Client Confidential

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Bacton Energy Hub

North Sea Transition Authority

making the difference

Contents

Rev	Status	Originator	Approved	Date
0	**00**	**Andrew Etherington**	**Charlotte Wright**	**07/October/2022**

1 Summary

This report has been generated to support the work undertaken by the North Sea Transition Authority to understand the business opportunity that the redevelopment of the Bacton terminals could bring as part of the energy transition.

A cross industry group has collaborated to explore the supply chain and technology challenges, needs and requirements as part of the wider programme of supply, demand, infrastructure, and policy & regulations that are being considered as part of the business opportunity.

This report summarises the objectives of the study, our approach as well as key assumptions. It presents a summary of the supply chain considerations including the UK's industrial clusters, a synopsis of East Anglia as a region (relative to developing the scheme), then looks at the industry bodies & trade associations whose membership could provide the resources to support the redevelopment.

It also looks at the skills and technology that will be needed and then provides a series of initial findings and objectives followed by a series of proposed next steps.

In terms of the business opportunity that Bacton represents,

The supply chain

1) are critical to the re-development and will be needed throughout the life cycle of the repurposed and new assets
2) can support its development through existing skills, competency and capability which is transferable from other sector including oil, gas, chemical & power sectors
3) can achieve a high level of UK content which supports the UK government ambitions
4) has resource availability however the skills capacity is a major concern to the energy sector over the years to come, in addition Bacton is not an area of significant indigenous resource availability. The use of modern methods of construction as well as reskilling the local workforce and attracting people from other sectors and locations can support East Anglian to grow both its on shore and offshore workforce
5) has industry and local stakeholder forums to advertise and attract suppliers including being able to share the opportunity it presents from employment, jobs and skills perspective.
6) planning should include early and appropriately timed engagement to ensure the optimum market response is obtained to support both the development, construction, and operation of Bacton

In addition, from a technology perspective

7) A high level of technology maturity exists for the equipment, plant and services that will be needed to deliver the business opportunity. The CCUS and Hydrogen technology are being developed and deployed globally however does require close attention during the concept development phase
8) The UK should be able to provide most of the plant, good & services if not they can be sourced internationally
9) The CCS enable Hydrogen solution is an area for specific market analysis, the technology is currently in development and moving to production at scale the project needs to engage early in the development phase with technology vendors to ensure it locks in capacity and importantly is aligned with the technology readiness and deployment
10) Bacton and the wider CCUS and Hydrogen related projects represent an opportunity to deliver a paradigm shift in the use of digital and automation this will be critical to cost effective deliver of major engineering construction projects going forward.

2 Introduction

The Special Interest Group: Supply Chain and Technology (SCT) was established to consider:

- The supply chain necessary to support the development and then delivery of the Bacton Energy Hub industrial decarbonisation project
- Mindful that we are in concept phase, does the supply chain have the necessary competency to deliver the scope associated with the re-development of the Bacton terminal
- What are the key considerations around the supply chain, type and nature of suppliers needed
- What is the UK context on industrial decarbonisation including opportunities and threats to the Bacton terminals redevelopment and reconfiguration plans
- The regional context of East Anglia in terms of a major industrial decarbonisation project
- What industry bodies and technology bodies are available to engage with the supply chain
- Technological considerations for the project
- Any skills considerations

The SCT is heavily reliant on the other SIGs to provide outline information on the scheme.

At this stage the base case (only) has been considered, that said it should not be a significant stretch to consider build out options.

Due to the level of information and time available supply chain capacity has not been considered.

3 Contributors

The following people and organisations have contributed to the SCT report:

- Anne Haase, Aquaterra (formerly Petrofac)
- Majd Barbari, Petrofac
- Charlotte Wright, Petrofac
- Karen Freeman, EEEGR
- Andrew Etherington, Turner & Townsend
- Julian Manning, Paradigm Group
- Max Richards, Oilfield Production Consultants (OPC)
- Bill Cattanach, NSTA
- David Broadhead, Axis Well Technology

4 Purpose/Objectives

The SIG's original objectives were considered as:

- Map the existing local, regional, national and international capability across the hydrogen value chain
- Assess key supply chain and technology gaps and identify opportunities to grow technology and the supply chain
- Assimilate best practice and learnings from other clusters to deliver the project at pace
- Explore and describe a delivery and contracting model for the project
- Establish local, regional and national hydrogen capability to support delivery of an executable project

During the work undertaken by the SIG these objectives were revised to develop:

- a scheme overview
- a work package breakdown
- a timeline
- using the above undertake a supply chain analysis

These are from a supply chain & technology perspective (rather than an organisation or cost breakdown perspective).

5 Approach

As the project is at initial stages, the SIG team, based upon discussions with and outputs from the other SIGs have developed the following:

Scheme overview - see attachment 1

It should be noted that the scheme has been developed from the supply chain perspective rather than from a technical or engineering viewpoint.

Work package breakdown - see attachment 2

Using the scheme overview, an initial work package breakdown has been developed, these work packages have been developed from a scope of work and supply chain perspective.

In developing the work package breakdown, the following has been considered:

- Level of supply chain maturity
- Type i.e., consultant, contractor, OEM, etc
- Key perceived risk area. It is acknowledged the competency, industry and financial standing will need to be verified

It is worth noting that a number of packages may be long lead or be schedule critical (including as relevant to the FEL stage gate).

The main process or equipment packages have been dealt with as a "black box" - as the engineering develops these may be broken down further however the package requires specialist supply chain input.

An initial assessment has been made of supply chain locally (within 30 miles), regionally (Norfolk plus adjacent counties) or nationally.

This assessment has been undertaken using existing knowledge and networks as well as supplier databases including the EIC's supply map.

Indicative timeline – attachment 3

To support the supply chain and technology group the team have developed an indicative timeline for the project including scenarios and approximate timeline per phase.

Although this timeline is indicative only, it has helped to shape thinking around:

- When key phases would need to be commenced, progressed and completed
- When the supply chain would need to be engaged to do work
- Support the development of the project's supply chain plan

5.1 Assumptions

A series of assumption were made during the development of this report

- Steam may well be required for Blue Hydrogen/CCUS package (potentially available from process)
- No hydrogen storage in base case
- Water is available however demineralised water supply needs consideration
- No supply chain engagement soft or hard would be undertaken at this phase of the project
- Timeline is 2030

5.2 Unknowns

The following are unknowns in relation to the development of the report

- The existing CO2 processing/separation
- Brine & seawater connections
- Project delivery "vehicle" and Contracting & Procurement strategy
- Impact to the UK supply chain from the ongoing energy crisis as well as wider world events

6 Supply Chain Considerations

6.1 Introduction

The supply chain is critical to future direction & implementation of the Bacton Energy Hub. It will be needed to support all phases from concept to selection to FEED to design & execute as well as beneficial operation. How the project engages with the supply chain will depend on how the consortium forms and how the contracting & procurement strategy evolves.

In developing both the scheme overview and work break down structure we have assumed the project will follow a standard FEL* gate process.

*Front-end loading (FEL), also referred to as pre-project planning (PPP), feasibility analysis, conceptual planning, programming/schematic design, and early project planning, is the process for conceptual development of projects in processing industries such as upstream oil and gas, petrochemical, natural gas refining, extractive metallurgy, waste-to-energy, and pharmaceuticals. This involves developing sufficient strategic information with which owners can address risk and make decisions to commit resources in order to maximize the potential for success.

Nationally significant infrastructure projects follow the Infrastructure and Projects Authority (IPA) process. This brings together national, cross sector information on infrastructure through the National Infrastructure Delivery Plan and National Infrastructure and Construction Pipeline. The IPA has developed a "Project Routemap" - Setting up projects for success Project Routemap is the IPA's support tool for novel or complex major projects. It helps sponsors and clients understand the capabilities needed to set projects up for success, incorporating learning from other major projects and programmes.

Irrespective of the project front end process the project will require the supply chain to support with engineering, technical, technology, fabrication, manufacturing, installation and testing & commissioning services.

6.2 Industrial De-carbonisation: The UK Context

Carbon capture equipment has been around for many years, mainly for use in Enhanced Oil Recovery.

In relation to CCUS this is more novel. Hydrogen electrolyser technology is still developing but is not "unique". It is also worth noting that over the next decade a number of UK projects and clusters will be developing which will provide valuable insight into the development of the Bacton Energy Hub.

The below is an extract from CCUS Investor Roadmap (via asset publications).*Figure 6-1 UK Cluster*

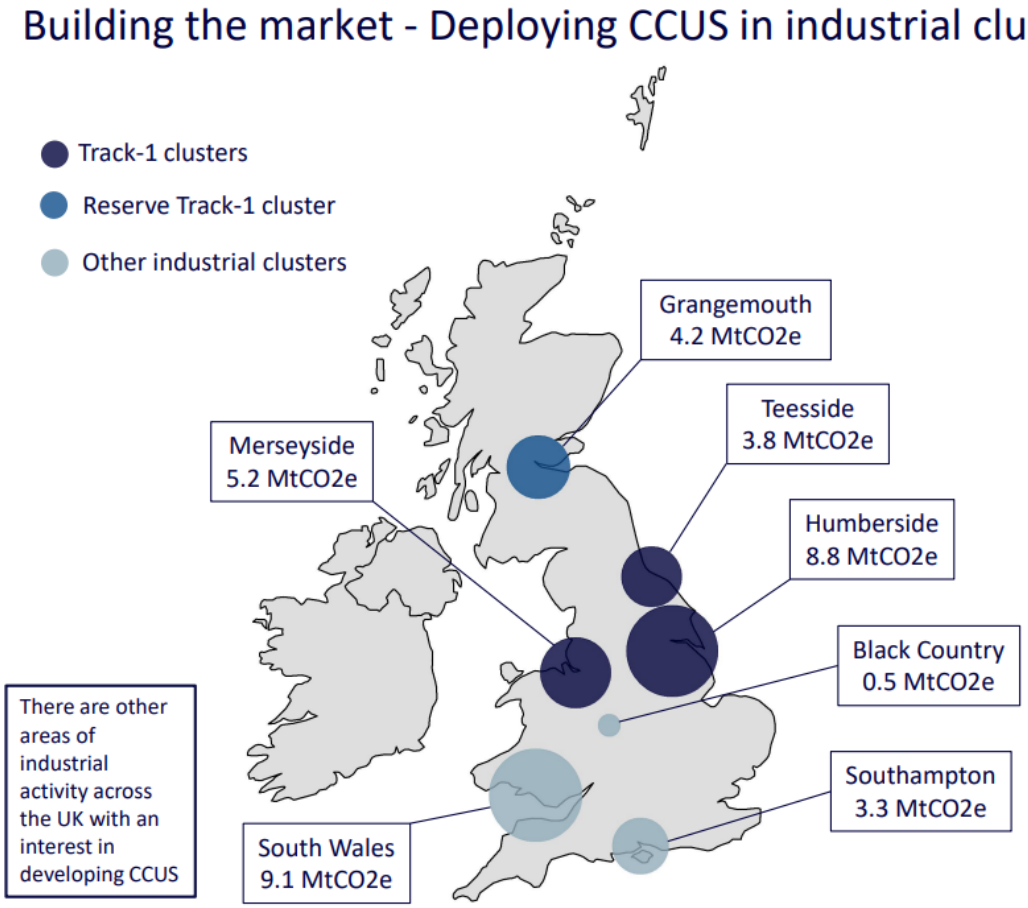


Figure 6-2 UK Cluster Map

On the 12th of August 2022 the UK government announced the phase 2 cluster projects which will progress to next phase. Following the selection of Hynet and East Coast Cluster as Track 1 CCUS clusters in November 2021, BEIS have selected the power CCUS, industrial carbon capture (ICC), waste and CCUS-enabled hydrogen projects to proceed to the due diligence stage of the Phase 2 Cluster Sequencing process.

The 20 projects represent a range of innovative CCUS technologies that have the potential to:

- accelerate our decarbonisation ambitions
- realise economic benefits in the North West, South Wales, Teesside and Humber regions
- kick start the hydrogen economy, and put us on a path to decarbonising our power system by 2035, while maintaining security of supply

This shortlist does not imply availability of funding for any or all of the shortlisted projects, it is purely the outcome of assessment against the Phase 2 criteria.

Power CCUS

East Coast Cluster

Net Zero Teesside Power

- Whitetail Clean Energy
- Keadby 3 Carbon Capture Power Station
- Hydrogen

East Coast Cluster

- bpH2Teesside
- H2NorthEast
- Hydrogen to Humber (H2H) Saltend

HyNet

- HyNet Hydrogen Production Project (HPP)

Industrial Carbon Capture (ICC)

East Coast Cluster

- CF Fertilisers Billingham Ammonia CCS
- Tees Valley Energy Recovery Facility Project (TVERF)
- Norsea Carbon Capture
- Redcar Energy Centre
- Teesside Hydrogen CO2 Capture
- Humber Zero – Phillips 66 Humber Refinery
- Prax Lindsey Oil Refinery Carbon Capture Project
- ZerCaL250

HyNet

- Hanson Padeswood Cement Works carbon capture and storage project
- Viridor Runcorn Industrial CCS
- Protos Energy Recovery Facility
- Buxton Lime Net Zero
- Carbon Dioxide Capture Unit – EssarOil UK

In addition, a number of hydrogen hubs are in development adjacent to Bacton including within the Humber, Lowestoft and Thames Estuary.

In addition to CCUS and hydrogen the region has the Sizewell 'C' nuclear new build and the East Anglian offshore wind project which can be leveraged from a supply chain perspective. Both have supply chain initiatives and can provide support and intelligence that Bacton can potentially utilise.

These projects, clusters and hubs provide both opportunity and threats for Bacton

Opportunities

- Shared development
- Knowledge transfer deliverables
- Engineering & technology progression at scale on a portfolio basis
- Multi-tasking providing synergies
- Shared supply chain planning, engagement, development, and capacity planning
- Shared skills development
- Digital & automation
- Modularisation

Threats

- Resource capacity gaps and pinch points
- Concurrent projects driving up pricing and "clashing"
- Different standards and specifications
- Overlapping supply chain needs leading to peak and trough of supply and demand
- Bacton's location relevant to industrial centres

Collaboration across the industry is going to be key to navigating the potential for CCUS and hydrogen over the next decade.

Attachment 2 includes an initial view of the work packages, type of contractors and risk profile of the supply chain companies needed to deliver Bacton.

6.3 CCUS

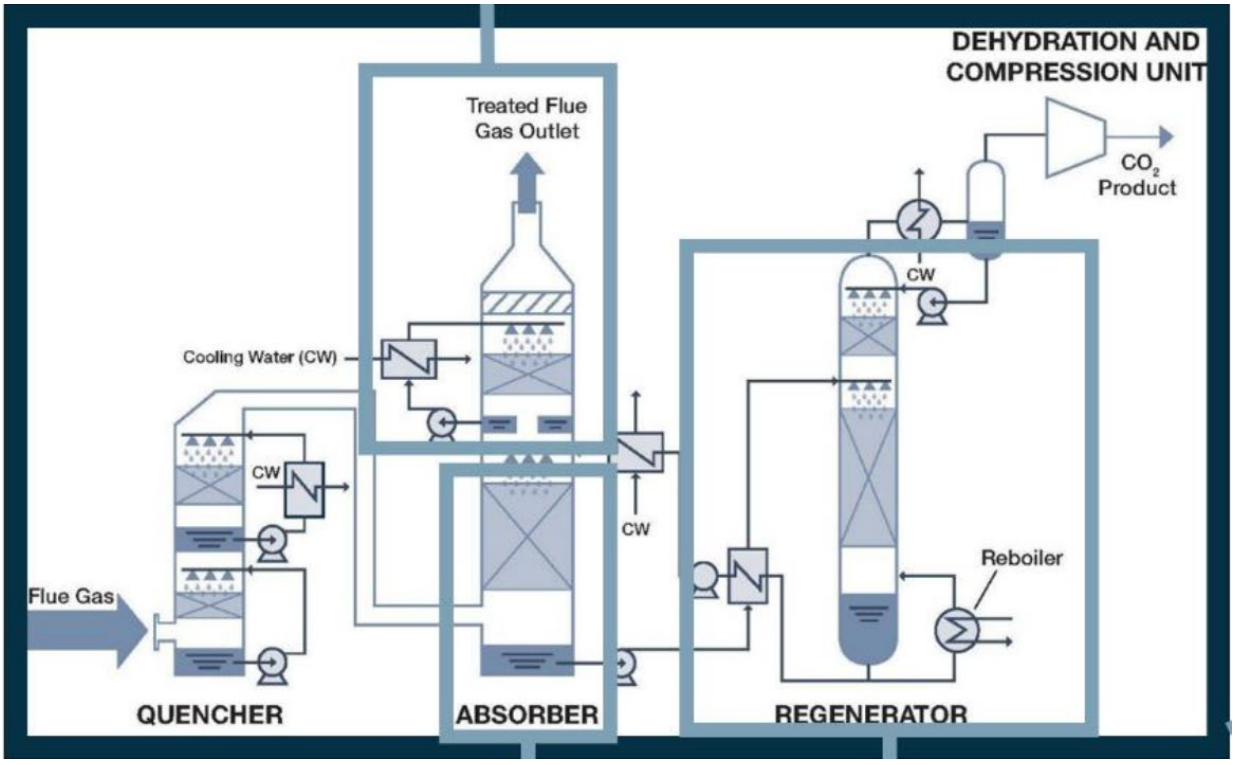
Carbon Capture is essentially a chemical process. According to industry body the Global CCS Institute, CCS is "a proven technology that has been in safe operation for over 45 years". It adds that all components of CCS are proven technologies that have been used for decades on a commercial scale.

CCS falls into three categories: post-combustion carbon capture (the primary method used in existing power plants), pre-combustion carbon capture (largely used in industrial processes), and oxy-fuel combustion system.

Today, incumbent amines are the most mature carbon-capture technologies that use solvents. These systems pump emissions through a solution that absorbs CO2 but lets through other gases, such as nitrogen. The CO2-rich solvent then flows into a boiler, where heat drives the pure CO2 back out of solution.

The below is a typical schematic for a CCS plant:

Figure 6-3 Typical CCS Schematic



CCS licence/technology companies

The building blocks for CCS projects has been either:

- Engage with project developers whose core competency including CCUS & Hydrogen
- Engage with CCS Technology solution providers

The UK has a number of technology biased project developers including Fichtner, Progressive Energy and Shell.

There is a growing number of CCS Technology solution provides including:

- Aker Solutions**
- Babcock & Wilcox
- Baker solutions
- BASF**
- Bechtel
- Carbfix
- CarbonBuilt
- Carbonclean**
- CarbonFree
- Climeworks
- CO2Capsol**
- Fluor**
- Global Thermostat
- Honeywell
- LanzaTech
- Man Energy Solutions
- MHI**
- Shell Cansolv**
- Svante

** These technologies are currently the most prevalent in procurement processes, FEED being executed, and project being developed, constructed, and commissioned.

Most of these organisations are not UK based, that said it is likely over the next few years more and more organisations will develop their technology solutions. It is unknown as this stage how many of these organisations would be interested or available to deliver for Bacton.

In addition, some of the listed organisations are not commercially mature at this stage and might not be suitable for supplying the required technologies / equipment.

6.4 Hydrogen

Hydrogen electrolysers and other hydrogen equipment as part of blue and green hydrogen projects are becoming more of an industry standard. A number of organisations are also offering a complete design or package solution including Protium, Lfyhe and ITM.

In listing out the OEMs, it would be important to segregate the list by type of electrolyser.

Polymer Electrolyte Membrane (PEM) Technology

- HYDROGENICS
- NEL Hydrogen
- Plug Power
- ITM
- Elogen
- Siemens
- H-TEC Systems
- Hydrogen Pro/TianJin Mainland
- Hoeller
- Idroenergy Spa

Alkaline Technology

- ThyssenKrupp
- NEL Hydrogen
- Sunfire / IHT
- GHS
- McPhy
- KOBE:CO
- THE
- Peric
- Hydrotechnik
- Cockerill Jingly Hydrogen
- Asahi Kasei

Solid Oxide Electrolysis Cell (SOEC) Technology

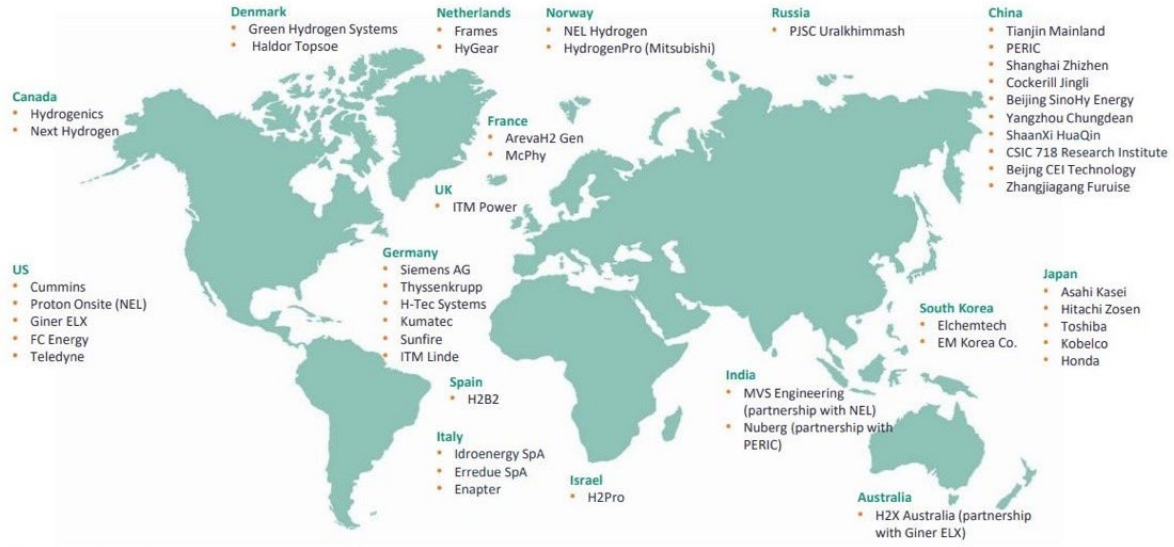
- Sunfire
- FC Energy
- Toshiba
- Haldor Topsoe

Anion Exchange Membrane (AEM) Technology

- Enapter
- Evonik

It is worth noting that most of these OEMs are based outside of the UK, although some do import and supply locally.

Significant number of key electrolyser manufacturers are located in Europe



GlobalData. Source: GlobalData Secondary Research

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Figure 6-3 Electrolyser Manufacturers by Country

A high level study of the various electrolyser OEMs has been conducted and the date is summarised in the below tables. A similar activity should be done at the time of equipment / process selection, which would be dictated by the selected operating conditions, capacities, pressurised conditions, response time, etc.

	NEL	Sunfire	John Cockerill	Thyssen -krupp	SinoHy	Longi	Peric
Stack Size	2.3 MW	5MW stack (10MW Module)	5 MW	20MW Module	10MW	5 MW	10MW
Technology	Alkaline						
Pressurised	No – Atmos.	Yes - 30barg	Yes - 30barg	No – Atmos.	Yes - 30barg	Yes – 16 barg	Yes - 20barg
Compressor to 30barg	Yes - Included in Cost	Not Required	Not Required	Yes - Required	Not Required	Compression from 16 to 30 barg required.	Compression from 20 to 30 barg required.
H2 Production Power Consumption (kWh/Nm3)	4.40	4.70	4.55	4.50	4.7	4.4	4.3
Turn Down (%)	15	7	33	TBC	30	30	30
Water per H2 (l/Nm3)	0.900	0.848	0.917	0.900	-	-	-
Factory Capacity (MW/year)	500	40	350	1,000	-	-	1500
Country of Manufacture	Norway	Switzerland	China	Germany	China	China	China
Cost / kW ($/kW)	400-500	400-500	400-500		380	460	400-700
Delivery Time (ex Works)	16-18 months				-	14 months	-

Table 6-1 - Alkaline Electrolyser OEM Comparison

	Plug Power	Siemens Energy	ITM Power
Stack Size	10MW module	17.5MW Array (24 modules)	5MW for 2 stack module
Technology	PEM		
Pressurised	Yes – 40 barg	No - Atmospheric	Yes - 20barg
Compressor to 30barg	No	Yes	Compression from 20 to 30 barg is required.
H2 Production Power Consumption (kWh/Nm3)	4.49	4.58	5.28
Turn Down (%)	-	5	-
Water per H2 (l/Nm3)	-	0.891	-
Factory Capacity (MW/year)	1000	Multi GW by 2023	1,000
Country of Manufacture	USA	Germany	UK
Cost / kW ($/kW)	750	1,500 to 2,300	-
Delivery Time (ex Works)	-	16 to 18 months	

Table 6-2 - PEM Electrolyser OEM Comparison

Note that OEM selection was not the intent of this review. The information gathered has been used to inform on the market and understand key technical and commercial parameters.

At the time of this document, the largest single electrolyser is 20MW and to achieve the 3 x 355 MW unit capacity, hence the equipment must be stacked. Furthermore, a supplier must be selected that has the plant capability to manufacture all of the required electrolyzers

A high level TRL analysis was done with regards to the OEMs.

Technology Provider	Type of Technology AEL	Type of Technology PEM	Type of Technology SOEC	Type of Technology AEM	Maturity Level
NEL	Y	Y			TRL6
Siemens		Y			TRL9
Thyssen Krupp	Y				TRL8
ITM		Y			TRL8
McPhy	Y				TRL8
SunFire	Y		Y		TRL7
Cummins	Y	Y			TRL7
Bloom Energy			Y		TRL8

Beijing CEI	Y	Y			TRL7
Asahi Kasei	Y	Y			TRL6
Tianjin Mainland	Y	Y			TRL7
Peric / Water2H2	Y				TRL6
Suzhou Jingli / John Cockerill	Y				TRL6
Fusion Fuel		Y			TRL8
CPH2	Membrane Free				TRL8
ohmium		Y			TRL7
1S1 Energy		Y			TRL6
Versogen		Y			TRL6
Plug Power		Y			TBC
Verde LLC		Y			TBC
Elongen		Y			TBC

Table 6-3 – High Level TRL Analysis

6.5 CCUS enable Blue Hydrogen

Bacton's base case is 3 x 355MW units which is a significant scale for Hydrogen generation (CCS enabled). The availability of this technology is a key focus area for the Bacton energy hub

Notably Essar* are basing their design on this sized unit, therefore Bacton can and could collaborate with other clusters to share supply chain and technology learning as well as potential synergies.

*The hydrogen will be produced using Johnson Matthey's best in class LCHTM technology (https://matthey.com/products-and-markets/energy/hydrogen/blue-hydrogen)

It is worth noting that with Carbon Capture and Storage (CCS) as key technology for blue hydrogen projects companies like Energean, Exxon Mobil, Air Products, BP, Shell, and Equinor are leaders in capturing CO2 when producing blue hydrogen

Air products are a leading playing in industrial gases and leading the development of a number of CCUS enabled hydrogen projects around the globe

https://www.airproducts.co.uk/company/innovation/hydrogen-mobility

Shell Catalysts & Technologies has spent years developing the Shell Blue Hydrogen Process (SBHP). SBHP integrates Shell SGP and ADIP ULTRA technologies and offers key advantages over ATR, including a 10–25% lower levellised cost of hydrogen, a 20% lower capital expenditure, a 35% lower operating expenditure (excluding natural gas feedstock price), >99% CO_2 captured and overall process simplicity.

https://www.shell.com/business-customers/catalysts-technologies.html

7 Skills Considerations

A significant amount of work has and is being undertaken in the skills needs to meet the energy transition including current via the skills task group as part of "East Wind", the Offshore Wind Cluster representing the East of England.

The below is an extract from the Office for National Statistics in their "Labour market overview, UK: August 2022"

The unemployment rate for April to June 2022 increased by 0.1 percentage points on the quarter to 3.8%. The number of people unemployed for up to 12 months increased during the latest three month period, with those unemployed for between 6 and 12 months increasing for the first time since February to April 2021. This increase was partially offset by a decrease in those unemployed for over 12 months.

The number of job vacancies in May to July 2022 was 1.274 million; a decrease of 19,800 from the previous quarter and the first quarterly fall we have seen since June to August 2020. Since vacancies fell to an all-time low in April to June 2020, they have increased by 945,000 in a little over two years.

The UK records three types of workers as below, with data as of August 2022:

- Employed: 75.5% or 32.792 million (16+)
- Unemployed: 3.8% or 1.294 million (16+)
- Economically inactive*: 21.4% or 8.891 million (16 to 64)

*people who are neither employed nor unemployed; they're not in paid work, but they're also not looking for a job or available to start work. You might be economically inactive for a number of reasons, such as being retired, a student or too ill to work.

It is acknowledged and well publicised that there are skills shortages with the sector plans seeking to address recruitment, retention, training & development.

From a "blue collar" or operative perspective:

The redevelopment of the Bacton terminals will call upon both civil and engineering construction operatives to deliver the "physical work". Engineering construction skills are an area of concern.

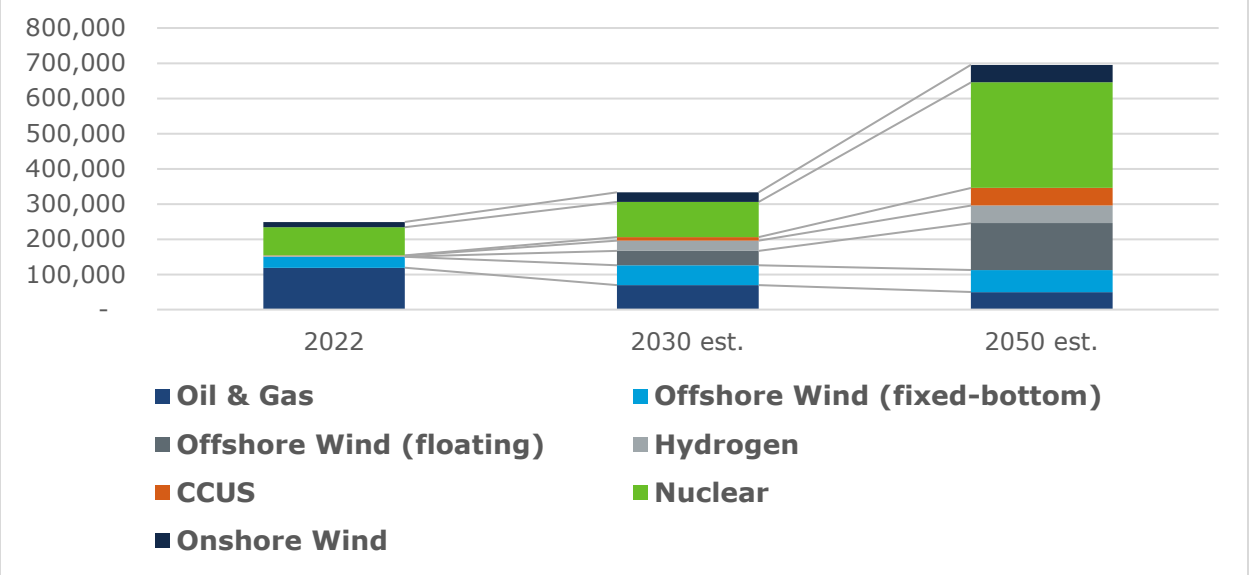
The ECIA publishes the "NAECI registered work force" statistics which will includes riggers, pipefitters, electrician, scaffolders who are working on "NAECI registered sites".

The total number of operatives in December 2019 stood at 10,235 operatives, in July this stood at only 6,626.

Conversely major infrastructure programme continues to attract resources with the likes of HS2 and nuclear new builds mobilising many thousands of construction industry workers. In 2021 over 20,000 people were working on Hinkley Point C, it is envisaged that the workforce will increase by 8,500.

Opergy have presented within their UK Energy Production & Storage forecast (see

Figure 6-4 Employment Predictions



In real terms what does this mean for Bacton:

Figure 6-5 Workforce Estimates by Sector

a) The project will be competing with other projects for scarce resources

b) Recruitment & retention is a major challenge

c) The UK does not have sufficient capacity to meet future demand

d) Sharing knowledge skills & experience has both threats & opportunities

e) The skills needed to deliver the project exist in both civil and engineering construction industry as well as the oil, gas, chemical and industrial gases sectors. For the majority of skills, it is a

capacity challenge rather than an upskilling issue (i.e. a scaffolder will still be building scaffolds)

7.1 CCUS and Hydrogen skills

With the volume of current and future CCS and hydrogen projects the industry will need to either 1) train people to be specialists in these technologies or 2) upskill people with additional skills & competencies.

Avoiding specialists where possible has advantages as otherwise this can create a workforce who cannot respond to future trends or technologies.

The skills challenge is its own workstream however there are a myriad of considerations to de-risk the project including:

a) Simplification & standardisation of components and assemblies (adopting DfMA and PDfMA principles)

b) Lock in critical consultants and/or contractors

c) Optimise local and regional network SME & local workers

d) Apprentices, graduates, and trainees

e) Digitalisation, automation, and robotics

f) Optimise use of modules, PAU & PARs (off site working)

g) Natural or longer durations to reduce peaks in workforce

h) Look at non-UK workers to support global issues (e.g. training refugees and displaced people from the conflict in Ukraine and other theatres)

i) Retraining ex-military and force personnel

7.2 Tapping into industry skills pathways

Opergy estimates that more than 108,000 new jobs are going to be needed before 2030 in industry. That's almost a 50% increase on today's workforce. Another 500,000 plus jobs will be created over the next two decades as offshore wind and hydrogen accelerate, and new nuclear projects, be they large or small, continue to develop. The demand for new skills is growing just as rapidly both for engineering and technical skills and non-technical roles. Opergy is fortunate to be working with some of the industry's largest names, helping to shape the future for energy skills across the region and nationally.

They are working with RenewableUK and the Offshore Wind Industry Council (OWIC) to lead the delivery of the People & Skills workstream of the Offshore Wind Sector Deal, with ambitious targets for growth in jobs including apprenticeships, and striving for greater gender balance. This includes working with the National Skills Academy for Rail to deliver a comprehensive annual industry skills survey, with the 2022 Intelligence Report underway ahead of release in spring.

Opergy is also working with the Offshore Renewable Energy Catapult's Floating Wind Centre of Excellence to deliver a broad skills model for this new and emerging sector, set for rapid expansion from the late-2020s into the next decade.

Understanding the jobs and skills needs for tomorrow helps us to educate, train and develop the talent we need, when we need it.

They are also supporting the development of an Integrated People & Skills Plan with OPITO on behalf of the UK Energy Skills Alliance. The plan sets out the future skills needs covering offshore oil and gas, offshore wind, hydrogen, and carbon capture across the UK, with a range of actions improving STEM education and inspiration, vocational and academic career pathways, and identifying measures to enhance workforce mobility.

OPITO, the global safety and skills body for the energy industry, has announced the creation of an Energy Transition team, to lead the development of innovative workforce standards, training and products to support the energy transition and decarbonisation agenda.

Led by newly appointed Head of Energy Transition, Andy Williamson, OPITO will build on its leading global position in oil and gas to identify opportunities across the renewable energy sector including hydrogen and Carbon Capture Usage and Storage, working in partnership with other industry and accreditation bodies to develop a safe, skilled and mobile workforce equipped with an 'all-energy' skills passport.

8 Regional Considerations for East Anglia

This section considers what might influence delivering a major industrial decarbonisation project in East Anglia.

East Anglia is an area in the East of England, often defined as including the counties of Norfolk, Suffolk and Cambridgeshire, it has a population of over 2 million.

Transport in East Anglia consists of an extensive road and rail network. Main A roads, such as the A12 and A47 link the area to the rest of the UK, and the A14 links the Midlands to the Port of Felixstowe. This is the busiest container port in the UK, dealing with over 40% of UK container traffic and is a major gateway port into the country.

There is very little dual carriageway or motorway within East Anglia, which is a major issue for delivering major projects in the region.

Rail links include the Great Eastern Main Line from Norwich to London Liverpool Street and the West Anglia Main Line connecting Cambridge to London. Sections of the East Coast Main Line run through the area and Peterborough is an important interchange on this line. The area is linked to the Midlands and north-west England by rail and has a number of local rail services, such as the Bittern Line from Norwich to Sheringham.

The only major commercial airport is Norwich Airport, although London Stansted Airport, the fourth busiest passenger airport in the UK, lies just south of Cambridge in north-west Essex.

The Port of Lowestoft handles around 30,000 tonnes of cargo per year and together with ABP's other two East Anglian ports, King's Lynn and Ipswich, contributes £360 million to the economy and supports 5,300 jobs. Lowestoft has emerged as a thriving centre for companies servicing the offshore energy industry.

The population estimates in 2021 are as follows:

- Norfork around 916,200
- Suffolk around 761,250
- Cambridgeshire around 678,600

Total number of registered companies in 2020:

- Norfolk: 41,185
- Suffolk: 39,507
- Cambridge: 45,063

East Anglia is not an industrial heart land when compared with likes of Teesside, Hynet or Grangemouth; therefore Bacton will need to consider how it competes for supply chain to ensure capacity is available to match needs.

Anglian Water is a water company that operates in the East of England. Anglian Water is regulated under the United Kingdom Water Industry Act 1991. It came into existence in 1989 as part of the partial privatisation of the water industry. The Strategic Pipeline Alliance partners are: Anglian Water, Costain, Farrans, Jacobs, Mott MacDonald Bentley.

The Anglian Water @one Alliance - comprises consultants, contractors, and other stakeholders who together will deliver projects accounting for over half of a capital investment programme. The @one Alliance will design and build around 800 schemes worth approximately £1.2 billion and these include: water and water recycling treatment centres serving more than six million people in eastern England. Alliance partners are: Anglian Water Asset Delivery, Balfour Beatty, Barhale, MMB, SWECO, Skanska and MWH Treatment.

The availability of towns water is a consideration for later phases, a potential collaboration with Anglian Water and EA may be an opportunity for the Bacton Energy Hub with potential to share development costs and develop a scheme which is supportive of shared business imperatives.

9 Other Considerations

9.1 Timeline Considerations & Observations

Within attachment 3 an outline timeline has been developed with a series of scenarios to achieve the timeline of 2030. We have also included typical timelines for key decision areas. As this is indicative the following is more for guidance at this stage.

To achieve the intended timeline the project would need to move through a number of phases, each of which have the need for supply chain input.

To achieve a timeline of 2030 for beneficial operation will require the project to commence during 2023 which is the same year several CCUS projects will be going through FEED into FID. It will also require the project to commence at pace and make key decisions during 2023 and 2024.

As this stage there is a high level of uncertainty around durations, however based upon typical major engineering projects timelines it would be reasonable at this stage to assume:

- Initiation, options study & pre-FEED during 2023
- FEED commencing 2024 into 2025
- EPC commencing 2025
- Long lead items could well be 12 to 28 months, there are low number of process critical items however they need to be on-site and into a construction sequence to avoid stacking to many critical activities later in the construction programme

The project timeline will lead to a rolling wave of supply chain engagement starting with consultants, engineering companies as well as potential technology providers. It is worth considering that subject to scope, complexity as well as the commercial & contractual model the process of supply chain engagement can add many months to each package. The FEED and EPC packages are both likely to be well over 6 months from EOI to contract award. It would not be unusual for an EPC package to take 9 to 12 months if competitively bid.

Worth noting that supply chain engagement will continue throughout the project lifecycle.

The project will require an end-to-end supply chain process which will likely include:

- Supply chain mapping and analysis
- Contract & procurement strategy
- Contract strategy workshops
- Contract gaming sessions (stress testing contracts)
- Training and development in contracts (targeted at all levels including supply chain)
- Contract development (including the development of contract terms & conditions)
- Supply chain analysis whether desktop, soft engagement or more formal competency & capability reviews and audits
- Supply chain events and engagement
    a) Media and internet campaigns
    b) Supply events & days
- Sourcing strategies
- An end-to-end procurement lifecycle including
    c) Deploying an e-tender system
    d) Procurement planning as part of the integrated management schedule
    e) Sourcing strategy

f) Shaping the bid list including packaging strategies, i.e., EOI & RFI

g) Developing the bid documentation including RFP, RFQ or RFS

h) The tender process through enquiry, launch events, bidders' days, Q&A, tender receipt, tender evaluation, bidder presentations, Q&A, decision support package and recommendation to contract award

i) Post tender contract & commercial management

j) Supplier evaluation

k) Lesson learnt, bench marking

- Expediting

Supply chain analysis and mapping

It is worth considering a supply chain analysis and mapping exercise especially considering the impact of COVID and the current economic turbulence and world events.

Supply chain analysis would also help to shape the local & regional companies who could support the Bacton Energy Hub.

As an example, based upon previous experience there are over 70 companies who have the potential as FEED contractors however factoring UK content and focusing in on those with relevant sector experience this list would be in the region of 10 to 20. With the volume of work in the UK this could be as low as 3 to 6. The capacity of UK engineering companies over the next three to five years is an area of concern.

9.2 Technology Considerations

A significant positive is the vast majority of equipment, plant and materials should be standard in the oil, gas, chemical and industrial gases sectors. This should not be left to chance, setting "standardisation & simplification" as a project & contract driver should be an imperative.

It is also important that the government, industry bodies, clusters and hubs ensure engineering consultants & contractors adopt commercial off the shelf principles (unless the design cannot be "standardised").

As with the supply chain there are industry organisations whose objectives and aims aligns to the development of the Bacton Energy Hub from a supply chain and technology perspective, the below provides relevant examples of organisations who could support the development of Bacton from a "technology perspective"

Global CCS institute

https://www.globalccsinstitute.com/

The Global CCS Institute is an international think tank whose mission is to accelerate the deployment of carbon capture and storage (CCS), a vital technology to tackle climate change and deliver climate neutrality.

With a team of professionals working with and on behalf of their members, they drive the adoption of CCS as quickly and cost effectively as possible by sharing expertise, building capacity and providing advice and support so that this vital technology can play its part in reducing greenhouse gas emissions.

Their diverse international membership includes governments, global corporations, private companies, research bodies and non-governmental organisations; all of whom are committed to CCS as an integral part of a net-zero emissions future.

They are headquartered in Melbourne, Australia, with offices in Washington DC, Brussels, Beijing, London, Tokyo and Abu Dhabi.

The Global CCS institute in their 2021 report identified there are 135 commercial CCS facilities in the project pipeline (27 are fully operational) from a diverse range of sectors including cement, steel, hydrogen, power generation and direct air capture.

Oil & Gas Climate Initiative

https://www.ogci.com/

The Oil and Gas Climate Initiative (OGCI) is a CEO-led initiative that aims to accelerate the industry response to climate change. OGCI member companies explicitly support the Paris Agreement and its aims.

As leaders in the industry, accounting for almost 30% of global operated oil and gas production, they aim to leverage their collective strength and expand the pace and scope of our transitions to a low-carbon future, so helping to achieve net zero emissions as early as possible.

Their members collectively invest over $7B each year in low carbon solutions. OGCI Climate Investments was set up by members to catalyse low carbon ecosystems. This US$1B+ fund invests in technologies and projects that accelerate decarbonisation in oil and gas, industry and commercial transport.

Worth noting the OGCI provide seed funding and expertise to support the development of projects

Member organisations include:

Figure 8-1 OGCI Member Organisations

9.3 Initial Findings & Observations

The redevelopment of the Bacton terminals as part of the UK's industrial decarbonisation challenge has a number of opportunities and threats. For ease see Table 8-1 for an initial SWOT analysis.

Strengths	Opportunities	Weaknesses	Threats
Including O&M the potential creates to support local supply chain for 30 years+ UK has an extensive network which can be tapped into from both a supply chain & technology perspective The opportunity exists for suppliers of goods and services to be engaged to support skills, capacity and future resource planning to optimise local and regional content A high level of UK content is achievable The project and supply chain processes and ways of working are mature and can be deployed at pace. The vast majority of skills & competency are core competencies at an individual, group & organisational level The opportunity exists for SME, local and regional companies to supply goods & services The supply chain exists for the main process technology with the likes of Shell, MHI, Flour all providing CCUS licenced technology. The CCS enabled blue hydrogen market is less mature however companies like Shell offer package solutions There are transferrable skills for Oil, Gas, chemical and other related industries. The scope of work will suit Civil & Engineering Construction contractors (ECIA members or equivalent) The maturity of the industry bodies and organisations who can support the project including those that specialise in linking clients & suppliers Membership of OGCI and other client organisations who can support project development	A high percentage of the work associated with the Bacton energy hub the UK can be provided from existing suppliers & consultants Keep it simple, standardise and use proven approaches where practical It is worth noting that many of the team involved in the development of the Bacton energy hub are members of supply chain and technology industry bodies who can help and support Bacton with the supply chain and technology work stream As the project includes novel and/or immature technologies including licensors with a collaborative early engagement is recommended. This could be initiated via request for solution (RFS) Reducing on site working through modularisation and pre-assembly is a key supply chain consideration (also links to digital, automation and robotics) The use of digital, automation and robotics should be considered as a work stream as the level of maturity has been reached the point that early adopters have proven the safety and productivity improvements potential Work with other clusters to create portfolio benefits to leverage supply chain synergies Simplification & standardisation - COTS v bespoke - standard industrial material for as much as possible Skills agenda should consider enhancing existing skills and future capacity planning. Leverage other local and national projects and programmes Business models for CCUS and hydrogen support supply chain & technology to develop industrial decarbonisation footprint & capability Attract organisations to the region	East Anglia is not an industrial heartland when compared with likes of Teesside, Hynet or Grangemouth therefore Bacton will need to consider how it competes for supply chain to ensure capacity is available to match needs Regional infrastructure Not clear path forward to project from 2022 to 2030 Availability of water for future phases Bacton is the shadow on offshore wind & Sizewell C on the national agenda Due to geographic considerations and the volume of work in the major programme capacity is high risk for the project - a key question is “will the required resources be available at the right time?” TRL for 355MW units	Project is not fundable/do nothing is path of least resistance Project timeline to hit 2030 Based upon industry activity and predicted spend, supply chain capacity is an area of risk including and notably the availability of FEED & EPC contractors UK does not have sufficient resources Main equipment and process packages are deemed to be long lead. Based upon previous experience this can easily be 3 years from initial engagement with main process equipment being 12 to 36 months from order placements Subject to project timelines there are potential number of long lead and/or schedule critical packages including Grid connection (although with ENI disinvestment this may not be needed) this could be negated Progress of other industrial clusters DCO planning, permitting has also been treated a schedule critical at this stage

Table 8-1 – Initial SWOT Analysis

10 Relevant Industry Bodies & Trade Associations

In terms of relevant industry bodies, the UK has both 1) long standing industry bodies who have helped the wider oil, gas & chemical suppliers engage with clients from many decades as well as 2) newer bodies focused on CCUS and/or hydrogen. These bodies provide an ideal knowledge base to support the supply chain work associated with the Bacton Energy Hub.

They also provide a great opportunity to collaborate with to help shape the supply chain for the Bacton Energy Hub.

10.1 Industry Bodies: Wider Oil, Gas & Chemical

There are many sector and/or geography related industry bodies who have information sources or who could help support the development of the supply chain activities associated with the Bacton Energy hub including:

CATCH

https://catchuk.org/

CATCH is an industry led partnership supporting the process, energy, engineering and renewable industries in Lincolnshire, Yorkshire and Humber. Created in 1999 to support the development of the £6 billion Humber chemical and chemistry using sectors, CATCH now boasts members and partners drawn from across the process engineering, energy, engineering and renewable sectors, their associated supply chains, regional and national government agencies and local authorities, including all four Humber local authorities.

CATCH has a membership of supply chain companies who operate in and supply into the process, renewable, energy, and engineering industries.

CIA

https://www.cia.org.uk/

The Chemical Industries Association (CIA) is the organisation that represents chemical and pharmaceutical businesses throughout the UK. It has a limited supply chain database however does includes potential suppliers who will have transferable skills.

ECA

https://www.eca.co.uk/

The Electrical Contractors Association (ECA) has 3000 members & associates. ECA has been a driving force in the electrotechnical and engineering services industry since the Association's formation in 1901. ECA continues to work on improving standards, supporting the industry and creating a sustainable business environment.

EIC

https://www.the-eic.com

The Energy Industry Council (EIC) has been serving members for 79 years and has over 800 member companies in their global network. EICSupplyMap holds data on over 3,500 UK energy sector supply chain companies (see **Error! Reference source not found.**) – this does not break down suppliers who have branches, offices or depots local to the Bacton sit

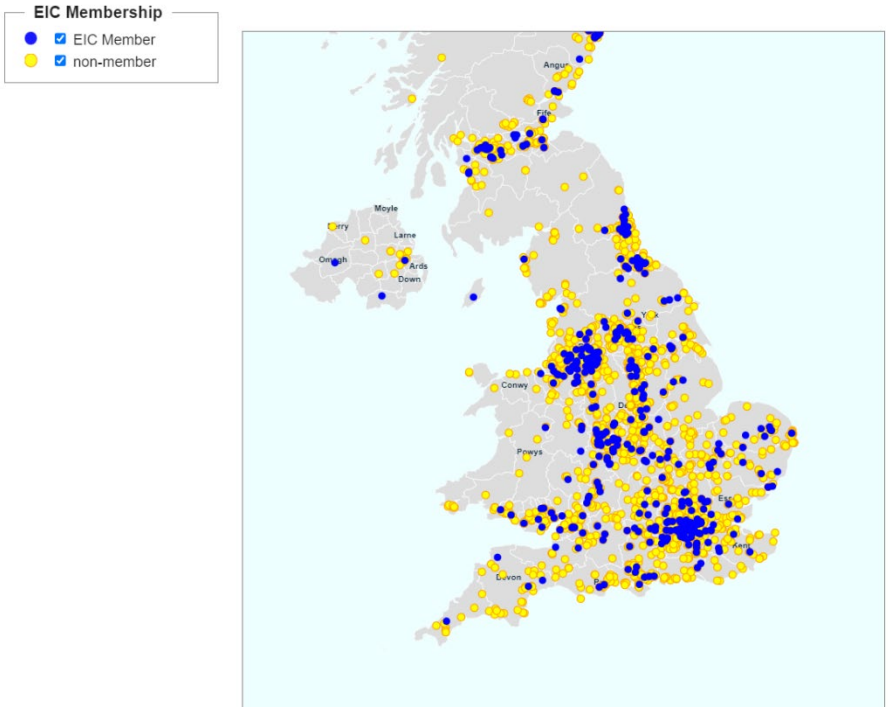


Figure 9-1 EIC Supply Map

ECIA

https://www.ecia.co.uk/

The Engineering Construction Industry Association (ECIA) is the principal trade and employer Association for the UK engineering construction industry. With over 300 members including many of the largest companies in the world that carry out engineering projects across the globe. Others are much smaller British contractors employing skilled craftspeople on sites all over the UK.

Onshore, members employ around fifty to sixty thousand personnel including plant designers, planners, project engineers and managers as well as site workpeople.

The ECIA provides its members with a collective voice to represent their interests on all matters affecting their industry. It is supported by a statutory Industry Training Board and, in partnership with two other employers' associations and two trade unions (Unite and GMB), it operates the National Agreement through the industry's National Joint Council.

ECIA members include global companies (involved in both new construction and repair and maintenance projects in the UK as well as overseas), most of the international design and procurement companies based in the UK, all the main employers of site-based craft employees and many smaller subcontractors.

EEEGR

https://eeegr.com/

EEEGR – Catalyst for the Energy Industry, Energy generation is going through an exciting phase in the East of England – offering opportunities to companies able to offer products, skills and services.

EEEGR's mission is to be the source of new opportunities and knowledge to enable member companies to strategically grow their businesses. The East of England Energy Group can help, by providing its members with a range of benefits including business introductions, networking opportunities, free job advertising, event discounts and up-to-date industry intelligence.

The sector has a £3.6bn turnover making it a major employer and economic driver in the region. EEEGR is playing a key role in helping members share in the success and growth, both now and in the future. EEEGR is also an influential voice lobbying national and regional government and championing the sector.

EEEGR directory have over 220 companies registered on their database, have access to and run a number of supplier events.

East of England SNS Gas Transition Sector Council

Although relatively new the council is another body which can support further work on supply chain going forward.

Firgure 9-1 East of England SNS Gas Transition Sector Council

OEUK

https://oeuk.org.uk/who-we-are-offshore-energy-industry/

Offshore Energies UK (OEUK) is a leading representative body for the UK offshore energy industries. It is a not-for-profit organisation with a pedigree stretching back almost half a century. Membership is open to all companies active in the UK continental shelf. From the largest producers and contractors through to SMEs working in low carbon energy.

Their aim is to ensure that the UK continental shelf remains an attractive place for energy producers so their supply chains to do business.

- The representative body that champions the whole sector
- The definitive source of information about the UK upstream
- The gateway to industry networks and expertise

They do this by:

- Industry-led events, forums and conferences so OEUK members help shape the agenda and work collaboratively with industry peers to identify and promote good practices.
- Through access to the latest market intelligence, comprehensive industry insights, award-winning guidelines and updates on legislative and policy developments.
- Raising the profile of the UK offshore energy industries.

- Promoting open dialogue across all sectors on activities, specifically technical, fiscal, safety, environmental and skills issues.
- Engaging with governments, regulations, and other external organisations on initiatives and programs.

NEPIC

https://www.nepic.co.uk/industry/

The North East Process Industry Cluster (NEPIC) represent the interests of the process & industry sector in the North East of England. Since 2004, 83 process sector investment projects have been delivered in the region valued at £4.3 billion. The region is home to the chemistry-using industries of chemicals, fine & speciality, petrochemicals, polymers and composites, pharmaceuticals, biotechnology, bioresources, biofuels and renewable energy and low carbon materials. There are more than 1,400 companies directly involved or in the supply chain of these industries, generating £26 billion of annual sales. Together they employ 190,000 people and the sector exports £12 billion each year – making this region the only net exporting region in the UK. The region is renowned for its industrial heritage and boasts more than 2,000 years of industrial activity and manufacturing.

Figure 9-3 NEPIC

NEPIC maintains a membership directory of over 100 companies in the chemical & process sector

NOF

https://www.nof.co.uk/

Northern Offshore Federation (NOF) is a not-for-profit organisation helping to make valuable connections between businesses in the global energy sector. They work on behalf of UK members and their network of partners to put companies of all sizes in touch with the best and most innovative supply chain businesses in the UK.

Like the EIC, NOF has a supply chain database although more limited due to sector coverage.

10.2 Industry Bodies: CCS and Hydrogen

As CCS and hydrogen technologies have emerged and developed in recent decades more technology specific industry bodies have emerged including:

CCSA

https://www.ccsassociation.org/

The CCSA is the trade association promoting the commercial deployment of Carbon Capture, Utilisation and Storage (CCUS).

The CCSA is made up of member companies across the CCUS industry; covering oil and gas, equipment manufacturing, distribution, industry, academia and regional bodies as well as a wide range of support services to the energy sector such as law, banking, insurance, consultancy and project management. These companies make up the core of the CCSA – providing vital input and guidance that shape CCSA's positions and objectives.

UK Hydrogen & Fuel Cell Association

http://www.ukhfca.co.uk/

FThe UK Hydrogen & Fuel Cell Association is the oldest and largest pan UK association, dedicated to supporting stakeholders across the entire value chain of both the hydrogen sector and the fuel cell industry. They launched in the summer of 2010, following the merger of Fuel Cells UK and the UK Hydrogen Association. With over 12 years of experience, the UK HFCA is a leader in advocating for and accelerating the transition

to Net Zero in the UK through the deployment of hydrogen and fuel cell solutions.

The Association supports members in understanding and enhancing the prospects for hydrogen and fuel cells in the UK, and acts on behalf of its members to accelerate the commercialisation of these clean energy solutions.

They cover:

- All fuel cell types and applications
- The full fuel cell supply chain (from research into material science through to systems integration and distribution)
- Hydrogen production and storage
- Hydrogen infrastructure
- Other issues around the delivery, storage and use of associated fuels

Their members include the leading UK hydrogen and fuel cell companies as well as organisations from the academic community and a range of other stakeholders with an interest in these clean energy solutions and the associated elements of the supply chain.

Hydrogen UK

https://hydrogen-uk.org/

Hydrogen UK is the trade association committed to the development and deployment of hydrogen solutions.

Hydrogen UK works to:

- Produce robust analysis to show how hydrogen can contribute to Net Zero
- Collaborate with government to grow markets for hydrogen solutions
- Support initiatives to deliver excellence throughout the supply chain
- Educate and excite stakeholders about the hydrogen opportunity

They engage with trade associations, academics, professional institutions and other opinion formers in building broad coalitions to build consensus around industry structure and policy changes.

Membership includes

Figure 9-5 Hydrogen UK members

10.3 Trade Associations

The UK has a network of trade associations whose members supply goods and services to the oil, gas & chemical industries. There are too many to name or list, a few examples are below. They provide knowledge of UK manufacturers for both commodity and niche products that could well be used as part of the re-development of Bacton Energy Hub.

- British Cables Association (BCA)
- British Valve & Actuator Association (BVAA)
- British Pump Manufacturers Association (BPMA)

As well as trade associations there are a number of on-line journals or business media sites including:

- Construction News
- Construction Enquirer
- Energy Voice
- LinkedIn
- The Engineer
- The engineering supplier network
- Power Technology
- Refining & Petrochemical ME
- ReNew
- Various online media/news

As well as the above there are a number of online "databases" of companies in East Anglia including:

- https://www.theconstructioncentre.co.uk/contractors/construction-contractors/in-norfolk.html
- https://www.glenigan.com/construction-companies-in-east-anglia/
- https://www.ceca.co.uk/

11 Suggested next steps

The entity who takes the project into the development phase will likely have their own approach to the contracting & procurement strategy however the following are worthy of consideration:

- A first pass contracting & project drivers including commitment to local content, SME, etc
- Supply chain analysis to identify local and regional content across work packages including suppliers, manufactures, fabricators and construction contractors
- Expression of interest or similar process for potential Pre-FEED/FEED consultant & contractors
- Market engagement with technology companies potentially via a request for solution or similar
- It is also worth considering a paid feasibility study to engage with key technology vendors
- Supply chain awareness campaign including media, social media, trade bodies, industry bodies and potentially supplier days. Mix of virtual and in person events

There are series of related workstreams which will impact SCT including:

- Standardisation & simplification
- Digital, automation and robotics
- Skills