

Top to bottom—moving hydrocarbon processing to the ocean floor

The world's first subsea processing plant moves closer to crossing the finish line.

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Components such as switchgears and variable speed drives (VSDs) will soon be capable of operating at depths up to 3,000 m (9,842 ft), supplied by a cable from shore up to 600 km (373 miles) long. This technology will enable operators to power entire processing plants on the ocean floor, close to the wellhead, improving efficiency and reducing costs.

The world's first subsea processing plant will soon be a reality. Development work is in its final stages at ABB for subsea power, and the commercial launch is scheduled for the second half of 2019.

The concept will see switchgear, VSDs and the driven equipment, such as pumps and compressors, placed on the seafloor close to the wellheads. The main purpose is to improve efficiency and recovery rates. Over the longer term, this new technology can even eliminate the need for a topside platform. With the infrastructure moved to the ocean floor, the rationale for a topside platform is eliminated.

Power will be supplied from shore using a single alternating current (AC) cable. Cables up to 70 km (43 miles) long with this technology are in use in several locations around the world. In the future, cable lengths of up to 600 km will be feasible using low-frequency AC transmis-

sion and distribution. In combination with components capable of operating at depths of up to 3,000 m, practically all of the world's known resources are within reach.

From subsea transformers

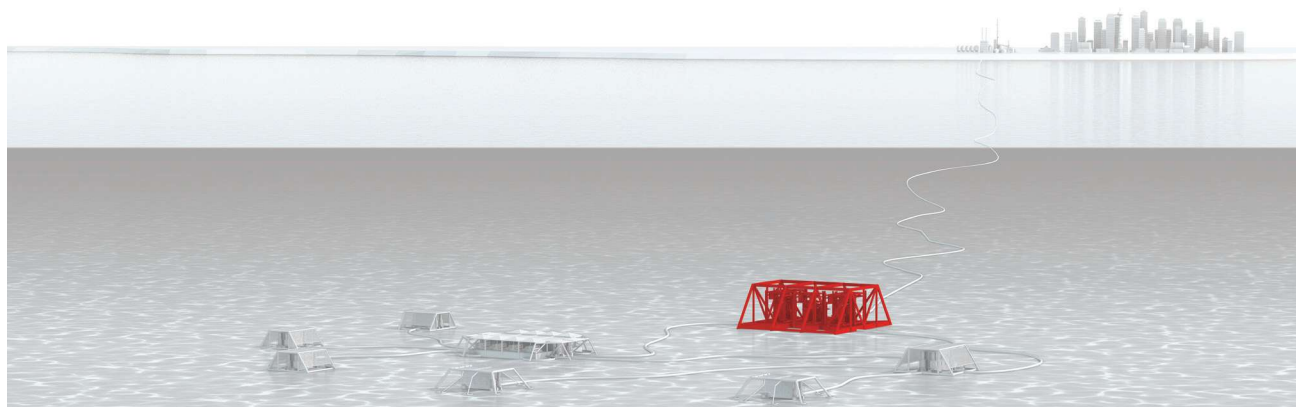
Key to this concept is ABB's work with subsea transformers over many years. Similar marinization as those used for transformers has been developed for other components, such as equipment for power distribution, conversion and control. This is the first time a VSD has been operated in a subsea environment.

The ultimate goal is to have an autonomous subsea factory, using digital solutions to enable intelligent remote and unmanned operations. This will reduce capex and opex while increasing recovery rates, improving safety, enhancing reliability and raising productivity. It also will minimize environmental impact.

By moving the control room onshore, operators can reduce cost and risks as well as increase the revenues from existing assets in production. It also may be possible to develop fields in locations deeper and farther away, which may not have been accessible with traditional technology.

Cable from shore

The subsea power system is based on AC power delivered via cable from a shore-based facility. All equipment



ABB's subsea power distribution solution will help oil and gas companies explore farther and deeper, improve production and save 50% on capex. (Source: ABB)



ABB's subsea VSD completed a shallow-water test in 2017.
(Source: ABB)

for medium voltage distribution, power conversion, automation and auxiliary power is fitted in subsea enclosures and installed on the ocean floor.

This results in significant savings. In a project with eight different loads (e.g., pumps or compressors), the potential capex saving has been estimated to about \$500 million. Efficiency also will be significantly improved, as the power consumers are placed closer to the well. Overall, the aim is to achieve 20% to 30% savings on capex and opex over a 30-year operational life as well as 25% more rapid schedule completion.

Optimized current

A main challenge with the long supply cable is to mitigate resonance points in the system. A long cable is like an electrical circuit with inductors and capacitors and induces resonance. This affects the waveform of the current and impairs the performance of the electrical equipment. By carefully modulating the input to the cable, the waveform can be optimized so that the resonance points are avoided and efficiency is maintained.

Drives, transformers and other components are designed to operate at 4,350 psi. The enclosures are oil-filled and pressure-compensated, with the hydrostatic pressure of the seawater acting on the oil to maintain ambient pressure inside the enclosure.

The equipment is designed to operate for 30 years without maintenance. The maintenance needs of rotating equipment are minimized using magnetic bearings. In the event of equipment needing repair, the units are modular and can be extracted using an ROV.

Pressure boost

The first steps toward a subsea processing plant were taken in 2014 when ABB, together with Equinor, com-

pleted the world's first subsea gas compression project at the Åsgard Field on the Norwegian Continental Shelf.

Originally, the operator had discovered that the internal pressure of the well was dropping at an alarming rate. As the remaining resources were considerable, new ways of boosting the pressure were investigated.

In this early application of subsea compression, the system was tied back to a floating topside rig. This required each pump and compressor to have a separate cable, as no power distribution existed on the seabed.

This issue has been addressed, and all process equipment in future projects will be located on the seabed, powered by a single cable with modular power distribution, driving pumps, compressors and other processing plants.

Access all areas

The equipment and the electrical infrastructure will be controlled using an ABB Ability System 800xA. This provides a single interface to the entire system, including all third-party equipment. Compared to a setup where each equipment vendor supplies an interface, this vastly improves transparency and simplifies management.

However, the overall system may not always include all equipment from the subsea level. There are often contractual obligations relating to subsea equipment that require these to operate through their proprietary interface. Standardization work is ongoing in the industry, which will help improve transparency over time. The aim is to have a system where all equipment is visible through one interface.

Collecting the data

The data from the control system are uploaded to the cloud. Diagnostic data are processed to analyze and predict equipment condition. Here, the VSD system is a key component. Frequently, device behavior can be more easily explained looking at the data in the drive rather than looking at the device itself. The aim is to collect sufficient volumes of data from each device to translate the behavior into an algorithm so that that future behavior can be predicted.

The system is tied into expert applications that optimize every aspect of the operation and links to the company's enterprise resource planning system.

The result is a system that tracks every key performance indicator all the way from the wellhead to the operator's bottom line. This is where the changes in the industry over the last few years have been most acutely felt, and this is what this new technology ultimately seeks to address. **ESP**