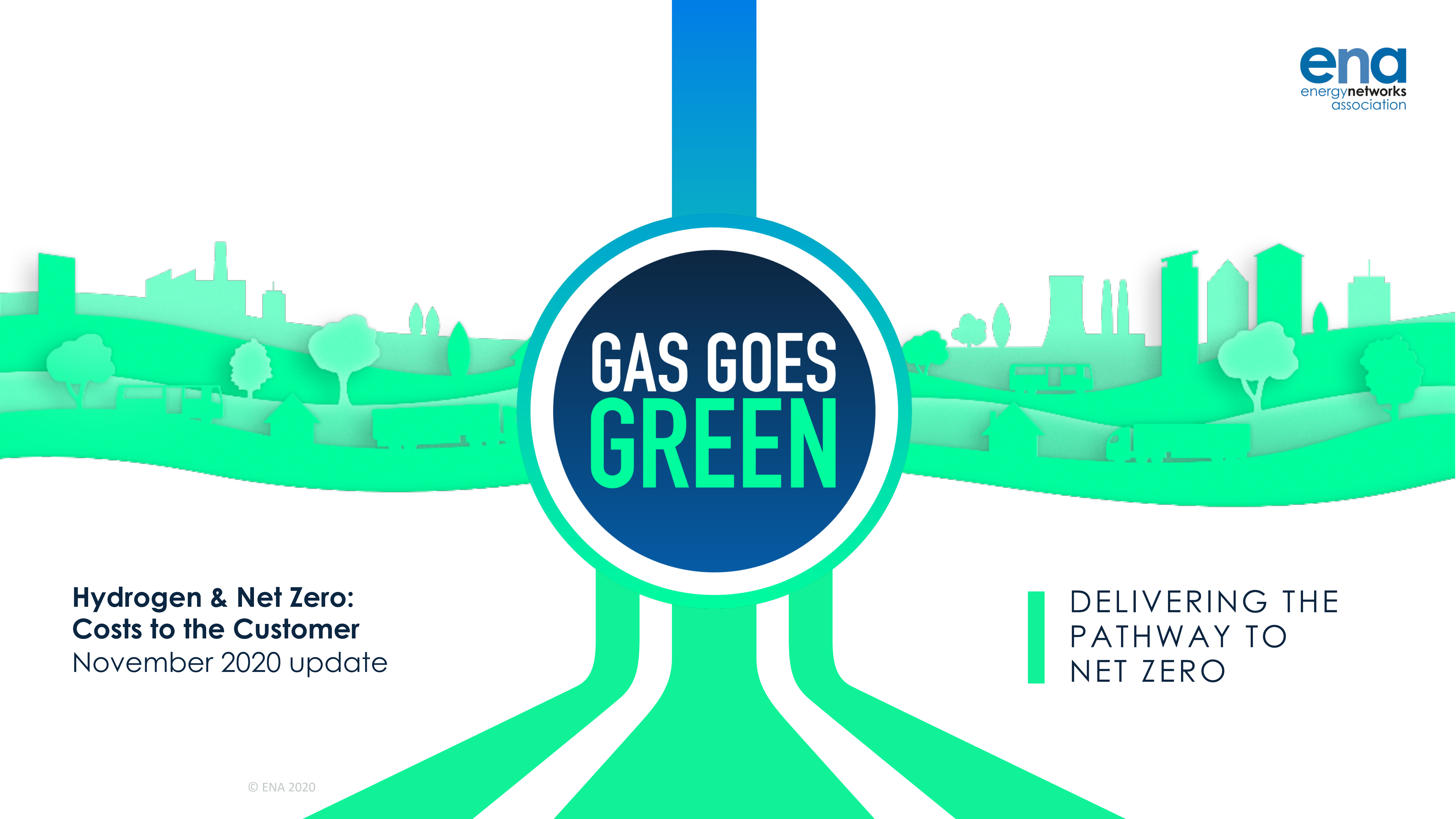


Hydrogen & Net Zero: Costs to the Customer

November 2020 update

DELIVERING THE PATHWAY TO NET ZERO

Glossary

Allowable emissions	Allowable emissions are the carbon dioxide equivalent emissions allocated to emissions from gas consumption in order to maintain a trajectory to hitting Net Zero by 2050 as per legislated Carbon Budgets
ALK	ALK or alkaline electrolysis is a technology that is utilised to produce Green hydrogen which is currently widely used in the chemical industry
ATR	ATR or auto-thermal reforming is an emerging technology utilised to produce Blue hydrogen which has a higher efficiency and carbon capture rate than SMR
Blue hydrogen	Blue hydrogen refers to hydrogen produced through means of splitting natural gas into hydrogen and carbon dioxide with the latter captured and stored with only a residual amount of carbon emissions going into the Earth's atmosphere
Capture price	Capture price is the price that an electricity generating asset or technology is able to achieve in the wholesale market
Carbon sequestration	Sequestration refers to the long-term storage of carbon dioxide and other firms of carbon to slow or reverse atmospheric CO2 pollution
Carbon Budget	Carbon budgets are legislated targets which restrict the amount of greenhouse gas that the UK can legally emit in a five year period
CCGT	CCGT or combined cycle gas turbine plant is a highly efficient energy generation technology that combines a gas-fired turbine with a steam turbine which produces additional power from heat associated with the gas turbine
CCUS	CCUS or Carbon capture, utilisation and storage is the process of capturing waste carbon dioxide and either utilising it for an industrial purpose or depositing it permanently in a storage facility such as a depleted oil well so it doesn't re-enter the atmosphere
CFD	CfD or contracts for difference refers to a government mechanism for supporting the deployment of new low carbon electricity generation projects by providing stability and predictability to future revenue streams
Dedicated Renewables	Dedicated renewables refers to low carbon electricity generation projects that are deployed primarily for the purpose of producing Green Hydrogen rather than supplying power to the GB electricity grid

Glossary

Green hydrogen	Green hydrogen refers to hydrogen produced by splitting water into hydrogen and oxygen through the usage of renewable energy resulting in no carbon emissions
GVA	GVA or Gross value added is the contribution made to an economy by an individual producer, industry, sector or region
I&C	I&C refers to the Industrial and Commercial sector of the UK economy
LCOE/LCOH	LCOE/LCOH or levelised cost of electricity (hydrogen) is a measure of the average net present cost of electricity generation (hydrogen production) for a generating plant over its lifetime
NBP	NBP or National Balancing Point is the wholesale gas market price for natural gas in the UK
OCGT	OCGT or Open Cycle Gas Turbine is an energy generation technology that utilises a single gas-powered turbine
PEM	PEM or Proton Exchange Membrane is a technology that is utilised to produce Green hydrogen which is less widespread than ALK but is more suited to pairing with renewable generation for hydrogen production
SMR	SMR or steam methane reforming is a mature technology which is widely used across the refining and petrochemical industries to produce hydrogen
SOEC	SOEC or solid oxide electrolysis is an early stage Green hydrogen production technology which has potential for improved energy efficiency over ALK and PEM but is still currently in the development stage
T&S	T&S or Transport and Storage is the transportation and long-term storage of the carbon dioxide captured from power generation plants and carbon intensive industry

Introduction

GGG Hydrogen & Net Zero Cost to the Customer research series

In June 2020, Energy Networks Association's (ENA) Gas Goes Green programme published its first analysis of the costs of building the UK's hydrogen economy – and the benefits that will deliver to Britain's energy billpayer.

Our Hydrogen & Net Zero Cost to the Customer research series analyses the upstream (production), midstream (transmission and distribution) and downstream (heat, power and transport) costs of establishing a hydrogen economy, now through to 2050.

It focuses heavily on forecasting how much blue and green hydrogen we will need to reach net zero and how much that will cost energy billpayers, taking account of technology developments, potential uptake rates, supporting markets and emissions trajectories.

Our June 2020 analysis found that if investment into zero carbon hydrogen infrastructure began today, then the country would be a net beneficiary of that investment before 2045, five years ahead of its 2050 net zero carbon emissions target and saving bill payers £116 billion by that date.

This November 2020 update

This November 2020 update to our analysis takes our methodology and combines it with the new electricity demand and power generation capacity assumptions provided by National Grid's industry-leading 2020 Future Energy Scenarios (FES) research, which for the first time accounts for the UK's net zero carbon emissions target.

In doing so, it provides new data on how hydrogen will help the UK meet its net zero emissions target but also an updated figure on the long-term financial benefit of investing in a hydrogen economy today.

The Gas Goes Green programme

Bringing together all of Britain's gas network companies, the Gas Goes Green programme will deliver the world's first zero carbon gas grid, helping meet the UK's net zero carbon emissions target.

Gas Goes Green will do this by following a 'Pathway to Net Zero' that is based on an independent, academic-reviewed assessment of gas decarbonisation pathways and their cost impacts.

This assessment presents a pathway through to net zero by 2050 showing that if more low carbon and renewable gases are used along with further electrification, this has the potential to save around £13 billion a year compared to a pathway that relies on electrification alone.

Why hydrogen? And why now?

1. UK climate policy

In June 2019, the UK Government committed to a net zero emissions target, which is accelerating the decarbonisation of the UK economy. Achieving net zero will require fundamental changes across all sectors of the economy, with hydrogen increasingly fulfilling energy demand across UK power, heat and transport.

2. The Committee on Climate Change

In its recommendations on how to achieve net zero in their "Hydrogen in a low carbon economy" report, the Committee on Climate Change recognised the significant role hydrogen should play in meeting the target, stating that "*hydrogen could replace natural gas in parts of the energy system, where electrification is not feasible or is prohibitively expensive, for example in providing heat on colder winter days, industrial heat processes and back-up power generation*."

3. The National Infrastructure Commission

In their 2020 net zero report, the National Infrastructure Commission conclude that a highly renewable power system, combined with flexible technologies including hydrogen powered generation, could be substantially cheaper than alternatives.

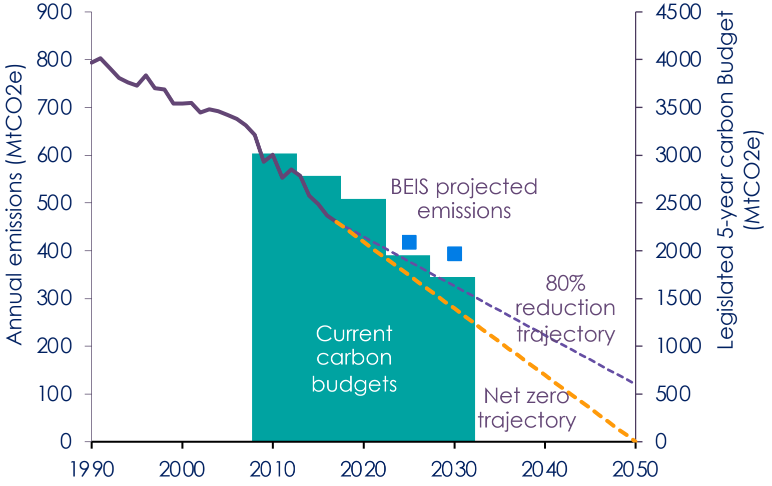
4. The challenge of heat decarbonisation

With stated ambitions for power and transport, the question remains as to how the UK will meet the challenge of decarbonising the heat sector. Hydrogen stands ready as a deployable technology to integrate power and transport decarbonisation with a readily deployable solution for heat.

According to a recent study by the Leeds Sustainability Institute, hydrogen receives indicative support from energy customers, who were generally willing to accept a moderate increase (presented as 7%) in their gas bills to support this conversion.

Taken together, these reports demonstrate that the hydrogen debate has now moved on from establishing whether there's a need for hydrogen in a net zero economy, with the discussion now focused on how to unlock its potential.

Trajectories for net zero emissions by 2050



Summary of our conclusions: November 2020

1 **Without hydrogen, the UK will not meet its 2050 net zero carbon emissions target.**

Today, the UK's gas emissions are exceeding the trajectory that is needed to be taken to reach net zero emissions by 2050, by the equivalent of 259TWh of natural gas consumption in combined cycle gas turbine (CCGT) power plants. There is no realistic scenario whereby the UK is able to achieve net zero carbon emissions by 2050 without hydrogen playing a key role in the decarbonisation of large emitting sectors such as industry, transport, power and heat.

Our analysis shows that the UK's gas emissions could be put back on track in just five years if capacity is built to provide 208TWh of hydrogen from combined blue and green production by 2025. Under the current trajectory, three quarters (77%) of that hydrogen will come from blue sources, unless additional green production capacity is created. With the right policies in place, the recent Government commitment to set a target of 40GW of offshore wind capacity by 2030 presents an opportunity to address this.

2 **The UK will need both blue and green hydrogen.**

Our analysis shows both blue and green hydrogen will be required to produce enough hydrogen to meet the net zero target. It also shows that the cost reduction trajectory for green hydrogen is similar to that experienced with solar and offshore wind over the past decade and are therefore considered readily achievable.

Meeting the UK Government's target of having one carbon, capture, storage and utilization (CCUS) project operational by 2025, with further roll out to 2050, is key to the deployment of cost-effective blue hydrogen. This will allow for rapid decarbonisation which will continue to deliver low carbon heat through to 2050. Meanwhile, green hydrogen is expected to become cost-competitive with natural gas by 2030 if investment into its uptake is made now.

3 **Investment today will unlock a total of £116bn of savings for billpayers by 2050.**

Our analysis shows that by the time we reach our net zero target in 2050, the £159 billion investment needed to build a world-leading hydrogen economy will have already delivered a return of £116 billion to energy billpayers. Based on Ofgem's 2020 gas consumption figures, this equates to an annual household bill saving of £48 a year.

The sooner investment is made into critical hydrogen infrastructure, the greater and timelier the return on investment would be to the UK Government. Our analysis shows that at a system level, with investment beginning today, the UK would start to see returns on its investment before 2045. Stimulating jobs and investment into a domestic hydrogen supply chain now, could crystallise GVA for UK plc by promoting the development of a world-leading hydrogen industry within the UK, mirroring or surpassing the success seen in the offshore wind sector.

[1] This number is based on Ofgem's 2020 Typical Domestic Consumption Values, for a medium household.

Our methodology

Our methodology

Calculating the Cost to the Consumer

Our Cost to the Customer research uses a methodology that calculates and compares the costs of a hydrogen-based system compared to the natural gas-based status quo, across the three main pillars of our energy system (upstream, midstream and downstream), using a set of assumptions and data sources. This allows us to calculate the different costs of these two systems and to understand the quantities and costs of hydrogen.

The upstream cost and volumes of hydrogen production

Using the System Transformation scenario from the 2020 National Grid Future Energy Scenarios report, the total volume of green hydrogen has been calculated based on the estimated excess renewable power generation available for utilisation by grid-connected electrolysers. This is then multiplied by a levelized cost of green hydrogen, driven by an estimated global rollout of green hydrogen technologies.

Blue hydrogen production is estimated based on the residual gas demand (from the 2020 FES System Transformation scenario) which cannot be met by green hydrogen in that forecast year. This is multiplied by a levelised cost for blue hydrogen, based on technology learning rates and global roll out of Carbon Capture, Usage and Storage (CCUS).

The midstream and downstream costs

Midstream and downstream costs have been aggregated from recognized, industry-leading published sources, at a system level, as referenced through this report. These include the Department of Business, Energy & Industrial Strategy, the Committee on Climate Change and Bloomberg New Energy Finance, amongst others.

The total cost for the energy system

These three components are summed to provide a total system cost through the period 2020-2050. This cost is also presented as a cost per unit (by dividing total system cost by the total hydrogen production volumes) and estimated bill impact.

National Grid's Future Energy Scenarios 2020

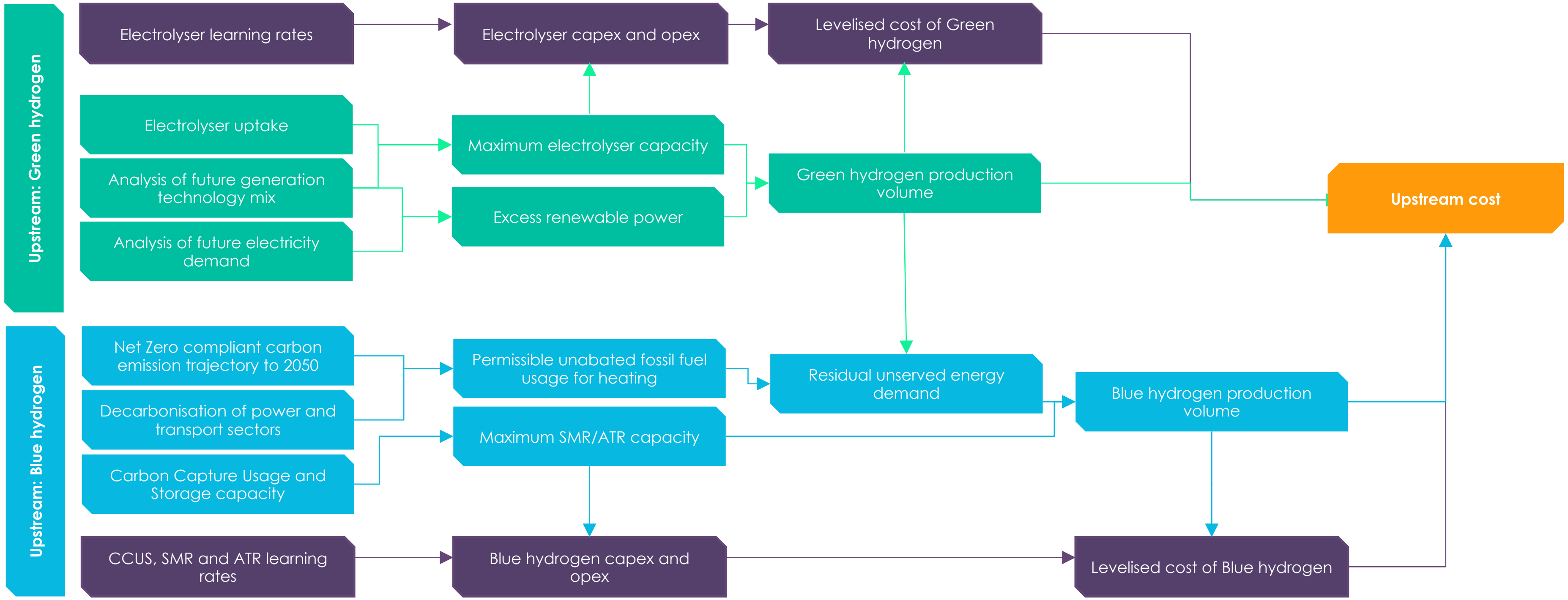
National Grid's Future Energy Scenarios report, with its in-depth, comprehensive analysis of the future make-up of the UK's energy system, is a key data source. In 2020, this was updated to account for the UK's 2050 net zero emissions target for the first time. Using this data source has been the main change to our analysis in this November 2020 report.

Our assumptions

1	**Total energy demand**	Forecast annual UK energy demand is based on National Grid FES data and is utilised in our analysis to determine both electricity and gas demand through the period, capping the total requirement for both blue and green hydrogen annual production.
2	**Allowable emissions**	Allowable natural gas emissions are utilised in our analysis to inform the maximum permissible natural gas use
3	**Generation capacity**	Generation capacity of all technologies informs our analysis of the available future intraday generation from intermittent renewable to be utilised for Green hydrogen production.
4	**Renewables capacity**	Intermittent renewables capacity determines the available renewable projects which could accommodate electrolysers. This has been constructed from National Grid FES, combined with CCC recommendations for offshore wind capacity required to achieve Net Zero.
5	**Merit order**	For the purposes of estimating future excess generation availability for Green hydrogen production, we assume a merit order which ranks renewable energy sources first in order of price followed by non-renewable sources in order of short-run marginal cost dictated by fuel cost and carbon intensity.
6	**Green hydrogen production methods**	Green hydrogen production methods inform the technology parameters utilised in our analysis to be paired with intermittent renewables for production of Green hydrogen.
7	**Green hydrogen levelised cost inputs**	Green hydrogen cost assumptions based on a range of market information are utilised in our analysis to establish the total production cost per MWh of Green hydrogen.
8	**Blue hydrogen production methods**	Blue hydrogen production methods inform the technology utilised in our analysis to determine the cost and efficiency of hydrogen production from natural gas.
9	**Blue levelised cost inputs**	Blue hydrogen capex and opex assumptions are utilised in our analysis to establish the levelised cost of production per MWh of Blue hydrogen, based on a range of technical and market data sources.
10	**T&S levelised cost inputs**	Transport and Storage cost is utilised in our analysis to establish the production cost per MWh of Blue hydrogen, on a user pays basis. This in turn is represented as an opex line item in the calculation of Blue production costs.

Calculating upstream costs

Our approach builds on forecasted market composition, to calculate a market share for green and blue hydrogen in five-year intervals during the period 2020 - 2050. This is coupled with a calculated levelised cost for each hydrogen production method to provide a total upstream cost.



Calculating midstream & downstream costs

1	**Distribution costs**	The cost of repurposing the distribution network including the replacement of gas network components has been estimated for our central case at £22.2 billion using the base case of Element Energy & Jacobs that 100% of the of the distribution network components have to be replaced on a like for like basis. Due to uncertainties over the percentage of network components that require replacement, we have taken £7.7 billion as our low case and £26.7 billion as our high case.
2	**Transmission costs**	We have therefore treated the establishment of an entirely new high pressure transmission pipeline network to transport hydrogen to local distribution networks as a high-cost scenario with no entirely new transmission pipeline being built in our central case. The cost of set up of a national hydrogen transmission network for our high case has been calculated using an average of aggregated sources using an assumed network length of 7,000km and £1.2m per km of pipeline, giving a total cost of £8.4 billion.
3	**Residential Costs**	We have calculated an average cost of conversion as £3,300 per property as our central assumption giving a total cost for converting residential properties for our central case as £80.9 billion. Sensitivities have been shown using the upper and lower bounds of total costs per property from our aggregated sources from £3,000 per property to £4,000 per property giving a cost for residential conversion in our low case as £71.7 billion and £95.6 billion in our high case.
4	**Commercial Costs**	The cost of converting commercial premises to hydrogen has been calculated in our central case as £5.9 billion by drawing upon Element Energy assumptions for cost of pipework and boiler replacement for commercial usage and using BEIS data on commercial premise sizing and number of non-domestic gas meter points. Using sensitivities around the average boiler and installation costs, the total cost of commercial premise conversion has been calculated as £4.7 billion in our low case and £7.0 billion in our high case.
5	**Industrial Costs**	The total capex cost to convert UK industrial equipment used primarily for production of heat uses Hy4Heat analysis by Element Energy and Advisian which calculated £2.7 billion as the base case which we have carried forward as our central case. We have carried the lower and upper bounds as calculated in the report with £1.0 billion as our low case and £3.9 billion as our high case.

Calculating the total system cost

Analysis of the total system cost shows a net saving, resultant from carbon savings as hydrogen becomes a cheaper source of energy than natural gas.

In the absence of a clear plan from government detailing how the UK will meet Net Zero, the market will continue to use natural gas. We have therefore adopted this scenario as our ‘business as usual’ scenario.

Based on the BEIS gas and carbon price forecasts, the total cost of meeting the UK’s gas demand requirements using unabated technology is equivalent to £1.4 tn over the forecast period. This is largely driven by the carbon price in the latter years.

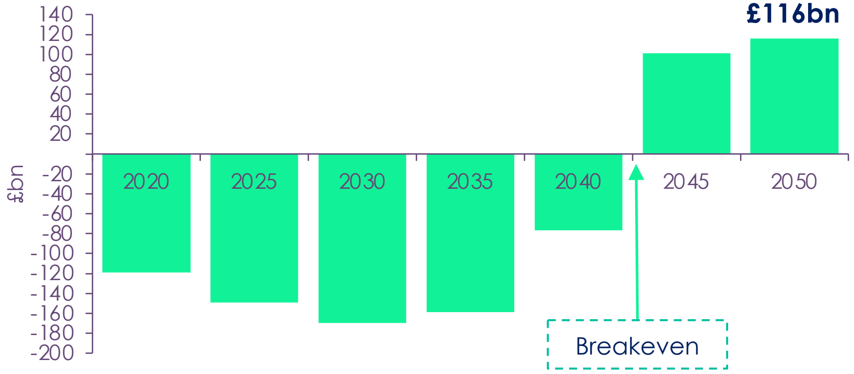
Applying the combined costs we have identified through this study, the costs of converting to and operating a hydrogen based economy in the period to 2050 is equal to £1.3 tn.

Analysis of the system cost profile shows an initial cost of developing the hydrogen network through the period to 2035. This cost represents investment into new infrastructure, technological advancement, supply chain development and conversion of point of use technology which enables a Net Zero economy.

This investment is paid back over the long term, as hydrogen insulates the economy from the cost of carbon emissions. The result is a net saving, whilst delivering the Government’s Net Zero ambitions for the gas sector.

Total system cost (£bn)

Supply chain segment	Unabated	Net Zero
Upstream		
Green Hydrogen	-	81
Blue Hydrogen	-	811
Nat Gas	1,520	401
Midstream		22
Downstream		90
Total System Cost	**1,520**	**1,405**



Rolling NPV of the UK’s hydrogen economy

Our conclusions

Our conclusions: The role of hydrogen

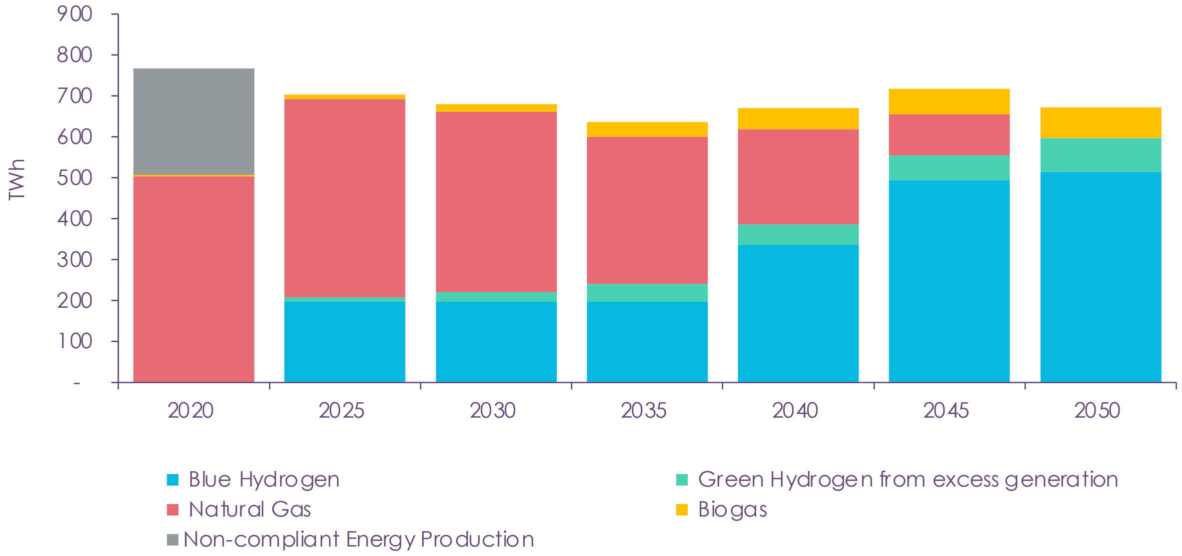
1

Without hydrogen, the UK will not meet its 2050 net zero carbon emissions target.

- Based on the Navigant Pathways report, the UK is currently unable to meet a net zero compatible trajectory for gas demand in 2020, falling short by 259TWh in that year.
- 208TWh per annum of hydrogen is required to meet a net zero trajectory in 2025 with blue hydrogen making up the majority of hydrogen production at 198TWh per annum.
- Green hydrogen is projected to play a limited role in achieving Net Zero, starting at 10TWh per annum in 2025 and growing to up to c.82TWh per annum by 2050
- Green hydrogen begins to provide a significant part of gas demand in the 2040s onwards, driven by an increase in renewable generation capacity with the UK predicted by National Grid FES System Transformation scenario. However, the absence of dispatchable baseload capacity in this scenario means excess power generation is limited.
- Therefore we anticipate a large-scale requirement for blue hydrogen to meet net zero requirements throughout the period, which grows to make up 77% of demand from the gas grid in 2050.

Sources: National Grid FES, Exelon, BEIS, Navigant Pathways to Net Zero, CCC

Annual Gas Production volumes



Green hydrogen as % of total gas demand

	2020	2025	2030	2035	2040	2045	2050
green hydrogen as % of total gas demand	0%	1%	3%	7%	7%	8%	12%

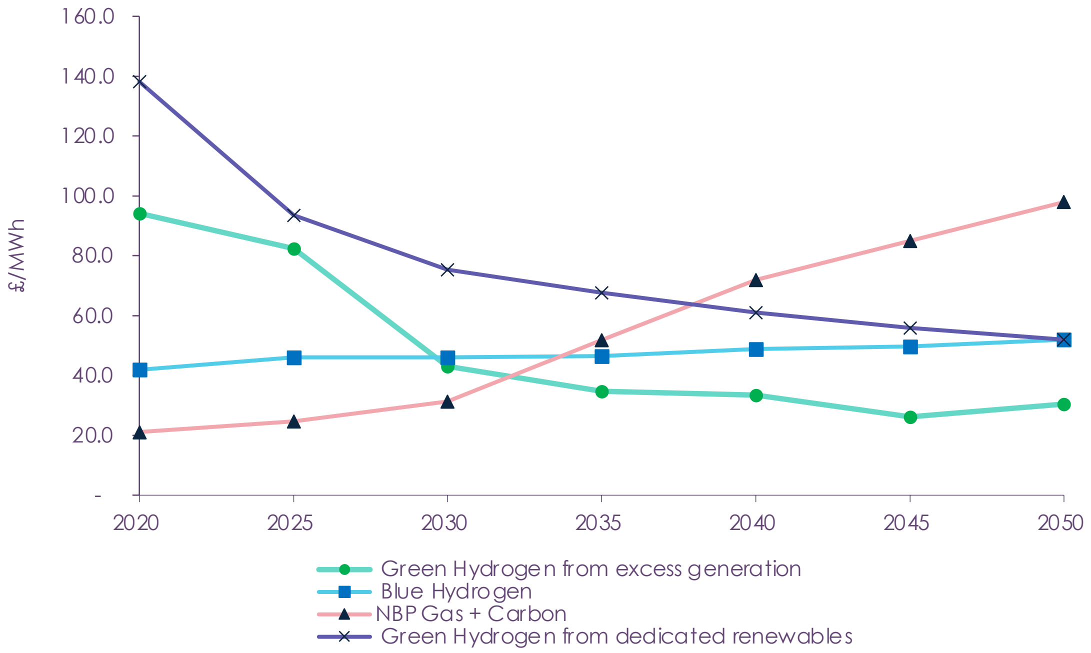
Our conclusions: Types of hydrogen

2

The UK will need both blue and green hydrogen to reach net zero.

- Blue hydrogen is currently the cheapest form of hydrogen at c. £42/MWh. However, this is still twice the cost of NBP gas + carbon price driven primarily by conversion efficiency from gas to hydrogen and CCUS costs.
- Blue hydrogen projects will provide bulk supply of hydrogen to the market, helping to establish the scale of the hydrogen economy in the UK.
- Green hydrogen produced from excess renewable power is rapidly becoming cheaper, falling to parity with NBP gas + carbon price in prior to 2030 as a result of capex reductions and falling electricity wholesale prices due to increased renewables penetration.
- Green hydrogen has the potential to be deployed quickly and flexibly over the short-term, to support hydrogen blending across gas networks. Government support for green hydrogen will ensure that the long-term cost benefits of green hydrogen are achieved.
- The cost reduction trajectory for green hydrogen is similar to that experienced with solar and offshore wind over the past decade and are therefore considered readily achievable.
- Under this scenario, methods for both blue and green hydrogen production become cost-competitive with natural gas + carbon by 2035.

Levelised cost of hydrogen



Sources: BEIS, BNEF, Element Energy, IRENA, Hydrogen Council, Navigant, National Grid FES, DNV-GL

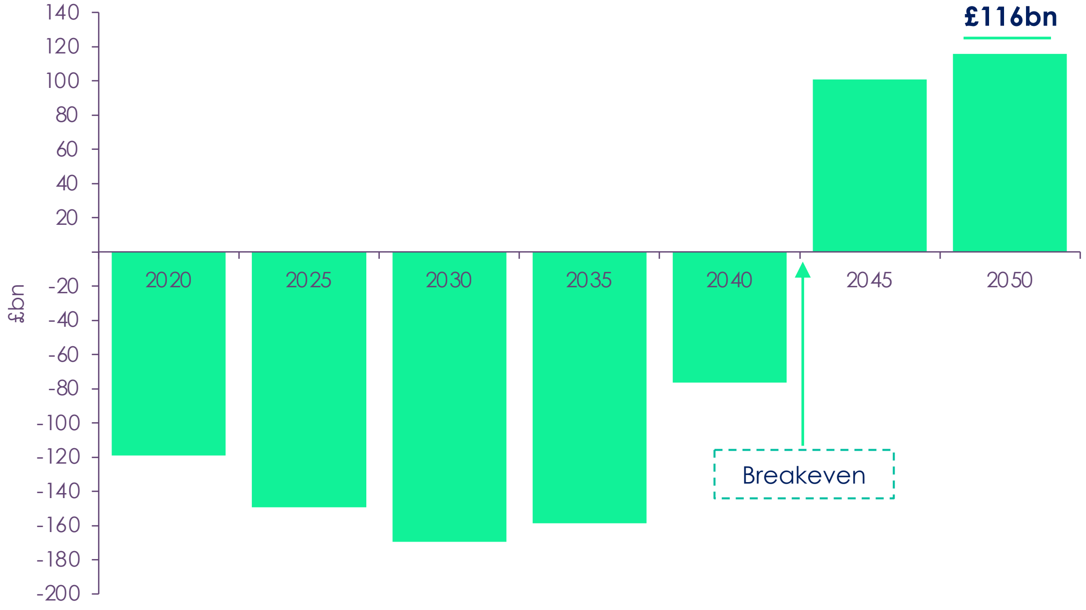
Our conclusions: Savings for billpayers

3

Investment today will unlock a total of £116bn of savings for billpayers by 2050.

- Converting to a hydrogen economy requires investment of £159 billion. However, our analysis shows that this investment will be paid back through benefits to customers, by 2045.
- By 2050, this investment into the UK's hydrogen infrastructure could deliver a net benefit to customers of £116 billion.
- Based on Ofgem's 2020 gas consumption figures, this equates to an annual household bill saving of £48 a year in 2050.
- The earlier that investment is made into hydrogen infrastructure, the sooner the benefits can be realised economically and environmentally for the UK.
- If investment into hydrogen infrastructure were to begin today, the UK would be able to achieve a return on the investment in 2045.
- Timely and substantial investment into hydrogen infrastructure will unlock savings earlier in the UK's transition to net zero and unlock the possibility for greater returns in the latter years.
- The development of the UK's hydrogen supply chain could yield wide ranging economic benefits including job creation and secure a world-leading hydrogen industry for the UK to export globally providing long-term GVA.

Rolling NPV of the UK's hydrogen economy



Our conclusions: Comparing costs to the customer

On a pence per kWh basis, by the early 2040s, the conversion to hydrogen will provide a net saving to customers compared the costs of continuing to use natural gas.

The total system cost is divided by total production volumes of hydrogen to arrive at a unit cost for each kilowatt-hour of hydrogen power.

Baseline cost to customer assumes natural gas represents all gas consumption throughout the forecast period to 2050. Based on Ofgem's 2020 12,00kWh gas consumption figure, this equates to an annual household cost of £608.40 a year in 2050.

Net zero cost is calculated as the cumulative upstream, midstream and downstream cost of hydrogen deployment between now and 2050, divided by total gas demand to arrive at a net unit cost for each kilowatt-hour of energy delivered. Based on Ofgem's 2020 12,00kWh gas consumption figure, this equates to an annual household cost of £561.60 a year in 2050.

Net cost to customer for delivery of a net zero compliant hydrogen economy is calculated by subtracting the baseline cost from the calculated net zero cost. Based on Ofgem's 2020 12,000kWh gas consumption figure, this equates to an annual household bill saving of £48.80 a year in 2050.

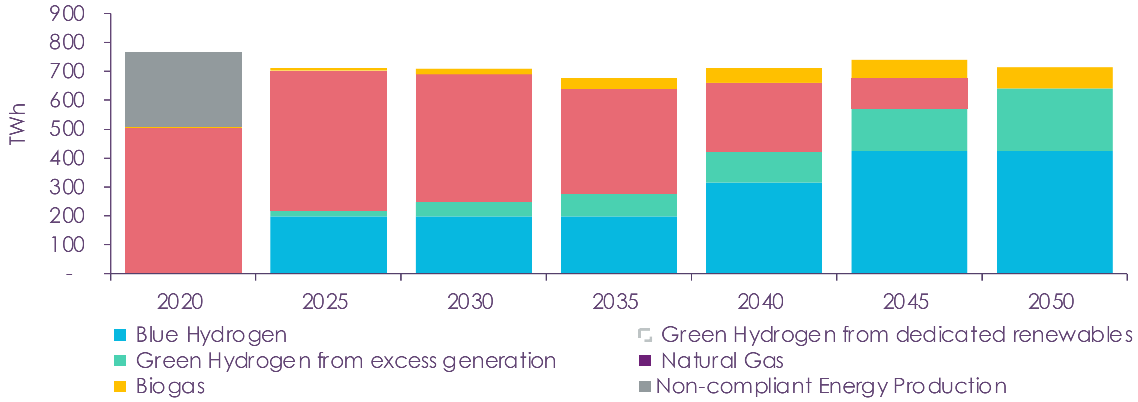
Baseline cost to customer (natural gas)	**5.07p per kWh**
Net zero cost to customer	**4.68p per kWh**
Net cost to customer	**-0.39p per kWh**

Our conclusions: An alternative scenario

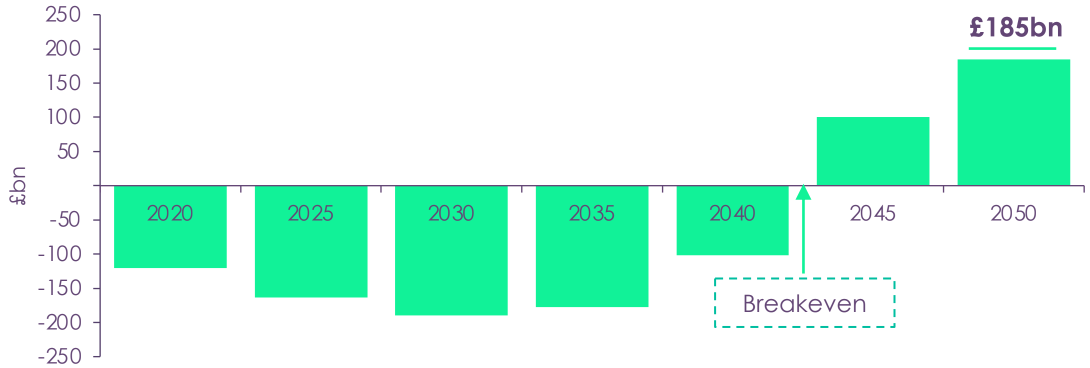
- An alternative scenario has been explored which utilises FES 2019 Two Degrees and Net Zero Scenarios generation capacity projections which differs from the base scenario through the retention of gas-fired generation capacity paired with CCS out to 2050.
- Under this scenario, gas-fired generation acts as a baseload capacity and grid support. This has an effect of increasing excess renewable generation available for green hydrogen production.
- Under these conditions, green hydrogen has the opportunity to play a more significant role in achieving Net Zero, starting at 19TWh per annum in 2025 and growing to 214TWh per annum in 2050 forming 30% of demand from the gas grid in 2050.
- Under this scenario, converting to a hydrogen economy requires investment of £177 billion representing a £20bn increase from the base scenario.
- Our analysis shows that this investment will be paid back through benefits to customers, by 2045 and by 2050, this investment into the UK's hydrogen infrastructure will have delivered a net benefit to customers of £185 billion.
- The net benefit of this alternate scenario represents a £69bn increase on the base scenario due to the increased use of green hydrogen in later years which benefits from the greatest cost differential to the natural gas alternative.

Sources: National Grid FES, Exelon, BEIS, Navigant, CCC

Annual Gas Production Profiles



Rolling NPV of UK Hydrogen Economy

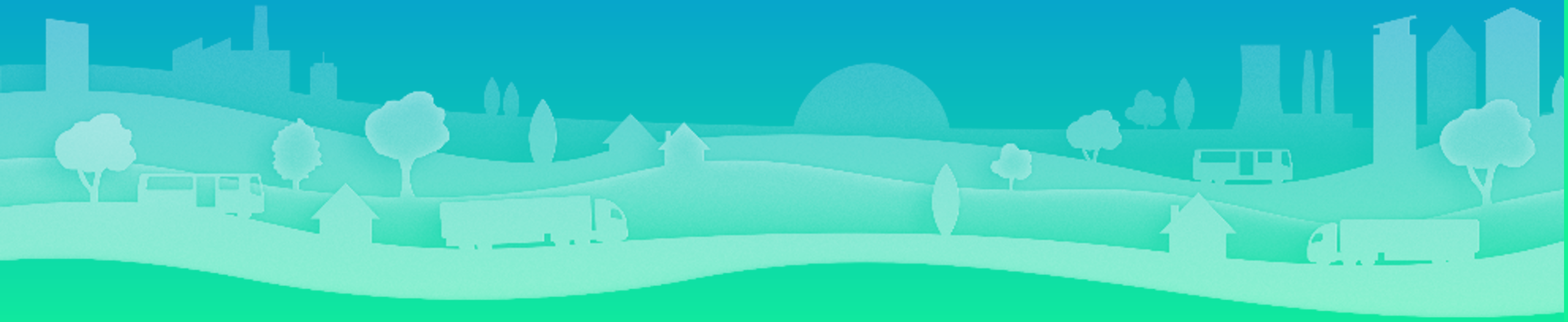


Next Steps: What is required

- The key conclusion of this analysis is that £160 billion of investment is required across the UK value chain in order to develop a diversified net zero economy with hydrogen at the forefront.
- The current fallout from COVID19 offers an opportunity for the UK government to ensure that any fiscal stimulus measures they decide upon align with the ongoing climate emergency.
- Recent analysis undertaken by a team of internationally recognised experts, and led by Oxford University, shows the potential for strong alignment between the economy and the environment. Their evidence suggests that green projects create more jobs, deliver higher short-term returns per dollar spend and lead to increased long-term cost savings, by comparison with traditional fiscal stimulus.
- The delay to COP26 equally provides the opportunity to develop a robust hydrogen proposition which can put the UK at the forefront of this technology and be presented to a global audience through such a prestigious forum.
- The private sector is ready and willing to act, and there are various policies available to the Government to drive this transition, either through mandating change or providing an investable framework in which private capital can be deployed.
- An example of mandating change could be the requirement for households to install a hydrogen ready boiler in all new and existing homes which require an upgrade to the central heating system by 2025. Manufacturers are already making progress in this area, and with the right incentive, could facilitate a seamless and cost-effective transition for customers.
- Stimulating investment through a well-designed framework which fairly apportions risks and costs between investors and customers may be more appropriate for certain technologies. For example, a subsidy akin to the CfD mechanism successfully deployed for Offshore Wind, would allow low carbon hydrogen production to compete with unabated technologies with the view to increasing utilisation and driving down costs.
- Allowing network operators to blend up to 20% hydrogen in to the the gas grid is a 'low regrets' way of stimulating hydrogen production and could save around 6 million tonnes of carbon dioxide emissions every year, the equivalent of taking 2.5 million cars off the road. The Government should begin the regulatory and process of implementing that change immediately,
- It is critical that any policy is practical, limits costs, instils confidence among investors and customers, is compatible with the net zero agenda and incentivises the private sector to deliver value to the wider economy.

Through ENA's Gas Goes Green programme, Britain's gas network companies are committed to working collaboratively with policy-makers to undertake detailed assessment of policy options available to government.

Appendix: Supporting data



Supporting data tables

Hydrogen production		2020	2025	2030	2035	2040	2045	2050
Biogas	TWh	5	11	19	37	51	64	75
Green Hydrogen from excess generation	TWh	0.11	9.61	23.49	42.78	50.28	60.58	82.23
Green Hydrogen from dedicated renewables	TWh	-	-	-	-	-	-	-
Blue Hydrogen	TWh	-	198	198	198	336	494	515
Natural Gas	TWh	503	485	439	359	233	100	-

Unit cost		2020	2025	2030	2035	2040	2045	2050
Green hydrogen from excess generation	£/MWh	94.2	82.5	43.0	34.7	33.3	26.2	30.5
Green hydrogen from dedicated renewables	£/MWh	138.2	93.6	75.4	67.6	61.0	56.0	52.0
Blue hydrogen	£/MWh	41.9	46.1	46.0	46.5	48.7	49.7	52.0
Blended hydrogen cost (excess only)	£/MWh	94.2	47.8	45.7	44.4	46.7	47.2	49.0
Blended hydrogen cost (inc. dedicated renewables)	£/MWh	94.2	47.8	45.7	44.4	46.7	47.2	49.0
NBP Gas + Carbon	£/MWh	21	25	31	52	72	85	98
Renewable capture price	£/MWh	47	48	28	24	24	19	24

Supporting data table: Alternate scenario

Hydrogen production		**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Biogas	TWh	5	11	19	37	51	64	75
Green Hydrogen from excess generation	TWh	0.55	19.14	50.50	79.05	107.29	144.39	214.95
Green Hydrogen from dedicated renewables	TWh	-	-	-	-	-	-	-
Blue Hydrogen	TWh	-	198	198	198	316	425	425
Natural Gas	TWh	502	485	441	362	237	107	-

Unit cost		**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Green Hydrogen from excess generation	£/MWh	94.2	82.5	43.0	34.7	33.3	26.2	30.5
Green Hydrogen from dedicated renewables	£/MWh	138.2	93.6	75.4	67.6	61.0	56.0	52.0
Blue Hydrogen	£/MWh	41.9	46.1	46.0	46.5	48.7	49.7	52.0
Blended hydrogen cost (excess only)	£/MWh	94.2	49.3	45.4	43.1	44.8	43.8	44.8
NBP Gas + Carbon	£/MWh	21	25	31	52	72	85	98
Renewable capture price	£/MWh	47	48	28	24	24	19	24

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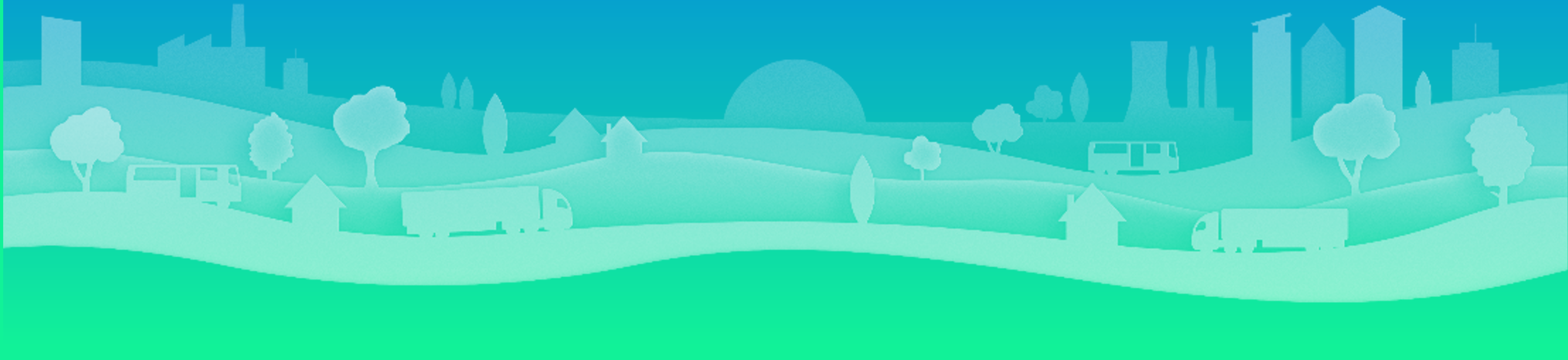

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