taking natural gas and converting to hydrogen adds an additional step to the process, with an unavoidable increase in cost.

- Although biogas production is projected to increase, by 2050 the biogas share in natural gas consumption is still expected to be relatively low (below 30%). It might ultimately make more sense to use it locally, potentially reaching 100% share of local demand, rather than having a minor share in the upstream gas distribution.

In summary, technologies to substitute natural gas for biogas and hydrogen are being promoted as a way to progressively decarbonise the existing gas network.

However the economic impact of switching from natural gas are huge, and for hydrogen there are a number of technical issues (around explosive risk and operation of combustion plant) that are not fully understood. Importantly the alternative fuel would almost certainly be more expensive, meaning an ongoing increase to the operational cost of sites.

Option 4: Fuel switch - electricity

The key issue is that grid supplied electricity is expensive. Papermaking requires low-temperature steam (<180°C). From a technical point of view, steam can be generated using electricity, thus replacing natural gas. Electrical boilers are a well-established technology and could be the first step towards the deployment of new electro-technologies and solutions.

Demand-side flexibility is potentially an important methodology to help better manage the increasing amount of intermittent electricity on the grid. On-site energy generation and industrial use of power is managed to allow grid supply to be drawn when there is an excess of renewable energy on the grid; while power is generated and use minimised when the grid is short of power. Part of this system could integrate electric boilers to generate steam. By switching the energy source, this solution allows paper mills to provide a service to the electricity sector in helping manage intermittent renewable electricity - without affecting paper production.

That being said, use of electricity for demand-side programmes and full electrification are two different concepts. In the first case, industry provides a service to the network, by absorbing excesses of renewable electricity. In the second case, it becomes a liability to the electricity sector, as it brings additional baseload demand to the electricity transmission networks. Replacing natural gas with electricity would increase the UK industry's electricity demand by a factor of 3.6. Because CHP would be redundant in this instance, total grid electricity demand for the papermaking sector would increase 7-fold.

Matching this additional demand would require major investments in both reinforcing transmission lines and an increase in electricity generation - the existing connections

for many sites could not cope. Delivering additional final electricity demand would in fact require an even larger use of primary energy due to energy conversion and network losses.

Such an increase in baseload demand would have to be matched by an increase in decarbonised electricity generation and by a programme to reinforce high voltage transmission lines. This aspect should be seen in the wider picture, where electrification could be a better option to decarbonise other sectors.

Last but not least, a 100% switch to electricity would require replacing current assets, thus making the exercise particularly CAPEX intensive. This should be seen in conjunction with electricity prices being already considerably higher than natural gas; in the UK the cost of grid supplied electricity is prohibitively expensive and mills could not fully electrify and be financially viable. And an increase in electricity generation and infrastructures to accommodate the additional demand from electrification would have an impact on the cost of using electricity.

In summary, while an increased role of electricity in paper mills is to be expected, a full electrification of paper mills doesn't seem to be economically viable in the foreseeable future unless the cost of grid supplied electricity can be driven down.

Option 5: Fuel switch - biomass

The Paper Industry has a long tradition in sustainably sourcing and using biomass. From an energy perspective, biomass already accounts for almost 60% of fuel used in the Paper Industry across Europe.

However, the opportunity for the further use of biomass seems limited. This is due to a combination of factors, the most relevant being:

- Limited access to biomass feedstock
- Lack of public acceptance by neighbouring communities and local planners
- Physical lack of space and storage facilities on sites
- Logistic constraints caused by the physical location of installations
- Higher emissions and more vehicle movements arising from an additional supply chain

In summary, the possibility to switch to biomass, although technically possible, is expected to play only a marginal role in further decarbonising the recycling of paper.

Option 6: Carbon Capture and Storage (CCS)

Carbon emissions from the combustion of natural gas could be captured and then stored. However, general issues on CCS

apply to the Paper Industry as well: storage location, infrastructures, public acceptance, economics, etc.

Moreover, emissions from gas-fired paper mills are relatively low – and often originate in different combustion facilities across the site. This makes CCS particularly expensive, as the ratio of volumes over costs of CO₂ captured would be low.

CCS deployment would also have to be assessed from an overall energy balance perspective, as carbon capturing generates efficiency penalties that might offset efficiency gains from cogeneration.

In summary, CCS doesn't seem to be a primary solution for the Paper Industry. It should be first developed to reduce emissions in other industrial sectors, especially those with large combustion units. One option to study should be the possibility to decarbonise industrial clusters by developing shared infrastructures to transport the captured CO₂.

Option 7: Industrial clustering and recovering waste heat

Across the UK a number of initiatives have sought to bring operational synergies and energy savings by clustering complementary industries together, with support promised from the Industrial Strategy Challenge Fund to deliver a world-first decarbonised cluster in the UK. In this context industries with higher temperature waste heat (say steel or glass plants) could supply paper mills, with paper mills in turn using lower temperature heats to supply a district heating system.

In a slightly wider sense there are some examples of waste-fired CHP where the papermaking makes use of the heat and power and helps provide part of the solution for local waste management planning. However, such opportunities are very location specific and expensive – additionally natural gas is normally used as a reserve fuel required to support the operation of such plant.

In practice such ideas are hard to deliver; planning systems don't offer flexibility; companies are reluctant to enter into the long-term supply contracts required by investors; and the cost of moving existing installations to new sites is prohibitive.

In summary, while this idea has merit it won't deliver for most existing sites, though it could be helpful if new operations can be attracted to the UK to make use of low-cost waste heat.

In conclusion

Simply pushing up the costs of using gas is a recipe to further decarbonise the UK by driving away industry and substituting UK production with imports from other parts of the world where carbon costs are lower and regulation of carbon emissions is less strict.

Indeed, Government should be encouraging businesses to invest in the UK, where carbon legislation is strict, so that these emissions can be managed down as quickly as possible, even if this means a short-term increase in domestic emissions to drive a faster fall in overall global emissions. Focusing on domestic emissions alone, and ignoring the growing levels of embedded carbon imported into the UK in imported goods, risks making the UK a climate hypocrite.

Focusing on domestic emissions alone, and ignoring the growing levels of embedded carbon imported into the UK in imported goods, risks making the UK a climate hypocrite. The previous 80% decarbonisation target accepted that gas should play a role as an interim fuel – a position that should be retained as alternatives continue to be developed and become commercially viable. EIs have long investment cycles and if the UK is to attract new investment there needs to be confidence that plant can economically operate throughout an investment cycle. Investments made now are likely to operate well into the 2030s and, at present, the alternatives to gas simply aren't economic.

Papermaking is hugely capital intensive and consequently risk-averse, meaning new technologies need to be well proven before widespread adoption. For a global industry deciding where to invest, demanding the use of new and unproven technologies simply drives investment to locations with lower carbon costs and importing even more manufactured goods.

- Energy and carbon efficiency improvements will continue to reduce the overall energy demand;
- On-site Renewable Heat production, through the integration of innovative technologies such as heat pumps or solar thermal, will reduce the demand for natural gas, thus delivering important co-benefits in terms of reducing carbon emissions, reducing primary energy consumption, and increasing the share of renewable energy sources;
- On-site valorisation of bioenergy from solid by-streams could reduce the demand for natural gas, thus delivering the benefits previously mentioned. Moreover, when seen in combination with the previous points, the relative role of bioenergy will be more important, though alternative uses for such by-products may limit this opportunity;

- More flexible CHP units and operational changes will enable the use of excess electricity produced from renewable electricity. By seamlessly switching the energy source, this solution would enable paper mills to provide a service to the electricity sector, by enabling further use of renewable electricity, without affecting paper production.

None of these options currently suggest that the use of natural gas could be reduced to zero by 2035 while keeping UK Energy Intensive Installations internationally competitive.

To move towards a decarbonised industry, there needs to be a partnership with Government to deliver:

- **Innovation**
 - Support research, development and deployment of new solutions
 - De-risking financing programmes, to mitigate the first-mover disadvantage
 - Make the identified areas eligible for sustainable financing programmes
- **On-site renewable energy sources**
 - Research, Development and Deployment of cost-competitive collection and use of biogas and of renewable heat solutions to be integrated in paper mills
 - Promote dialogue between heat producers, developers, industry and public authorities, in order to understand and address barriers (knowledge gap, financing, public acceptance...)
 - Promote energy recovery technologies, in compliance with the Waste Framework Directive
- **Energy supply**
 - Ensure the timely availability of clean and affordable energy supply. This requires the availability of both clean energy and related infrastructures
 - Develop local and regional plans and partnerships to develop biogas production
 - Allow industry to compete in the electricity market, on equal footing, in providing flexibility solutions

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