



# TOMORROW'S OIL AND GAS SOLUTIONS

**RAMBOLL OIL & GAS**

INDEPENDENT CONSULTANCY FROM FEASIBILITY TO DECOMMISSIONING

**RAMBOLL**

## MEETING TODAY'S CHALLENGES WITH TOMORROW IN MIND

The oil and gas industry today is facing major challenges. Some of these are to explore and develop new fields in remote areas, to adjust to a growing shift from oil to gas production and to maintain production on mature fields. Indeed, the industry's contribution to climate change and exploring new technical solutions are also major issues to address.

As an international and independent engineering consultancy with more than 30

years of experience in the field, Ramboll is well-qualified to help oil companies and plant owners tackle these challenges.

Our business practice is guided by high ethical standards, and we deliver sustainable and innovative solutions that add value to our clients and society at large.

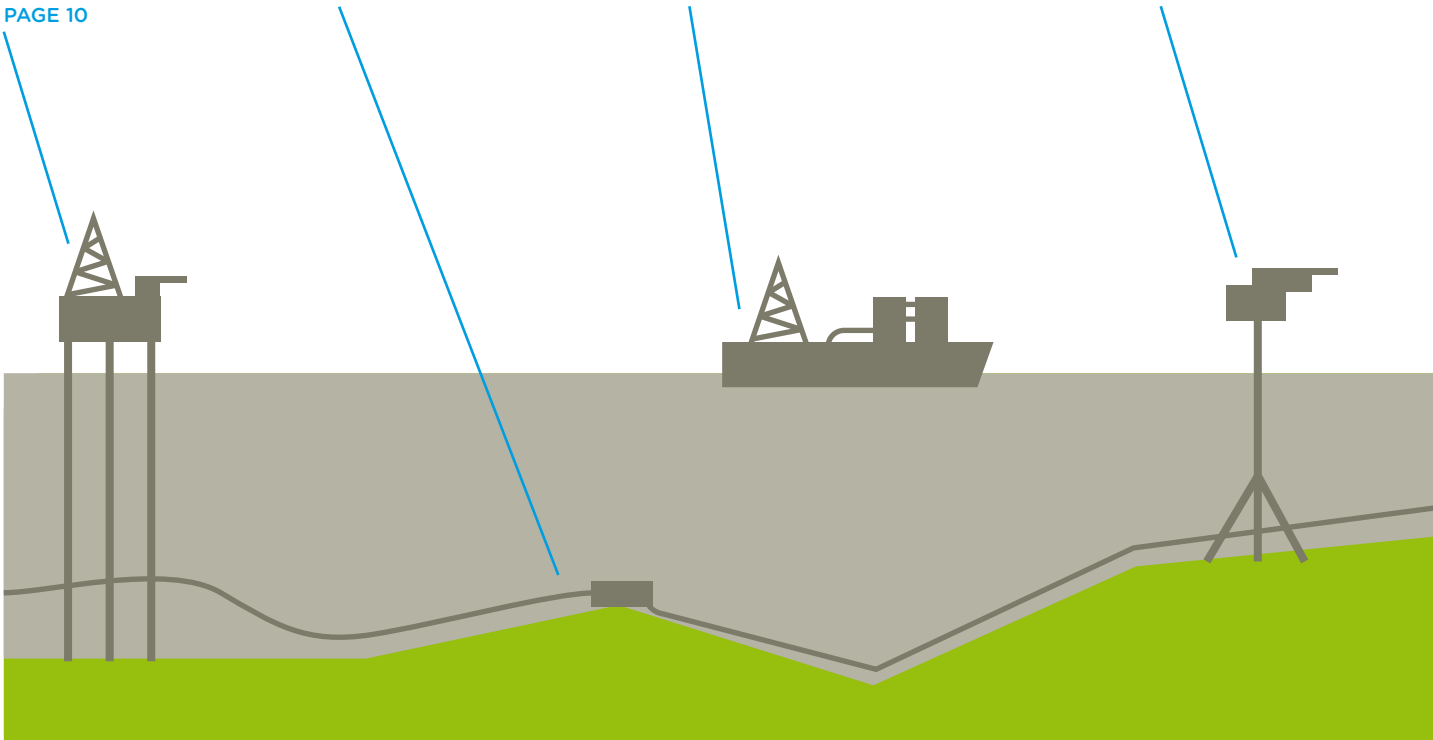
Our approach to sustainability is multidisciplinary and integrated in all of our services. Our solutions meet international safety and

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environmental regulations and can be tailored to meet local regulations as well.

Through our services, clients are able to plan and implement solutions that are far-sighted, cost-conscious and practical. We assist through all phases of a project from planning, feasibility, FEED, detailed design and strategy development to operation and maintenance onshore and offshore.



John Sørensen  
Managing Director,  
Ramboll Oil & Gas.

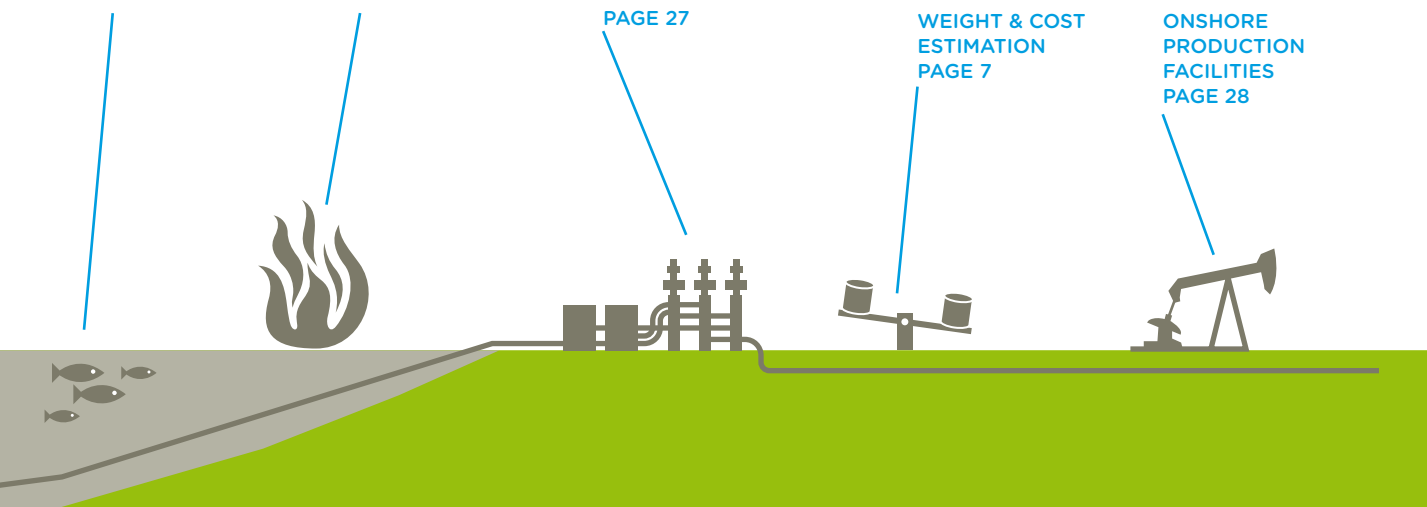
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Ramboll is a leading international engineering, design and consultancy company founded in Denmark in 1945 by two young Danish engineers, B.J. Rambøll and J.G. Hannemann. Today, we employ close to 10,000 dedicated specialists and have a significant presence in Northern Europe, India, Russia and the Middle East. With more than 200 offices in 23 countries we emphasise local experience combined with a global knowledge-base.

# OUR ASSETS

## EXTRAORDINARY PEOPLE

Ramboll is a truly people-based organisation. We believe that the key to our success lies with the motivation, persistence, skills and commitment of our employees. This makes us a preferred and key partner in engineering consultancy services in the oil and gas industry. The right solutions depend on the creativity, insight and integrity of the people within our organisation. That is why it is important to empower our employees and believe in their inherent abilities, embrace their individual differences and enable them to work in multi-talented teams to produce inspired solutions.

We focus on the Lean philosophy to ensure the best project management and effectiveness in our services so our clients can count on the best solutions

at the right time. And we always stay ahead of the development to contribute with new technologies and cutting-edge solutions that just might be the decisive factor for our clients.

To be able to stay in front, we believe that it is important to constantly challenge our employees and have the opportunity to learn more. This is why we offer our employees further training, cross-organisational stays and internal courses to make sure that we stay in front in the oil and gas business to the benefit of our clients. We are able to set the best team for each project and draw on the wide spectrum of knowledge within our organisation. Our competences and experience are some of the factors that our clients value the most about us. All because of our extraordinary people.

### OUR BRAIN POWER STAYS

The value of Ramboll Oil & Gas is the sheer knowledge capacity we have built for the past three decades. Some of our most experienced employees have been in the industry for more than 30 years. Many of our clients value that they speak to the same person when they approach us. This way we have built long-standing relations with many of our clients over the years.

We are proud of our high retention rates. On average our appointed employees have been with us for more than 12 years, and 10% have been Ramboll employees for more than 25 years! This means that our brain power stays in the organisation and is constantly developed and challenged by innovative, young minds, business partners and clients.

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# STARTING THE PROJECT LIFE CYCLE - CONCEPT DEVELOPMENT AND FEED

Ramboll offers feasibility, screening, conceptual and FEED studies as analytical tools during the deliberation phase of a project cycle.

## An informed basis for decision

We offer our clients several scenarios to provide the most informed basis for decision making.

Ramboll's provision of concept development studies to the oil and gas industry comprises several services. Some of these are technical, financial and commercial analyses and environmental studies. We also perform authority management and evaluation of different alternatives to optimise and develop new projects.

The preparation of the study requires a strong grounding in both technical and financial aspects of the project. The perceived objectivity of the evaluation is an

important factor in the credibility placed on the study by potential investors and financiers.

## All-round feasibility studies

From the design basis of the oil and gas fields, we develop flow assurances, flow diagrams, concept layouts and master equipment lists. The feasibility study may include:

- Conceptual design
- Field development studies
- Infrastructure evaluation
- Construction and installation studies
- Weight and cost estimates and analyses
- Market analyses and availability
- Environmental studies
- Risk and safety studies
- Economic studies
- Authority management
- Project schedule

### CONCEPT STUDIES ON THE HEJRE FIELD

In 2006-2007 Ramboll performed a series of concept studies for DONG Energy regarding production options for the Hejre field with and without tie-ins to and from neighbouring fields. DONG Energy, field operator and lead partner in Hejre, may choose to develop it with a stand-alone platform with integrated wellhead, process, utility and living quarters. One of the main challenges in the development of this field is the handling of NGL (Natural Gas Liquids).

Ramboll has performed a series of concept studies and come up with the following two options: one calling for rich gas exports and tanker loading; another for sales gas and live oil export. The Hejre field is expected to start production in 2015.



## STABILITY AT THE RIGHT PRICE - ESTIMATING WEIGHT AND COST

For all offshore investments, precision weight and cost engineering makes a big difference on the bottom line, and is also one of the best insurances against stability problems of new and retrofit structures. Based on the most extensive weight and cost database in Europe, Ramboll can provide top of the line weight and cost estimations, verifications and benchmarking for a wide variety of different offshore projects.

### Weight and cost estimation

A carefully prepared shopping list is the best way to avoid pricey mistakes both in stores and offshore. Using Ramboll's software program WEPS—renowned for its un-

surpassed precision ratio—we can provide exact information regarding equipment lists, area requirements, dry weights, costs, man-hours, norms and rates for one or a series of integrated projects.

Based on this information our clients are able to make well-founded concept decisions, increase the efficiency in the project execution, minimise risks and ensure successful management planning. The WEPS system calculates project specific requirements based on key project data such as a field's forecasted oil and gas production benchmarked against the as-built information in our database. The new data may be re-fed into WEPS for further calculations.



The Snorre B platform in the North Sea.

#### MONITORING AND CONTROL OF WEIGHTS AND CENTRE OF GRAVITY

For topsides projects we have developed the software system MON for monitoring and controlling weights, loads and centre of gravity (CoG) as well as quantities and costs of topsides for all offshore structures and vessels. MON - which stands for monitoring - follows industry standards.

With MON we provide weight details for all phases of a project from detailed design

through fabrication, installation, operation and decommissioning. The system's flexibility in terms of item selection makes it easy to generate the specific reports needed for a project at any given time.

So, with MON our clients get an inexpensive insurance against stability problems, structural overloads as well as budget overrun and failure to meet deadlines.

### Simulating safety and stability

When modifying existing offshore facilities for lifetime extension purposes, it is crucial to perform continuous weight and stability controls to ensure safety. For Statoil we perform weight and stability analyses on the Snorre A, B and Visund platforms located in the Norwegian sector of the North Sea. The objective is to update the lightship weight in the ballast control system. This is done based on weight input from service and modification projects as well as other modifications on the platforms.

### Safety is top priority

We simulate future situations in order to determine stability in connection with all modifications on the platforms using our in-house developed weight monitoring system, MON. Safety is a top priority on all platforms, and the stability studies performed by Ramboll Oil & Gas in close cooperation with Statoil are required by the authorities.

### Lifetime extension

Ambitious life time extensions of 30 years or more pose significant safety challenges. Ramboll has assisted in many of these types of modifications, for example, in the extension of the Statoil operated Snorre A, Snorre B and Visund platforms.

Snorre A is a tension leg platform (TLP), which is moored to the seabed with 16 steel tethers, whereas the Snorre B and Visund are semi-submersible platforms tied with 16 anchors. In the modification of these platforms Ramboll's weight control services have played a key role with regard to the choice of concepts for and location of the platforms. Our cooperation with DNV (Det Norske Veritas) is a very important part of the process as DNV is responsible for running all global models for Statoil through MON.

The Visund platform operated by Statoil in the North Sea.



## LIFETIME EXTENSION ON MATURE FIELDS

On the Siri, Nini and Cecilie platforms in the North Sea, we have carried out thorough reviews of all structures to develop a decision basis that enables the operator DONG Energy to identify required actions to lifetime extend the field to 2020.

Enhanced recovery methods have enabled oil companies to draw new life from maturing fields, and the expected boom in decommissioning work has been deferred indefinitely. Instead the industry is seeing a surge of investments in modifications and maintenance as ageing platforms require a high level of maintenance and new technologies call for minor as well as major modifications.

Ramboll carries out close to a thousand modifications and maintenance projects every year and enjoys a high client satisfaction rate as we are able to meet key success

criteria such as short commissioning time, minimal shutdown time, state-of-the-art solutions and advanced software tools for extending lifetime and increasing capacity.

### Modifications on mature fields

To keep mature fields pumping in times of dwindling reservoirs, new recovery technologies are necessary and their implementation require platform modifications. Ramboll carries out a wide variety of different projects within this field ranging from minor modifications to complete revamps. Regardless of scale, however, we utilise our



Courtesy of DONG Energy

in-house developed software programs RONJA and ROSAP for re-evaluation and documentation of increased structural capacity, the latter could be based on our advanced 'push over' analyses. Notable projects include the ongoing Al Shaheen development project, which ranks among some of the biggest modification projects in the world. Al Shaheen lies off the coast of Qatar and is operated by Maersk Oil Qatar. Ramboll has also been deeply involved in the make-over of South Arne, a 10-year-old platform in the Danish sector of the North Sea; our projects here range from upgrades of produced water facilities to modifications of the facility's loading system.

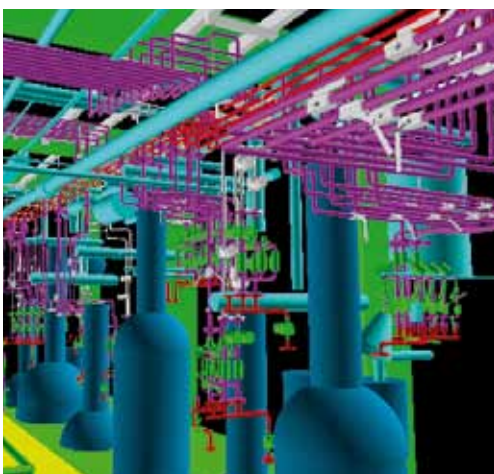
### 3D scanning and surveys

To ensure minimal shutdown time and avoid geometrical flaws in connection with modification projects, we integrate precision surveys and 3D scanning in our modification solutions. Ramboll's in-house team of surveyors are able to conduct precision surveys that minimise or completely eliminate the inherent geometrical problems associated with new or retrofit designs and constructions. Eventually scanning results

are converted into 3D models that our engineers can later base their design on. Shutdown time is reduced to a minimum with 3D scanings that allow for the control of new components prior to implementation. Having an in-house survey team is a great advantage as our surveyors and engineers are able to share knowledge about projects on a continuous basis. Therefore we are able to fine-tune our surveying approach in accordance with its practical application.

### Maintaining and optimising

The demand for maintenance strategies and systems has increased dramatically in the past couple of years as more and more ageing platforms remain in operation. Ramboll's department for maintenance optimisation offers consulting on the development and implementation of maintenance procedures and strategies for all offshore facilities. The primary goal is to ensure an optimised maintenance programme that can be operated by platform personnel and be put into service. We produce these results by introducing new processes and practices to organisations, focusing on accountability, competences and change management.



3D point clouds of offshore installations.



The impressive Al Shaheen, located 80 kilometers off the coast of Qatar, is Qatar's largest oil producing field covering 2,214 breathtaking square kilometers. The field is being developed by Maersk Oil Qatar in cooperation with Qatar Petroleum.

Not only is Al Shaheen the largest producing oil field in Qatar, the Al Shaheen project is also one of the largest and most complex offshore oil and gas projects undertaken in the world today.

The project is one of the most extensive projects ever in Ramboll Oil & Gas history

with more than 80 persons working on the project for five years. Today we are the largest independent consultancy within oil and gas in Qatar and offer our services to all major oil companies in the region.

The ambitious Al Shaheen project involved installation of 15 new platforms with a weight of over 140,000 tonnes of steel, production and accommodation facilities, achieved through expansion of existing fields, and also the introduction of three new production fields - including 160 new production and water injection wells.

# AMAZING AL SHAHEEN - QATAR'S LARGEST OIL PRODUCING FIELD



## EXPANDING WATER INJECTION CAPACITY ON AL SHAHEEN

One of our many projects on Al Shaheen is to expand the water injection capacity to twice the existing capacity by using identical equipment as much as possible with shared lift pumps and coarse filtering system. The project also aims to recover heat for process heaters by installing a new waste heat recovery unit (WHRU) on the water injection pump gas turbine exhausts.

The new installations contain the following:

1. New coarse filter package
2. New water injection deaerator and vacuum package
3. Two new booster pumps
4. New gas turbine driven water injection pump
5. New 24"/28" horizontal pig launcher for export of injection
6. New waste heat recovery unit and new WI pumps
7. Upper deck for new equipment
8. Increase the height of the existing crane to clear the new upper deck
9. Electrical and instrumentation equipment room
10. Provision of new 3kV and 400V switchgear



## CONTINUOUS IMPROVEMENT AT SOUTH ARNE PLATFORM IN THE NORTH SEA

Since 2004 Ramboll has had a partnering contract for modification jobs on Hess Denmark's South Arne platform. Ramboll manages the team of internal engineers and external sub-contractors working on the project and performs the full scope of work from initial idea to final handover. Key factors on the improvement projects are safety, efficiency, smooth project execution and on-time completion.

The project comprises of an upgrade of the existing water injection module including

produced water facilities, installation and construction of production flow lines, studies and detailed design of extensions for accommodating additional production wells. HSEQ procedures have been strictly observed and our efforts to take adequate safety measures have been proven successful given the fact that our offshore team has performed more than 2200 days without lost time incidents (LTIs) by June 2009. This achievement reflects the good working environment and of course the safety awareness of all employees and managers.

## PUMP UP THE VOLUME AT HALUL ISLAND

80 kilometers offshore Qatar, the 1.5 square kilometer small Halul Island makes up the base for 11 large crude oil storage tanks, crude oil pumping facilities, power generation and water desalination plants.

The island, which has all the facilities of a major international oil terminal and houses up to 900 personnel, is operated by Qatar Petroleum.

Here, crude oil is received from various offshore sources via subsea pipelines and stored in storage tanks. The oil is then exported via single buoy moorings into crude tankers using crude oil loading pumps driven by electrical speed drivers and gas turbines.

As a part of Halul Island expansion plans to accommodate larger vessels, the power utilities are being upgraded.

Ramboll has been chosen to carry out the detailed design of the crude oil import and export terminal under an EPIC contract with Doha Petroleum Construction Co. Ltd for Qatar Petroleum.

The two main objectives of the EPIC contract are to increase the reliability of the existing crude oil facilities and to upgrade the system for enhanced operational flexibility, which includes installing four new giant 2.3 MW pumps with electrically variable speed drive. The scope of work involves all engineering disciplines.



Despite its small size Halul Island is a big part of Qatar's oil and gas industry.



## SUBSEA ENERGY HIGHWAYS - HPHT PIPELINES

Designing high pressure, high temperature (HPHT) pipelines ranks among the most challenging projects in the industry. When you are working with internal pressures between 300-500 bar, fluid temperatures ranging from 120 to 160°C and highly uneven seabed terrain that sometimes causes the pipelines to rest merely on “mountains” with free spans of 50-100 metres, intensive pipeline engineering is required. Further, offshore fields are generally in deep waters where divers are not an option, so all sub-sea work has to be engineered to allow for installation using unmanned remotely operated vehicles.

### Modelling the pipeline

Our highly specialised in-house developed software package Goliat (General Offshore

Linepipe Analysis Tool) makes it possible to model the full pipeline history from installation, flooding, system pressure test to operational condition by using a full 3D model of the pipeline.

The material for the pipelines must resist internal corrosion. Some of the pipelines may be provided with thermal insulation to prevent hydrate formation inside the pipeline and/or electrical heating system to heat the multiphase fluid in the pipeline.

### Environmental impact

Another significant consideration involved in designing subsea systems is the environment. In order to design and construct the transportation systems in an environmentally responsible way, the impact on flora

The Tyrihans pipeline  
in the North Sea.

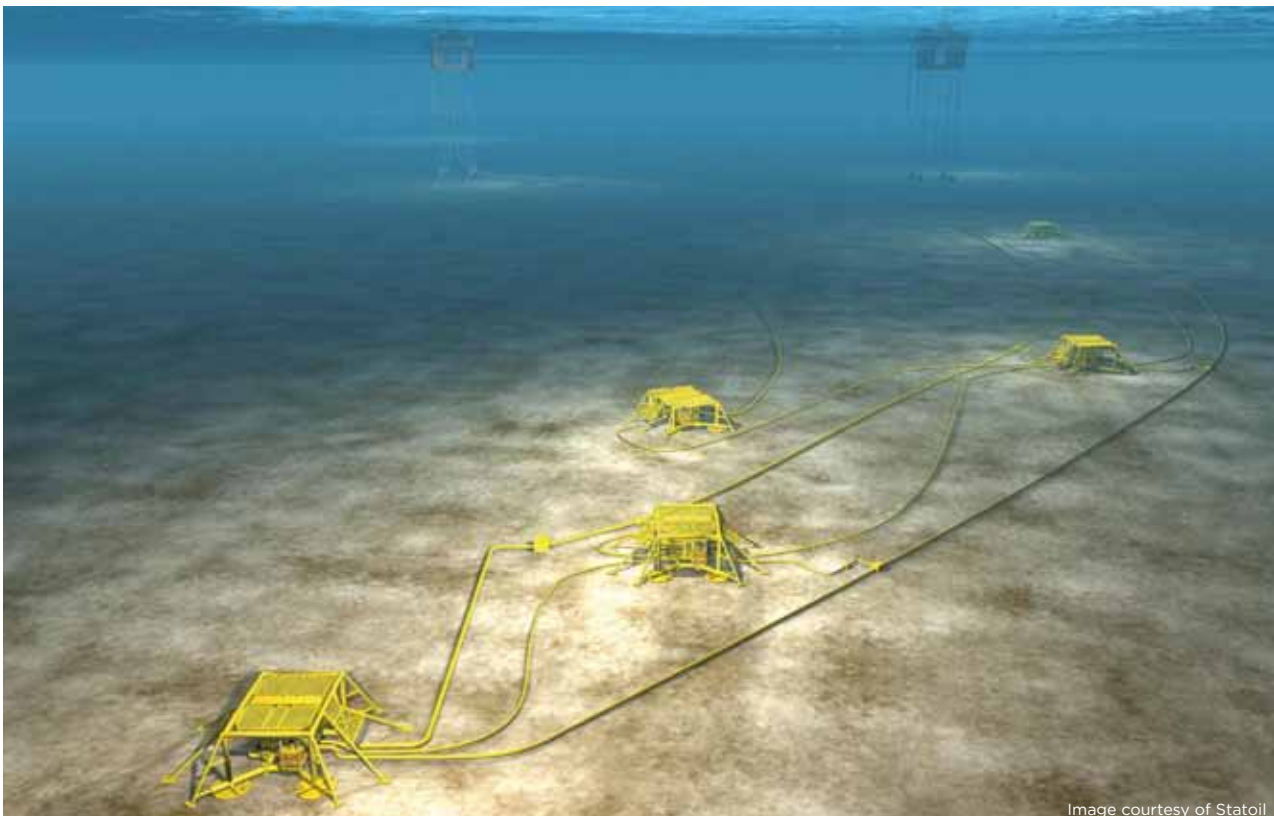


Image courtesy of Statoil

and fauna must be assessed as part of the offshore development. Ramboll has vast experience with performing environmental impact assessment (EIA).

### State-of-the-art solutions

Meeting all of these challenges is costly. But with the right design, subsea pipelines have proven to be a reliable and safe way to transport the oil/gas from offshore fields to onshore terminals for further distribution to end-customers.

We have been working with design of pipelines for many years. In fact, we have designed some of the most challenging pipeline systems in the world using state-of-the-art solutions and technical engineering tools, adopted to provide cost-effective and robust solutions for our clients.

### Design of complex pipeline systems

The Gjøa field development in Norway is one example of our design capabilities within large and complex subsea pipeline projects. The Gjøa project includes HPHT infield subsea flowlines connecting the subsea production templates to the semi-

submersible Gjøa platform. Gas is exported through a gas pipeline with a subsea tie-in to the existing FLAGS pipeline. Oil is transported through an oil pipeline routed to the TOR II oil pipeline with connection via a subsea Y, and further on to the Mongstad oil terminal in Norway.

### Tyrihans on stream

Tyrihans, a Statoil field in the North Sea, is rated as one of the top five pipeline projects in the world. Ramboll started engineering this project in 2004, and the Tyrihans field was put on stream in 2009. We carried out the detailed design for the field, developing it with four subsea production templates to be connected to the Kristin semi-submersible platform through a production pipeline. To maintain the reservoir pressure, gas is injected into the reservoirs through a gas injection pipeline from the Åsgard B semi-submersible platform to the subsea templates.

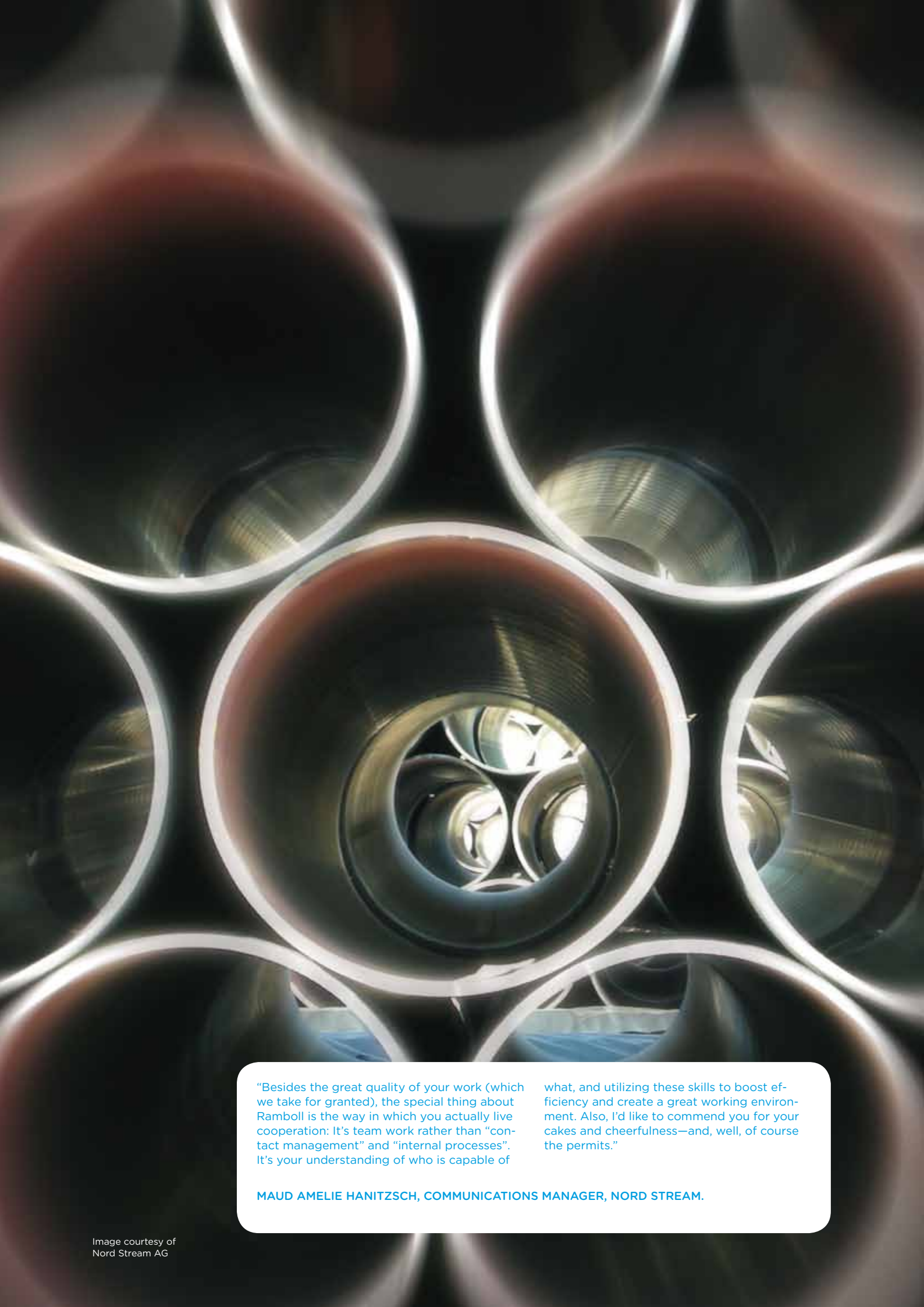
The produced oil and gas is processed at Kristin platform, and the gas is exported to shore via the existing pipeline system. The oil is transported to offloading facilities and then transported by tanker to oil refineries.



Left:  
The Kristin platform  
in the North Sea.



Right:  
Spool installation for  
the Gjøa project



“Besides the great quality of your work (which we take for granted), the special thing about Ramboll is the way in which you actually live cooperation: It’s team work rather than “contact management” and “internal processes”. It’s your understanding of who is capable of

what, and utilizing these skills to boost efficiency and create a great working environment. Also, I’d like to commend you for your cakes and cheerfulness—and, well, of course the permits.”

**MAUD AMELIE HANITZSCH, COMMUNICATIONS MANAGER, NORD STREAM.**

# NORD STREAM - BUILDING BRIDGES - PIPELINES FROM RUSSIA TO EUROPE

The Nord Stream Pipeline is the most advanced planned pipeline project in Europe and will transport gas from the vast reservoirs in Russia to Europe already from 2011. This alone is quite impressive, but also the fact that the pipeline will ensure fast, safe and long-term supplies of energy marks a historic energy cooperation between Russia and Europe.

## Transboundary authority management

The project builds bridges between countries and cultures, fossil fuels and sustainable energy, and between governments, NGOs and the developer. We have played a significant role in strengthening the understanding of the project and building bridges between stakeholder groups.

In close cooperation with the technical and permitting teams of Nord Stream AG, we have conducted numerous studies of the environmental situation in the Baltic Sea as part of the planning basis of the two pipelines. We have prepared a number of environmental impact assessment reports as part of the permit documentation in Finland, Sweden and Denmark. Further studies and meeting facilitation have been concluded for a comprehensive assessment of environmental impacts in a transboundary context according to the Espoo Convention.

Because of our in-depth understanding of regulators and traditions in the Baltic Sea region and due to our local presence in all concerned countries, we have successfully been able to draw on vast expertise from multidisciplinary national teams.

## Managing environment and safety

The pipeline route through the Baltic Sea traverses unique ecosystems as well as intensely trafficked shipping routes, areas where chemical munitions have been dumped and areas where dangerous sea mines are abundant.

We have assisted in planning and execution of extensive marine survey activities and environmental studies. Route planning, investigations and route optimisations have been performed as an iterative process during nearly five years.

## Bridging developer and stakeholders

When five nations have to agree on a 1220-kilometre pipeline system, while four other nations and the rest of Europe are watching, and while caring for the unique environment of the Baltic Sea, stakeholder facilitation and a solid bridge between the developer and stakeholders are imperative factors. Ramboll has built this bridge.

## Bridging energy gaps

The pipeline system will run from Vyborg, Russia, to Greifswald, Germany, and pass through the exclusive economic zones (EEZ) of five countries and the territorial waters of Russia, Denmark and Germany. The Nord Stream Pipeline Project is part of the EU Energy Policy and plays a decisive role in bridging future European energy import gaps. Once in operation, the Nord Stream Pipeline will transport up to 55 billion cubic metres of gas per year. The energy flow is measured to meet 25% of the predicted natural gas import gap by 2025.

The two 1220 kilometre Nord Stream pipelines are made of 12-metre long carbon grade steel pipes with a diameter of 48".

## ENVIRONMENTAL CHALLENGES

In most countries extensive environmental legislation has become widely implemented during the last decades. And the industry has well-established routines reflecting this legislation as well as more specific objectives such as, for example, clean production.

Today the main challenges within this field are increasing demand for faster project execution and consequently faster authority processes. This involves minimising the risk of unexpected requirements from authorities that would compromise tight schedules and investment schemes.

In order to meet these challenges, it is important to have comprehensive technical and scientific know-how coupled with in-depth knowledge of legislation.

### Environmental solutions

In Ramboll we have gathered a team of highly specialised experts such as environmental engineers, biologists, geophysicists and geographers to assist our clients in addressing issues of environmental concern. Our services range from expert opinion memos to Environmental Impact Assessments of large, transboundary projects.

### Our main areas of expertise:

- Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) of oil and gas projects and energy projects, such as offshore wind farms
- Decommissioning of offshore facilities
- Environmental monitoring programmes during construction and production
- Programmes for seabed sampling and analysis for environmentally hazardous substances – often in combination with modelling of sediment spreading
- Planning and execution of marine biological and marine geophysical surveys

Our staff has highly specialised knowledge of environmental engineering, environmental legislation and HSE management, biology, geophysics, hydrodynamic modelling, seabed sampling and sampling in process & storage facilities. High quality charts and comprehensive graphical presentations are important for successful communication and we are experienced in using GIS tools for preparing such charts as well as GIS-based analyses.

One way to cut hydrocarbon emissions at offshore facilities is to install flare gas recovery systems. The systems recover process releases from the flare system and direct this gas back into the gas processing system.



Heightened environmental awareness calls for possible alternative solutions and choice of best materials, procedures and management plans.

We facilitate this by environmental analyses supported by specialised software and staff educated within:

- Best Available Technology (BAT)
- Life Cycle Assessment (LCA)
- Best Environmental Practice (BEP)
- Environmental cost-benefit analyses

#### Authority interaction

To ensure timely project execution, we identify legislative and environmental requirements and devise environmental programmes comprising all necessary steps towards obtaining approvals and permits. We handle consultations with governmental institutions and the public. Additionally, we prepare and participate in public hearings on a regular basis.

A key to success in this area is detailed knowledge of national legislation and a good working relationship with relevant authorities. As we work closely with our many regional offices, we are able to combine our overall expert knowledge with insight into local and national particulars, ensuring the best possible solutions for our clients and the environment.

#### Responsible decommissioning

More than half of all hydrocarbons today come from mature fields with ageing facilities. And while many may be rejuvenated through modifications, a good number will face decommissioning in coming years. To ensure an environmentally happy ending for offshore facilities, a series of environmental studies are typically required. We are able to tackle anything from HSE audits of dismantling and disposal to planning and permitting of complete decommissioning projects.



Biological assessment of seabed conditions is made very efficient by using our ROV-mounted underwater video.



Responsible dismantling and disposal of topside. From a decommissioning HSE audit.

# MOVING TOWARDS DEEPER WATERS

## List of FPSOs

Peregrino  
- Maersk FPSOs

Ngujima-Yin  
- Maersk FPSOs

Gryphon  
- Maersk FPSOs

Nexus  
- Samsung Heavy  
Industries

Sevan Piranema  
- Kanfa

White Rose  
- Maersk FPSOs and  
NSB, Canada

Petrobras Marlim Sul  
- Maersk FPSOs

Roncador  
- Maersk FPSOs

Santos Mutiner-Exe-  
ter - Maersk FPSOs

Shell Generic FPSO  
- Maersk FPSOs

Moho Bilondo  
- Maersk FPSOs

Alvheim  
- Maersk FPSOs

Golden Eagle  
- Maersk FPSOs

The floating production sector has been going ahead full steam for the past couple of years. Even though the oil market is volatile, the long term prospects remain promising, as, in order to meet the world's energy demands, the industry will have to move into deeper waters and harsher environments, where FPSOs continue to be the best answer. The advances in subsea production techniques also make FPSOs a cost-effective solution on deep water fields as they can deal with multiple subsea wellheads and are easily transported to a new field compared to traditional fixed platforms.

## On top of FPSOs

FPSOs come in different shapes and sizes, but whether we are talking about converted tankers, or purpose-built ship and cylindrical shaped vessels, there is relatively little space on board. These circumstances naturally call for highly optimised topsides designs, which is one of our key areas of expertise.

Built upon our vast experience designing topsides for traditional rigs in harsh environments, we have further developed our topsides designs to also fit the dynamic movements and confined space of an FPSO. And we have accomplished this without compromising operability, safety or cost. Simply put, we offer durable solutions that meet the highest HSE standards and ensure our customers a high return on investment.

## Safety on board

Safety is a key concern on all installations and we have made risk and safety studies an integral part of our service portfolio. We have conducted comprehensive risk and safety studies on most of our FPSO projects ranging from hazard identification to marine analyses. Using advanced Computational Fluid Dynamics-based modelling and simulations, we are able to anticipate accidents with great accuracy, design against them, and set down necessary safety procedures.

## Extracting energy on tight deadlines

FPSOs must be designed to operate under unknown conditions with high production capacities meeting tight deadlines, which can be a challenging task. But we believe that a close partnership with our clients sets the ground for a long-term and economically sound solution that meets the individual future demands for extracting energy on deep waters all over the world. We have through the successful conclusion of several such projects proven our project management capabilities to the satisfaction of all of our clients.



“Ramboll Oil & Gas demonstrated and provided an excellent integrated engineering solution for NEXUS # 1 FPSO through their absolute transparency in engineering. Ramboll Oil & Gas delivers professional solutions on time and we look forward to work together again on another FPSO Project in the future.”

**JO. YONG-HO, TOPSIDES PROJECT MANAGER, SAMSUNG HEAVY INDUSTRIES**

### **Nexus - topsides engineering**

The colossal Nexus 1 FPSO project is a grand-scale project in Ramboll Oil & Gas with more than 310,000 man hours spent on pre-engineering design, detailed design of all topsides facilities. The scope of work included all design documentation required by the yard in order to build, test and commission the facility. Everything was completed on time and within budget to the satisfaction of our client Samsung Heavy Industries.

The ship-shaped FPSO was designed to operate in deep waters all over the world, especially in harsh and volatile environments such as hurricane and typhoon prone waters for example in Brazil. The generic FPSO with a free and fully weather-vaning turret mooring can accommodate up to six risers.



Hull capacity: 950,000 bbl storage for liquids, oil, water and gas. The vessel can accommodate 80 persons.

## FIT-FOR-PURPOSE SUBSTRUCTURES

### Nini Cecilie monotower platform facts

- Installed at 61 m water depth
- Two platforms, each equipped with 10 well slots and 7 risers
- Two minimum topsides, each weighing 700 tonnes, incl. helideck
- Jacket weight of 1,900 tonnes
- Designed to produce 40,000 barrels/day
- Unique because: light-weight, monotower to reduce wave loads, cost-effective
- Unmanned
- Successfully installed in 2003

In the over 30 years we have worked in the oil and gas business, we have acquired solid experience in traditional offshore fields as well as marginal fields. In each project we strive to reduce costs without compromising safety and efficiency by optimising the structural design.

Since 1981 we have designed 21 conventional 4-legged jackets that support large structures, 15 light-weight monotower platforms, and 4 monopile supported platforms. Our design of 4-legged jacket substructures also includes designs for early production facilities — expediting first oil — on the actual jacket itself.

### Minimalist design with maximum return

Our exceptional monotower platform may be used as a stand-alone or as a satellite platform for successive developments of existing fields, where it has proven to be a cost-effective solution.

The monotower presents a unique alternative to subsea solutions, which are traditionally the choice for subsea developments of marginal fields with difficult reservoirs. In cooperation with operators on the Danish continental shelf, Ramboll has been instrumental in pioneering and perfecting the monotower platform, designed to recover oil from marginal fields at minimal costs without compromising operability and the exacting ISO, NORSOK and European HSE standards.

As an active and long-term member of the ISO committee, Ramboll has been in the forefront with the application of the new ISO standard for offshore structures.

### A singular design

What has made our monotower platform a winner around the world is its singular design. The wellheads are arranged very closely in an ingenious circle configuration within the column, minimising wave load on the conductors and allowing for easy operation of the valves on the X-mas trees. Another key design feature is the scaled down topsides of only 700 tonnes. All process facilities not strictly required for the treatment and transfer of fluids to the pipeline have been eliminated.

The result is a robust, low-weight, and easy-to-produce structure, which is able to operate at water depths of 20 to approximately 110 metres.

### Advanced analysis software

In our efforts to increase the lifetime of existing platforms and to document additional capacity, Ramboll has developed the cutting-edge analysis software programs RONJA and ROSAP for the re-evaluation of existing facilities. Using these tools we perform conventional linear analyses as well as push-over analyses and analyses to account for the dynamic effects of slender structures. And for our clients in the Middle East we further utilise the SACS software package for analysis of structures.



**“DONG ENERGY AND RAMBOLL OIL & GAS HAVE WORKED SUCCESSFULLY TOGETHER FOR MANY YEARS. “**

“Our crowning achievement is our cooperation on designing two satellites, tied back to the Siri field, where Ramboll designed two almost identical platforms, Nini and Cecilie, for us.

At the time, the low oil prices called for cost-effective solutions. But the design also had to meet international standards and DONG’s requirements for safety, easy access and maintenance. Ramboll proposed a design for two lightweight, mono-column platforms

with internal conductors, a helideck and boat landing that are perfectly suited for the harsh environment of the North Sea.

The platforms are still going strong and producing as planned, so it is no accident that DONG has nicknamed them NiCe.”

Lars Bruvoll,  
Senior Vice President, DONG Energy A/S

# DESIGN OF ADDITIONAL PLATFORM JACKETS IN THE HALFDAN FIELD



In 2005 the Danish oil production was increased by an impressive 20 percent. The installation of three new platforms in the Halfdan field in the North Sea significantly boosted the oil recovery on this site.

The Maersk-operated Halfdan complex consists of the HDA, a combined wellhead and processing platform, the HDB, an accommo-

modation platform, the HDC, a gas flare platform, and finally the HBA, an unmanned satellite wellhead platform without helideck.

The HBA satellite platform is provided with electric power, injection of water and lift gas. Ramboll provided detailed design for the three jackets in just a few months.

## GOING DOWNSTREAM

### - REFINERIES, GAS TREATMENT AND STORAGE

Ramboll has provided consultancy services to the downstream sector for years, and our solutions have evolved with the needs and challenges facing the industry. Our service portfolio ranges from conceptual and detailed design of zero-flare systems to gas-supply studies. Regardless of the scale or type of project we undertake, we are able to meet the demanding environmental regulations, deliver cost-efficient solutions and meet our clients' great expectations regarding efficiency and high return on investment.

#### Securing supply

The European gas markets have been changing dramatically in response to a number of different developments, notably the reduction in indigenous production that is making Europe increasingly dependent on long distance imports. Issues such as supply security, transmission systems and storage capacity are therefore on the top of political as well as business agendas.

#### Studies and design capabilities

Ramboll has carried out studies regarding supply security, transmission corridors and storage capacity for the EU and we have

conducted studies for the Danish Energinet.dk—the company that oversees volume-balance in Denmark—with studies concerning the expansion of the capacity for a new gas transmission system to import gas from Germany and secure the future supply in Denmark. We have furthermore conducted a number of environmental studies, most notably the world's most comprehensive marine study for Nord Stream, who is planning a 1220 kilometre gas pipeline system to run through the Baltic Sea.

Within design, our reference list includes a wide variety of different projects: from the design of process facilities onshore to offshore transmission systems, compressor stations and process, described in detail on pages 16-17. Onshore, Ramboll has been responsible for conceptual engineering and front end engineering design of the above ground plants on Etzel, a large gas storage facility in Northern Germany which is expected to become one of Europe's new energy hubs. In Denmark, Ramboll was responsible for the detailed design of the Stenlille gas storage. At present we are engaged in a pre-construction design study of an underground gas storage in Georgia. Also, we carry out environmental impact assessments for expansion of the LI. Torup gas storage.



The Danish Stenlille Gas Treatment Plant where Ramboll has designed all above-ground facilities and thereby securing gas supply for the Copenhagen metropolitan region.

Image courtesy of DONG Energy



## SUSTAINABLE DEVELOPMENT AT STATOIL REFINERY IN DENMARK

Since 1995 Statoil has executed large scale extension and modification projects on their refinery in Kalundborg. The projects have not only improved the production facilities but also benefited the environment. Especially it has been possible to reduce the amount of the problematic chemical benzene in gasoline considerably. Also, the amount of sulphur in diesel oil has been reduced.

Ramboll's skilled team of engineers have been involved in engineering the 'green projects' providing studies and/or detailed design for

key elements of the various projects as the installation of a degasser module, a visbreaker train, a new splitter and diesel reactors.

And in 2008-2009, we undertook the HSE and conceptual study for the New Flare Project, which comprised major modifications on the existing facility with the aim to reduce hydrocarbon discharge into the atmosphere. The purpose of the HSE study was to evaluate HSE issues related to the operation of the new flare system, including normal operations, maintenance and emergency.

### Optimising production on refineries

The global downturn combined with tougher fuel standards have intensified refineries' efforts to optimise production and increase earnings by turning, for example, low-value heavy fuels into high-value hydrocarbon products. Ramboll is able to consult clients within a wide range of areas allowing them to meet these challenges.

We have designed a fuel reduction plant for a Statoil plant that by means of thermal cracking and vacuum distillation converts heavy fuel oil into primarily diesel fuel. The project involved the integration of a brand new grass-roots section with the refinery's

old visbreaker while the refinery was in operation. We have also carried out modification projects on refineries in both Europe and the Middle East that have increased efficiency and output considerably.

### Smokeless flare systems

Furthermore so-called green solutions have become a big part of our diverse project portfolio. In the Gulf region, we have been involved in smokeless flare systems for several installations, which minimised the adverse environmental effects usually associated with traditional flare systems.



The Ras Laffan Industrial City, where Qatargas and Rasgas are some of the largest suppliers of LNG.

Image courtesy of Qatargas.

## DEALING WITH THE RISKS

There are many risks and hazards associated with onshore and offshore work. Extensive risk assessments are required to ensure the safety of personnel, surrounding areas and installations, which are designed and laid out for mitigation considerations. Based on many years of designing offshore and onshore facilities, Ramboll has accumulated a wide-ranging expertise in risk-based design and analysis of oil and gas facilities such as pipelines, FPSOs, platforms, storage facilities and refineries.

We deliver risk and safety services throughout the lifecycle of an installation from the onset of new projects through operation of existing facilities to decommissioning. All in accordance with national HSE legislations.

### Hazard mitigation

An important part of a design process is to identify and mitigate hazards to ensure a safe operation. This is of key importance for both existing installations and new projects. Ramboll provides an expert team within identification of hazards (e.g. HAZID, HAZOP, SIL/LOPA) through a structured approach based on industry standards and solid experience.

Risk-based design is crucial for FPSOs where the limited available space reduces layout possibilities. Ramboll carried out risk and safety studies on the Nexus, Ngujima-Yin and Peregrino FPSOs. Risk-based design was also carried out for the Etzel gas storage facility. And for the gas storage facilities in Stenlille and for LI Torup quantitative risk analyses were executed.

### OUR SERVICES INCLUDE

- Risk assessment
- Consequence analysis
- Hazard mitigation
- RAM analysis
- HSE management
- Working environment analysis
- Technical safety

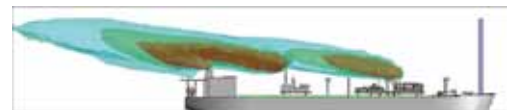
Identifying and mitigating hazards according to the ALARP principle are the key drivers in risk based design. It is repeated as an iterative process throughout a project to ensure the safety of the personnel working on an installation and neighbouring facilities.

### Risk assessment of oil and gas facilities

Using expert knowledge and state-of-the-art software, risks are thoroughly analysed and presented in a format readily understandable to both clients and authorities. Frequency and consequence analyses are carried out for all onshore and offshore installations. Individual solutions are tailored to each project using a structured approach ensuring that all risks are quantified and their risk level determined, including maritime risk assessments that optimise routing and location of offshore facilities to minimise interaction with maritime traffic.

### Technical safety

The safety requirements identified through hazards, industry standards and legislative requirements are an integrative part of our services.



# THE FINAL FACTS

## - RAMBOLL OIL & GAS IN BRIEF

Ramboll Oil & Gas provides highly specialised and multidisciplinary engineering consultancy services to the worldwide oil and gas industry. Our 700 employees constantly strive to deliver innovative and customised engineering solutions that make a genuine difference to our clients, the end-users and society.

### World class engineering

Our knowledge is based on more than 30 years of experience from the hostile North Sea and over the years we have expanded our business to projects in Europe, Asia, Middle East and USA.

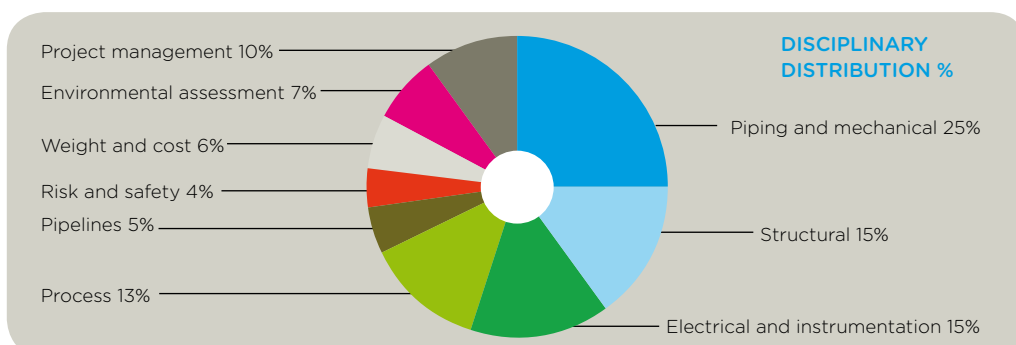
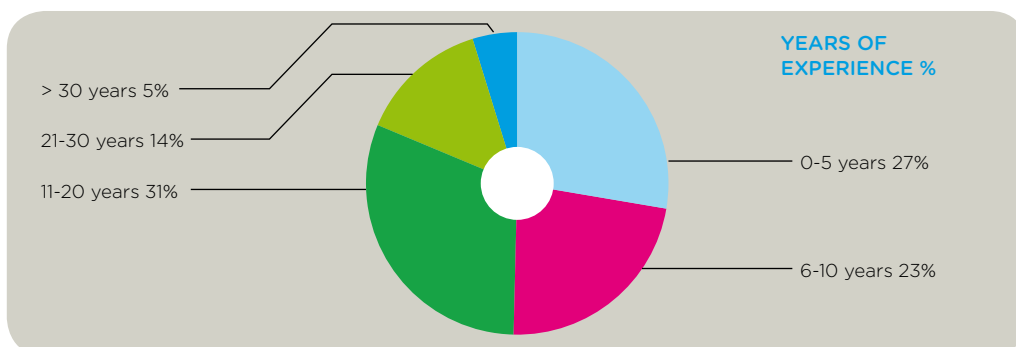
In 2009 and 2010 we have executed more than 2,900 projects, both small and large, for a wide range of clients, including Maersk Oil, Hess Denmark, BP, Statoil, Shell, Total, ConocoPhillips, DONG Energy, Qatargas, Nord Stream, Energinet.dk, the EU Commission, Gasum, Samsung Heavy Industries and RasGas with whom we have built long-

standing and mutually rewarding relations over the years.

Today Ramboll Oil & Gas holds offices in Denmark, Norway, Qatar, Abu Dhabi (U.A.E.), Russia and India. Based on our strategy for growth we expect to open offices in other locations in the coming years.

### Independent partner

We believe that the best consultancy comes from an independent partner. We work independently of third party interests which makes us able to ensure our clients the best and most economical solutions. We hold an ISO 9001 certification, and our services meet both national and international standards such as Norsok, API, ANSI, ASME and other standards. We successfully execute projects under EPCM, engineering, procurement and construction management services, and prioritise very detailed documentation on all projects.





**BUILDINGS & DESIGN  
INFRASTRUCTURE & TRANSPORT  
ENERGY & CLIMATE  
ENVIRONMENT & NATURE  
INDUSTRY & OIL/GAS  
IT & TELECOM  
MANAGEMENT & SOCIETY**