The UK Continental Shelf has been producing large amounts of oil and gas since the 1970s. Virtually all of the infrastructure put in place in the North Sea since then will require decommissioning over the next 30 years. Brian Nixon, Chief Executive of Decom North Sea, outlines how the industry plans to do this in one of the harshest of maritime environments.

Over the last few decades, the North Sea oil and gas industry has steadily developed into one of the strongest and most highly regarded clusters anywhere in the world, with engineering contractors, technology developers, service specialists and consultants now active in over 100 countries. Part of this success has been due to the industry’s ability to extend the economic and productive lives of mature offshore platforms, developing marginal and remote satellite reservoirs, introducing new technologies, optimising efficiency of the production processes and assuring the integrity of the assets.

Despite this success, it is now recognised that a growing number of oil and gas assets have either reached, or are approaching, the end of their economic lifespans, and, in accordance with current regulations, will have to be decommissioned and removed. This presents challenges for the owners and operators of these assets, but offers major business opportunities for engineering consultants, contractors and service specialists.

The best estimate of decommissioning expenditure in the UK Continental Shelf over the next five years is a figure approaching £5 billion; this includes 40 platforms, approximately 350 wells, pipelines and subsea structures across 80 fields. To put this figure in context, the latest estimates for the same period show that the decommissioning costs in, arguably, the world’s most mature petroleum region, the Gulf of Mexico, will amount to around £3 billion. From this background, Decom North Sea was established in early 2010 to drive the development of the industry in advance of the main programme of decommissioning – see Decom North Sea.

The industry forum Decom North Sea is charged with sharing the (limited) experience in this sector, developing models and guidelines, and facilitating of joint industry projects designed to increase efficiency and reduce or contain costs. It also stimulates collaboration and cooperation, and seeks to secure economic benefit from a programme of activity estimated at some £35 billion over the next 30 years. The not-for-profit organisation now has 230 member companies drawn from operators, contractors, consultants, service providers, technology developers, equipment providers, marine and heavy lift specialists, logistics, subsea engineering, wells, onshore disposal facilities, and professional services providers. In other words, the whole industry.

The forum is witnessing encouraging signs of cooperation, sharing of ideas, joint industry projects, and open dialogue between operators, contractors and supply chain specialists. This is important because the cost of the decommissioning programme will be shared between the private and public sectors.

**FINANCIAL RESPONSIBILITIES**

The owners and operators of oil and gas infrastructure in the UK Continental Shelf are liable for the cost of each decommissioning programme. However, following recent confirmation from the UK government, tax relief will be made available once decommissioning expenditure is incurred, effectively resulting in the public sector contributing between 50 and 75% of the costs of each decommissioning programme. Although some 7-8% of North
Sea infrastructure has already been decommissioned and removed; this has taken place sporadically. As a result, the approaches and models needed to optimise the performance of decommissioning projects have yet to evolve. The majority of operators gearing up to undertake their first decommissioning programmes are taking time to develop their own approaches and strategies. There is currently no time constraint on offshore decommissioning programmes, which gives project teams time to consult various forms of engineering studies, surveys, inspections and analyses from the very beginning of the process.

The industry is currently utilising the same planning, approval and investment decision procedures as are used for the design and development of new offshore production facilities. However, the respective performance measures are very different. A new capital investment project will be judged on its ability to produce first hydrocarbons by a certain date; its operating lifetime; the cost, efficiency, availability and reliability once in production; and by a prompt return on investment. Decommissioning is expenditure with no return; there is little perceived benefit to accelerating completion date; and reliability and process performance are not relevant. Certainly safety, environmental performance and cost containment are common to every oil and gas industry project, but the other drivers are very different.

**PLATFORM CHARACTERISTICS**

There are a variety of different sizes and types of asset found in the North Sea, and the dismantling of each presents specific engineering challenges and opportunities. The southern North Sea is a region with relatively shallow water and modest sea states, accommodating almost 400 platforms producing (mostly) natural gas. These platforms typically have ‘topsides’, that part of the platform above the water. These are able to be removed in a single lift using a single-hull lifting vessel, known as a shear-leg. The supporting structures (jackets) are in a similar weight range and can also normally be lifted from the seabed in one piece. The topsides and jackets can then be transported by barge or on the lift vessel ( singly or together) to a shore-based facility for final cleaning and waste treatment, dismantling, disposal and recycling.

Platforms located in the harsh climatic conditions and deeper waters of the central and northern North Sea are designed to support complex production facilities. However, those in the southern North Sea. The options for removing these structures (jackets) are very different. The piece small approach is for the design and by a prompt return on investment. Decommissioning is expenditure with no return; there is little perceived benefit to accelerating completion date; and reliability and process performance are not relevant. Certainly safety, environmental performance and cost containment are common to every oil and gas industry project, but the other drivers are very different.

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**DECOMMISSIONING NORTH SEA GIANTS**

Until it ceased production in 2003, the North West Hutton platform, 140 km North East of the Shetland Islands in 144 m of water, was the only integrated oil and gas drilling, production, processing and accommodation facility in that field. Its topsides alone included 21 modules and seven caissons weighing some 20,000 tonnes, while its jacket support structure comprised a further 17,500 tonnes of steelwork. Overall, this giant early-1980s structure posed a significant challenge to engineers charged with its decommissioning and removal.

Offshore removal was carried out in two separate phases, with topsides removal in 2008 and jacket removal in 2009. All materials removed were brought back to shore on cargo barges for further processing and recycling. The pipelines decommissioning was executed in 2011 and 2012 with some sections of pipeline and mattresses being removed and brought onshore for recycling and other sections trenched into the seabed.

In total, 98.34% of the platform and pipelines was reused and recycled. Apart from the accommodation module and the module support frame, which were reused, the rest of the steel went for smelting or cold rolling.

Twenty-two modular lifts were needed to complete the reverse installation of NW Hutton’s topsides and module support frame. The largest module removed was 2,800 tonnes. Attention then turned to the 17,500-tonne jacket, a mass beyond the capability of then-current single-lift vessels. Derogation permission was granted which enabled the jacket footing (extending 46m above the seabed) and the piles that fix the structure to the sea bed to remain in place while the remainder of the structure, totalling some 9,000 tonnes, was dismantled by cutting and lifting sub-sections onto barges for transportation to shore. The largest jacket section removed was 2,350 tonnes.

For the jacket removal, a total of 224 subsea cuts were made using a combination of diamond wire, abrasive water jetting and hydraulic cutting shears to remove 58 jacket sections. Innovative diamond wire techniques were developed by Cutting Underwater Technologies of the UK (one of three contractors), that were used to cut the massive 3.05m-diameter corner legs with a wall thickness of 6.9cm. The company also developed a novel castellated form of cutting to maintain maximum stability of the severed leg structures before lifting operations began.

The total topsides and jacket offshore removal programme and pipeline decommissioning was executed over 266 days, requiring over 1 million hours of work.

BP carried out all North West Hutton decommissioning and removal activities under a UK government-approved decommissioning programme.

All that now remains of North West Hutton are the footings, which extend 49 m from the seabed (95 m below sea level) and the cuttings pile. The footings are marked on nautical charts and are recorded in the Kingfisher bulletin and FishSAFE database. Some sections of pipelines, which cross other operator pipelines or enter 500 m zones, will be subject to future decommissioning activities.

BP is responsible for the periodic integrity and environmental surveys of the footings within the 500m zone, and is required to report on this regularly to the responsible government departments as part of the agreed North West Hutton decommissioning programme.

**NORTH WEST HUTTON PLAT FORM**

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cost to both industry and the UK government. It also presents many opportunities for UK business, with decommissioning of oil and gas installations continuing around the world. Decommissioning requires a pool of suitably skilled engineers and technicians at all levels, and industry and government must work together to ensure that enough young people acquire the necessary skills and training.

The report also considers the work being done on developing carbon capture and storage and the potential for existing infrastructure to be reused to generate offshore renewable energy. It concludes that, if success depends on maintaining and building on the working relationship between the industry, government and other relevant authorities.

Read the report on www.raeng.org.uk/offshoredemcomissioning

The reverse installation method recognises that several offshore platforms were built in a modular fashion. During the 1970s and 1980s, using a 'blanket agreement' technique, these pieces of infrastructure were held together in the topsides. These modules were loaded onto floating crane vessels, then dismantled at sea and re-floated a structure of this magnitude that has been sitting in place - see www.ingenia.org.uk

The Murchison platform has a total of 6,000 tonnes capacity. These modules were loaded onto floating crane vessels, then re-floated and repositioned at the site. It is therefore likely that the operators in question will qualify for a derogation. Decommissioning is an engineering process that must undertake large-scale infrastructure being taken ashore for reuse, recycling or disposal. Read more about the Murchison decommissioning at www.ingenia.org.uk

SUSTAINABILITY

DECOMMISSIONING NORTH SEA GIANTS

INGENIA

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DECOMMISSIONING IN THE NORTH SEA

ACADEMY REPORT

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 decommissioning in the North Sea. The aim was to discuss the issues relating to decommissioning in the North Sea, to bring together representatives of the oil and gas industry along with relevant stakeholders from government and academia and to discuss the issues relating to decommissioning in the North Sea. The report summarises that meeting.

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SEABED HEAVYWEIGHTS

North Sea production platforms provide accommodation for hundreds of people. They also contain power generation services, drilling equipment, a helicopter facility, redundant evacuation systems, and various production processes that are housed together in the topsides. They can weigh up to 40,000 tonnes for larger facilities and the large majority are supported on steel ‘jackets’, lattice-framed tubular structures, which themselves weigh up to 25,000 tonnes. The third concept, single lift, is expected to become a reality during 2015 when a new breed of super heavy lift vessel comes to the market. The Peter Schiebe is being built by Allseas, one of the world’s largest pipe-lay contractors. Although also designed as a pipe-lay vessel, it has the ability to lift complete topsides of up to 40,000 tonnes on its bow, plus a jacket structure of up to 25,000 tonnes on its stern. It offers the potential of a game-changing approach to offshore decommissioning by being able to transfer complete production platforms from an offshore to an onshore location in single movements. It is anticipated that this will help to manage many of the safety, technical and environmental issues inherent in offshore working, and also to contain costs. Other designs of single lift vessel exist but they are still at the furnishing stages.

One particular challenge with concrete designs lies in the contents of storage cells that often form part of these structures. If the operator and regulator are to be convinced that it is acceptable to leave such a structure in situ, then evidence is required to show that no environmental or ecological harm will result when the concrete degrades over a few centuries. These storage cells can measure up to 20m in diameter and 60m in height, and their contents will require to be analysed before a derogation can be granted.

Other engineering challenges include the large inventory of subsea infrastructures which must be accessed, cleaned for decommissioning and removed. There are also thousands of wells that will need to be permanently plugged and abandoned. Subsea and floating production developments have become important contributors to the ongoing production from the North Sea.

Although it is hoped that floating production and storage vessels can be relocated to alternative platforms, it is unlikely that the associated subsea flowlines, umbilicals, risers, wellhead protection covers, mooring systems, mattresses or inter-field pipelines will be able to be reused. It is expected that these pieces of infrastructure will also need to be cleaned, decommissioned, removed and recycled. The plugging and abandonment of both platform and subsea assets is one of the highest-cost areas of any decommissioning programme, and is widely regarded as creating the greatest need for innovation and technology development.

DECOMMISSIONING PROCESS

Long before any infrastructure can be removed, the owner (operator) (and any co-shareholders) are required to develop detailed plans and programmes for each production platform, pipeline, well or similar piece of infrastructure. Each programme is submitted for review and comment prior to final approval being awarded by the appropriate regulator. This process which in itself can take upwards of a year. In the UK, the regulator is the Department of Energy and Climate Change. The research, analysis and appraisal required to develop each of these individual programmes can take additional years of analysis, comparative assessment and technology development.

DECOMMISSIONING MURCHISON

The Murchison platform in the Northern North Sea is the world’s biggest steel jacket to go through the decommissioning process to date, weighing in at 4,000 tonnes. Decommissioning planning work started in 2009, with three years of extensive surveying, data collection and studies taking place before a decommissioning programme was submitted to the Department of Energy and Climate Change in 2012.

Work to plug and abandon its 33 platform wells started late in 2013, with permanent shutdown of the platform scheduled for 2014. The complex processes to clean it and make it safe will continue to 2016. Detailed engineering work will go on in tandem, building up to the infrastructure being taken

With 99.5% of its recoverable reserves produced, the Brent North Sea Field is being decommissioned after more than 35 years in operation. Shell has started planning for decommissioning the platform. The single lift vessel will be 362m long and 117m wide, and the first vessel ever built to have the ability to remove topsides in one lift. The vessel will remove and transport the Brent topsides, and load them in to shore.
During the productive life of offshore oil and gas fields, numerous engineering modifications, upgrades, process plant modifications designed to improve production throughput and efficiency, and conversion projects are likely to be undertaken.

**Frigg’s Buoyancy Tanks**

More than 27 years in operation, the gas production from Total’s Frigg reservoir was finally shut down in 2004. The Frigg Field had by then delivered about 192 billion standard cubic metres of gas to the UK domestic market. The first removal operations offshore started in early 2005, after the facilities were made safe. The final offshore lift took place in 2009, followed by post-removal activities within the 50nm zone during 2010.

The removal of the DP2 subsea jacket including the module support frame, was done in one single lift using buoyancy tanks attached to the four corner legs. The total weight of jacket with module support frame was 11,381 tonnes. This represented a patented technology never used before, allowing the complete substructure to be removed and towed to shore in one piece. It consisted of adding buoyancy to the jacket to enable a refloat. Brining the 60m long buoyancy tanks into their final position with a tolerance of only 15mm was the most challenging part of this operation. After being located in contact with the leg, a locking system on each buoyancy tank was activated to fix it in position. Each of the four steel buoyancy tanks had a net lifting capacity of 2,250 tonnes, providing the necessary buoyancy to the structure to float it up 11m from the seabed. The structure was then towed in vertical position into a fjord before disposal and taken to Stord harbour to dismantle. The buoyancy tank refloat method was developed and patented by Aker Solutions.

**Jacket Removal**

Jacket support structures also require detailed engineering assessment and inspection. It is likely that jacket structures will need to be cut into appropriate sections in order to come within a safety and environmental perspective it may be more appropriate to leave these sections in place if derogation is granted (as was the case with BP’s North West Hutton platform) the cut is made just above the top of the footings (or pile clusters).

One option for jacket removal is the use of buoyancy tank assemblies as designed by Aker Solutions. This solution, used once on Total’s Frigg field, involved attaching buoyancy tank assemblies to the legs of the jacket, ballasting accordingly and then towning the structure to a deepwater port for inshore dismantling and recycling – see Frigg’s buoyancy tanks.

Once removal has been undertaken, all sections of toppises, jacket and subsea infrastructure need to be transported either by barge or on the lift vessel to a licensed onshore disposal facility. Some marine growth may be removed offshore, but the majority is likely to be done at the onshore yard. Similarly, NORM (naturally occurring radioactive material) and other hazardous wastes will be managed within the operator’s waste management procedures and relevant environmental policies.

Finally, a decommissioning site survey is required to a radius of 500m from the installation, and 200m along the route of any pipeline, with any significant debris being recovered in these areas.

**Looking Forward**

**The decommissioning of the UK Continental Shelf is a major engineering challenge. It also represents a significant opportunity for UK industry, with expenditure estimated to be in the order of £5.5 billion over the next 30 years. The North Sea is not the only place where there will be decommissioning of such infrastructure, and lessons learned there will almost certainly be transferred abroad.**

Knowledge transfer and the sharing of best practice will be essential if the industry is to progressively increase efficiency and reduce costs in decommissioning. Work is underway by Decom North Sea and others to drive and capture experience, but it requires greater emphasis from all parties before the true benefits can be realised. It is fair to say that until recently, decommissioning has not been considered within the overall lifecycle of an offshore asset. As a result, maintenance regimes have often overlooked key terms of plant and equipment that would be needed during the abandonment stages, leading to significant and arguably unnecessary costs. There are welcome signs that this attitude is changing, with some companies now introducing decommissioning as part of their graduate development programmes. However, further effort is required before decommissioning is fully considered throughout the lifecycle.

Brian Nixon has been Chief Executive of Decom North Sea since 2010. His energy industries career started with private sector engineering organisations, including Motherwell Bridge and Wood Group. He has several years of public sector experience which started with a secondment as 1st Secretary, Oil and Gas, to the British Embassy in Angola in 2001, followed by a long period as Director of Energy at Scottish Enterprise.

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