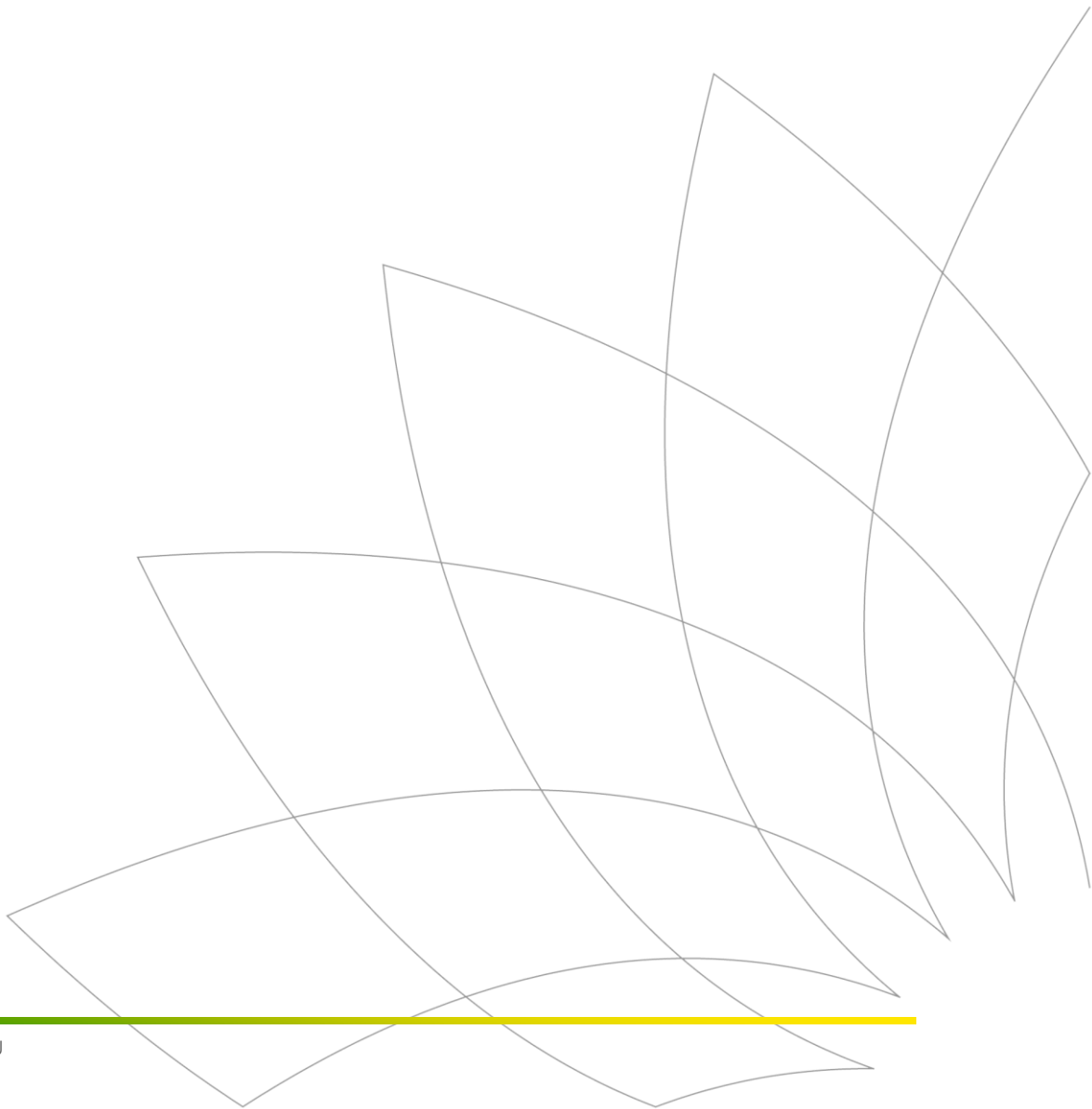
Energy science and technology at the frontiers

Dr Angela Strank

Head of downstream technology and chief scientist

24 November 2015



Good evening everyone and thank you for the kind introduction.

It's a great pleasure for me to be in Manchester today – I have so many personal memories and business connections here.

It is a very long time since I sat in this lecture theatre as a student.

BP has had a long-standing strategic relationship with the University of Manchester and this relationship covers three main areas.

The first is research – where we invest in areas of mutual scientific and business interest.

The second is Executive Education – where the university runs specialist technical and commercial course to train BP staff.

And the third is, of course, graduate recruitment. Manchester has produced many great graduates who choose to work in the energy industry.

Today, one of the 'jewels in BP's crown' is here at the university, as Manchester is the hub of the BP International Centre for Advanced Materials – commonly known as the BP ICAM. I will talk a bit more about this later.

This evening, I am going to talk to you about science and technology at the frontiers of the energy industry and how we collaborate with universities, suppliers, external partners and competitors, to produce the heat, light and mobility for the world's rapidly growing population and developing economies.

Sunbury 1980s

This evening's innovation story starts here.

This was BP's main research facility at Sunbury on Thames Middlesex – as it looked in 1982 when I started at BP as a recently qualified geologist.

It was a world where pure, scientific research took place mainly in universities.

And where the more practical activity of 'applied' research was done mainly in industry.

And Sunbury, at that time, was where BP did most of its research.

At any one time we had six hundred or more research projects on the go, carried out by several thousand scientists and engineers.

Like other large corporations – such as BT, GE and perhaps most famously Bell – BP's research was predominantly an in-house, confidential activity.

Sunbury 2015

Sunbury now looks like this, and we call it the BP International Centre for Business and Technology.

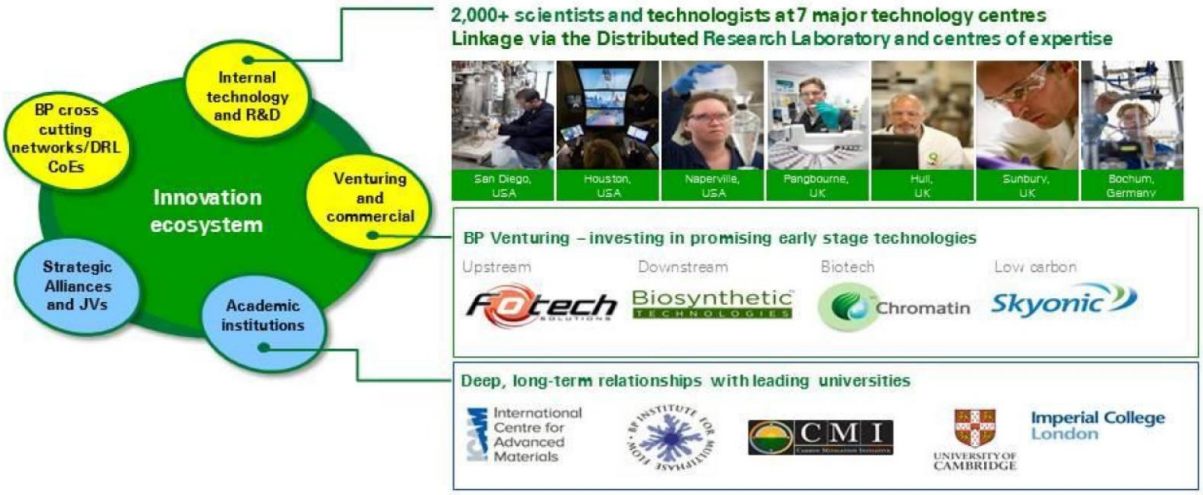
While it looks very different today, it remains an important centre of scientific research – albeit as one lobe of a very much 'bigger brain'.

Since the '80s, the world has changed hugely, it is faster, more complex, more connected, more global than ever before. And innovation is coming at us thicker and faster, and from more countries than ever before.

In the oil and gas industry we have moved beyond our traditional core of geosciences, chemistry and engineering, into advanced digital technology, materials science, biotechnology, robotics etc. – all of which are pushing forward the frontiers of innovation.

Today, no company, however big – can possibly afford the luxury of deep and wide research in all of the scientific disciplines they need. So how do we access all the expertise we want? The first challenge for today's oil and gas technology team is not only to choose the right project, but to choose the right technology partners too.

BP's Innovation Ecosystem



This is BP's collaboration model – we call it our Innovation Ecosystem – sometimes known as the 'bigger brain.' There are three key elements:

- Firstly, we have extensive in-house capability – seven major research centres around the world, including Sunbury. Collectively this accounts for about half our annual spend on R&D – which was c.$700 million last year.
- Secondly, we have an extensive network of relationships globally with over a hundred of the world's leading academic institutions. A number of them are large, long-term and deeply strategic investments, such as we have at Manchester for advanced materials; at Berkeley, where we specialise in biosciences; and Princeton, where we have undertaken climate science research for 15 years.
- Thirdly, also in house, we have a thriving venturing business which invests in a range of new start-up technology companies – from clean tech and batteries to exploration and renewable petrochemical technologies.

Finally, we form alliances and partnership with other companies and businesses – such as GE, Amec Foster Wheeler and many others. These are relationships built up over many years on major engineering development projects such as platforms and pipelines.

Together, this is how we do science, technology and R&D.

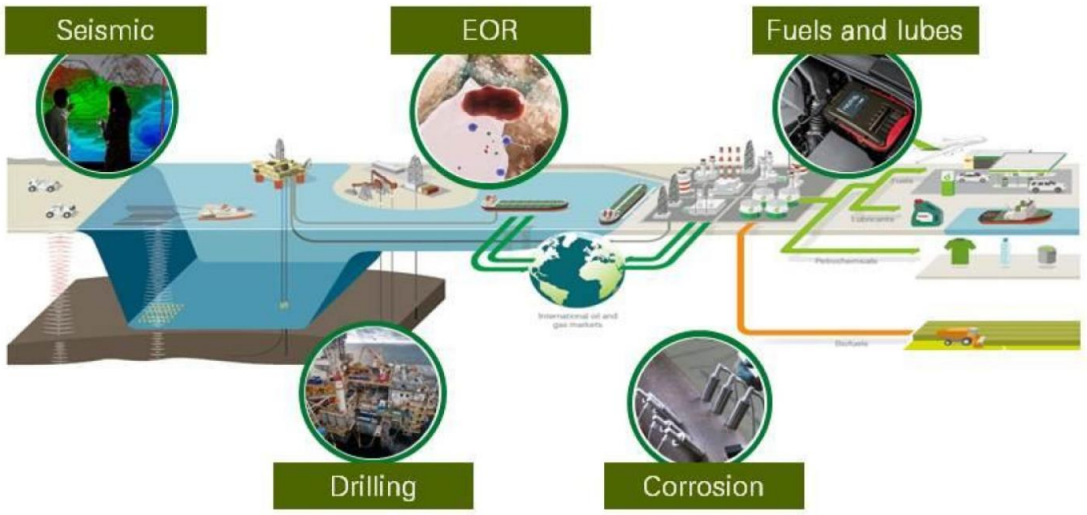
Production: the early days

Before we look at what is being achieved by this ecosystem, let's pause a moment and look at how far the industry has come in the development of technology since the early days of oil and gas exploration.

Look closely to see what comes out of this oil well. That was genuine footage of production operations in Baku in Azerbaijan in the early 1900s. Oil and gas production really was a dirty and unpleasant job.

Technology advancements have changed our industry and we now have a range of very sophisticated tools and techniques at our disposal.

Oil and gas: exploration to the customer



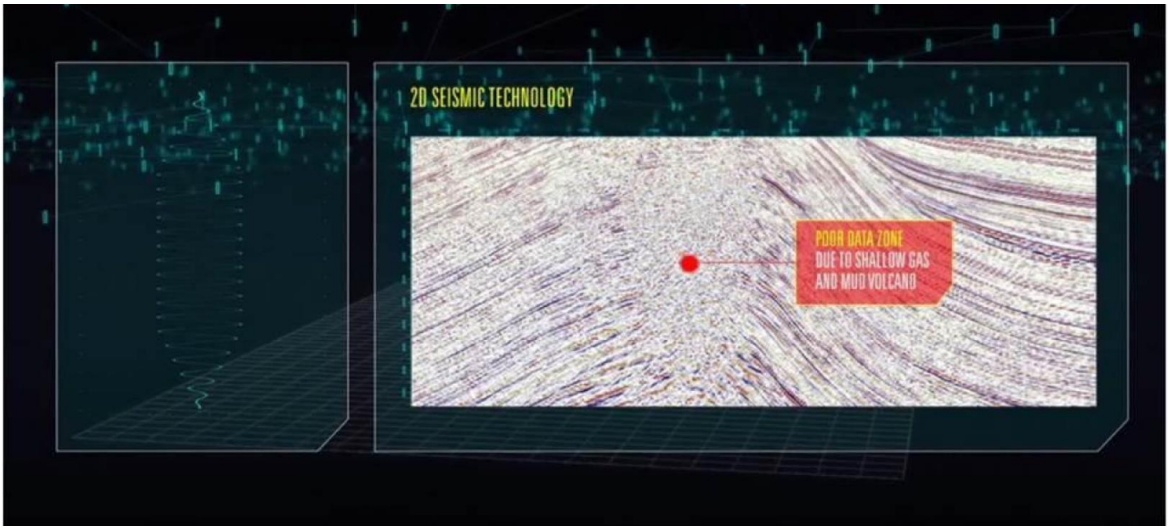
This diagram shows the oil and gas value chain from end to end – from exploration on the far left – the discovery of oil and gas – to the markets and customers at the other end.

I am going to pull out five examples:

- Seismic imaging – an area where BP has world-leading expertise.
- Drilling
- Enhanced Oil Recovery

- Corrosion management – a constant maintenance activity in our physical assets from platforms to refineries.
- Fuel and lubricants products

Exploration: seismic imaging



First is Exploration.

Today, the main subsurface imaging technology used in oil and gas exploration is seismic imaging – using sound-waves to create a picture of the sub-surface. And it's a technology that has seen extraordinary advances in the last two decades.

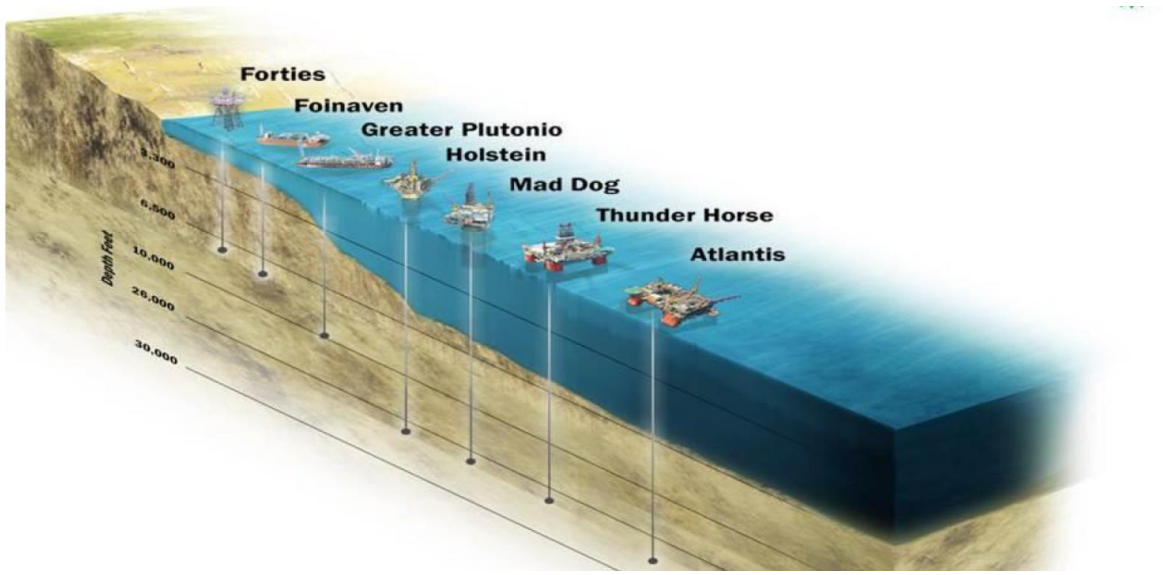
We are at the point now where we can not only find hydrocarbons more effectively than before using 3D seismic images – but also track the movement of oil, gas and water through reservoirs in a way that helps engineers optimise production. This inclusive of front of fluid movement is called 4D seismic imaging

This is a great example of the innovation ecosystem at work. These developments are the result of collaboration with a range of in-house and external geoscientists, engineers, seismic acquisition and processing experts and computer scientists – at Sunbury and our research centre in Houston.

To enable these advances in imaging, two years ago BP invested in the world's biggest supercomputer for commercial research – the BP supercomputing centre in Houston.

This centre has 3.8 petaflops of processing power – meaning it can undertake nearly four-thousand-trillion calculations per second, and it now takes a geologist a single day to carry out analyses that would have taken four years just a decade ago.

Production: moving offshore and into deep water



Like seismic, drilling technology has moved on quite some distance, and this picture shows how innovation has pushed out the frontiers of drilling and production over the past 40 years – going from onshore to offshore – and then into deeper and deeper water.

In the 1960s and 70s, oil and gas were discovered in the North Sea, with fields like Forties in shallow water. Later Foinaven was discovered in depths of over 500m and that was considered to be the real frontiers of technology, innovation and weather conditions for offshore platforms at the time.

Today, the industry is drilling wells in more than 3km of water and then through an additional 9km or more of rock.

That requires equipment that can work in temperatures varying from to (–50ºC) above ground in an Alaskan winter to around 150ºC below ground in the reservoir. And at those reservoir depths that pressure can be around 15,000psi.

And for the non-scientists in the room, that pressure is equivalent to standing the Eiffel Tower on the roof of a Mini.

Thunder Horse, Gulf of Mexico

Just to give you some idea of scale and complexity of these facilities – this is a slide of the Thunder Horse platform in the Gulf of Mexico – being towed out to sea from the Texas coast into its permanent position offshore.

Operating at this sort of scale is a massive undertaking and it is supported across industry by a variety of collaborations and technical specialisms. No one company can do this alone.

Drilling technology is being further revolutionised at the moment as a result of digital technology.

The advance of digital means we are increasingly able to collect enormous amounts of data from our operations using sophisticated sensors and fibre optic cables etc.

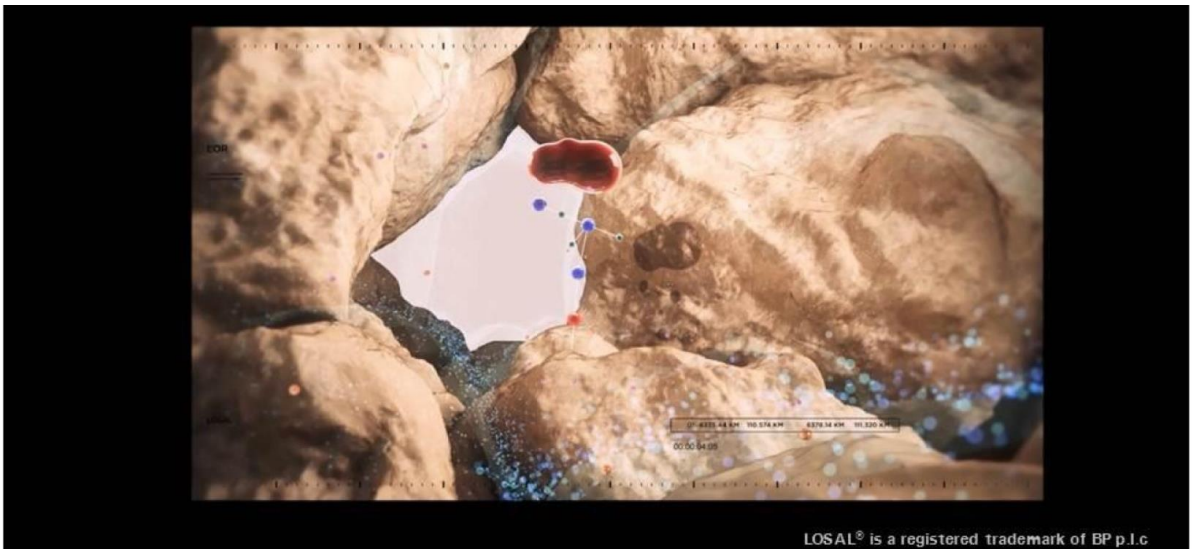
During drilling, data relating to pressures, depths, direction, casing, blow out preventers, condition of the hardware downhole, and a range of other variables cannot be transmitted to the surface.

We have been working with an external partner in Norway to develop a system that gathers the data and turns into easily understood displays on a series of dashboard-style consoles to enable the operator to make clear real time decisions.

The tool is called the BP Well Advisor

One of the Well Advisor dashboards monitors ‘running casing’ – that is lowering casing tubes into wells to line the hole. It’s a delicate process and if the casing gets stuck this can mean extra costs and delays, potentially resulting in the loss of millions of dollars. Since the invention of BP’s well advisor we’ve now used this technology on 400 casing runs without a single stuck pipe – which is a significant achievement.

Enhanced oil recovery



I’m going to move on to production now and talk about Enhanced Oil Recovery or EOR.

An oil reservoir is like a sponge full of holes, but most of solid rock. The hydrocarbons are trapped in tiny pores between the rock grains. During production, about 10% of the oil in the reservoir will flow to the surface, but the majority remains held in reservoir between the pores.

More oil can usually be brought to the surface by a process known as waterflooding – pumping water downhole into the reservoir to maintain pressure.

Even with conventional waterflooding, the average oil recovery factor from a reservoir is only about 35% to 40% – meaning that almost two-thirds is still left behind stack in the pore spaces. Technologies that improve on this recovery rate are known as Enhanced Oil Recovery.

EOR is an area of considerable strategic importance when you think that the industry is probably at a point in time when the potential for enhanced recovery from known oil and gas reservoir exceeds the potential from new discoveries.

BP has developed a number of enhanced oil recovery technologies specifically for different kinds of reservoirs and situations. Let's take a look at one of these techniques called LoSal® EOR.

Our Prudhoe Bay field in Alaska has been a brilliant proving ground for EOR technologies.

In 1977, the estimated recovery from our super-giant Prudhoe Bay field in Alaska was expected to be less than 40% at the end of field life. It has already passed 40% and we are expecting to recover more than 60% of the initial oil in place.

We're moving now something completely different – to the consumer and customer end of the business – something much more familiar to all of us in the shape of the fuels and lubricants we all put in our cars.

In BP we have a long history of working collaboratively with motor manufacturers – like Ford, on the development of advanced fuels and lubricants for rapid evolving modern engine.

We have several hundred technologists in Pangbourne UK and Bochum Germany developing new differentiated fuels and lubricants in BP and it is the largest technology group in the company.

In Lubricants we mainly go to market under the Castrol Brand, and recently we launched a new differentiated product called Castrol EDGE with TITANIUM Fluid Strength TechnologyTM.

As many of you will know, engines have become smaller, and temperatures and pressures have increased hugely inside these engines – and that has resulted in the need for stronger oils to protect engine parts.

Castrol Edge incorporates a new polymer containing titanium into the oil to improve the oil film strength.

It changes the way the oil behaves under extreme pressures, helping to form shock-absorbing pads that prevent damaging metal-to-metal contact. It is currently one of the best engine oils in the market.

Moving to new fuels – this summer we launched a new gasoline and diesel fuel called BP Ultimate fuels with new 'Active' Technology.

These fuels contain a new, bespoke 'dirt-busting' additive. BP's Active molecules cling to dirt in the engine, pulling it away from critical engine components and into the combustion chamber where it is burned. They also attach themselves to clean metal surfaces in engines, forming a protective layer to stop dirt building up again.

This cleaning and preventative action improves engine efficiency and significantly improves fuel economy.

Castrol: Nexcel

It's not only fuel and lubricant products that are important. The ICE has changed very little for 75 years, but over the last 15 years significant automotive developments have occurred. There are plenty of opportunities for innovations in this space and here is an example – just a few weeks ago Castrol launched Nexcel.

It is an easy-to-change modular unit containing both the engine oil and an oil filter in a sealed unit. Changing your oil with Nexcel is a clean experience that takes 90 seconds – unlike the messy, time-consuming routine oil change today. And importantly all the oil is recyclable which is better for the environment.

At the moment Nexcel is only available on the track-only Aston Martin Vulcan, but Castrol is in discussion with OEMs and other industry players to promote adoption in future vehicle production.

This could be a game-changer in the oil change market.

Preventing corrosion

My final example is corrosion – an issue that cuts across the whole of the industry and everyday lives.

In the USA we had somewhere in the region of 28,000 miles of pipes and hundreds of vessels across our upstream and downstream operations combined.

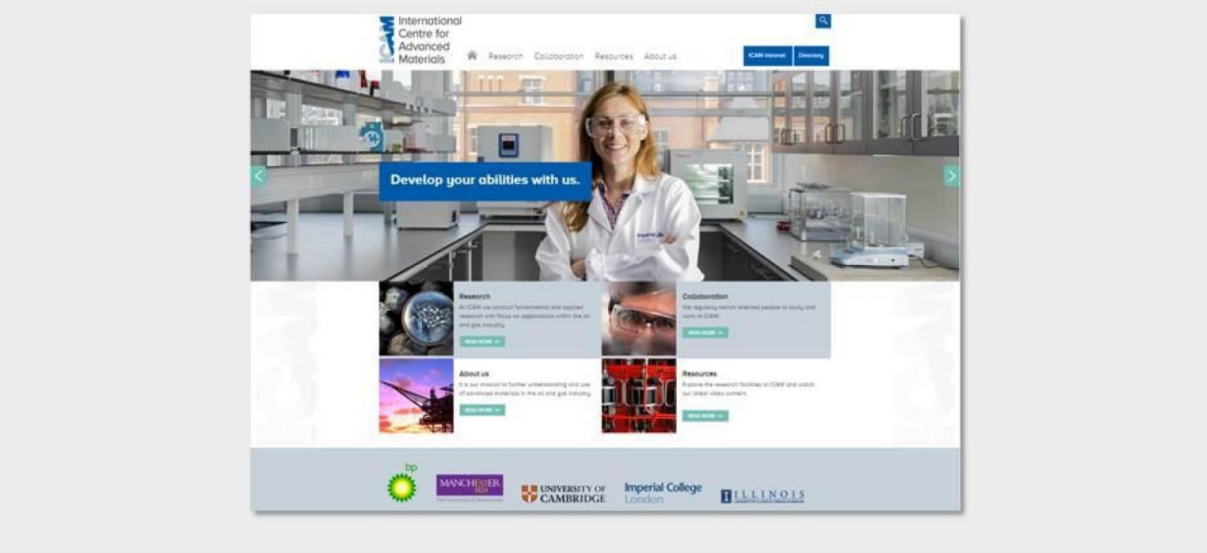
Often pipelines are in hard to reach, hard to inspect areas when pipes operating at high temperatures in refineries.

Estimates for the cost of corrosion to the across all industries in the USA is about 3 to 4% of GDP. That gives you some sense of the scale of the problem.

It's no surprise then that we commit considerable resources to addressing corrosion – here in Manchester, we support research to improve our understanding of the processes to develop monitoring technologies and corrosion-resistant materials.

The photograph shows our Permasense sensors developed with Imperial College. These sensors working to gather in a wireless network give us data to detect changes in pipe thickness.

BP-ICAM



And that is a very good point to introduce the BP International Centre for Advanced Materials.

We established the BP-ICAM in 2012 as a $100 million, 10-year investment in the fundamental science of materials associated with industry challenges.

More specifically, it's a commitment to fundamental research areas in protection (including corrosion), materials, surface interaction and separation that we believe could be transformative – not just for oil and gas but potentially for other sectors as well.

We set it up on a hub and spoke model with four university partners – Imperial College, Cambridge and Urbana-Champaign Illinois as the spokes, with the hub here at Manchester.

By the end of this year we will have 40 programmes running at BP- ICAM with over 100 researchers engaged across the four universities with a roughly equal split of PhDs and PostDocs.

Manchester is involved in over 20 of those projects

Future technology breakthroughs – membranes….?

So, finally I'll end on this note.

Technology, science and engineering underpin the energy sector. They drive and enable economic development, and help improve the quality of life for the world's rapidly increasing population and developing economies.

Science and technology are moving very fast and innovation is coming from more and different places around the world than ever before.

Today, we are all familiar with this technology. When the iPhone was launched in 2006 it took two years to sell a million handsets. When the iPhone 6 was launched earlier this year it took three days to sell 13 million. When change happens it can happen quickly. Mobile digital technology and new digital business models are now part of our lives – what could the new breakthrough technology be in five years' time?

Maybe this rather unassuming image will be one of them? It is a major scientific breakthrough right at the start of its journey.

This is an ultra-thin, super strong membrane – the result of scientific research funded jointly by the Engineering and Physical Sciences Research Council and BP-ICAM at Imperial College.

Membranes are selectively permeable barriers that act as filters in various separation processes.

This prototype membrane is unique in that it's only 8-10 nanometers thick – a stack of 10,000 of these membranes would be no thicker than a human hair – and this 'thinness' makes it very permeable and very efficient.

It might be thin but it is also incredibly strong and can withstand pressures of around 50 bar – that is about the same as the pressures we find 500m below the ocean's surface.

This membrane can also be crumpled – like this piece of paper. The crumpled membrane is even more spectacular in performance as it can separate substances 400 times faster than a conventional membrane.

This real scientific breakthrough could slash energy consumption in industry compared with conventional, heat- related separation methods, such as distillation and evaporation – techniques we use in the oil and gas industry.

It could revolutionize filtration processes such as desalination – removing salt from sea water – both to provide drinking water and for more cost and energy efficient industrial uses such as enhanced oil recovery offshore.

It has significant benefits in the pharmaceutical and other industries, as well as in medicine, such as filtering the blood of kidney patients reliant on dialysis.

The uses of this incredibly strong but delicate looking membrane are in their infancy.

What is clear today is that the impact of this new BP-ICAM technology on energy efficiency, on reducing carbon emissions and on the environment could be significant.

Who knows what other technologies are on our doorstep that may change our lives for the future.

It has been a pleasure to talk to you today Thank you all for listening.