ROYAL ACADEMY OF ENGINEERING

Decommissioning in the North Sea

A report of a workshop held to discuss the decommissioning of oil and gas platforms in the North Sea

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Decommissioning in the North Sea

A report of a workshop held to discuss the decommissioning of oil and gas platforms in the North Sea

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1. Introduction

The UK Continental Shelf (UKCS) has been producing large amounts of oil and gas since the 1970s. Production peaked around 2000 but has since gone into decline. Virtually all of the infrastructure put in place in the North Sea will require decommissioning over the next 30 years in a safe and responsible manner, a task that must be carried out in one of the harshest maritime environments. This represents an enormous engineering challenge.

In March 2012 the Royal Academy of Engineering brought together representatives of the oil and gas industry along with relevant stakeholders from government and academia to discuss the issues relating to this task. The following is a summary of the meeting.

2. The scale of the challenge

The infrastructure in the North Sea consists of a variety of different structures, consisting mainly of production platforms supported by large gravity-based concrete foundations or steel frames (or 'jackets'). In addition to this, there are some smaller structures either floating on the surface or positioned on the seabed as well as interconnecting pipework and wells.

At present the total infrastructure that is estimated to require decommissioning from the UKCS consists of[i]:

- 8 installations with large concrete substructures
- 31 installations with large steel jackets (> 10,000 tonnes)
- 223 other steel jackets
- 280 subsea production systems
- 21 floating production systems
- Over 3,000 pipelines and around 5,000 wells.

To give a sense of the size and weight of these installations, the current Heerema contract for the removal of nine Platforms from the Norwegian Ekofisk oilfield between 2008 and 2014 involves the removal of a total of 113,500 tonnes. This is equivalent to three times the weight of all the cabs in London or 54 London Eyes – see figure 1 on page 4.

Figure 1: Illustration of North Sea Platforms relative to the London Eye

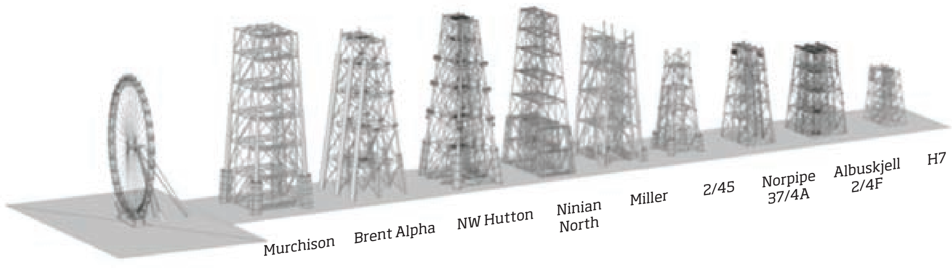
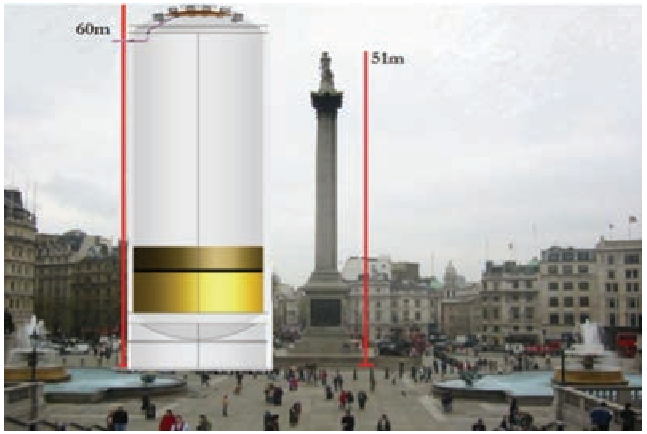


Figure 2: Comparison of height of storage cells compared with Nelson's Column



Storage cells are also an integral part of many of the concrete installations; the three Brent concrete structures have a total of 64 cells measuring 60m in height each – figure 2 opposite gives an indication of the scale of these cells.

In addition to the installations, a major part of decommissioning is well plug and abandonment (P&A). Shell data reveals that the average P&A costs on Brent Delta are £2.7 million per well, each taking an average of 30 days to complete. There are 160 wells within the Brent Field and the vertical depth of these wells is typically between 2,800m and 3,000m. Based on these figures it could take over 13 years to plug and abandon all the Brent wells at a total cost of £432 million, although this assumes only one well crew working at a time where Shell currently have three crews working in the field.

To date, 7% of existing North Sea installations have been decommissioned including: three gravity-based structures (GBS), one large steel jacket, 19 other steel jackets, eight floating production systems, six subsea production systems, 19 pipelines and 11 other facilities. There are currently 18 active decommissioning programmes with a further 20 decommissioning programmes on the horizon[ii].

It is estimated that the cumulative expenditure for decommissioning in the UK sector of the North Sea may be above £30 billion over the next 30 years[iii], including new discoveries and incremental projects, although estimates are subject to a larger degree of uncertainty (see section 4).

"Government will seek to achieve effective and balanced decommissioning solutions, which are consistent with international obligations and have a proper regard for safety, the environment, other legitimate uses of the sea, economic considerations and social considerations…"

3. The regulatory framework

The Department of Energy and Climate Change (DECC) is responsible for most of the regulations related to decommissioning of UK offshore oil and gas installations and pipelines using legislation under the Petroleum Act 1998, amended in the Energy Act 2008[iv]. In support of this DECC provides guidance notes for decommissioning based on prior learning from previous decommissioning projects[v]. In these notes DECC state that its policy regarding decommissioning can be summarised as follows:

"Government will seek to achieve effective and balanced decommissioning solutions, which are consistent with international obligations and have a proper regard for safety, the environment, other legitimate uses of the sea, economic considerations and social considerations. Our policies and practices on decommissioning will recognise the need to:

- *maximise energy production as a contribution to UK energy security, and*
- *take impacts on climate change into account."*

These international obligations stem from the Convention for the Protection of the Marine Environment of the North-East Atlantic ("the OSPAR Convention"). This is the mechanism by which 15 governments off the western coasts and catchments of Europe, together with the European Community, cooperate to protect the marine environment of the North-East Atlantic[vi]. The original OSPAR Convention came into force on 25 March 1998 and is reviewed every five years.

A later addition to the Convention – OSPAR Decision 98/3 – established a new regime that came into effect in February 1999. This banned the disposal of offshore installations at sea as well as requiring all the topsides of all installations to be returned to shore and subsea structures weighing less than 10,000 tonnes to be completely removed. Due to the difficulty of removing larger structures, those built before February 1999 can be exempted from the regulations, or 'derogated'. These are considered on an individual basis, although there is still the presumption that they will be completely removed unless a suitable alternative can be agreed. In cases where this is not deemed possible due to damage or deterioration, the following alternative scenarios are generally considered:

- Concrete-based structures left in situ with vertical structures above water level with illumination. Footings of heavy steel jackets left on the seabed
- Vertical structures are removed to below the sea level (International Maritime Organisation requirements state they must be at least 55 meters below the Lowest Astrological Tide not to present a hazard to shipping).

In addition, there are also requirements that:

- The position, surveyed depth and dimensions of any installation not entirely removed should be indicated on nautical charts and any remains, where necessary, properly marked with aids to navigation[vii]
- A 500 metre zone around any abandoned platform and areas 100 metres either side of a pipeline should be debris free.

It is vital that this regulatory regime retains the trust of all interested stakeholders. This will only be achieved by open dialogue, robust monitoring programmes and transparency.

Exact decommissioning costs are notoriously difficult to calculate as there are many unknowns and fluctuations…

4. Costs and liabilities

Central to the issue of decommissioning are the cost and the question of who holds the liability. According to the OSPAR Convention, ultimate responsibility remains with the owner:

The persons who own an installation or pipeline at the time of its decommissioning will normally remain the owners of any residues (ie any remaining abandoned facilities, fluids or pollutants). Any residual liability remains the owner's in perpetuity[viii].

Ownership of assets may transfer during the life of a field. Transfer of ownership is a strategic decision that typically occurs between about 10 and 20 years when income from production is reducing and the risk profile begins to increase – see figure 3 opposite.

When an installation is sold, the liability may or may not transfer to the new owner, depending on the commercial arrangement. Although in the vast majority of cases liability does transfer to the new owner, there are limited cases of it remaining with the seller. Should a new owner default, liability then transfers back to the original licence holder. In fact there is a generally accepted understanding within the industry that, 'if you put it there, you take it away'.

Exact decommissioning costs are notoriously difficult to calculate as there are many unknowns and fluctuations such as estimated risks, material change in condition, market volatility, industry experience, loss of key personnel, supply chain inflation, technical data and information management systems.

Figure 3: Risk vs return profile[ix]

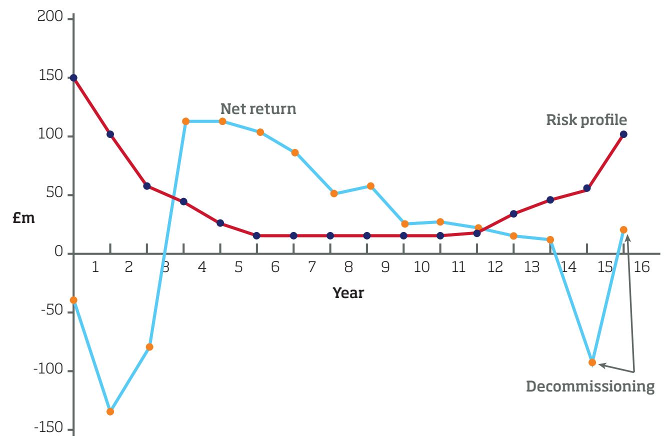
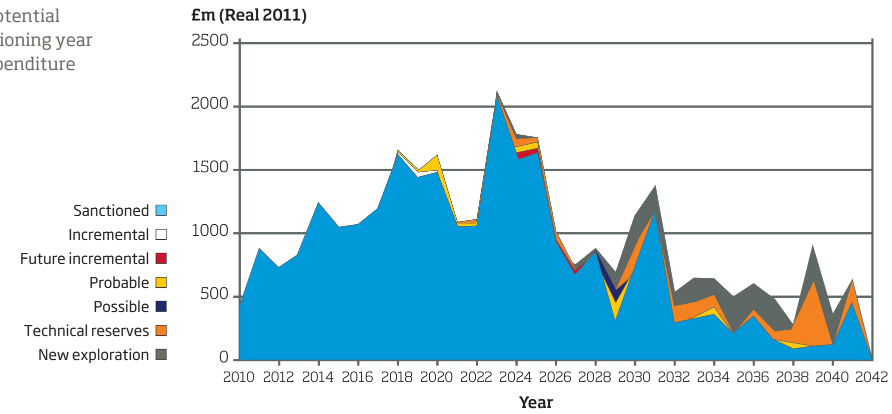


Figure 4: Potential decommissioning year on year expenditure



Potential decommissioning expenditure
$70/bbl and 40p/therm | Hurdle: Real NPV @ 10%/Devex @ 10% > 0.3

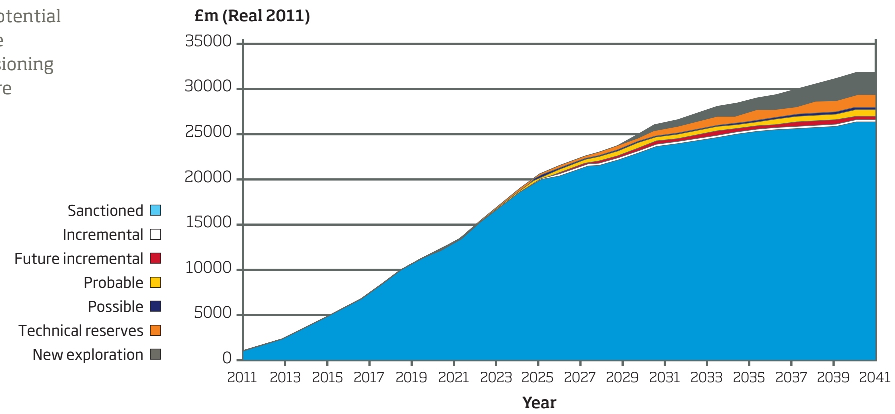
Oil & Gas UK currently estimate costs at £28.7 billion by 2040 with £10.3 billion of that to be spent in the next decade[x]. However, as more decommissioning projects are undertaken and completed, calculations of future costs have an increasing amount of information to base modelling on. One such model[xi] has produced figures for predicted year-on-year costs for decommissioning, assuming a scenario where oil is at $70 per barrel (Figure 4). It indicates as much as £2 billion per year will be required over the next 12 years before gradually falling to less than £0.5 billion per year by 2040.

Cumulative expenditure increases in an almost linear fashion initially, evening out beyond 2026, resulting in a total spend reaching £31.9 billion over the next 30 years (figure 5).

For a scenario of $90 per barrel using the same modelling, the decommissioning expenditure year on year is distributed more evenly but with the overall cumulative expenditure increasing from £31.9 billion to £36 billion.

In both of these calculations, reductions in expenditure resulting from learning from experience have not been included: and while this may contribute to cost reduction, it is clear that very large amounts of money will be required in any scenario. With much of the experience being built up within the personnel and technology of the UK supply chain, this is an important opportunity for UK plc.

Figure 5: Potential cumulative decommissioning expenditure



Potential cumulative decommissioning expenditure
$70/bbl and 40p/therm | Hurdle: Real NPV @ 10%/Devex @ 10% > 0.3

Government will incur more than half of these costs through tax relief mechanisms, making the UK taxpayer one of the most important stakeholders despite the fact that few are aware of the issue. Industry perspective is that from the outset this was a business partnership and it is fair that at the end of field life a "tax rebate" as an offset to decommissioning costs was not only implicit but essential to future developments in the North Sea.

Currently, HM Revenue & Customs estimates that the total cost of tax relief will be £20 billion[xii] or around 60% of total costs. Industry has already made significant financial contributions through the Petroleum Revenue Tax (PRT)[xiii]. This was introduced in 1975 with the aim of obtaining for the government a share of the profits that arise from oil and gas production. It allowed the industry to quickly recover initial costs but then start paying a relatively high rate of tax as soon as fields started producing. It was abolished in 1993 with industry now paying corporation tax and supplementary charges resulting in a marginal tax rate of 81% on profits from PRT-paying fields and 62% for other fields.

The cost of decommissioning is clearly an issue that has to be carefully thought through and subjected to detailed reviews at regular intervals. Communication between government and industry is vital along with close consultation with other relevant stakeholders and high levels of transparency for all activities. The Treasury is currently consulting on measures to ensure that a lack of certainty over decommissioning tax relief will not create barriers to asset trades, joint ventures or continued investment in the UKCS[xiv].

Removal is often more complex than installation as most installations will have been added to over their years of operation.

Innovation and shared learning

The history of decommissioning goes back as far as the 1960s. Since that time, many advances have been made and lessons learned. As with installation, challenges due to the nature of the working environment play a significant role in how the process is carried out. Conditions are too uncertain during the winter months for lifting large structures, therefore removal tends only to occur in the summer months.

Contractors recommend proper project planning to determine the optimum pace for decommissioning in terms of cost and safety. Removal is often more complex than installation as most installations will have been added to over their years of operation. Ideally, installations should be removed in the largest sections possible, but the handling capacity of current onshore dismantling facilities can be limiting. Added to this, a typical decommissioning project may only be able to partially remove the deck in the first season, so the complete removal of topsides and the jacket may take a number of seasons.

While these decommissioning activities represent a significant business opportunity for UK contracting and consulting companies, they are also a major liability to the owners of the assets and the UK government: hence the drive to reduce costs by learning from experience, sharing of knowledge and innovative approaches. Indeed, it is estimated that the **lessons learned from decommissioning any one installation as well as focused campaigns may reduce the cost by 10-15% for successive facilities**.

However, as service companies involved in decommissioning installations are the same as those employed in the installation of new facilities where activity is high and order books full for many years, there is often little financial incentive for innovation in the way decommissioning is implemented. Often companies that take the lead on innovation find that they incur all the costs of innovation while those that follow gain all the advantages without the costs. **Innovation is costly and there can often be a 'race to be second' mentality throughout the industry**.

Despite this, and the absence of regulation for shared learning from decommissioning, industry has an established culture of sharing accrued knowledge. It is important that this is encouraged and developed. Mistakes and failures to plan and execute decommissioning in an optimal way are costly for the companies involved as well as the wider industry image. Therefore **sharing this knowledge and learning from others' successes and mistakes is in the interest of all parties**.

One of the main lessons learned is the importance of taking a whole-system view of the installation over its entire lifecycle from manufacture and operation through to final decommissioning. This is increasingly the case for facilities designed after 1998[xv] but even then, over time, each installation undergoes modification with additional structures added, all of which add complexity to the decommissioning process.

The market for decommissioning is expected to grow in the coming years, and therefore the likelihood of game-changing innovations is high. This happened with the installation of offshore structures and **if a sustainable market develops, the incentive to invest in innovative decommissioning technologies will be high**. Reducing costs in the supply chain is likely to be the other main area where innovation occurs, but it will be a difficult road as operators want to reduce costs and contractors want to maximise profits.

The intellectual property (IP) that will inevitably build up must not act as a barrier to the decommissioning process. It is currently unclear as to who might own this IP, if it will have value, and if so how, it will be licensed. There is therefore a risk that as learning increases, companies could become more protective over this knowledge and stall progress in what is already an over long project. However, it must be recognised that IP accumulated by owners, contractors and consultants has intrinsic value, as well as providing the opportunity for UK companies to gain a share of the global market.

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Skills deficiency

North Sea platform decommissioning will be an ongoing activity over the next 30 years with an estimate of 500 – 690 facilities reaching the end of their operational life. Current figures indicate[xvi] that the UK will have a major shortage of workers skilled in these activities unless there is a significant increase in production of engineering and technical graduates from schools, colleges and universities as well as sustained retention of experienced workers within the industry. Failure to develop, recruit and retain sufficient resources can be attributed, in part, to:

- **Lack of resource**
  - **Experience**: as in many industries, experience is valued rather than pure academic background, but industry still needs to attract young people to give them that experience
  - Recent **withdrawal of funding** for apprentice schemes; this is already having an impact on the industry, with a resulting shortage of workers in a number of areas to add to the deficit of skilled resources.
- **Lack of retention**
  - **Competition** from within the oil and gas industry worldwide, as well as other industries. Recent recruitment campaigns have been conducted in Aberdeen by global (for example Australian) resource companies offering highly attractive remuneration packages
  - **Poor retention** of the existing skilled workforce with many moving within the oil and gas industries, having been enticed to other companies or locations, or to other industries.

- **Image of decommissioning**
  - The **image and promotion** of decommissioning fail to attract sufficient numbers of students, graduates and qualified engineers to keep up with expected future needs.

This skills shortage is not restricted to decommissioning alone but is prevalent throughout the oil and gas and other engineering-based industries. For example, a new fleet of nuclear reactors is planned to replace the existing fleet which is mostly due to be closed over the next decade, all of which will add to the deficit of resources in the engineering sectors.

Suggested measures to address the shortage in decommissioning specifically include:

- Promotion of decommissioning as a long-term career option with integrated environmental and ecological aspects
- Encouragement of technical education organisations to offer specific courses on decommissioning, to provide students with an understanding of the issues, processes and challenges prior to embarking on a career
- Increased business awareness of the challenges and opportunities from further development of the UKCS.

Decommissioning any one platform is a long and expensive process. The Brent oil field infrastructure, for example, will take 12 years to decommission. A skills shortage in the industry will only compound this.

… the issue of decommissioning was not simply a Scottish or UK issue but one with international interest.

Public awareness

Offshore decommissioning first made the headlines in 1995 with the proposal to dispose of the Brent Spar storage facility at sea. Greenpeace opposed this approach on environmental grounds, even though they had been approved by the regulator, and began a campaign that eventually led to Shell changing their plans in light of adverse public opinion. Ultimately an alternative use was found for Brent Spar as part of harbour facilities in Stavanger, Norway.

The incident had a profound effect on the future of decommissioning. Despite the fact that Shell retained the support of independent experts for their original proposals and the fact that Greenpeace apologised for using inaccurate data, it became clear that the industry had to change its whole approach to its operations.

It was realised that the issue of decommissioning was not simply a Scottish or UK issue but one with international interest. It was also realised that much wider engagement with a greater range of stakeholders was required.

At present, decommissioning is an area that is, once again, largely below the radar for the majority of the UK population. In order to avoid negative views and backlash from the differing agendas of interested parties there is a **need for transparency and openness** within the industry, in particular towards the general public.

In order to achieve public acceptance, communicating the process that has been followed during the decision stage, justifying why decommissioning decisions have been made and demonstrating clearly that it is being carried out in the responsible manner, in every situation, is of paramount importance.

In recent years, the regulatory processes for the oil and gas industry have increased significantly. As a result, there is already an established culture of transparency and public engagement: but with decommissioning this regulatory regime can be expected to become more intrusive in the light of environmental and other interest groups' differing views as well as the public expenses implications.

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Alternatives

The primary alternative use for infrastructure in the North Sea is the transport and burial of carbon dioxide as part of carbon capture and storage (CCS) schemes. The North Sea has been at the forefront of this technology since Statoil started separating CO_2 from the natural gas at its **Sleipner West gas field** and re-injecting it under the seabed. This began in 1996, and currently around 1 million tonnes of CO_2 are sequestered per year, funded in part by a CO_2 offshore tax imposed by the Norwegian government. CCS is currently used to prolong the life of a depleting field – enhanced oil recovery (EOR) – but it is hoped that this will move to deep saline formations where there is much greater potential storage capacity.

Further projects are now in the planning stage including:

- **Peterhead gas CCS project**: a Scottish and Southern Energy proposal to capture CO_2 from the exhaust stream of a gas powered plant and store it in depleting gas fields. Feasibility studies have been completed and operations could begin in 2015
- **North Killingholme power project**: C.GEN is developing an integrated gasification combined cycle (IGCC) plant that would capture the CO_2 pre-combustion and transport it to a deep saline formation or depleted oil field via a pipeline being developed by National Grid. A front-end engineering design study is underway and operation could begin in 2015
- Two other IGCC plants are planned at **Teesside** and **Grangemouth** that could be operational by 2016 and 2018 respectively.

National Grid and the **Energy Technologies Institute** (ETI) are also intending to conduct drilling assessments of a saline formation off the Yorkshire coast as part of a wider project to develop a commercial CCS network in the North Sea.

CCS is a seen as an essential part of the government's carbon mitigation policies. However, it is yet to be systematically integrated into decommissioning strategies. There are a number of technical barriers that will need to be addressed, such as:

- **Supply** – if being used for EOR, a stable and constant supply of CO_2 is required. However, the CO_2 will need to be supplied by a base load power plant to ensure reliability and continuity of supply
- **Post CCS** – the abandonment costs are likely to be similar to those incurred with current decommissioning, plus there is the additional responsibility for stored CO_2 and ongoing monitoring
- **Handling** – at pressures below 35 bar CO_2 is present in a gaseous form and above 95 bar it is a liquid (dense phase super critical). However, between these pressure ranges it becomes very difficult to handle, so keeping the CO_2 at the correct pressure is critical
- **Infrastructure** – as well as withstanding the high pressure requirements (above 95 bar), CO_2 can also have a corrosive effect on the cement used in the existing wells.

It should be possible to overcome these technical issues as the technology is developed through demonstration projects. But there are other barriers to the development of CCS.

Financing is perhaps the most significant issue. Early, commercial-scale demonstration projects are expensive and EOR on a single field will be insufficient to finance the required infrastructure, so a series of projects will be required. This will require investment from various field asset owners as well as the CO_2 suppliers and government together with a clearer understanding of how to share the risks. Ultimately, CCS will require a sufficient economic imperative to develop, either through direct subsidies or a carbon price.

In addition there are many cultural differences between the different sectors involved and a reluctance to transfer to ways of working that are outside of each sector's usual comfort zone. Traditionally the core business of the oil and gas industry has always been to produce oil and gas – something it has become very efficient and skilled at. There is increasing awareness that more must be done to address carbon emissions, but expecting to find alternative solutions that benefit all parties involved, and indeed appear sensible to all, will be a challenge.

CCS is clearly an area where more guidance and support are required from government if it is to be a serious option as an alternative to decommissioning.

Existing infrastructure also has the potential to be reused for wind and marine power generation.

Existing infrastructure also has the potential to be reused for wind and marine power generation. Large areas of the North Sea have been allocated for offshore wind farms by Crown Estates and the government's Renewable Energy Roadmap predicts that up to 18GW could be installed offshore by 2020. Increasing amounts of wave and tidal demonstrations are also expected. But as with CCS there are a number of hurdles to overcome:

- **Size** – the size of wind turbines is increasing, presenting new installation and maintenance challenges
- **Grid connections** – expensive power cables will be required to connect the generators to the National Grid. Communication between oil and gas experts and energy generating experts will be critical
- **Submerged structures** – with wave or tidal generation, large submerged structures may be tethered to existing infrastructure, causing unseen obstacles for fishermen and seagoing vessels
- **Liability** – perpetual residual liability remains with the owner of the original infrastructure at the time of decommissioning according to OSPAR, however it remains unclear as to where the liability lies when it is re-commissioned for another purpose
- **Long term considerations** – by the time infrastructure is being removed from the North Sea, the introduction of renewable installations may have changed the way the North Sea operates and therefore will impact on how we address decommissioning.

With a variety of options for prolonging the life of North Sea platforms and infrastructure, there is a real need for government direction, leadership and investment.

Conclusions

The decommissioning of the UK Continental Shelf is a major engineering challenge. It will be expensive, take many years and must be carried out with great care to protect the environment. It also represents a significant opportunity for UK industry. The North Sea is not the only place that will be decommissioning such infrastructure and lessons learned there could potentially be transferred abroad. In addition, there is the potential to utilise some of the existing facilities for emerging, low-carbon sectors such as CCS.

Of primary importance is to maintain and build on the working relationship between the industry, government and other relevant stakeholders. This will enable progress to be made on the following issues:

- **Costs** – a significant proportion of these will be met by UK taxpayers and should therefore be kept as low as possible. Careful auditing of the projected costs should be carried out by DECC at regular intervals to ensure they remain manageable
- **Knowledge sharing** – best practice is constantly being revised and updated. Ensuring that the whole industry is aware of the latest practices will help reduce costs and build up the skill set of the industry
- **Skills** – a shortage of suitably skilled people of all levels is already being felt by most energy sectors. Decommissioning will require its share and both industry and government must work together to ensure more young people acquire the necessary skills
- **Trust** – developing robust licensing regimes and monitoring programmes and ensuring transparency and openness within the industry will increase public confidence in the decommissioning programme
- **Common objective** – both government and industry must understand the scope and scale of the task and be working to a common goal of least cost and certainty of tax regimes going forward.

In addition, the engineering profession must address these broader issues:

- **Whole-life systems analysis** – decommissioning of the UKCS demonstrates the importance of considering the whole-life of a product from manufacture and installation, through its operational phase and finally its disposal. This systematic approach is important if products are to be more sustainable and should be encouraged across all sectors of engineering
- **Break down cultural differences between sectors** – if alternative uses for North Sea infrastructure are to be successful, cultural differences between the different sectors needs to be addressed. In the case of CCS this would require oil and gas producers and electricity generators gaining a better understanding of each other's needs and ways of operating to facilitate such companies working together.

Footnotes

i DECC presentation at workshop (see DECC website for a full list of approved decommissioning programmes)

ii www.gov.uk/oil-and-gas-decommissioning-of-offshore-installations-and-pipelines

iii Oil & Gas UK 2012 Decommissioning Insight

iv Other agencies including the Health and Safety Executive and the Scottish Environment Protection Agency are also responsible for certain aspects of decommissioning

v www.gov.uk/government/uploads/system/uploads/attachment_data/file/69754/Guidance_Notes_v6_07.01.2013.pdf

vi www.ospar.org

vii 1989 IMO and OSPAR 98/3 guidelines

viii Guidance Notes – Decommissioning of Offshore Oil and Gas Installations and Pipelines under the Petroleum Act 1998, DECC March 2011

ix Hyperion Energy Limited, Tom Roberts presentation 23rd March 2012

x Oil & Gas UK 2012 Decommissioning Insight

xi Prospective Decommissioning Activity and Infrastructure Availability in the UKCS, Professor Alex G. Kemp and Linda Stephen, University of Aberdeen, October 2011

xii HMRC Annual Report and Accounts 2011–12

xiii www.hmrc.gov.uk/oilandgas/prt.htm

xiv www.hm-treasury.gov.uk/consult_decommissioning_relief_deeds.htm

xv 1989 IMO and OSPAR 98/3 guidelines

xvi www.raeng.org.uk/news/publications/list/reports/Jobs_and_Growth.pdf

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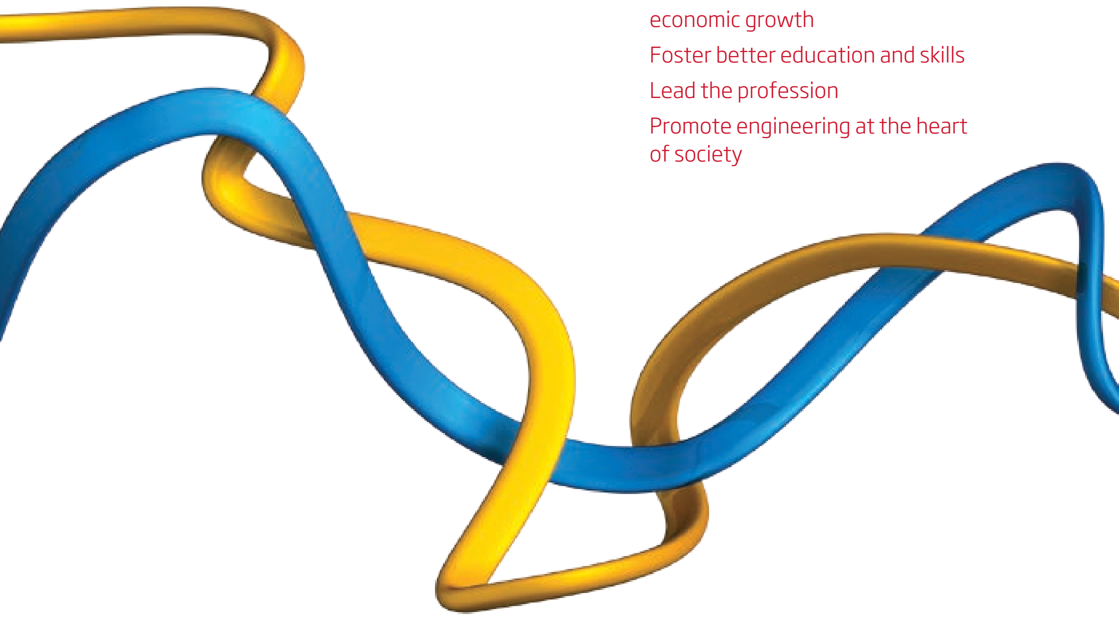

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