

The LEIF Brief: Water Innovation in Oil and Gas

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The London Environmental Investment Forum (LEIF) is managed and owned by Carbon International, a capital-raising, investor relations and business development consultancy for clean technology industries. Carbon International is authorised and regulated by the UK's Financial Conduct Authority. LEIF provides a research and business development platform for Carbon International clients – high-growth companies seeking investment and commercial partners, and institutional and corporate investors seeking a quality pipeline of investment ideas. LEIF research is presented and discussed at events around the world.

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About Global Corporate Venturing

Global Corporate Venturing is both a monthly magazine and website written for the in-house venture capital units of businesses. The monthly magazine, due out the first Monday of each month, covers each economic sector in turn throughout the year to provide the most comprehensive data and analysis of companies' activities in buying minority stakes in third-party businesses as well as the best comment from the most highly-regarded thinkers. The analysis centres on an exclusive ranking of the top corporate venturing units in each sector.

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Tom Whitehouse LEIF chairman and Carbon International chief executive

Tom Whitehouse is Chairman of the London Environmental Investment Forum (LEIF), a research and networking platform for investors and innovators. The industries and investment themes covered at LEIF events in the LEIF reports between 2009 and 2013 include Resource Efficiency in Agriculture and Food, Water Innovation in Extractive Industries, Remanufacturing and Recommerce, Resource Recovery, Energy Efficiency, Asian Cleantech, British Low Carbon Power and the Smart Grid

He is also CEO of Carbon International, a capital-raising and business development consultancy for environmental industries. In the ten years since establishing Carbon International in 2003, Tom has worked with leading global technology and investment companies, supporting over \$1bn in capital raising and directly raising over \$55m for clients since 2008.

He has worked across a broad range of businesses, industries and geographies; from British FTSE 250 hydrocarbon giants to European, North American, Israeli and Taiwanese public equity and venture capital investment companies and start-ups.

Previously, Tom worked as an adviser on political risk to large energy companies, including Shell and BHP Billiton, and as a foreign correspondent. From 1997-99 he was Moscow correspondent for the Guardian and from 1991-97 he was a reporter for the BBC World Service, based in Prague and Moscow.

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Carbon International

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London Environmental
Investment Forum

Connecting capital with environmental innovation

Foreword

The water technology needs of the oil and gas majors are growing considerably as they move into more water scarce regions, expand into unconventional resources such as shale gas and oil sands – which are much more water-intensive – and as new regulations are introduced on their treatment of waste water.

One of the ways they are responding is to increase their investment in water technology start-ups. This growth in corporate venturing is a global multi-industry trend. Leading corporations are establishing venture units that are charged with finding a new generation of technologies that can spur growth while solving some of the parent company's problems.

The purpose of this report is to capture some of the investment and innovation activity in this area, identify leading investors and technology innovators, and highlight opportunities and potential obstacles.

The report will be distributed at the LEIF and Global Corporate Venturing event Venturing in the Water-Energy Nexus on July 2 in London and at Water Energy 2013 conference in Houston on September 25. See the LEIF website for details: www.london-eif.com/next-seminar/seminar/overview?id=141

We would like to thank the report's sponsors and contributors, who are world leaders in their respective fields.

Wayne Evans is vice-president of Veolia Water Solutions and Technologies, one of the world's leading water service providers, which is partnering with new technology companies to help bring them to market while further advancing its water service offering.

Neil Foster and Hamish McArdle are partners at Baker Botts, an international law firm headquartered in Houston, arguably the world's oil and gas capital. With a network of 14 offices around the globe, Baker Botts is widely regarded among the top law firms in the world and recognised as a leading firm in the energy, technology and life sciences sectors.

Christopher Gasson is the publisher of Global Water Intelligence, the leader in high-value business information for the water industry.

We would also like to thank all those we interviewed for this report.

It is worth remembering that energy remains the world's biggest industry by far. Nothing else comes close. And next to nothing happens in the energy industry without water. Oil and gas exploration and production are multi-faceted – onshore and offshore, conventional and unconventional. This report barely scratches the surface of this industry. We hope merely to give you a sense of the scale of the water technology need and opportunity.

Tom Whitehouse,
LEIF Chairman and
Carbon International CEO

Toby Lewis
Editor
Global Corporate Venturing



Neil Foster
partner
Baker Botts

Neil Foster's practice covers mergers and acquisitions, venture capital and private equity, and corporate finance. His principal sector experience is in the areas of alternative energy, clean-tech, renewables, technology and telecommunications, media and entertainment and life sciences.

Foster is a leading practitioner in corporate venturing transactions, having advised US, South African and south-east Asian clients on corporate venture capital deals over many years. He is on the advisory board of Global Corporate Venturing.



Hamish McArdle
partner
Baker Botts

Hamish McArdle advises clients on all aspects of the energy value chain including large-scale projects and corporate and commercial matters, with a particular focus on those associated with the upstream and midstream oil and gas sectors and LNG.

McArdle advises leading energy companies in the structuring and negotiation of oil and gas development projects and transactions, and he acts for sellers, purchasers and joint venture project companies, with particular recent experience in Africa and the Middle East.

www.bakerbotts.com



Supporting the focus on water

Baker Botts is pleased to support the publication of the LEIF Brief: Water Innovation in Oil and Gas, in association with Global Corporate Venturing, which comes at a time when the oil and gas industry, and those regulating it, are increasingly focusing on the key role of water-based technologies.

These technologies have a substantial role in facilitating the development of enhanced recovery technologies and, more generally, in hydraulic fracturing in unconventional gas and liquids exploration and production. These activities are water intensive, often in locations of scarce supply. Increasing emphasis is being placed on efficient water use, recycling, treatment and disposal. We see such trends strengthening as these hydrocarbon extraction techniques – particularly as unconventional techniques are applied more broadly outside the US – become more standardised to the industry, and attract less opposition on environmental grounds at the regulator and local community levels.

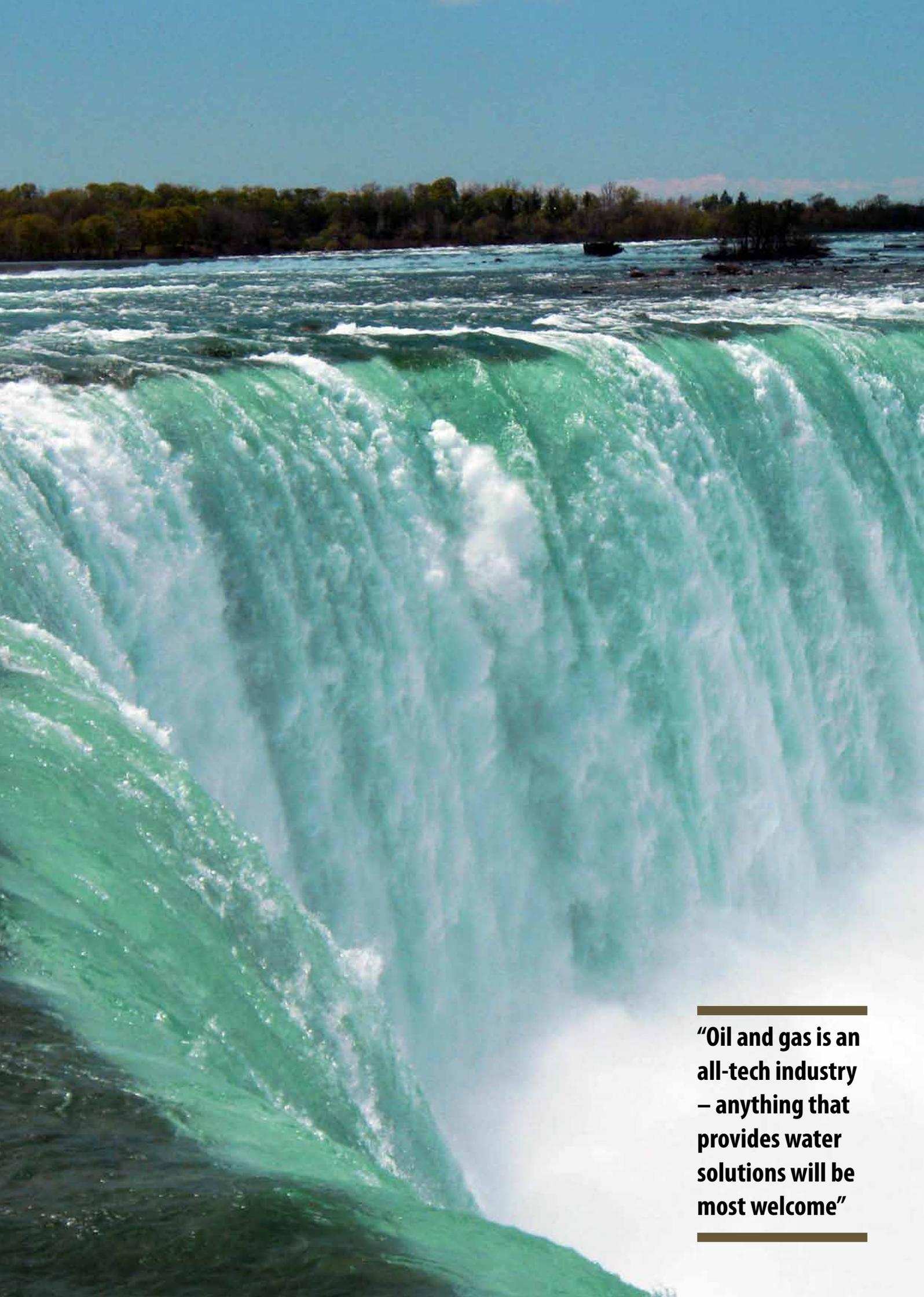
As an international law firm with its origins in Houston, Texas, and with over 130 years of practice in the energy industry, we have a deep understanding of the commercial, technical and legal issues which our clients face as upstream oil and gas developers, oilfield services providers, as industry regulators, and those complying with and, in some cases, challenging the regulatory framework of the industry. In our role as counsel to Halliburton, supporting the development of Halliburton's Total Water Management Solution, we have seen the critical role innovation in water technologies can play both from the perspective of the technology developer and investor, and the upstream operator, where the stated goal is elimination of the need for the use of fresh water in fracturing.

This white paper contains reports, insight and analysis of current technology initiatives and investment opportunities and trends from contributors including Global Water Intelligence, Veolia, and LEIF. It is clear that innovations in water technology have significant immediate and long-term potential within the oil and gas upstream, but also at the midstream and downstream distribution and sales levels, as well as with utilities, in areas including smart metering and water quality monitoring.

Incumbent oilfield services companies have a proven track record and interest in the development of water technology complementary to their businesses. However, a strong theme of this white paper is that smaller companies are successfully developing and promoting new technologies, providing more cost-effective and efficient options to source, treat, recycle and store water and waste and produced water from oil and gas operations. For these companies the challenge lies in promoting their new and sometimes unproven technologies, and in accessing the end-user companies, regulators and industry bodies, to be able to demonstrate the application of these technologies within the industry at scale.

Frequently the chosen approach to this challenge is addressed via the corporate venture capital division of the major energy companies. The energy sector is among the most active in such partnership deals, whereby the corporate provides capital, via minority equity investment, and often a channel to market, and in exchange the smaller research and development company will provide access to new innovation and new technologies.

For Baker Botts, this white paper addresses the intersection of our two leading sectors – energy and technology. Legal issues surrounding exploitation of intellectual property, equity financing, environmental law and corporate governance are at the heart of these topics. We hope that you find this report as helpful as we have.



**“Oil and gas is an
all-tech industry
– anything that
provides water
solutions will be
most welcome”**

Executive summary

Tom Whitehouse, LEIF chairman

The world's largest oil and gas companies are making large investments in early-stage water-tech because water problems jeopardise their core business, hydrocarbon extraction.

In the last two years, ConocoPhillips, Saudi Aramco, Statoil and Shell have established new corporate venturing units that prioritise water. BP has refocused its existing corporate venturing unit to prioritise water. Total, Chevron and Cenovus have slightly longer-standing corporate venturing exposure to water.

Despite its historical reputation as a Wild West industry, oil and gas is highly conservative and risk-averse. It takes a lot of time for water-tech companies to commercialise. Corporate and financial investors need to be patient and have sufficiently deep pockets to sustain their investments.

Partnership models are emerging between start-ups and established service companies – which are trusted by the oil and gas industries – that can help accelerate technology commercialisation.

In Partnering with innovators, Wayne Evans of Veolia Water Solutions and Technologies, one of the sponsors of this report, sets out the Veolia Innovation Accelerator, the Veolia open innovation strategy which is helping technology companies get to market.

Christopher Gasson, publisher of Global Water Intelligence, reports on how Texas has emerged as the global capital of the water-energy nexus and proof-point of the interdependence of water and energy. The Texan boom in unconventional oil and gas exploration – which are more water-intensive than their conventional counterparts – combined with a severe drought, adds urgency to water-tech innovation there.

The three boxes in our transaction report – Ten oily corporate venture capital firms (VCs) investing in water-tech, Ten water-tech companies with oily corporate investors and Top ten new oilfield technologies to watch – provide a snapshot of who is investing, who has raised capital and the sectors worth watching. They are by no means exhaustive lists. There is a lot going on.

The emerging areas of water-tech innovation include enabling as well as end-of-pipe technologies. End of pipe technologies are applied to waste water produced during oil and gas extraction. Enabling technologies are focused on reducing or eliminating water use during extraction.

There is a vast array of technologies in play. Bio-tech, nano-tech and chem-tech all offer water solutions of great potential. But oil and gas is an all-tech industry – anything that provides water solutions will be most welcome.

Given the diversity of technologies in development, investors are sourcing deals globally, though North America and Europe remain the dominant centres of technology – Houston, Calgary, Stavanger and Edinburgh.

Our analysis reveals that investor coalitions are emerging between corporate and financial venture investors. This is a virtuous circle – corporate VCs provide the reassurance required by financial VCs that their investments can get to market. Financial VCs then invest, thereby providing the companies with the financial firepower to get to market.

The LEIF investment formula is:

**(Innovation + regulatory change) x corporate appetite
= a potentially very good clean technology investment**

For those with expertise, patience and capital, water-tech could be the real deal.

The two investors we profile at the end of the report, George Coyle of ConocoPhillips and Sandra Eager of BP, are among those taking the plunge.



Wayne Evans
vice-president
– industrial technology
Veolia Water
Solutions & Technologies

Wayne Evans is a chartered engineer and a fellow of the Institution of Chemical Engineers. He has spent most of his career with blue-chip companies in the field of water treatment, covering the municipal, nuclear, food and beverage, chemicals and oil and gas industries. In his position as VP industrial technology at Veolia Water Solutions & Technologies, Evans manages the selection, industrialisation and commercialisation of innovative technologies and services for the global water industry.

Veolia Water Solutions and Technologies, a subsidiary of Veolia Water, is a leading design and build company and a specialised provider of technological solutions and services in water treatment. With more than 10,800 employees in 60 countries, Veolia Water Solutions & Technologies recorded revenue of €2.4bn in 2012. The company is a global leader in the municipal and industrial water treatment sectors.

www.veoliawaterst.com

www.via.veolia.com



Solutions & Technologies

Veolia Innovation
Accelerator

Partnering with innovators

The global oil and gas industry continues to develop new ways to meet the global demand for hydrocarbons for use as petrochemical feedstocks as well as in energy production. The much-publicised shale gas developments are being augmented by other unconventional hydrocarbon sources such as coal seam gas, tight gas and shale oil.

Operators of conventional oilfields are deploying subsea solutions to reduce operating costs and environmental impact while utilising advanced polymers and surfactants in chemically enhanced oil recovery processes to increase the conversion of oil-in-place to recoverable oil. Advances in liquefied natural gas production, gas to liquids and coal to liquids technologies allow ever increasing flexibility in the global oil and gas market.

With water management being a fundamental part of any production system, the rapid evolution of the oil and gas sector is providing Veolia Water Solutions & Technologies with technology-led opportunities for growth in this sector. While Veolia continues to invest in internal research and development, the company also sees the benefit of long-term partnerships with technology companies in the open innovation space. The Veolia Innovation Accelerator (www.via.veolia.com) is the vehicle through which such partnerships are developed.

The Veolia Innovation Accelerator (VIA) has been developed to link Veolia Environnement with start-up and technology companies and with their investors. Veolia looks to develop partnerships that provide it with preferential access to innovative technologies in defined markets. In return, Veolia provides technical evaluation and support, analytical and pilot plant facilities and access to its global markets, with an unrivalled capability to move a technology from one market to another, for example by bringing a technology from the mining industry into the oil and gas industry. The model works particularly well where a technology can be incorporated into a larger Veolia offering, allowing synergistic development where Veolia can add value to the innovation.

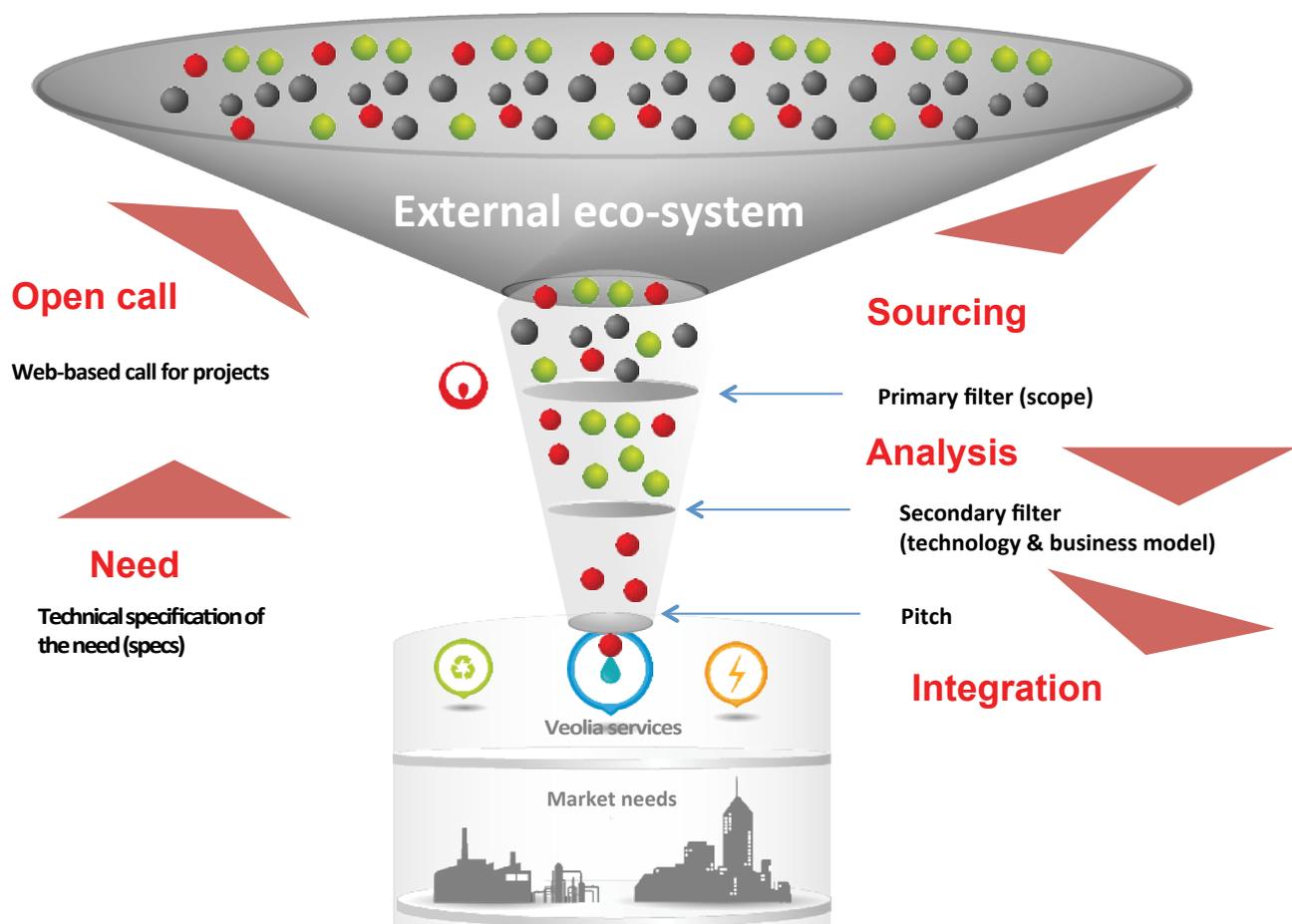
Agreements within the VIA are designed to create value for all three stakeholder groups:

- The innovation company grows more quickly as a result of the technical support it receives, the backing of the Veolia brand and the exposure to new industries and additional global markets
- The investment company receives a faster return and a higher value on exit, agreements being structured with the investor exit strategy in mind
- Veolia has access to leading edge technologies that can be incorporated into their offering

A good example of this process is the recently completed deal with Genesis Water which will allow Veolia Water Solutions and Technologies exclusive rights to promote the Genesis Water Rapid Dewatering solutions in the global mining sector as well as conferring approved vendor status in the oil sands market. The Genesis Water system was originally developed for the urban dredging market. With Veolia's capability to access other markets and to customise solutions to meet the specific needs of the operators, it is anticipated this partnership will enable Genesis Water to grow more quickly than it otherwise would, while providing Veolia with a technology that fills a gap in its current offering for which the markets are demanding a solution.

In 2013, Veolia has further developed the VIA to incorporate targeted open innovation initiatives to identify specific topics of interest and to call for solutions. The first of these initiatives was launched earlier this year to identify technologies associated with sludge dewatering. A

second is in progress looking for technologies associated with low energy desalination. Each of these initiatives defines the basic parameters of the problem for which the company seeks new technologies. A period of six weeks is allocated for technology company responses, after which all submissions are evaluated technically and commercially. Those technologies that are determined to be a good fit with the Veolia business model are then referred to the most appropriate Veolia business for development of eventual agreements.



The Veolia Innovation Accelerator continues to provide Veolia with new ways to interact with the innovation community and allows Veolia to meet the demands of its key markets. This is especially relevant in the oil and gas sector, where the rapidly changing market requires a constant flow of new solutions to meet the demands of advanced hydrocarbon production techniques and of new regulatory drivers such as selenium and mercury limits, environmental impact assessments and pressures to move to zero liquid discharge solutions.

Veolia Environnement offers a complete range of creative solutions for the environment. Supplying water and recycling wastewater; collecting, treating and recovering wastes; supplying heat and cooled air; and optimising industrial processes. These solutions are designed to find a balance between the development of human activities and environmental protection.

Veolia partnership case study: Genesis Water

Headquarters: Denver, Colorado

Established: 2000

Technology: The Genesis Water Rapid Dewatering System efficiently dewateres dredged slurries or tailings at high throughputs. The patented Genesis technology instantly releases large quantities of clear water from a wide range of solids, immediately returning it to the waterway or industrial circuit. The equipment is scalable to handle any volume of inflow, while still maintaining a compact and mobile footprint.

Investors: Genesis Water is the main operating division of Colorado-based Joshua Water Technology, which raised \$2m of fresh equity in October 2012 from investors including the Impact Opportunities Fund to fund its near-term expansion plans.

Partnership: Veolia Water Solutions and Technologies has exclusive rights to promote the Genesis Water Rapid Dewatering solutions in the global mining sector as well as conferring approved vendor status in the oil sands market. The Genesis Water system was originally developed for the urban dredging market.

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The Veolia Innovation Accelerator continues to provide Veolia with new ways to interact with the innovation community and allows Veolia to meet the demands of its key markets



Christopher Gasson
publisher
Global Water Intelligence

Christopher Gasson is an authority on water finance and markets. After a degree in politics and economics at Oxford University, he worked as a financial journalist and in corporate finance, before acquiring Global Water Intelligence (GWI) in 2002.

GWI aims to do two things for its readers:

- Tell them where their next dollar is coming from by tracking major water projects around the world from conception to contract award.
- Discuss with them the emerging trends in the industry to help them formulate strategy in a rapidly changing world.

It has made GWI the unchallenged leader in high-value business information for the water industry.

www.globalwaterintel.com



Texas Water Watch: a case study in water-energy interdependence

Unless Texans start looking at water, they are going to find that their oil-driven economic boom could be set to crash.

A 30-month drought that shows few signs of abating has caused the worst water scarcity problem in the state's history. At the same time, the soaring economic growth fuelled mainly by shale oil and gas production has Texans talking about petrochemical plants and LNG export terminals, in other words, more growth. The kind of growth they are talking about means more demand for power and that will eventually mean building more power plants.

So Texas could build more power plants. Thanks to the hydraulic fracturing boom, they have plenty of gas to fuel them. But where is the water for boiler feed and cooling going to come from?

The creative answer to this is the Guadalupe-Blanco River Authority's proposal for the first independent water and power plant in the Americas (see *GWJ's project tracker for more information on this project at www.globalwaterintel.com*).

The IWPP model was developed in the Middle East as a means of meeting soaring demand for water and power as oil prices drove economic growth to unexpected heights. Texas today is in a similar position to the Eastern Province of Saudi Arabia five years ago, when the oil price crashed through the \$100 barrier. Texas oil production has doubled since 2010, and all that additional cashflow is creating unprecedented demand for power and water, just as it did in Jubail in Saudi Arabia.

In Texas, as in Saudi Arabia, water is a bigger problem than energy, but the two are inextricably linked. Sooner or later, if Texas wants to keep its economic miracle from coming to an abrupt halt, it is going to have to start spending money on water and looking at cost effective ways to save it.

Why we are watching Texas

It is difficult to talk about water in Texas without talking about hydraulic fracturing. There's some irony here – the very process for shale oil and gas production that engineers the current economic growth in Texas also plays a significant role in exacerbating the prolonged drought, and results in the dwindling supplies of water that could eventually bring the whole Texas economic boom to a halt.

Hydraulic fracturing, the drilling technique commonly known as fracking, blasts huge volumes of water, fine sand and chemicals into the ground to crack open valuable shale formations to produce shale oil and gas from tightly packed rock, and in doing so uses huge amounts of water.

Not only in Texas, but in Arkansas, Colorado, New Mexico, Oklahoma, Texas, Utah and Wyoming, energy companies have been expanding their water-intensive fracking operations in the very regions where crops are failing and water sources are all but dried up due to severe drought.

Although fracking consumes less water than farming, it is nevertheless driving up the price of water in drought-ridden regions like Texas as oil and gas companies are in a position to pay a lot more than farmers for the scarce resource, leading some farmers to see the push for fracking as an opportunity to make money by selling their water to energy companies in lieu of growing crops. In some places fracking companies buy or lease property belonging to water districts, landowners and cities. So while shale oil and gas flourishes, many of the reservoirs and aquifers throughout Texas are drying up, a situation with potentially devastating economic results.

But water stress could be a technology driver

And yet, what seems to be a well-entrenched fracking scene in Texas looks as though it could be in for a paradigm shift. The amount of water required for fracking is drawing new levels of scrutiny from the Texas state legislature and evidence suggests that the oil and gas industries are paying attention. There is a lot of money at stake in the Texas shale industry – even with the

recent decline in gas prices – and that means there are technologies now developing around the treatment and recycling of the water used in hydraulic fracturing (frack water) that could turn out to be a significant growth area, with repercussions for other areas of oil and gas production. While industry giants like Halliburton, Schlumberger and Baker Hughes may have a leading edge when it comes to pursuing new technologies for frack water reuse, the emerging interest in water recycling and the rising demand for it is creating opportunities for smaller players as well. Houston firm Select Energy Services has reported a rapid rise in demand for its water-recycling services. Ecologix, an Alpharetta, Georgia, recycling company, is building new facilities in west Texas to purify 31,000 barrels a day of wastewater after having earlier sold all its recycling units to Halliburton.

The upshot is that the combination of water scarcity and a booming oil and gas industry is making Texas a key region for new and developing water technologies – especially those with non-conventional applications.

A couple of Texas based companies with creative frack water technologies

WaterTectonics is giving electrocoagulation, the process that uses electric current to bind together contaminant particles, thereby filtering them from water a new lease on life through their licensing agreement with Halliburton for the treatment of frack water and other applications. Their particular design for electrocoagulation, the Wavelonics System, with a cell structure geared for handling high volumes, has been implemented on several projects across the US and in most major shale plays. The company reports that they have tripled in size since 2009 and they are set to implement the technology offshore and outside the US.

Austin-based Omni Water Solutions was established four years ago to deliver mobile solutions for oil and gas companies that use large amounts of water in hydraulic fracturing operations. By integrating eight different treatment processes, their patent-pending Octozone technology is able to sense rapidly changing water conditions and configure the appropriate treatment while using a minimum amount of energy. Omni's platform is a highly efficient, low – energy and maintenance system that allows oil and gas producers to deal with unforeseen levels of contamination – which is exactly the kind of flexibility the industry is looking for. Omni Water Solutions have established strong relationships within the Texas investment community and recently closed a \$7.9m series A round of funding led by Austin Ventures.

And another one in Florida

Ecosphere Technologies of Stuart, Florida, has developed, patented and now manufactures Ozonix, a water treatment system for both flowback water and produced water during hydraulic fracturing that delivers bacteria control and scale inhibition without using chemicals. From December 2008, the company reports that it has implemented Ozonix technology to treat, recycle and reuse over 2 billion gallons of wastewater around the US. Their next step will be to adapt its technology to the recovery of natural gas from unconventional shale plays.

It is not all fracking

But the new areas emerging for water technology in the oil and gas industries are not all about hydraulic fracturing and water companies with sources to develop would do well to think before leaping onto the frack water bandwagon. Frack water is one part of the produced water whole and the companies most likely to have success in developing new water technologies will be those that keep their eye on the bigger picture, where flexible solutions and an ability to adapt to changing water conditions are the primary requirements.

When considering the bigger picture, the emerging areas to watch are:

Low salinity water

Low salinity enhanced oil recovery is water flooding of a sandstone reservoir using water

“While shale oil and gas flourishes, many of the reservoirs and aquifers throughout Texas are drying up, a situation with potentially devastating economic results”

with TDS (total dissolved solids) content of less than 2000-8000ppm. It works by altering the chemistry of the water used for water floods, both in terms of salinity levels and ionic composition, to relax the chemical environment in the reservoir and thereby weaken the attraction of the oil to the reservoir rocks and clay. Testing over the last 20 years has shown that the incremental improved oil recovery using this method is potentially significant, with sandstone reservoirs showing a range of 5% to 40% incremental oil recovery based on original oil in place (OOIP).

The idea of improving the oil sweep of a well by flooding it with a water adjusted for a specific salinity and ionic composition has been the subject of industry research since the early 1990s and different companies have trademarked it under different names. The most significant of these is BP's LoSal EOR.

BP plans to implement LoSal EOR (enhanced oil recovery) as a secondary water flood at its Clair Ridge platforms in the North Sea (scheduled for completion in 2015 with first oil in 2016). Their second project using LoSal EOR will be Mad Dog Phase 2 in the Gulf of Mexico with first oil scheduled for 2020.

Shell, a joint venture partner on the Clair Ridge project – through subsidiary companies Enterprise Oil and Shell Clair UK – has been working on scaling up low-salinity technology with trials in its Omar and Sijan fields in Syria (operated by Shell subsidiary Al-Furat). Shell has also been reported to be evaluating the Ursa field in the Gulf of Mexico for commercial application of low-sal water technology, following the introduction of secondary recovery with an SRM (sulphate removal membrane) unit and facilities for water treatment in 2008.

In Norway, Statoil has the offshore Heidrun, Snorre and Gullfaks fields under consideration for low-salinity pilots, while Saudi Aramco is currently conducting tests on the effectiveness of low-salinity water – smart water – in carbonate reservoirs, and has reported positive results. Also in the Gulf of Mexico, Shell's Ursa field is currently reported to be under consideration for a low-salinity water application.

The current movement on the low-salinity front is certainly creating a buzz in the oil industry. It will not be an easy market to penetrate, but there should be money to be made for specialist membrane technology companies who understand the oil business.

Real-time onsite multi-parameter water quality sensors

The development of a water quality sensor that could be used to measure and monitor the produced water at oil and gas fields accurately and quickly would solve a major problem in the industry. By eliminating the need to send field samples off for testing, it would provide an effective tool for meeting discharge regulations and for determining the correct composition when using produced water for flooding.

Membrane de-oxygenation

Desalinated water has to be treated for oxygen removal before it can be used for water flood. For the most part this is currently achieved through the use of conventional vacuum and de-aeration towers. Oxygen removal by means of a membrane would be lighter and take up less space on offshore platforms. The implementation of membrane de-oxygenation technology in deep water oil fields would be an area with huge growth potential for EOR and is considered to be a viable technology with significant potential for improving recovery and reducing costs.

A number of the oil majors – Total, BP and Shell – are looking at ways to implement oxygen removal via a membrane. If the industry could implement membrane de-aeration or de-oxygenation then this would give a boost to other water flooding technologies, including sulphate rejection and low-salinity water.

It's the environment, stupid

Market pressures and persistent drought could be a winning combination: just the thing to get water on the agenda in the middle of the Texas shale boom. It is getting the attention of the oil and gas industry and there is evidence that a change in the way the oil and gas majors look at water now has an impact on their long term investment strategies. In fact, there is no way to get away from it: the Texas drought brings into plain view exactly how dependent onshore energy production is on the availability of water. It is turning out to be a key driver behind developing new technologies for the reuse of frack water and those technologies could easily have applications in water flood and other forms of enhanced oil recovery.

That is why we are watching Texas.

Analysis: LEIF Chairman Tom Whitehouse

All of the venture investors backed by, or linked to, the oil and gas majors we approached for this report are planning to invest in water-tech companies. Though many do not disclose the sums they have available for venture investing, extrapolating from their bullishness over their water-tech dealflow and from what they have invested to date, it is clear that hundreds of millions is poised for investment in oily water-tech.

The motivation is simple. The oil and gas industry needs to reduce its water costs, get water to work more efficiently in extracting hydrocarbons and stay on the right side of the politics of water. For big energy, water venturing is not driven by the desire to diversify. It is directly related to the future success of their core business, the extraction of hydrocarbons.

Oil and gas corporate venturing units are typically not afraid of early stage technologies, are prepared to invest globally and are aware of the need to provide hands-on support to their investments to help them penetrate their conservative industry. They are conscious also of the need to be collaborative with financial venture investors rather than dominant. For some, acquisition is the end game, but for most technology development is the priority.

There is a vast array of technologies in play. Bio-tech, nano-tech and chem-tech all offer water solutions of great potential. But oil and gas is an all-tech industry. Anything that provides water solutions will be most welcome.

Water is both a tool and a waste product. Vast volumes of tailored water – not just any old water – are required for extraction. Water is then typically produced with the oil and gas that comes to the surface, often with a mix of naturally-occurring pollutants alongside any chemicals and other compounds that went into the tailored water before use.

Thus some technologies address the need to reduce or eliminate water used during extraction. Others address technologies which will be deployed at the end of the pipe – they will treat waste water produced after extraction.

Big Energy's Oily Waters

BP established its venture unit in 2006, but changed its name from BP Alternative Energy Ventures to BP Ventures in 2011 to reflect an evolution in strategy – BP is now making investments on behalf of its oil and gas operations as well as its alternative energy interests.

“While financial returns are important, our venturing business is driven by the need for technology access. So, that is what drives our investment strategy and style,” said Sandra Eager, BP Ventures Technology Manager, who has spent the last year consulting widely within the company before writing what is referred to internally as its ‘water investment thesis’ (see page 26 for full interview).

She added: “Seven key areas have been identified. Recycling and reuse is top in terms of importance because regulation is only going to increase and become ever tighter ... EOR is equal top in importance, explaining our interest in desalination technologies.

At the time of writing, BP Ventures is expecting to make a new water investment “soon”, has a “healthy pipeline” of other investment opportunities, and is prepared to invest across all stages – including seed funding.

BP's strategic interest in water typifies a wider trend. New venturing units set up over the last two years by ConocoPhillips, Statoil, Saudi Aramco and Shell also have an express interest in water. The venture teams at Total, Cenovus and Chevron have been around a little longer and have all already made water technology investments.

“[Water] is a part of our energy-tech focus. We want to use and extract energy more efficiently,” said George Coyle, of ConocoPhillips Technology Ventures, which has made several water-tech investments. “The common theme across all [water-tech investments] is that they have the potential to significantly reduce our water costs and improve our stewardship of the environment,” he added (see page 24 for full interview).

According to the water page of the Saudi Aramco Energy Ventures' website, the largest oil company in the world seeks to “invest in technologies applicable across the water value chain in

“There is a vast array of technologies in play. Bio-tech, nano-tech and chem-tech all offer water solutions of great potential”



the kingdom, including desalination, distribution, end-use, water and wastewater treatment, and recycling”.

These approaches to water venturing do not reflect a desire to diversify away from oil and gas. They reflect a strategic need from within their core businesses.

“We spend a lot of time listening to our business units to find out exactly what they need, what problems they have so that we can then go and find solutions,” said Coyle. “We do not want to find a solution looking for a problem.”

Investing to acquire or to source innovation?

Financial venture investors sometimes have reservations about oil majors’ corporate venturing ambitions. They ask whether business cultures typically focused on outright acquisition can work effectively in the more subtle and sensitive business of venturing.

But the new generation of oil and gas corporate venturing units are keen to reassure that this concern, which is as old as corporate venturing itself, is misplaced.

“Our role is to source external innovation for ConocoPhillips. We are not there to acquire,” said Coyle. “We are there to source. Then we will have a successful venture investment and we will improve the performance of our assets. In other words, we are looking to back companies whose products and services ConocoPhillips can buy and use.”

ConocoPhillips is taking two complementary approaches to venturing. Its in-house corporate venturing unit invests off the parent company’s balance sheet. It has also allocated an undisclosed sum to Energy Technology Ventures, its joint venture VC fund with GE and NRG Energy, which has \$300m under management.

In addition to operating its internal venture unit, BP has also allocated capital to arm’s-length venture funds where they are just one of a group of limited partners, but where they have access to dealflow and a window on technology development.

“[BP] can invest at any stage, even seed funding and we will be happy to invest with other oil majors and alongside institutional investors; we have common interests and complementary skills,” said Eager. “We will also be happy to see the likes of Veolia, GE and Schlumberger involved. They offer, after all, a natural exit for early-stage companies.”

Service companies join the party

Large corporations servicing clients in the oil and gas industry are also seeking and making

Ten water-tech companies with oily corporate investors

	HQ	Summary	Institutional investors	Corporate investors	Latest fundraising
NanoH2O	US	high efficiency desalination	Khosla Ventures and others	Total, BASF	\$40m in equity, \$20.5 in 'credit facilities' (2012)
Oxane	US	novel proppants to increase 'fracking' efficiency requiring less water	Energy Ventures and others	ConocoPhillips, Chevron, BP Ventures	\$100m since 2002 (last round was in 2012)
FilterBoxx	Canada	modular tar sands waste water treatment	XPV Capital, EnerTech Capital	Kuwait Petroleum Energy Ventures (LP in EnerTech Capital)	\$9m 2011
Saltworks	Canada	energy efficient purification, desalination, and brine treatment systems	n/a	Cenovus Energy EOF, Teck	C\$2.5m 2011
Taxon Biosciences	US	smart microbes to reduce water needs in oil extraction	Formation 8	BP, ConocoPhillips	\$4.01m 2013
Glori Energy	US	high efficiency surfactants which reduce water us	Gentry Venture Partners and others	ConocoPhillips	\$20m 2012
Zilift	UK	high efficiency pumps requiring less energy to lift both oil and water	Viking Venture and others	Saudi Aramco, ConocoPhillips, Chevron Technology Ventures,	2013 - undisclosed
Lance Energy Services	US	using nanotech to make ceramic membranes organophobic	n/a	ConocoPhillips	2013 – undisclosed
Enaqua	US	UV disinfection company	n/a	Grundfos	Aquired in 2012
Clean Filtration Technologies	US	novel filtration component for use in multiple applications including the oil & gas Industry	n/a	Dow Venture Capital	\$5.5m 2009

This table lists ten leading technology companies that offer novel and ambitious solutions to the water problems of the oil and gas industries. I am not saying they are necessarily the best, but they are compelling for at least two reasons – they are drawing on the most advanced science in, for example, nanotech and biotech, and they have raised money from corporate venture capital groups backed either by oil and gas companies or by their service providers. Investment of this kind is both a vindication and a potential route to commercialisation. Oil and gas companies are investing in companies whose products and services they want to buy.

Some of the companies are end of pipe – they apply new technologies to treat waste water produced during oil and gas extraction. Others are focused on reducing or eliminating water use during extraction.

A comprehensive and eclectic approach to technology is required to address the varied and considerable water challenges of the oil and gas industries.

The cost of preparing water for use in extraction and for treating waste waters after extraction is an increasing factor in determining the profitability of established oil and gas fields and the feasibility of new ones. Moreover, water is highly political. It has become the new stick with which non-governmental organisations and campaigners will try to hit the oil and gas industry.

Technologies and solutions are therefore required that lower costs and contribute to the general wealth of the water environment, rather than detract from it.

water-tech investments. Denmark-based pumps company Grundfos launched an innovation platform three years ago to help its expansion into water treatment.

“We are excited by the growth prospects in decentralised waste water markets such as food and beverage, pharmaceuticals, and oil and gas,” said Fei Chen, Grundfos innovation platform director. “These are markets where demand for our pumps is already strong. We think this gives us the opportunity to offer other services.”

With one acquisition under its belt, the California-based ultraviolet disinfection company Enaqua, Grundfos is now also seeking minority investments in membrane technology, sensors and controlling, advanced biological treatment and advanced disinfection.

“We will take minority stakes in technology companies that have proof of concept. By proof of concept I mean they must have at least pilot test results to demonstrate the technology performance,” explained Fei Chen. “We would like to have the option to acquire the companies we invest in – we would like to have the right of first refusal.”

The corporate venturing unit of US-based chemicals company Dow has invested in one water-tech company, Clean Filtration Technologies, which has a novel filtration component for use in several industries including oil and gas.

“Dow Venture Capital invests in promising start-up companies in North America, Europe and Asia,” said Mark Felix, investment manager at Dow Venture Capital. He said Dow was interested in “differentiated component business opportunities which address the challenges facing the oil and gas industry”. It was prepared to “enter into very early-stage opportunities and is willing to lead rounds of investment.”

Early-stage investors required

The willingness of corporate venturing firms to invest in early-stage technology is significant. A lot of the water technologies required by the oil and gas industry are indeed in their infancy. With some financial venture capitalists wary of early-stage investing unless corporates are also involved, new technology companies’ best hope of raising capital may be to start with the corporates.

The companies in our water-tech table – Ten water-tech companies with oily corporate investors – are all relatively early stage. Some have commercial products in the field. Others are in piloting stage. With the exception of Filterboxx, corporate venture investments have either preceded or accompanied financial venture investments, thereby increasing the companies’ capital base. This is a virtuous circle – corporate VCs provide the reassurance required by financial VCs that their investments can get to market. Financial VCs then invest, thereby providing the companies with the financial firepower to get to market.

“I am proud to say we helped leverage an additional \$100m [for Oxane Materials] from other corporate and institutional investors” said Coyle.

Corporate-led investor coalitions

This additional \$100m included undisclosed sums from BP Ventures, Energy Ventures (an institutional Norway-based energy-tech VC), and other institutional and private investors.

Californian bio-tech company Taxon Biosciences also had early backing from ConocoPhillips which was followed by a series A round in May this year involving BP Ventures and San Francisco-headquartered financial VC, Formation 8.

In June this year, Saudi Aramco Energy Ventures joined Energy Ventures and other financial VCs, and fellow corporate investors Chevron and Energy Technology Ventures, among the shareholders in Zilift, a Scotland-based company with highly efficient pumping technology.

Coalitions of corporate and institutional investors can evidently do wonders for an early stage company’s balance sheet. BASF Venture Capital, Total Energy Ventures and Keytone Ventures co-led the November 2012 \$40m equity financing in NanoH2O, which also included its previous

“We would like to have the option to acquire the companies we invest in – we would like to have the right of first refusal”

Fei Chen, Grundfos

institutional venture investors Khosla Ventures and others. Furthermore, \$20.5m in what the company describes as “growth capital, working capital and equipment financing credit facilities” were provided by Comerica Bank and Lighthouse Capital Partners, with the working capital line backed by the Export-Import Bank of the US. NanoH₂O, a high-efficiency desalination technology company, is proud to describe itself as “one of the most highly funded water technology companies in the industry”.

Of course, it also works the other way – venture funds source dealflow and investments for their corporate backers and financial VCs lead investment rounds which include corporates.

Pangaea Ventures is a Vancouver-based venture fund with an impressive roster of corporate backers. Its general partner Keith Gillard said Pangaea had a “keen interest in the opportunities to improve the usage of water in the oil and gas industry”. BASF and Asahi Kasei both have established water interests and are limited partners in Pangaea Venture Fund 3.

“As an advanced materials investor, our focus is on such solutions as membranes, ion exchange resins, catalysts, electrochemical approaches, oxidative chemistries and biological solutions,” said Gillard.

“It is now increasingly easy to take technologies global, particularly as they become more modular and transportable”

Dave Henderson, XPV Capital

Energy Capital Management (ECM), which has offices in Norway and Scotland, is another institutional energy-tech VC working closely with large corporates. In August last year it announced it had swapped Statoil for Saudi Aramco. A company statement reads: “In August 2012 ECM entered into a contract with Saudi Aramco Energy Ventures ... Prior to that, between October 2008 and July 2012, ECM supported the Norwegian oil and gas major Statoil.”

Water-tech, meet nano-tech, chem-tech and bio-tech. In fact, just meet global all-tech

Lance Energy services is using nanotech to make ceramic membranes organophobic, which can then be used to treat waste water in oil and gas. Taxon Bioscience is applying bio-tech to develop smart microbes to reduce water needs in oil extraction. Glori Energy is also developing bespoke microbes to increase the effectiveness of surfactants, which improve the efficiency of water flood. Chemical innovation is at the heart of a lot of water-tech.

Cruise Jones manages the Texas-based oil/gas production and stimulation unit of German chemicals giant Evonik. He explained the potential of chemical innovation to increase the efficiency of oil and gas extraction processes and “make water work harder”.

“For example, Evonik works with companies that apply novel surfactants to reservoir rock so that hydrocarbon fluids flow more readily through them relative to water flow. We are trying to modify reservoir surfaces to create an effect essentially opposite to what occurs when one waxes a car surface. That is, instead of water beading up and flowing quickly across a waxed car surface, we treat the reservoir surface so that oil beads up and flows more quickly across the surface relative to water.

As Wayne Evans of Veolia pointed out, such chemical innovation can create the need for further water innovation to treat the mix of water and chemicals that flows back.

He said: “The growth of enhanced oil recovery and of chemically enhanced oil recovery is also driving water technology innovation. Polymers, sometimes combined with surfactants, mobilise additional oil and drive it through the reservoir, but then polymers need to be removed from the waste water stream before it is disposed of or before they are reused in the extraction process.”

The breadth of technologies with relevance to oil and gas explains the increasingly global outlook of water-tech investors.

“There is no Silicon Valley of water technology,” explained Dave Henderson, managing partner at the water-focused Toronto-based growth investor XPV Capital. “Technologies have been developed in response to oil and gas challenges in local markets. For example, that is why

Ten oily VCs investing in water-tech

	Headquarters	Fund size	Date established	Water investments include
ConocoPhillips Technology Ventures	US	\$300m	2011	Oxane Materials, Lance Energy Services, Taxon Biosciences
Chevron Technology Ventures	US	>\$250m	1984	Oxane Materials, Soane Energy
BP Ventures	UK	\$175m invested in total	2006	Oxane Materials, Taxon Biosciences
Total Energy Ventures	France	\$750m	2002	NanoH2O
Statoil Technology Invest	Norway	exact sums undisclosed	2000	Soiltech, Resman, Silixa
Shell Technology Ventures	UK, Netherlands	exact sums undisclosed	2013	Glasspoint Solar
Saudi Aramco Energy Ventures	Saudi Arabia	exact sums undisclosed	2012	Zilift
Dow Venture Capital	Switzerland	exact sums undisclosed	1993	Clean Filtration Technologies
Grundfos Innovation Platform	Denmark	exact sums undisclosed	2010	Enaqua (acquisition)
Pangaea Ventures	Canada	Has raised \$50m of a planned \$100m third fund	2001	Rayne Corporation

The ten companies in the table are all serious about water. They include six oil and gas companies, one chemicals company selling into the oil and gas industry (Dow), one pumps company (Grundfos) diversifying into waste water treatment, and one VC fund backed by corporations selling into the oil and gas industries (Pangaea Ventures).

I am not saying that these investors are necessarily the best or the most active, just that they are interesting because they are symptomatic of two related trends – the increased interest of the oil and gas industry in water-tech and the emergence of oil and gas-focused water-tech as a distinct investment opportunity or asset class. There are many other corporate and financial investors that could have been included in the table. It is not an exhaustive list.

The water-tech investments they have made could be split into two categories, end-of-pipe and enabling. A water technology is end of pipe when it treats waste water produced at the end of oil and gas extraction. An enabling technology allows an oil and gas company to use less water at the beginning of and during the extraction process.

Europeans are good with technology used in the offshore oil and gas industries.”

This high science is a world away from the clichéd oil and gas images of nodding derricks and oil-soaked rig workers. But, as Henderson explained, to meet the needs of the oil and gas industry, high science will ultimately come down to earth, preferably in a 40-foot container, and be integrated into service provision.

“It is now increasingly easy to take technologies global, particularly as they become more modular and transportable. This is a big paradigm shift. Water assets used to be fixed, but this is changing,” said Henderson.

XPV’s portfolio includes FilterBoxx, a Canadian company providing transportable “packaged potable water and wastewater treatment systems” to the oil, gas and mining industries. Ceramic membrane technology is at the heart of its offering. FilterBoxx’s investors also include EnerTech Capital, a US energy-tech fund, with Kuwait Petroleum Energy Ventures among its backers.

Penetrating a conservative and risk-averse industry

So much for the array of technology that is available and coming through. How can it get to market?

“Contrary to popular belief, oil and gas is not a Wild West industry. It is very conservative,” said Henderson. “This is where the corporate venturing and open innovation models can add value. To penetrate the industry you need to win trust. So a large corporate or an established service provider can help.”

Gillard agreed: “This is especially true in larger scale operations such as the oil sands. Typically, progress can be accelerated when partnered with one of the oil and gas service companies such as Schlumberger & Halliburton.”

Water service companies are not standing idly by. Veolia Water Solutions & Technologies, one

of the sponsors of this report, is keen to integrate new technologies into its service package for the oil and gas sector and has an open innovation platform for this purpose, the Veolia Innovation Accelerator.

“Operating companies in the extractive industries are focused on their production systems, not on their water treatment problems. [We] recognise this reality and look to offer the complete solutions to the operator, by combining our own technologies with those of our partners to build a water treatment process,” said Wayne Evans, VP – industrial technology for Veolia Water Solutions & Technologies.

“Such an approach allows innovators access to markets and pilot plant facilities while providing Veolia with the opportunity to offer state-of-the-art processes and services to its clients.”

NanoH2O has a partnership agreement with Veolia, which has supplied its membranes to two clients in the Americas, having first worked with NanoH2O to qualify the membranes by means of pilot plants in the Middle East, the Mediterranean and Australia.

“Veolia has established the Veolia Innovation Accelerator as a mechanism to facilitate the development of such partnerships,” said Evans.

ConocoPhillips Technology Ventures takes an in-house approach when tackling the conservatism of its industry.

“We confront this problem head on at ConocoPhillips by having both a business development team and an investment team behind our portfolio,” said ConocoPhillips’ George Coyle. “It is the business development team’s job to get our portfolio companies into our operations. Where necessary we can draw also on extensive project management expertise so that projects using our portfolio’s technologies are properly implemented and measured.”

Conclusion

The conservatism of the oil and gas industry is just one of the challenges faced by water-tech companies. A lot of patient and determined capital is required to commercialise. But for the oil and gas industry, water-tech is not merely a nice-to-have, a municipal recycling facility that could be built next year or next decade. It is a strategic necessity.

The LEIF investment formula is:

**(Innovation + regulatory change) x corporate appetite
= a potentially very good clean technology investment**

For those with expertise, patience and capital, water-tech could be the real deal.

Top ten new oilfield technologies to watch

This article is contributed by World Desalination Report, part of Global Water Intelligence

As produced water volumes grow, disposal options dwindle and regulations tighten, the upstream oil and gas industry looks for a treatment silver bullet. Meanwhile, water treatment companies continue to adapt their technologies to address the oilfield's unique challenges.

The technologies are listed alphabetically:

Carrier gas extraction (CGE) – A modular volume reduction system for highly saline produced water applications which uses a unique bubble column dehumidifier and packed bed humidifier while recovering up to 85% of the feed as high-purity distillate, by Massachusetts-based Gradient Corporation. Long-term lab pilot studies have been conducted and a commercial-scale field pilot is now under construction.

Ceramic microfiltration/ultrafiltration (MF/UF) membranes – Rather than a specific product, this technology includes a family of ceramic MF/UF membrane products for produced water applications offered by several membrane suppliers and/or OEMs, including iTn Nanovation, LiqTech, Metawater, PWN and Veolia. Each company focuses on certain applications within the upstream oil and gas market, and the products are at various stages of commercialisation.

ElectroChem – An electrochemical-based platform for softening, desalination and brine concentration of oilfield waters and wastewaters that employs highly cross-linked ion exchange membranes to reduce organic and hydrocarbon fouling, by Canada's Saltworks Technologies. Micro pilot systems available and larger-scale pilot tests are now underway.

Hybrid forward osmosis/reverse osmosis (FO/RO) – An oilfield volume reduction process that employs FO to concentrate saline wastewater while diluting feedwater for a HiCor high recovery RO, which generates a highly concentrated osmotic agent that improves FO system performance, by Hydration Technology Innovations (HTI). In-house demonstrations have validated the system's operation, and a production scale pilot system is expected to be in the field later this summer.

H2Ocean Spectrum – A water quality control technology that allows users to dial in and maintain the desired permeate salinity and hardness for sulphate removal, low salinity and chemical EOR injection, regardless of changing feedwater quality, downstream produced water reinjection effects, membrane age or reservoir conditions, by Houston-based Water Standard. The system has been pilot tested and validated to meet the API's TRL for commercial application.

Membrane brine concentrator (MBC) – A membrane-based volume reduction system that employs forward osmosis to concentrate up to 4,000 barrels per day (bbl/d) of high salinity produced water at recovery rates of up to 85%, by Oasys Water. Field pilot tests have been conducted and the first, full-scale commercial unit is planned to be operational this November.

Multi-effect membrane distillation – A modular volume reduction process that can concentrate high salinity water from unconventional oil and gas recovery operations to near-saturation levels while producing distillate quality water using a unique mechanical vapor compressor, by GE/memsys. A pilot unit is now in operation.

ROSS – A ceramic membrane-based produced water treatment system that simultaneously removes oil, solids and silica while softening up to 50,000 bbl/d in a single modular unit, by Veolia Water. One unit is now in commercial operation on a produced water application and the system is commercially available.

SPRINGS – A subsea sulphate removal system, which relocates the membrane treatment system from floating production units to subsea stations, by Veolia/Saipem/Total. The first test unit is currently being fabricated for on-site trials off the West African coast in 2014.

Vorti-SEP – A fully automated, modular and transportable produced water treatment system designed to handle influent flows to 27,000 bbl/d containing up to 5% solids and 30% oil while producing high-quality product water for disposal, reuse or membrane desalination and also recovering valuable oil products, by Los Angeles-based Water Planet Engineering. Two demonstration-scale systems have been built and pilot studies are planned for heavy oil EOR projects.

George Coyle



George Coyle leads ConocoPhillips Technology Ventures' venture capital and Energy Technology Ventures JV investing activities. He is focused on accelerating the commercialisation of innovative technologies that can improve the performance of ConocoPhillips. Coyle is a director or observer on the boards of Ciris Energy, Foro Energy, Lance Energy Services, Oxane Materials, Skyonic, Ziebel, and Zilift. He has over 25 years of experience in E&P and technology commercialisation, including being president and CEO of a venture capital-backed company developing and manufacturing composite pipe for the offshore and deepwater oil and gas markets. He worked with Chevron for 19 years, starting as a geophysicist and holding positions of increasing responsibility in business and strategic planning, information technology, asset management, new ventures and corporate venture capital. He has a BSc in earth sciences from the University of New Orleans, an MSc in geology (geophysics option) from the University of Kansas, and an MBA from Tulane University.

Describe your investment company and state how much you can invest on a yearly basis.

ConocoPhillips Technology Ventures was set up in 2011 to invest in next generation energy technologies that can be adopted and deployed by our operations, when commercialised and scaled, to improve the performance of our core business. We invest in two ways – directly and through Energy Technology Ventures, a \$300m joint venture we set up with GE and NRG Energy. Our ConocoPhillips Technology Ventures team plans to make three to five direct investments per year and we are fulfilling that plan. Typically we will be investing \$1m-\$5m per investment. We have made 25 investments in total, 15 through ETV and ten direct investments. There is a little overlap – in two companies, we have invested both directly and through ETV.

Have you made investments in innovative technology companies that offer solutions to the water problems of the oil and gas industries?

We certainly have. The common theme across all of them is that they have the potential to significantly reduce our water costs and improve our stewardship of the environment. If you are reducing your water costs you are typically also reducing your energy costs. Our investments that relate to water include, in no particular order:

Glori Energy, a Houston-based company that has developed microbes which act as a surfactant to improve the efficiency of water flood. Basically, the microbes grow on the water and make the water more mobile, which means you can do more with less water.

Zilift is a Scottish company based in Aberdeen that provides a highly efficient pump, which means you need much less energy to get both oil and water out of the ground. This reduces energy costs associated with water management.

Ziebel is a Norwegian company, based in Stavanger, which has developed technology to put fibre optics in horizontal wellbores so that we can assess what our water is doing in real time. This means we can understand which perms the water is going into, which perms it is not getting into so that we can make necessary adjustments. This helps prevent water waste by improving the efficiency of water injection.

Lance Energy Services is a Houston-based company commercialising nanotech out of Rice University that can be applied to ceramic membranes to make them organophobic. This means that conventional ceramic membranes can be used in the oil and gas sector without the fouling which typically limits them as an option in oil and gas operations. Lance Energy Services' technology will allow for the much easier separation of oil from water, which has all sorts of benefits in terms of costs and environmental stewardship.

Oxane is a Houston-based company producing advanced nanotech-enabled ceramic proppants, which hold fracs open so that oil and gas can flow more easily, thereby reducing water needs. Conocophillips Technology Ventures led a recent D round, having initially seeded the company. I am proud to say we helped leverage an additional \$100m from other corporate

and institutional investors.

Taxon Bioscience is a Californian company using biotech to reduce the viscosity of heavy oil and improve efficiencies in enhanced oil recovery, thereby reducing the need for water. We have been joined as investors by BP Ventures and by an institutional investor, Formation 8.

Other companies we have invested in that have water benefits include Ciris Energy, which can potentially reduce the need to dewater CBM fields while increase reserves and production of biogenic methane, Emefcy which is focused on industrial water clean-up and Lux Assure which has commercialised technology to measure in real time the level of corrosion inhibitor in a pipeline.

Are you planning to make investments in companies with solutions to the water problems of the oil and gas industry in the next two years?

Yes, water is certainly one of the important areas for us.

What technologies and business models interest you most?

We are interested in any technology or business model that can lower the cost of handling water and make it easier to reuse. We spend a lot of time listening to our business units to find out exactly what they need, what problems they have so that we can then go and find solutions. We do not want to find a solution looking for a problem. That is the wrong way to do it. So we can be clear about what we need and want, which means that companies tend to come forward with the technologies we are after.

In which regions of the world do you expect to invest?

We expect to carry on investing in North American and Europe. Houston, Aberdeen, Calgary and Stavanger are recognised technology centres for us. ETV also looks at technology out of Israel.

What will be your investment strategy or style?

Our role is to source external innovation for ConocoPhillips. We are not there to acquire. We are there to source. Then we will have a successful venture investment and we will improve the performance of our assets. In other words, we are looking to back companies whose products and services ConocoPhillips can buy and use.

What are the biggest factors driving innovation and growth in this area?

There are a number of factors: the growth of unconventional oil and gas which requires water services in new remote areas and the need to reduce costs such as the cost of transporting waste water, and our continuing focus on sustainable operations and stewardship of the environment.

What are the potential obstacles to growth?

The water business is very disaggregated because the issues vary widely. You have to bear in mind that scale up of an individual solution is challenging because the water issues and water challenges vary greatly field by field and thus the solutions need to vary field by field.

We confront this problem head on at ConocoPhillips by having both a business development team and an investment team behind our portfolio. It is the business development team's job to get our portfolio companies into our operations. Where necessary we can draw also on extensive project management expertise so that projects using our portfolio's technologies are properly implemented and measured.

Do you regard your interest in water as a clean-tech, green-tech or other tech investment strategy?

It is a part of our energy-tech focus. We want to use and extract energy more efficiently.

What research would you like to see in this area? What technologies are currently absent?

Desalinating high-salinity brines and water at moderate or distributed scale that can make economic impact would be interesting. We would like scalable technologies that reduce the cost of removing metals and organics from water. We would like to have the ability do testing of water in the field so that we can immediately assess what type of water situation we are dealing with. At the moment, water has to be sent to labs for testing, which is time-consuming and inefficient. It would be great if we could find out immediately what the water chemistry is in our oil and gas field, including, metals, salts, organics and the scale potential whenever we take a sample.

Sandra Eager

Dr Sandra Eager joined BP in March 2001 and is the ventures technology manager within BP Ventures. She is responsible for evaluating start-up and growth-stage technology companies with novel technologies in water and has written BP's internal water investment thesis. Eager previously worked for BP Solar as a Photovoltaic Technologist and has worked in a technology team supporting BP's wind strategy.



Describe your investment company and state how much you can invest on a yearly basis.

First established in 2006 as BP Alternative Energy Ventures, we changed our name in 2011 to BP Ventures. This was to reflect the growing outreach of our ventures operation into the wider BP Group, which now makes investments on behalf of its core oil and gas operations as well as its alternative energy interests. Today, we have some £112m (\$175m) invested in total across companies and other venture funds.

Have you made investments in innovative technology companies that offer solutions to the water problems of the oil and gas industries'?

Yes. Our water-focused investments include Oxane Materials and Taxon Biosciences.

Oxane is based in Texas and is commercialising high-efficiency proppants that lead to producing more oil and more gas but without the excessive use of large quantities of water .

Taxon is a Californian biotech company developing microbes that will decrease viscosity in heavy oils. This can reduce and potentially eliminate the need for steam in heavy oil extraction. It is also working to increase efficiency of enhanced oil recovery (EOR), which will also reduce water usage.

Are you planning to make investments in companies with solutions to the water problems of the oil and gas industry in the next two years?

Yes. We hope to make at least one other investment soon. We have a healthy pipeline of investment opportunities, which are being actively evaluated.

What technologies and business models interest you most?

Over the past year I have consulted widely within BP to develop our internal water investment thesis. Seven key areas have been identified. Recycling and reuse are top in terms of importance because regulation is only going to increase and become ever tighter. So we are looking for technology which can ideally work with a variety of different types of waste water. You can never predict what exactly will come back from the well so we need the technology to be adaptable, but I understand the challenge with this.

EOR is equal top in importance, explaining our interest in desalination technologies. BP has already developed LoSal™ which uses low-salinity water for EOR, which has proven to be more effective. But, often this will be needed offshore, where footprint and weight are big issues. Increasingly, our future portfolio is in more water-scarce regions such as Oman, Iraq and Jordan. In order to operate in these countries, we have to be able to desalinate more water.

Again, I am anticipating lots of interesting investment opportunities here. Certainly, there is a lot of attention on frac water at the moment. It is a fashionable area of interest. However, produced water is a bigger market where new technologies need to provide solutions.

In which regions of the world would you like to invest?

We invest across the globe. With people in our BP Ventures team stretching from London and the US to India and China, we are organised to invest wherever we see the best opportunities.

What is your investment strategy or style?

We can invest at any stage, even seed funding and we will be happy to invest with other oil majors and alongside institutional investors; we have common interests and complementary skills.

We will also be happy to see the likes of Veolia, GE and Schlumberger involved. They offer, after all, a natural exit for early-stage companies.

While financial returns are important, our venturing business is driven by the need for technology access. That is what drives our investment strategy and style.

What are the potential obstacles to growth?

Oil and gas is more conservative than municipal water. Every new technology is subject to huge health and safety scrutiny before it can be adopted which is key to its success and longevity. This can take time and significant investment to address.

What research would you like to see in the area of water investment?

To date, water has not really been monitored adequately, or if it has no one has done anything with the proprietary data they have produced.

As a result, it is a challenge to assess water technologies against benchmarks, so it would be great to have more research done to secure more data for benchmarking purposes.

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