Bacton Energy Hub

Oil & Gas Authority


Sheringham North Norfolk Coastal Path

Contents

With thanks to PROGRESSIVE ENERGY

Bacton gas terminal

The Key study conclusions were:

Bacton is ideally positioned
to become a significant hydrogen production site for London and the South East.

A sustainable market for hydrogen
will emerge over the coming years.

Hydrocarbons play a key role
to unlocking this hydrogen potential.

Blue hydrogen is expected to be dominant
in the 2030s and into the 2040s; green hydrogen technology is expected to be matured to become cost competitive on an industrial scale by the late 2040s/early 2050s.

Hydrogen presents a credible value proposition
which could unlock a significant economic value and substantial reductions in carbon which could be as much as 18MT/yr (by 2050 across the Bacton Catchment Area).

There will be a requirement to blend hydrogen with natural gas
as the hydrogen consumer market develops. This blend is expected to be transportable in existing pipelines in the interim as distribution networks are established for increasing hydrogen blends up to a total switch to 100% hydrogen.

Undeveloped hydrocarbons in the Bacton Catchment Area
are believed to be sufficient to meet the feedstock requirements for hydrogen production into the late 2030s/early 2040's.

A hydrogen energy hub could unlock incremental hydrocarbon volumes up to an estimated 2 trillion cubic feet (tcf)
inclusive of high CO_2 ('off-spec') developments which are currently economically unattractive via more traditional development routes.

Continuing production and development of natural gas in the near term
is needed to maintain existing infrastructure to ensure its availability to provide a feedstock for blue hydrogen. Foresight of the developing hydrogen market could therefore result in life extensions for key infrastructure of up to a decade.

Southern North Sea offshore wind power can provide electricity for green hydrogen production
and there is a recognised material value that can be unlocked from otherwise wasted wind energy if a solution to redeploying it can be reached.

Pursuing hydrocarbon development in the near future is critical
to ensure protection of infrastructure and to build a future funnel of developments to provide a consistent feedstock for blue hydrogen production. Failure to act could result in otherwise viable energy and economic opportunities for the UK being foregone.

Scenarios and timing

The study evaluated the merits and technical and economic feasibility of both blue hydrogen and green hydrogen to determine the role and the timing of each in meeting hydrogen demand.

Two scenarios have been considered for the Bacton Catchment Area: “hydrogen from hydrocarbons”, and “hydrogen from wind”.

Hydrogen from hydrocarbons

Hydrocarbon production is maintained and increased in the basin, supporting life extension of pipelines and platforms, and used for blue hydrogen production as the hydrogen market develops. The blue hydrogen process potentially allows use of high CO_2 fields and can also use gas imported through international interconnectors. CO_2 captured from blue hydrogen production and other industrial processes is stored offshore.

Hydrogen from wind

The development of offshore wind capacity, a proportion of which will be constrained by grid limitations and imbalances between supply and demand, can provide power for green hydrogen production.

These scenarios are not mutually exclusive: both can be delivered, although it is anticipated blue hydrogen will dominate from 2030 to the mid 2040s, when green hydrogen’s costs will have reduced to compete with blue.

The study demonstrated a wide range of value-adds that these scenarios could deliver: Table 1 shows these, and demonstrates that most value could be captured by pursuing “hydrogen from hydrocarbons” in the near term and then “hydrogen from wind” in the long term.

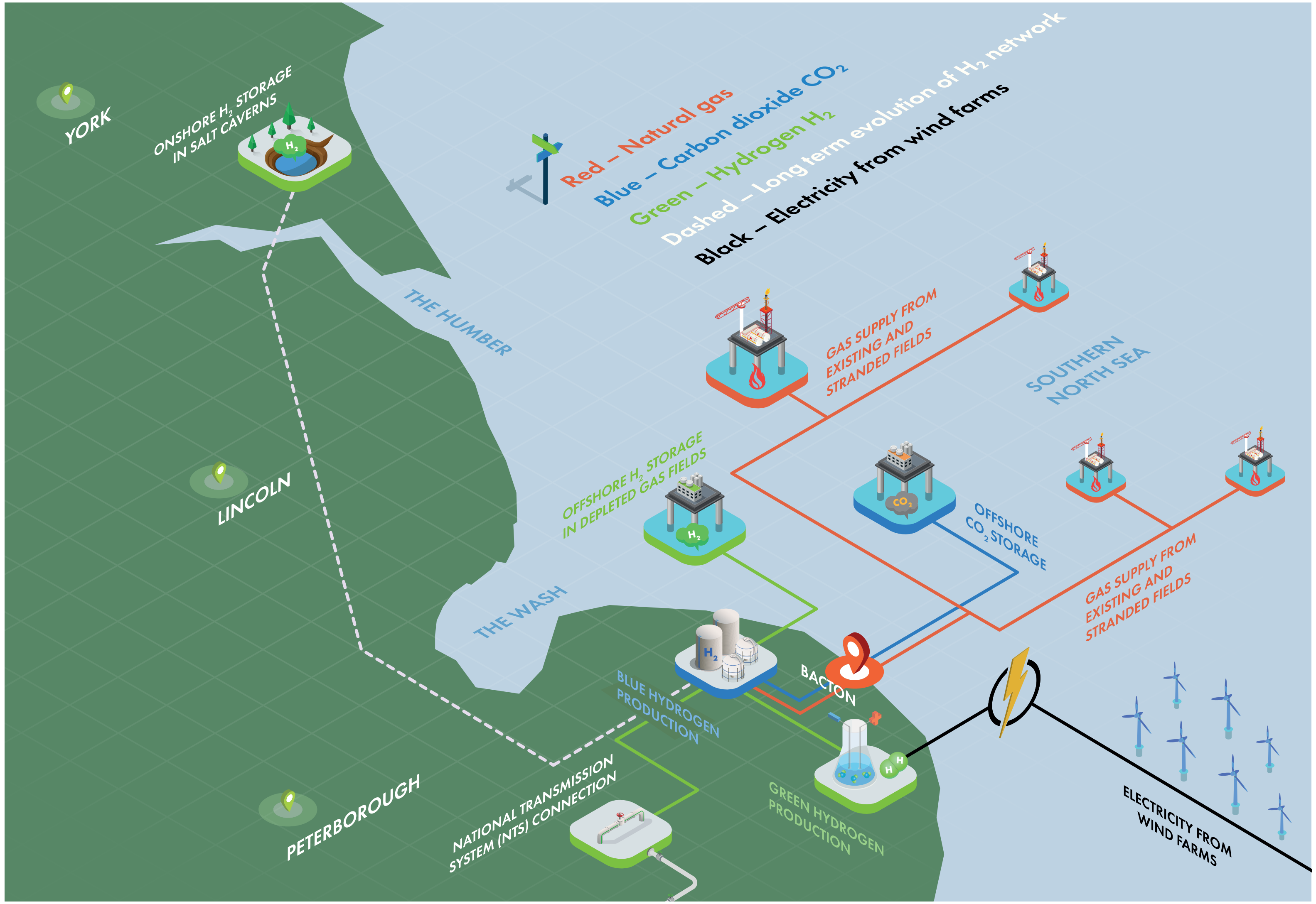
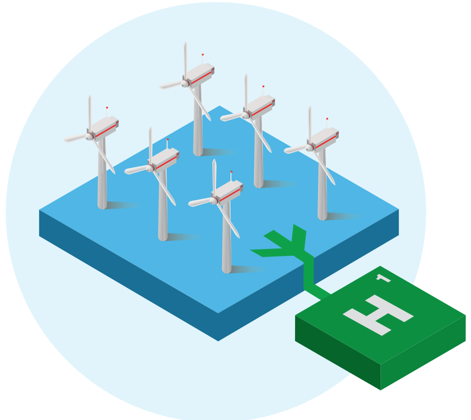


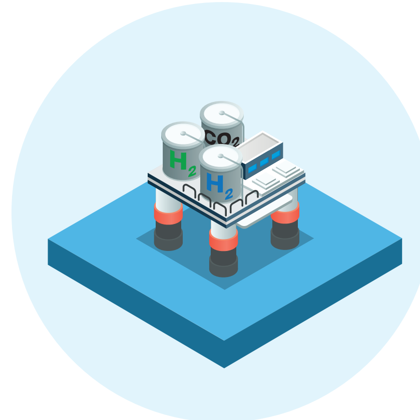
Figure 1: Bacton Catchment Area development concept. For the purposes of this study the Bacton Catchment Area is defined as the geographic area covering the Southern North Sea, specifically the fields whose pipelines make landfall at Bacton or which could use pipelines making landfall at Bacton, and the adjacent onshore areas where hydrogen from Bacton might be used or stored.

Bacton Catchment Area's key advantages are:

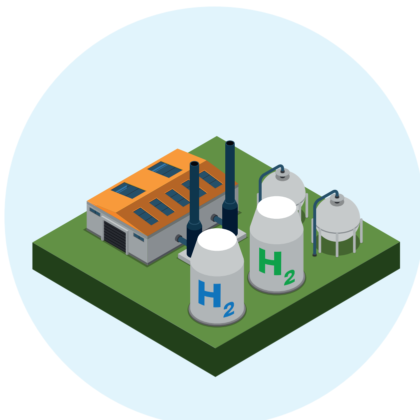
Access to indigenous and, later, imported natural gas for blue hydrogen production



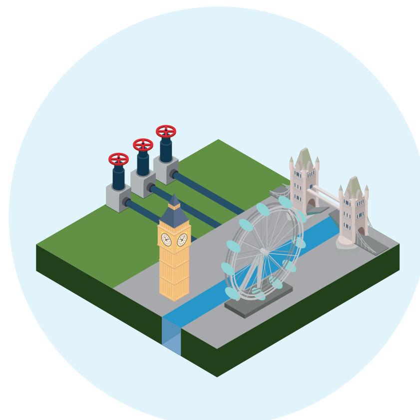
Access to offshore wind farm output for green hydrogen production



Availability of offshore structures for CO_2 and hydrogen storage



Ample land for development of hydrogen production facilities

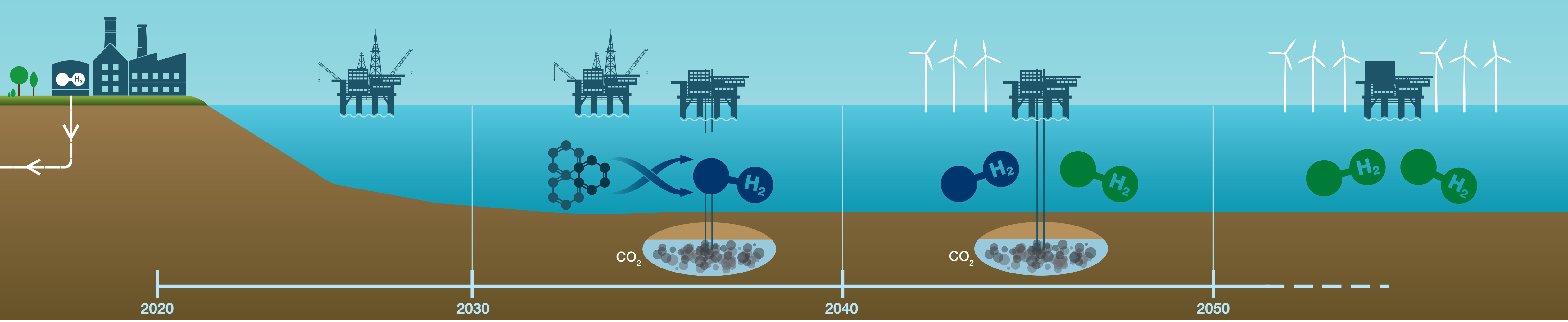


Excellent onshore gas connections to London and the South East

Table 1: Scenarios and value opportunities

Scenario and value stream	Hydrogen from hydrocarbons		Hydrogen from wind	
	How value is created	Impact on value	How value is created	Impact on value
CO_2 emissions reductions from fuel switching from natural gas to hydrogen	CO_2 emissions savings realised by decarbonisation from 1.2 Mt to 18 $MtCO_2$/yr, UKETS permits no longer required, cost savings made	High	CO_2 emissions savings realised by decarbonisation from 1.2 Mt to 18 $MtCO_2$/yr, UKETS permits no longer required, cost savings made	High
Development of hydrogen production	Implementation of blue hydrogen production opportunity maintains existing activity and creates valuable new industry	High	Development of green hydrogen production, depending on economics and support, creates valuable new industry	Medium
Offshore CO_2 storage	Development of CO_2 storage to accommodate CO_2 from blue hydrogen production	High	No development in Bacton Catchment Area. East coast development limited to Endurance structure and Humber/ Teesside clusters	None
Use of constrained electrical generation	Use of constrained and otherwise wasted wind energy could complement blue hydrogen production and provide an incremental value potentially in the region of up to half a billion pounds per year	Medium	Constrained wind energy could be used to generate green hydrogen at Bacton, for blending into the National Transmission System. Constrained wind energy could supply 50% of local hydrogen demand. Potential for hydrogen storage in depleted gas fields	High
New field development, life extension of existing fields and pipelines	Provides an alternative potential lower CAPEX development solution for economically challenged off spec hydrocarbon fields and offers life extension and cessation of production deferral to existing infrastructure, potentially up to a decade	High	Doesn't provided a development route for economically challenged off-spec hydrocarbon fields and offers no life extension to existing infrastructure to enable re-use	Low
Job creation and maintenance, knowledge development	Near term potential from additional field development and operation, blue hydrogen development, commissioning and production at Bacton	High	Potential in longer term from green hydrogen, plus support of offshore wind and Bacton Catchment Area decommissioning	Medium

Mundesley Beach, Norfolk



Introduction

The Oil & Gas Authority's Strategy sets out the central obligation on industry and all relevant persons to maximise the value of economically recoverable petroleum whilst also taking appropriate steps to assist the Secretary of State in meeting the net zero target.

The Southern North Sea has been a critical part of the UK's energy system for half a century. Over the past two decades, offshore wind power has added a new dimension to its energy mix. Bacton has been identified as a key OGA area plan.

The OGA commissioned Progressive Energy to undertake a study to consider the Bacton Catchment Area, analysing the key end users to define how the Bacton Catchment Area hydrogen market might emerge and generating an indicative future hydrogen demand profile for the region. Based on this analysis, the study has identified credible routes to hydrogen production to meet this demand, and has framed the directional value-add that hydrogen could unlock.

The study has confirmed that there is a significant economic opportunity for a hydrogen led Energy Hub at Bacton and has developed a vision for the Bacton Catchment Area in this context, to inform the next phases of the Bacton Area Plan.

The natural gas fields of the Southern North Sea and the Bacton gas terminal have been part of the UK's energy backbone for more than 50 years. Since 2004, offshore wind power has also contributed to the energy mix in the area. As society decarbonises and energy in the UK moves to a net zero footing, Bacton and the Southern North Sea can continue to play a major role.

This report summarises the main findings of analysis undertaken by Progressive Energy on behalf of the Oil & Gas Authority to explore this potential, with particular focus on the prospective role for the Bacton gas terminal, and its associated gas fields and nearby offshore wind power.

The analysis concludes that there is very significant potential for the Bacton Catchment Area to play a major role in the UK's energy future through the production of hydrogen from natural gas produced from existing and undeveloped gas fields, and from electrolysis powered by new offshore wind power and nuclear capacity. This will deliver a critical zero-carbon fuel for local and regional markets and enable the economic development and life-extension of gas fields across the region and the creation of jobs and valuable Intellectual Property.

This summary report describes the market potential for hydrogen, the main processes for hydrogen production, the role of hydrocarbons and the associated opportunities, the role of offshore wind and its limitations, and the other opportunities available to the Bacton Catchment Area in pursuing these strategies.

Hydrogen markets

Hydrogen is recognised to be a critical energy vector in the net zero economy of 2050. It offers complementary benefits to electricity and can offer a decarbonisation route for areas of the economy which are hard to decarbonise by electrification.

Additionally, it offers the potential to reuse existing energy infrastructure; onshore in the form of the National Grid operated National Transmission System for gas, and the Gas Distribution Networks operated by Cadent, Northern Gas Networks, Scottish Gas Networks and Wales & West Utilities, and offshore pipelines, platforms and wells.

Total gas demand for 2019 in the Bacton Catchment Area is shown in table 2. In principle, much of this demand could be "fuel switched" to hydrogen, resulting in significant end-use CO_2 emissions reductions.

Sector	Annual demand	Equivalent CO_2 emissions (MMt/yr)
Power	37.7 TWh	6.9
Industry	7.7 TWh	1.4
Domestic/Commercial	82.7 TWh	15.1
TOTAL	**128.1**	**23.4**

Table 2: Current Bacton Catchment Area gas demand

Uses of hydrogen

Power

Even as the amount of renewable power on the national grid increases, there remains a requirement for "dispatchable" power (power which can be guaranteed to be available as required), to provide power and resilience when renewable sources are not available.

Although storage and demand management may reduce this requirement, modelling shows that there can be extended periods over which output from renewables (and nuclear, which operates as base load) are inadequate to meet demand.

This power demand could, in future, be met by supply from hydrogen-powered power stations.

The demand for hydrogen for power will be driven by seasonal patterns, as well as the need to fill a supply shortfall whenever wind and solar are insufficient to meet demand.

As there will always be periods in which solar and wind output is minimal, a requirement for dispatchable power will persist. Hydrogen can provide the required feedstock for this power, contributing to net zero.

Industry

Industry is expected to shift much of its energy demand from natural gas to hydrogen. This process is likely to be low cost and relatively simple, as it may only require changing burners (potentially as part of the normal investment cycle) rather than major capital expenditure. This will create demand for hydrogen which is relatively constant across the seasons.

Domestic, commercial heating

The majority of domestic and commercial heating demand in the UK is currently met by the supply of natural gas through the National Transmission System and local distribution zones. As the UK decarbonises, this demand is expected to shift to hydrogen boilers, electrical heat pumps and hybrid systems which combine both of these technologies.

The demand profile for heating is highly variable, both daily and seasonally, and the energy system will have to meet this demand pattern. The report anticipates much of this heating demand continuing to be met by natural gas up to 2030, with hydrogen being blended with natural gas from 2030 in increasing proportions over time, until by 2050, the gas network in the UK is carrying hydrogen only.

National Grid and others are currently investigating the potential for the reuse of the NTS and other pipeline systems for transporting hydrogen instead of natural gas, and blending trials are under way for hydrogen in natural gas.

Transport

The decarbonisation of transport will be achieved by the adoption of both battery electric and hydrogen fuel cell technologies. Trains, heavy goods vehicles, buses and other heavy vehicles are expected to use hydrogen as an energy source, while cars, vans and other light vehicles will be battery-powered. This too will contribute to hydrogen demand (Figure 2).

Total hydrogen demand across the Bacton Catchment Area could rise to nearly 90 terawatt-hours per year (TWh/yr) by 2050 (Figure 3).

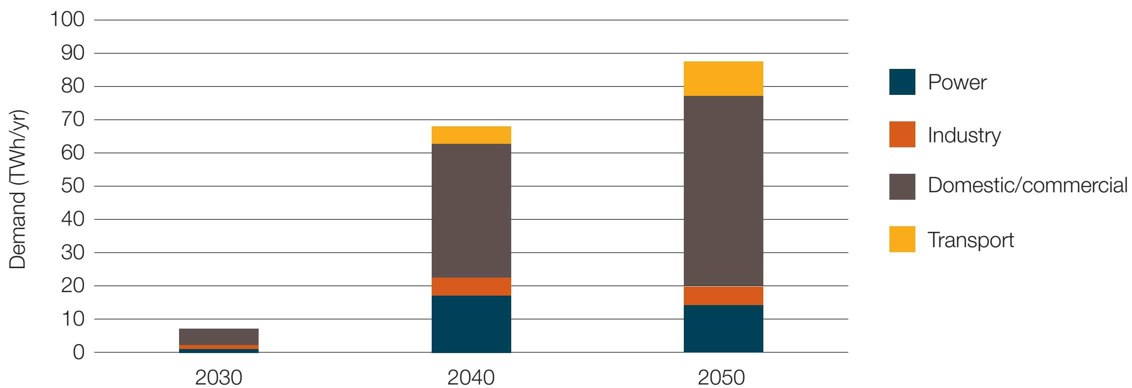


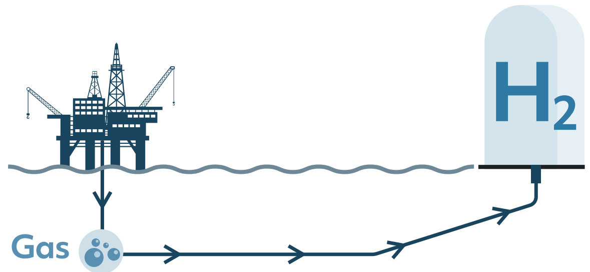
Figure 3: Indicative hydrogen demand, 2030-2050, Bacton Catchment Area

Figure 2: A hydrogen bus

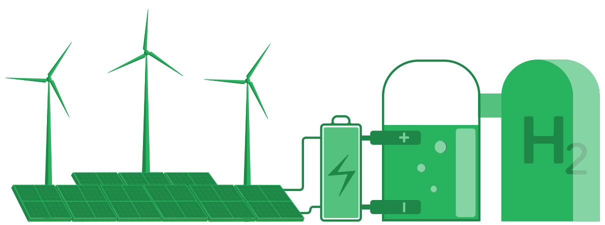
Hydrogen production

Hydrogen can be produced in industrial quantities through two main technology families: processing of natural gas with carbon capture and storage (known as "blue" hydrogen) and electrolysis of water using renewable energy ("green" hydrogen).

Each of these technology families has strengths and weaknesses, and it is the generally-held view that both will be important aspects of the decarbonised UK energy world. Government has committed to a "twin track" approach involving blue and green hydrogen, and business models are being developed to support both technologies.



Blue hydrogen production can be continuous, as it depends on the availability of a natural gas feedstock. This could be provided by indigenous gas reserves on the UK Continental Shelf, including gas reserves with concentrations of contaminants like nitrogen, CO_2 and hydrogen sulfide (H2S) which would make them unsuitable for the gas grid, potentially enabling the development of new UK Continental Shelf finds. In the meantime, continuing gas production will maintain critical offshore infrastructure which will be required for blue hydrogen production.



Green hydrogen production is powered by intermittent renewable energy, and its economic viability is driven by the load factor of the power being used in the process. It is suggested that green hydrogen production may be able to use "constrained" renewable power, which is available only when the grid is unable to accept power generation from wind farms. The low load factor offered by constrained wind, even as total installed wind capacity increases, means that green hydrogen produced with constrained wind will require tailored support to be economically competitive with hydrogen produced from electrolysers able to achieve higher load factors or blue hydrogen. The Government has stated that it plans to support the development of both blue and green hydrogen.

	Blue hydrogen	Green hydrogen
Technology	Reforms natural gas into hydrogen, captures CO_2 and stores it permanently in geological storage	Uses intermittent renewable electricity to electrolyse water to produce hydrogen
Carbon footprint	Low (capture rate > 95%) if offshore storage sites for permanent CO_2 capture are available	Very low if electricity usage does not create additional emissions from backup thermal generation (i.e. Grid is fully decarbonised)
Cost	Currently low, c. £50/megawatt-hours (MWh)*, dependent on gas prices	Currently high, c. £100/MWh*, dependent on electricity prices
Expected cost evolution	Decline expected due to upscaling of technology and learning effects	Sharp decline expected following development investment, upscaling and learning effects
Key risks	CO_2 storage availability	Not proven at large (>100MW) scale, cost trajectory dependent on investment
Other issues	Residual CO_2 slip must be offset	Upscaling critically depends on Government support and investment

Table 3: Blue and Green Hydrogen - key issues
* Study scoping: indicative Levelised Cost Of Energy

Hydrocarbon potential

To support the maximising value of economically recoverable petroleum from the UK Continental Shelf, a key consideration of the study was to assess the potential for undeveloped discoveries to unlock regional value as part of a wider Bacton energy plan. This considered use of these hydrocarbons as feedstock for hydrogen rather than a more traditional piecemeal hydrocarbon development route. The study considered value propositions such as the potential for life extension of production from existing fields and maintenance of existing export routes which could reduce the required infrastructure investment to develop the higher CO_2 hydrocarbons.

The OGA estimates around 1.4 Tcf of reserves in commercial fields which are currently in production and exporting gas to the Bacton terminal, together with up to 2.2 Tcf of undeveloped gas reserves in the Southern North Sea.

Conventional reserves

Conventional reserves, whose hydrocarbon gas is within the required specification for the National Transmission System, are found in fields of up to 150 Bcf, with a median size of around 70 Bcf. In many cases, these fields have not been developed to date as they are economically challenging and there is insufficient certainty of evacuation route given the basin is in decline.

Achieving the life extension of this export infrastructure could enable the economic development of many of these smaller and satellite fields.

High CO_2 reserves

A number of significant finds, with potential reserves of some hundreds of Bcf, contain high proportions of CO_2 which make their gas unsuitable for entry into the National Transmission System without significant and costly treatment.

The Progressive Energy report found that if these fields' gas were to be used for blue hydrogen production, rather than treated to allow its entry into the National Transmission System, these fields could be economic, and the increased volumes of gas in offshore pipeline systems could also reduce the cost base for other, smaller, currently undeveloped fields, making these economically viable too.

Development of these high CO_2 fields could therefore unlock significant value potential across the Southern North Sea.

A bridge to blue hydrogen

The economics of development of these currently stranded assets will require the continuing availability of pipeline infrastructure to transport their hydrocarbons to the beach.

The production of existing hydrocarbon reserves is essential to justifying the ongoing operation and maintenance of pipeline systems which will be important to the future role of the Bacton Catchment Area in blue hydrogen production. These reserves could provide sufficient feedstock into the late 2030s, after which there would be potential to import hydrocarbons via the interconnectors located at Bacton. These transitions, from hydrocarbons to blue and then green hydrogen at Bacton, will take place over an extended period.

Figure 4: OGA energy map of Southern North Sea

Muckleburgh Hill and Weybourne in Norfolk

Wind power performance

Wind power is expected to become the dominant renewable electricity generation technology in the UK by 2050. The Government's recent Ten Point Plan restated a goal of 30 GW of offshore wind capacity by 2030, and the Climate Change Committee has suggested that the UK will require 75 GW of installed capacity by 2050. The pro-rata share of this capacity could meet 50% of hydrogen demand in the Bacton Catchment Area if dedicated to green hydrogen production.

Electrical output from wind farms can be used in two ways: to directly service electricity demand and to power electrolysers to produce green hydrogen.

However, the output of wind farms varies between years, from hour to hour and with geographical location.

Modelling shows that the output profile over time of two wind farms in an area closely match: when it is windy at one, it is windy at the other. This means that pooling output from wind farms within a region does not significantly smooth output. This is also true on a national scale, as wind farms even a few hundred km apart broadly correlate in output.

The variability between years and intermittency (variability of output within a year from hour to hour) are key issues for considering wind power as a feedstock for green hydrogen production, and mean that there is an irreducible demand for dispatchable power, to meet demand when it is not windy.

Additionally, as wind capacity increases, there will be periods when the Grid is unable to accommodate generation, and when generation exceeds demand. This output could potentially be used for green hydrogen production, but due to the low load factor of this power, would require significant cost reductions in green hydrogen production technology and tailored Government support to make this hydrogen economically competitive.

Hydrogen production and storage

Hydrogen supply must be matched to variable demand, generating a requirement for storage. Table 4 sets out the key features of hydrogen production technologies and their relationship to storage, and notes that in all cases, hydrogen storage is required.

Storage of limited volumes of hydrogen is possible onshore, as linepack and potentially in onshore salt caverns. As storage demand grows, the use of offshore geostructures will be required.

Storage in offshore structures could include depleted gas fields, aquifers or purpose-built offshore salt caverns.

The total storage requirement depends on the market for hydrogen. An estimate can be made by assuming that all hydrogen production in the summer months is stored until the winter when it is required.

Demand estimates suggest storage requirements potentially reaching tens of TWh by 2050 for the Bacton Catchment Area and potentially some hundreds of TWh nationally. An opportunity exists to review potential geological structures in the light of the table opposite to develop a risk ranking, and to move to select, licence, de-risk and develop appropriate hydrogen storage capacity for both the Bacton study area and potentially as a national resource

Supply	Output variability	Comments
Blue hydrogen production only	Production can be ramped within operational limits to match demand	Potential to match output to demand, but storage may be part of least cost solution
Green hydrogen production	Production tied to availability of intermittent renewable electricity; limited potential to demand-match	Storage required to cover periods of zero renewable generation and therefore no green hydrogen production
Blue and green hydrogen	Blue hydrogen production can potentially be ramped to match green supply and demand	Potential to manage blue supply to ensure blue and green supply matches demand. Some storage may still be part of least cost solution

Table 4: Hydrogen supply and demand variability

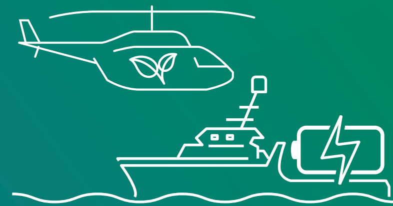
Other opportunities

The Oil & Gas Authority describes its role as to "work with the industry and government to maximise the economic recovery of UK oil and gas and support the UK government in its drive to reach net zero greenhouse gas emissions by 2050".

In addition to the opportunities for blue and green hydrogen production at Bacton to contribute to net zero, the Oil & Gas Authority recognises the potential for hydrocarbon operations to reduce their own emissions, by reducing emissions in production and in their supply chain "scope 1 and 2" emissions. Using natural gas to produce blue hydrogen, rather than burning it directly, effectively allows the capture of the CO_2 which would have formed the "scope 3" emissions associated with this gas.

Electrification of offshore activities

Potential electrification of offshore operations to reduce the burning of natural gas for power generation was recognised in the report. The co-location of production with offshore wind farms may present an opportunity for lower-cost electrification of offshore activities than supplying electricity from shore, although technical issues regarding management of intermittency (by installing electricity storage offshore), import voltage and pricing and supply contract will require detailed consideration.



Support services

Potential to reduce emissions of offshore supply vessels and helicopters that are responsible for significant emissions of CO_2. This could be by improved logistics planning, fuel switching supply vessels to ammonia and/or batteries, and potentially fuel switching helicopters to biofuel alternatives may be possible.

Link to nuclear

Nuclear projects may be able to contribute electrical output at periods of low demand for hydrogen production. Sizewell B nuclear power station (1.2 GW) operates on the Suffolk coast close to Bacton. The Sizewell C project (3.2 GW) is planned. These projects would generate hydrogen production through electrolysis, potentially enabling electrolyser capacity at Bacton to achieve higher load factors, and better economics, than if it were powered by offshore wind alone.

Jobs and Intellectual Property

The life extension of the Southern North Sea fields and the creation of new industries in the Bacton Catchment Area offer significant potential to maintain and create employment opportunities and to create and exploit Intellectual Property as these new industries develop.

These opportunities include:

Job maintenance through life extension of onshore and offshore activities

Job creation in gas development and production, from new fields

Job creation in hydrogen production (blue and green)

IP development and exploitation potential, including export potential, from the new industries of blue and green hydrogen production

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