



Scottish Oil and Gas Diversification Opportunities

Heat & Cooling, Water and Energy Storage & Systems

Final Report | 6 December 2017

Document Verification

Project Title	Scottish Oil and Gas Diversification into Heat, Energy and Water	Job Number
Report Title	Opportunities for Scottish Oil and Gas in Heat, Energy and Water	File Reference

Revision	Date	Prepared By	Checked By	Approved By
Final Report	6 December 2017	Name Julius McGillivray, David Vernon	Stuart Allison, Stephen Cook, Martin Shouler	Martin Shouler
		Signature 		
		Name		
		Signature		
		Name		
		Signature		

Contents

Report Section	Page Number
Executive Summary	4
1. Introduction	9
2. Methodology	13
3. Literature Review	17
4. Heat Market Assessment	21
5. Water Market Assessment	30
6. Energy Storage / Systems Market Assessment	42
7. Hot Spot Analysis	51
8. Deep Dive Assessment - Introduction	62
9. Deep Dive Assessment - Heat Networks	67
10. Deep Dive Assessment - Geothermal	78
11. Deep Dive Assessment - Municipal Water and Wastewater Treatment	87
12. Deep Dive Assessment – Industrial Wastewater Treatment	100
13. Deep Dive Assessment – Smart Water Management	110

Executive Summary

Executive Summary – Context and Purpose

Arup have been commissioned by Scottish Enterprise to carry out an assessment to identify key sub sectors and areas of opportunity in alternative markets for the diversification of the Scottish oil and gas supply chain.

Through a detailed analysis and methodology Arup have identified these sub sectors within Heat, Water and Energy Storage and Systems and assessed the viability of these diversification opportunities for the oil and gas supply chain. The report highlights and analyses these subsectors and also identifies and maps active companies in the oil and gas sector in Scotland who may be well suited to capitalise on opportunities.

This report also provides a detailed list of recommendations for Scottish Enterprise. These recommendations provide a strategy for Scottish Enterprise to work closely with oil and gas companies and key stakeholders in alternative markets to identify specific projects and opportunities in relevant subsectors.

Context

- Currently, the global low oil price is driving the need for Scotland’s oil and gas sector to adapt and become more resilient.
- In order to prosper, companies must now look to implement different strategies. This includes re-assessing how they currently serve existing customers and potential new opportunities in growth markets and other sectors.
- Scottish Enterprise has identified key sectors which may provide diversification opportunity for the upstream oil and gas supply chain:
 - Heat
 - Water
 - Energy Storage and Systems

Purpose of the document

- **Review** of key capabilities across the oil and gas supply chain.
- **Market assessment** of the three identified markets: Heat, Water, and Energy Storage and Systems.
- **Prioritisation** of opportunities in identified markets (hot spot analysis).
- **Deep dive assessment** of prioritised sub-sector opportunities for the oil and gas supply chain.
- A list of **recommendations** to support Scottish Enterprise and the Scottish oil and gas supply chain to access identified opportunities.

Executive Summary – Market Assessment

Overview of market assessment

This market study assessed opportunities for upstream oil and gas supply chain companies in the water, heat and energy storage / systems markets. Firstly, a high level market assessment was carried out to create a long list of opportunity areas within each of the markets. All the identified opportunities were then taken forward to a hot spot analysis. The following criteria was used to assess each opportunity:

- Scale of opportunity: market size to 2020
- Relevance of area to oil and gas supply chain
- Immediacy of the opportunity
- Barriers to market entry

A red, amber, green (RAG) scoring system was used to prioritise these opportunities for a deep dive assessment (more detailed analysis). The top market opportunities selected were:

- Heat Networks
- Geothermal Heat
- Municipal Water and Wastewater Treatment
- Industrial Wastewater Treatment
- Smart Water Management

Cross sectorial opportunities in energy systems and operations and maintenance were also assessed in the deep dive.

Heat Networks

This study highlights the large growth potential of heat networks in the UK following strong Government policy support. The detailed assessment provides a breakdown on the heat network supply chain and strong crossovers were found in the following areas:

- Specialist hydraulic analysis
- Sensors, controls and instrumentation
- Pipe and components manufacturer
- Specialist pipe services and design
- Operation and maintenance

Additionally, the heat networks supply chain is relatively underdeveloped in the UK and there is market evidence to suggest it is not ready to deliver the capacity increase forecast.

Geothermal Heat

The deep geothermal market in the UK is currently small with only one commercial operational well of significant depth (Southampton). However, there have been numerous feasibility studies highlighting the growth potential of the industry if investment barriers can be overcome. Strong crossovers were found in:

- Well drilling and associated services
- Geoscience studies
- Operation and maintenance

The oil and gas supply chain already provides the above services and is therefore very well positioned to deliver geothermal projects and help to drive market growth.

Water Market

Growth in market opportunities within the water industry are predominately driven by two key factors. Firstly, the UK and rest of the world continues to face a number of challenges across water security and scarcity. Secondly, the UK water industry is faced with ageing infrastructure and assets.

As a result of these two factors, there has been increased pressure on utilities from Ofwat to meet leakage targets and to not pass on upgrade costs to customers. This is driving the need and appetite for water and sewage treatment companies to seek innovative solutions in water sourcing and wastewater treatment and has also driven the need for smart water solutions.

The Government is also driving sustainable solutions for the wider industry in relation to wastewater treatment and this is also creating an opportunity for the Scottish oil and gas Supply Chain.

The alternative subsectors that present key areas of opportunity for the oil and gas supply chain are listed below:

Municipal Water and Wastewater Treatment

- Sensors, controls and instrumentation
- Pipe and components manufacturer
- Data analytics and network modelling
- Operation and maintenance

Industrial Wastewater Treatment

- Sensors, controls & instrumentation
- Pipe and components
- Data analytics
- Filters and membranes

Smart Water Management

- Advanced pressure management
- Supervisory, control and data acquisition
- Sensors, controls & instrumentation

Cross Sectorial

Energy systems (controls, sensors and instrumentation, data analysis, etc.) was identified as a cross cutting theme across all the selected sectors. There is a strong (oil and gas) expertise in energy systems and therefore diversification opportunities were considered within each of the selected sectors.

Operation and Maintenance in the water and heat markets also presented as potential opportunities and were included within the market opportunities examined.

Executive Summary

Summary

- 1 The heat networks market is expected to grow significant in the short term and strong crossovers have been highlighted in piping components, operation and maintenance, hydraulic analysis and sensors / controls.

- 2 There is direct crossover of skills and technology from the oil and gas industry to the geothermal market. In particular, oil and gas expertise in the drilling and reservoirs modelling sectors could be used to reduce investment risk associated with drilling.

- 3 Longer term potential exists for oil and gas companies to enter the hydrogen market. The largest of known opportunity is the H21 Leeds project that is expected to require £2bn investment. £1bn of this project is being invested in areas with direct crossover for the oil and gas industry.

- 4 Opportunities to diversify into smart water management may be more accessible in the short term, compared to both the municipal and industrial wastewater treatment markets. This is primarily due to the different procurement process, outside of typical alliance frameworks.

- 5 Scottish Enterprise should target both an internal and external engagement strategy to accelerate the transition for SMEs in oil and gas into alternative markets. Firstly, understanding who the active companies are in the relevant sub sectors, whether Scottish Enterprise have an existing relationship and then ascertain which of these companies are seeking diversification opportunities.

- 6 Internally, Scottish Enterprise need to work closely with SMEs to understand their unique selling points, gaps in the supply chain and optimal market entry strategy. Scottish Enterprise could use a range of engagement tools from subsector workshops, one to one maturity assessments or utilising online portals to inform companies of opportunities or assess in-house capability.

- 7 In parallel, Scottish Enterprise should engage key external stakeholders to further understand specific needs and capability gaps in alternative markets and also to inform relevant parties of the offering in the Scottish oil and gas supply chain. This could involve building relationships with governing organisations, attending alternative market conferences and seminars to share oil and gas capability, or run cross-sector workshops to connect oil and gas supply chain with relevant stakeholders in other markets.

Executive Summary

Figure 1 shows an overall summary of the key crossover areas identified in this report. The graph shows the likely timing of opportunities, the number of Scottish supply chain companies with a crossover and the type of company. All sectors were found to have strong crossovers with the upstream oil and gas industry but the relevance axis provides a comparative assessment of the relevance between sectors. The figure shows that heat networks and smart water management are diversification opportunities that can be realised in the near term. The timing of growth in the geothermal market is uncertain but it is unlikely this market will grow significantly prior to 2020. There are direct crossovers with the hydrogen industry, particularly in relation to storage and carbon capture. However, the hydrogen opportunity prior to 2025 is predominantly feasibility work that will be carried out by large consultancies. Opportunities for SMEs are likely to arise post 2025. Municipal wastewater treatment projects are often delivered through framework agreements between utilities and a consortium of companies. Therefore, opportunities to diversify into these markets will require longer term strategy into the next asset management period (2020 – 2025).

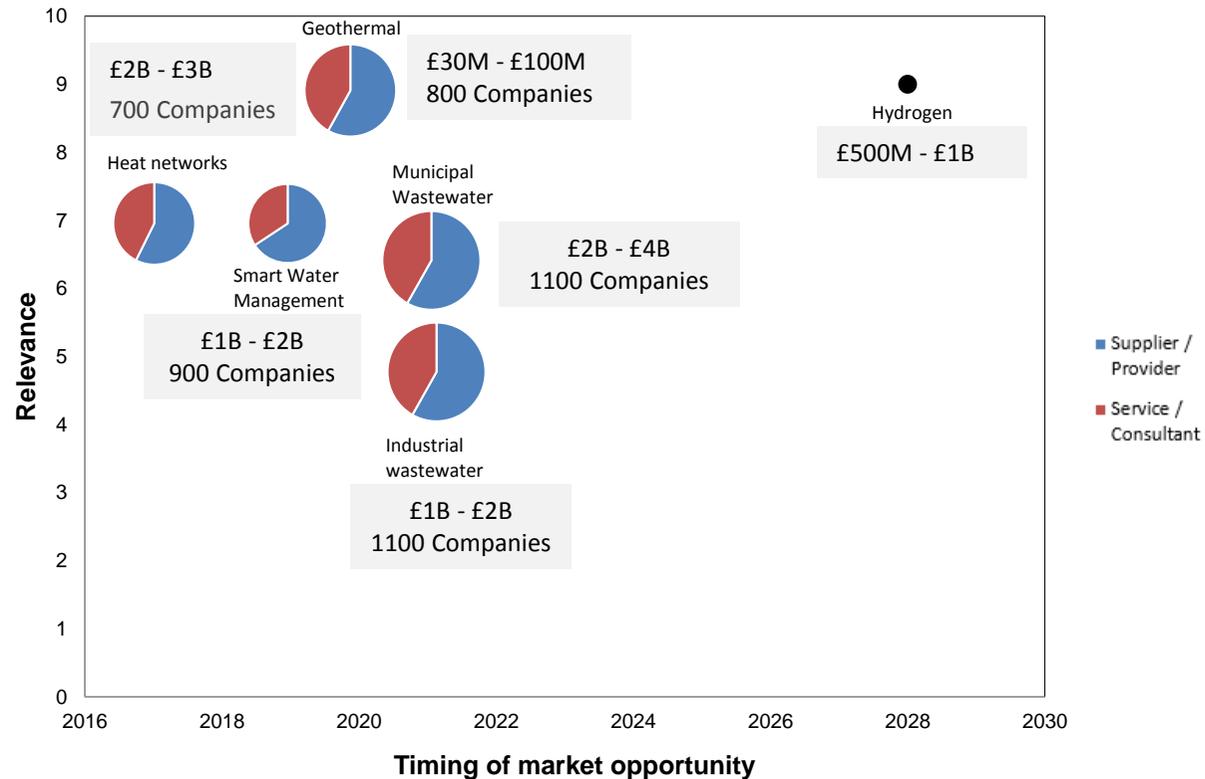


Figure 1: Opportunities for Scottish Oil & Gas Companies in Key Alternative Markets
 Note: The company mapping assessment was not carried out for the Hydrogen market due to the timing of the market opportunity.

1

Introduction

1. Introduction

1.1 Overview

In the current global low oil price scenario, it is vital that Scotland's oil & gas sector should adapt itself to be resilient. In order to prosper, companies must now look to implement different strategies. This includes re-assessing how they currently serve existing customers and potential new opportunities in growth markets and other sectors.

1.2 Background

The Scottish Offer – Oil & Gas

Scotland is estimated to have the largest oil reserves in the EU and the Scottish energy sector is internationally renowned for research and innovation. With 40 years' experience, Scotland has a reputation for expertise and energy education. Scotland's oil & gas sector supports 2,000 supply chain companies, 132,000 -165,00 jobs and exports to 130 countries worldwide.

The city of Aberdeen is world-renowned as an international oil & gas centre of excellence and is widely regarded as the 'oil capital' of Europe.

The supply chain companies associated with the oil and gas sector in Scotland are specialized and cover a vast range of expertise. The maturity of this existing supply chain base can be beneficial for other less experienced sectors in terms of innovation, experience and lessons learnt.

Due to an established offshore market in the North sea region, the Scottish oil and gas sector has developed key logistic links to support supply chain. There are major ports on both east and west coast of Scotland capable of accommodating local and global exports. There are well established road and rail links to major centres within the UK and wider Europe.

There is currently a huge opportunity for Scottish oil and gas to precipitate into other sectors and potentially form the cluster hub for supporting other energy sectors.

Scotland has led the way in areas like safety and integrity, subsea, supply chain management, which has given Scotland a competitive advantage on the global stage. There is a huge opportunity for acquiring the supply chain slot for upcoming offshore and energy markets in other rapidly growing regions like the middle east, Canada and the US. Hence, it is vital to have the necessary readiness and capability to diversify into new expanding markets and geographies.

Scottish Enterprise has already identified the key sectors which may provide diversification opportunity for the upstream oil and gas supply chain. This piece of work provides background and maps oil and gas supply chain segments into heat, water and energy storage systems. The opportunities are based on current upstream supply chain capability and sub-sector levels.

The Scottish oil and gas sector can provide manpower, the expertise and the crucial experience to develop other cross-functional sectors. Therefore, the Scottish oil & gas supply chain is a compelling offer to other sectors in domestic and international regions.

1. Introduction

1.3 Sector Overview

Water Sector

A growing population and urbanisation are increasing pressures and demands on water supply and infrastructure, the Water Resources Group estimating a projected 40% gap between demand and supply by 2030.

Therefore, the estimated current \$650 billion global water market will need to adapt and innovate to meet this challenge. The Hydro Nation - First Annual Report - 'Towards a water economy' estimates that the water technology industry could be worth £900 million per annum for Scotland. The Hydro Nation has identified innovation and growth in the water sector as priority areas.

While Scotland has a developed, diverse and specialised supply chain in the water sector there are potential opportunities for oil and gas businesses to help drive innovation and growth.

Specifically, there are strong synergies for oil and gas SMEs in areas such as subsurface, drilling, processing, equipment, environmental and engineering. Through existing links with the Scottish supply chain for water, oil and gas SMEs and larger companies may be able to leverage these strong capabilities to access relevant opportunities.

Heat Sector

The affordable supply and decarbonisation of heat represents one of the most significant opportunities to the energy industry over the next 30 years. The global heat market is forecast to grow to £308bn by 2050, in recognition of increased government ambition in this sector. Recent policy direction from the Scottish Government regarding heat, energy efficiency strategies, and regulation of district heating demonstrates a level of ambition and leadership which puts Scotland at the forefront of this market. The Scottish Heat Partnership is coordinating and driving forward effort to deliver new and increased infrastructure investment in the sector.

The heat sector, which has been identified as a high growth industry, has synergies with the oil and gas supply chain, in particular in areas of district heating and geothermal. In particular companies in the Scottish oil and gas supply chain could consider the following:

- Innovation around low carbon heat supply technologies, including geothermal, heat pumps and hydrogen systems.
- Expanding current service capabilities and into the roll out of heat infrastructure;
- Building on a strong hydrocarbon supply chain to lead the development of the market for clean hydrogen supply and distribution

While there are a number of potential opportunities for the oil and gas sector in Scotland they may face challenges from a strong offering in Europe, with mature supply chains in Finland, Denmark, Sweden and Poland already well established.

Energy Storage / Systems

Energy storage is recognised as being on the cusp of enormous growth. As an accelerating demand for electric vehicles reduces the cost of battery technology, commercially viable applications for utility scale energy storage are being demonstrated in markets across the world.

Battery costs have reduced by 40% since 2014, and 2017 is expected to deliver \$2.5billion invested in energy storage systems globally. This market is projected to increase 15-fold by 2024. Utility applications coupled with the deployment of wind and solar generation at larger scale, provide long term contracts attractive to investors.

Changes to grid balancing mechanisms, including the capacity market in the UK, further improves the economics for battery applications at large scale.

1. Introduction

1.4 Key Objectives

It is important to recognise the richness of the oil & gas supply chain in Scotland which includes commercial, academic and public stakeholders. While the offering in Scotland is mature, an understanding of how the oil & gas supply chain can access other markets domestically is less developed. This report looks at state of the markets in water, heat and energy storage / systems in more detail to track and forecast needs for the future.

Key outcomes from this work are:

1. Literature review of the key capabilities across the oil and gas supply chain, identifying any relevant knowledge gaps in the process.
2. Market assessment of the three identified key markets: Heat, Water and Energy Storage and Systems to identify a long list of potential opportunities.
3. Filtering and prioritisation of the opportunities in Heat, Water and Energy Storage and Systems (based on opportunity hot spot analysis) against the key capabilities across the oil and gas Supply chain.
4. Deep dive assessment to further understand prioritised opportunities for the oil and gas supply chain in the three key markets and relevant sub-sectors. Focussing on understanding key competitors, significant barriers to entry and existing key suppliers and buyers.
5. A list of recommendations and road map to support the Scottish Enterprise in the facilitation process to allow SMEs in oil and gas in Scotland to access these opportunities.

2

Methodology

2. Methodology

2.1 Overview

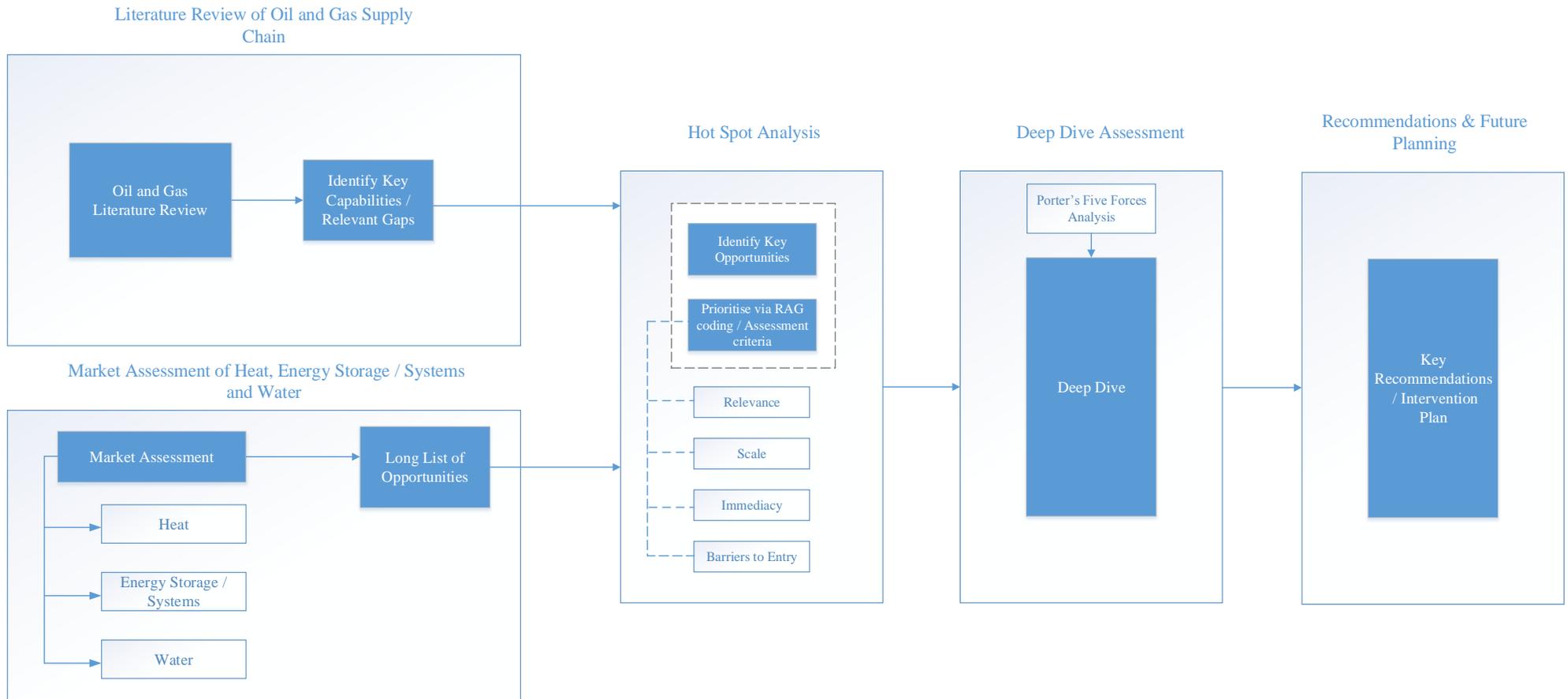


Figure 2: Methodology diagram

2. Methodology

2.2 Detailed Overview

Figure 2 on the previous page shows the methodology applied to assess opportunities and filter them for a deep dive assessment.

Literature review

Initially, a literature review was undertaken to assess any gaps in the previous market assessments and highlight any additional oil and gas supply chain areas.

High level market assessment

The market assessment for each sector included as assessment of the relevance to the oil and gas supply chain, scale of opportunity, immediacy and the barriers to entry. These categories are described in more detail in table 1 (next slide).

Hot spot analysis

The hot spot assessment prioritised the long list of opportunities for further assessment in the deep analysis. This was achieved through assessing crossover between the oil and gas supply chain as well as the sector or sub sector opportunities in alternative markets.

Deep dive assessment

A Porter's Five Forces assessment was used as the basis for the detailed market assessment. This included assessment of new entrants, existing buyers, existing suppliers, potential substitutes and industry

competitors. Additionally, the supply chain of each opportunity was assessed in more detail to detail the exact crossover opportunities.

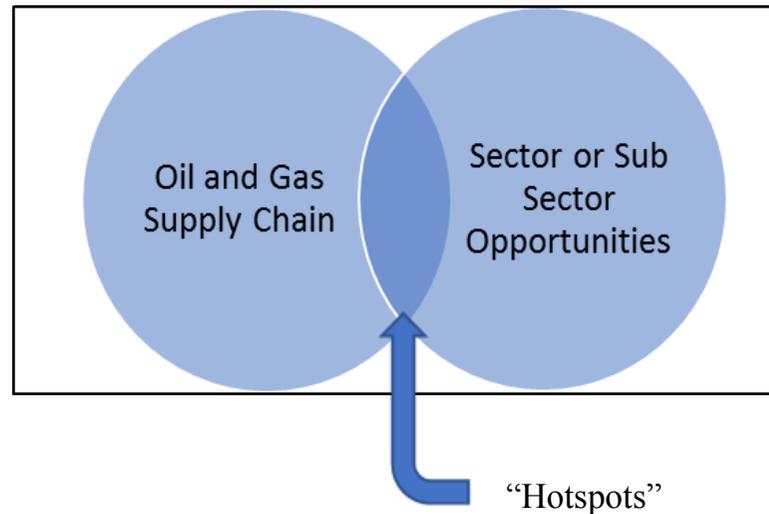


Figure 3: Hotspot Analysis

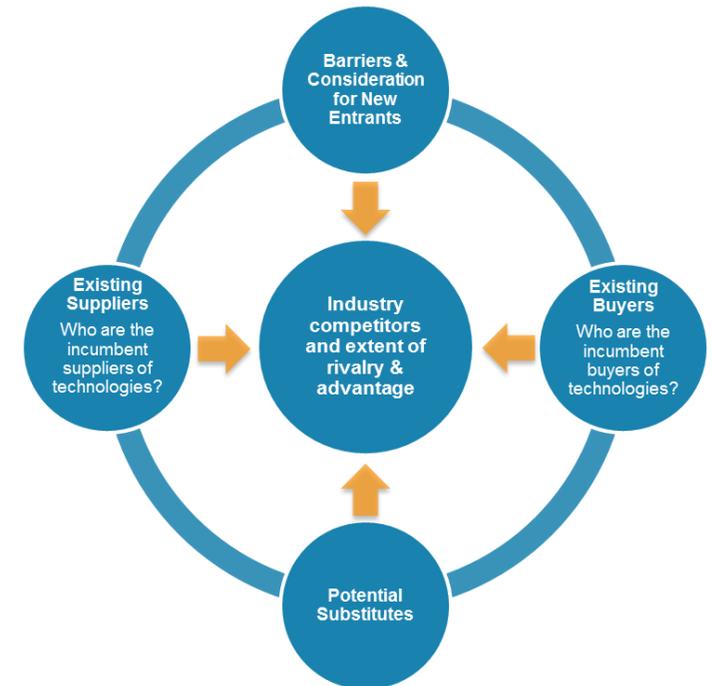


Figure 4: Porter's Five Forces Assessment

2. Methodology

2.3 Hotspot Methodology

Table 1: Market assessment criteria

Category Scoring	Relevance	Immediacy	Barriers to Market Entry	Scale – whole market	Total Assessment
Score: 1	High: Clear cut cross-sectoral opportunities. Technology and knowledge can be directly transferred into other sectors.	Short term (0 < 5 years): <ul style="list-style-type: none"> Market developed in the UK. Multiple opportunities to be realised within five years. 	Low: Limited international and domestic competitor presence. Transition costs are relatively low and there is also strong appetite and demand from the market. Existing relationships are likely to be weak and pathway to form these can be developed by new market entrants.	Large: UK Market estimated to be greater than £1 Billion by 2025.	Score: 4 - 6
Score: 2	Medium: Opportunities present but limited to a small number of specific sub sectors. Technology transfer may not be as direct, while knowledge transfer opportunities exist.	Medium Term (5 – 10 years) <ul style="list-style-type: none"> Majority of market opportunities are likely to be realised over a 5-10 year period. 	Medium; Some established domestic and international players from current or other sectors. Costs may be high for the transition of the oil and gas supply chain into alternative markets, this may be due to adapting technology costs. Market demand exists but the presence of existing players limits the appetite. There may be some existing relationships across the supply chain which may hinder attempts at market entry by oil and gas industries.	Medium: UK market estimated to be between £500 Million - £1 Billion by 2025.	Score: 7 - 9
Score: 3	Low: Limited opportunity across the sector or sub sectors. Technologies are not directly relevant and would need considerable adaptation. Knowledge transfer opportunities are also limited.	Long Term (10 years or more) <ul style="list-style-type: none"> Market potentially in early stage development in the UK. Majority of market opportunities are likely to be realised after 10 years. 	High: A considerable presence of competitors: <ul style="list-style-type: none"> International Domestic Other sectors Related costs could potentially create an economically unviable transition into alternate markets. The market appears to be saturated with long term existing relationships across the supply chain. There may be limited technology / knowledge crossover.	Small: UK Market estimated to be less than £500 Million by 2025.	Score: 10 - 12



Literature Review of oil and gas Supply Chain

3. Literature Review of oil and gas Supply Chain

3.1 Background

Scottish Enterprise has provided supporting documents to assist the capability mapping exercise in this scope of work. A critical review of the literature provided by SE including the Pale Blue Dot report has been conducted, to establish the key capabilities across the oil and gas supply chain.

A desk based study has been carried out to review all existing documents to form the basis of this scope of work. Knowledge gaps in existing information have been identified and addressed.

In combination with SE's existing reports, the literature review has been supported by Arup's in-house information management team, which provides access to a wide range of in-house and third-party generated information resources. It includes subscription services such as ASTM, Economist Intelligence Unit, ProQuest and ScienceDirect.

3.2 Review

A range of reports provided by SE captures the businesses representing the Scottish oil and gas companies, specifically upstream.

This dataset does not include operators or any activities which occur downstream e.g., refining, marketing and distribution.

The database provided has been developed

from a range of existing sources (18 in total, plus individual company websites). A range of individuals including specialist research team appointed by SE, SE Oil & Gas team, SE Account Managers etc. have collectively allocated various business to segments and company type categories. The database provided includes businesses existing till 2013.

The segmentation realised in existing reports has been based on the approach adopted by Oil & Gas UK and previous study conducted by SE.

- The segmentation has 'five application areas' – Reservoirs, Drilling & Wells, Platforms & Topsides, Marine Subsea & Pipelines, Integral & Support services.
- Two tiers – 'top tier' and 'second tier'.
- Circa 70 activity 'segments' distributed across the five application areas and two tiers.
- A classification of ten distinct 'company types' – three within the top tier and seven in the second tier.

The upstream oil and gas sector segmentation includes the follow sectors.

Reservoirs

The reservoir and wells related services are one of the key activities in developing the upstream infrastructure. The subsurface studies are crucial and are helps to monitor the reservoir throughout the life cycle of a

field. It largely consists of data acquisition, interpretation and processing. The collected data is directly used and complimented by geophysical surveys and modelling of reservoirs. The equipment required for collecting data can be bespoke, but can be directly applied to carry out similar tasks for other energy sectors.

Drilling & Wells

The drilling and wells services comprises of drilling units, completions, associated accessories, drilling fluids and chemicals etc. Well enhancement and abandonment are one of the major aspects in drilling and wells. The associated machineries, equipment and tools may be used in other similar energy sectors. Waste treatment, management and disposal also form a part of drilling service offerings. The service offerings can range from well design and engineering to manufacturing and supplying drilling modules and packages.

Platform and Topsides

The platform and topsides capabilities cover a wide range of services like design, engineering, technology, fabrication, commissioning etc. Disciplines like mechanical, electrical, process, instrumentation, structural, health & safety and metallurgy support the service offerings for platform and topsides. The platform and topsides consist of specific aspects like rotating equipment, piping, truss structures,

process modules, instrumentation and process control, structural integrity etc.

Marine, subsea and pipelines

Marine, subsea and pipeline offerings involves services like engineering, design and construction, installation/removal processes, maintenance and modifications, etc. The major offerings lie under aspects like vessel/equipment, flexible risers / flowlines, buoyancy protection/aid and mooring/foundations. The complex subsea structures like Xmas trees, tie-back connections, burial of subsea pipelines and utility cables also form a part of this segment of offerings. The marine, subsea and pipelines for upstream projects have been well established since past few decades, and the specialist skills gathered in this area can be transferred to similar sectors like wind, tidal and decommissioning.

3. Literature Review of oil and gas Supply Chain

Integral Support Services

The success of Scottish upstream industry has been reliant on key integral support services like air/sea transport, ports/logistics and warehouses, legal and IT consultants, emergency response providers, offshore manning agencies, medical and laboratory assistance, risk and costing etc. The support services despite being specialised in upstream oil and gas sector, could be transferred to back other similar energy sectors.

3.3 Knowledge gaps

We have identified several gaps in the existing knowledge base provided by Scottish Enterprise.

4D Arrays and associated Installation

4D arrays is one of the pioneering seismic techniques used in both exploration and production. It is used to examine reservoir performance over time and indicate changes in fluid dynamics. 4D seismic adds the element of time to the traditional 3D seismic acquisition regime.

Structural integrity/data monitoring

Structural monitoring offshore helps to capture information valuable for both integrity management, software benchmarking and R&D purposes. Instruments may be installed at locations on

the offshore and subsea structures identified as fatigue critical or high risk during the design stage. The measured field data is also used to calibrate design tools by comparing results from software predictions against field measurements. This exercise increases the degree of confidence in future designs.

Marine Warranty surveys

The marine warranty surveys provide independent third-party technical review and approval of high value and high risk construction and transportation project operations. These operations can range from planning to physical execution stage. Upstream warranty survey covers assets like fixed and floating platforms, subsea gas and oil pipelines, electric cables etc. The marine warranty survey guarantees that the work is planned and performed according to a level of risk that is consistent with the reference international standards, and tolerable for the industry and other players, especially the insurer.

Emergency response

The development of north sea oil and gas has demanded parallel advancement in emergency response over period of time. The emergency response for the upstream sector involving specialist vessels, equipment and personnel is well established and has matured in past decades. The

experience and lessons learnt over the years from upstream emergency response can be transferred and shared into other sectors.

Offshore personnel manning

In order to support the huge upstream oil and gas sector, specialist manning services have evolved and thrived in Scotland. These firms are dedicated in identifying and filtering the experts suitable for supporting the upstream industry in various aspects. The services may include but may not be limited to recruitment, crew management and training services.

3. Literature Review of oil and gas Supply Chain

Table 2: Literature review updated table

COMPANY TYPES	RESERVOIRS	DRILLING & WELLS	PLATFORMS & TOPSIDES	MARINE, SUBSEA & PIPELINES	INTEGRAL & SUPPORT SERVICES
<ul style="list-style-type: none"> • Main Contractor • Integrated Services • Project Management 	<p>Reservoir Engineering / Management</p> <p>Data Acquisition / Processing / Interpretation</p>	<p>Drilling Units</p> <p>Well Engineering / Design</p> <p>Oilfield / Well Services</p> <p>Drilling Modules / Packages</p>	<p>Engineering, Design and Construction</p> <p>Installation / Removal</p> <p>Operations, Maintenance, Modifications and Decommissioning</p>	<p>Engineering, Design and Construction</p> <p>Installation / Removal</p> <p>Operations, Maintenance, Modifications and Decommissioning</p>	<p>HSSE</p> <p>Air / Sea Transport</p> <p>Ports / Logistics / Freight / Warehouse</p> <p>Utilities / Catering / Facilities Management</p> <p>Recruitment & Training</p> <p>QA/QC / Certification & Integrity</p> <p>IT / Communications</p> <p>Medical</p> <p>Meteorological</p> <p>Laboratory</p> <p>Finance, Legal & Insurance</p> <p>Risk, Cost & Planning</p> <p>Other Consultancy</p> <p>Emergency response</p> <p>Offshore personnel manning</p>
<p>In Scotland -</p> <ul style="list-style-type: none"> • Manufacturing / Fabrication • Supplier / Distributor / Stockist • Agent • Consultant • Services • Technology Provider • Specialist 	<p>Data Acquisition / Processing</p> <p>Data Interpretation / Evaluation</p> <p>Survey Equipment</p> <p>Geosciences Survey / Studies</p> <p>Reservoir Modelling / Development</p> <p>Software, Storage & Management</p> <p>4D Arrays/Installation</p>	<p>Tubulars, Completions & Accessories</p> <p>Drilling Machinery & Equipment</p> <p>Drilling Fluids & Systems</p> <p>Downhole Tools & Instruments</p> <p>Wells/Wellhead Equipment</p> <p>Well Testing, Control & Monitoring</p> <p>Well Enhancement</p> <p>Well Abandonment</p> <p>Waste Treatment, Management & Disposal</p>	<p>Production / Process / Accommodation Modules & Equipment</p> <p>Rotating / Power Equipment</p> <p>Piping & Components</p> <p>Instrumentation / Process Control</p> <p>Production Enhancement</p> <p>Inspection / Repair / Maintenance</p> <p>Steel, Metal & Non Metal Materials</p> <p>Chemicals / Gases / Paints</p> <p>Lifting & Handling</p> <p>Safety / Fire Protection</p> <p>Electrical / Electronic Engineering</p> <p>Mechanical Engineering</p> <p>Waste Treatment, Management Cleaning & Disposal</p> <p>Structural Integrity/Data monitoring</p> <p>Warranty surveys</p>	<p>Vessels / Equipment</p> <p>Mooring & Foundations</p> <p>Survey / Positioning</p> <p>Structures / Xmas Trees / Manifolds / Templates / Wellhead Equipment</p> <p>Process, Pumping and Power Systems</p> <p>Controls, Sensing, Monitoring & Communication</p> <p>Pipe / Flexibles / Risers / Flowlines</p> <p>Umbilicals / Cables</p> <p>Diving / ROV / AUV</p> <p>Subsea Inspection / Repair / Maintenance</p> <p>Subsea Well Intervention</p> <p>Buoyancy / Protection</p> <p>Environmental / Site Studies / Monitoring</p>	

4

Heat Market Assessment

4.1 Heat Market Overview

Heat market categorisation

The heat market has been broadly categorised into 3 principal areas; heat energy sources, heat delivery infrastructure and associated services. The categories reflect the range of market sectors that the oil and gas industry could diversify into. Biofuels has not been included as part of this analysis because the oil & gas industry has already diversified into this sector

Heat policy review

Scotland

The Heat Policy Statement from the Scottish Government was published in 2015. It sets out their goal to achieve a resilient heat system which transitions to be an affordable low carbon heat system for all. The statement places energy efficiency at the heart of the approach to decarbonise the whole energy system, including a district heating policy which identifies a commitment to deliver 1.5TWh/yr of heat via district heating and have 40,000 homes connected to district or communal heating by 2020¹.

The Heat Policy statement outlines strong support for biomass, deep geothermal, waste heat recovery and heat pumps. The statement does not set a specific penetration target for each technology but sets an overall target of 11% of non-electrical heat demand to be met by renewables by 2020.

In January 2017 the Scottish Government

released a consultation document entitled *Heat and Energy Efficiency Strategies, and Regulation of District Heating*. This document proposes several mechanisms that are likely to increase investment in the Scottish district heating market². These include:

- Establishing district heating zones to coordinate developers, building owners and local authorities.
- Creating concession zones to connect customers to reduce the risk of stranded assets.
- In the long term, requiring surplus waste heat from industry and power generation are connected to DH networks.

Rest of UK

Figure 5 shows the general strategy of the UK government towards the future of heating. The strategy states that heat networks should be promoted in dense urban areas and that heat pumps should be prioritised in rural areas. Through the Heat Network Investment Programme, the UK has committed to £290m in capital project funding for heat networks. This is expected to deliver significant growth in the market. The majority of other low carbon technologies receive policy support through the renewable heat incentive (RHI), whereby operators are paid per unit of heat (kWh) that they produce for a 20 year period.

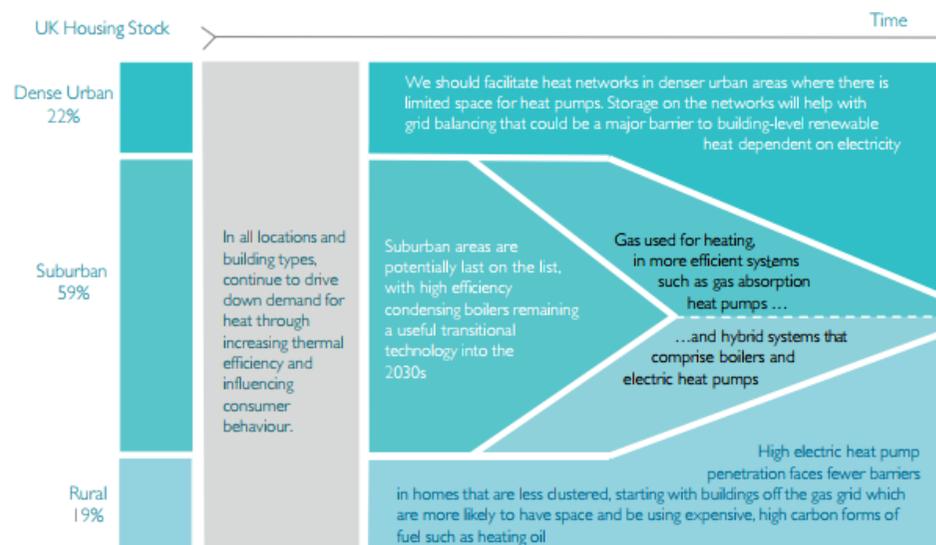


Figure 5: UK government heat strategy

1. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/190149/16_04-DECC-The_Future_of_Heating_Accessible-10.pdf
 2. <http://www.gov.scot/Publications/2017/01/9139>

4.2 Heat Market Segmentation Table

1 = High Priority
2 = Medium Priority
3 = Low Priority

Table 3: Heat Market Segmentation Table

Business Sector	Categories	Market size ¹	Market size rank	Immediacy	Barriers	Relevance (target oil and gas sectors)	Identified Oil & Gas hot spots
Heat Energy Sources	Geothermal	£30 - £100m	3	1	1	1	Drilling units, Well engineering / design, Geoscience surveys, drilling machinery, Reservoir modelling
	CHP	£1-2bn	1	1	3	3	Inspection / repair and maintenance, Software, storage and management, Equipment supply (CHP specific)
	Energy from Waste	£3-9bn	1	1	3	3	IT / Communications, Risk, cost & planning, Ports / logistics / freight management, Chemicals / gases / paints, HSSE
	Biomass	>1bn	1	2	2	2	IT / Communications, Risk, cost & planning, Ports / logistics / freight management, Laboratory, Finance / legal / insurance
	Heat pumps and chillers (heating and cooling)	£500 - £1bn	2	3	3	2	Petrochemical processing (downstream crossover)
	Hydrogen production	£1bn	1	3	2	2	Development of steam methane reformers for hydrogen production – Leeds hydrogen H21 project, Geoscience surveys, Risk, cost and planning, Heat and safety (high pressure gases), Engineering design, Maintenance and operation
Heat delivery infrastructure	Heat networks (pipeline and including waste heat)	£2 - £3bn	1	1	1	2	Pipe inspection, repair and maintenance, Piping components, Hydraulic modelling / engineering, Instrumentation / controls
Associated services	Operation, maintenance metering and billing	£3.2bn - £6.4bn (2025)	1	1	2	3	Pipe inspection, repair and maintenance, Piping components, Hydraulic modelling / engineering, Instrumentation / controls

1. Potential Market Size (2025, UK)

4.3 Business Sector Summaries – Heat Energy Sources

Geothermal

Market Size

The growth of the geothermal market is likely to be closely linked to the heat network market. This is because geothermal offers a near zero carbon heat supply option for networks. CHP has previously been favoured as the supply option for district heating because electricity sale revenues improve the business case and reduce pay-back periods of the network infrastructure. As the electricity grid decarbonises, the carbon benefit of CHP reduces and heat networks will need to move to alternative heat supply technologies and these include geothermal, EfW and heat pumps.

As set out in the heat networks market assessment, the required investment in heat supply plant for heat network to 2020 could be as high as £285m. The capital cost of a single geothermal well to supply heat (approx. 2000m) ranges from £1-2m. Assuming geothermal comprises 5-10% of the heat networks market by 2020, the potential capital expenditure on geothermal will be £10m-£30m. It should be noted that geothermal is still relatively unproven in the UK and success of pilot projects could result in increased deployment.

Immediacy

The geothermal market in Scotland is still in relative infancy and only 1 deep geothermal

well have been developed to date (Southampton). Funding has also been confirmed for a 400 kW heat only deep geothermal well in Kilmarnock that will supply a new development site. A report by AECOM in 2013 that looked at the potential for deep geothermal recommended that the next 5 years of development should focus on the development of shallower wells that only supply heat and a timeframe of 5-10 should be considered for electricity generation.

Barriers

The principal barrier to the development of geothermal heat has been the high capital costs and combined with the risk of drilling failure. An additional contributing factor is relatively low costs of alternative heat supplies (mostly gas boilers). The commercial viability of deep geothermal projects is also still reliant on subsidy in the form of RHI (5p/kWh for deep geothermal). The highest component of the capital cost for geothermal wells is the well drilling. The oil & gas industry is uniquely placed to remove some of these barriers and reduce the capital cost of drilling by increasing market competition.

Relevance

There is a strong crossover between the oil & gas and geothermal markets. In particular, expertise in drilling and geological surveys could be transferable to the geothermal industry. A previous report by Arup and Geothermal Engineering Limited (GEL)

stated¹ 'As part of the 2013 Atkins review of geothermal energy a questionnaire was issued to a range of stakeholders (including the oil and gas industry) which included questions aligned to synergies between deep geothermal development and oil and gas technology developments. The responses to this questionnaire (from institutions including Durham University and Baker Hughes Reservoir Engineering) highlighted that there could be key contributions to deep geothermal development from existing technical areas including drilling, completions, water conditioning, fluid processing and pump systems in addition to the potential for 3D reservoir modelling technologies to be adapted for 3D modelling of thermal resources.'

Hot Spot Analysis

The industry crossovers from oil & gas to geothermal are both in services and equipment. Service offering crossovers include:

- Well design / engineering
- Geoscience services / studies
- Data interpretation / evaluation
- Well testing / modelling
- Hydraulic engineering

Equipment and personnel crossovers include:

- Drilling units / drilling machinery

- Well head equipment
- Operation, inspection, repair & maintenance

Arup Expert

Mike Collins

- Mike.Collins@arup.com
- Kilmarnock deep geothermal well is at an advanced stage of funding and the DBOM tender is expected in late 2017.
- INEOS are looking for opportunities to show low carbon credentials and Grangemouth is also an active target for geothermal well development and heat network opportunities.

1. <http://www.gov.scot/Publications/2016/03/9242/16>

2. Deep geothermal review study, Atkins, 2013

4.3 Business Sector Summaries – Heat Energy Sources

CHP

Market Size

Gas CHP has seen market growth over the last few years and total capacity has risen from 4.4 GWe in 2001 to 8 GWe in 2015. A report by Riccardo AEA estimated the market will continue to grow to an estimated 10 GWe by 2020¹. 2GWe of additional installed capacity would approximately represent £1.5bn in capital investment.

Immediacy

The UK CHP market is already well established and there are active market opportunities, particularly with regard to heat network development and supply of plant for large heat and electricity consumers.

Barriers / Risks

The benefits of CHP are that it offers both carbon savings and often high commercial returns from offset electricity purchase or export. However, the carbon benefit of CHP continues to reduce as the electricity grid decarbonises. Expected updates to planning guidance in SAP 2016 will reduce the grid electricity carbon factor and small scale CHP is likely to be less attractive for developers after these changes are implemented. However, large scale CHP engines supplying district heat networks could still offer carbon savings these systems can also be combined with lower carbon supply technologies such

as geothermal and heat pumps.

Relevance

The oil and gas sector currently accounts for 39% of the Good Quality CHP registered in the UK². CHP is used in petrochemical processing. There is therefore already an established supply chain for CHP companies that supply the oil & gas industry. However, oil & gas expertise in the CHP industry is predominantly in the downstream supply chain and there is limited crossover with the upstream supply chain.

Hot Spot Analysis

The industry crossovers from oil & gas to CHP include:

- Inspection / repair and maintenance
- Software, storage and management
- Equipment supply (CHP specific)

Arup Expert

Mark Anderson

- Associate Director - Energy Consulting
- Mark.anderson@arup.com

Energy from waste

Market Size

The UK government estimates that energy from waste will require an investment of £3-£9bn by 2020³.

Immediacy

The Energy from Waste market in the UK is already well established and there is significant growth in the number of tenders. There are currently 8 projects with a total capacity of 2.85 Mt which are in active development.

Barriers / Risks

Veolia, Viridor and Suez have a dominant market position and together operate over 60% of the existing EfW plants. Veolia in particular is a successful vertically integrated company and opportunities to enter the supply chain are limited⁴.

Relevance

The crossover between oil & gas and EfW sectors is predominantly in the logistics and support services required behind large scale energy projects.

In addition, there is also crossover in specialist services such as chemicals (including handling) and health and safety.

Hot Spot Analysis

Specific crossovers examples include:

- IT / Communications
- Risk, cost & planning
- Ports / logistics / freight management
- Chemicals / gases / paints
- HSSE

Arup Expert

Ben Glover

- Associate Director
- ben.glover@arup.com

1. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/191543/Projections_of_CHP_capacity___use_to_2030_2204.pdf
 2. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/540963/Chapter_7_web.pdf
 Calculated on a benchmark capital cost £750 / kWe.
 3. <https://invest.great.gov.uk/us/industries/energy/energy-from-waste/>
 4. <http://www.tolvik.com/wp-content/uploads/UK-EfW-Sector-Report-2015-Final.pdf>

4.3 Business Sector Summaries – Heat Energy Sources

Heat pumps and chillers (heat and cooling)

Market Size

The heat pump and chiller market can be split between residential and commercial / applications. Domestic heat pumps currently account for a very small 0.2% of the domestic heat supply market. The UK heat policy outlines the development of heat networks in dense urban areas and heat pumps in rural areas. This market is therefore expected to grow significantly but concerns remain over system performance and customer acceptance. The CCC committee estimates that 4 million homes will have heat pumps by 2030¹.

Immediacy

The domestic heat pump market is not a major opportunity for oil & gas supply chain companies within the next 5 years. The commercial / industrial heat pump market is already an established market and opportunities are available.

Barriers / Risks

This is a relatively niche market and companies that specialise in providing services for heating and cooling may already have diversified to other market areas such as district heating and industrial refrigeration.

Relevance

The oil and gas industry uses industrial scale heat pumps and chillers for various processes in petrochemical production. There is strong technical knowledge crossover between these applications and large scale heat pumps used in district heating networks and industrial chillers. STAR refrigeration are an example of a company that provide services to both the oil & gas industry but also newer markets such as district heating².

Hot Spot Analysis

The main diversification opportunities for oil & gas companies is in downstream services including those providing services for petrochemical processing.

Arup Expert

Stuart Allison

- Senior Engineer – Energy consulting
- Stuart.Allison@arup.com

Biomass

Market Size

The biomass market can be broadly categorised into large scale biomass fuelled power stations for electricity production and smaller scale plants that are usually only for heat production. A government drive to phase out coal resulted in the conversion of 5 power stations and increased the capacity from approximately 400 MW in 2009 to greater than 3,000 MW in 2016.

Immediacy

The biomass heat & power markets are well established in the UK.

Barriers / Risks

The major uncertainty for oil & gas supply companies is future uncertainty over biomass policy. The government has recently announced subsidy cuts to small and medium scale biomass plants in the non-domestic

Relevance

The technical crossovers between the biomass industry and upstream oil & gas supply chain companies is limited. However, there are synergies between the supply chain management of complex biomass delivery contacts and oil & gas supply.

Hot Spot Analysis

Specific crossovers examples include:

- IT / Communications
- Risk, cost & planning
- HSSE

1. https://www.theccc.org.uk/wp-content/uploads/2013/12/1785b-CCC_TechRep_Singles_Book_1.pdf

2. <http://www.star-ref.co.uk/market-sectors/petrochemical-nuclear.aspx>

4.3 Business Sector Summaries – Heat Energy Sources

Hydrogen production

Market Size

The current market size is extremely small because there have only been demonstration projects but the UK HFCA (Hydrogen Fuel Cell Association) estimates a £1bn market in the UK by 2020¹.

Immediacy

The hydrogen market is not expected to develop at a significant scale before 2020. The UK roadmap for hydrogen and fuels cells sets a timeline where the period of 2016-2020 is used for technology demonstration and policy implementation. Post 2020 is then used as a period for ramping up deployment and 2025 onwards for widespread use.

The immediate opportunity (0-5 years) for oil & gas is in the production of hydrogen and associated services for demonstrator projects. The most immediate opportunity is the Leeds H21 demonstrator projects.

The Scottish hydrogen market is still in the early stages of development but there has been significant investment in Aberdeen and commercial scale hydrogen production has already begun. This investment has been supported by the Scottish government and there are plans to expand the scheme with additional grant funding from the government.

Barriers / Risks

The hydrogen market is not expected to develop at a significant scale below 2020. The UK roadmap for hydrogen and fuels cells sets a timeline where the period of 2016-2020 is used for technology demonstration and policy implementation. Post 2020 is then used as a period for ramping up deployment and 2025 onwards for widespread use.

The major risk for diversification into the hydrogen market is uncertainty over future scale and investment opportunities. Estimates of hydrogen vehicle penetration vary widely. National Grid's 'Future Energy Scenarios' estimates that there will be practically no penetration by 2030 and UK H2Mobility estimate 10% market share by 2030².

Hydrogen could also be used as a fuel source for generation and seasonal storage in salt caverns could balance large fluctuations in renewable outputs between seasons.

Relevance

Hydrogen is already produced as part of the petrochemical processing and therefore downstream oil and gas companies have strong technology crossovers. Expertise in the upstream oil and gas supply chain has more crossover with hydrogen storage market. Geoscience and drilling services will also be required if salt caverns are utilised for storage.

Hot Spot Analysis

Specific crossovers to the hydrogen industry include:

- Development of steam methane reformers for hydrogen production – Leeds hydrogen H21 project.
- Geoscience surveys
- Risk, cost and planning
- Heat and safety (high pressure gases)
- Engineering design
- Maintenance and operation

Arup Expert

Helen Charlick

- Senior Engineer
- Helen.charlick@arup.com

1. <http://www.e4tech.com/wp-content/uploads/2016/11/UKHFC-Roadmap-Final-Main-Report-171116.pdf>

2. https://www.theccc.org.uk/wp-content/uploads/2013/12/CCC-EV-pathways_FINAL-REPORT_17-12-13-Final.pdf

4.3 Business Sector Summaries – Heat Delivery Networks

Heat Networks

Market Size

The Heat Network Partnership of Scotland estimates that a total investment of between £85m-£190m is required in heat distribution networks to 2020.

Additionally, a maximum of £232m is required for heat plant costs and £70m for end user connections. This gives a maximum of £483m invested in heat networks up to 2020¹.

Across the whole of the UK, the government estimates that £2bn investment will be required over the next 10 years. This brings the total investment across the UK to approximately £2.5bn to 2020.

Immediacy

Currently 10,000 homes are connected to district heating networks in Scotland and this is predicted to grow to 40,000 by 2020. The indicates a rapid growth is expected in the heat network market from a relatively low penetration of 2% of homes today. This growth may even increase if the Scottish government implements some of the proposals put forward in the recent government consultation on heat networks. These include heat network zoning and mandatory use of waste heat supplies. Across the whole of the UK, the government has a projected pipeline of 280 projects commencing procurement between now and

2025.

Barriers / Risks

The main risk to market entry for oil & gas companies is the uncertainty over future heat policy. Although the Scottish and UK government continues to support heat networks, high market penetration can only be gained if networks expand to connect existing commercial and residential properties. The total market size and growth beyond 2020 is still relatively uncertain.

Relevance

There are strong technology and service crossovers with the heat networks industry that include expertise in pipe manufacturer and components, hydraulic modelling and general engineering services.

In addition to direct supply chain crossovers, heat networks also provide an opportunity for the oil & gas industry to diversify revenue streams. In particular, waste heat off-take from industrial processes could be captured and sold to heat networks. The most prominent opportunity for this is the Grangemouth oil refinery. There are plans to develop district heating networks in nearby Falkirk and waste heat could be used in these networks. This offers the refinery both the opportunity to diversify revenues but also significantly lower carbon emissions of the network.

Hot Spot Analysis

The primary areas of crossover between DH and Oil & Gas include:

- Pipe inspection, repair and maintenance
- Piping components
- Hydraulic modelling / engineering
- Instrumentation / controls

Arup Expert

Stephen Cook

- Associate Director
- Stephen.cook@arup.com

1. http://www.low-carbonscotland.scot/wp-content/uploads/2015/11/DECC_HeatNetworks_acc2.pdf

4.3 Business Sector Summaries – Heat Associated Services

Maintenance, operation, metering and billing (heat networks)

Market Size

There are an estimated 17,000 heat network customers in the UK¹. Many of these properties would have been connected before the EU metering and billing regulations that require individual properties to be metered. The average cost to provide billing services to a heat network customer is £70-£90 / year and gives an estimated revenue of £1.5m per year.

The UK government estimates that the supply chain for heat networks represents £3.2bn to £6.4bn in operation and maintenance contracts².

Immediacy

As set out in the heat network market assessment (page 24), the district heating market is expected to grow rapidly up until 2020 and there are a significant number of active procurement opportunities.

Barriers / Risks

The main risk to market entry for oil & gas companies is the uncertainty over future heat policy. Although the Scottish and UK government continues to support heat networks, high market penetration can only

be gained if networks expand to connect existing commercial and residential properties. The total market size and growth beyond 2020 is still relatively uncertain.

Relevance

The most significant crossovers for the oil and gas industry are for pipe maintenance, modelling and operation of heat networks. Oil and gas supply companies have relatively little customer facing interaction and therefore the metering and billing market has less crossover opportunities.

Hot Spot Analysis

The primary areas of crossover between DH and Oil & Gas include:

- Pipe inspection, repair and maintenance
- Piping components
- Hydraulic modelling / engineering
- Instrumentation / controls

Arup Expert

Stephen Cook

- Associate Director
- Stephen.cook@arup.com, +44 20 7755 3834

1. <https://www.theade.co.uk/resources/what-is-district-heating>
2. http://www.low-carbonscotland.scot/wp-content/uploads/2015/11/DECC_HeatNetworks_acc2.pdf



Water Market Assessment

5.1 Water Market Overview

Introduction

Scotland is fortunate to have significant and high-quality water resource. Water is of central importance to the economy of Scotland, both as a sector in its own right and as a critical resource in the manufacturing, agriculture, food and drink, tourism and energy sectors.

Scotland has made a commitment to establish itself as a global water player as part of the Hydro Nation Agenda. This has provided a focus for Scottish water technology for both home and the international markets.

According to the first annual report of Scottish Government's Hydro Nation 'Towards a water economy', it is estimated that the Water Technologies industry could be worth around £900 million per annum for Scotland.

The OECD estimates the current global market to be worth \$650 billion, and the United Nations is projecting global water demand will dramatically increase over the next two decades, with specific pressures and demands on water supply and infrastructure in developing countries.

Water policy review

Water is a global resource and Scotland is raising its international profile as a Hydro Nation through knowledge exchange and developing trade opportunities for services, manufacturing, research and supporting

international water aid. The Hydro Nation has identified innovation and growth in the water sector as a priority area and is delivering dedicated programmes of activity and support. Scotland has developed a highly-developed, diverse and specialised supply chain which can be exploited at home and internationally.

Scotland as a Hydro Nation will gain direct economic benefit and enjoy an enhanced international profile. In addition to Scottish Water, and its international arm, Scottish Water International, it is estimated there are over 200 companies actively working across the water and wastewater sectors in Scotland.

It is important to recognise that the supply chain includes the university and research and technical sectors. A report from Innovas Consulting into the make-up of the sector in Scotland highlighted the range of companies with a 'water technology' offer from start-ups to SMEs and larger established businesses.

Water market categorisation

The water sector in the UK operates on five-yearly cycles called Asset Management Plan (AMP) period and a six year cycle in Scotland. In the UK prices are set by Ofwat at the beginning of each period, following submissions from each company about what it will cost to deliver their business plans (asset management plans).

For the purposes of this report, the water market has been broadly categorised into 4 principal areas; clean water, wastewater, water management and services.

The classification / categories have been adopted to provide the current view of the water sector relevant for this project. This was achieved by integrating the findings from the Pale Blue Dot report, Assessing International Water Market Opportunities Report (Arup), Assessing India Water Security (Defra report) and consulting key Arup Experts.

1 = High Priority
2 = Medium Priority
3 = Low Priority

5.2 Water Market Segmentation Table

Table 4: Water Market Segmentation Table

Business Sector	Categories	Market size ¹	Market size rank	Immediacy	Barriers	Relevance (target oil and gas sectors)	Identified Oil & Gas hot spots
Clean Water (Water Sourcing, Treatment and Transport)	Water Sources and treatment	£900m - £3bn	1	2	2	2	Water Treatment Equipment (including Novel Technology), drilling / boring / pumping equipment and piping components, well engineering/design, reservoir modelling/development, mechanical engineering
	Water transport and pipelines	£400m - £600m	3	2	3	1	Piping equipment/components, controls, sensing monitoring & communication equipment, leak detection and control equipment
Wastewater	Municipal & Industrial Wastewater Treatment and Reuse	£2bn - £6bn	1	1	2	1	Process, Pumping and Power Systems, Control, Sensors, Monitoring & Communication and Instrumentation / process control, Engineering, Design & Construction, Production / Process / Accommodation Modules & Equipment, Waste Treatment, Management Cleaning & Disposal
	Municipal & Industrial Wastewater Transport and Pipelines	£400m - £600m	3	2	3	1	Piping Equipment / Components, Drilling / boring / pumping equipment
Catchment Management	Flood Management and Defences	£3bn - £5bn	1	2	3	3	Piping Equipment / Components, Sensors, Monitoring & Communication and Instrumentation / process control
	Urban drainage	£2bn - £3.5bn	1	2	2	3	Piping Equipment / Components, Water Treatment Equipment (including Novel Technology)
	SMART Water Management	£1bn - £2bn	1	2	2	1	Controls, sensing, monitoring & communication equipment and Instrumentation / process control, Data Management - Software, Storage & Management, Data Acquisition / Processing, and Data Interpretation / Evaluation, Well testing, control and monitoring, Reservoir Modelling / Development, Inspection / Repair / Maintenance
Services	Operations and Maintenance	£500m - £1bn	2	3	2	1	Pipe inspection, repair and maintenance, Water quality testing, control and maintenance, HSSE, Inspection/ Repair/ Maintenance, Subsea Inspection / Repair / Maintenance
	Professional Services	£500m - £1bn	2	1	3	2	Hydraulic and Sewer Flow Modelling, Geoscience survey / studies, Network Management, Engineering design and construction, Wastewater Management

5.3 Business Sector Summaries

Municipal & Industrial Wastewater Treatment and Reuse

The UK is a world leader for sewage treatment, renowned for its ability to turn wastewater into a resource. The UK water industry has 9,000 wastewater treatment plants¹. The oil and gas industry is also renowned for its expertise in managing wastewater created during oil and gas production.

Market Size

GW1 estimates water companies in the UK will spend an estimated £21 billion on wastewater treatment and conveyance throughout AMP 6. For the ten water and sewerage companies in the UK planned expenditure on water and wastewater amounts to £37.4 billion; representing a sizeable proportion of total UK water industry expenditure, and potential market opportunity². GW1 expects total spend on water treatment in the UK to peak in 2018/19 at £1.3bn, it is therefore estimated that the market size by 2025 is between £2bn – 6bn.

Immediacy

Current expenditure on maintaining and enhancing wastewater treatment standards is expected to accelerate as it is believed that much of the UK will be considered “water stressed” by 2025. UK water and sewerage

companies’ predicted wholesale wastewater expenditure totals £21 billion throughout AMP6, thus demonstrating an immediate and ongoing investment into the UK wastewater industry².

Barriers / Risks

Global water shortages could bring about an advancement in cheaper wastewater treatment technologies, in particular desalination. This international competition to provide cost-efficient treatment services may present a potential barrier for oil and gas industries, as cheaper imported wastewater treatment equipment may take precedence over their expertise in newer technologies in countries facing extreme water shortages.

Relevance

The Overall Performance Assessment (OPA) for Scottish Water 2014 -15 reported a positive overall performance, however some areas which require improvement were identified. Elements highlighted as a concern were most notably wastewater treatment works³

Eight barrels of wastewater are created for each barrel of oil produced. The largest by-product of oil and gas production is so-called “produced water” which contains hundreds of chemicals known to be detrimental to public health and the environment if not managed correctly.

The most prominent opportunity to the oil and

gas companies is the pollution prevention technologies used in treating “produced water”, which can be easily transferred to the wastewater industry. The expertise within the oil and gas industries of the effects of wastewater on soil properties can provide a foundation for wastewater companies on remediation of affected soils⁴. This knowledge can be applied across the UK, as well as the plant and equipment for treatment processes, in particular that used for reverse osmosis.

Analysis of current literature and stakeholder interviews indicated that Scotland has a relatively low capability across the supply chain in; heat recovery from pipes, nutrient recovery (in particular, Phosphorus and Nitrogen), Bio-refinery and also in industrial water reuse. There are a number of synergies technically in these processes when compared to upstream oil and gas processes. Therefore, it can be concluded that there may be an opportunity for the oil and gas supply chain to target these areas.

Hot Spot Analysis

The principal areas of crossover between wastewater between oil and gas and wastewater include:

- Process, Pumping and Power Systems
- Control, Sensors, Monitoring & Communication and Instrumentation / process control
- Engineering, Design & Construction

- Production / Process / Accommodation Modules & Equipment
- Waste Treatment, Management Cleaning & Disposal

Arup Expert View

Thomas Sagris

- Associate
- Wastewater Treatment
- Thomas.Sagris@arup.com

Martin Shouler

- Associate Director
- Water Reuse
- martin.shouler@arup.com

1. <http://www.watercommission.co.uk/UserFiles/Documents/Performance%20Report%202014-15.pdf>, 2. https://www.globalwaterintel.com/client_media/uploaded/Chantal/market%20profile%20sample.pdf, 4. <https://www.hindawi.com/journals/aess/2016/2707989/>, <http://www.water.org.uk/policy/environment/waste-and-wastewater>, 3. <http://www.watercommission.co.uk/UserFiles/Documents/Independent%20Assuror%20-%20Report%20on%20growth%20FINAL.pdf>

5.3 Business Sector Summaries

Municipal & Industrial Wastewater Transport and Pipelines

Both across the UK and worldwide there is an increased focus on the rehabilitation of existing sewage pipelines and the creation of new ones.

Market Size

The global forecast of capital spending on sewage by 2018 is £88bn; the UK aims to have a 10% share of this by 2030 (Water Briefing, 2014). A revenue forecast by Frost and Sullivan predicts the European wastewater network rehabilitation market to rise from €1.43bn in 2017 to €1.78bn in 2021, for which the UK's market share in this industry is predicted to rise to 14.3% by 2021. Using these estimations the market size is predicted to be £880mn-£1bn by 2025.

Immediacy

Scottish Water has gone out to tender with a contract worth up to £340 million for its wastewater infrastructure programme between 2015-21. Subject to reviews, then the contract may be extended into the next regulatory period 2021-27. The scope of works will include renewals and modification, maintenance and refurbishment of the sewage networks and pumping stations as well as new assets (Water Briefing, 2014). Sewer rehabilitation aims to maintain and

improve the sewer network and maintain and improve serviceability targets, a goal which all sewage companies across the company are striving towards achieving now, and will continue to invest in this in the future.

Barriers / Risks

There is significant competition from international competitors in the market, offering cheap manufacture of materials and equipment, particularly in China. With the established market competitors in the UK offering cheaper international imports, the barriers to market entry are challenging.

In addition to strong market competition, the Scottish and UK government targets are focused on sustainable industrial water usage and treatment, thus the focus of investment lies in this sector more significantly than in wastewater transport and pipelines. Furthermore, framework contracts with alliances of consultants/contractors are awarded every 5-15 years which may present an additional potential challenge to market entry.

Relevance

The oil and gas industry, heavily reliant on water, are always looking into ways to conserve energy and increase efficiency in wastewater treatment and transport in today's current climate. As experts in underground utilities the oil and gas industry have developed skills and equipment readily

available to be utilised by sewage companies across the country.

In addition to crucial sewer network improvement, there is a need to provide efficient ways to manage the increasing amount of sludge created as wastewater production across the country rises. With the greater volumes of sludge being produced more pressure is being put on existing infrastructure to pump and transport sludge to points of disposal. This increase in sludge management, which requires treatment and transportation, goes hand in hand with the oil and gas expertise for wastewater management underground pipe networks as transportation methods. Although not the most commonly used method, sludge transportation by truck/boat is also an opportunity to be explored by oil and gas companies.

Hot Spot Analysis

The crossovers between water transport and pipelines, and the oil and gas industry include:

- Piping Equipment / Components
- Drilling / boring / pumping equipment#

Arup Expert View

Thomas Sagris

- Associate
- Thomas.Sagris@arup.com

Martin Shouler

- Associate Director
- martin.shouler@arup.com

<https://www.waterbriefing.org/home/water-issues/item/8863-uk-water-tech-sector-must-act-fast-to-win-%C2%A388bn-share-of-global-market-by-2030>

<https://www.waterbriefing.org/home/contracts/item/8867-%C2%A3340m-scottish-water-civils-contract-out-to-tender>

5.3 Business Sector Summaries

Clean Water (Water Sources and treatment)

Across the world desalination continues to be a rapidly growing industry as arid countries rely more heavily on seawater as a large percentage of water supply as groundwater and river supplies dry up. Depleting water supplies, affecting mainly the South East of the UK, are driving a market for new water sources, in particular desalination technology.

Market Size

With growing pressures on water supply resulting from climate change and population growth, the UK water industry plans to invest at least £5bn a year for the next 5 years, with clean water treatment being of rapidly increasing importance and water stress in cities becomes a pressing issue (Water, UK).

Membrane technology reverse osmosis (RO) is likely to see the largest growth in water treatment, with the global market reaching \$39.46 billion by 2020 (Membrane technology, 2011).

It is assumed that with increasing demand for clean water supply the market will continue to grow by 2025, thus market size is estimated at £900m - £3bn.

Immediacy

The immediacy of introducing new water supplies varies significantly with the degree of water stress in different regions of the UK. In

Scotland, Wales and Northern Ireland desalination as a new source water supply is not generally regarded as an economically viable option as these areas are in lower levels of water stress. Whereas in other areas, most prominently in London, alternative water supplies to meet the demand of the growing population are being sought now as a solution to imminent water scarcity, alongside the need to urgently repair the existing water networks and reduce leakage and water wastage. The Institute of Chemical Engineers predicts at least four major municipal desalination plants will be built on UK coastlines by 2050, and up to 800 smaller units. It is predicted that the number of desalination units across the world will double by 2050 (WaterWorld, 2015). Therefore, desalination opportunities are likely to be longer term as water scarcity issues are of growing, ongoing concern.

Barriers / Risks

Desalination is believed by some to be an expensive, needless solution to water scarcity in the UK. Experts argue that the focus of investment should be put into repairing existing leaking infrastructure to reduce wastage and improve sustainability. Legal challenges to reverse the planning permission for Thames Water desalination plant reflected much of the general public's discontent with the scheme, however, this issue was overruled by the expected population growth in London predicted to

cause a huge deficit in water supply. With climate change and population growth in cities more prominent now than ever, sourcing alternative water supply is of growing interest to the water industry.

Relevance

The oil and gas industry has driven a huge amount of technology development within the desalination industry, and owns a 14% market share in desalination. 60% of the world's desalination processes use reverse osmosis, a treatment process for which the oil and gas industry is a pioneer.

Thames water opened its first desalination plant in 2010 capable of providing up to 150 million litres of treatment drinking water per day. The plant uses a four stage process, including reverse osmosis, suggesting that oil and gas industries have significant potential opportunities for future UK, as well as global, desalination plants. Other desalination technologies commonly used, such as granular activated carbon, also present further potential market opportunities as the oil and gas industry already possesses vast assets to be utilised in these sectors.

Considering desalination opportunities outside of the UK, engineering consultancies across the UK are providing their expertise in water treatment projects, often desalination plants, to dry countries such as Jordan where increasing percentages of the countries' water supply comes from desalinated water.

Hot Spot Analysis

The crossovers between clean water sources and treatment are:

- Water Treatment Equipment (including Novel Technology)
- Drilling / boring / pumping equipment and piping components
- Well Engineering / Design
- Reservoir Modelling / Development
- Mechanical Engineering

Arup Expert View

Vince Glancy

- Associate Director
- Process Engineering
- Vincent.Glancy@arup.com

Jordan Rogers

- Senior Engineer
- Process Engineering
- jordan.rogers@arup.com

Sources: Membrane Technology, Volume 2011, Issue 10, October 2011

5.3 Business Sector Summaries

Clean Water (Water Transport and Pipelines)

Scottish Water, together with the Water Industry Commission for Scotland are working towards reducing leakage and creating economical, sustainable water networks throughout their 29,910 miles of water supply pipes through efficient maintenance, operation and repair.

Market Size

It is estimated that the potential global market opportunities for leakage minimisation and pipeline rehabilitation is between \$3-5 billion.

The UK currently represents 3% of the global market, which could increase to 10% by 2025 meaning potential market opportunities could increase from \$250 million to \$500 million for clean water network repair and rehabilitation. Therefore a potential market size has of £400 million – 600 million has been estimated.

Immediacy

Potential long term opportunities in the clean water sector are the ongoing maintenance and operation of water supply networks. However, more immediate opportunities to be considered are those in the wind farm industry, which is seeing huge growth and investment in Scotland to construct new wind farms. The construction of the associated infrastructure represents a potential entry into the water supply market through the oil and

<http://utilityweek.co.uk/news/scotland-thumbs-up-for-new-onshore-windfarm/1306652#.WWOIgoTytOR>
<https://www.hnwis.scot/media/1101/2-launch-event-seonaid-vass.pdf>

gas industries equipment and knowledge of underground water networks.

Barriers / Risks

Despite the UK's success in detection and repair of leaks to water networks, large losses due to leakage are still being reported. While this may present as an opportunity for oil and gas companies in network management, it is worth noting that many water utilities in the UK are operating at the Sustainable Economic Level of Leakage (SELL). This is determined by OFWAT (regulator) for each individual utility. Therefore, there is little incentive due to marginal gains for the utility to invest more heavily in reducing leakage and improving network management. This may act as a hindrance for market entry.

Relevance

With vast knowledge in water network management, repair and rehabilitation the oil and gas industry possesses a wealth of knowledge and skill relevant to the ongoing improvement works to water networks across the UK. This offers a potential large scale, long-term prospect for the oil and gas industry to share skills in rehabilitation and maintenance of underground water networks in support of an ongoing, important target across the Scottish Water Industry, as well as the rest of the UK, to reduce leakage.

Hot Spot Analysis

- Piping Equipment / Components
- Controls, sensing, monitoring & communication equipment
- Leak detection and control equipment

Arup Expert View

Philip Songa

- Senior Engineer
- philip.songa@arup.com

Peter Edwards

- Associate Director
- Peter.Edwards@arup.com

5.3 Business Sector Summaries – Water Management

Urban Drainage

With strategic design SUDS can be used as a facilitator to recharge groundwater and effectively manage storm water, providing positive environmental impact in urban areas and minimise the impacts of storm events. In Scotland, and many built up areas of the UK, managing surface water via innovative urban drainage design is of huge significance in the holistic water management initiatives by the government.

Market Size

A report published by the UK Water Research & Innovation Partnership (UKWRIP) says that huge commercial opportunities will be available smart flood protection and Sustainable Urban Drainage Systems (SUDS) with an estimated global market of \$20-35billion, of which the UK aims to represent 10% of by 2025. Additional reports from UKWRIP identifies a potential market value of £12-21bn for smart flood protection combined with sustainable urban drainage systems by 2020, suggesting the market will continue to grow. Using this information the estimated market size for Urban Drainage in the UK is between £1.5bn-3bn by 2025.

Immediacy

With stresses from climate change meaning the UKs infrastructure needs to be more and more resilient to storm water and flooding, there is growing pressure on existing

drainage and sewage systems, particularly in built up cities which require innovative sustainable drainage solutions.

The 2014 report by UKWRIP says that “huge commercial opportunities will be ripe for exploitation” within the next six years, including the potential market for SUDS.

In April 2016 a new government planning policy on eco-friendly sustainable drainage systems for major housing developments came into effect, resulting in SUDS being a key design consideration in built-up areas.

Barriers / Risks

It has been reported that there have been limited opportunities for UK firms to develop activities in SUDS, and suggest a low, and decreasing, R&D spend is partly to blame for this.

Some reports suggest that the UK currently significantly underperforms in many areas of sustainable drainage, partly due to the lack of regulatory incentives for innovation and a comparatively low research and development spend in comparison to other world leaders (Water Briefing, 2014).

Relevance

Smaller scale SUDS strategies used by the oil and gas industry for large onshore facilities where localised flooding requires management are transferrable to larger scale urban developments which require innovative

solutions to manage wastewater without causing harm to the environment. Additionally, the treatment used by oil and gas companies to treat produced water can be utilised in commercial and industrial applications where monitoring effluent is necessary to ensure required standards are met to minimise negative environmental impact of wastewater discharged via SUDS. In all urban developments the design, operation and maintenance of water treatment plants and drainage networks is a key consideration.

Hot Spot Analysis

- Piping Equipment / Components
- Water Treatment Equipment (including Novel Technology)

Arup Expert View

Paul D Davies

- Associate
- paul-d.davies@arup.com

Richard Brown

- Associate
- richardc.brown@arup.com

Peter Holt

- Senior Engineer
- Peter.Holt@arup.com

<https://www.waterbriefing.org/home/water-issues/item/8863-uk-water-tech-sector-must-act-fast-to-win-%C2%A388bn-share-of-global-market-by-2030>
http://wwtonline.co.uk/news/uk-falling-behind-on-innovation-investment#.WW_I4ITyupo

5.3 Business Sector Summaries

Flooding

Market Size

The UK has faced and overcome flooding challenges for centuries, and therefore has developed strong expertise in forecasting, modelling and mitigating flood events. This field requires a high level of training and expertise. By 2021, the government plans to invest approximately £2.5 billion in flood defences across the UK and more than 1,400 flooding schemes and coastal erosion projects are needed to be delivered. With the risk of climate change worsening the effects of flooding in the UK this market is predicted to continue to grow. Therefore the estimated market for flooding in the UK is by 2025 is between £3bn - £5bn.

Immediacy

Lessons learnt from recent flooding in the UK have sought a revised approach to flood resilience and has concluded that better protection and risk mitigation needs to be implemented as soon as possible – by 2021. In July 2016 Scottish government set out £420m flood defence plans for 10,000 homes (£42m a year for 10 years). The project will deliver 40 new flood protection projects and flood risk management plans (Water Briefing, 2016).

With large investment into flood defence over the next 10 years, significant immediate and longer term opportunities are available.

<https://www.gov.uk/government/news/new-plan-for-stronger-flood-defences>

Barriers / Risks

The UK is a global leader in flood defences and management, with market competitors among the best in the world. With few specific, relevant hotspot areas identified, it would be costly for the oil and gas industry to transfer its skills to focus on flood management. With significant, well-established competition in the market, and significant investment required to enable transition into the market it, the challenges are great for entry to this market.

Relevance

Outside of general surface water management strategies, more closely related to SUDS than flood defences, it is hard to identify clear links between the flood defence sector and the oil and gas industries.

Hot Spot Analysis

There is potential in the following sectors for oil and gas to cross over:

- Piping Equipment / Components
- Controls, sensing, monitoring & communication equipment
- Instrumentation / process control

Arup expert view

Will McBain

- Associate Director
- Will.McBain@arup.com

David Wilkes

- Associate Director
- david.wilkes@arup.com

Siraj Tahir

- Senior Engineer
- Siraj.Tahir@arup.com

5.3 Business Sector Summaries

Smart Water Management

Smart Water Management can be divided into three sub sectors: advanced water meters, smart water solutions and smart services. For the purposes of this report services will be included in Section 5.5 of the report.

Advanced water meters can be broken down to include meter type and meter read technology. While Smart water solutions comprises the following areas; asset management, pressure management, network monitoring, advanced analytics, meter data management, SCADA systems, water efficiency methods and smart irrigation.

Market Size

The global water size for smart water management is estimated to grow to between \$16 – 23 billion by 2020. Research has indicated that the UK could potentially capture 10% of this global market in water technology by 2030. Therefore, it is estimated that the current share of approximately £1.5 billion will grow to £8.8 billion by 2030.

Immediacy

Water services providers face unprecedented challenges to their businesses. Our climate is changing and becoming increasingly unpredictable: energy costs are rising; populations and their needs for water services are growing; regulatory pressures to

improve operational efficiency and to increase environmental standards are mounting; and economic uncertainty is complicating investment planning.

The key to addressing these challenges lies in gaining a better understanding of current operations, asset performance and what the future is likely to bring. This understanding comes from making intelligent use of the data that is available, in exponentially increasing volume and variety, from a multitude of sources including operating infrastructure, environment, customers, equipment providers, weather bureau and many others.

The view from the UK Government and OFWAT is strengthening toward the value of Smart Water Management. Consequently, opportunities may present in a relatively short time period.

Barriers / Risks

Major competitors

Currently, operating in Smart Water Management in the UK are a number of international players including: iABB Group, IBM Corporation, Schneider Electric, General Electric Company, Itron, and Siemens. These established companies with pre-existing relationships and contracts may pose as a considerable barrier for the Scottish oil and gas Supply chain.

Also worth considering is the appetite and drive from the water utility to move toward

smart meters and smart infrastructure. The business case for smart metering is not well defined and the costs and benefits are not well understood in the water industry.

Therefore, in Asset Management Planning 7 (AMP7) which runs from 2020-2025, the utilities may still not be looking toward transitioning toward Advanced Meter Infrastructure (AMI) in this period.

This may act as a hindrance and limit the opportunity for the oil and gas supply chain over the next 8 – 10 years.

However, it is also worth noting that a deeper understanding and insight into these costs and benefits more the more advanced oil and gas capability may provide knowledge and technology transfer opportunities.

Relevance

Analysis of the Scottish water industry supply chain indicated that there are a number of limitations to the offerings in advanced water meters and smart water solutions.

In particular, limited capability was identified in the supply of AMI and related meter reading technology in Scotland. Sensors, controls, flows, telemetry, remote inspection and data management were also identified as weaker areas across the supply chain in water.

Comparatively, the oil and gas sector has a much stronger offering in some of these areas due to the nature of the market and the

potential threat to the environment through mismanagement of resources.

Hot Spot Analysis

- Controls, sensing, monitoring & communication equipment and Instrumentation / process control
- Data Management - Software, Storage & Management, Data Acquisition / Processing, and Data Interpretation / Evaluation
- Well testing, control and monitoring
- Reservoir Modelling/ Development
- Inspection / Repair / Maintenance

Arup Expert View

Ian Gray

- Associate Director
- Ian.Gray@arup.com

Mark Fletcher

- Global Water Lead
- Mark.Fletcher@arup.com

5.3 Business Sector Summaries

Professional Services

Market Size

The UK is home to a large number of highly skilled professional service companies. With growing global water challenges including scarcity and flooding, consultancies are being looked to, to provide new innovative ideas to overcome the uncertain future.

UK water utilities are spending \$5.17 billion in services each year to develop these integrated water-resource management solutions and techniques. Professional services within the water industry generate £510 million in the UK, part of a £12.3 billion global market.

Within the current UK Asset Management Plan (AMP) 6, water utilities are planning on spending a totex of £41 billion, much of which will require consultancy advice from innovation ideas to design.

Immediacy

As the worsening effects of climate change and exponential population growth are observed around the world, water leaders are becoming increasingly aware of the urgent need to find long lasting innovative solutions, immediately.

Thames Water (TW) is facing a water deficit by 2025 and are looking to consultancies for innovative ideas to address this supply demand gap. In response, TW have set up a

new mega contract, the Technology and Transformation Alliance which is estimated to be worth £340 million over the remaining AMP6 period. It was awarded to Accenture, Bilfinger, Deloitte and IBM to tackle the digital market help implement converging technologies.

This is the type of contract that utilities throughout the UK are putting out to tender more frequently to ensure innovative ideas and technologies are being developed and to help tackle challenges such as water scarcity and flooding.

Barriers / Risks

A barrier to entry for oil & gas supply sector professional service companies could be that they will be competing with limited knowledge / experience and competing with globally reputable professional services companies that already have a very strong footing in Scotland.

Relevance

While the whole water sector professional services requires extensive specialist technical knowledge and experience, many professional services in the UK are multi-disciplinary, so there is potential for knowledge transfer from water to oil and gas within individual companies. Large consultancies such as Arup, Mott MacDonald and Atkins as well as SMEs are well placed to consider knowledge transfers as increasing

global water challenges prove the need to expand their water businesses whilst their oil and gas businesses are forecast to decline due to significant challenges such as declining crude oil prices, governments zero carbon initiatives and focus shifting to renewable energy.

Hot Spot Analysis

The industry crossovers from oil & gas to professional services crossovers include:

- Hydraulic and Sewer Flow Modelling
- Geoscience survey / studies
- Network Management
- Engineering Design and Construction
- Wastewater Management

Arup expert view

Steve Lloyd

- Head of Management Consulting
- Steven.Lloyd@arup.com

Peter Edwards

- Associate Director
- Peter.Edwards@arup.com

5.3 Business Sector Summaries

Operations and Maintenance

The efficient operation and maintenance of property and equipment are of growing importance throughout the water industry as a drive to increase efficiency is reflected in investments

Market Size

Sources suggest that the global market value in 2016 was £190bn, including both services and equipment related to operations and maintenance. With the market predicted to experience considerable growth, the UK market size is approximately £5-10bn by 2025 (with a 3% growth rate). The operational and maintenance “services” are estimated to account for 10% of this market, hence the market size for services in the Municipal Water Industry for Operations and Maintenance could be between £500m-£1bn.

Immediacy

Predictive maintenance is now being applied by water utilities in asset and network management. For example, companies are now able to monitor and predict when pumps found in water and wastewater treatment facilities are likely to fail. As a result, engineers are able to service these assets appropriately, avoiding costly unplanned failures and disruption to customers. Applications are also being developed to implement predictive technology into households. This will potentially help predict

incidents, such as sump pump failures.

Barriers / Risks

There are already several, well-established competitors within the market, at both a domestic and international scale, presenting a notable barrier for the oil and gas industry. It may be a difficult market to penetrate as contracts are secured through frameworks.

Although the technology crossover and approach is similar and therefore clear parallels can be drawn between the two industries, the profit margins are lower in the water industry than in oil and gas, thus this market may be less appealing.

Relevance

There are clear crossovers in oil and gas processes that transfer to the water industry operations and maintenance. Due to the hazardous nature of the oil and gas upstream process, procedures within the industry are well developed and a particular strength of the industry. These include the network and monitoring to control the threats posed by hazardous substances.

Additionally, buildings and structures could be designed to incorporate operational systems, sensors and maintenance, reducing the need for large accessible areas to perform maintenance.

Hot Spot Analysis

- Operations, Maintenance, Modifications

and Decommissioning

- Controls, sensing, monitoring and communication
- Instrumentation / Process Control
- Well Testing, Control and Monitoring
- Network Modelling / Management
- HSSE Inspection / Repair / Maintenance

Arup expert view

Steve Lloyd

- Head of Management Consulting
- Steven.Lloyd@arup.com

Fred Mukonoweshuro

- Associate
- Fredrick.Mukonoweshuro@arup.com



Energy Storage & Systems Market Assessment

6.1 Energy Storage Market Overview

Introduction

Energy storage includes a wide range of technologies, such as pumped hydro and batteries, which can be deployed at various scales and levels of the energy system. Storage technologies are able to absorb and release energy when required, offering great benefits in terms of power system stability and resilience, as well as enabling flexibility and integration of low carbon technologies.

The energy storage market is still a relatively new and expanding market. Energy storage in the UK has been gaining increased attention in the recent years due to significant increase in renewable energy supplies and increasing pressure on the electricity distribution network.

Developers and commentators endorse the ambition to increase the energy storage in the UK by 2,000 MW by 2020 (ELEXON). This indicates an overall potential energy storage market capital investment of about £1bn between now and 2020¹.

Energy storage policy review

Energy storage plays an important role for the decarbonisation of UK energy supplies but policy and regulation has been slow to adapt in order to ensure high storage penetration.

Historically in the UK, energy storage has not been recognised as either an activity or as asset class. The lack of a distinct

classification for energy storage has led to its classification as a generation asset, leading to major policy barriers.

A UK Government policy paper highlighted one of the key barriers to energy storage is that it is currently classified as demand and generation. This means that its use incurs two BSUoS charges and the Climate Change levy is also incurred twice. It should be noted that these charges are avoided when co-located with on-site renewable generation².

Additional barriers to deployment include:

- Limited knowledge of energy storage technologies
- High technology costs
- Lack of available finance
- Lack of available market products
- Lack of compensation mechanisms
- Minimum system requirements (operation and duration constraints)
- Policy barriers (lack of distinct energy storage classification, lack of specific regulations).

Energy storage market categorisation

The energy storage market is complex because of the many forms of energy storage technology and market areas that these can be deployed in. In order to appropriately assess the potential for oil & gas companies,

the market has been segmented by market areas rather than technology. Given that the energy storage market is still in relative infancy, this approach provides an overview of scale and immediacy without being technology specific. Technology specific crossovers with the oil & gas supply chain are then drawn out in order to identify suitable opportunities. The market areas have been classified as follows:

- Customer side storage solutions
 - Domestic storage
 - Non-domestic storage
- Utility side storage
 - Load shifting (diurnal and interseasonal)
 - Grid balancing services

1. https://www.elexon.co.uk/wp-content/uploads/2015/03/Electricity_storage_in_the_GB_market_March2015.pdf,

2. <https://www.publications.parliament.uk/pa/cm201617/cmselect/cmenergy/267/267.pdf>

6.2 Energy Storage Segmentation table

1 = High Priority
2 = Medium Priority
3 = Low Priority

Table 5: Energy Storage Segmentation Table

Energy storage / systems market categorisation	Sub-categorisation	Applicable battery technologies	Market size (£) ¹	Immediacy	Barriers	Relevance (target oil and gas sectors)	Identified Oil & Gas hot spots
Customer Side Storage Systems	Domestic Scale (Electrochemical storage)	Electrochemical batteries	£ 250-500 m	3	2	3	<ul style="list-style-type: none"> IT / Communications Electrical / electronic engineering
	Non-Domestic Scale (Electrochemical storage)	Electrochemical batteries	£ 200-500 m	3	2	3	<ul style="list-style-type: none"> IT / Communications Electrical / electronic engineering
Utility Side Storage Systems	Load Shifting (diurnal and interseasonal)	Electrochemical batteries Hydrogen storage Compressed Air Pumped hydro	>£1bn	2	2	2	<ul style="list-style-type: none"> IT / Communications Risk, cost & planning Process, pumping & power systems (relevant for pumped hydro) Drilling Geoscience surveys Electrical / electronic engineering
	Grid Balancing Services	Batteries Flywheels Pumped hydro DSR – Kiwi Power	£ 400-600 m	1	2	2	<ul style="list-style-type: none"> IT / Communications Risk, cost & planning Controls, sensing, monitoring & communication Electrical / electronic engineering
Energy systems	Sensors, controls and power electronics	n/a	>£1bn	1	2	1	<ul style="list-style-type: none"> Controls, sensing, monitoring and communication Rotating / power equipment Electrical / electronic engineering
Energy systems	Data analytics and ICT / Communications platforms	n/a	>£1bn	1	2	1	<ul style="list-style-type: none"> IT / Communications

1. Potential Market Size (2025, UK)

6.3 Business Sector Summaries

Customer side – Domestic scale storage

Market Size

The installation of energy storage at domestic level is currently closely linked to domestic solar photovoltaic. This is likely to remain the target market for domestic battery providers until smart meters are fully rolled out in 2020. The smart meters rollout is likely to lead to an increase in the use of time-of-day tariffs. These changes are likely to result in an expansion of the domestic energy storage market, as customers might install batteries at domestic level to reduce their energy costs (avoiding peak times).

However until 2020, the market size of domestic energy storage is likely to be proportional to the market size of domestic solar PV. In the UK there are 887,500 domestic PV installations¹.

Assuming an optimistic energy storage market penetration of approximately 10%, domestic energy storage has a potential market of about 80,000 households. This suggests a current domestic energy storage market size of about £250m.

Immediacy

Domestic battery storage is not yet considered a mature market and companies investing in this are still considered early market entrants.

1. <https://www.gov.uk/government/statistics/solar-photovoltaics-deployment>

Barriers / Risks

The main customer side domestic scale energy storage barriers / risks include the followings:

- High technology costs and limited available market products
- Lack of available finance
- Lack of compensation mechanisms
- Limited knowledge of energy storage technologies

However, the cost of batteries (especially lithium-ion batteries) has been forecasted to decrease substantially by 2020. This will lead to an improvement in domestic energy storage affordability and availability.

Relevance

Domestic battery storage technologies only include electrochemical batteries such as lithium ion and lead acid. There is a relatively limited crossover between upstream oil & gas companies and opportunities in the domestic energy storage market.

Hot Spot Analysis

Specific crossovers are predominantly in support services:

- IT / Communications
- Electrical / electronic engineering

Arup expert view

Steve Saunders

- Associate Director
- Steve.saunders@arup.com

6.3 Business Sector Summaries

Customer side – Non-domestic storage

Market size

Similar to domestic battery storage, the immediate opportunity for the non-domestic battery storage (customer side) market is for building owners who also have onsite generation.

In the UK there is approximately 4GW of medium size solar PV (installations between 10kW and 50 kW)¹.

Assuming a market penetration of about 10%, the customer side non-domestic energy storage market size to 2020 is approximately £200m.

Immediacy

Significant market penetration is not expected before 2020.

Barriers / Risks

The main customer side non-domestic scale energy storage barriers / risks include the followings:

- High technology costs and limited available market products
- Lack of available finance
- Lack of compensation mechanisms
- Limited knowledge of energy storage

1. <https://www.gov.uk/government/statistics/solar-photovoltaics-deployment>

technologies

However, the cost of batteries (especially lithium-ion batteries) has been forecasted to decrease substantially by 2020. This will lead to an improvement in energy storage affordability and availability.

A barrier to entry for oil & gas supply sector companies could be the limited knowledge/experience with the energy storage technologies.

Relevance

On-site non-domestic battery storage technologies only include electrochemical batteries such as lithium ion and lead acid. Similar to domestic batteries, battery storage technologies for the non-domestic market mainly include electrochemical batteries such as lithium ion and lead acid. There is a relatively limited crossover between upstream oil & gas companies and opportunities in the non-domestic (customer side) energy storage market.

Hot Spot Analysis

Specific crossover examples include:

- IT / Communications
- Electrical / electronic engineering

Arup expert view

Steve Saunders

- Associate Director
- Steve.saunders@arup.com

6.3 Business Sector Summaries

Utility Side – Load shifting (diurnal and inter-seasonal)

Market Size

Pumped hydro storage accounts for 99% of the energy storage capacity in the UK. There are currently four pumped hydro sites in the UK with a total storage capacity of approximately 24 GWh. No new plants have been constructed since 1984 but two are proposed at Glyn Rhonwy and Coire Glas that will require a £0.9bn investment^{1,2}.

Immediacy

The market for diurnal load shifting is developing rapidly but market opportunities outside of pumped storage are predominantly limited to electrochemical battery technologies. A particular focus for energy companies is the co-location of renewable assets with battery storage. Commercial opportunities in compressed air and hydrogen storage are unlikely to come to market before 2020.

Barriers / Risks

The relative infancy of the energy storage market means there are uncertainties over future government policy and market size. For example, significant investments such as the pumped scheme at Coire Gas are yet to receive confirmation of funding and these could significantly alter the long term opportunities for oil & gas companies looking

to diversify.

Relevance

The major opportunity for oil & gas companies is to utilise consultancy, drilling and geoscience expertise for compressed air and hydrogen storage opportunities.

However, these opportunities are unlikely to come to market before 2020. The exception for hydrogen storage may be at the Leeds hydrogen demonstrator project but this is still at an early planning stage and the developments should be closely followed by oil & gas companies in Scotland.

Hot Spot Analysis

Specific crossover examples include:

- IT / Communications
- Risk, cost & planning
- Process, pumping & power systems (relevant for pumped hydro)
- Drilling
- Geoscience surveys
- Electrical / electronic engineering

Arup Expert

Steve Saunders

- Associate Director
- Steve.saunders@arup.com

1. <https://www.edie.net/news/6/Green-light-for-first-UK-hydro-storage-project-in-30-years/>

2. <https://www.ice.org.uk/knowledge-and-resources/briefing-sheet/pumped-hydro-storage-and-the-coire-glas-scheme>

6.3 Business Sector Summaries

Utility Side – Grid balancing services

Market Size

The market size of balancing service contracts in 2016/2017 is approximately £590m. This is value of contracts awarded annually for grid balancing services.

Immediacy

The increase in renewable penetration has resulted in national grid developing multiple ancillary service offerings to provide different functions to the grid. A consultation is currently underway with the aim to simplify the services available and provide more assurance on long term investment risk as energy storage capacity increases.

Barriers / Risks

The major grid balancing services barriers are:

- Minimum system requirements (operation and duration constraints)
- Policy barriers (lack of distinct energy storage classification, lack of specific regulations).

High market saturation and competition also represent a barriers to entry for oil & gas supply sector companies.

Relevance

The most significant crossovers for oil & gas supply companies are in the planning and design of large scale storage facilities. However, electrochemical batteries and demand side response (DRS) have a much faster response time and the majority of frequency balancing services are being awarded to these technologies.

Hot Spot Analysis

Specific crossovers examples include:

- IT / Communications
 - Monitoring of plant and dispatching / switching off generation and demand requires communications infrastructure.
- Controls, sensing, monitoring & communication
 - Complex control systems are required to integrate DSR into electricity networks.

Arup Expert

Steve Saunders

- Associate Director
- Steve.saunders@arup.com

6.3 Business Sector Summaries

Energy systems – Instrumentation, controls, sensors & power electronics

Market Size

The global market size for controls and instrumentation is estimated to be worth £600Bn¹.

The power electronics market is valued at £135bn with a 10% compound growth rate. The UK market is valued at greater than £4bn but 90% of these services / products are exported abroad².

Immediacy

The power electronics industry has applications in many new 'smart energy' industries including DCAC conversion, smart controls / meters, energy storage, power quality devices and renewable power integration.

Barriers / Risks

Companies that provide power electronics, sensors and controls and highly specialised and therefore some of the diversification opportunities may have already been realised by companies. Analysis by TBR for Scottish Enterprise identified 30 companies in Scotland that provide powers electronic and controls / instrumentation. Arup have

undertaken further research on this list and all the companies that provide services to the Oil & Gas industry also provide services to other sectors. The most common sector crossovers were aerospace, energy utilities and industrial applications. However, new market opportunities in energy storage and heat will develop and the application of sensors / instrumentation in the water and heat sector is still at the relatively early stages (see section 5).

Relevance

Sensors and control instrumentation are widely used in upstream oil & gas processes and the application of sensors and control instrumentation is particularly relevant to geothermal, heat networks (pipelines) and widely relevant to the majority of energy storage applications. Similarly, power electronics are widely used across all smart energy (storage and heat applications) applications and the crossovers are significant.

Hot Spot Analysis

Specific crossovers examples include (score refers to relevance):

- Controls, sensing, monitoring and communication
 - Sensors have wide applications in pipe systems (district heating), geothermal systems (well monitoring) and also energy storage applications (pumped

- hydro and electrochemical storage)
- Rotating / power equipment
 - Power electronics equipment has a particularly strong crossover with large battery storage systems and their integration with the electricity grid.
- Electrical / electronic engineering
 - Specialist consultancy services for power electronics and sensors are particularly relevant to the energy storage market.

Arup Expert

Steven Saunders

- Associate Director
- steve.saunders@arup.com

Sources: 1. <http://census.org.uk/about/>, 2. <http://www.newelectronics.co.uk/electronics-magazine/supplements/outlook/growing-the-uks-power-electronics-sector/57577/>, [http://www.powerelectronics.ac.uk/documents/prof-bill-drury-\(1st-july\).pdf](http://www.powerelectronics.ac.uk/documents/prof-bill-drury-(1st-july).pdf)

6.3 Business Sector Summaries

Energy systems – Digital / ICT platforms & data analytics

Market Size

The global energy and utilities analytics market analytics is expected to grow to \$3.5bn by 2021 at a 13.5% compound growth rate¹.

Immediacy

The oil & gas industry was one of the first to capitalise on the potential benefits of big data analytics and ICT platforms. The use of data analytics has allowed oil & gas companies to increase production efficiencies, improve safety and increase monitoring of complex infrastructure. The use of data analytics has been further pushed by the reduction in the oil price that has resulted in companies looking for greater cost savings. The main use of big data in the energy storage and heat markets include optimising operation of assets to increase revenues and monitoring condition of assets to understand maintenance and safety conditions.

Barriers / Risks

Similar to the power electronics industry, the majority of companies providing data analytics services to oil & gas companies also work in the energy sector. However, the use of data analytics in the heat market is still at a

relatively early stage and it is estimated that data analytics could save the heat networks industry £400m in the next 10 years².

Relevance

There is a strong crossover between the use of big data in the oil & gas industries and other sectors. The relevance is particularly strong for the heat and water sectors where adoption of data use and ICT platforms is still at a relatively early stage.

Hot Spot Analysis

Specific crossovers examples include:

- IT / Communications
 - Digital platforms, data gathering and analysis services are all transferable to the heat, energy storage and water industries.
 - An example of this is the use of data to improve performance of heat networks by monitoring flow and return temperatures, pressures and flow rates at each point of hydraulic separation to reduce heat losses and improve system operation. Whilst the benefits of big data in energy storage applications are well understood and applied, the use of data analytics in the heat industry is still at a relatively early stage.

Arup Expert

Steven Saunders

- Associate Director
- steve.saunders@arup.com

1. http://www.marketsandmarkets.com/Market-Reports/energy-analytics-utility-market-993.html?gclid=EAlaIqobChMI74CJo7IX1QIVYrXtCh2EEATqEAAYAIAAEgJ_hfD_BwE

2. <http://www.gurusystems.com/2016/11/18/guru-pinpoint-could-save-uk-energy-market-400-million-in-next-10-years/>



Hot Spot Analysis

7.1 Hotspot Approach

The hotspot analysis utilises the outputs from the Literature Review and Market Assessment to conduct a high level mapping exercise. This mapping process identified “hotspot” sectors and sub sectors where capability in the Scottish oil and gas supply chain matched identified opportunities across Heat, Water and Energy Storage / Systems. A ranking system was then implemented to prioritise these hotspots into high priority areas (primary), medium priority areas (secondary) and not viable opportunities in alternative markets (tertiary).

Ranking Process and Approach

Primary – High priority areas of opportunity

Filter opportunities to consider only those areas which scored a maximum of 6/12 on the overall assessment.

Secondary – mid tier levels of opportunity

Consider other opportunities which:

- Scored at maximum of 7/12 on the overall assessment.
- Scored a 1 on the relevance ranking.
- Where they represent a good fit and could be grouped as an offering with other Hot Spots.
- Conduct a further review of barriers and consider whether opportunities should be progressed in the deep dive assessment.

Tertiary – not viable opportunities

Opportunities were not included in the deep dive if they:

- Scored 8/12 or more on the assessment.
- Did not score a 1 on the relevance ranking.
- Were not a clear fit as part of another offering.

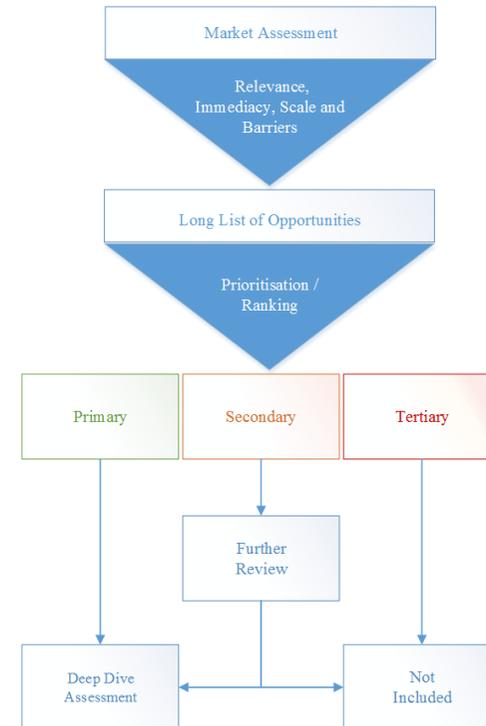


Figure 6: Hotspot Prioritisation Process

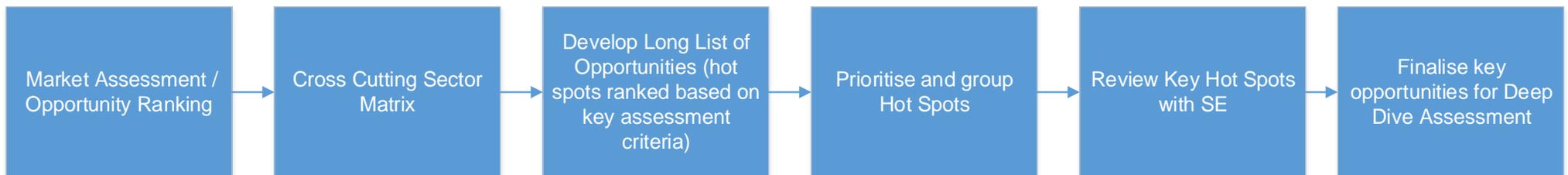


Figure 7: Hotspot Methodology

7.2 Hotspot – Primary Opportunities

Primary Opportunities

The information captured in Table 6 summarises the key scoring for each of the primary hotspot /opportunity areas determined through the market assessment. All of these areas will be analysed further in the Deep Dive Assessment.

Table 6: Primary opportunities

Market	Business Sector	Categories	Market size / Investment potential (by 2025)	Market size score	Immediacy	Barriers	Relevance	Total Sum
Water	Wastewater	Wastewater treatment and reuse	£2bn - £6bn	1	1	2	1	5
Heat	Heat delivery infrastructure	Heat networks (pipeline and including waste heat)	£2bn - £3bn	1	1	1	2	5
Water	Catchment Management	SMART Water Management	£1bn - £2bn	1	2	2	1	6
Energy Systems	Sensors, controls, instrumentation and power electronics		>£1bn	1	1	2	1	5
Energy Systems	Data analytics and ICT / Communications platforms		>£1bn	1	1	2	1	5

7.2 Hotspot – Primary Opportunities

Primary Opportunities

The information below outlines the key reasons why the hotspot /opportunity was included in the Deep Dive Assessment.

Energy Systems

Sensors, controls, instrumentation and power electronics

There are a number of crosscutting opportunities for this sector across all of the heat, water and energy storage markets assessed. Markets taken forward for the deep dive assessment will specifically assess the potential diversification opportunities related to sensors, controls, instrumentation and power electronics. Therefore, this sector will be assessed with relation to heat networks, geothermal and wastewater and water treatment.

Data analytics and ICT / Communications platforms

There are a number of crosscutting opportunities for this sector across all of the heat, water and energy storage markets assessed. Therefore, markets taken forward for the deep dive assessment will specifically assess the potential diversification opportunities related to data analytics and ICT communication.

Heat Delivery Infrastructure

Heat networks (pipeline and including waste heat)

The heat network industry is growing rapidly and the government has announced future funding support. There are strong crossovers with the oil and gas industry and there are immediate and longer term market diversification opportunities. This category has therefore been progressed for a deep dive assessment.

Catchment Management

Smart Water Management

The smart water management market is predicted to grow considerably over the next 8 years. There are a number of direct technology crossovers, limited barriers to entry and a relatively large market size that could be explored by the oil and gas supply chain. As such, this hotspot will be explored further in the deep dive assessment.

Clean Water and Municipal & Industrial Wastewater

Municipal & Industrial Wastewater treatment and reuse

There are strong, evident crossovers with the wastewater treatment industry, in particular regarding the increasing market opportunities in reverse osmosis technologies and the treatment of industrial wastewater using novel

technologies, which are also closely linked. These technologies can also be utilised in clean water supply chains as the desalination market increases rapidly across the world. In addition, there are limited barriers to entry into industrial wastewater treatment markets when compared to the strong barriers posed by alliance frameworks in the municipal market. However, there may be an opportunity for sub contractors or tier 3 manufacturers to target these types of opportunities. Therefore, this will be considered for deep dive assessment alongside clean water treatment technologies.

7.3 Hotspot – Secondary Opportunities

Secondary Opportunities

The information captured in Table 7 summarises the key scoring for each of the secondary hotspot /opportunity areas determined through the market assessment. The majority of these areas have been integrated into the primary opportunities and included in the deep dive assessment. However, some areas have not been included and the discerning factors have been discussed on the following page.

Table 7: Secondary opportunities

Market	Business Sector	Categories	Market size / Investment potential (by 2025)	Market size score	Immediacy	Barriers	Relevance	Total Sum
Heat	Heat generation	Geothermal	£30m - £100m	3	2	1	1	7
Heat	Heat generation	Hydrogen production	£1bn	1	3	2	2	8
Water	Services	Operations and Maintenance	£500m - £1bn	2	3	2	1	8
Water	Wastewater	Municipal & Industrial Wastewater Transport and Pipelines	£880m - £1bn	2	2	3	1	8
Water	Clean Water	Water transport and pipelines	£400m - £600m	3	2	3	1	9
Water	Clean Water	Water Sources and treatment	£900m - £3 bn	1	2	2	2	7
Heat	Associated services	Operation, maintenance metering and billing	£3.2bn to £6.4bn (2025)	1	1	2	3	7

7.3 Hotspot – Secondary Opportunities

Secondary Opportunities - Included

The information below outlines the key reasons why the hotspot / opportunity was included or excluded from the Deep Dive Assessment. A number of secondary opportunities have been integrated into other areas rather than excluded completely from the assessment.

Heat Generation - Geothermal

There are direct crossovers between the geothermal sector and oil and gas companies. The main risk is the growth of the market as geothermal is still relatively unproven in the UK. The growth of the heat networks market is likely to support the growth of geothermal and there could be significant expansion if pilot wells prove successful. Geothermal was selected for the deep dive assessment because of the direct relevance with oil and gas and potential market growth.

Clean Water - Water Sources and treatment

There are notable crossovers between clean water sources and treatment, which are also linked to wastewater treatment technologies. oil and gas industries are global leaders in water treatment technologies directly applicable to desalination. Although desalination is considered a future market opportunity for the UK (post 2050), and more immediate globally, the technologies are

ready to be utilised in other sectors. Therefore, due to potential market size and highly relevant crossovers between sectors, this will be further analysed in the deep dive assessment in conjunction with wastewater treatment technologies.

Heat – Associated Services - Operation, maintenance metering and billing

The operation and maintenance of heat networks and customer services is also a growth market. oil and gas companies are well positioned for the infrastructure monitoring and maintenance but not customer services. Operation and maintenance will therefore be included under heat networks in the deep assessment.

Services – Operation & Maintenance

Ageing infrastructure combined with a large number of municipal and industrial wastewater treatment plants in the UK is driving growth in this market. oil and gas companies are well positioned for infrastructure monitoring and maintenance, in particular the supply chain has an advanced offering in predictive maintenance. Operation and maintenance will therefore be included and assessed in the deep dive under smart water management and municipal and industrial wastewater treatment.

Secondary Opportunities - Excluded

The information below outlines the key reasons why the hotspot / opportunity was excluded from the Deep Dive Assessment.

Clean Water - Water Transport & Pipelines

There are a number of crossovers between the water transport and pipelines sector and oil and gas companies. In particular, there is a highly relevant crossover in piping and leak detection and control equipment. The approach from the utility toward network management and leakage is unlikely to see a significant step change in approach and culture over the next asset management period until 2025. Therefore, the lack of appetite from the water sector, coupled with existing high barriers to entry and a longer time scale to project realisation rules out this opportunity to be taken forward for deep dive assessment.

Heat Generation - Hydrogen Production

There are very strong crossovers with the hydrogen industry but these opportunities are unlikely to be realised at scale before 2020. In addition, crossovers with the upstream sector are much more closely aligned to hydrogen storage than hydrogen production. Hydrogen is already produced as part of the downstream petrochemical refinery process. Therefore, hydrogen production has not been considered for the deep dive assessment.

Wastewater – Municipal & Industrial Wastewater Transport & Pipelines

Although there are links in the supply chain for pipe networks and equipment, there are strong barriers which may pose a hindrance to market entry. There is currently considerable competition from manufacturers for pipes and water network related equipment, in companies which already have a prominent position in the supply chain to the water sector. It is also Arup's view that tenders and contracts for large infrastructure pipe rehabilitation will be limited over the next five years. It is therefore difficult to foresee a clear path to market, thus this will not be taken forward for deep dive assessment.

7.4 Hotspot – Changing Market Conditions

Secondary Opportunities

Opportunities that were highly relevant to the oil and gas supply chain but faced adverse market conditions or considerable barriers to entry were assessed in more detail. This was conducted to further understand what market conditions would need to change or barriers that would need to be addressed in order for these markets to become a more viable diversification opportunity for the oil and gas sector.

This included further assessment of the following subsectors:

- Water transport & pipelines
- Wastewater transport & pipelines
- Hydrogen

Water transport & pipelines

Although there are significant crossovers between industries meaning that existing technologies and skills within the oil and gas sector could be utilised in water and transport pipelines industry, the current nature of the market suggests minor benefit, to utility companies, of championing a significant reduction in leakage via large investment in their infrastructure. What is needed is a meaningful shift towards major infrastructure management to reduce leakage. Without incentives to invest in infrastructure repair and maintenance and consequential minor marginal gains for utilities, the future of the market, in terms of entry for a new competitor, is uncertain. Therefore this has been discounted for deep dive assessment.

However, if in the future a new substantial drive towards reducing leakage emerges across the sector (perhaps as a result of drought resulting in a push for water conservation, or shift in sustainability focus on leakage targets) then the market may become more open to new competitors and suppliers offering skills in network management, pipe repair and inspection etc.

Wastewater transport & pipelines

With greater amounts of wastewater being produced and therefore needing transportation, increasing pressure is being put on existing sewer networks across the UK. Research demonstrates that although ongoing investment into sewer repair and rehabilitation is evident across water companies in the UK, the focus of large scale investment is into wastewater treatment. Sustainability goals focus more significantly on the management of wastewater, in particular treatment and the construction of new and upgraded wastewater treatment plants. It is likely that ongoing sewer maintenance and repair contracts are likely to be rewarded to existing competitors in the market, therefore entering the market as a new competitor will be challenging as there isn't appetite in the market for new suppliers. Investment focus also lies with innovation in wastewater technologies for the increasing amount of potentially dangerous wastewater produced industrially.

If the market were to change, perhaps driven by harmful pollutants causing environmental damage as a result of leaking sewer networks

causing groundwater contamination, then a drive to invest in sewer repair may emerge, and entry to the wastewater transport and pipeline market may become easier.

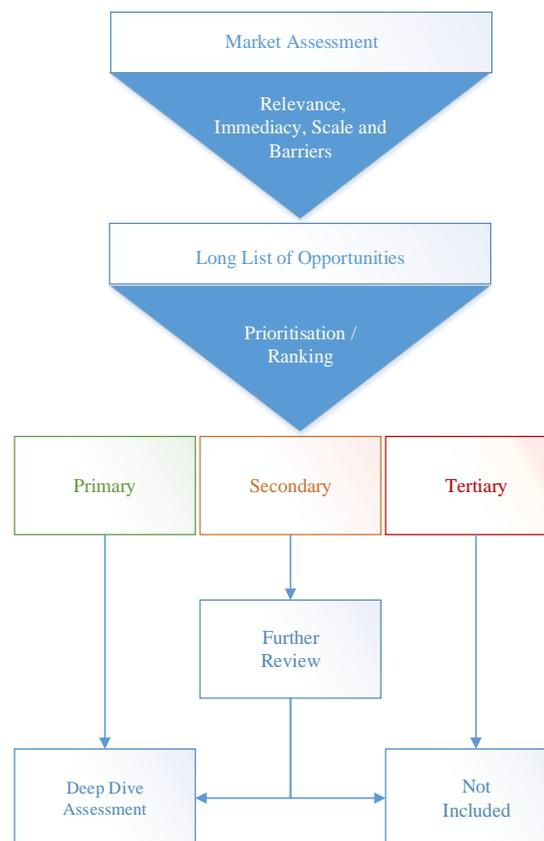


Figure 2: Prioritisation Process

Primary Opportunities – Strong opportunity for diversification

Secondary Opportunities – Opportunity for diversification but challenging market conditions.

Tertiary Opportunities – Not a recommended market or sub sector for diversification. 57

7.5 Hotspot – H21 Hydrogen Opportunity

Overview

The most significant Hydrogen opportunity in the UK is the H21 Leeds City Gate project. The project aims to convert the existing natural gas network in Leeds to 100% hydrogen¹. The initial phase of the project will determine the technical and economic feasibility of the conversion. A report has been published that sets out the strategy and defines a timescale and workstreams for the project.

Project timeline

The report sets out a delivery timeline for the H21 project. The roadmap is to be developed from 2016-2020 and a final decision on whether to proceed is expected in 2021. Following a decision to proceed, detailed design is expected to run from 2021-2025 and the delivery and build from 2026-2028.

Project workstreams

The scoping report identified 16 workstreams that would come forward as a result of the project. These include

1. Pressure reduction
2. Below seven bar mains consideration
3. Industrial and commercial appliances
4. Domestic considerations
5. Multiple occupancy buildings

6. Blending
7. Odourisation / gas detection
8. Technical standards
9. Regulation
10. Public perception
11. Appliance demonstration
12. Carbon capture and storage
13. Transportation
14. Electrification
15. Unconventional gas
16. UK wide development

The most relevant work packages for the upstream oil and gas industry are carbon capture and storage, transportation and unconventional gas.

Capital cost

The H21 report sets out an estimated capital cost of £2bn. The capital cost elements are:

- Network Capacity and conversion pipework: £10 million
- Steam methane reformer costs: £395 million
- Intraday salt caverns: £77 million
- Inter-seasonal salt caverns: £289 million

- Appliance conversion (Domestic, commercial and industrial): £1,053 million

- Hydrogen transmission system: £230 million

Operation cost

The estimated operational costs are:

- Carbon Capture and storage: £60 million
- SMR/Salt Cavern/HTS Management: £31 million
- SMR Efficiency Loss: £48 million

Upstream Scottish oil and gas crossover

The Scottish oil and gas supply chain has already had early stage involvement with the H21 project. AMEC Foster Wheeler, a large engineering consultancy with offices in Aberdeen, were appointed on the 'Hydrogen System Design' team.

When considering the list of capital costs, there is crossover in every area except for 'appliance conversion'. The strongest crossover for the upstream sector is intraday and interseasonal salt caverns. Some of the salt caverns are expected to be offshore and therefore offshore oil and gas expertise across all the main business areas (reservoirs, drilling, platforms, etc.) will be relevant.

Conclusion

The H21 project presents a significant opportunity for the oil and gas industry to diversify. Approximately half the capital cost (£1bn) will be invested in areas where there is a strong crossover for the Scottish supply chain supply. However, early stage design and feasibility opportunities prior to 2025 will most likely be limited to large consultancies such as Wood Group and AMEC. Delivery is set to start post 2025 and opportunities for SMEs will likely come to market after this date.

1. <http://www.northerngasnetworks.co.uk/wp-content/uploads/2017/04/H21-Report-Interactive-PDF-July-2016.compressed.pdf>

7.6 Hotspot – Tertiary Opportunities

Tertiary Opportunities

The information captured in Table 8 summarises the key scoring for each of the tertiary hotspot /opportunity areas determined through the market assessment. All of these areas will not be assessed further in the Deep Dive Assessment.

Table 8: Tertiary opportunities

Market	Business Sector	Categories	Market size / Investment potential (by 2025)	Market size score	Immediacy	Barriers	Relevance	Total Sum
Energy Storage	Load Shifting (diurnal and interseasonal)		>£1bn	1	2	3	2	8
Energy Storage	Grid Balancing Services		£400m - £600m	3	1	2	2	8
Heat	Heat generation	Heat pumps and chillers (heating and cooling)	£500m - £1bn	1	2	2	3	8
Heat	Heat generation	CHP	£1 - £2bn	1	1	3	3	8
Heat	Heat generation	Energy from Waste	£3 - £9bn	1	1	3	3	8
Water	Services	Professional Services	£520m - £1bn	2	2	3	2	9
Water	Water Management	Urban drainage	£2B - £3.5bn	1	2	2	3	8
Heat	Heat generation	Biomass	>£1bn	2	1	3	3	9
Water	Water Management	Flooding	£3bn - £5bn	1	2	3	3	9
Energy Storage	Customer Side storage solutions	Domestic Scale (Electrochemical storage)	£ 250 m (to 2020)	3	3	2	3	11
Energy Storage	Customer Side storage solutions	Non-Domestic Scale (Electrochemical storage)	£ 200 m (to 2020)	3	3	2	3	11

7.6 Hotspot – Tertiary Opportunities

Tertiary Opportunities - Excluded

The information below outlines the key reasons why the hotspot / opportunity were not included in the Deep Dive Assessment.

Energy Storage

Load Shifting (diurnal and interseasonal)

There are very strong crossovers with the hydrogen industry but these opportunities are unlikely to be realised at scale before 2020. There is significant uncertainty over the future of pumped hydro and projects are likely to be one off opportunities rather than for longer term diversification. Upstream oil and gas companies are not well positioned to diversify into large scale electrochemical batteries and there is significant competition in this sector. Therefore, this category has not been taken forward for the deep dive assessment.

Grid Balancing Services

There is currently very strong competition in this sector and the main technologies being applied are electrochemical batteries and demand side response (DSR). The main crossovers for oil and gas are in power electronics, sensors and control instrumentation.

Domestic Scale (Electrochemical storage)

Upstream oil and gas companies are not well positioned to compete in the domestic battery storage market. This is because there is limited expertise in the electrochemical

battery technologies and oil and gas companies are not well suited to dealing with individual customers. Therefore, this category has not been taken forward for the deep dive assessment.

Non-Domestic Scale (Electrochemical storage)

Upstream oil and gas companies are not well positioned to compete in the domestic battery storage market. This is because there is limited expertise in the electrochemical battery technologies and oil and gas companies are not well suited to dealing with individual customers. Therefore, this category has not been taken forward for the deep dive assessment.

Heat CHP

The CHP industry has crossovers with the oil and gas industry but predominantly in the downstream sector where these technologies are already used for petrochemical processing. Therefore, this category has not been progressed for the deep dive assessment.

Energy from Waste

Energy from waste projects are large and complex infrastructure projects with several crossovers areas. However, competition in this market is very strong and market entry would take significant investment by oil and gas companies.

Heat pumps and chillers (heating and cooling)

The heat pump / chiller industry has crossovers with the oil and gas industry but predominantly in the downstream sector where these technologies are already used for petrochemical processing. The market is expected to grow significantly but the major growth area will likely be residential and oil and gas companies are not well positioned for this market. Therefore, this category has not been progressed for the deep dive assessment.

Biomass

Upstream oil and gas companies are not well positioned to compete in the biomass market and there are limited technology crossovers. Therefore, this category has not been taken forward for the deep dive assessment.

Water

Professional Services

A number of immediate opportunities have been identified in consulting for the oil and gas Supply chain. These include knowledge transfer opportunities which companies could aim to target in the future; this could include retraining or restructuring. The market is close to saturation, with a number of domestic and international consultancies present in the water sector in Scotland. The higher transition costs and smaller margins also contribute to lessening the appeal of this opportunity for the oil and gas supply chain.

For these reasons this will not be considered in the deep dive assessment.

Urban drainage

It is possible to identify some areas of crossover between urban drainage design and oil and gas industries, however there is not a clear identifiable entrance to the market. Although there does not appear to be prominent competition in terms of leading urban drainage technologies, it is difficult to identify what percentage of the SUDS market could be explored by oil and gas industries and therefore this is not considered a large-scale opportunity within the next 10 years. Therefore, this will not be taken forward in the deep dive assessment.

Flooding

Without a clear crossover between industries, despite the market for flood defences being an immediate, large scale market, this opportunity will not be

7.7 Deep Dive Summary

The following areas will be assessed in the deep dive assessment:

- Heat networks
- Geothermal Heat
- Municipal Water and Wastewater Treatment
- Industrial Wastewater Treatment
- Smart Water Management

Energy systems (controls, sensors and instrumentation, data analysis etc) was identified as a cross cutting theme across all the selected sectors. There is a strong oil & gas expertise in energy systems and therefore diversification opportunities were considered within each of the selected sectors.

Operation and maintenance in the water industry was also identified as an area of opportunity to be explored. Therefore, it was assessed within the smart water management, industrial wastewater treatment and municipal water and waste water treatment.

Operation and maintenance was also considered and included under heat networks in the deep dive assessment.

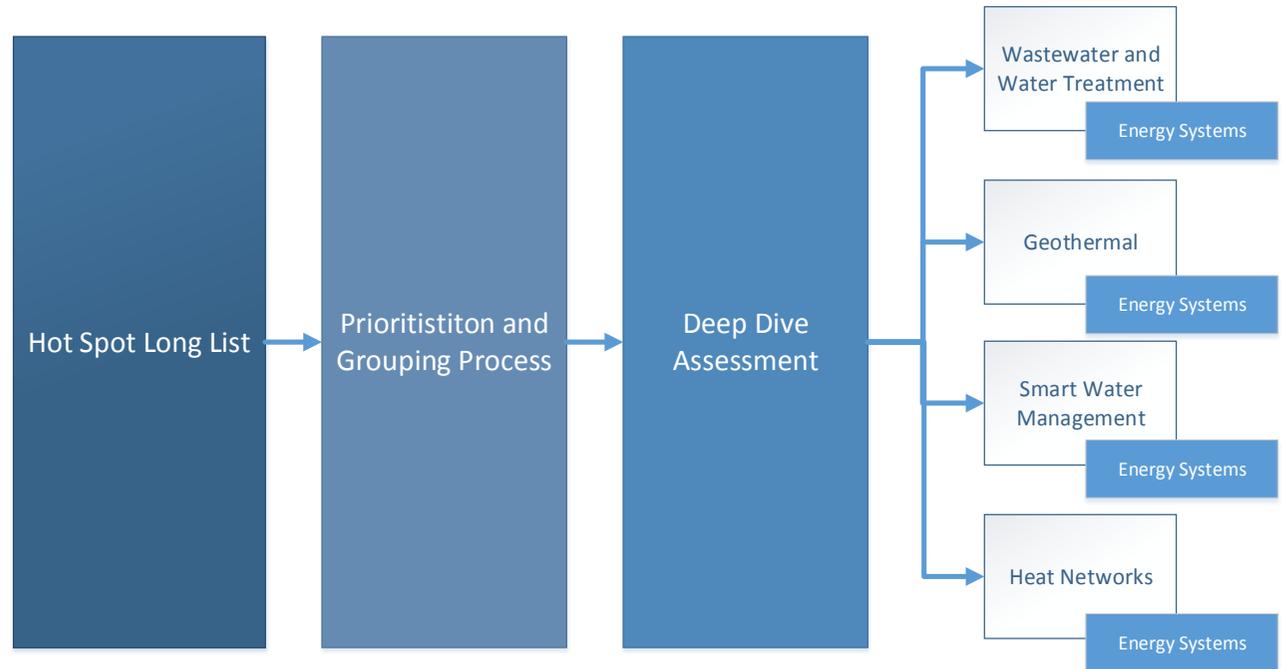


Figure 9: Prioritisation process



Deep Dive Assessment

8.1 Deep Dive Assessment – Introduction

The deep dive assessment has built on the prioritisation of the hotspots, with a particular focus on domestic opportunities, a deeper analysis was performed for the identified markets and the respective priority opportunity areas.

The analysis followed ‘Porter’s Five Forces’ method, which assessed the level of overall competition in the market, considering the following in more detail:

- The **barriers** to new entrants (country-wide);
- **Existing buyers** (country-wide);
- **Existing suppliers** (country-wide and technology area-specific);
- **Potential substitutes** (technology area-specific);
- **Industry competitors.**

The following areas were also analysed within the Porters Five Forces Assessment:

- Competitiveness;
- Sales and marketing approaches;
- Collaboration;
- Supply chain alliances;
- Technical innovation.

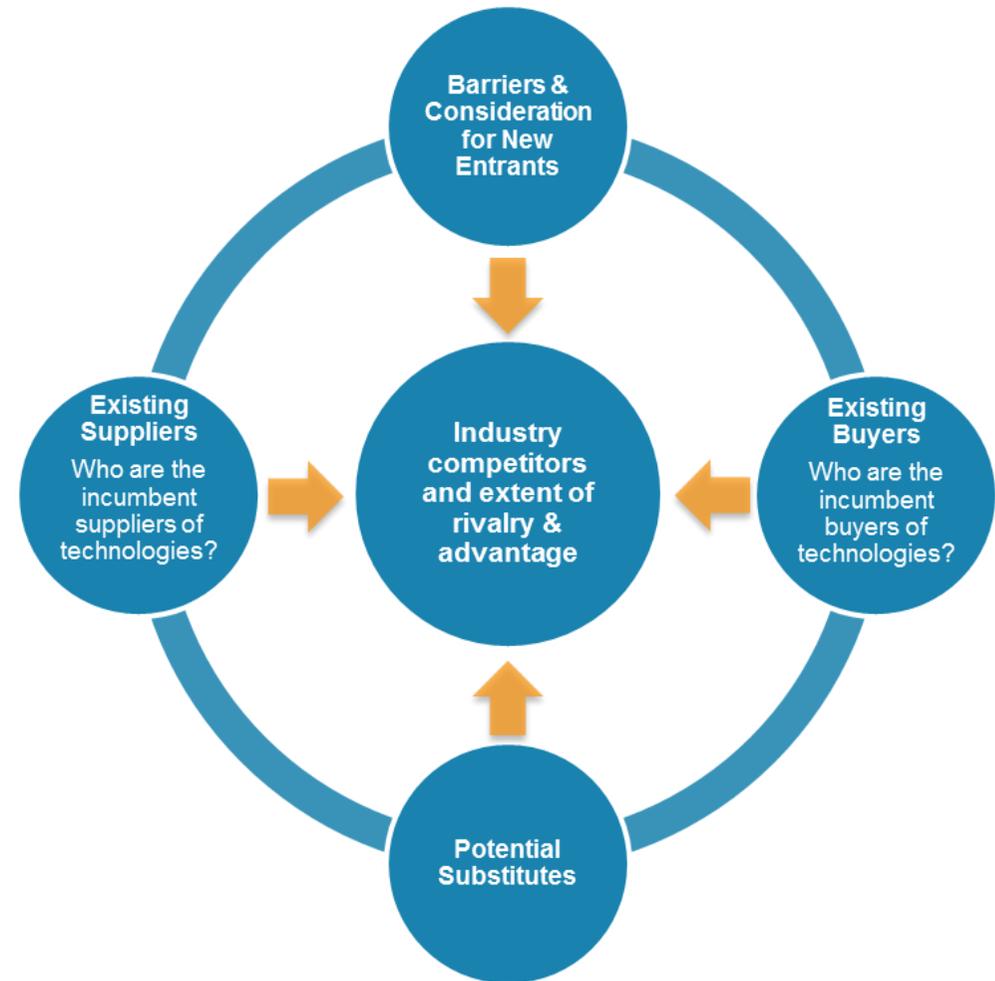


Figure 10: Approach to Porter’s Five Forces Assessment

8.2 Company Mapping Methodology

The company mapping analysis portrays the offering across the oil and gas supply chain for each of the potential hotspots in Smart Water Management.

Figure 11 highlights this offering which includes the number of companies active and the company classification:

- Technology Provider;
- Specialist;
- Supplier / Distributor / Stockist;
- Consultant;
- Manufacturer, Fabricator;
- Agent;
- Service Provider.

It is important to note that companies that are active across multiple service offerings will be counted in each. For example, a company offering both consultancy and specialist services is counted twice. Therefore, the company analysis doesn't reflect the total number of companies but rather the number of companies that are active within the particular market sub-sector or hotspot.

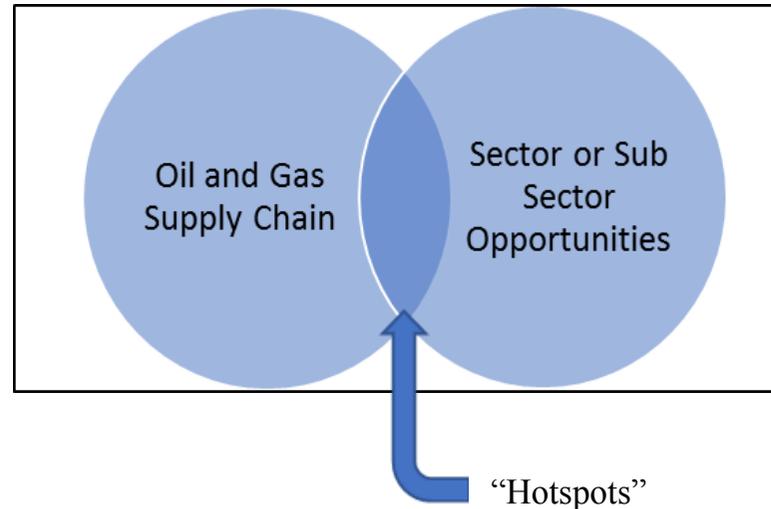


Figure 11: Company Mapping Assessment

8.3 Deep Dive Assessment – Heat Market Opportunity

Table 9: Heat Market and Geothermal Opportunities

The hotspot assessment identified the following key sectors in the heat market:

- Heat networks
- Geothermal

Table 9 highlights the relevant oil and gas sector and sub-sectors where potential opportunities exist for the Scottish oil and gas supply chain. The deep dive assessment examines the geothermal and heat network markets in more detail. This includes an assessment of the competition in these markets, identifies relevant Scottish oil and gas companies and likely methods of diversification in the new market areas.

Business Sector	Sub Category	Relevant oil and gas Sectors	Relevant Oil & Gas Sub Sector 1	Relevant Oil & Gas Sub Sector 2	Relevant Oil & Gas Sub Sector 3
Heat Networks	Network installation and design	Platforms & Topsides	Pipes / flexibles / risers / flowlines	Piping components	Inspection / Repair / Maintenance
	Pipe Manufacturer and components	Platforms & Topsides	Pipes / flexibles / risers / flowlines	Piping components	
	Specialist pipe services / welding / jointing	Platforms & Topsides	Pipes / flexibles / risers / flowlines	Piping components	
	Energy centre design / construction	Platforms & Topsides, Marine, Subsea & Pipelines	Engineering, design & construction	Inspection / Repair / Maintenance	
	Secondary network / heat interface units	Platforms & Topsides, Marine, Subsea & Pipelines	Inspection / Repair / Maintenance	Mechanical / hydraulic engineering	
	Engineering / consultancy services	Engineering and consultancy services (mechanical, electrical, finance, legal)			
	Customer service and management	Reservoirs, Platforms & Topsides	Software, Storage & Management	Data Interpretation / Evaluation	Inspection / Repair / Maintenance
Sensors, controls and instrumentation	Reservoirs & Marine, subsea & pipelines	Data Acquisition / Processing	Control, Sensors, Monitoring & Communication		
Geothermal	Drilling	Drilling and Wells	All sub-sectors		
	Geoscience surveys and monitoring	Reservoirs	All sub-sectors		
	Topside Energy Centre	Platforms & Topsides	Platforms & topsides		
	Operation and maintenance	Platforms & Topsides, Marine, Subsea & Pipelines	Platforms & topsides	Inspection / Repair / Maintenance	
Engineering / consultancy services	Engineering and consultancy services (mechanical, electrical, finance, legal)				

8.4 Deep Dive Assessment – Water Market Opportunity

Table 10: Water Market Opportunities

To recap the hotspot assessment identified the following key sectors in the water market:

- Clean Water and Wastewater Treatment and Reuse
- Smart Water Management

In order to develop specific opportunities for the Scottish oil and gas supply chain the hotspots have been broken down further into the following sub-sectors:

- Municipal Water and Wastewater Treatment and Reuse
- Industrial Wastewater Treatment
- Water Sources and Treatment
- Smart Water Management

The table (right) highlights the relevant oil and gas sector and Sub-Sectors where potential opportunities may exist for the Scottish oil and gas supply chain. The deep dive assessment examines the four sub-sector in more detail, assesses the competition in these markets, identifies examples of relevant Scottish oil and gas companies, outlines an example of a typical project in this market and develops strategies for market entry.

Water Market – Sub Sector	oil and gas Sector	oil and gas Sub-Sector Hotspot 1	oil and gas Sub-Sector Hotspot 2	oil and gas Sub-Sector Hotspot 3
Industrial Wastewater Treatment	Platforms & Topsides	Production / Process / Accommodation Modules & Equipment	Waste Treatment, Management Cleaning & Disposal	Instrumentation / Process Control
	Marine, Subsea & Pipelines	Process, Pumping and Power Systems	Control, Sensors, Monitoring & Communication	Engineering, Design & Construction
Municipal Water & Wastewater Treatment Equipment, Plants and Process	Platforms & Topsides	Production / Process / Accommodation Modules & Equipment	Waste Treatment, Management Cleaning & Disposal	Instrumentation / Process Control
	Marine, Subsea & Pipelines	Process, Pumping and Power Systems	Control, Sensors, Monitoring & Communication	Engineering, Design & Construction
Water Sources & Treatment Equipment, Plants and Process	Platforms & Topsides	Piping & Components	Mechanical Engineering	
	Reservoirs	Reservoir Modelling / Development		
	Drilling and Wells	Drilling / Boring / Pumping Equipment	Well Engineering / Design	
Smart Water Management	Advanced Pressure Management	Drilling and Wells	Well Testing, Control & Monitoring	
	Enterprise Asset Management	Platforms & Topsides	Inspection / Repair / Maintenance	
	Enterprise Asset Management	Marine, Subsea & Pipelines	Subsea Inspection / Repair / Maintenance	
	Mobile Data Management (MDM)	Reservoirs	Software, Storage & Management	Data Interpretation / Evaluation
	Network Modelling and Management	Reservoirs	Reservoir Modelling / Development	
	Network Modelling and Management	Marine, Subsea & Pipelines	Environmental / Site Studies / Monitoring	
	Supervisory control and data acquisition	Reservoirs	Data Acquisition / Processing	
	Meter and Meter Read Technology / Infrastructure	Drilling and Wells	Well Testing, Control & Monitoring	
	Meter and Meter Read Technology / Infrastructure	Platforms & Topsides	Instrumentation / Process Control	
	Meter and Meter Read Technology / Infrastructure	Marine, Subsea & Pipelines	Controls, Sensing, Monitoring & Communication	



Heat Network Deep Dive Assessment

9.1 The District Heating Opportunity

Introduction

Decarbonising heat in Scotland and the rest of the UK presents a significant challenge for government. Heat accounts for approximately 55% of energy demand in Scotland. The overarching message from government is to promote district heating in areas with high heat demand densities (cities) and heat pumps in areas of lower heat demand density.

Targets to deliver district heating projects will require a capital investment of £2bn in England and Wales and greater than £500m in Scotland over the next 5 years.

Across the whole of the UK, estimates vary between 25-50 TWh by 2030, supplying up to 15% of buildings.

The Scottish Heat Policy Statement sets a target of 1.5TWh/yr (40,000 homes) of heat delivered by district heating by 2020.

In January 2017 the Scottish Government released a consultation document entitled *Heat and Energy Efficiency Strategies, and Regulation of District Heating*. This document proposes several mechanisms that are likely to increase investment in the Scottish district heating market. These include:

- Establishing district heating zones to coordinate developers, building owners and local authorities.
- Creating concession zones to connect customers to reduce the risk of

stranded assets.

- In the long term, requiring surplus waste heat from industry and power generation are connected to DH networks.
- It should be noted that if the outcome of consultation recommends establishing DH zones in Scotland then the market could be worth substantially more than £500m.

Additionally, the Government's Heat Network Investment Project (HNIP) has secured £320 million in capital funding support for heat networks to 2020². This investment programme will support marginal projects that would not have been delivered without government support.

The policies and targets highlighted above show that the primary driver of heat networks is government support. This support is set continue and grow the heat networks market from a relatively low base today presenting opportunities for new market entrants.

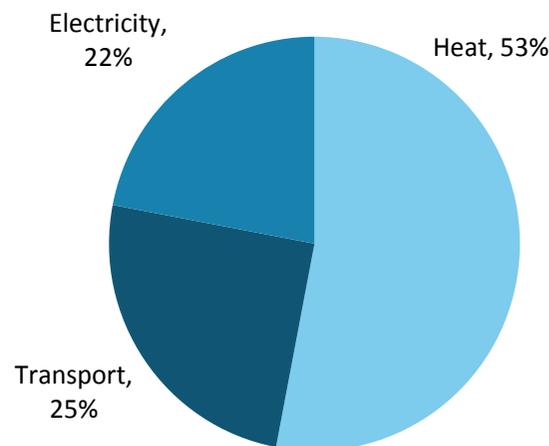


Figure 12: Scotland's energy demand¹

1. <http://www.gov.scot/Resource/0047/00478997.pdf>

2. <https://www.gov.uk/government/publications/heat-networks-investment-project-hnip>

9.2 Heat Networks Porter's Assessment

Porter's Five Forces Assessment

The following deep dive utilise a Porters Five Forces assessment to analyse the competition present in the heat network market. This is the first step to develop the Roadmap and recommendations. This will help to shape the conversation and discussion with the Scottish oil and gas supply chain.

Existing buyers

Heat network buyers can be can be categorised into the public and private sector.

Public Sector

Prior to 2010, heat networks in the UK were predominately developed by the public sector. The largest installers of networks were local authorities (housing associations) and hospitals. Some of the oldest and largest networks in the UK (including Sheffield and Nottingham network) are Council owned.

After recent government funding support, there is a renewed drive among local authorities to form publically owned ESCos (Energy Service Companies) that deliver networks.

Local Authorities are increasingly seen entering the heat network market as municipal ESCos. Edinburgh and Aberdeen have formed municipal ESCos, while others are in the process of establishing entities.

Private Sector

For developments where the project can support the cost of DH, developers are delivering new networks. This is particularly the case in areas where local planning policy incentivises the connection of DH through planning requirements. The strictest planning policy guidelines with respect to DH have been implemented in London and this is also where the vast majority of new private networks are being delivered. Other private sectors buyers include universities campuses. ESCos usually build, operate and maintain the network and can also act as funders depending on the commercial arrangement.

In summary, the largest buyers of heat networks are:

- Private Developers
- ESCos
- Local authorities (housing associations)
- NHS
- Universities

Industry suppliers

A list of industry suppliers can be found in section 9.3 (page 69). This list is not exhaustive but provides the names of suppliers under each heat network subsector. These supplies make up a significant market share of the district heating supply chain.

Industry competition

When compared to operations in continental Europe, the UK district heating supply chain is relatively underdeveloped because of the small number of large networks that have been delivered. Official government statistics state there are over 17,000 networks (UK Government) but the vast majority of these are single blocks of flats with a boiler as the heat supply. A recent government consultation requested feedback on the readiness of the UK supply chain to deliver the growth that is expected and 'more than half of respondents said the supply chain is not ready, citing weakness in the civil contracting market for trenching, consultancy and delivery capability'¹.

The above statement indicates that the market perceives there is room for new market entrants that could increase competition in the sector. This is a positive indicator for new market entrants.

Potential substitutes

Electrification

A significant risk to the growth of the heat networks market is that electrification may be preferred as a decarbonisation route. Electrification of heat can be in the form of heat pumps and direct electric heating. Heat networks currently rely on support from local and national government in the form of planning regulations that encourage developers to build new networks or connect

to existing networks. Historically, heat networks supplied by gas CHP have resulted in high carbon savings but the carbon benefit is reducing as the grid decarbonises. New SAP 2016 emission factors may undermine the development of heat networks if gas CHP no longer provides significant carbon savings that are required to meeting Part L building regulations. However, policies such as those proposed by the Scottish government whereby district heating zones are mandated will likely to be worked into planning guidance and therefore reduce this risk.

Decarbonisation of Gas

An additional potential substitute is the use of the hydrogen and biogas injected into the gas grid to supply low carbon heating. The CCC's report on the next steps for UK heat policy stated that the 'next parliament' should set out the role for hydrogen in replacing gas (CCC)². However, with the early election in 2017 the government may delay major decisions on the future of the gas grid until after Brexit negotiations have been completed. However, support for hydrogen has been less direct than that for heat networks and currently the largest project being developed in the UK is the H21 Leeds demonstrator. This pilot project will be used as a way to understand whether large scale hydrogen deployment is a feasible way of decarbonising heat. However, the market is unlikely to grow significantly unless there is government support and this looks likely not to come before 2020.

1. <https://networks.online/gphsn/news/1000342/accelerated-deployment-exacerbate-design-issues-warns-heat-industry>, 2. <https://www.theccc.org.uk/wp-content/uploads/2016/10/Next-steps-for-UK-heat-policy-Committee-on-Climate-Change-October-2016.pdf>

9.2 Heat Networks Porter's Assessment

Barriers and considerations for new entrants

In some cases, heat networks are financially viable and deliverable in single owner campus-type developments such as universities, hospitals and housing estates. Beyond these enclaves, heat networks face a range of barriers which, are the focus of government attention to enable the scale seen in many other European Countries.

UK Government is seeking to deliver large scale investment that will result in 'grid-scale' networks such as those developed in Copenhagen and Amsterdam.

However, with the exception of a few examples in the UK such as Sheffield and Nottingham, the majority of networks are centred on areas of new development and not yet at a significant scale. Oil & Gas competencies in the delivery of large scale, complex projects will be better suited to diversify into the heat networks market if there is potential for these networks to grow to city scale.

In order to deliver large scale networks existing private domestic and non-domestic customers will need to be connected and this faces significant challenges.

Barriers for consideration include:

Gas is relatively clean and cheap

Gas is the heating fuel for approximately 65%

of existing buildings owners. Owners of existing private properties with in-unit gas boilers have little incentive to switch away.

This situation excludes most existing buildings from economically viable connections to heat networks, which reduces the scope for heat networks to reach beyond concentrated pockets of new development or other anchor loads without further incentives.

Heat in the UK is an unregulated utility

Each heat network effectively has its own regulatory regime as set out in the contracts under which the network is operated. This has resulted in a wide diversity of practice and performance, and high transaction costs for promoters of new heat networks.

Developers looking for a simple site delivery and an early exit are often reluctant to incorporate heat networks in their proposals.

No public powers exist to compel existing property owners to connect to a heat network

As an extension of its unregulated status, heat network operators must secure connection agreements on the open market. They are typically only able to do so when it is cheaper for the customer to connect than the alternative. For existing buildings with an incumbent gas boiler system in place, the connection and related retrofit measures are in most cases significantly more costly than renewal of the existing system.

Public perception is unclear

Heat networks have received some adverse reporting recently, with concerns with high heat prices and poor performance. Pricing of heat networks can also be difficult for customers to understand.

These public concerns make developers cautious about including heat networks, which might affect the attractiveness of new properties and lower their sale price.

Local authorities cannot establish concession areas on land not within their ownership or equivalent control

Concession areas provide ESCOs with the necessary certainty of future demand to enable the long term investments needed for heat networks. Most land in cities is not owned or controlled by the local authority, so there is no mechanism today by which a local authority or other party can procure a concession for a heat network which will exclude competing suppliers and competing heat systems.

The experience of the coordinated procurement at Nine Elms Battersea is the exception which proves the rule. Although successful, the process took years and relied on the combination of persistence by the Greater London Authority, a strong planning policy and an available large scale heat source in the area.

The industry is capacity constrained

We perceive that recent growth in heat network investments exceeds the ability of the industry to supply, which is leading to delays or quality sacrifices. This was supported by the findings of a recent government consultation, as set out in section 4.

International Opportunities

District heating is a well established market in northern and western Europe. Denmark, Germany, The Netherlands and several other Eastern European countries have very large city wide networks. These countries are predominantly looking to grow existing networks rather than establish new networks like the UK. The maturity of the industry in these countries means that opportunities for market entry from the Scottish oil and gas supply chain companies are relatively small.

9.3 Existing UK Suppliers

Table 11: Existing UK Suppliers

Business Sectors	Companies	Business Sectors	Companies
Energy Centre Design and Construction	Clarke Energy Edina Power Ener-g group Veolia P3P partners	ESCO's	E.On Engie SSE Veolia Nottingham Enviroenergy Vital Energi Metropolitan Aberdeen Heat and Power Energetic Pinnacle Power EDF Energy Services
Network Installers	Enviropipe Reach Active Clancy Docwra PPSL District Heating Eneteq Morrison Utility Connections Varlowe Industrial Ltd Fortem Energy Services Galliford Try Exaclon Ltd Hollingsworth Bros UDP (Utilities Design and Planning) Interserve Skanska Kier Bouyges	Customer Services & data analytics / communications	Switch2 Guru Systems Wilson Energy SW Energy Insite Energy
Pipe manufactures	Logstore Rehau Brugg Powerpipe Flex Energy CPV Engineering Pipework Solutions	Heat interface units	Envinox Energy SAV Systems Worcester Bosch Danfoss Swep Heatraesadia

9.4 Typical Supply Chain

Figure 13, shows typical UK district heating organisation chart for the delivery of a district heating project in the UK. A typical private sector project will be delivered by an Energy Services Company (ESCo) who will partner with various other service providers to deliver a heat network. The contractors will have relationships with suppliers from whom they will purchase equipment and parts. The contractors will have relationships with suppliers from whom they will purchase equipment. Separately, an ESCo may have in-house specialist design services or subcontract these to consultancies. Operation and maintenance may be separately tendered to a specialist maintenance company or be provided in house by the ESCo.

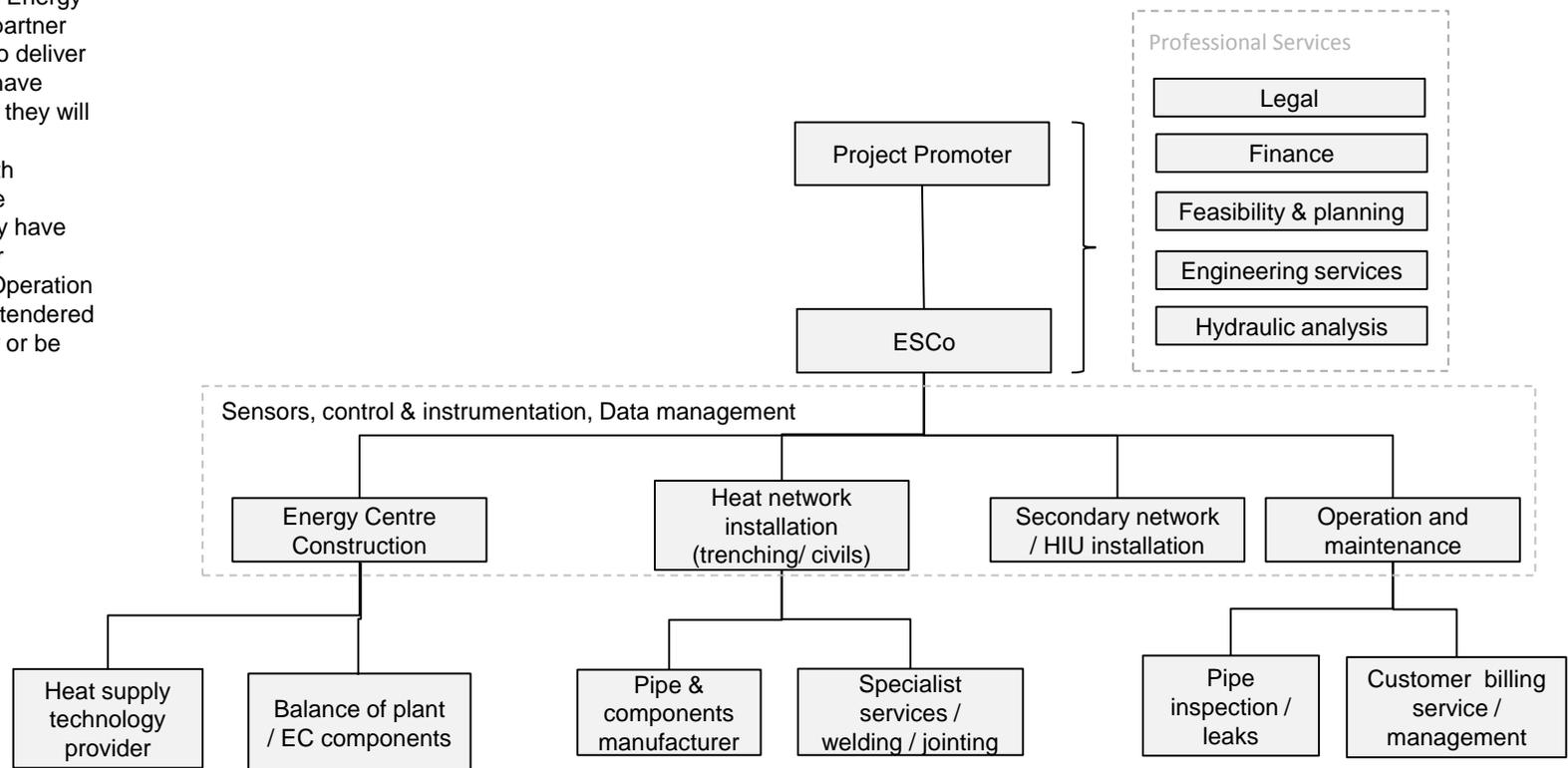


Figure 13: Typical supply chain

9.4 Heat network sub-sector analysis

Barriers to Entry ● High ● Medium ● Low

DH Supply Chain area (Example)	Oil and gas Hotspots	Capital per project (£20m average project)	Barriers	Example oil and gas companies	Method of diversification
Energy service ESCo (Engie)	No upstream oil and gas crossovers	N/a (ESCo may provide capital investment and make return from energy sales)	●	N/a	N/a
Engineering services (mechanical and electrical design)	Engineering services	£0.15 – 0.3m	●	Wood Group, Mott Macdonald	Targeted recruitment / acquisition, Alliance / partnerships
Specialist hydraulic analysis (Hydraulics Analysis Ltd)	Hydraulic analysis	£0.02-£0.03m (Varies depending on complexity of project)	●	MMI Engineering Ltd	Direct sales, Product / service development
Sensors, controls and instrumentation	Control, Sensors, Monitoring & Communication	Sensors and control equipment provided as part of contractors packages for EC, pipework and HIU installation	●	Omni instruments, Emerson Valves	Product / service development, targeted recruitment / acquisition
Energy Centre construction (Clarke Energy)	Engineering, design & construction, Inspection / Repair / Maintenance	£6m	●	Wier Group	Product / service development, Establish subsidiary

Table 12: Heat Network Sub-Sector Analysis

9.4 Heat network sub-sector analysis

Barriers to Entry ● High ● Medium ● Low

DH Supply Chain area (Example)	Oil and gas Hotspots	Capital per project (£20m average project)	Barriers (RAG rating)	Example oil and gas companies	Method of diversification
Network installation and design	Pipes / flexibles / risers / flowlines, Piping components, Inspection / repair / maintenance, Mechanical / hydraulic engineering	£6m	●		Establish subsidiary
Pipe + Components Manufacturer	Pipes / flexibles / risers / flowlines, Piping components	£2 - 3m	●	Global PipeCo	Product / service development, direct sales
Specialist pipe services / welding jointing	Pipes / flexibles / risers / flowlines, Piping components, Inspection / repair / maintenance	£0.1-0.2m	●	A&B Welding Services Ltd, N J Slee Welding and Fabrication, Pipeline technique	Product / service development, direct sales
Secondary network / heat interface units	Rotating / power equipment	£0.5m	●	Glacier Energy Services	Product / service development, Targeted recruitment / acquisition
Operation and maintenance (incl pipe inspection)	Inspection / repair / maintenance	£0.3 - 0.5 m / annum	●	Wood Group	Product / service development, Targeted recruitment / acquisition
Customer service / management	IT / Communications	N /a (ongoing cost)	●	Boston Networks, The Marsden Group	Product / service development, direct sales

Table 12 (continued): Heat Network Sub-Sector Analysis

9.5 Heat Networks – Diversification Opportunities

There is significant growth in the heat networks market which has predominantly been driven by national government policy and funding support. District heating in the UK is set to grow significantly and the existing supply chain does not have sufficient capacity to deliver the expected growth. Market growth and strong technology crossovers mean there is an opportunity for oil and gas companies to diversity into this market.

Figure 3 summarise the crossovers between heat networks sub-sectors and the upstream oil and gas supply chain. The crossover for 'primary heat supply' is technology dependant and therefore a relevance score was not included. The colour of the dots provides an indication of the likely diversification route. It should be noted that the diversification model is likely to differ for every company depending on their target market and current business structure. Whilst the relative market size provides useful context, it does not necessarily mean a larger opportunity is better because relevant oil and gas companies will have different target markets and expectations on project return and size. The relative market size for operation costs (customer service and operation and maintenance) was calculated using the NPV (6% discount rate for 20 years) in order to provide an appropriate comparison with capital costs.

In summary, strong crossovers were found in:

- Specialist hydraulic analysis
 - This is relatively small market but there are strong service provision crossovers and direct sales could be made.
- Sensors, controls and instrumentation
 - Control and equipment and instrumentation such as temperature and flow sensors and directly applicable to the heat networks market.
- Pipe and components manufacturer
 - Piping costs and components accounts for a significant proportion of project costs but oil and gas companies will be need develop specific products that are heat networks specific in order to enter the market.
- Specialist pipe services and design
 - There are direct sale opportunities for services such as welding and jointing.
- Operation and maintenance
 - Network owners typically tender long term (>20 years) operation and maintenance contracts. oil and gas companies would likely need to alter their service provision and / or set up a subsidiary in order to provide these services.

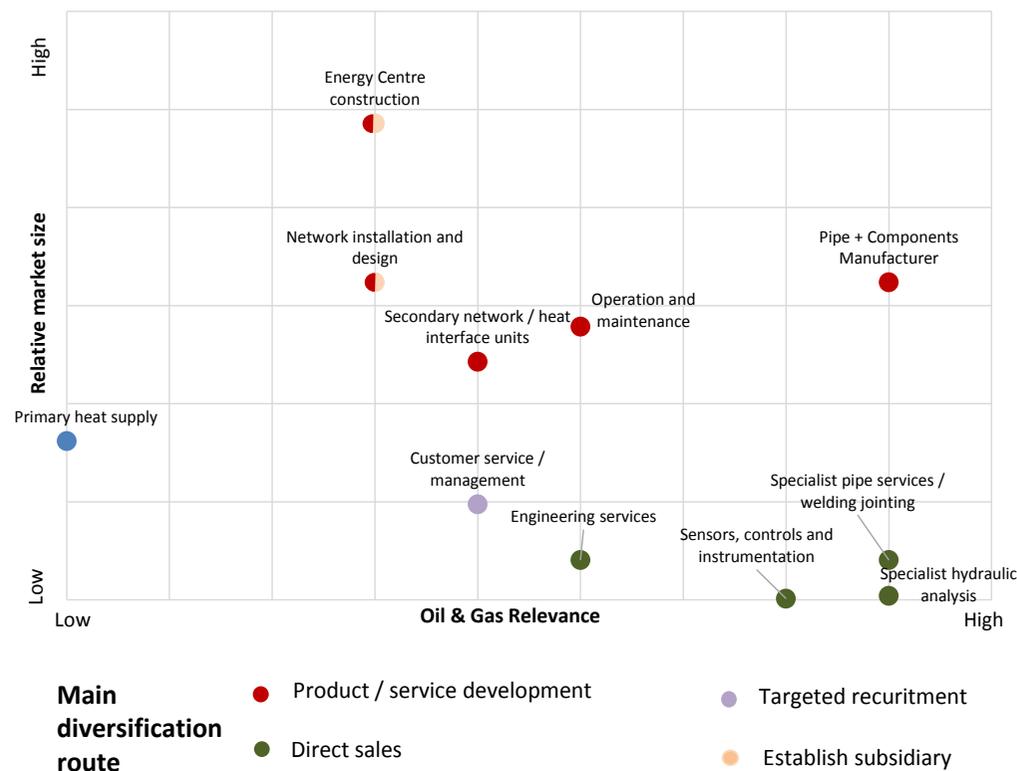


Figure 3: Sector crossovers and market size

9.6 Heat Networks – Company Mapping

Figure 4 indicates that there is strength in the Inspection, Repair & Maintenance Scottish supply chain with over 300 active companies.

Within piping components, a large proportion of the companies are manufacturers and suppliers for there are likely to be diversification opportunities supplying the heat networks industry. In addition, a large proportion of the companies included in this sub-sector are SMEs.

There are over 100 active companies in the pipe / flexible / risers and flowlines. Between this sector and piping components, there is expertise such as pipe welding that has direct crossover to the district heating market.

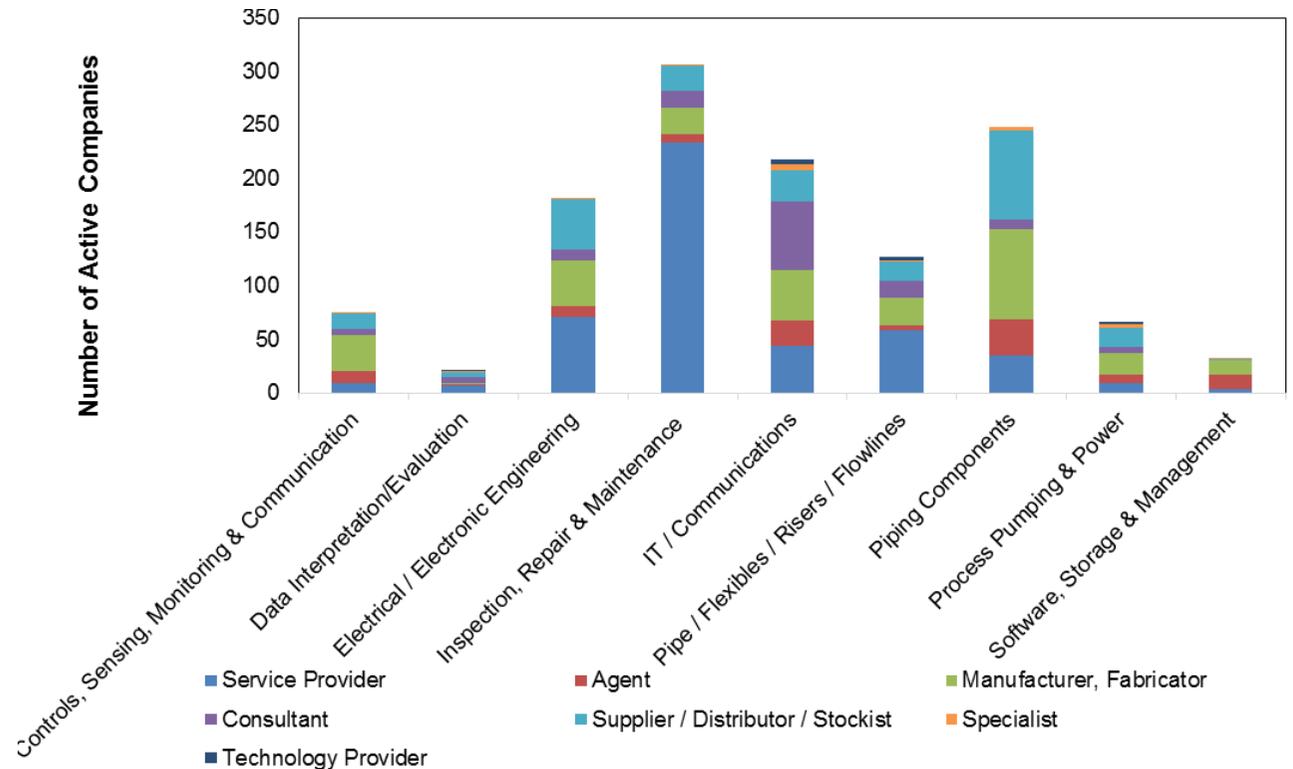


Figure 4: Opportunities for Scottish Oil & Gas Companies in Heat Networks

9.7 Heat Networks – Recommendations

Scottish Enterprise Stakeholder Engagement ● External ● Internal

Recommendations for Scottish Enterprise

- 1 Scottish Enterprise’s primary focus should be on supporting companies in the following oil and gas sub sectors; Inspection, Repair & Maintenance, Pipes and Piping Components, Data Interpretation / Evaluation and Controls, Sensing and Monitoring.

- 2 Scottish enterprise should work with companies in the sub-sectors outlined above to develop a ‘market entry strategy’. The target heat network sub sectors that Scottish Enterprise should focus on are specialist hydraulic analysis, pipe and component manufacturer, specialist pipe services and design, operation and maintenance and sensors, controls and instrumentation.

- 3 Scottish enterprise should refine the long list of companies highlighted in this report to establish a priority list of companies who are receptive to diversification opportunities. Scottish Enterprise’ engagement with companies should include testing the attractiveness of the heat network market to oil and gas companies, developing diversification strategies and provide assistance in developing cross sector relationships with the heat network industry. Engagement with these companies could include running a series of workshops to assess opportunities in more detail.

- 4 Scottish enterprise should look to engage with organisations such as Resource Efficient Scotland, The Association for Decentralised Energy and Heat and the City. These organisations have relationships with the heat network supply chain and collaboration could include testing new oil and gas companies market offering to gauge initial opinion. Engagement with the organisations listed will also help to refine companies diversification strategies and could result in the creation of partnerships.

- 5 Scottish Enterprise should engage with national governments (Scottish and UK) to further understand policy decisions, timing of future support and the pipeline of projects that are coming to market. This engagement should include collaboration with BEIS and HNDU (Heat Networks Delivery Unit) to better understand supply chain gap and how the oil and gas industry is best places to capitalise on opportunities.

Internal – Refers to engaging with companies within the Scottish oil and gas supply chain that are relationship managed by Scottish Enterprise.

External – Refers to engaging with external bodies / organisations outside of the oil and gas sector, some of these companies may have an existing relationship with Scottish Enterprise.

10

Geothermal Deep Dive Assessment

10.1 The Geothermal Opportunity

Overview

The following section provides a detailed assessment of the crossover potential for oil & gas companies to the geothermal heat market. Geothermal heat resource can be utilised from abandoned mine workings or hot sedimentary aquifers. Mine workings are shallower and typical temperatures are approximately 20-30 degrees. Extracted heat needs to be upgraded with a heat pump to suitable. Depending on depth and location, hot sedimentary aquifers can provide heat direct to heating at 70-80 degrees. Typically geothermal wells of >2,000m are required to reach these temperatures. There are various designs for geothermal heat extraction and there include single, doublet and triplet geothermal well systems.

Geothermal heat is an undeveloped market in the UK. Multiple feasibility assessments have concluded there is widespread potential for geothermal heat but deployment remains limited to several pilots studies and one commercial project in Southampton. The primary reason these resources have not been exploited is because of the high upfront capital costs combined with uncertainty over well output. In addition, heat is a relatively low value product that requires a nearby heat source to supply.

10.2 Porter's Five Forces Assessment

The following deep dive will utilise a porters five forces assessment to analyse the competition present in the geothermal market. This is the first step to develop the Roadmap and recommendations. This will help to shape the conversation and discussion with the Scottish oil and gas supply chain.

Existing buyers

Geothermal heat is a supply technology for district heating and therefore buyers of district heating networks are also buyers of deep geothermal wells. Geothermal well buyers include:

- Private Developers
- ESCo's
- Local authorities (housing associations)
- NHS
- Universities

Project examples

The Southampton District Energy Scheme, originally developed by the Council but now owned and operated by Engie, is an example of a public sector funded geothermal project. This is only example of significant exploration for geothermal heat extraction in the UK.

There are several small pilot schemes in Scotland utilising minewater heat recovery. An example scheme is the supply to 19 residential units in Glenalmond street, Glasgow.

Industry suppliers

A list of industry suppliers can be found in section 10.3 (page 79).

Industry competition

The deep geothermal market in the UK is still underdeveloped. The majority of companies providing geothermal services do as a secondary service provision to either the ground source heat pump market or the gas (including shale) industry. During early market growth of the geothermal market there is likely to be significant competition for relatively few tenders.

Potential substitutes

The substitutes for geothermal are alternative low carbon heating technologies. See Section 9 for a description of heat pumps and hydrogen.

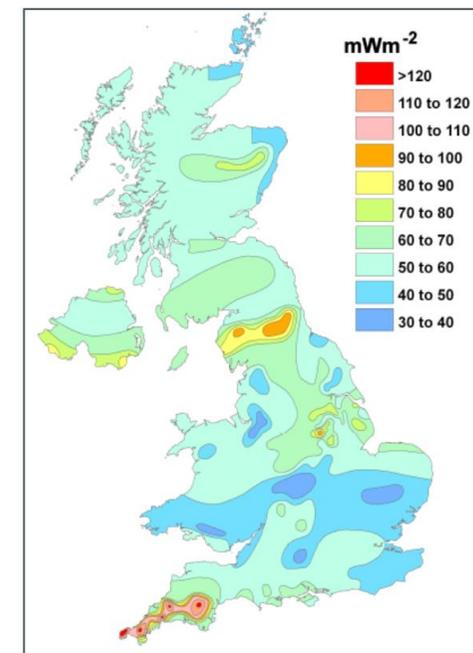


Figure 16: UK geothermal flux (Atkins)

10.2 Geothermal Porter's Assessment

Barriers and considerations for new entrants

Barriers to development of the UK geothermal industry are highlighted below:

Drilling risk

A significant risk for geothermal heat is the risk that a drilled has a lower permeability and / or temperature than modelled. This can significantly impact the heat output and consequently the commercial returns for an investor. Unlike oil, heat is a very low value product and therefore losses from multiple drilling failures cannot be recouped by the success of one drill. This has meant investors are unwilling to risk capital. Conversely, after the well has been drilled and productivity proven, the risk significantly reduces because maintenance and electricity costs are very low. This protects network operators from fluctuations in commodity prices.

Alternative technologies require significantly lower capital investment

Alternative low carbon heat supply options include:

- Energy from waste heat offtake
- Heat pumps (air, ground and water)
- Solar thermal
- Hydrogen injection
- Biomethane gas injection

Excluding hydrogen and biomethane

injection, the majority of alternative low carbon heat technologies require a lower capital investment and the investment risk is significantly lower.

The deployment of geothermal is location specific

Geothermal heat is constrained to locations where there is appropriate geology and the bedrock temperature is high enough to justify capital cost of drilling. Although some of other low carbon technologies are also location specific (water source heat pump), the majority can be deployed in most locations.

The growth of the geothermal heat market will be linked to the growth of heat networks market

Heat networks are technology agnostic and therefore the growth of heat networks will provide a much larger opportunity for geothermal wells to supply heat. Although heat networks are mostly supplied by gas CHP engines and boilers, these supply sources will need to be replaced by alternative low carbon heat technologies. Geothermal heat provides the lowest carbon heat of all the alternative technologies and is therefore attractive to heat network owners / operators. Government policy is expected to drive heat network decarbonisation after they have been installed but this policy is not yet in place and therefore this is an additional risk to the deployment of geothermal.

If the heat networks market fails to deliver on

growth expectations then the deep geothermal market will be more constrained to supplying individual buildings with large heat loads. Individual buildings will be less likely to choose geothermal heat because of the high capital cost and risk on well output.

Case Study: Science central geothermal well

In 2011, a 1,800m deep geothermal well was drilled at Newcastle Science Central. This is deepest well drilled to date in the UK. However, actual well permeability was considerably lower than modelled and subsequently the well has not been utilised for geothermal heat extraction. This project highlights the significant drilling risk associated with geothermal.

10.3 Existing UK Geothermal Suppliers

Table 13: Existing UK Geothermal Suppliers

Business Sectors	Companies
Energy Centre Design and Construction	Clarke Energy Edina Power
Well drillers	Marriott Drilling Meehan Drilling Moorhouse Drilling and Completions Hydracat Drilcorp Geo tech developments Ltd
Geoscience surveys	B.A. Hydro Solutions ESI Ltd Marton geotechnical services Large consultancies (Arup, Aecom, WSP etc)

Business Sectors	Companies
ESCos	E.On Engie SSE Veolia Nottingham Enviroenergy Vital Energi Metropolitan Pinnacle Power EDF Energy Services
Heat interface units	Envinox Energy SAV Systems Worcester Bosch Danfoss Swep Heatraesadia

10.4 Typical Supply Chain: Incumbent buyers

Figure 17 shows a typical UK geothermal project organisational chart for the delivery of a geothermal well to supply low carbon heat. A geothermal well will usually supply either a building with a relatively large heat demand or a heat network supplying multiple buildings.

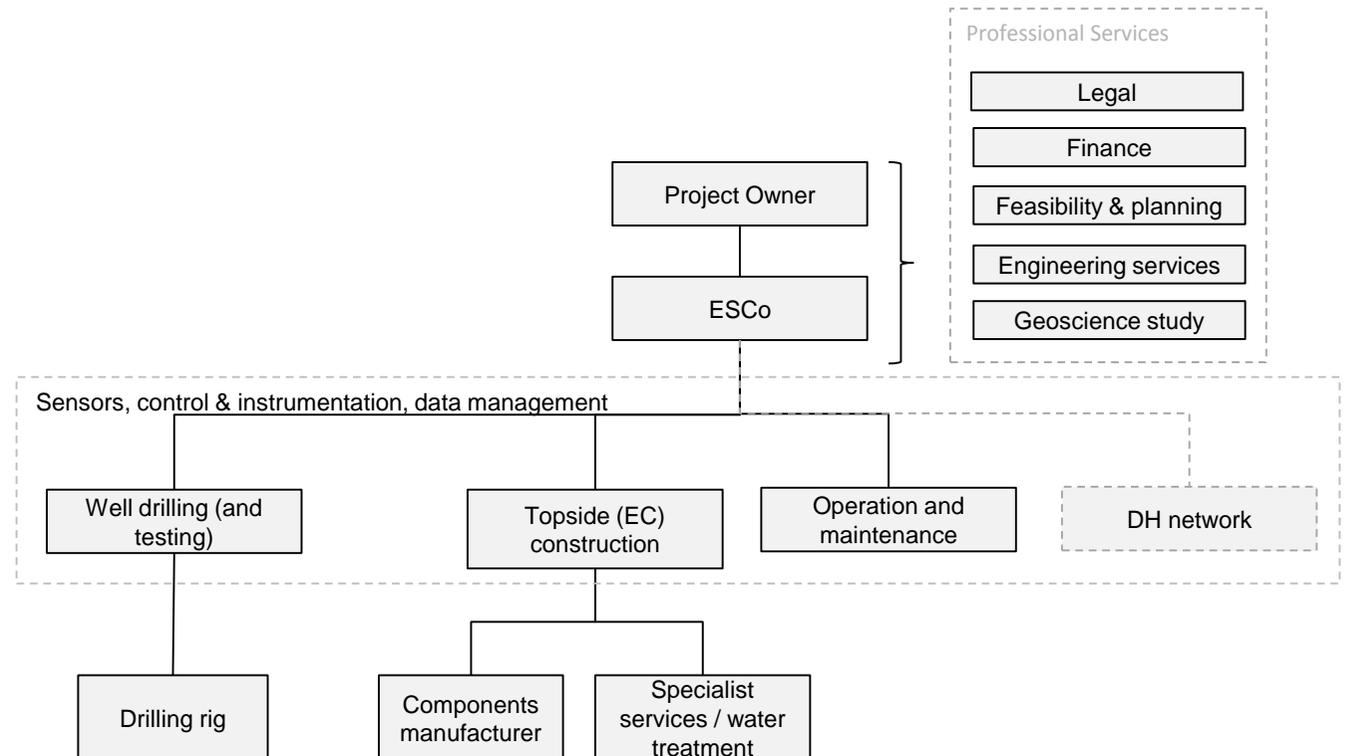


Figure 17 : Typical supply chain

Table 14: Geothermal Sub-sector Analysis

Barriers to Entry High Medium Low

10.5 Geothermal sub-sector analysis

Geothermal Supply Chain area (Example)	Oil and gas Hotspots	Capital per project (approx. £1.5m average project – 2km well – 70-80 degree water)	Barriers	Example oil and gas companies	Method of diversification
Energy service ESCo (Engie)	No upstream oil and gas crossovers	N/a (ESCo may provide capital investment and make return from energy sales)		N/a	N/a
Engineering services (excluding geoscience)	Engineering, design and construction	£0.15m		Wood Group, Mott Macdonald	Targeted recruitment / acquisition, Product / service development
Geoscience studies	All 'Reservoirs' subsectors	£0.05m		Task fronterra, Integrated Reservoir Modelling, Perigon Solutions Ltd, Pegasus International	Direct sales, Targeted recruitment / acquisition, Product / service development
Well drilling	All 'drilling & wells' subsectors	£1.1m		Tam Drilling Ltd, Tor Drilling	Direct sales, Service development
Topside construction	Inspection / repair / maintenance	£0.2m		Wood Group, Wier Group	Targeted recruitment / acquisition, Product / service development
Operation and maintenance	Inspection / repair / maintenance	£0.03m / annum		Wood Group, Pegasus International	Product / service development

Note: The costs indicated in the table are for one well approximately 2km deep. This cost should be multiplied for doublet or triplet well projects.

10.6 Geothermal – Diversification Opportunities

Geothermal in the UK is currently a very small market but there is potential for rapid growth if investment barriers can be overcome. The growth of the geothermal is likely to be facilitated by the growth of the heat networks. There are very strong technology and service crossovers that present an attractive diversification opportunity, particularly for upstream oil and gas companies categorised under ‘reservoirs’ and ‘drilling & wells’ the Pale Blue Dot classification.

Figure 5 summarises the crossovers between geothermal sub-sectors and the upstream oil and gas supply chain. Strong crossovers were found in:

- Well drilling
 - Oil & gas companies providing drilling services onshore will be able to directly tender for geothermal well contract opportunities. The well drilling accounts for approximately 80%.
- Geoscience surveys & related services
 - There is direct service provision crossover for companies providing geoscience surveys, data interpretation and survey equipment. However, typically this only accounts for a small proportion of total project costs.

- Operation and maintenance
 - Project owners typically tender long term (>20 years) operation and maintenance contracts. oil and gas companies already provide similar services to onshore wells and could therefore make direct sales or small alterations to service provision in order to supply the geothermal market.

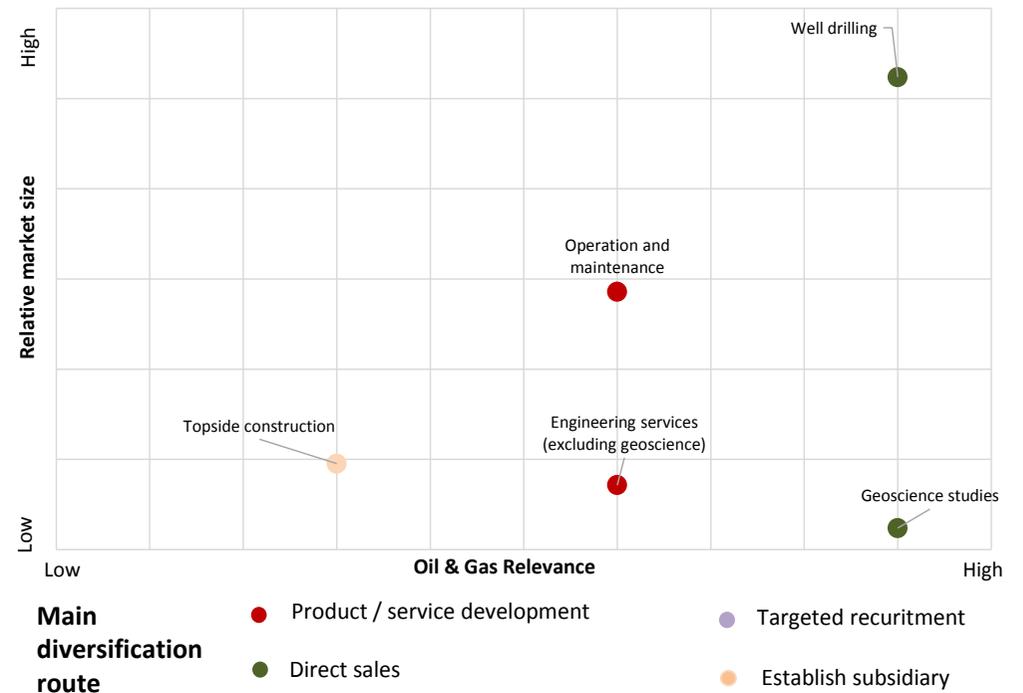


Figure 5: Sector crossovers and market size

10.7 Geothermal – Company Mapping

Figure 6 indicates that the oil and gas sub-sector with the largest number of companies in relation to geothermal is Inspection, Repair & Maintenance. Operation and maintenance of geothermal systems was highlighted as a key crossover area.

The number of companies with expertise in reservoir modelling and geoscience surveys is relatively small when compared to other sub-sectors and this is an area with significant crossover. However, the total market size for geoscience surveys is relatively small in comparison to the investment required in drilling and maintenance.

There are a large number of manufacturers and suppliers in drilling machinery and well testing. The majority of these companies are SMEs who are well positioned to capitalise on new well drilling opportunities.

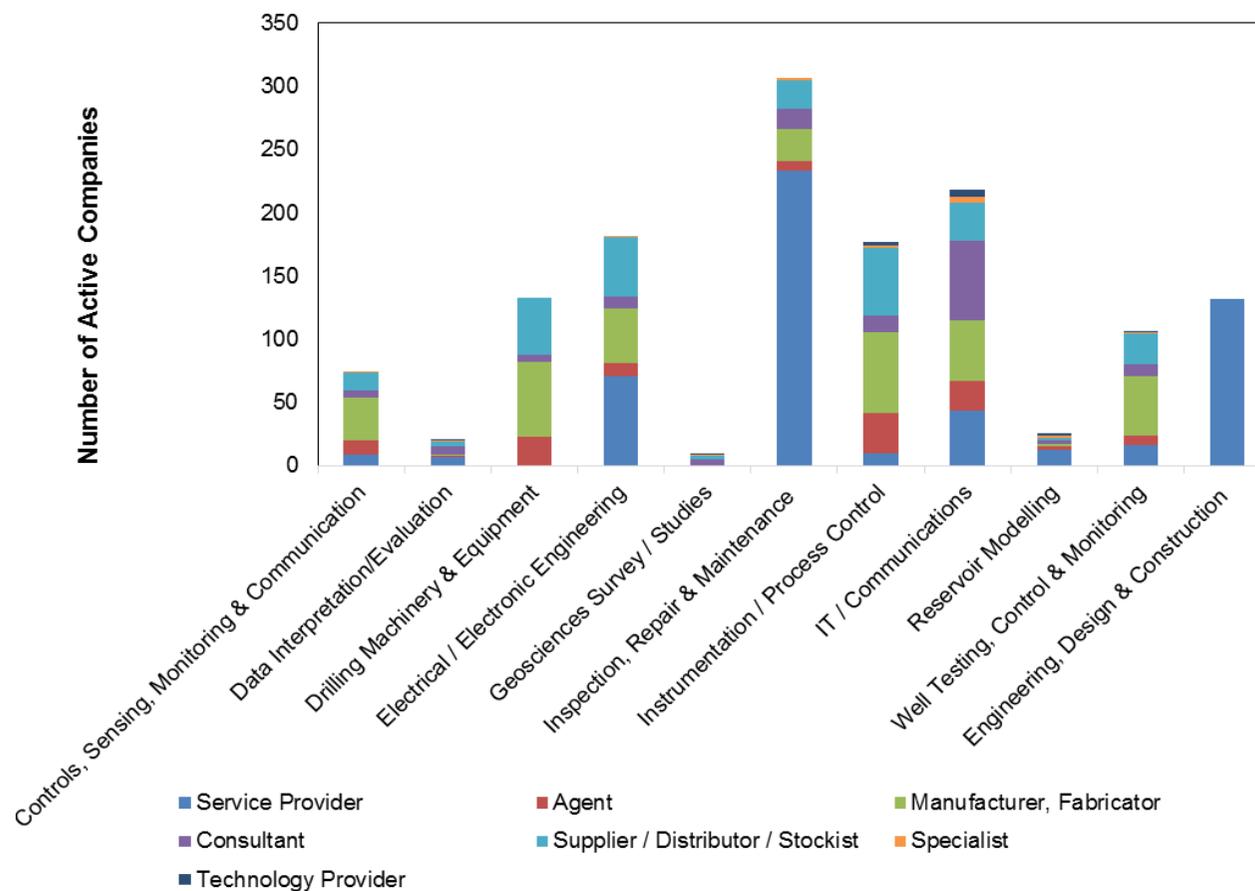


Figure 6: Opportunities for Scottish Oil & Gas Companies in Geothermal

10.8 Geothermal – Recommendations

Scottish Enterprise Stakeholder Engagement ● External ● Internal

Recommendations for Scottish Enterprise

- 1 Scottish Enterprise’s primary focus should be on supporting companies in the following oil and gas sectors; drilling and wells, reservoirs. The majority of sub-sectors in the these areas have crossovers with geothermal industry.

- 2 Scottish enterprise should work with companies in the sub-sectors outlined above to develop a ‘market entry strategy’. The target geothermal sub sectors that Scottish Enterprise should focus on are well drilling, geoscience surveys and operation and maintenance.

- 3 Scottish enterprise should refine the long list of companies highlighted in this report to establish a priority list of companies who are both receptive to diversification opportunities and those who Scottish Enterprise have a working relationship with. Scottish Enterprise’ engagement with companies should include testing the attractiveness of the geothermal market to oil and gas companies, developing diversification strategies and provide assistance in developing cross sector relationships with the geothermal industry.

- 4 The crossover between the geothermal industry and oil and gas has been explored by other organisations and Scottish Enterprise should engage with other organisations to collaborate on findings. For example, the American Association of Petroleum Geologists (AAPG) recently held a workshop in Durham exploring the diversification opportunities between the sectors. Scottish Enterprise should also collaborate with Deep Geothermal Group within the Renewable Energy Association (REA) to better understand future policy support and upcoming opportunities.

- 5 Scottish Enterprise could run an event / workshop that specifically focusses on how Scottish oil and gas expertise in drilling and reservoir modelling could be used to de-risk the well drilling process as this is currently the largest barrier preventing growth in the industry.

Internal – Refers to engaging with companies within the Scottish oil and gas supply chain that are relationship managed by Scottish Enterprise.

External – Refers to engaging with external bodies / organisations outside of the oil and gas sector, some of these companies may have an existing relationship with Scottish Enterprise.

11

Deep Dive Assessment – Municipal Water Sources &
Wastewater Treatment

11.1 Municipal Water & Wastewater Treatment and Reuse

Overview

The UK led the way in effectively treating wastewater in the late 1800's and early 1900's, and now with over 17000 sewage treatment works, and 98% of urban and rural households connecting to the sewage treatment service, wastewater treatment works is an area of strength in the UK¹.

11.2 Porter's Five Forces Assessment

The following deep dive will utilise a porters five forces assessment to analyse the competition present in these markets. This is the first step to develop the Roadmap and recommendations. This will help to shape the conversation and discussion with the Scottish oil and gas Supply Chain.

Existing Buyers

The regulated water sector comprises of organisations in the supply, distribution, collection and treatment of water and wastewater. Organisations in the UK are broken down into Water Only companies, Water & Sewerage companies and publically owned corporations in Northern Ireland and Scotland. Existing buyers in municipal wastewater treatment will therefore comprise of organisations across these areas.

These organisations have been listed as well as their investors in the Table 15 on pages 90 - 93.

The supply of water and collection and treatment of wastewater could be regarded as a natural monopoly in the UK. This is mainly due to two factors, the very high fixed costs of the infrastructure and the way these companies in the UK operate across large geographic areas. Therefore, the buyers (water and sewerage treatment companies) have considerable power to dictate terms, including determining costs of projects.

Existing Suppliers

The UK has a vast array of world leading professional services companies such as Arup, Mott MacDonald, Jacobs and Scottish Water International, a majority of which have international experience. These companies have a global reputation in the design of plants, and financial and contractual frameworks.

UK contractors have a proven track record of operating at a high standard in wastewater treatment works. Many UK construction contractors such as Skanska, Balfour Beatty and Costain have experience in municipal wastewater treatment works. While a number of these companies are operating internationally there is little evidence to suggest they are tackling global challenges specifically in municipal water treatment

works. Water utilities within the UK also have a strong domestic capability in operating wastewater treatment plants.

Due to drivers of change in the water industry and water scarcity issues arising globally, the industry has focused more closely on desalination processes. In more recent years, the UK has demonstrated a relatively good capability and solid reputation in this field.

For example, Thames Water opened the first major municipal desalination plant in Beckton in 2010. It uses river water and sea water, and produces 150 million litres per day, which is enough for 400,000 homes. There are a wide range of manufacturing companies in the UK that specialise in wastewater treatment works. As many are smaller innovative companies, they may not have the capacity to operate internationally. However, UK Water and Bluewater Bio are an example of manufacturers that do operate internationally.

The table on the following page summarises the key Tier 1, Tier 2 and Tier 3 organisations currently operating in the water sector in the UK.

From analysis of the supply chain it is evident that there is a comprehensive and mature offering across Tier 1 – 3 companies. Due to the large number of active companies in this space with a similar offering, competition is high and prices (margins) are relatively low. For this reason the suppliers do not

necessarily hold the power or control prices in the market. Therefore, it is relatively easy and cheap for the water companies to switch suppliers when framework contracts have ended.

Case Study: Scottish Water International
Drawing expertise from its Scottish business, offering services to governments, utilities and international clients who are looking to use their water resources as efficiently as possible, Scottish Water International are a UK operation that have strong capability in wastewater treatment works with capacity to operate internationally. An example of their international experience is their work for water company, Ashghal, in Qatar providing consultancy services and implementing systems, procedures and methodologies for sewage treatment plants wastewater network².

Case Study: UK Water and Bluewater Bio

In partnership, the two companies improved efficiency of an activated sludge plant in Bahrain based on its HYBACS secondary treatment. This produces nitrified effluent that surpasses the quality requirements for discharge to the sea. This upgrade created a 150% increase in capacity. Domestically, Bluewater Bio is developing sewage and water purification that uses half the power and half the land a treatment plant would usually use.

1 <https://www.gov.uk/government/publications/water-and-treated-water/water-and-treated-water#treated-water>

2. Scotland: the Hydro Nation – Delivering Results in the Water Sector

11.2 Municipal Water & Wastewater Treatment and Reuse

Barriers & Consideration for New Entrants

Competitors

A number of international and domestic competitors are identified in the table on the following pages. Scottish Oil & Gas companies would face considerable competition to market entry.

Appetite from the market (buyers / key stakeholders)

Since the privatisation of the water sector in England in 1989, companies in the UK are estimated to have spent between £108 billion - £126 billion on maintaining and improving assets. The majority of this spend has been to address environmental compliance including the upgrading or replacement of both infrastructure and non-infrastructure that was failing the new, more rigorous standards imposed by the European Union. However, this amount has widely been reported as considerably lower than the required amount to effectively maintain UK water assets. As such, infrastructure of UK Water assets are now beginning to receive a renewed attention and this can be expected to drive the need for new and innovative solutions and projects in the future.

Existing relationships in the supply chain

As noted under Existing Suppliers, there are a number of alliances which incorporate companies from Tier 1 consultants, Tier 2 sub consultants and contractors as well as Tier 3 manufacturers.

Therefore, these existing relationships may hinder the ability of successful market entry from the relevant oil and gas supply chain in Scotland.

Technology

Oil and gas companies would be well equipped with the relevant technologies and processes to address challenges in the municipal water and wastewater treatment industry. Given the highly advanced technology within oil and gas companies, directly relevant to water wastewater treatment, little technological diversification would be required before market entry could be considered.

Costs

The supply of water and collection and treatment of waste is generally regarded as a natural monopoly due to the very high fixed costs of the infrastructure and the way it operates across large geographic areas. Therefore, the set up costs and adapting technology costs will be key considerations for the relevant oil and gas companies in Scotland. The costs to the buyers to change supplier are not likely to be as significant.

Potential Substitutes

Decentralised supply and treatment systems can provide safe water where centralised supply and treatment systems are not feasible due to technical, economical or institutional reasons. They can also provide direct access to water sources that would otherwise not be locally utilised. Adoption of these technologies could vastly reduce fresh

water consumption and wastewater treatment facilities. Domestic wastewater reuse systems are also available. As these can reduce the amount of wastewater discharged to municipal wastewater systems there is scope for substitution.

Scotland is one of the world leaders in Sustainable Urban Drainage Systems (SUDS), as one of the first countries to institute policy for their implementation, and has a strong background in decentralised water treatment. This includes: stormwater management, greywater recycling, packaged water treatment plants and sewer mining technologies.

Industry Competitors and Extent of Rivalry

The level of competition in this market is high. The reason for this is mainly due to the vast number and maturity of domestic and international competitors. The other key reason is due to the framework procurement process that often entails awarding an alliance of companies / organisations for a period of time.

For municipal water and wastewater treatment works an alliance partner/s are awarded between 5-15 year frameworks to deliver related projects.

For example, Anglian Water has awarded the @OneAlliance to deliver integrated main capital works. This alliance consisting of Balfour Beatty, Barhale, Grontmij, MWH, Mott MacDonald, Bentley and Skanska and will cover all types of complex construction and

refurbishments projects.

This includes water and wastewater works. Although the alliance contracts are reviewed every five years in England (6 years per AMP cycle in Scotland), the contract runs for AMP6, 7 and 8 (2015-2030). Therefore, market entry is increasingly difficult without partnering with an alliance company, sub-contracting or targeting opportunities as a Tier 3 manufacturer.

International Opportunities

Key international opportunities for Municipal Water and Wastewater Treatment and Reuse have been identified in the following areas:

Canada

- Treatment of highly charged wastewater using reverse osmosis in the mining industry.
- High-growth in membrane filtration in the production of drinking water.

India

- Low-cost membrane technology solutions for residential markets, and innovative technology for desalination plants.

Europe

- Treatment methods for spill control and containment;
- Management, measurement and monitoring of wastewater;
- Mechanical sludge dewatering processes in the process of waste-to-energy.

11.3 Existing Suppliers and buyers

Table 15: Existing buyers and suppliers in municipal water and wastewater (contracts / frameworks currently in place).

Investors / Owners	Existing Buyers -Water and Sewage Company	Existing Suppliers / Tier 1,2 & 3 Key Companies under contract	Contract details
Consortium-Canada Pension Plan Investment Board, Colonial First State IFM Investors and 3i.	Anglian Water	<ul style="list-style-type: none"> Balfour Beatty, Barhale, Grontmij, MWH, Mott MacDonald Bentley and Skanska. Anglian Water, Barhale, Kier nd Morrison Utility Services. Anglian Water, Kier, Clancy Docwra, Claret Civil Engineering, Danaher & Walsh and Public Sewer Services. Anglian Water, Clancy Docwra and Kier 	<ul style="list-style-type: none"> The @one Alliance (Integrated Main Works Capital) - the largest alliance covers all types of complex construction and refurbishments projects. Integrated Operational Solutions - covers water and water recycling local refurbishment and maintenance Integrated Maintenance and Repair - covers water and water recycling network infrastructure maintenance.
Glas Cymru	Dwr Cymru Welsh Water	<ul style="list-style-type: none"> Morgan Sindall working with Arup Skanska Construction UK Limited working with Hyder Consulting (UK) Limited Mott Macdonald Bentley Limited 	<ul style="list-style-type: none"> Morgan Sindall and Arup - Wastewater infrastructure design and build works to maintain and upgrade DCWW's assets throughout Wales – £25 M / year.
Cheung Kong Infrastructure Holdings	Northumbrian Water	<ul style="list-style-type: none"> Esh Construction and MWH Joint Venture Integrated Water Services Interserve and Mott MacDonald Bentley 	<ul style="list-style-type: none"> Planned maintenance work on Northumbrian Water's network over the ten-year contract. Large scale capital projects designed to improve overall asset infrastructure.
Listed on LSE	Severn Trent Water	<ul style="list-style-type: none"> Costain Amey Laing O'Rourke Construction Imtech Process Morgan Sindall Mott MacDonald Bentley MWH Treatment North Midland Construction 	<ul style="list-style-type: none"> Amey - Repair and maintenance of the sewer network across the entire Severn Trent region - £250M.

11.3 Existing Suppliers and buyers

Table 15 (continued): Existing buyers and suppliers in municipal water and wastewater

Investors / Owners	Existing Buyers -Water and Sewage Company	Existing Suppliers / Tier 1,2 & 3 Key Companies under contract	Contract details
Greensland Holdings Ltd	Southern Water	<ul style="list-style-type: none"> CMDP - JV Costain and MWH GTM, a joint venture between Galliford Try and Imtech, supported by strategic design partner Atkins. MGjv, a joint venture between Morrison Utility Services and Galliford Try, supported by strategic design partner AECOM. 	<ul style="list-style-type: none"> Maintenance and improvements to water supply and wastewater treatment works in the eastern half of Southern Water's region. Capital partners for AMP6 (2015-2020). With option to extend 5years, £200m. Expanding and maintaining Southern Water's network of mains and sewers, which are more than 53,000 kilometres in length.
Kemble Water Ltd	Thames Water	<ul style="list-style-type: none"> Costain and Atkins Skanska, MWH Treatment and Balfour Beatty (SMB) MWH IBM 	<ul style="list-style-type: none"> D&B - part of infrastructure alliance eight20 D&B - part of infrastructure alliance eight20 Programme Manager - part of infrastructure alliance eight20 Technology Innovator - part of infrastructure alliance eight20
Listed on LSE	United Utilities	<ul style="list-style-type: none"> C2V+ (CH2M Hill and VolkerStevin) Advance (Balfour Beatty and MWH) LiMA (Laing O'Rourke and Imtech, with support from Atkins) Jacobs UK 	<ul style="list-style-type: none"> Construction and engineering service partners for AMP6 (2015-2020). With option to extend 5years.
YTL Corporation	Wessex Water	<ul style="list-style-type: none"> Lewis Civil Engineering, Interserve Construction, Raymond Brown Construction, Dawnus Construction, Nomenca. Interserve Construction, Nomenca, Trant Engineering, ACIEM Group. Atkins, Mouchel, AECOM, Hyder Consulting, Grontmij and Pell Frischmann Consulting Engineers. 	<ul style="list-style-type: none"> Civil's delivery team EMI delivery team Design capital delivery

11.3 Existing Suppliers and buyers

Table 15 (continued): Existing buyers and suppliers in municipal water and wastewater

Investors / Owners	Existing Buyers -Water and Sewage Company	Existing Suppliers / Tier 1,2 & 3 Key Companies under contract	Contract details
Saltire Water	Yorkshire Water	<ul style="list-style-type: none"> Byzak Entec Earthtech Morrison Morgan Sindall Grontmij JV Barhale WSP Mott MacDonald Bentley Black & Veatch Morrison Utility Services Balfour Beatty Utility Solutions 	<ul style="list-style-type: none"> Delivery Partners AMP6 2015-2020 £1b YSW AMP6 framework value
		<ul style="list-style-type: none"> Arup MWH Turner and Townsend 	<ul style="list-style-type: none"> Consultants AMP6 2015-2020 £1b YSW AMP6 framework value
		<ul style="list-style-type: none"> Nomenca Cema Clayton Consortium Eric Wright Group Damar Group 	<ul style="list-style-type: none"> MEICA AMP6 2015-2020 £100m AMP6 MEICA contract
Scottish Government	Scottish Water	<ul style="list-style-type: none"> Caledonia Water Alliance (Morrison Utility Services and AECOM) BBV alliance (Black & Veatch and Byzak) 	<ul style="list-style-type: none"> Infrastructure alliance partner, Quality & Standards IV (Q & S IV) Programme management, design and construction of works associated with the water network - delivering £360M over 2015-2021. Infrastructure alliance partner £340m over 2015-2021.

11.3 Existing Suppliers and buyers

Table 15 (continued): Existing buyers and suppliers in municipal water and wastewater

Investors / Owners	Existing Buyers - Water Only Company	Existing Suppliers / Tier 1,2 & 3 Key Companies	Contract details
Morgan Stanley/M&G Investments	Affinity Water	<ul style="list-style-type: none"> Morrison Utility Services, Kier Integrated Service Ltd. 	<ul style="list-style-type: none"> Developer Services Contract AMP6 (2015-2020) £8m
Pennon Group	Bournemouth Water	<ul style="list-style-type: none"> Kier Integrated Service Ltd. 	<ul style="list-style-type: none"> Delivery Partners AMP6 (2015-2020) £17.5m
Suez and CaixaBank	Bristol Water	<ul style="list-style-type: none"> Land and Marine Engineering Ltd . Kier Integrated Service Ltd. 	<ul style="list-style-type: none"> Trunk mains contract, £7m Network Maintenance Services Programme, £100m AMP6 (2015-2020)
Cheung Kong Infrastructure Holdings	Essex and Suffolk Water	<ul style="list-style-type: none"> Fastflow Pipeline Services, Crossglade Lowman T4 Survey 	<ul style="list-style-type: none"> £20.5m annually in the North East and £9.5m in Essex £5m annually £1m £1m
Independent	Portsmouth Water	<ul style="list-style-type: none"> Cappagh Contractors have 	<ul style="list-style-type: none"> £24.2m infrastructure contract
Hastings Diversified Utilities Fund/Utilities Trust of Australia	South East Water	<ul style="list-style-type: none"> BAM Nomenca JV Enisca Browne JV 	<ul style="list-style-type: none"> Non infrastructure major works Non Infrastructure Intermediate Capital Works and Minor Capital Works AMP6 (2015-2020) option to extend for 10 years
Kohlberg Kravis Roberts & Co LP	South Staffordshire Water	<ul style="list-style-type: none"> IWS Ltfd T&K Gallagher Uniplumb 	<ul style="list-style-type: none"> AMP6/7 repair and maintenance contract £13m £700k £300k
Sumitomo Corporation	Sutton and East Surrey Water	<ul style="list-style-type: none"> Clancy Docwra Ltd J Murphy & Sons Ltd 	<ul style="list-style-type: none"> Infrastructure and Resilience contracts £87m

11.4 Municipal Water & Wastewater Typical Supply Chain

Figure 20, shows typical UK organisation chart for the delivery of a water and wastewater treatment project in the UK. Since privatisation in 1989, water utilities have followed an Asset Management Period (AMP), whereby the privatised water boards tender contracts to help keep infrastructure properly maintained and undertake new projects. This first AMP period lasted five years, and was followed by four further five year periods, AMP6 begun in 2015. In recent periods AMP5/6 the industry has moved toward forming alliances and partnerships amongst the supply chain to more effectively deliver programmes of work for the Utility.

A framework agreement is often tendered in advance of the AMP cycle and can be extended.

A typical framework will consist of a Tier 1 consultant and also a Tier 1 contractor. The various roles for each organisation type are highlighted in Figure 20.

Tier 2 subcontractors and Tier 3 Manufacturers will often be utilised and included in the alliance to deliver and support the work being completed.

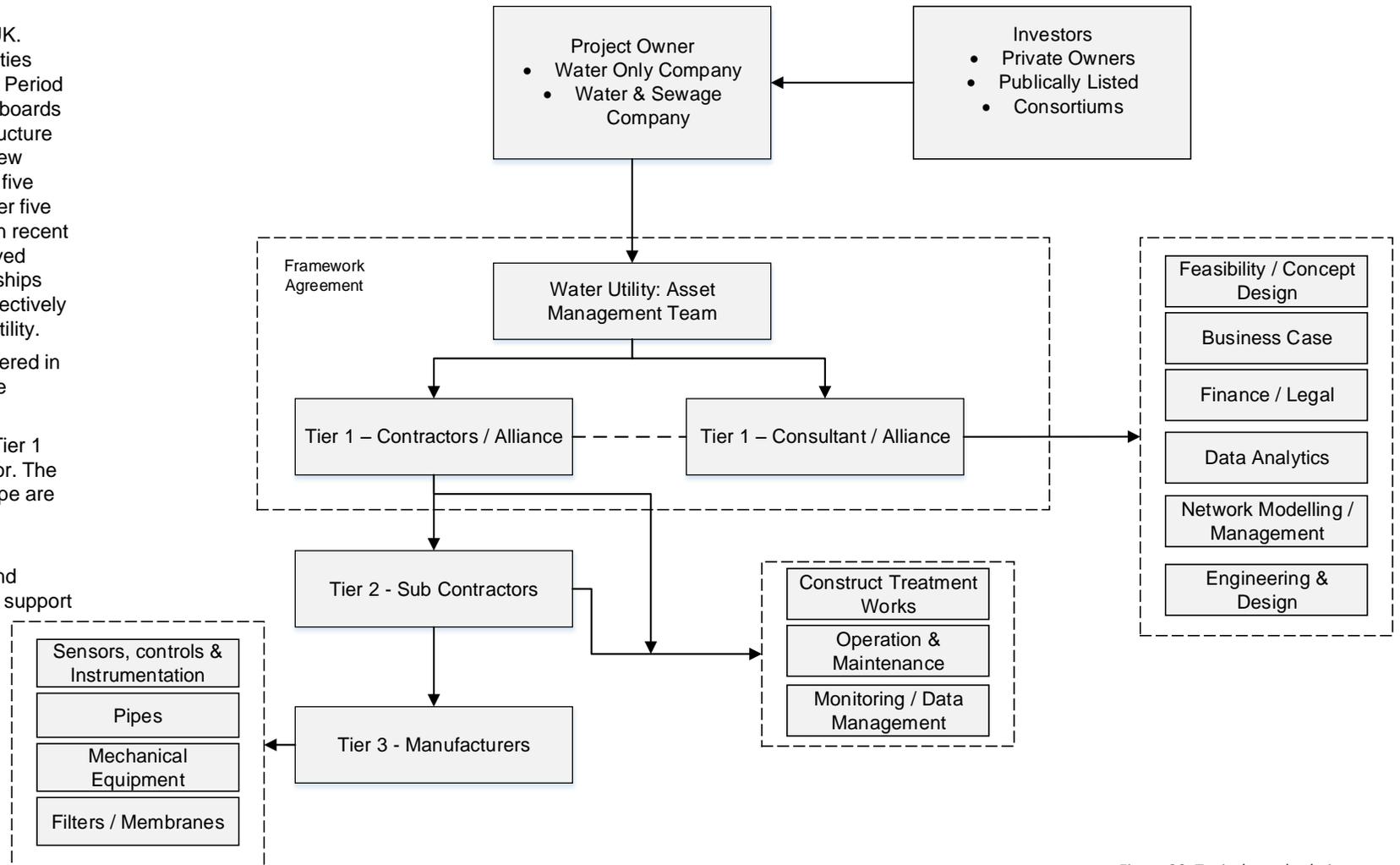


Figure 20: Typical supply chain

11.5 Municipal Water & Wastewater Treatment and Reuse

Table 16: Municipal water and wastewater treatment and reuse sub-sector analysis

Barriers to Entry High Medium Low

Municipal Supply Chain area (Example)	Oil and gas Hotspots	Capital per project (£100m - £250m average project)	Barriers	Example oil and gas companies	Method of diversification
Feasibility, Design & Consult <ul style="list-style-type: none"> Tier 1 Consultant / Alliance Partners Tier 2 Sub-consultants 	<ul style="list-style-type: none"> Engineering Services / Design Reservoir Modelling / Development Well Engineering / Design 	£1M - £3M		Avanteq Ltd Zenith Energy Norwell Engineering SPD Ltd	<ul style="list-style-type: none"> Alliance / Partnerships Collaborative Groups Merger / Acquisition Targeted Recruitment Establish Subsidiary
Construct Treatment Works <ul style="list-style-type: none"> Tier 2 Contractors 	<ul style="list-style-type: none"> Process, Pumping and Power Systems Waste Treatment, Management Cleaning & Disposal 	£50M - £150M		Rolls-Royce Oil & Gas GE oil and gas	<ul style="list-style-type: none"> Partnerships / Sub Contract Merger / Acquisition Product / Service Development
Construct Treatment Works <ul style="list-style-type: none"> Tier 3 Manufacturers 	<ul style="list-style-type: none"> Piping & Components Drilling / Boring / Pumping Equipment Production / Process / Accommodation Modules & Equipment 	£15M - £75M		Pipeline Equipment LFF Group Allied International UK	<ul style="list-style-type: none"> Direct Sales Product / Service Development
Operation & Maintenance <ul style="list-style-type: none"> Tier 2 Contractors 	<ul style="list-style-type: none"> Inspection / Repair / Maintenance Subsea Inspection / Repair / Maintenance 	£15M - £25M		MMI Engineering Ltd Innospection Ltd	<ul style="list-style-type: none"> Partnerships / Sub Contract Merger / Acquisition Product / Service Development Direct Sales
Sensors, controls and instrumentation <ul style="list-style-type: none"> Tier 2 Contractors Tier 3 Manufacturers 	<ul style="list-style-type: none"> Control, Sensors, Monitoring & Communication Instrumentation / Process Control 	Sensors and control equipment provided as part of contractors packages for treatment plants.		Omni instruments, Emerson Valves Permasense	<ul style="list-style-type: none"> Product / service development Targeted recruitment Merger / Acquisition Direct Sales

11.6 Municipal Water & Wastewater Treatment and Reuse – Diversification Opportunities

There are a number of key areas of opportunity for the Scottish oil and gas supply chain to target in the municipal water and wastewater markets in the UK.

Market forces such as ageing infrastructure, water scarcity and security issues as well as increased pressure from Ofwat are creating opportunities as utilities look to address operational efficiency and maintain profits.

Therefore, these factors are driving considerable growth in Municipal Water and Wastewater Markets as utilities upgrade existing assets and look to address water scarcity issues.

This market growth, coupled with strong technology crossovers, means there are strong opportunities for oil and gas companies to diversify into this market.

Figure 7 summarise the crossovers between municipal water and wastewater treatment sub-sectors and the upstream oil and gas supply chain. The colour of the dots provides an indication of the potential main diversification route.

It should be noted that the diversification model is likely to differ for every company depending on their target market and current business structure. Whilst the relative market size provides useful context, it does not necessarily mean a larger opportunity is better because relevant oil and gas companies will have different target markets

and expectations on project return and size.

In summary, strong crossovers were found in:

- Sensors, controls and instrumentation
 - Control and equipment and instrumentation such as temperature, flow and pressure sensors are directly applicable to these markets.
- Pipe and components manufacturer
 - Piping costs and components accounts for a significant proportion of project costs. Some oil and gas companies may have an opportunity for direct sales into these markets but oil and gas companies will need to develop specific products.
- Data Analytics & Network Modelling
 - Companies with strong capabilities in data analytics and network modelling will be able to target direct opportunities in these markets. Alliance / partnerships with established players should also be explored.
- Operation and maintenance
 - A number of operation and maintenance contracts are now being tendered outside of the framework agreements between utilities and consultants / alliances.

Therefore, there are direct opportunities as well as the need for further product / service development for market entry.



Figure 7: Sector crossovers and market size

11.7 Municipal Water & Wastewater Treatment and Reuse – Company Mapping

Figure 8 indicates that Inspection, Repair & Maintenance including Subsea stands out as the most prominent relevant area of the oil and gas supply chain based on the number of companies active in this sector.

There are also a large number of companies offering services and products in Pipes and Piping Components. Specifically, these subsectors (Pipes) have the largest number of manufacturers active that are relevant to Municipal Water and Wastewater Treatment.

Therefore, these sub sectors along with Production / Process / Accommodation, Drilling Machinery & Equipment and Instrumentation and Process Control should be a key focus due to the large number of Manufacturers and likely number of SMEs who could benefit.

On this basis, companies active in Controls, Sensing and Monitoring should also be considered with approximately 35 companies active in this sector.

The Scottish Offering in Process, Pumping and Power as well as Reservoir Modelling appears to be limited due to the low number of active companies. This may reduce the impact that Scottish Enterprise can have in this sector.

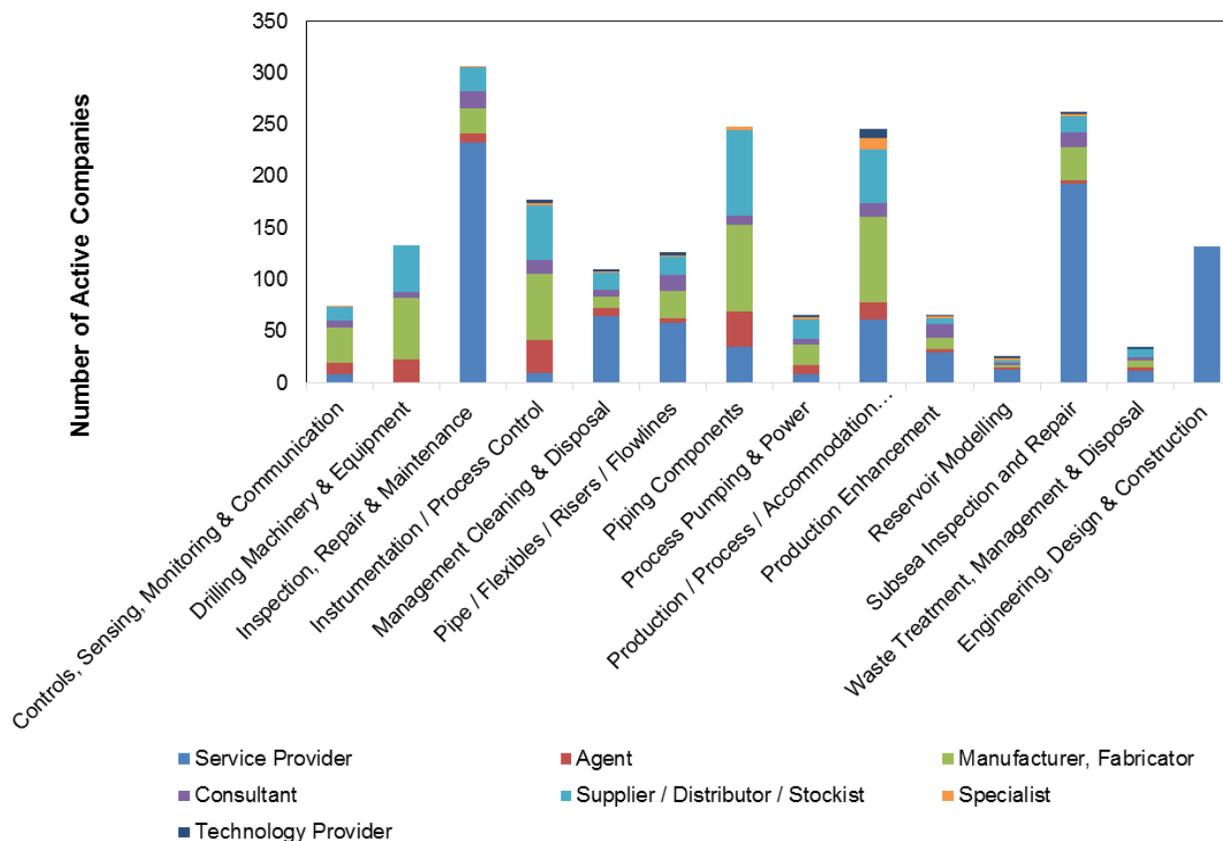


Figure 8: Opportunities for Scottish Oil & Gas Companies in Municipal Water and Wastewater Treatment

11.8 Municipal Water & Wastewater Treatment and Reuse – Recommendations

Scottish Enterprise Stakeholder Engagement ● External ● Internal

Recommendations for Scottish Enterprise

- 1 Target Municipal Water & Wastewater Treatment opportunities based on relative market size and relevance to the oil and gas sector are Pipe and Pipe Components, Data Analytics, Operation and Maintenance, Sensors, Controls and Instrumentation, and Network Modelling.

- 2 Scottish Enterprise’s primary focus should be diversification of the following sub sectors of the Scottish oil and gas supply chain; Inspection, Repair & Maintenance including Subsea, Pipes and Piping Components, Production / Process / Accommodation, Drilling Machinery & Equipment and Instrumentation and Process Control. Controls, Sensing and Monitoring should also considered.

- 3 The capacity of the Scottish oil and gas supply chain to capitalise on opportunities in Network Modelling and Management in Municipal Wastewater may be limited despite their (oil and gas) advanced expertise and direct technology transfer. This is due to the limited number of companies that appear to be active in this sub-sector.

- 4 Scottish Enterprise to identify the companies active in the primary focus sub sectors, whether they currently relationship manage these relevant companies, and whether these companies are interested in opportunities to diversify into alternative markets.

- 5 The majority of projects in Municipal Water & Wastewater Treatment and Reuse are delivered by companies that are part of their capital delivery framework or alliance partners. This poses the biggest barrier for Scottish oil and gas companies to successfully diversify into this sector. Once relevant companies have been identified, Scottish Enterprise should connect, build and foster relationships with oil and gas SMEs with Water Utility Asset Management Departments, and existing Tier 1 Consultants and Contractors that are currently on frameworks or bidding for the next Asset Management Period in 2020. The majority of these frameworks are now out for tender in time for Ofwat’s price review in 2019.

- 6 In parallel with Recommendation 5, Scottish Enterprise need to engage with individual companies or run a series workshops with companies to assess opportunities and competitors in more detail. This will help SMEs to develop unique selling points’ as they diversify and target opportunities in Municipal Water & Wastewater Treatment. During this process Scottish Enterprise should work with oil and gas companies to identify novel technologies within their industry that might be commonplace, but have not yet been integrated into the water industry.

- 7 Scottish Enterprise should engage with Ofwat and Government bodies (NIC / Defra / BEIS) to further understand their agenda, regulatory requirements for new products, potential projects and direction in future AMP cycles. This will likely drive future projects and provide clear opportunities for Scottish oil and gas companies looking to develop relevant products for the future.

Internal – Refers to engaging with companies within the Scottish oil and gas supply chain that are relationship managed by Scottish Enterprise.

External – Refers to engaging with external bodies / organisations outside of the oil and gas sector, some of these companies may have an existing relationship with Scottish Enterprise.

11.8 Municipal Water & Wastewater Treatment and Reuse – Recommendations

Scottish Enterprise Stakeholder Engagement ● External ● Internal

Recommendations for Scottish Enterprise

- 8** Post internal workshop, Scottish Enterprise could explore further engagement with individual companies or small groups to help facilitate and conduct maturity assessments of their in-house capability, including skills, staffing requirements and any potential changes to supply chain. This will allow companies to develop and identify specific strategies for methods of diversification (company structure, subsidiary requirement, partnerships).
- 9** Scottish Enterprise could explore showcasing key technologies or companies at water industry based conferences, events or exhibitions. For example, Scottish Government is running an event in Leeds called The UK's Big Water Challenges: Opportunities to Collaborate, events such as these or World Water Tech hosted in London would be a good opportunity for Scottish Enterprise to showcase relevant companies and technologies that could make the transition into municipal water and wastewater treatment.
- 10** Scottish Enterprise should explore the possibility of running cross sector workshops or networking events. These events could link relevant parties, creating connections between key oil and gas supply chain companies and crucial stakeholders such as Water Utility Asset Managers, Innovation Team Leaders or Technical Policy makers.
- 11** Scottish Enterprise should continue to build relationships with governing bodies and organisations (The UK Water Partnership, British Water, Future Water Association, Water Industry Forum) to further understand the industry's needs and capability gaps. The UKWP is an example of an organisation with ties to Innovation departments in water utilities across the UK. There may be an opportunity to present new technologies and service offerings at quarterly meetings to key industry stakeholders.

Case Study – Sarco Stopper

Sarco Stopper been supported by Scottish Enterprise account management for a number of years. Sarco is the UK's leading manufacturer of specialist under pressure bagging-off systems for the water and gas utility companies, off-shore and on-shore oil and gas process companies and other industries like food processing. Their products allow customers to repair pipes in situ to minimise the loss in supply of water, gas etc. Water and gas companies are fined if they disrupt the flow of utilities to their customers. Sarco are working with these utility companies world-wide to develop innovative solutions to minimise downtime and reduce the regulatory fines by reducing disruption and without interrupting supplies to nearby customers.

Relevance to oil and gas Companies

Sarco, whose technologies originated in the oil and gas sector before adapting to the meet needs of the water sector, diversified their products in order to gain entry to the water market. Through identifying the change of mind set and customer focus required, Sarco were able to transition their technologies, which were commonplace in the oil and gas sector but novel in the water sector. They were able to address the needs of the water sector and entered the market as an innovative supplier, resulting in a 30-50% increase in turnover for the company. If oil and gas companies used their expertise to adapt and redesign products and processes to suit the water market, market entry to a new competitor becomes significantly more viable.

Internal – Refers to engaging with companies within the Scottish oil and gas supply chain that are relationship managed by Scottish Enterprise.

External – Refers to engaging with external bodies / organisations outside of the oil and gas sector, some of these companies may have an existing relationship with Scottish Enterprise.

12

Deep Dive Assessment – Industrial Wastewater Treatment

12.1 Industrial Wastewater Treatment and Reuse

Overview

The UK water sector is made up of a vast range of stakeholders. For industrial wastewater treatment and reuse the wider water market is considered.

Other industries that require water services other than buying them from a water company include local authorities, highways authorities, rail, developers and the commercial and wider industrial sectors such as chemicals, F&D, life sciences and energy.

12.2 Porter's Five Forces Assessment

The following deep dive will utilise a porters five forces assessment to analyse the competition present in these markets. This is the first step to develop the Roadmap and recommendations. This will help to shape the conversation and discussion with the Scottish oil and gas Supply Chain.

Existing Buyers

For industrial wastewater treatment the following sectors existing buyers, including agriculture, power, pharmaceuticals and food, among many other wider industrial sectors. It has been estimated that these markets in the UK are potentially in total worth about 30% of the municipal water market (3)

Buyers in industrial wastewater treatment

markets do not necessarily have a geographic monopoly when compared to municipal opportunities. Therefore, due to the larger number and more diverse nature of buyers in this market they have a lot less power to dictate terms and drive down costs.

Existing Suppliers

Existing Suppliers – International

Manufacturers

Key international manufacturers Industrial wastewater treatment include:

General Electric: GE is an American conglomerate which operates worldwide. GE Water manufactures a wide variety of wastewater treatment equipment.

Siemens: Siemens is a German conglomerate. Within the wastewater sector Siemens focus mainly on process and control systems.

Xylem: Xylem is an American manufacturer of water and wastewater treatment equipment which currently manufactures and sells products.

Contractors

Key international contractors in the industrial wastewater treatment industry include:

Veolia: Veolia is a French conglomerate. Veolia Water offer design, build, operate and maintain services for industrial wastewater treatment plants and currently serves over

40,000 industrial clients worldwide.

Suez Environment is a French utility company operating in the water treatment and waste sectors. Suez offer design, build, operate and maintain services for industrial wastewater treatment plants.

Professional Services

The contractors mentioned above are typically vertically integrated such that they both design and build the wastewater treatment plant. However, Fichtner (a German multidisciplinary engineering consultancy firm) are a consulting firm engaged in the design of such systems.

Existing Suppliers – Domestic

Table 17 on the following pages summarises the key Scottish organisations currently servicing the UK Industrial Water sector.

In summary, UK professional services, contractors and manufacturers have strong capability to contribute to the sustainability of the industrial sector. With a recent push to minimise environmental impact and water consumption, UK designers, consultants, contractors and manufacturers have been involved in improving existing practice and industrial wastewater treatment processes.

Domestic competition is also well developed across the supply chain, for example Dryden Aqua - one of the manufacturers leading the way in Scotland.

Case Study: Dryden Aqua (Scottish Strength)

Dryden Aqua is a Scottish SME company, they manufacture sufficient activated filter medium (AFM) to provide clean water for over 50 million people per year. However they only have around 20 million receiving drinking water filter by AFM, 6 systems in Ireland but hundreds of systems in India, Bangladesh and Africa, where there is a desperate need for clean safe drinking water. They also provide over 250,000 water treatment systems in Europe for the swimming pool industry and provide clean water for Diageo to make Guinness, Budweiser for China, half of Bahrain, China Steel and many other applications.

IFTS in France have confirmed that AFM is one of the best mechanical filtration media in Europe, recent test confirm that grade 0 AFM can remove 99.9% of all particles in water down to 4 microns without the use of coagulation or flocculation chemicals, the best that a 16 x 30 sand can do is 70% at 5 microns.

1 <https://www.gov.uk/government/publications/water-and-treated-water/water-and-treated-water#treated-water>

2. Scotland: the Hydro Nation – Delivering Results in the Water Sector

3. Frost and Sullivan, 2016.

12.2 Industrial Wastewater Treatment and Reuse

Potential Substitutes

Decentralised Wastewater Treatment

Growing demand for small scale point of use technologies can only be met with the development of a number of technical solutions. Recent trends indicate that the following technologies will continue to grow and develop in this market:

- Reverse Osmosis (RO) which is regarded as one of the most effective mobile water purification systems and is predicted to account for approximately 30% of market share by 2020.
- Localised (onsite) recycling of greywater – has the potential to reduce the volume of water consumed for industrial processes.
- Ion exchange, new filtration methods, and distillation processes are also being developed and adapted to small-scale point of use.

Barriers to Entry

Recently, there has been a push from the UK government to focus on improving and implementing sustainable practices across industries¹. This indicates that the state of the UK's capability may not be as advanced as its global counterparts.

Industrial Wastewater markets in the UK present a number of opportunities for Scottish oil and gas Supply chain across various Business Sectors; professional services,

manufacturers, contractors and governance and regulation.

Oil and gas companies seeking opportunity in industrial wastewater in the UK and abroad may be well placed to secure initial contracts with private companies, build relationships domestically and then migrate into wider markets and opportunities, mitigating risks through a strong initial foundation.

Industry Competitors and Extent of Rivalry

Due to the widespread competition in industrial wastewater treatment and reuse the Scottish oil and gas chain will be forced to compete through a number of means such as; aggressive pricing strategy, advanced technical expertise, well developed project management, execution and the potential for an integrated offer.

One potential route to market for the Scottish oil and gas supply chain is through an integrated approach to opportunities in the Design-Build-Operate of industrial wastewater treatment plants. Problems faced both in the UK and globally with industrial processes leading to pollutants such as nitrates, fluoride, arsenic and iron contaminating groundwater may present an opportunity to the oil and gas industry to influence and manage this problem by offering partnering to build relationships and utilise potential opportunities in the market.

Oil and gas companies looking to enter the market as new manufacturers will face strong competition from the international offering in industrial wastewater treatment, as well as in the domestic supply chain. However, the highly technologically advanced solutions rife within the oil and gas companies are not as readily available from domestic manufacturers across the supply chain.

Therefore, there may be an opportunity for the supply chain to adapt and produce advanced technology solutions.

International Opportunities

Key opportunities for industrial wastewater treatment and reuse technologies and expertise have been identified in India and across Europe.

Market opportunities in India include:

- Products and services for wastewater treatment, resulting from an expansion of industrial manufacturing zones.
- Groundwater protection zero waste discharge solutions will be needed, as a result of the development of 20 new industrial clusters.
- Supply of package plants to cater for developing industrial estates and zones.

Across Europe opportunities have been identified in:

- Treatment methods for spill control and containment.

- Management, measurement and monitoring of wastewater, and industrial wastewater discharge.
- Mechanical sludge dewatering processes in the process of waste-to-energy.

¹ <https://www.gov.uk/government/publications/water-and-treated-water/water-and-treated-water#treated-water>

² Scotland: the Hydro Nation – Delivering Results in the Water Sector

12.3 Industrial Wastewater Treatment Suppliers

Table 17: Industrial Wastewater Treatment Suppliers

Oil & Gas Hotspots	Companies	
Control, Sensors, Monitoring & Communication <ul style="list-style-type: none"> • Sensor Design, • Internet of Things 	<ul style="list-style-type: none"> • Filpumps Ltd • Ondeo Industrial Solutions (part of SUEZ Group) • Scottish Water • Sustainable Water Company (Scotland) Ltd. • Albion Environmental Ltd. • Chemtech Consultancy • Dryden Aqua • EPM Ltd • Hydroklear Services Ltd • Kontrotech Limited • Albagia Ltd • Clearwater Controls 	<ul style="list-style-type: none"> • Legionella Control Services • M&K Faulkner LLP • Panton McLeod • Pressure Test Scotland (Water) Ltd. • Spectrum Engineering Solutions • Sunvic Controls Ltd. • Strathkelvin Instruments Ltd. • Smart Metering Systems PLC • Omni Instruments Ltd • NetThings Limited. • LUX Assure Limited.
	Waste Treatment, Management Cleaning & Disposal <ul style="list-style-type: none"> • Aerobic & Anaerobic Digestion, • Sludge treatment, • Water treatment, • Wastewater treatment, • Nutrient recovery & pollutant removal • Bio-mimicry, living labs, phytoremediation. 	<ul style="list-style-type: none"> • Biomatrix Water Solutions Ltd. • EPM Ltd. • Hydroklear Services Ltd. • Ondeo Industrial Solutions (part of SUEZ Group) • Scottish Water • Sustainable Water Company (Scotland) Ltd. • Dryden Aqua • Greenthread Ltd • Spectrum Engineering Solutions

Oil & Gas Hotspots	Companies	
Data Management - Processing and Analytics <ul style="list-style-type: none"> • Cloud computing, data mining, network, watershed, ecosystem and process modelling. 	<ul style="list-style-type: none"> • ABC Flood & Fluid Technology Solutions Ltd. • Scottish Canals • Scottish Water • M&K Faulkner LLP 	<ul style="list-style-type: none"> • Smart Metering Systems PLC • EYECademy • EPCC • NCIMB Ltd
Production / Process / Accommodation Modules & Equipment & Process, Pumping and Power Systems	<ul style="list-style-type: none"> • Avista Technologies • Dryden Aqua • Hydroklear Services • Spectrum Engineering Solutions • Aqualution Systems • Greenthread Ltd • Scottish Water • Wastewater Wizard 	<ul style="list-style-type: none"> • Scottish Water • Ondeo Industrial Solutions (part of SUEZ Group) • Ross-Shire Engineering • Atlantic Water Company
Engineering, Design & Construction	<ul style="list-style-type: none"> • Dryden Aqua • Ondeo Industrial Solutions (part of SUEZ Group) • Panton McLeod • Albion Environmental Ltd. • Chemtech Consultancy • Scottish Water • Spectrum Engineering Solutions • Sustainable Water Company (Scotland) Ltd. 	<ul style="list-style-type: none"> • IDS (IDSystems) • EnviroCentre • Greenthread Ltd. • Dustacco Engineering Ltd • Waterfront Fluid Controls • Aqualution Systems • Torishima Energy Systems • Centrifuges Unlimited • Opus (Part of Fjord Technologies)

12.4 Industrial Wastewater Typical Supply Chain

Figure 23 shows a typical UK organisation chart for the delivery of an industrial wastewater project. Typically, the project will be delivered by a contractor with design, build and operate capability. They will often partner with various other service providers to deliver an industrial wastewater treatment plant. The contractors will have relationships with suppliers from who they will purchase equipment and parts. Separately, a contractor may have in-house specialist design services or subcontract these to consultancies. Operation and maintenance may be separately tendered to a specialist maintenance company or to a subcontractor.

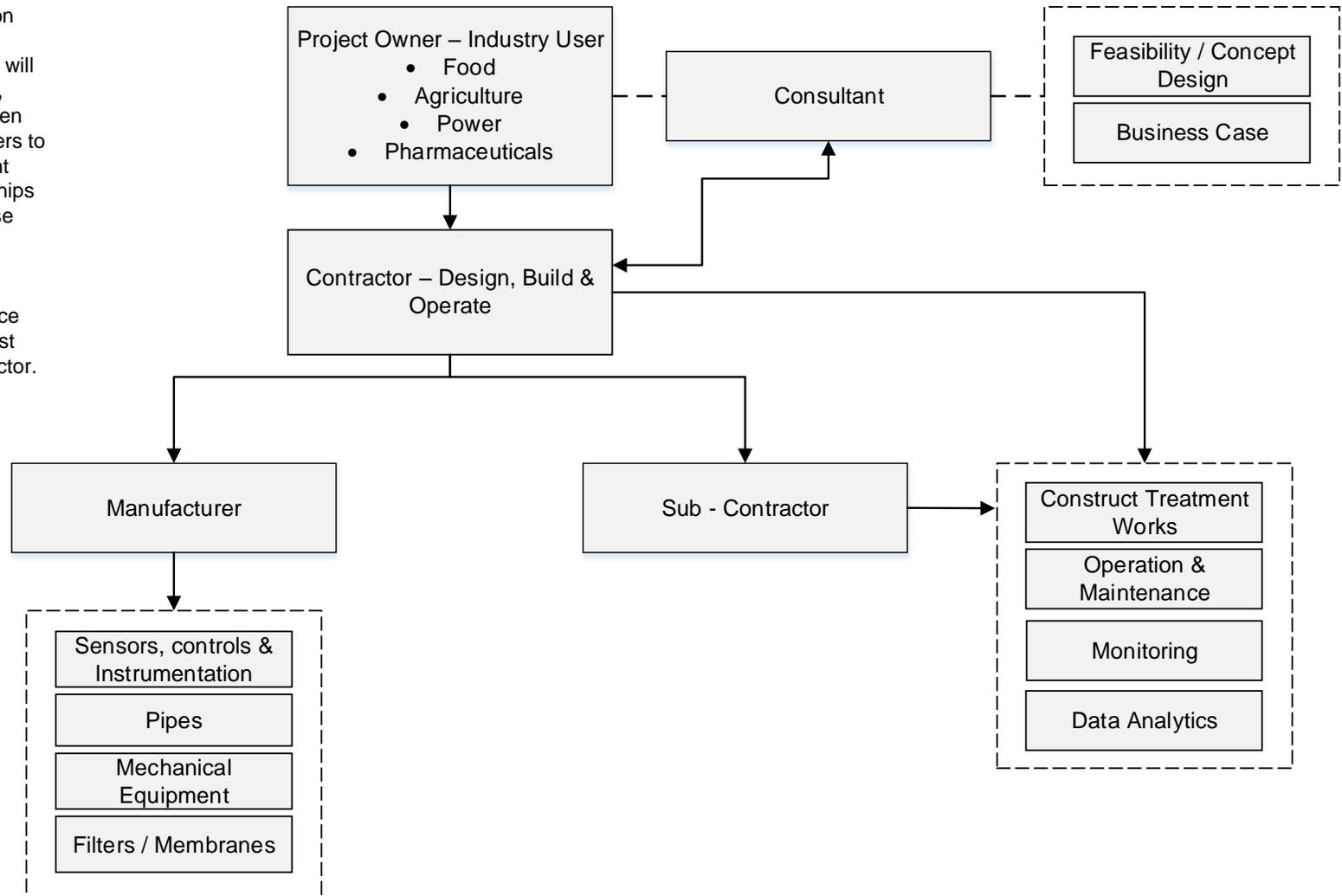


Figure 23: Typical supply chain

12.5 Industrial Wastewater Treatment and Reuse

Table 18: Industrial Wastewater Treatment Sub-sector Analysis

Barriers to Entry  High  Medium  Low

Industrial Supply Chain Area (Example)	Oil and gas Hotspots	Capital per project (£1m - £10m average project)	Barriers	Example oil and gas companies	Method of diversification
Feasibility & Concept Design <ul style="list-style-type: none"> Consultant Note – this stage may be completed by the Project Owner 	<ul style="list-style-type: none"> Engineering Services / Design 	£30 - £100k		Genesis Oil & Gas Consultants Ltd. Xodus Group	<ul style="list-style-type: none"> Alliance / Partnerships Collaborative Groups Merger / Acquisition Targeted Recruitment Establish Subsidiary
Design / Build & Operate <ul style="list-style-type: none"> Contractor Sub – Contractor Manufacturer (providing the package plant) 	<ul style="list-style-type: none"> Process, Pumping and Power Systems Waste Treatment, Management Cleaning & Disposal Production / Process / Accommodation Modules & Equipment 	£500k - £10M		ESMIL TWMA GE water	<ul style="list-style-type: none"> Partnerships / Sub Contract Merger / Acquisition Product / Service Development Direct sales
Monitoring and Sensors, controls and instrumentation <ul style="list-style-type: none"> Contractors 3 Manufacturers 	<ul style="list-style-type: none"> Control, Sensors, Monitoring & Communication Instrumentation / Process Control 	Sensors and control equipment provided as part of contractors packages for treatment plants		Omni instruments, Emerson Valves Permasense	<ul style="list-style-type: none"> Product / Service Development Targeted recruitment Merger / Acquisition Direct Sales

12.6 Industrial Wastewater Treatment – Diversification Opportunities

The Government focus on sustainable industrial practices with regard to wastewater treatment coupled with companies need to reduce costs and improve quality are driving a renewed focus on innovative and cutting edge solutions. This is driving growth in the UK market. Consequently, a number of opportunities may be available for upstream oil and gas companies.

The majority of industrial wastewater projects are delivered by a contractor who has capabilities in design, build and operation. This poses as the biggest barrier to market entry from oil and gas companies with technology crossovers.

Oil and gas manufacturers and companies potentially have a more technological advance / developed offering across the following areas:

- Sensors, Controls & Instrumentation
- Pipe and Components
- Data Analytics
- Filters and Membranes

These companies could potentially look to partner with contractors active in the design, build and operation of industrial wastewater treatment plants, also targeting direct sales opportunities when possible. This would mitigate the largest barrier to entry and may allow for a more cost effective market entry

for oil and gas companies. Manufacturers should look to take advantage of technological superiority and more advanced processes when compared to users in the water industry.

Figure 9 further summarises the crossovers between industrial wastewater treatment sub-sectors and the upstream oil and gas supply chain.

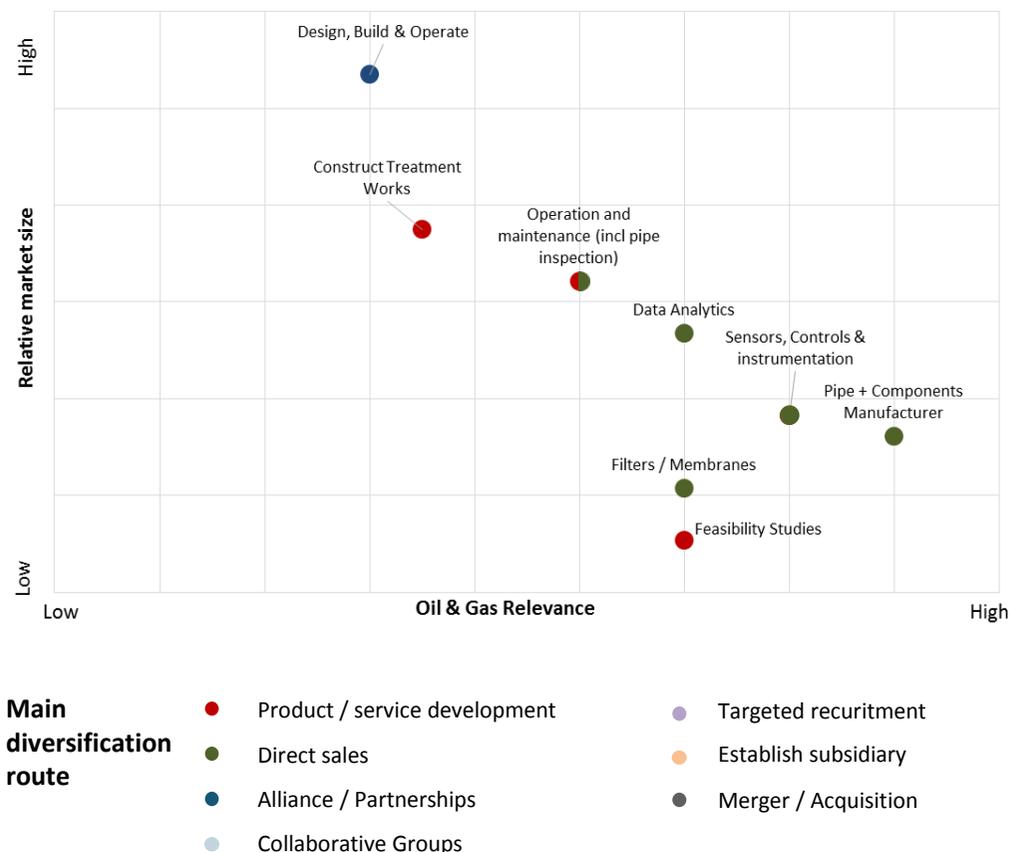


Figure 9: Sector crossovers and market size

12.7 Industrial Wastewater Treatment – Company Mapping

The Scottish oil and gas supply chain possesses strong capability across a number of different sub sectors that could potentially target and capitalise on opportunities in Industrial Wastewater Treatment Markets.

Figure 10 highlights that there are a large number of companies active in Inspection, Repair and Maintenance, including Subsea. There are also over 100 companies active in Engineering, Design and Construction. However, a more detailed analysis of these companies indicates that this sub sector in Scotland consists of larger companies that have explored or are exploring diversification opportunities.

The majority of Manufacturers across the oil and gas supply chain are active in the following areas:

- Production / Process / Accommodation Modules & Equipment;
- Controls, Sensing, Monitoring, & Communication;
- Instrumentation and Process Control;
- Drilling Machinery and Equipment.

Waste Treatment, Management and Control arguably has one of the most relevant crossovers to Industrial Wastewater Treatment. However, it is evident from the Company Mapping analysis that less than 35 companies are active in this sector.

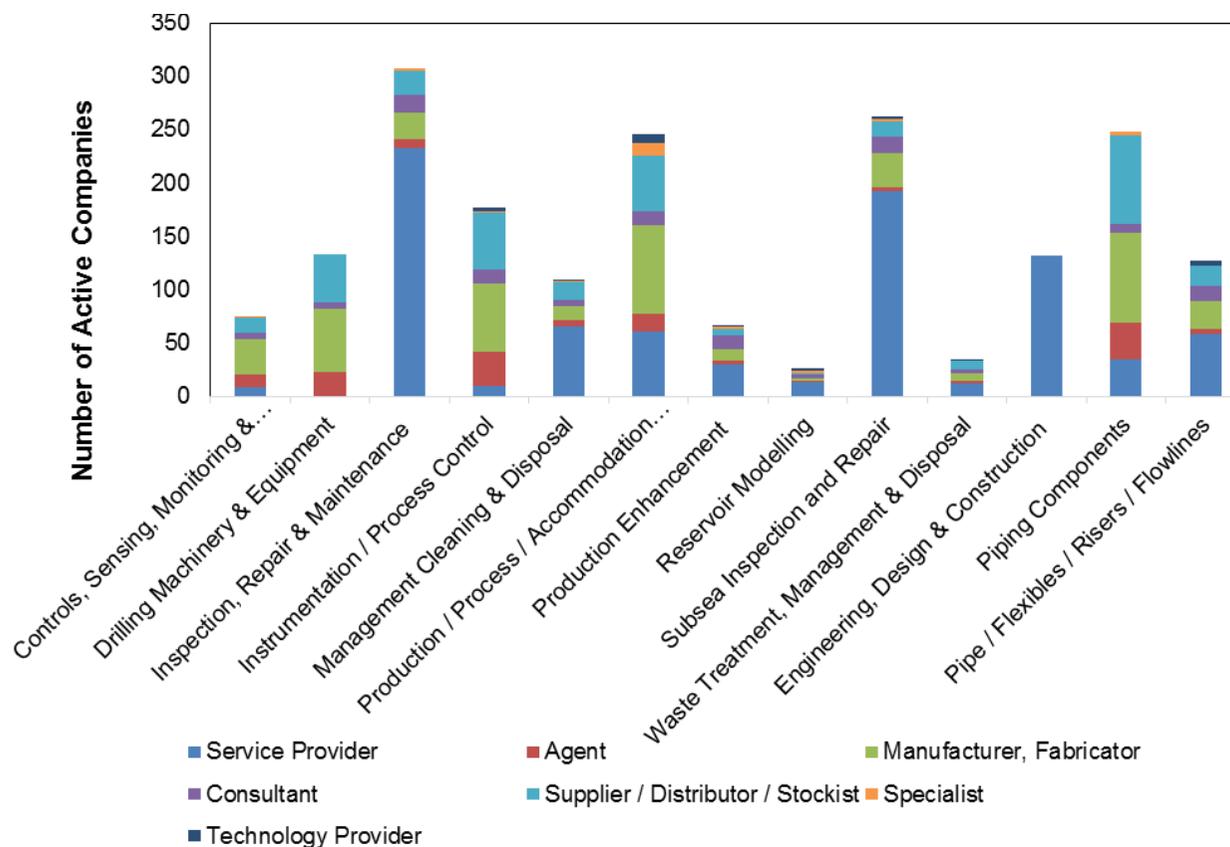


Figure 10: Opportunities for Scottish Oil & Gas Companies in Industrial Wastewater Treatment

12.8 Industrial Wastewater Treatment – Recommendations

Scottish Enterprise Stakeholder Engagement ● External ● Internal

Recommendations for Scottish Enterprise

- 1 Scottish Enterprise should focus on guiding relevant companies to opportunities in the following sub sectors of Industrial Wastewater Treatment markets; Sensors, Controls & Instrumentation, Pipe and Components, Data Analytics, and Filters and Membranes.

- 2 Scottish Enterprise’s primary focus should be helping companies in the following sub sectors; Inspection, Repair & Maintenance including Subsea, Pipes and Piping Components, Production / Process / Accommodation, Drilling Machinery & Equipment, Instrumentation and Process Control and Controls, Sensing and Monitoring, diversify into the Industrial Wastewater Treatment market.

- 3 Although there is a strong crossover and technical expertise in the Scottish oil and gas supply chain within Engineering, Design and Construction and there are over 100 companies active in this space, it appears through the company analysis that the majority of these companies are larger companies or organisations such as Wood Group who have already diversified and are active in other markets.

- 4 The majority of industrial wastewater projects are delivered by a contractor who has capabilities to design, build and operate industrial wastewater plants at a variety of scales. This poses as the biggest barrier to market entry for oil and gas companies with technology crossovers. Once relevant companies have been identified, Scottish Enterprise focus should be to connect, build and foster relationships with oil and gas SMEs and companies that are delivering these solutions (design, build & operate) across a number of different industries.

- 5 In parallel with Recommendation 5, Scottish Enterprise need to engage with individual companies or run a series workshops with companies to assesses opportunities and competitors in more detail. This will help SMEs to develop unique selling points' as they diversify and target opportunities in Industrial Wastewater Treatment. It is important that, during this stage, Scottish Enterprise work with oil and gas companies to identify novel technologies within the oil and gas sector that might be commonplace, but not so in other industries such as agriculture, power, pharmaceuticals and food.

Internal – Refers to engaging with companies within the Scottish oil and gas supply chain that are relationship managed by Scottish Enterprise.

External – Refers to engaging with external bodies / organisations outside of the oil and gas sector, some of these companies may have an existing relationship with Scottish Enterprise.

12.8 Industrial Wastewater Treatment – Recommendations

Scottish Enterprise Stakeholder Engagement ● External ● Internal

Recommendations for Scottish Enterprise

- 6 Scottish Enterprise should engage with Government bodies (NIC / Defra / BEIS) to further understand their agenda, regulatory requirements for new products, potential projects and direction. This will likely drive future projects and provide clear opportunities for Scottish oil and gas companies looking to develop relevant products for the future.

- 7 Post workshops, Scottish Enterprise could explore further engagement with individual companies or small groups to help facilitate and conduct maturity assessments of their in-house capability, including skills, staffing requirements and any potential changes to supply chain. This will allow companies to develop and identify specific strategies for methods of diversification (company structure, subsidiary requirement, partnerships).

- 8 Scottish Enterprise could explore showcasing key technologies or companies at different industry based conferences, events or exhibitions. Examples include the International Conference on Agriculture & Horticulture held in London and the WRE Conference and Exhibition on Innovations in Water Reuse held in Belgium. This would facilitate connections between SMEs in oil and gas and wider industry leaders.

- 9 Scottish Enterprise should explore the possibility of running cross sector workshops or networking events based. These events could link relevant parties, creating connections between oil and gas supply chain companies and other relevant industries such as agriculture, power, pharmaceuticals and food.

- 10 Scottish Enterprise should continue to build relationships with governing bodies and organisations (The UK Water Partnership, British Water, Future Water Association, Water Industry Forum) to further understand the industries needs and capability gaps. The UKWP is an example of an organisation with ties to companies directly and indirectly involved in the water sector. For example, Sainsbury's is a strong supporter of The UKWP and there may be an opportunity to connect through this medium.

Internal – Refers to engaging with companies within the Scottish oil and gas supply chain that are relationship managed by Scottish Enterprise.

External – Refers to engaging with external bodies / organisations outside of the oil and gas sector, some of these companies may have an existing relationship with Scottish Enterprise.

13

Deep Dive Assessment – Smart Water Management

13.1 Smart Water Management

Overview

Analysis of the Smart Water Management market identified crossovers and areas of opportunity for the oil and gas supply chain in both advanced water meters and also across smart water solutions. Specifically, opportunities were identified in enterprise asset management, advanced pressure management, network management, and SCADA systems.

13.2 Porter's Five Forces Assessment

The following deep dive will utilise a porters five forces assessment to analyse the competition present in these markets. This is the first step to develop the roadmap and recommendations. This will help to shape the conversation and discussion with the Scottish oil and gas Supply Chain.

Existing Buyers

Opportunities in advanced water meters and smart water solutions are predominately driven by both water and sewage companies and water only companies in the UK.

A list of these companies can be found in Table 19.

As a large number of smart water management projects are tendered by water companies they are often attached to large

infrastructure based projects. Therefore, due to their regional (impact of retail to be discussed) monopoly these companies often have the power to dictate terms, including pricing. This adds another layer of complexity and barrier to market entry.

Existing Suppliers

Existing Suppliers – International

Established international companies with pre-existing relationships and contracts in the UK include:

- Visenti (part of Xylem),
- iABB Group,
- IBM Corporation
- Schneider Electric
- General Electric Company
- Itron,
- Siemens.

Existing Suppliers – Domestic

Table 19 on the following page summarises the key Scottish / UK companies active in the smart water management market.

There are a number of key companies as part of the Scottish offer in smart water management. These include companies with strengths in controls, sensors, instrumentation and monitoring as well as

data processes sing and analytics:

- Omni Instruments Ltd: who have an expertise in supply of instrumentation & data logging systems.
- NetThings: provide low-cost and scalable internet of things platform for energy insight, building automation and business intelligence.
- Albagaia Ltd: Manufacturer of HydroScense which claims to be the world's fastest and only on-site legionella test.
- Smart Metering Systems PLC - Expertise in meter asset management and remote reading solutions, which is a growing market internationally .
- EYecademy - Specialises in cleansing, management and analysis of data. Data entry system design, logical modelling, database design & creation.
- EPCC- houses high performance 'supercomputers'. Home to ARCHER (Advanced Research Computing High End Resource) and RDF (UK Research Data Facility).

In summary, analysis of the domestic and international suppliers indicates that there is strong competition and a mature offering in this market across the supply chain.

Case Study: i2O Water
i2O Water, are a water technology company based in Southampton, specialising in smart pressure management solutions. They are currently regarded as one of world's leading developers in this field. Their system automatically optimises and remotely controls water pressure in networks. Water utilities from Kuala Lumpur to London have utilised and employed their technologies.

International Opportunities

Currently, the size of the international smart water market is segmented as follows:

- North America –36.3%
- Europe –13.1%
- Asia Pacific –40.0%
- Middle East & Africa –7.6%
- Latin America –3.0%

The Asia Pacific region is expected to experience the highest growth rate out of all the regions to 2024.

1 <https://www.gov.uk/government/publications/water-and-treated-water/water-and-treated-water#treated-water>

2. Scotland: the Hydro Nation – Delivering Results in the Water Sector

13.2 Smart Water Management

Potential Substitutes

New Market

The move in the water industry toward a 'Smart' water sector is a relatively new development; therefore, there are no direct potential substitutes to the smart water market. Market forces in the UK, both external and internal, such as ageing infrastructure in the sector, Government focus as a result of Brexit, utilities attempting to restrict non-revenue water losses, increased regulatory compliance and sustainable use of energy are driving innovative solutions and the growth of the smart water market.

Growing demand for small scale point of use technologies can only be met with the development of a number of technical solutions. Recent trends indicate that the following technologies will continue to grow and develop in this market.

Barriers & Consideration for New Entrants

Competitors

A number of international and domestic competitors were identified in the table on the following pages. Scottish Oil & Gas companies would face considerable competition to market entry.

Appetite from the market (buyers / key stakeholders)

1 <https://www.gov.uk/government/publications/water-and-treated-water/water-and-treated-water#treated-water>

2. Scotland: the Hydro Nation – Delivering Results in the Water Sector, 2017 Global Opportunity Report released by DNV GL, Sustainia and the United Nations Global Compact.

Since the privatisation of the water sector in 1989 in England companies in the UK have estimated to have spent between £108bn - £126bn on maintaining and improving assets. The majority of this spend has been to address environmental compliance including the upgrading or replacement of both infrastructure and non-infrastructure that was failing the new, more rigorous standards imposed by the European Union. However, this amount has widely been reported as considerably lower than the required amount to effectively maintain UK water assets. As such, several reports have indicated that the smart water management market is the biggest global market opportunity, and is likely to experience considerable growth from now until 2021². Reports have indicated that the UK market is also likely to follow suit. In particular in the UK demand drivers such as:

- Ageing UK Water assets are now beginning to receive a renewed attention and this can be expected to drive the need for new and innovative solutions and smart water management projects in the future.
- Leakage levels – several UK utilities have faced heavy fines from regulator Ofwat due to missing leakage targets. Innovative products and services around smart water management may be the best option to reduce these leakage levels.
- In addition, climate change and urbanisation will continue to contribute to

the strain on natural resources and urban systems.

Existing relationships in the supply chain

As noted under suppliers, a number of smart water management projects are delivered through alliance frameworks. However, the barriers here are not as restrictive as municipal wastewater treatment as a large number of projects are delivered by consultants and contractors outside this framework.

Technology

Oil and gas companies would be well equipped with the relevant technologies and processes to address challenges in the smart water market.

Costs

The associated costs to relevant oil and gas companies to enter the smart water management market are relatively low. This is due to the ability for companies to adapt technologies to the water industry (due to their similar applications), combined with the lower fixed costs when compared to other markets. The costs to the buyers to change supplier could be considerable if they need to upgrade a large number of sensors / meters across catchment areas. This may hinder the buyers appetite to switch to new market entrants.

Industry Competitors and Extent of Rivalry

Utilisation of cloud computing capabilities and big-data is still relatively in its infancy. The implications for the understanding and design of water distribution networks, watershed management, and water quality analysis and the associated positive economic impact may be difficult to quantify. The potential for continued innovation and evolving application in this space is vast.

Cloud computing capabilities and big-data has the potential to considerably deepen the understanding of these water distribution networks and associated socio-economic impacts.

Growth in international markets and demand for smart water management technologies may present opportunities for Scottish oil and gas companies with available adaptable technology and processes.

It is important to note that Scottish oil and gas companies will face potentially strong competition from the international offering. Domestic competition is also developed across the supply chain. Therefore, aggressive strategies such as mergers / acquisition or recruitment of talent may be required to compete.

13.3 Smart Water Management Existing UK Suppliers and Buyers

Table 17: Smart Water Management Existing UK Suppliers and Buyers

Company Type	Existing Key Buyers - Scottish and UK Companies	
Water & Sewage Utility	<ul style="list-style-type: none"> • Anglian Water • Dwr Cymru Welsh Water • Northumbrian Water • Seven Trent Water • Southern Water • South West Water 	<ul style="list-style-type: none"> • Thames Water • United Utilities • Wessex Water • Yorkshire Water • Scottish Water
Water Only	<ul style="list-style-type: none"> • Affinity Water • Albion Water • Bournemouth Water • Bristol Water • Cambridge Water Company • Cholderton and District Water Company • Dee Valley Water • Essex and Suffolk Water • Hartlepool Water 	<ul style="list-style-type: none"> • Portsmouth Water • South East Water • South Staffordshire Water • Sutton and East Surrey Water • Youlgrave Waterworks

Oil & Gas Hotspots	Existing Key Suppliers -Scottish and UK Companies	
Control, Sensors, Meters, Monitoring & Communication	<ul style="list-style-type: none"> • Filpumps Ltd • Ondeo Industrial Solutions (part of SUEZ Group) • Sustainable Water Company (Scotland) Ltd. • Albion Environmental Ltd. • Chemtech Consultancy • Dryden Aqua • EPM Ltd • Hydroklear Services Ltd • Kontrotech Limited • Albagaia Ltd • Clearwater Controls • I2O Water 	<ul style="list-style-type: none"> • Legionella Control Services • M&K Faulkner LLP • Panton McLeod • Pressure Test Scotland (Water) Ltd. • Spectrum Engineering Solutions • Sunvic Controls Ltd. • Strathkelvin Instruments Ltd. • Smart Metering Systems PLC • Omni Instruments Ltd • NetThings Limited. • LUX Assure Limited.
Data Management - Processing and Analytics	<ul style="list-style-type: none"> • ABC Flood & Fluid Technology Solutions Ltd. • Scottish Canals • M&K Faulkner LLP • I2O Water 	<ul style="list-style-type: none"> • Smart Metering Systems PLC • EYecademy • EPCC • NCIMB Ltd

13.4 Smart Water Management Typical Supply Chain

Figure 26, portrays a typical Smart Water Management organisation chart for the delivery of related projects in the UK.

Smart water management projects can be classified as utility framework or non-framework projects and as such the barriers to entry are less restrictive.

For example, Anglian Water contract an alliance to deliver smart metering programme over a five year period. This alliance includes: Clancy Docwra and Kier which cover industrial and domestic metering, new housing and estate infrastructure and water efficiency audits.

However, outside of these frameworks, a number of projects classified under smart water management are also awarded by utilities. For example, United Utilities recently put out a tender for projects in the following areas:

- Proactive Customer Actions
- Digital Strategy
- Predictive Asset Maintenance
- Future of Water

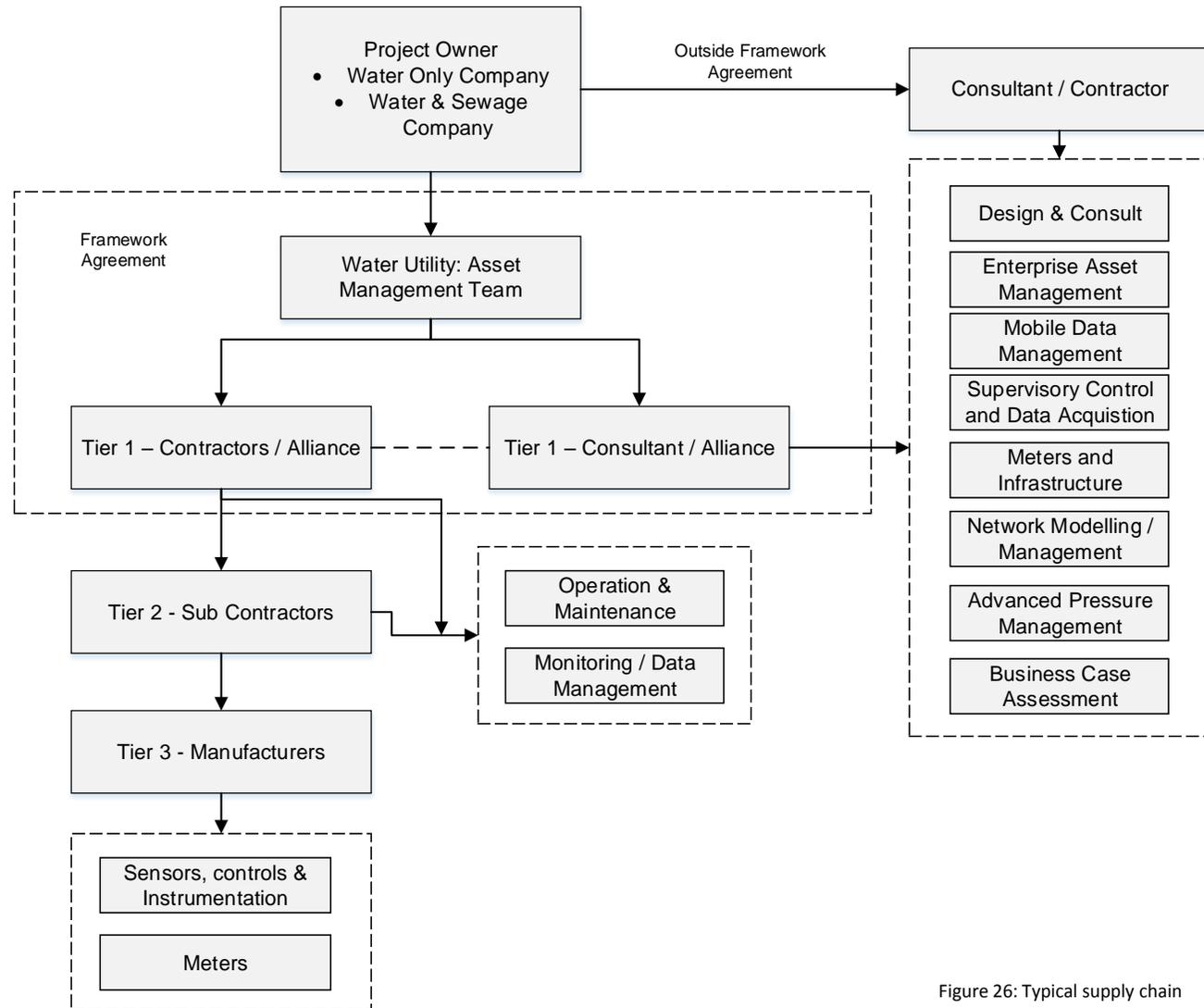


Figure 26: Typical supply chain

13.5 Smart Water Management

Table 18: Smart Water Management Sub-sector Analysis

Barriers to Entry High Medium Low

Municipal Supply Chain area (Example)	oil and gas Hotspots	Capital per project (£100k - £50m projects have a huge range in this area.)	Barriers	Example oil and gas companies	Method of diversification
<p>Design / Consult / Feasibility</p> <ul style="list-style-type: none"> • Consultant • Contractor • Note – this could be completed within the framework or outside framework. 	<ul style="list-style-type: none"> • Engineering Services / Design 	<p>£30k – 60k – Feasibility Studies £50k - £100k – Design Consult</p>		<p>Ingen Ideas CDC Scotland Ltd. Optimus Aberdeen</p>	<ul style="list-style-type: none"> • Alliance / Partnerships • Collaborative Groups • Merger / Acquisition • Targeted Recruitment • Establish Subsidiary
<p>Implementation:</p> <ul style="list-style-type: none"> • Consultant • Contractor <p>Key Areas: Mobile data Management, Asset Management, SCADA and Network Management</p>	<ul style="list-style-type: none"> • Data Acquisition / Processing • Data Interpretation / Evaluation • Software, Storage & Management • Inspection / Repair / Maintenance • Well Testing, Control & Monitoring • Reservoir Modelling / Development 	<p>Project Dependent Example: Thames Water - £35 – £50M contract for:</p> <ul style="list-style-type: none"> • Meter Reading Services. • Sales Investigation Services. • Meter Reading Services and Sales 		<p>CGI Baker Hughes (now part of GE) ISN PDC Systems Monitor Systems Scotland Ltd Finesse Control Systems Ltd Laplace Solutions (already diversifying)</p>	<ul style="list-style-type: none"> • Partnerships / Sub Contract • Merger / Acquisition • Product / Service Development • Direct Sales
<p>Monitoring and Sensors, controls and instrumentation / Meters</p> <ul style="list-style-type: none"> • Contractors • Manufacturers 	<ul style="list-style-type: none"> • Control, Sensors, Monitoring & Communication • Instrumentation / Process Control 	<p>Project Dependent: Thames Water- has awarded a contract for a software package for a new Meter Data Management System to Siemens plc. No costs provided. Yorkshire Water – contracted Itron to provide 500,000 high-end water meters equipped with radio communication modules No cost data provided.</p>		<p>Omni instruments, Emerson Valves Weir Group Pressure Control Systems Ltd Permasense JWF Ltd Elite Control Systems (already diversifying)</p>	<ul style="list-style-type: none"> • Product / Service Development • Targeted Recruitment • Direct Sales

13.6 Smart Water Management – Diversification Opportunities

As the value of water rises globally and the UK faces issues around flooding, water scarcity and security, there is a growing opportunity for Smart Water Management to help address some of these domestic challenges.

A number of technological advancements are now driving new methods of customer engagement and data analytics by integrating smart household appliances, and enabling remote control and unified billing. This will improve the security of data and enable the delivery of real time applications, which will consequently drive step changes in performance, agility of operations, customer engagement and research and development into the future.

The oil and gas industry in Scotland has a strong offering in smart solutions, with a number of direct crossovers into the smart water market.

Due to the smaller nature of some of these projects compared to larger capital infrastructure works, utilities have started to award tenders outside of AMP frameworks. This presents a more appealing opportunity for the oil and gas supply chain as they would now be able to bid for relevant jobs.



Figure 11: Sector crossovers and market size

13.7 Smart Water Management – Company Mapping

Figure 12 indicates that there is a strong offering in both Inspection Repair and Maintenance and Subsea Inspection and Repair. This is evident through the number of established companies and the different types active across the supply chain.

The Scottish offering is also well represented in both Well Testing, Control and Monitoring and IT / Communications.

It is important to note that Scottish capability or capacity to expand into Smart Water Management areas may be limited by the smaller number of companies present in Data Interpretation / Evaluation and in Software, Storage and Management.

Controls, Sensing, Monitoring and Communication was also a key hotspot identified in the Smart Water Management Market. Therefore, there may be opportunities for the 75 companies identified with an offering in this area.

Supervisory Control & Data Acquisition within the Smart Water Management market had a very high relevance and crossover with the oil and gas sector. Therefore, through product / service development there may be opportunities for over 100 companies active in Well Testing, Control and Monitoring.

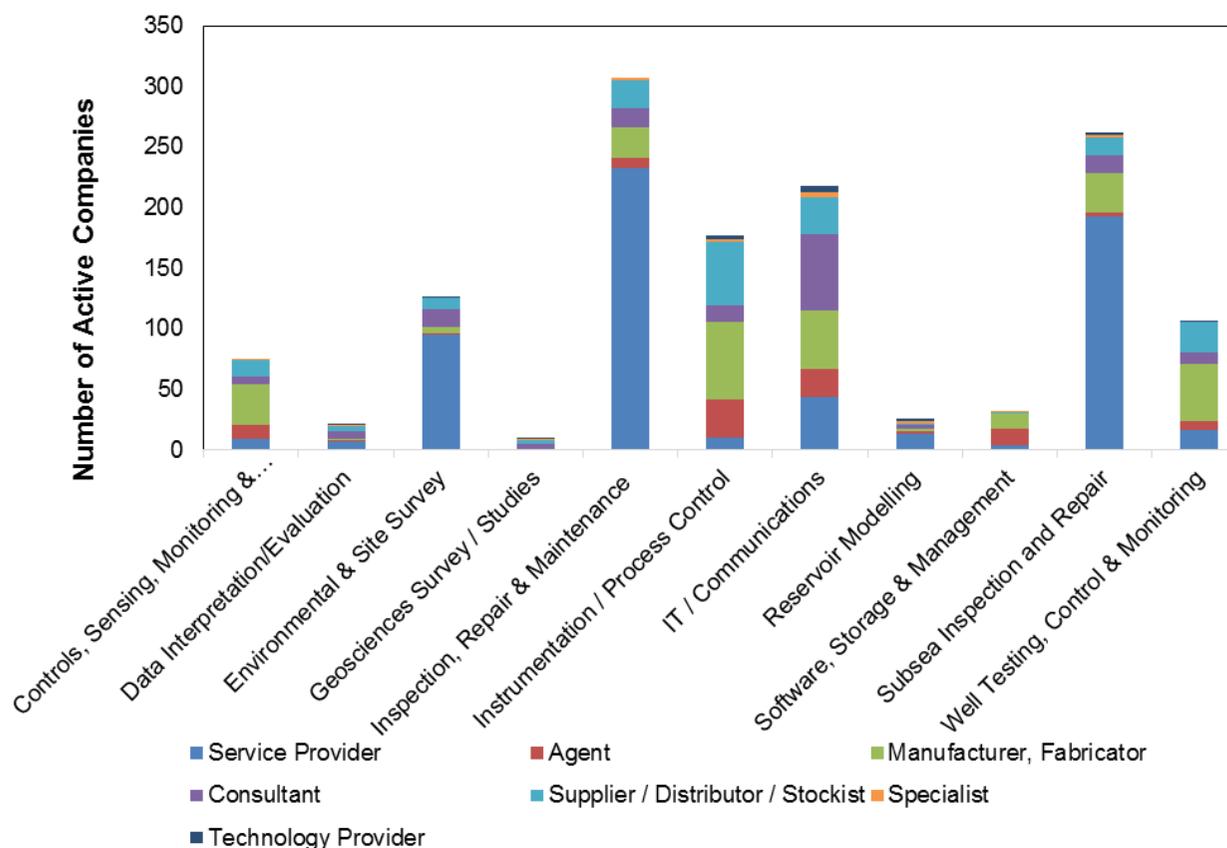


Figure 12: Opportunities for Scottish Oil & Gas Companies in Smart Water Management

13.8 Smart Water Management – Recommendations

Scottish Enterprise Stakeholder Engagement ● External ● Internal

Recommendations for Scottish Enterprise

- 1 Target Smart Water Management opportunities based on relative market size and relevance to the oil and gas sector are Enterprise Asset Management, Operations & Maintenance, Advanced Pressure Management, Sensors Controls and Instrumentation and Supervisory Control and Data Acquisition.

- 2 Focus sub sectors for Scottish Enterprise based on the current offering in the oil and gas supply chain are Controls, Sensors and Monitoring, Inspection Repair and Maintenance, Subsea Inspection Repair and Maintenance, IT / Communications and Well Testing, Control and Maintenance.

- 3 There are a limited number of Scottish oil and gas companies that are active in Data Interpretation / Evaluation, Reservoir Modelling and Software, Storage and Management. This may limit the impact of Scottish Enterprise to influence a large number of companies in the diversification process. Clearly identifiable opportunities with direct technology transfer in the Smart Water Management market could be explored.

- 4 Scottish Enterprise should identify which companies within these focus areas they currently relationship manage and those which they do not. Scottish Enterprise should then follow a two step engagement process to firstly reach out to both types of companies to understand whether they are specifically looking to diversify, and then to attempt to build relationships with companies that are not currently managed.

- 5 Scottish Enterprise should engage with individual companies or run a series workshops with companies in similar sub sectors interested in diversifying into alternative markets. This is needed to assess opportunities and competitors in more detail which will help to develop unique selling points for relevant companies as they diversify and target alternative markets. This process also needs to happen in parallel or after Recommendation 7 to ensure Scottish Enterprise have built a deeper understanding on specific and relevant opportunities.

- 6 Scottish Enterprise should continue to build relationships with governing bodies and organisations (The UK Water Partnership, British Water, Future Water Association, Water Industry Forum) to further understand the industries needs and capability gaps. The UKWP is an example of an organisation with ties directly to Innovation departments in water utilities across the UK. There may be an opportunity to present new technologies and service offerings at their quarterly meetings to key industry stakeholders.

- 7 Scottish Enterprise needs to engage with Ofwat and Government bodies (NIC / Defra / BEIS) to further understand their agenda, regulatory requirements for new products, potential projects and direction in future AMP cycles. This will likely drive future projects and provide clear opportunities for Scottish oil and gas companies looking to develop relevant products for the future.

Internal – Refers to engaging with companies within the Scottish oil and gas supply chain that are relationship managed by Scottish Enterprise.

External – Refers to engaging with external bodies / organisations outside of the oil and gas sector, some of these companies may have an existing relationship with Scottish Enterprise.

13.8 Smart Water Management – Recommendations

Scottish Enterprise Stakeholder Engagement ● External ● Internal

Recommendations for Scottish Enterprise

- 8** Post workshops, Scottish Enterprise could explore further engagement with individual companies or small groups to help facilitate and conduct maturity assessments of their in-house capability, including skills, staffing requirements and any potential changes to supply chain. This will allow companies to develop and identify specific strategies for methods of diversification (company structure, subsidiary requirement, partnerships). During this process Scottish Enterprise should work with oil and gas companies to identify novel technologies within their industry that might be commonplace, but have not yet been integrated into the water industry.
- 9** Scottish Enterprise could explore showcasing key technologies or companies at water industry based conferences, events or exhibitions. For example, Scottish Government is running an event in Leeds called The UK's Big Water Challenges: Opportunities to Collaborate, events such as these or World Water Tech hosted in London would be a good opportunity for Scottish Enterprise to showcase relevant companies and technologies that could make the transition into the Smart Water Management market. Attending Dragon's Den style event 'Wet Networks' or posting on online Innovation Portals such as Venturi are alternative strategies that may also help SMEs with new technology and solutions become identified by the water sector.
- 10** Scottish Enterprise should explore the possibility of running cross sector workshops or networking events based. These events could link relevant parties, creating connections between key oil and gas supply chain companies and crucial stakeholders such as Water Utility Asset Managers, Innovation Team Leaders or Technical Policy makers.
- 11** Rather than encouraging SMEs to focus on forming Alliance Partnerships in Framework agreements with utilities, Scottish Enterprise could encourage companies to target specific and direct opportunities in the water industry. A number of smart water management projects are now being directly awarded by utilities, as well as BEIS, Defra and the NIC. For example United Utilities have recently reached out for expressions of interest for SMEs and technologies to partner in an accelerator programme to develop solutions in the water industry. This could present as a viable opportunity for SMEs in oil and gas. This would require Scottish Enterprise to identify key opportunities (Recommendation 7).

Internal – Refers to engaging with companies within the Scottish oil and gas supply chain that are relationship managed by Scottish Enterprise.

External – Refers to engaging with external bodies / organisations outside of the oil and gas sector, some of these companies may have an existing relationship with Scottish Enterprise.