Energy Systems Catapult: Response to National Infrastructure Commission Call for Evidence

The Second National Infrastructure Assessment: Baseline Report

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About Energy Systems Catapult

Energy Systems Catapult (ESC) was set up to accelerate the transformation of the UK's energy system and ensure UK businesses and consumers capture the opportunities of clean growth. The Catapult is an independent, not-for-profit centre of excellence that bridges the gap between industry, government, academia and research. We take a whole-system view of the energy sector, helping us to identify and address innovation priorities and market barriers, in order to decarbonise the energy system at the lowest cost.

Overarching remarks

What are the main opportunities in terms of governance, policy, regulation and market mechanisms that may help solve any of the Commission's nine challenges for the Next assessment? What are the main barriers? Your response can cover any number of the Commission's challenges.

Only thirty years remain before the UK must legally reach Net Zero carbon emissions. All major emitting sectors – transport, heating, manufacturing, power generation, and farming – will need to change radically to get as close as possible to zero emissions by 2050. Our **Rethinking Decarbonisation Incentives** project, however, found that the UK's current carbon policy framework is not fit for purpose to deliver such ambitions.

Our work showed that the current incentives (i.e. the 'effective carbon price' paid per tonne CO_2e) arising from UK policies vary wildly across different sectors, even though the value of emissions reductions for mitigating climate change is the same. In simple terms, this suggests we may be over-rewarding some kinds of emissions-reducing activity while under-rewarding it in other activities or sectors.

The chart below shows the effective carbon prices and emissions in the UK by sector – the chart can be downloaded here, along with the underlying assumptions and data.

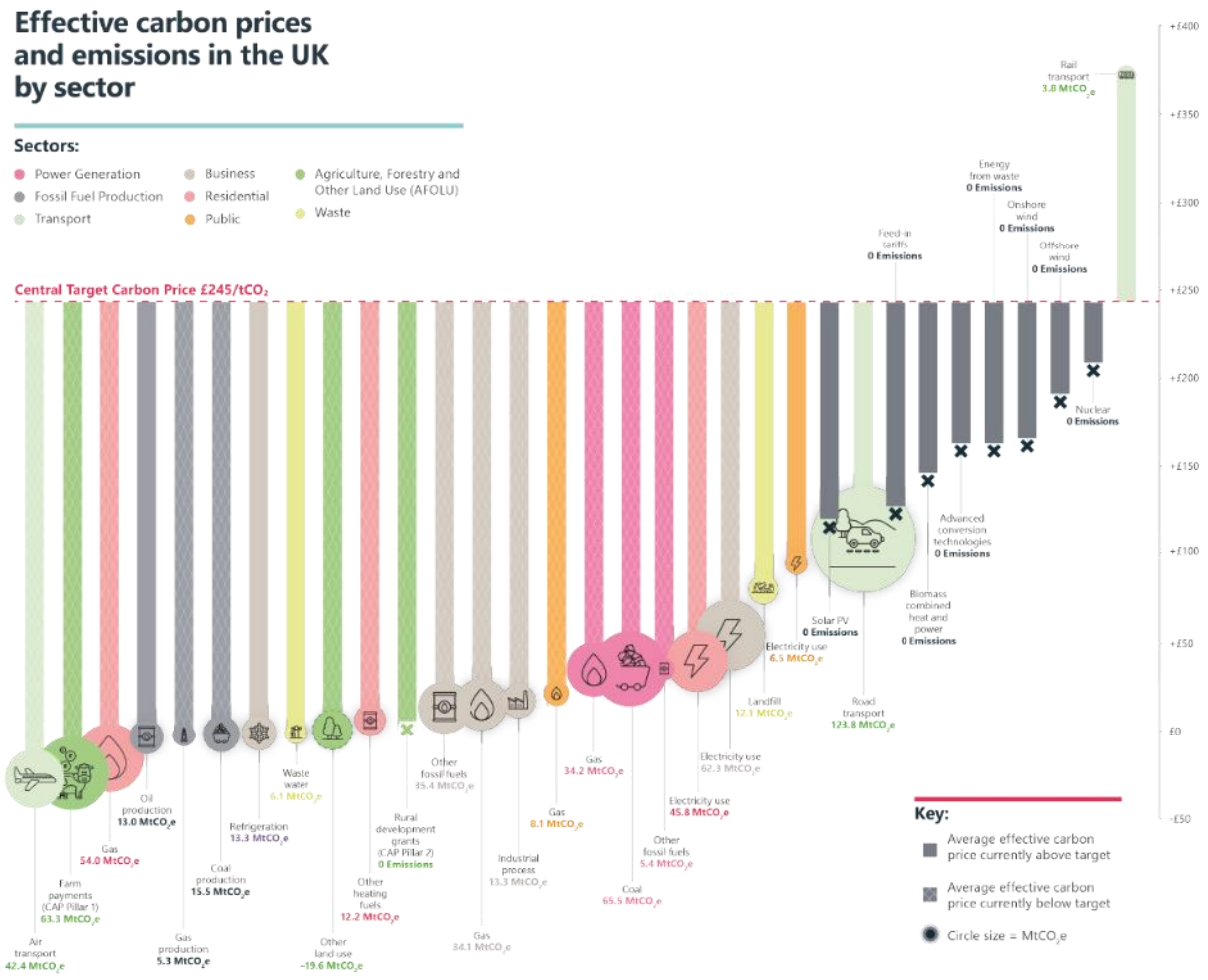


Figure 1: Effective carbon prices and emissions in the UK by sector

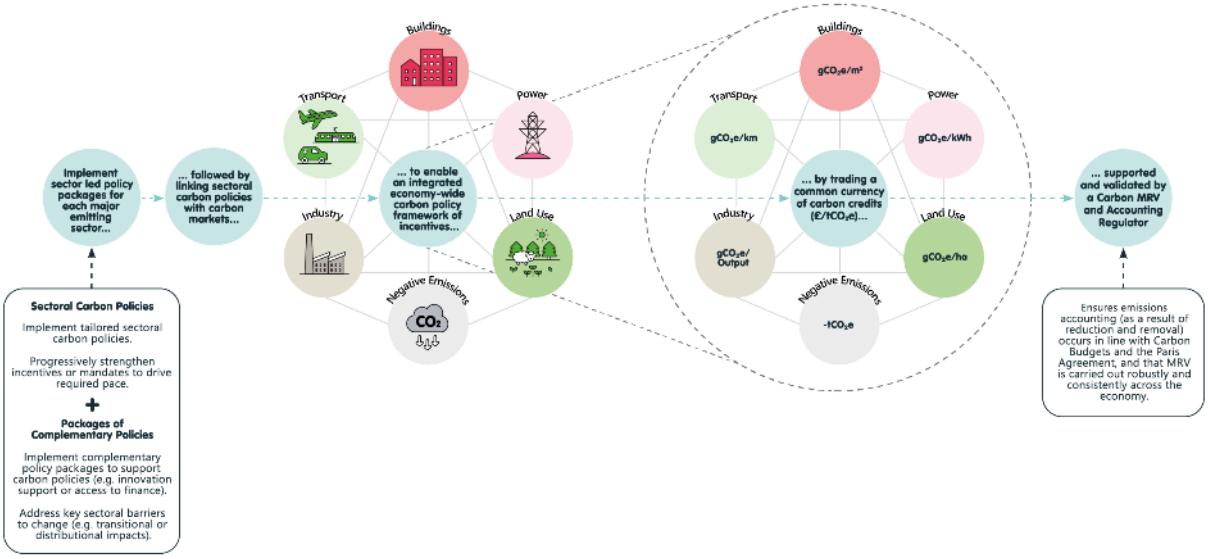
A Sector Led Approach to an Economy-Wide Carbon Policy Framework

We have proposed that a sector led approach, which recognises the importance of sector specific barriers to change, provides the best opportunity to develop an economy-wide carbon policy framework pursuant with Net Zero. This approach can exploit the greater freedom the UK now enjoys following the creation of the UK ETS to develop its own ambitious approach to emissions trading and carbon market development.

By avoiding reliance on a single overarching carbon pricing mechanism, policy can be designed at a sectoral level to address sector specific challenges, for example mitigating competitiveness impacts in industrial decarbonisation or enabling energy suppliers to create attractive consumer propositions for home energy services and heat decarbonisation.

Similarly, transitional and distributional impacts often have sector specific characteristics that require sector specific policy responses (e.g. targeted fuel poverty interventions).

Click here to download image below which sketches out the features of a sector-led approach to building an economy-wide framework for decarbonisation.


Implement sector led policy packages for each major emitting sector...
... followed by linking sectoral carbon policies with carbon markets...
Buildings
Transport
Power
Industry
Land Use
Negative Emissions
CO₂
... to enable an integrated economy-wide carbon policy framework of incentives...
gCO₂e/m²
gCO₂e/km
gCO₂e/kWh
gCO₂e/ Output
gCO₂e/ha
-tCO₂e
... by trading a common currency of carbon credits (£/tCO₂e)...
... supported and validated by a Carbon MRV and Accounting Regulator
Sectoral Carbon Policies
Implement tailored sectoral carbon policies.
Progressively strengthen incentives or mandates to drive required pace.
+
Packages of Complementary Policies
Implement complementary policy packages to support carbon policies (e.g. innovation support or access to finance).
Address key sectoral barriers to change (e.g. transitional or distributional impacts).
Ensures emissions accounting (as a result of reduction and removal) occurs in line with Carbon Budgets and the Paris Agreement, and that MRV is carried out robustly and consistently across the economy.

Challenge 1: The digital transformation of infrastructure – the Commission will consider how the digital transformation of infrastructure could deliver higher quality, lower cost, infrastructure services.

ESC's work on the energy transition since its inception points to the central importance of digitalisation in enabling the efficient transformation of the UK's energy system to a net zero future.

Most recently ESC has played a key role in delivery of the work of the Energy Digitalisation Taskforce. The Taskforce's report was commissioned by government, Ofgem and Innovate UK and published in January 2002. It makes six recommendations to help shape the requirements to deliver a digitalised and decarbonised energy system.

The report – Delivering a Digitalised Energy System – describes the clear necessity to deeply digitalise the energy system. In the near future the sector will be managing millions of new assets on the system, from electric vehicles through to heat pumps, grid scale storage and industrial demand-side actions – all of which need to seamlessly coordinate and deliver a stable system.

Crucial to this transformation will be the customer; building their trust, giving them control and significantly minimising the complexity of the future system.

The Taskforce focused on four key areas: bringing value to consumers; accelerating decarbonisation; maintaining a stable, secure and resilient system; and optimising whole system investment and operation.

Among the key actions in the Taskforce's recommendations are:

- developing a customer consent dashboard to help consumers understand who has access to their energy data, and why – building trust and consumer protection;
- mandating smart energy assets to unlock flexibility by making sure consumer devices have a minimum level of smart functionality and connectivity;
- creating a digital spine for the energy system to enable plug and play options, encouraging whole system interoperability and standardised data sharing;
- mandating carbon data monitoring to improve visibility and understanding around carbon impacts, and help drive future policymaking and consumer actions;
- establishing a digital delivery body to develop core public interest assets quickly and independently from vested interests.

The six high-level recommendations from the Taskforce are as follows:

RECOMMENDATION 1: Unlock value of customer actions and assets – Crucially building trust and delivering control through a Consumer Consent portal, delivering a seamless ability for assets to connect and benefit from system value by mandating all large customer energy assets to be energy enabled. Consumer protection will need to be enhanced to reflect different risks and smart meter data needs to be released for the public good.

RECOMMENDATION 2: Deliver interoperability – The sector needs to deliver interoperability through the development and deployment of four Public Interest Digital Assets with particular focus on a 'Digital Spine' To ensure interoperability we can build on some existing assets but

require Data Sharing Fabric, Data Catalogue and development of some limited but crucial Standards.

RECOMMENDATION 3: Implement new digital governance approach and entities – Governance of new digital assets and actions will be important and need to be developed soon. Governance around public interest assets, interacting algorithms and opening up regulated assets to digital competition will be important. There also needs to be a Digital Delivery Body established by Government to deliver the public interest assets quickly to be subsequently handed over to the sector.

RECOMMENDATION 4: Adopt digital security measures – Digital security principles and interventions are crucial but need to be fit for digital purposes with particular focus on cascade impacts, zero trust principles and a sharing culture.

RECOMMENDATION 5: Enable carbon monitoring and accounting – Carbon visibility sits at the heart of all we propose, but much greater carbon visibility and standardisation is required. We recommend that dynamic carbon monitoring is put in place, and an open carbon standard needs to be deployed economy wide.

RECOMMENDATION 6: Embed a digitalisation culture – Digitalisation is not valued or understood in all parts of the energy sector, with not enough skills or value given to digital assets and activities. BEIS should employ a Chief Data Officer and importantly investors and the rating agencies need to value digital assets as well as their traditional value assessment for infrastructure.

Challenge 2: Decarbonising electricity generation – the Commission will consider how a decarbonised, secure and flexible electricity system can be achieved by 2035 at low cost.

What are the greatest risks to security of supply in a decarbonised power system that meets government ambition for 2035 and what solutions exist to mitigate these risks?

It is a decade since the UK Government began to implement its Electricity Market Reform (EMR 1.0). Including major mechanisms such as Contracts for Difference (CfD) to support investment in low carbon generation and a new Capacity Market (CM) to ensure resource adequacy. These kickstarted the rapid decarbonisation of the GB electricity system and drove extraordinary innovation and cost reduction, especially in offshore wind.

While the EMR 1.0 policies have been successful in transforming the cost of renewables, the context has changed in important ways since they were first introduced, including:

- The new goal of Net Zero greenhouse gas emissions by 2050. Partly because of the success in cost reduction, this is likely to drive even higher penetrations of variable renewables, and an earlier role for electrification of transport and heat;
- the emergence of new system issues as a result of the rapid growth of variable renewables (e.g. a more variable and decentralised system makes the operational dimension of security of supply more important) which we know more about today compared with 2012; and
- the inability of demand-side response and storage ('flexibility') to keep pace with variable renewables growth, despite the availability of new technologies.

A key theme of ESC's work on power system decarbonisation has been the need for ambitious market reforms. There are a number of key risks associated with continuing to rely on existing centralised contracting policies including:

- Failure to unlock sufficient flexibility, particularly on the demand side, and to bring forward consumer-friendly service innovation
- a perpetual reliance on government decision-making to drive technology choices
- less effective integration of zero-carbon electricity with other low carbon energy vectors
- failure to optimise the combination of technologies and resources, resulting ultimately in higher costs and less reliable service outcomes.

Our major report Rethinking Electricity Markets sets out the case for ambitious market reforms including

- Reforms to introduce more dynamic and granular wholesale market signals to accurately reflect system physics locationally and in real time.
- Reforms to phase out centralised contracting (CfDs & CM) by mid 2020s and to replace with outcome-based policy mandates – including a sector decarbonisation mandate.

A shorter blog post makes the case for the urgency of reform.

Challenge 3: Heat transition and energy efficiency – the Commission will identify a viable pathway for heat decarbonisation and set out recommendations for policies and funding to deliver net zero heat to all homes and businesses.

What evidence do you have on the barriers to converting the existing gas grid to hydrogen, installing heat pumps in different types of properties, or rolling out low carbon heat networks? What are the potential solutions to these barriers?

Gas grid regulation

The decisions taken on the future of the gas networks will affect when people need to change away from natural gas and shape the alternatives they will have available. How we regulate gas networks could be a key driver of the pace of decarbonisation in key sectors, and of the shape of emerging hydrogen markets.[1]

Despite this, there has not been much focus on this space since the Net Zero target was put into law. Given the importance of this area, we commissioned Frontier Economics to consider the needs of future gas network regulation in a report 'Gas network regulation for Net Zero'.

Net Zero requires a fundamental transformation of the gas network. Using natural gas led to at least 35% of the UK's emissions in 2018. If the UK is to reach Net Zero this system must be transformed by 2050. That is a relatively short timeframe to transition for a massive and complex network of long-life assets, worth approximately £26bn, that currently serves over 23 million users of different types.

For each section of the network, the UK needs to decide whether to convert it to carry hydrogen, decommission it, or maintain it for a small number of large natural gas users. The case for each of these solutions is likely to vary based on the needs and characteristics of an area (considering the age of the assets and surrounding users etc), implying a future where a mix of these solutions are adopted across the country. Some of the decisions will need to be taken soon as there is a lot of high cost pipeline which was built in the 60s, 70s and 80s which is coming to the end of its design life. We need to start taking "Net Zero-coherent" decisions about the future of these assets.

Today, regulation does not incentivise Net Zero or have a way of managing the complexity. Gas networks are operated to make money based on the regulatory incentives Ofgem places on them. This regime does not currently include incentives or processes to spur the necessary network action for Net Zero. It will need Ofgem to shape and drive a robust process and probably some incentives, to drive network companies to make coherent strategic decisions across their networks, and to do this in a way that delivers maximum value for the wider energy system transition. The regulatory framework will need to be robust in the face of inevitable uncertainties as well as vested interests.

Gas network regulation will be a key shaper of how the electrification vs hydrogen debate plays out. There is a charged debate developing on the relative benefits of using electricity or hydrogen to decarbonise different sectors. Gas network regulation will be a key factor which, alongside

[1] https://es.catapult.org.uk/insight/how-should-we-regulate-gas-networks-for-net-zero/

market signals, technology developments and consumer preference, will shape where electrification or hydrogen operate. Gas network regulation and the surrounding processes will ultimately decide what infrastructure citizens can access, including a potential hydrogen market, shaping the decisions that consumers take about changing their reliance on natural gas.

As such it is likely to make sense for there to be a much stronger link between gas network regulation and local area energy planning and locally led processes to make decisions that take account of local priorities and opportunities.

Network regulation decisions will influence how costs are recovered from customers. It is important the costs of the transition are distributed fairly across society. In 2020, almost 30% of a consumer's gas bill came from network charges. How these evolve must be carefully considered to ensure the costs of network conversion, decommissioning or expansion are fairly distributed across users of the natural gas network, the hydrogen network, the electricity system, as well as taxpayers more broadly.

Overall, it will be very hard to have transformative action on decarbonisation in the UK without strategic thinking around how we use gas network regulation to shape decisions for a fair and efficient transition to Net Zero, with gaseous energy vectors playing a key role. It will affect whether we lock ourselves into expensive and potentially high carbon pathways, as well as how a hydrogen system develops.

One of the key reforms for natural gas network regulation should be the introduction and integration with Local Area Energy Planning (LAEP). The need for this process has been reinforced by Frontier's conclusion within this new report that gas network regulation needs to 'Establish processes to enable coordination across the whole system'. A robust, well-evidenced process for LAEP can help deliver that. It will help us manage the challenges discussed above; enabling action whilst balancing uncertainty and vested interests.

It is a process which gathers stakeholders, led by local government, to interrogate different energy futures for an area and to develop the most promising, cost-effective options for decarbonisation based upon the characteristics of the area. Inherently this leads to different technologies being deployed in different areas by recommending the most promising technology mix. It considers costs across the whole system, including gas network and electricity network costs, whilst considering the values in the local area. These plans would create a foundation for decisions on network infrastructure.

The report, 'Gas network regulation for the net zero transition', considers

- the gas network regulation reforms and interventions needed to deliver net zero
- the challenges of coordinating low carbon gas network investment,
- steps for policymakers and how the costs could be distributed across citizens.

Heat pumps

ESC recently published Conclusions from the BEIS Electrification of Heat project installation phase. This concluded that there is no property type or architectural era that is unsuitable for a heat pump – the Government-funded Electrification of Heat project has demonstrated.

From Victorian mid-terraces to pre-WWII semis and a 1960s block of flats – the project has proven that heat pumps can be successfully installed in homes from every style and era.

A wealth of further material from the EoH project is available on the ESC website.

Heat networks

ESC's previous work on Heat Networks in the UK: Potential barriers and opportunities may be informative.

What evidence do you have of the barriers and potential solutions to deploying energy efficiency in the English building stock?

Our work on heat and buildings decarbonisation points to the importance of the Energy Performance Certificate (EPC) system, and the need for it to be reformed. The Energy Efficiency Rating of the Energy Performance Certificate (EPC) is primarily a cost metric, not a measure of actual energy use or a measure of carbon emissions. Our preferred long-term solution to driving decarbonisation in buildings would require substantial reforms to the way in which carbon emissions are measured, requiring the current EPC system to be reformed and replaced with a smarter, more accurate view of a building's carbon and energy performance, which is fit for purpose. This would create much clearer incentives for the right combination of energy efficiency measures along with other improvements to deliver full decarbonisation of the building stock.

We would encourage proposals targeting a dual metric, which would work towards measuring actual carbon emissions through the Environmental Impact Rating, an improvement on the single Energy Efficiency Rating metric of the EPC. As suggested, Government should be looking to reform this system, making it fit for the purpose of measuring actual carbon emissions, using digital technology and placing greater overall emphasis on emissions targets.

Over time, carbon and energy performance could be evidenced by a Green Building Passport, with carbon emissions targets considered across all properties. Equally, opportunities and incentives should be distributed equally across all types of occupancy, including in privately rented homes. Our Six Steps to Zero Carbon Buildings policy work proposes a mix of new planning processes, standards, obligations, subsidies and market incentives to create an enduring framework for building decarbonisation.

Challenge 4: Networks for hydrogen and carbon capture and storage - the Commission will assess the hydrogen and carbon capture and storage required across the economy, and the policy and funding frameworks needed to deliver it over the next 10-30 years.

ESC has carried out a range of work relevant to considering the challenges of developing hydrogen and carbon capture and storage across the economy.

This is perhaps best summarised in our 2020 publication Innovating to Net Zero, which draws on ESC's whole energy system modelling and analysis capabilities.

- **CCS and bioenergy are both essential to delivering Net Zero**. While an 80% target was still possible without CCS and scaling up biomass but with a much higher system cost. Failure to deploy either option means foregoing the negative emissions essential to offsetting continued demand for aviation and livestock products. Under Net Zero, CCS is also vital for mitigating industrial emissions and hydrogen production.
- **Land use must be optimised to balance carbon sequestration with other priorities**. New forestry can provide a net carbon sink for decades during growth and bring wider environmental benefits. Biomass crops, when regularly harvested for energy (coupled with CCS), offer more intensive and indefinite sequestration.
- **Hydrogen may need to grow from virtually zero to levels equivalent to today's electricity** generation to supply industry, heat and heavy transport.

CCS

Our work on CCS in the power sector also suggested that gas power stations with CCUS fitted can provide anchor loads for CO2 pipelines and stores that serve emerging CCUS clusters, unlocking a pathway for CCUS to cut emissions in industry and support hydrogen production.

Hydrogen

In relation to Hydrogen we note that current policy proposals amount to a complex regime of revenue support for hydrogen producers. We urge the Government to proceed with caution to avoid the risks of creating long term dependence on policy maker led contracting and revenue support mechanisms. We urge the Government to give further consideration to the strategy for shaping competitive markets and demand from customers and end users for low carbon energy vectors, creating an environment within which low / zero carbon hydrogen can and should compete against other low and zero carbon energy vectors.

As an innovation body we of course support measures to support early deployment of new technologies. But it is also easy for market actors to become dependent on revenue support[2].

[2] For example, consider the experience of electricity generators – ESC set out the key risks associated with centralised support mechanisms and the need for and challenges associated with moving away from them: https://es.catapult.org.uk/report/rethinking-electricity-markets-the-case-for-emr-2/

Complex support mechanisms are also risky with respect to distorting and anti-competitive impacts and unintended consequences through interactions with markets and other policy areas and because it is challenging for Government and authorities to mitigate risks in an agile and timely manner.

We endorse the long-term vision outlined in the proposals of a *"a liquid, competitive, and transparent market for low carbon hydrogen where it competes on an equal footing against other technologies, without the need for financial support.*" We also note the key elements of the Hydrogen Strategy (p.23) that aim to achieve this through a combination of market developments. We stress, however, that it would be beneficial to have a roadmap as to how this vision will be achieved and the producer-specific support mechanism exited. Within this we think:

- Carbon policy should be the urgent priority as carbon reduction is the overarching investment driver for low carbon hydrogen. Therefore, in parallel with introducing the 'hydrogen producer model', our work suggests that **work should start in earnest on achieving a coherent, effective carbon price across all energy vectors and sectors** of the economy.
  We agree with the current proposals to improve the UK ETS but believe that **downstream sectoral carbon performance regulations are also needed to drive the demand for low carbon resources** and can be designed in a way to complement both carbon pricing and upstream support mechanisms.
- It is crucial to get market price signals right if costs are to be minimised for consumers as they directly impact the efficiency of resource allocation, energy vector switching and the subsidies that will be paid out. Getting carbon regulations (e.g. carbon intensity of electricity sales) in place without delay is crucial to pave the way for scale-up and to avoid dependency on Government for revenue support.
- The long-medium term development of a hydrogen market will be impacted by the availability of network and rules surrounding its development and provision. Therefore, a long-term approach to delivering network infrastructure for net zero would support the creation of a well-functioning hydrogen system. To reduce costs for consumers this approach needs to look across vectors and be able to manage uncertainty. At ESC we have developed Local Area Energy Planning (LAEP), a process which gathers stakeholders, led by local government, to interrogate different energy futures for an area and to develop the most promising, cost-effective options for decarbonisation. It considers costs across the whole system, including gas network and electricity network costs, whilst considering the values in the local area. These plans would create a foundation for decisions on network infrastructure. For more information see https://es.catapult.org.uk/reports/local-area-energy-planning/.