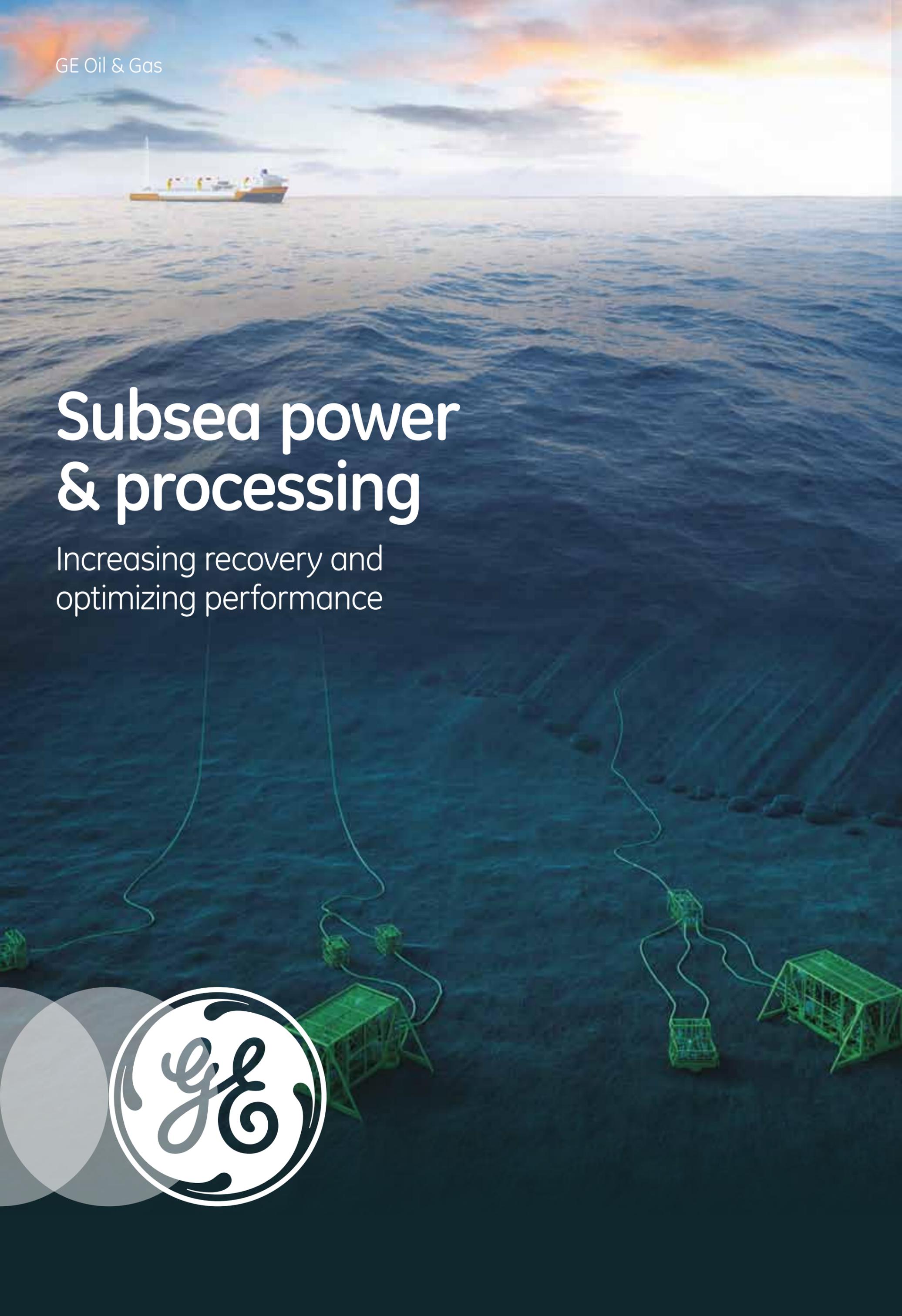


# Subsea power & processing

Increasing recovery and optimizing performance





Subsea processing technologies are routinely deployed to improve field-development economics in challenging environments, such as deep water or long step-outs.

GE Oil & Gas has been pioneering subsea processing for over 20 years, investing in resources to innovate, test and qualify new technologies. Combining our longstanding heritage and expertise in the subsea arena, with unmatched access to best practices and know-how from adjacent industrial sectors, we partner with operators across the oil and gas value chain to tackle complex subsea projects in a safe and reliable way.

Our philosophy is to develop and apply technologies that help simplify system design, minimize footprint and weight, increase reliability, and ultimately reduce overall life-of-field costs.

**getting more**  
**from the seafloor**

# Technologies from across the GE Store

The GE Store is a global exchange where the world's most brilliant minds mix and match technologies, tools and ideas to create solutions for our customers. Engineers and scientists across several GE business units collaborate every day to develop our advanced subsea systems.

## A strong combination of technologies and expertise

GE Oil & Gas has the unique ability to tap into the full portfolio of technology and service solutions from the broader family of GE businesses. We call this continually growing inventory of knowledge and technology the 'GE store.' It allows us to collaborate, share best practices across different industries, and develop synergies among different technology areas — to overcome hurdles and drive innovation, performance and outcomes, bringing speed-to-market and propelling growth in the most demanding industry landscapes.

For the subsea power and processing world, the GE Store brings together capabilities in rotating equipment, flow assurance, subsea production, water treatment, power systems and advanced monitoring and diagnostics. This allows us to provide our customers with truly comprehensive solutions that can be seamlessly integrated for optimized performance and efficient operations.

Our network of seven Global Research Centers provides a pool of unmatched expertise and technical depth. Here, more than 3,600 scientists and engineers drive advanced technologies for all of GE's industrial businesses, helping to transfer technical knowledge from one business to another.

When it comes to project execution, we draw on the deep experience and expertise of our subsea operations teams, providing an integrated approach to minimize the technical and commercial challenges associated with large systems.

GE also recognizes that standardization and modularization can help reduce overall systems costs for the industry, so we work closely with industry initiatives to ensure that our modules are aligned with the latest standards, and provide the flexibility to be used by other system integrators.

## Subsea Power & Processing Systems



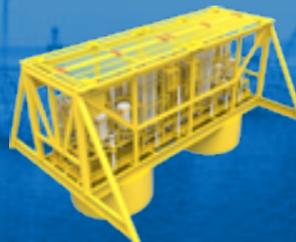
Boosting



Compression



Separation



Seawater Injection



Power

## GE Store

Subsea Systems



Power Conversion



Digital Solutions



Aviation



Turbomachinery Solutions



Well Performance Services



Power & Water



7 Global Research Centers

# proven pioneers for subsea

## Boosting



Subsea boosting adds energy to the wellstream to accelerate or improve oil recovery in both new and mature wells. Even in the most challenging environments, such as long tiebacks, low-pressure reservoirs, or wells with difficult flow-assurance conditions, subsea boosting can be used to unlock and enable access to these assets.

Our subsea boosting systems can handle a variety of flow rates and compositions, and can be configured with either centrifugal or helico-axial pumps. Each system is designed for high reliability, and all our pumps incorporate the same integrated condition-monitoring technologies as used on our topside rotating equipment.

The latest innovations and qualification processes are incorporated by drawing on proven GE expertise in other challenging areas — including subsea production systems, subsea power, condition monitoring and rotating machinery. We also involve customers in the design process to ensure that our technologies and systems meet their current demands, while providing the flexibility to enable future expansion.



## Compression

Subsea gas compression is an emerging technology area that can significantly improve the economics of many mature gas fields. Reservoir gas pressure declines naturally over time and can eventually be too low for production. The traditional solution is to compress the gas on a platform or at the receiving facility. Today, however, we have the ability to place compression systems on the seafloor — which accelerates production while eliminating the need for costly topside facilities.

GE's Blue-C™ technology is the heart of both our subsea dry-gas and wet-gas compression systems. It is a high-speed centrifugal compressor specifically designed for subsea applications, with a

motor architecture that enables operation from 4 MW up to 20 MW. Our 12.5 MW Blue-C unit was qualified, along with our subsea power distribution system, in a long-term pilot at Shell's Nyhamna facility in Norway.

In dry-gas mode, an external subsea separator is used to remove any liquid from the gas stream. Our new wet-gas version, on the other hand, can handle up to 5% liquid, which eliminates the need for a subsea separator — and results in a more compact and lower-cost system.

Our compression systems combine the best technologies from the GE Store — condition monitoring, electrical actuators, acoustic leak detection, and control systems — all supported by robust power solutions for both short and long step-out distances.



## Separation

Subsea separation is used to de-bottleneck topside and subsea facilities and increase recovery. Separation of gas from liquid allows higher-pressure boosting and can be used to improve overall flow assurance. It can also enhance availability in deeper waters where hydrate formation is a challenge.

By separating water on the seafloor, significantly less topside processing is required. This frees up deck space, reduces weight, and cuts energy costs associated with transporting water-heavy streams to the platform. Separated water can be injected back into the well for enhanced recovery or disposal.

Our approach is to maintain a simple and robust system utilizing well-proven conventional gravity separation in water as deep as possible. GE has considerable field-proven experience in this area, including Statoil's Troll C, the world's longest-running subsea separator — operating continuously since 2001 and enabling significant increases in the field's oil production.

# frontiers

For separation in deeper water, GE brings expertise, experience and an open-interface approach to develop the optimal solution for any particular field requirement. We also have a broad range of production chemicals that can be combined with our separation systems for maximum performance.

## Seawater injection

High-pressure injection of water into a reservoir is one of the most commonly used methods for increased oil recovery. Produced water is readily compatible with the reservoir, but seawater often requires treatment to remove sulphates and bacteria that can cause scaling and souring of the reservoir. This process is typically done in large, topside processing stations using membrane technology.

GE has now developed a sulphate-removal solution based on leading membrane technologies from our water processing business, to process seawater on the seabed prior to injection. This innovation avoids the need for costly high-pressure risers and large, heavy structures on the platform or FPSO.

The modular system processes seawater in three stages:

1. Coarse filtration to remove solids >80 microns
2. Ultra-filtration for matrix flooding and removal of fines and bacteria >0.01 microns
3. Nano-filtration to remove sulphates and other divalent ions

GE's seawater sulphate removal system is designed for high reliability and minimal intervention. We avoid the use of membrane-cleaning chemicals by using low-flux membranes and a unique process of in-situ back-washing. The result is a highly reliable system that only requires intervention on the membrane modules every five years. Each system can be tailored to different seawater conditions and flow rate requirements by adding or removing filtration modules.



## Power

A reliable power supply is mission-critical for all types of subsea processing activities — especially when the project faces challenges such as long tie-backs, multiple loads, deep water, harsh conditions or sensitive areas.

GE is a pioneer of subsea power, having designed and qualified the world's first full subsea power transmission, supply and distribution system for Shell's Ormen Lange Pilot in Norway. Today, we are able to supply fully integrated AC power solutions for all types of applications — from the simplest single-load scenario to long step-out systems in deep water with multiple, high-power loads.

The system building blocks include:

- Topside drive systems
- Integrated HV subsea connection systems
- Multi-port switchgears and stand-alone circuit breakers
- Subsea variable-speed drive solutions
- 5–20 MVA subsea transformer modules
- Controls and monitoring

Our field-proven systems are designed for manufacturing ease, maximum installation efficiency, and long-term operating reliability — and they can be tailored to meet specific project needs.





[geoilandgas.com](http://geoilandgas.com)

**Global Headquarters**

The Ark  
201 Talgarth Road, Hammersmith  
London, W6 8BJ, UK  
T +44 207 302 6000  
[customer.service.center@ge.com](mailto:customer.service.center@ge.com)

**Subsea Systems Headquarters**

Silverburn House, Claymore Drive  
Aberdeen, AB23 8GD, UK  
T +44 1224 852 000  
F +44 1224 852 434  
GE Oil & Gas UK Ltd.

**Subsea Power & Processing  
Center of Excellence**

Eyvind Lyches vei 10  
1338 Sandvika, Norway  
T +47 66 98 53 00

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