Hydrogen, Energy Hubs and East Anglia

Framework Paper by Hydrogen East

FOR DISCUSSION WITH POTENTIAL SCHEME SPONSORS AND PARTICIPANTS

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1 Introduction

Attitudes to hydrogen and its use in the energy sector have changed rapidly over the past six – 18 months both internationally and here in GB. It is now seen through its versatility as a key – indeed essential - enabler of meeting the 2050 Net Zero target. In a world of increasing renewable power surpluses and falling technology costs, it is expected to have a major role in filling the decarbonisation gap through a growing number of uses across the energy and transport sectors, and not just those that are "hard to reach". It also has a potentially important role in helping to "build back better" as a part of the green recovery.

Interest in the role of hydrogen and its role in supporting delivery of Net Zero has recently translated into more focussed policy interest. The government has said it will issue a cross-departmental hydrogen strategy in Spring 2021[1]. BEIS is then looking to publish a consultation on hydrogen business models in 2021, having issued a research paper by Frontier Economics in August 2020[2]. before finalising the preferred approach in 2022.

Against this rapidly shifting background, Hydrogen East was formed in summer 2020 to research, analyse and promote pathways for development of a hydrogen economy that connects supply and demand in East Anglia, and which looks to complement and reinforce delivery of other regional economic and clean growth priorities. We have already reached out to many local stakeholders, who have generally expressed support for a more "joined up" approach based on detailed analysis of regional hydrogen resources, capabilities and opportunities.

There is growing awareness that transformative opportunities are likely to exist over the next 10 years or so as the North Sea is decarbonised and as aggressive offshore wind roll-out continues. East Anglia is ideally situated to benefit from these developments. These opportunities now need to be defined and translated into coherent project proposals for the region that can be scoped, detailed and incorporated into a coordinated assessment programme.

This paper sets out at a high level progress we have made at Hydrogen East since our launch event on 29 July and the approach we are now proposing to adopt to progress key regional projects and priorities that will drive our initial work programme over the period to end 2021 (phase 1), The aim is to simultaneously support the Local Industrial Strategy and emerging national Hydrogen Strategy. In particular, the paper focuses on activities that prioritise three grouped regional but deliberately different "energy hub" configurations that should enable the region to move from being hydrogen laggard to hydrogen leader.

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[1] https://www.gov.uk/government/publications/committee-on-climate-changes-2020-progress-report-government-response

[2] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/910382/Business_models_for_low_carbon_hydrogen_production.pdf

2 Energy hubs

The term "energy hub" is increasingly appearing in energy industry literature and as a focus within the debate about the Net Zero economy. While there is no stock definition, the term is usually applied to cross-sector integration projects around energy facilities comprising a mix of existing assets, some of which might be repurposed, and new ones. It aims to deliver outcomes that are mutually supportive and in which the benefits are expected to be greater than the sum of the individual parts. Hydrogen - its production, transport, storage and use - is often a key feature.

In the past, separate energy systems were planned and managed independently. But today integrated development can lead to benefits across different vectors such as electricity, gas, heating, and transport (distribution and use). Energy hubs can combine these technologies driving efficiencies through sharing of facilities and building scale, and thus can create a more rapid movement towards multi-energy systems and decarbonisation on a whole system basis. In such systems, different energy carriers and systems interact together in a synergistic way.

An energy hub can be described as the place where the production, conversion, storage and consumption of different energy carriers can take place. In doing so it potentially provides a comprehensive model for development and deployment of sustainable energy systems, including flexible use. It should also allow local and regional resources and assets to be combined based on specific use cases, which might differ from one location to another. Where applied successfully, it can enable a pathway through the energy transition, support regional growth and jobs as well as providing a major contribution to decarbonisation and delivery of the Net Zero target by 2050.

Thinking around development of implementation of such pathways is at a relatively early stage, including the potential role of hydrogen. A variety of supply-based industrial clusters projects have emerged in the UK under the Hydrogen Supply Competition[3], and other demonstration projects are being developed at Drax, Immingham, Warrington, Teesside as well as other places. However, the concept of a more joined up, integrated approach is increasingly chiming with policy makers, regulators and industry practitioners, and it can be applied to any regional grouping of assets allowing them to be planned, developed and used in a more coordinated way at lower cost, creating real consumer benefit.

A more integrated approach is already being scoped by the Shetland Isles.[4] This project could see the West of Shetland oil and gas assets become net zero by 2030, while providing 5% of the UK's total low carbon energy demand for 2050. There is also the Milford Haven "energy kingdom" project being managed by ORE-Catapult.[5]

Noteworthy in this context are two recent reports, which have begun the process of "reimaging" current energy production and supply processes. and highlighting the importance of hydrogen across a range of integration projects. They recognise not only the desirability of accelerating thinking around hydrogen integration into the energy system but also key dependencies with existing and planned energy developments off the coast of East Anglia.

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[3] https://www.gov.uk/government/publications/hydrogen-supply-competition/hydrogen-supply-programme-successful-projects-phase-2

[4] https://www.newangliaenergy.co.uk/latest-news/shetland-set-for-energy-hub-concept/

[5] https://ore.catapult.org.uk/stories/milford-haven-energy-kingdom/

The first is by the Oil and Gas Authority (OGA)[6], which endorsed in August development of the energy hub concept as a way forward for the energy transition and made a number of sensible recommendations around data sharing and enhanced coordination of regulatory and stakeholder engagement processes to support delivery. It also set out the need for further work to explore ways to accelerate the timeline of cross-sector projects.

The second is by the Oil and Gas Technology Centre (OGTC)[7], which published in September 2020 a report by Wood Mackenzie setting out a roadmap of technologies needed to deliver an integrated net zero energy system on the UKCS, along with associated costs and benefits of each.

3 Hydrogen East's phase 1 priorities

There is already a strong commitment within Norfolk and Suffolk across stakeholders towards region becoming the UK's "clean growth region". The New Anglia Local Enterprise Partnership (NALEP)'s driving objective embedded in the Local Industrial Strategy is for the region to be "a globally recognised, technology-driven, creative and inclusive economy, which is leading the transition to a post-carbon economy through sustainable food production and sustainable energy generation"[8]. Latterly this need to achieve the 2050 Net Zero target has been supplemented by the need to "build back better" following the pandemic. This objective focussed on green growth should lead to adoption of strategies supplementing on-going programmes to strengthen decarbonisation in agriculture, energy (including heat) and transport, while looking to build security of demand and increased energy resilience regionally.

The merits of application of the energy hub concept here in East Anglia can be easily explained.

In part this is because of the rich, existing energy infrastructure, assets available in and around the Southern North Sea and also Sizewell and because of the ease of access to proximate markets and significant centres of local demand. However, a key aim of the Hydrogen East project is to enable existing assets to be repurposed and provision of access to growing demand in other economic sectors of importance within the region that will support clean growth. Understanding where this demand is and how it can be expected to grow is an important feature of our work, which we believe provides an important differentiator with most other hydrogen-based workstreams across the UK.

However, there are also opportunities outside of East Anglia. There is the important access offered to nearby large demands for energy and transport in London and the South East and the Midlands, which existing high pressure pipelines could support. Additionally, East Anglia is also ideally situated to exploit export opportunities to the Continent via the existing Zeebrugge and BBL gas interconnectors. This includes potential integration with the European "hydrogen backbone" project[9] over the medium to longer term.

There region is also a large net exporter of electricity through the 275/440kV transmission network, a position that is being reinforced by steady further build-out of large-scale offshore wind projects off the East Coast.

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[6] UKCS Energy Integration, Final Report, OGA, https://www.ogauthority.co.uk/news-publications/publications/2020/ukcs-energy-integration-final-report/

[7] https://www.theogtc.com/newsroom/news/2020/closing-the-gap-realising-a-net-zero-north-sea/

[8] https://newanglia.co.uk/local-industrial-strategy/

[9] https://gasforclimate2050.eu/sdm_downloads/european-hydrogen-backbone/

A central proposition of our work is that, with the existing import and export infrastructure for gas, continued development of offshore wind beyond Allocation Road 4 and the continued operation of Sizewell B and its development through construction of Sizewell C, the region is ideally placed to build its position as the UK's clean energy region. We believe it can quickly diversify into the emerging hydrogen sector stimulating both the local market and supporting the decarbonisation of the wider economy.

3.1 Mapping the basics

Hydrogen East's approach will be to start by comprehensively mapping existing regional energy assets and demand, for electricity, heat and transport use, both offshore as well as onshore. We will also quantify present and future limitations arising from the export and import of energy into both the wider UK economy but also the Continent based on credible development scenarios, including an integrated North Sea grid.

We plan to develop a bespoke portal to provide access for local stakeholders to this "building block" information. The demand assessment based on specific user cases is, we believe, an important element given high levels of latent hydrogen demand in East Anglia in the agriculture, transport and other sectors. To this we will also add development scenarios consistent with "best in class" assessments such as National Grid's *Future Energy Scenarios (FES)*,[10] UKPN's *Distribution FES*[11] and Cadent's *Long-term Development Plan*[12] to support business evaluation of the options and opportunities.

There is a strong focus within the project on existing major energy sites at Bacton and Sizewell and the surrounding areas. Historically both these sites have been used as essential energy infrastructure, but the energy associated with them is at present largely supplied through East Anglia to other regions. Identifying local demand in key economic sectors and applications, and how it can be developed to pull through hydrogen production, is therefore an important focus of the project. There are also aging gas generation assets at Great Yarmouth, Spalding and Sutton Bridge, which could be incorporated into hub design or be leveraged to support regional hydrogen infrastructure.

Of the three priority projects we plan to assess, all have characteristics that could enable different energy hub structures to be scoped, tested and, potentially, developed. These projects focus on different combinations of technologies and applications, and they are briefly described below. This is a synthesis of our thinking and we do not necessarily have the support of all asset owners and developers at this stage.

3.2 Three priority workstreams

3.2.1 Bacton/Southern North Sea (SNS) 2.0

This scoping project is centred on the Bacton gas terminal, which supplies 30% of the UK's natural gas, and the associated interconnectors.

A key focus will be to look at integration of CCS and decarbonisation of gas from the SNS and the UK"s largest potential CO2 storage network, including the options offered by repurposing gas networks (offshore and onshore) for transport of hydrogen.

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[10] https://www.nationalgrideso.com/future-energy/future-energy-scenarios/fes-2020-documents

[11] https://innovation.ukpowernetworks.co.uk/2020/02/06/distribution-future-energy-scenarios/

[12] https://cadentgas.com/nggdwsdev/media/media/reports/futureofgas/Long-Term-Development-Plan-2019-Final.pdf

A further focus will be the scope for pipeline reuse as North Sea assets are progressively scheduled for decommissioning, with potentially blending of hydrogen into the onshore gas networks.

Over 50% of the UK's operational offshore wind fleet is also off the coast of East Anglia, and this market share is set to increase. This will inevitably cause increasing periods of surplus electricity supply over demand, and this can be converted to hydrogen through electrolysis, which is seeing major technological change and a rapid fall in production costs, both of which are expected to continue.[13] Further significant development through existing site development and new site expansion is also planned to allow the country to reach its 2030 40GW target.

There is also the Great Yarmouth 398MW CCGT power station owned by RWE. This is already connected to Bacton by a dedicated 25-mile pipeline. The station was commissioned in 2002 and its future operating mode is set for review imminently. It is possible this could be converted for up to 50% hydrogen use. There may also be opportunities with possible conversion at other local gas generation sites such as Kings Lynn, Sutton Bridge and Spalding.

Other regional markets and demand centres will be considered, including use of pipelines for distribution to London as well as export opportunities through the interconnectors to Belgium (Interconnector UK) and the Netherlands (BBL).

We will also address existing and potential local demands including in agriculture, tourism and transport (including rail and shipping as well as HGVs) and how these might develop and exploit hydrogen for the benefit of the North-east Norfolk economy and the wider East Anglian region.

This workstream is now live, and we have embarked upon mapping the onshore system and economy. We have already had confirmation of funding in principle from the New Anglia LEP, ORE-Catapult and North Norfolk District Council, and this now meets the terms of conditional support offered by the Oil and Gas Technology Centre. There will be a formal project launch early in November, and the project will run for six months.

3.2.2 The New Anglia Clean Transport Hub

This second scoping project will allow us to explore application of hydrogen production and use in a number of markets in transport (buses, heavy goods vehicles and agricultural vehicles, rail and shipping), especially around major growth locations.

Under the NALEP development plans a number of sizeable growth locations on major roads have been identified. These include (i) Ipswich and the surrounding area, (ii) Norwich and the Greater Norwich area, (iii) The Norfolk and Suffolk Energy Coast, including Bacton, Great Yarmouth, Lowestoft and Felixstowe, (iv) the Norwich-Cambridge Growth Corridor, and (v) the east-west growth corridors along the A47 from Lowestoft and Great Yarmouth to King's Lynn and the A14 from Felixstowe through Ipswich, Stowmarket, Bury St Edmunds, Newmarket and Haverhill to Cambridge.

There is also a challenge around decarbonising rail in East Anglia, which is very dependent on a network of feeder lines, but with a number of key lines not ear-marked for electrification. These could be converted away from diesel to hydrogen, and Network Rail has already identified some local branch lines that are prospects for conversion to hydrogen and batteries.

Shipping is at present almost wholly reliant on fossil fuels and was flagged as an important area of hydrogen demand growth in the FES 2020 scenarios. The treatment of hydrogen into ammonia

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13 https://s3-eu-west-1.amazonaws.com/media.newore.catapult/app/uploads/2020/09/07105124/Solving-the-Integration-Challenge-ORE-Catapult.pdf

is thought to be a likely route for the sector, as it provides a high energy density fuel. The shipping industry is itself already evaluating the potential to transition to hydrogen. Equally, scoping projects to introduce hydrogen powered ferries are underway in Orkney and elsewhere.

East Anglia already hosts large ports and harbours. The Port of Felixstowe is the busiest container port in the United Kingdom and is a key gateway for container traffic into the country dealing with over 40% of container traffic. The port is operated by Hutchison Ports, and employs over 2500 people as of 2013. A £300mn expansion to the port was completed in 2011 and a new rail terminal opened in June 2013. The A14 provides road links to the port.

Other significant ports in the region include Ipswich docks, the Port of Lowestoft, Great Yarmouth Outer Harbour, King's Lynn Docks and Wisbech Port. Ipswich deals with more than two million tonnes of cargo a year and has freight rail links on site. King's Lynn and Wisbech are focussed on dealing with agricultural products from the surrounding farmland, whilst Lowestoft and Great Yarmouth play an important role in servicing the North Sea energy industries.

A number of smaller ports and leisure harbours, such as at Wells-next-the-Sea and Southwold operate around the region's coast. The major freight and passenger port of Harwich International Port is located just to the south of Felixstowe in Essex. Ferry services run from here to Esbjerg in Denmark and Hoek van Holland. Within the region a number of local vehicle and passenger ferry services remain in service, including the Reedham Ferry across the River Yare in Norfolk and the King's Lynn passenger ferry across the River Great Ouse. Broads boating similarly needs switching away from diesel.

The aim will also be to support ambitious decarbonisation programmes being developed by local authorities, several of which (including West Suffolk) are already looking to test hydrogen potential in regional transportation later this decade.

We will also be actively seeking out opportunities to extend the project to support key adjacent markets in agriculture, refuse disposal, tourism, and other sectors all requiring urgent decarbonisation, and these will be an important part of the scoping exercise.

We have not gone out to seek funding for this workstream yet, but a launch briefing is scheduled for 27 October. Our project plan for this workstream envisages another six-month assessment and initial report writing process, but probably commencing in January 2021.

3.2.3 The Sizewell/ Leiston Energy Hub

This third scoping project will consider how the development around EDF Energy's existing Sizewell site in Suffolk can be used to stimulate local net zero infrastructure using electrolysers and transportation associated with the existing nuclear site in the Sizewell/Leiston area. We will also consider use of low carbon energy for the long-term benefit and decarbonisation of businesses, households and transport in the East Suffolk region.

A nuclear power station a large amount of low-carbon heat. This heat is typically used to generate electricity, but the Sizewell C project, which is currently in the planning process, is also investigating using some of the heat directly for district heating networks, for process heat demands within industrial applications or agriculture, and to increase the efficiency of low-carbon fuel production. Developing the energy hub concept here could offer an integrated system of heat and power generation, storage and use under single ownership using a unique local power source, on a scale that would be difficult to achieve elsewhere.

EDF Energy is also considering options to develop a pilot electrolyser project of possibly 2MW at Sizewell B in the short-term. This pilot will showcase the benefits of hydrogen production linked with nuclear power, and it will also allow the hydrogen market in the local area to develop. Ultimately, learning from this pilot project could contribute towards a larger-scale electrolyser at

Sizewell C in the event that is approved, as part of a larger energy hub. An electrolyser here, where heat could be tapped off at different temperatures using valves, could be used to increase the efficiency of the hydrogen production process. It is possible that direct air capture[14] could also be deployed.

More generally, an energy hub deployed in the East Suffolk region can support further development of the renewables industry in a number of ways. Hydrogen produced from the existing or planned future site could be used to "green" the vessels that build, operate and maintain offshore wind farms. It could also be integrated within the emerging freeports concept[15], currently under development by the government. As well as supporting decarbonisation at the freeport, it could be an area of greater regulatory flexibility, which is a test bed where innovation and new frameworks can be trialled within a safe space before being rolled-out nationwide.

There are also important potential interactions with two other future energy/innovation schemes already in play in the part of the region. These are listed below, but both projects could be flexed to understand existing and potential use of and demand for hydrogen in the surrounding local economy.

First the Net Zero Leiston scheme is being taken forward by EDF Energy, Atkins, Suffolk County Council, Opergy and Carbone4, under a project managed by the Energy Systems Catapult, focussing on how a net zero route-map can be developed for other rural towns.[16]

Second, the Sunrise – Suffolk and Norfolk Research and Innovation on the Sustainable Energy Coast – project has received initial BEIS support under the *Strength in Places* programme to prepare a full bid.[17] A research-driven programme, this involves UEA, Cefas, EEEGR, NALEP and Opergy, but it is likely to extend to recommissioning of redundant assets within the circular economy and enabling an integrated approach to continued development of the Southern North Sea. There might also be aqua-tech and other opportunities in the marine environment.

EDF Energy have already provided us with some limited start-up funding, and we will be making an energy hub proposal to them early in 2021, with a view to formally launching this project in April 2021. Again, the base workstream is likely to last six months.

3.2.4 Indicative pathways

The final part of this initial phase 1 of the project will involve a consistency check across the draft reports for all three workstreams. This will then be used to identify interactions, gaps and duplications. From this review work we will also set out some high-level consolidated conclusions to move forward to a regional hydrogen economy and define a clear specification for options for further work for 2022 and beyond.

In summary, the overall programme of assessment for this phase 1 will involve three scoping exercises, each lasting six months, starting October 2020, January 2021 and April 2021. It will be concluded by the three month "indicative pathways phase", which will ensure consistency across

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[14] Direct air capture (DAC) is a process of capturing carbon dioxide (CO2) directly from the ambient air (as opposed to capturing from point sources, such as a cement factory or biomass power plant) and generating a concentrated stream of CO2 for sequestration or utilisation.

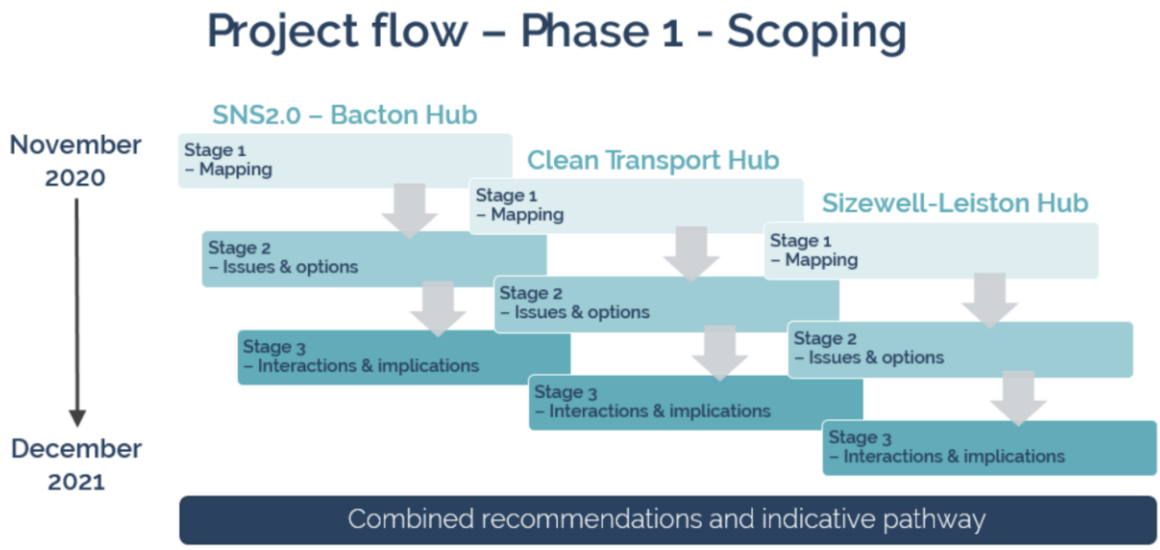
[15] https://www.gov.uk/government/news/government-outlines-new-plans-for-freeports-to-turbo-charge-post-brexit-trade

[16] https://es.catapult.org.uk/impact/projects/net-zero-leiston/

[17] https://www.ukri.org/news/more-r-d-funding-to-develop-projects-set-to-boost-local-economic-growth-across-the-uk/

the three workstreams and address conclusions and recommendation for further work during phase 2. The phase 1 programme is shown at Figure 1.

Figure 1



4 Our approach

Hydrogen East is a not-for-profit company. While we are keen to identify sponsors and supporters as we seek to raise awareness of the opportunities opened up by development of the regional hydrogen economy and the supporting supply chain, we are not a membership organisation or a trade association. Our focus is on developing our own research and analytical capability and skills necessary to define, evaluate and deliver hydrogen projects for the benefit of East Anglia, its energy users and stakeholders. We must therefore generate added-value work to demonstrate our knowledge and how it can be applied to support regional delivery of the Net Zero target and the Local Industrial Strategy.

This framework paper has already set out three high level energy concepts that we are proposing to scope. At this stage Bacton/SNS2.0 is the most fully defined and, as noted, we are shortly to confirm funding arrangements, but we are producing project plans on the other two. In each case we will develop scoping papers, identifying key assets, players and technical options with supporting market assessments.

Our approach will then focus on developing more detailed feasibility and technical studies, defining potential local hydrogen clusters, and then developing this thinking and available implementation pathways into specific recommendations following wide-ranging engagement with stakeholders. We will resource our work through a combination of paid research to support build-up of internal resource and external "in-kind" support.

For these three projects we will adopt a modular approach based on a common structure and analytical building blocks, comprising:

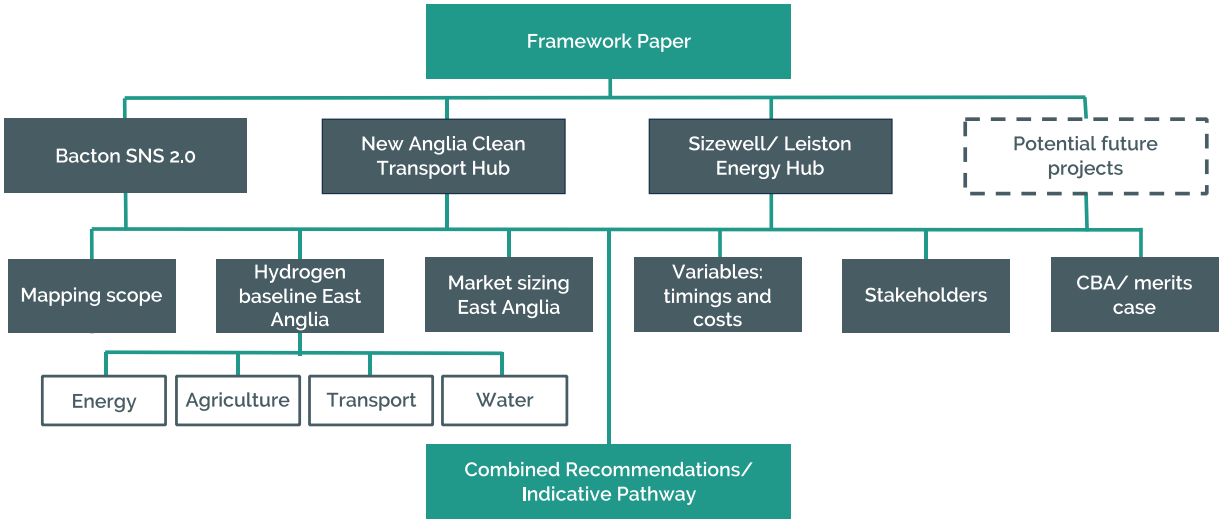
- A thorough local area mapping exercise
- This will be used to produce a current baseline of regional assets and markets relevant to the project
- We will then estimate the potential local market at 5, 10, 20 and 30 years
- Each will then consider relevant variables, including timing considerations and costs, and possible market and policy change as well as possible technology innovations

- In each case we will also define relevant stakeholders and establish a project/engagement group to inform and guide the project, and
- Finally, again in each case, we will develop a high-level assessment of the costs and benefits.

We will then develop an indicative pathway and recommendations for further developmental work moving forward.

The approach is summarised in the diagram below.

Figure 2: Hydrogen East analytical approach



Each scoping exercise will be separately funded, and the first covering Bacton/SNS2.0 will commence shortly once offers of support from OGTC, New Anglia LEP, North Norfolk District Council and ORE-C are confirmed, which we are now formalising. In each of the three cases we estimate there will be a need to secure a minimum of £50,000 of financial support to underwrite the research. Support in kind is also welcome, and already committed by National Grid and the OGA, and discussions are underway with other stakeholders. We will be looking to formalise support for the other two exercises over the coming month. In each case we will seek direct support from impacted parties locally and regionally.

As new project concepts are added in future periods, each will be evaluated and tested in the same way.

5 Project Governance

The income we generate will be recycled into report development and building core in-house analytical resource. Technical and specialist resource will need to identified externally, partly through support in kind but also through bartering. As noted we are not a membership or member advocacy body

Over the initial phase, we propose oversight will be provided by a governance board or steering committee of local stakeholders which will meet monthly. We will then have specific project group meetings of participants directly involved for the three scoping projects separately, typically every two weeks. There will also be an opportunity for three-monthly web-based engagement sessions targeted on the supply chain and regional actors.

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