Water and Wastewater

SUBSEA ENGINEERING OPPORTUNITY
International Market Insights Report Series

May 2018

Scottish Enterprise

Contents

1. Introduction

This report is part of a series of reports considering the opportunities for the Scottish oil and gas (O&G) subsea supply chain in other subsea and related markets. The report is a desk review considering the international activity of each of the sectors including where there is current activity and where there is the potential for activity based on published targets and available resource and opportunity. The report also considers the particular synergies of the given sector and the subsea oil and gas supply chain. These opportunities cover where there is a direct cross over and also where there are opportunities for collaboration to provide innovative solutions.

The water and wastewater sector covers both municipal and industrial water, a sector which is expected to grow dramatically in the coming decades and is already worth an estimated $650 billion according to the Organisation for Economic Co-operation and Development (OECD). Water technologies alone are expected to be worth £900 million annually to Scotland.[1]

Although not a subsea industry in its own right, there are significant synergies between the water sector and subsea oil and gas supply chain. These include areas such as water distribution, e.g. pipelines, pumps and power systems; operations and monitoring, including sensors, control equipment, monitoring, communication, risk detection; and engineering such as reservoir modelling, drilling operations, well design and construction.

Water is also a global industry, and expected to grow, with some predictions saying that a market for water will eclipse that for oil and gas.[2] Challenges, and therefore solutions, vary around the world depending on access to water, as well as policies and existing infrastructure. This creates an interesting international opportunity for Scotland’s subsea oil and gas supply chain. Scotland already has a robust reputation for novel water technologies and water treatment, collaboration between these two sectors therefore presents an interesting opportunity.

[1] ARUP, Scottish Oil and Gas Diversification Opportunities, Heat and Cooling, Water, and Energy Storage and Systems, 2017.
[2] Buiter, W., Citi's Top Economist Says the Water Market Will Soon Eclipse Oil, Business Insider, 2011.

2. Sector Overview

Water and wastewater is a global sector that encompasses the sourcing, distribution, storage, protection and treatment of water in both an industrial and municipal context. The water industry includes aspects such as flood prevention and sustainable drainage system (SuDS), these areas will not be looked at as part of this report as they are not as relevant to the subsea O&G supply chain.

Water companies differ from country to country and can be public, private or consumer owned. In the UK all three models are represented with the public sector Scottish Water in Scotland, the customer owned Dwr Cymru (Welsh Water) and approximately 20 private water utilities in England including United Utilities, Thames Water and Anglian Water.

The importance of water is critical and a global industry, in terms of the provision of clean water for drinking as well as sanitation, but also for agriculture and industry. Globally countries have different challenges when it comes to water whether it is scarcity, or too much water causing flooding, but all have to address the challenges of growing populations and climate change. The United Nations Sustainable Development Goal number 6 (SDG6) is related to the provision of clean drinking water and sanitation. Globally, 663 million people (approx 10% of the population) still do not have access to improved drinking water supplies, and 1.8 billion people have water supplies that are contaminated with faeces.[3,4] Water treatment and distribution are therefore high priority areas. Even in countries where water quality is good and abundant, challenges faced for the industry include adapting to increasing populations, climate change, affordability, ageing infrastructure and increased regulatory standards.

The water that we use comes from various sources, including:

- Rainfall water: this is water that falls as rain and is collected in rivers, streams and reservoirs
- Groundwater: that is abstracted from springs and aquifers underground
- Desalinated water: freshwater that is generated from sea water through a desalination plant, this is energy intensive and is used where the previous two sources do not cover the water requirements.
- Recycled water, known in Singapore as NEWater: this is water that has been recycled from previously used water and is treated through various membranes, micro-filters and disinfection techniques to bring it up to drinking water quality. In Singapore NEWater accounts for 40% of water supply, and is added into reservoirs to be mixed with raw water before entering the system.[5]
- Imported water: water that is imported from a neighbouring country or region.

In some countries, including the UK, water infrastructure was built originally in the 1850s and some of these pipelines, such as sewers, are still in use today. The challenge that needs to be overcome is to make ageing infrastructure suitable for modern demands, including water quality, customer expectation on supply, and security of supply.

The following sections give an overview of the sectors of the water industry that have the greatest crossover with the Scottish subsea supply chain sector.

---

[3] United Nations Water, Water Quality and Wastewater, http://www.unwater.org/water-facts/quality-and-wastewater/ accessed April 2018

[4] World Health Organisation, Water sanitation hygiene, Key facts from Joint Monitoring Programme 2015 report, http://www.who.int/water_sanitation_health/monitoring/jmp-2015-key-facts/en/ accessed April 2018

[5] Public Utilities Board, NEWater, 2018 https://www.pub.gov.sg/watersupply/fournationaltaps/newater accessed April 2018

2.1. Water treatment

- *Drinking water treatment*

Drinking water treatment requires a number of steps and varies depending on the source of the water, groundwater is generally cleaner than surface water, i.e. that from rivers and reservoirs. Initial screening removes any floating debris. Water is then treated to remove any suspended matter. This is done through adding a coagulant which causes the dirt to come together in larger clumps, known as 'floc'. The floc settles on the bottom of the tank as sludge. The clear water is then passed through a series of filters including sand, gravel and charcoal which remove different sizes of particles. Added benefits of these techniques include the use of bacteria within the gravel and sand which biologically clean the water as well. Further steps include aeration, and the use of additives such as ozone, chlorine and ammonia (to create chloramine with the free chlorine) as disinfectants.[6,7]

- *Wastewater treatment*

Wastewater is any water that has been used and is therefore contaminated, it also includes storm water drainage. Wastewater must be treated to a level where it does not have a negative impact on the environment, such as oxygen depletion, pollution or damage to animals and fish. Wastewater treatment (WWT) is the process of removing any suspended solids from the water, as this organic matter uses oxygen as it breaks down. The first step removes non-organic solids, e.g. plastics, grit, etc. through screening; followed by primary treatment which involves the removal of the majority of solid organic waste through settling in large tanks; next the water is aerated to encourage the growth of good bacteria which 'eats' the bad bacteria, ensuring the removal of bugs that could cause diseases; a second settlement stage is then used to remove the good bacteria, and depending on the sensitivity of the water course that the treated water is being released into a final filter through a sand bed may be used. The 'sludge', the settled organic matter from primary settling, is treated biologically. This 'digesting' process releases methane gas, which some water utilities gather for the generation of electricity, and the digestate can be used as a fertiliser in agriculture. Further treatment with UV light can also be used to remove unwanted bacteria and viruses. The water that is released from the WWT works, also known as bilge water, in many countries, including the UK is, heavily regulated in terms of what can be released.[8,9]

2.2. Water distribution and storage

Water and wastewater distribution has been part of our infrastructure for centuries, historically through aqueducts and canals, with open sewers often being released into rivers within cities. These conditions had big impacts on public health, with cholera and typhoid outbreaks occurring. In the mid-1800s cities started to build underground sewers for moving wastewater out of the cities and initially exporting it further out into the water bodies, e.g. into the Thames estuary rather than into the Thames river in the city, before the installation of waste water treatment works (WWTW) in the 20th Century.

- *Pipeline infrastructure*

Pipeline infrastructure for water distribution in many industrialised countries dates back to the 1850s, and has a mixture of materials from which the pipes are constructed, the eldest including cast

---

[6] Centers for Disease Control and Prevention, Water Treatment, Community Water Treatment, 2015, https://www.cdc.gov/healthywater/drinking/public/water_treatment.html accessed April 2018
[7] Thames Water, Drinking Water Treatment, 2016
[8] WaterUK, Wastewater, https://www.water.org.uk/about-water-uk/wastewater accessed April 2018
[9] Southern Water, The Wastewater Process, https://www.southernwater.co.uk/the-wastewater-process accessed April 2018

iron, spun iron, steel, lead, ductile iron, through asbestos cement, pre-stressed concrete to plasticized polyvinyl choride (PVC) and polyethylene (PE) more recently. Dimensions of water pipes vary depending on the location in the network, e.g. large trunk pipes or smaller distribution pipes into housing estates and based on material, most are within a 50-600 mm range, with prestressed concrete pipes having larger diameters around 1000 mm.

- *Storage reservoirs and containers*

Reservoirs can be naturally occurring, through lakes that have been adapted, or manmade and act as a storage location for water that is collected from a catchment before being transported to the distribution network. Water towers can also be used as part of the network to store water more locally to demand and also create a hydrostatic head.

2.3. Water challenges:

2.3.1. Security of supply

For many countries, particularly, although not exclusively, in the developing world, security of supply is a significant issue. Countries such as Australia, Ethiopia, South Africa and China, and many more, have experienced drought in all or parts of the countries, and situations will only be worsened by climate change[10]. In addition, a growing global population, estimated to be increasing to over 9 billion by 2050, from 7.3bn in 2015 (a 33% increase) will see an increased demand in water, through personal use as well as the requirement for agriculture and industry, which are the two biggest water users.[11]

Security of supply is dependent on efficient use of resources, such as, battling leakages, and more efficient water use in agriculture and industry, e.g. more focus put on water recycling and water-lean practices, such as Levi's waterless dyeing technique.[12]

Using and further developing techniques for water recycling, for example NEWater in Singapore, can be beneficial as a water source, but also for industrial water users. In an industrial setting drivers will depend on cost, as in water abundant countries abstraction may cost less than treatment for recycling water, although the equation should include the energy use for treatment for recycling or for treating the effluent to a degree that it is safe to return to the environment.

2.3.2. Water quality

There are two aspects to drinking water quality, one that it meets the required regulations, e.g. the EU Drinking Water Directive, and secondly that it meets customer levels of acceptability. Changes to colour and odour, even where the water still meets the regulated quality can have an impact on trust between consumers and water utilities.

[10] Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds, Section 3, Linking climate change and water resources: impacts and responses, Climate Change and Water, Technical Paper VI, International Panel on Climate Change, 2008

[11] UN Department of Economics and Social Affairs, World population projected to reach 9.7 billion by 2050, 2015.

[12] Levi Strauss, Sustainability, Plant: Water, http://www.levistrauss.com/sustainability/planet/water/ accessed May 2018

Environmental understanding and licensing is increasing across the globe, this is having an impact on water and wastewater in terms of stricter legislation regarding releases into the water environment, etc. In Scotland, water quality regulations – the European Drinking Water Directive 1998 - are met 99.91 per cent of the time, and work is still ongoing to better this[13]. Elsewhere in the world, water quality falls short of regulations, with access to clean drinking water not available to the whole population. The quality of water discharged from industrial and municipal wastewater treatment plants into water courses is regulated by, in most cases, the national environment protection agency. Regulations for industrial wastewater tend to be industry specific, based on the likely contaminants and their interaction with the environment. These will include specifications such as the Biological Oxygen Demand (BOD) and/or Chemical Oxygen Demand (COD) which give an indication of any contaminants in the water and the impact they may have on natural water courses; salinity; pH range; amongst others.[14]

Developing cost effective, energy efficient and robust solutions to improving water quality is an important part of meeting regulations, improving global health and meeting SDG6.

2.3.3. Installation

Pipeline installation techniques can be the cause of leakages on water distribution networks, e.g. poorly fitted and sealed joints. Initial pressure testing does not always show up the problem as the faults appear after continuous use, and particularly exacerbated after pressure surges caused by the incorrect opening of valves. These problems can be overcome through training of installers, and techniques for installing joints that are less susceptible to ground conditions, e.g. temperature and contamination by soil and mud and development of new materials. Improving the installation practices can lead to an improvement in the lifespan of the network.

Installation should also include an understanding about the lifetime and needs of the network. Newly installed water networks should include the ability to inspect, clean and repair the pipeline, such as valves for launching and receiving pigs; tagging to allow easier location of underground pipelines, particularly those made of plastics; and leak detection equipment e.g. sensors.

2.3.4. Leakages and bursts

Leakage is a major problem globally with some countries losing up to 50% of treated water from the water distribution network, as highlighted in Figure 1.[15] Globally, the daily loss is 46 billion litres per day. Leakages contribute to Non-Revenue Water (NRW) which also includes losses due to metering inaccuracies, authorised other uses (e.g. fire hydrants) and theft. NRW costs water suppliers £9bn per year.[16]

Leakages can be major events, where the leak is visible with a potential to cause flooding, or a smaller event where it is not visible, and these can go undetected for long periods of time. In Scotland, approximately 500 megalitres (ML) are lost per day. The impact of such leaks include: intermittent

[13] Drinking Water Quality Regulator for Scotland, Drinking Water Quality in Scotland 2017 Public Water Supply, 2017
[14] Cotruvo, J., Wastewater Discharge Regulation is Industry-Specific, Water Technology, 2016
[15] European Environment Agency, Water use efficiency (in cities): leakage, 2003
[16] LaBrecque, S., Water loss: seven things you need to know about an invisible global problem, The Guardian, 2015

supplies, for example in India where almost all Indian cities only have couple of hours of water supply every few days - without leakage losses a continuous supply would be achievable without any additional water sources[17]; reluctance for consumers to curb personal water use when they feel the water utilities are not doing enough to reduce water wasted through leakages[16]; bacterial contamination in the water supply[15,18]; removing water from an already stressed system, e.g. those that are in drought as experienced in Cape Town, South Africa in 2018; higher operational costs through the treatment, pumping and distribution of water that leaves the system before it can be used; and a more vulnerable system as intermittent supply damages the network resulting in more frequent bursts and therefore greater leakage.[17]

The challenge with leakages is that although there is some value in the water, in that it has been collected, treated and distributed, the cost of infrastructure repairs and replacements is not incentivised, particularly in countries with a plentiful supply of water, where it is cheaper to abstract more water from renewable sources, e.g. rivers, than upgrade the infrastructure. Regulation can play a part with leakage reduction targets, which exist in the UK and are set by the regulator with fines for non-compliance. However, these are not always seen as going far enough to address the problem, where major infrastructure upgrades would involve serious disruption including digging up major city centre roads and impacts to water supplies.[17]

Technology development can assist the resolution of leakages, this will be covered further in section 3.2, but includes the use of internal and external pipeline investigations, improved reliability of the non-destructive testing (NDT) results; improving understanding of the root cause of failures and developing failure predictions to allow preventative work to be carried out and reducing cost of inspections. This is a potential area of interest for the subsea oil and gas supply chain.

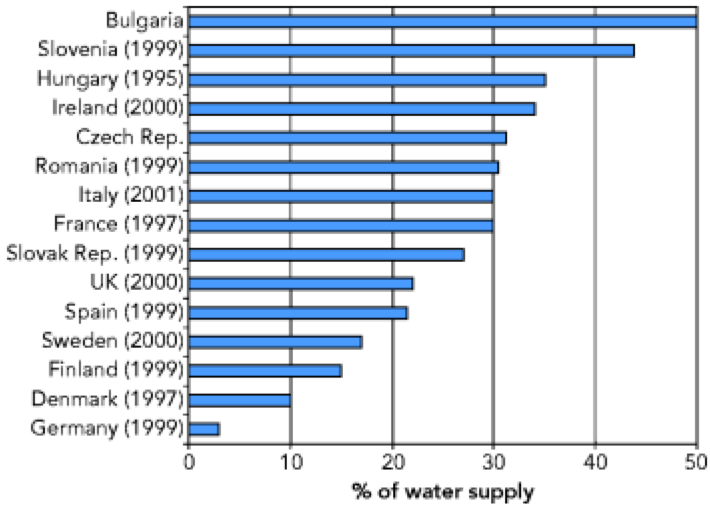

Figure 1: Chart showing the percentage of water lost from the network due to pipeline leakages. Source: European Environment Agency

2.3.5. Pressure transients

Pressure transients, pockets of low pressure within the network, are caused by the pattern of water

[17] Liemberger, R., After two decades of water loss progress, why are leakage levels still so high?, International Water Association, 2016

[18] Saria, J. A., Effects of Water Pipe Leaks on Water Quality and on Non-Revenue Water: Case of Arusha Municipality, *Journal of Water Resources and Ocean Science,* **4(6)** 2015 pp86-91

use from the closing of valves, pump operations, industrial use (water being drawn at a fast rate from the network) and instrument failures.[19] The problem with transients is that they can cause damage, either as a sudden dramatic failure of a pipe or through the variable pressure in the pipeline over years causing incremental damage, and eventually the failure of the pipe, resulting in the issues described in section 2.3.4 above. Work can be done to minimise pressure transients with e.g. the soft opening of valves and a build up in pump usage, this can help protect the network against bursts. More needs to be done to understand the impact and find remedies, this is a potential area of crossover with the subsea oil and gas industry.[20]

2.3.6. Mains cleaning

Due to age of network, and material used for pipes a build up of slime occurs as well as particulates. These particulates need to be removed, typically through high pressure water jets, but access is a problem as many, particularly older networks were not built with access for cleaning and maintenance in consideration. Other cleaning technique examples include the use of gels which pick up the debris. Not cleaning pipelines in the network has an impact on water quality as biological sludge accumulates over years of use, it is mostly settled on the pipe surface and the bottom, however, pipeline failures can result in the increased turbulence and pressure changes which stir up the impurities. Cleaning and maintaining the network, will have an impact in terms of supply interruptions for customers, but is an essential element of the network, development of techniques that can minimise disruption are therefore of interest. Oil and gas techniques such as pipeline pigging can be used in the water industry where there is an opportunity to launch and receive the pig (this can be out at sea through an outflow).

2.3.7. Intelligent water networks

Use of sensors within the water network can be used to collect data on the use and integrity of the pipelines: it is imperative that information is collected with a purpose and a use.

Sensors can be used to help in the management of the network, such as monitoring the build up of debris; understanding pressure transients (as currently pressure readings are taken at approximately 15 minute intervals which does not give an accurate picture of pressure transients); monitoring conditions, e.g. corrosion to allow preventative maintenance; leak detection e.g. through changes in pressure; water use and water quality.

In water scarce situations, or in times of increased water demand, monitoring the water in the network becomes even more critical, additional deployment of sensors could support the more efficient use of the available water.

[19] Starczewska. D., Collins, R. and Boxall. J., Occurrence of transients in water distribution networks, Procedia Engineering 119 (2015) pp1473 – 1482

[20] Pothof, I. and Karney, B., Guidelines for Transient Analysis in Water Transmission and Distribution Systems, Water Supply System Analysis - Selected Topics, Intech, 2013

3. Subsea Engineering Synergies

3.1. Sourcing

Many oil and gas (O&G) techniques for understanding and sourcing reserves from underground can cross over with the water industry. This can include ideas such as reservoir modelling, boring and drilling, well design and engineering, and pumping equipment. Given that drilling for water abstraction will occur onshore, the greatest crossover with subsea is likely to be reservoir modelling and pumping equipment.

3.2. Distribution

The distribution of water has many crossovers with the oil and gas supply chain such as: pipelines; valves, including those for launch and recovery of inspection and cleaning tools; pumping equipment; sensors, including those for pressure; flow modelling; leak detection; corrosion monitoring; and network management and control. A significant difference between water and oil and gas is the value of the fluid being distributed. Leaks in the water network, although not desired, occur due to the challenges and cost of finding and fixing them. However, due to the environmental and safety implications as well as the monetary loss of an oil or gas leak, leaks here must be prevented. Much learning can be taken from the O&G industry about monitoring, inspection and control.

As can be seen from section 2.3.4 damage to pipelines and the resultant leakage is a major consideration for the water industry, and so a number of improvements need to be made and new solutions developed to tackle these issues, these include:[21]

- Improvement in the reliability of NDT results. Current methods are not giving an accurate picture of the pipeline conditions and therefore opportunities to do preventative maintenance are being missed.
- Improve the understanding of the root causes of mains failures.
- Deliver solutions that suit the varied nature of the network including the different materials, diameters, distances under investigation.
- Novel techniques for inspection where the pipeline network was not designed with consideration for inspection. Leak detection can include listening devices that recognise the sound profile of a leak (already used in some forms, e.g. worker with a listening stick, geophones and other sonic techniques, but only once a leak is suspected); or radio signals which can detect flowing water.[22]
- Maintain high quality through any novel techniques as additives and techniques could have an impact on water quality and therefore public health.
- Improve the cost of inspection, as currently prohibitively high.
- Finding underground pipelines (plastics a particular issue).
- Future networks could include: live hydraulic modelling analysis, artificial intelligence, pressure correlations, and predictive networks.[21]

3.3. Wastewater treatment

The synergies between the O&G sector and wastewater treatment are similar to those for distribution: i.e. the crossover will be around pumping and power equipment, control, sensors, monitoring and communication. The O&G industry also manages produced water from the drilling

[21] Scottish Water, Pipeline Workshop, Aberdeen, June 2018.
[22] European Environment Agency, Water in the city, 2012

process, techniques here can be compared with wastewater treatment and lessons and best practice shared.

3.4. Operations and maintenance

As has been seen previously there is significant focus on reducing leaks within the water network, operations and maintenance (O&M) activities are part of tackling this problem the crossover with the O&G industry will be in pipeline inspection repair and maintenance, including inline inspection. Inline inspection is not always suitable for the water networks as the ageing infrastructure was not designed with such techniques in mind. Therefore, the opportunity to launch and receive (LAR) pigs (pipeline inspection tools) can be limited in the water network. Learning from the O&G sector about how to incorporate the appropriate valves and equipment to allow for inline inspection can be used for future network planning. Inspection can also be carried out externally and although not strictly crossing over with subsea pipeline inspection which will largely use ROV tools, water pipe inspection could include aerial surveillance with drones, as well as other geotechnical techniques.

A direction for both the water industry and the O&G industry is to embrace the new developments in digital technology and automation, where learning can be achieved for both sectors in the use of sensors to develop a ‘smart’ network. For the water industry, this would include continuous monitoring, automatic chemical dosing and more efficient operations (e.g. pumping and aeration).

O&M will include all aspects of the water network, such as wastewater treatment plants, pumping stations and valves. Crossover from the subsea sector will include inspection, repair and maintenance (IRM) techniques and companies which the Scottish supply chain excel in.

Other areas of crossover will include project management; control; and health and safety.

4. Global Markets of Interest

The OECD estimates that annual expenditure on water infrastructure in member countries and Brazil, Russia, India, China and South Africa (BRICS) countries alone will be in the range of US$800 billion to US$1 trillion between 2014 and 2025.[23]

4.1. Europe, Middle East and Africa

Europe covers an area that includes those countries and regions with abundant water supplies as well as those who suffer from water stress, in 2014 this latter category included 86 million European inhabitants. Areas of Europe also suffer from over-abstraction of ground water resources. The main pressure for water resources is agriculture which uses just over half of the water demand in Europe, and as much as 66% during the spring months.[24]

Water markets of interest in Europe include:

THE NETHERLANDS is a global and European leader in water technology and management. It's prominence is largely due to the Netherlands being situated on a delta and with 29 percent of the country below sea level. Flood risk is therefore a national security situation. In 2012 the Dutch adopted the Delta Act which amongst other provisions has brought about the Delta Fund to respond to current and future water challenges and freshwater supply.[25]

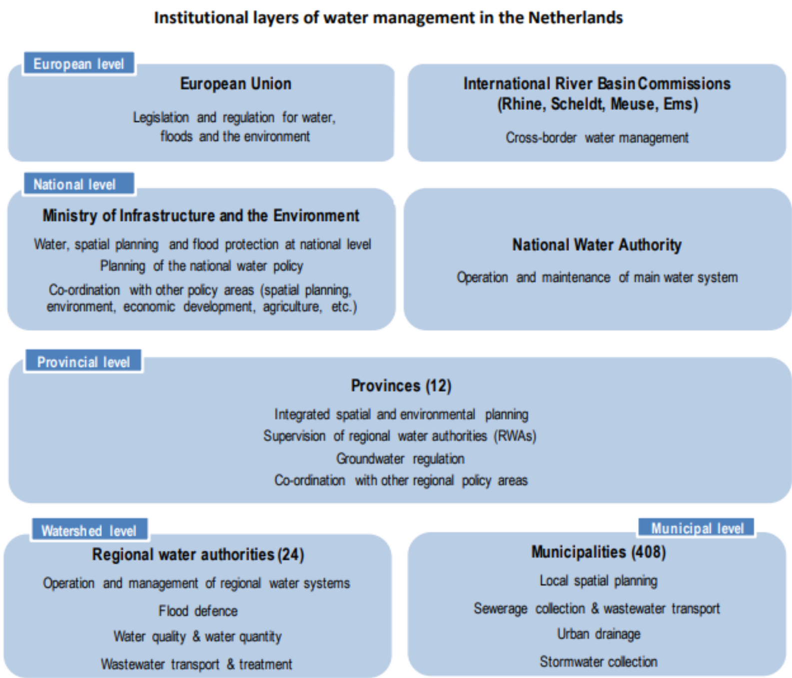

Figure 2: The structure of Dutch Water Management. Source OECD

The Netherlands is home to *Wetsus*, a centre of excellence which facilitates developments in the water sector across private companies and research institutes. It has a physical campus for research

[23] Upper Quartile, International Market Opportunity Analysis for the Scottish Water and Wastewater Sector, 2015
[24] European Environment Agency, Use of freshwater resources, 2016
[25] OECD Studies on Water: Water Governance in the Netherlands Fit for the Future?, 2014

and collaboration as well as providing funding.[26] Developing relationships between the Dutch water sector and the Scottish subsea oil and gas community could be an interesting way into the Dutch and other water sectors.

POLAND is the largest economy of the new EU member states and in central Europe, however it's water and wastewater infrastructure has suffered from continuous lack of investment and only 55 percent of the rural Polish population have access to an effective water supply. Funding and regulation from the EU have promoted progress in the industry and work is continuing to improve the water distribution network, waste water treatment and access to the sewerage network. It is estimated that Poland spent €16.6 billion on construction and modernisation of the water network and wastewater treatment between 2003-2013. Further investment of €20 billion is required to bring the water network up to accepted EU environmental standards. The improvement work is being co-ordinated by the National Water Management Authority.[23,27] Work on infrastructure is progressing with 2,800 kms of water pipes laid (an increase of 1.8%) and over 82,000 new sewerage connections made (increase of 2.5%) in 2017.[28] Poland provides a market opportunity into other central European countries, who have similar water and wastewater challenges, although there are already strong ties between Poland and the Netherlands and Germany within the water sector.[23]

The Middle East is heavily reliant on desalination with 70 percent of the world's desalination plants located there, and **SAUDI ARABIA** alone is responsible for 20 percent of global desalinated water production. Desalination technology has been well developed over previous decades, however, current techniques are highly energy intensive. Research is continuing, largely in the Middle East, into new techniques and membranes to reduce the energy requirement of desalination. Desalination is a high value opportunity across the Middle East, particularly in Saudi Arabia, Qatar and the United Arab Emirates.

4.2. Asia and Pacific

SINGAPORE has a small land area, and therefore a small catchment, in 2015 it was listed by the Water Resources Institute as one of the most water-stressed countries globally. The Singaporean government and their national water agency, PUB, have therefore developed a multi-source approach to water security, known as the 'Four National Taps'. Water in Singapore comes from the local catchment, desalination, NEWater (recycled water) and imported water from Malaysia. A higher emphasis is being placed on NEWater and desalination in the future, up to 55% and 30% respectively. This is an ongoing strategy, and as part of it, underground tunnels are still being built to separately carry domestic and industrial wastewater. The opportunities in Singapore are well funded, but it is a busy market place, access to the market would be through specialist products. [29]

Elsewhere in Asia, **MALAYSIA** and **THAILAND**, may present opportunities as there is a growing awareness of pollution and river basin management strategy, this is manifesting in a government level appetite in addressing the water market. Pumps and pumping technology could be a particular opportunity here.

---

[26] Wetsus, https://www.wetsus.nl/research accessed May 2018

[27] Water and Wastewater International, Poland to upgrade wastewater infrastructure with €430 EU funding, 2017.

[28] Statistics Poland, Water supply system and sewage management in Poland in 2017, 2018

[29] PUB, Our Water, Our Future, 2017. https://www.pub.gov.sg/Documents/PUBOurWaterOurFuture.pdf accessed April 2018

INDIA is currently in a water crisis, with challenges being faced from climate change, an increasing population, pollution, contaminated and decreasing ground water, inefficient farming practices and poor sanitation. Not a single Indian city has continuous access to clean drinking water.[30] There is an interest by the Indian Government to tackle these challenges, and foreign businesses, including Scottish companies, have begun to engage with India, particularly around water treatment technologies. Environmental pollution monitoring technologies, and sensors will be a significant opportunity looking at those for both water quality and ground water levels.

CHINA has abundant water in the South, albeit there are concerns over pollution levels, but a scarcity of water in the North. Increasing environmental awareness, coming through stricter regulations on pollution from the Premier, is changing the market in China. China is looking to other countries for 'plug & play' type technologies, but for water treatment, this has to be coupled with data capture and monitoring of industrial use and effluent. Improvements can be made to the water treatment process, with better control of treatment before sludge is released to be used as fertiliser. Other opportunities may be presented such as the massive pipeline installation delivering water from the South to the North. Known as the South-to-North Water Diversion Project, when completed will divert 44.8 billion cubic metres of water annually with an estimated project cost of $62bn. As part of this project $80 million is earmarked for water treatment plants.[31]

4.3. The Americas

CANADA is of significant interest for the water industry, where the estimated investment needed for the maintenance of the Canadian water management system is expected to be $4bn annually, to 2030. Key areas of interest are membrane solutions for water treatment and smart management and instrumentation.[23] Canada has taken a lead in 'Smart Water' with the province of Ontario boasting a jurisdiction-wide smart water meter programme, with Saskatchewan and British Columbia also having smart metering programmes.

Technologically, the Ontario Water Technology Acceleration Project (WaterTAP) has proven to be a successful medium for supporting the development of water industry related innovation, as well as enhancing public and private cooperation.[32]

Canadian water practices has also been impacted by a water-borne disease outbreak in 2000, when a town's water supply was contaminated with E.coli and Campylobacter, causing six deaths. Improvements in water management techniques and monitoring have occurred since.[33]

Within **Latin American and Caribbean (LAC) countries** water policy and governance is not well coordinated, with fragmentation of policy, such as the delivery of service for water and wastewater at a local level, but resource management governed at a regional and/or provincial level. This leads to potentially inefficient use of resources but progress is being made to bring coordination.[34] The region has a quarter of the world's freshwater sources, but also has significant arid areas.[35] Frost and Sullivan

[30] Kapoor, A., India staring down the barrel of a major water crisis, The Economic Times, 2018
[31] Water Technology, South-to-North Water Diversion Project, https://www.water-technology.net/projects/south_north/ accessed May 2018
[32] Water Technology Acceleration Project, http://watertapontario.com/the-story/ accessed May 2018
[33] Moffatt, H. and Struck, S., Water-borne Disease Outbreaks in Canadian Small Drinking Water Systems, Small Drinking Water Systems Project, National Collaborating Centres for Public Health, 2011
[34] Akhmouch, A., *Water Governance in Latin America and the Caribbean: A Multi-Level Approach*, OECD Regional Development Working Papers, OECD Publishing, 2012.
[35] South America's Water Colonization

predict that the water and wastewater municipal market in Latin America will be worth US$21.16 billion, due to the development of basic infrastructure and regional government commitment to funding WWTW projects. In addition, the industrial water market could be worth an additional US$10.73 billion in 2018. The value of this sector is due to the increasing industrial base and increased enforcement on water treatment. There is also an increase in the use of desalination plants as well as water recycling and reuse, the technology needed here, principally regarding membranes will be a particular opportunity. Additional challenges, that can be opportunities for the Scottish O&G supply chain include, include 40% loss due to leakage in the water distribution network and improved metering. Investment of US$12.5bn annually is required in the Latin America water sector to ensure universal access to drinking water by 2030 says the Andean Development Corporation. Additionally, investment of US$80bn and US$33bn are needed respectively for sewerage infrastructure and wastewater treatment between 2010 and 2030. Brazil, Mexico and Argentina are expected to be the biggest municipal and industrial water markets.[36]

[36] Frost and Sullivan, Latin American Water and Wastewater Industry Outlook, 2018, 2018.

Annex 1: List of Acronyms

BOD	Biological Oxygen Demand
BRICS	Brazil, Russia, India, China and South Africa
COD	Chemical Oxygen Demand
EU	European Union
IRM	Inspection, repair and maintenance
LAC	Latin American and Caribbean
LAR	Launch and Recovery
ML	Megalitre (1 million litres)
NDT	Non-Destructive Testing
NRW	Non-Revenue Water
O&G	Oil and Gas
O&M	Operations and Maintenance
OECD	Organisation for Economic Co-operation and Development
PE	Polyethylene
PUB	Public Utilities Board (Singapore)
PVC	Plasticised polyvinyl chloride
ROV	Remotely Operated Vehicle
SDG6	Sustainable Development Goal 6
SuDS	Sustainable Drainage Systems
UV	Ultraviolet
WWT	Waste Water Treatment
WWTW	Waste Water Treatment Works