CRISIS MANAGEMENT

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THE MARINE and offshore oil and gas industries are coming under immense pressure to reduce emissions and improve the sustainability of their operations. Considering this, the application of low voltage direct current (DC)-based diesel-electric propulsion systems has gained significant traction.

Low voltage DC grids provide numerous advantages when compared to traditional power systems based on alternating current (AC) electrical distribution, including the ability to optimize the loading on diesel gensets by changing the speed according to the load, which reduces specific fuel consumption and associated emissions.

Additionally, by reducing loading on the gensets, maintenance intervals can be extended. These benefits are especially relevant for offshore rigs and platform support vessels (PSVs), which have highly variable power demands for drilling, dynamic positioning, and station-keeping. DC power plants also enable easy incorporation of energy storage technologies to create hybrid or all-electric power schemes.

Siemens delivered the first modern diesel-electric propulsion system to a Norwegian offshore supply vessel in 1996. The company has since implemented similar systems on 300+ marine vessels worldwide. In 2018, another significant milestone was achieved on the West Mira drilling rig in the North Sea. It became the world’s first modern drilling rig to operate a low-emission power plant using lithium-ion batteries.

DC POWER GRIDS
The application of DC power grids on offshore marine vessels is not new and can be traced as far back as the 1880s. However, most ships and rigs in operation today use AC power distribution. In these systems, prime movers (typically diesel engines) are connected to a generator, which distributes power to various consumers across the facility, including the propulsion system.

Although these systems have been used with success for decades, one inherent disadvantage is that the diesel engine must be kept running at a fixed speed in order to maintain constant frequency and voltage within defined static and dynamic
limits. This speed is typically less than the rated output of the engine, which results in partial loading. When this occurs, engine temperature is not high enough to burn all the available fuel. As a result, unburnt fuel passes into the exhaust system, reducing efficiency and increasing specific fuel-oil consumption (SFOC) – both of which lead to higher emissions.

Modern low-voltage DC solutions solve this problem by decoupling the power grid from frequency and allowing the diesel engines to be operated at variable (i.e., more optimal) speed, which lowers SFOC. This can yield substantial fuel savings and emissions reductions for PSVs, which only require full power a small proportion of the time they are in operation. In such cases, total fuel reduction on the order of 10-25% can be achieved. NO\textsubscript{x} emissions reductions as high as 80-85% are also possible due to higher exhaust temperature and more efficient utilization of scrubbers.

In addition to the environmental benefits, DC power grids are more flexible and unlike AC grids, do not require a frequency converter for connection to onshore power sources. There are also safety advantages, including rapid fault clearing, which eliminates the possibility of generator synchronization failures and drastically improves blackout recovery time.

**LEVERAGING ENERGY STORAGE**

Another significant benefit of low voltage DC power grids is that they allow for easy incorporation of energy storage technologies to create hybrid (i.e., diesel-electric) or all-electric power schemes. The latter is typically not feasible for large PSVs with high power loads; however, there are many commercial transport vessels in operation today that are fully electric.

In 2015, Siemens supplied the power system for the world’s first electrically powered ferry boat. Named *Ampere*, the ferry carries passengers and cars across a 6-km (4-mi) crossing between two communities in the Fjord area of Norway. At 80 m (262 ft) long, it is driven by two 450 kilowatt (kW) electric motors powered by lithium-ion batteries. The batteries have a combined capacity of 1,000 kilowatt-hours (kWh). With electricity in the Fjord area being generated exclusively by hydroelectric plants, *Ampere* cuts emissions by 95% and lifecycle cost by 80% compared to a fuel-powered ferry traveling the same route, which consumes around one million liters of diesel fuel and emits 2,680 tons of CO\textsubscript{2} and 37 tons of NO\textsubscript{x} each year.

Similar savings are possible in hybrid power plants by enabling diesel engines to be operated at an optimal combustion level most of the time, which improves fuel utilization. This is the case with the Norwegian offshore construction vessel, *Edda Freya*. This vessel was commissioned in 2016 and features Siemens’ BlueDrive PlusC DC power grid with 23MW installed power generation and 500kWh battery capacity, coupled with an energy storage solution from Corvus Energy. The hybrid power system enables lower fuel consumption when compared to vessels of similar size – and in turn, a lower emissions profile.

In the case of offshore rigs with hybrid power plants that use energy storage, excess power produced from diesel generators or gas turbines could potentially be stored and used to support and improve operation of the primary energy source. Energy could be used for immediate consumption to improve dynamic operation of engines with low response capability in critical situations, as well as for reducing rapid speed changes during normal operation.

The application of energy storage for drilling rigs or PSVs ultimately enables companies to fundamentally change the way they...
operate assets. A summary of the key benefits is outlined below.

**Reduced fuel consumption and lower emissions.** As previously stated, by integrating low voltage DC power grids with energy storage, it is possible to optimize the loading on combustion units, such as diesel gensets, which reduces specific fuel consumption and associated emissions. This is particularly beneficial on drilling rigs, where power plants have highly variable power demand for drilling, dynamic positioning, and station-keeping. Hybrid power schemes can also be used to lower transient loads on gensets and improve dynamic response times of thrusters.

**Improved reliability with better redundancy schemes.** Relatively speaking, diesel engines are slow to handle large, abrupt load changes. Using batteries or supercapacitors to provide temporary power affords facility/vessel operators more flexibility and provides the opportunity for new redundancy schemes, thus ensuring safety, lower opex and improved uptime throughout operations by reducing the number of engines / gensets on the platform. For example, in a power plant where there have been traditionally three gas turbines, an operator could potentially use two gas turbines with an energy storage solution attached to it. Additionally, batteries can be used to remove the need for load shedding and bridge the gap between one engine failing and another starting up.

**Reduced footprint and increased payload.** Low voltage DC grid diesel-electric plants incorporating ESS have a smaller footprint than traditional power schemes which use gas turbines. For example, a 6.6kV high-voltage power plant with dual fuel turbine-driven generators and one auxiliary diesel generator requires approximately 120 sq m (1,292 sq ft) of space in the process area. By comparison, a 690V plant with four 4MW diesel generators, a main switchboard, integrated variable speed drive (VSD), and ESS requires zero square meters of space in the process area. This increases payload and enables operators and EPCs to rethink topsides philosophies, opening the door to more flexible designs.

### PAVING THE WAY FOR RENEWABLES

The concept of using renewable sources of energy, such as offshore wind farms, to provide clean power to offshore oil and gas assets continues to gain traction. But there are still many hurdles to overcome in order to make this a reality, not the least of which involves finding ways to offset the intermittence and inherent unpredictability of electricity generation from wind. Energy storage is an important part of the solution to this problem and will play a key role in helping the offshore industry drive toward decarbonization.

In 2018, Siemens took an important step on the way to reducing emissions and eventually harnessing renewable sources of energy to power oil and gas operations by supplying the world’s first lithium-ion battery solution to an offshore drilling rig. The *West Mira* is a sixth-generation, ultra-deepwater semisubmersible that will operate in the North Sea’s Nova field, about 120 km (75 mi) northwest of Bergen, Norway. It will be the world’s first modern drilling rig to operate a low-emissions hybrid (diesel-electric) power plant using Siemens’ BlueVault lithium-ion battery technology.

The solution consists of four converter-battery systems (total 6MW). The battery system is connected to the main switchboard using a Clean Grid Converter (CGC) and step-up transformer to medium voltage AC connections. The batteries are charged from the rig’s two diesel-electric generators and used for supplying power during peak load times. In addition, they serve as back-up to prevent blackout situations and provide power to the thrusters in the unlikely event of loss of all running machinery.

The installation of the ESS on the *West Mira* will result in an estimated 42% reduction in the runtime of on-platform diesel engines, reducing CO₂ emissions by 15% and NOₓ emissions by 12%, which is equivalent to annual emissions from about 10,000 automobiles.

### THE ROAD AHEAD

The long-term success of the offshore oil and gas industry is predicated on reducing costs and minimizing environmental impacts. Low voltage DC power grids coupled with energy storage provide a means to achieve that objective by providing clean, flexible, and dispatchable power.

The benefits of deploying a hybrid power plant with energy storage in the offshore environment could potentially be realized on any facility. However, regional economic, environmental, and regulatory factors play an important role in cost-effective deployment.

In Norway, for example, the government is incentivizing the industry to reduce emissions. This is one of the main benefits of developing and using energy storage solutions for offshore facilities in the North Sea. Other countries, including the USA and other EU nations, do not heavily incentivize the industry to support emissions reductions. However, new International Maritime Organization (IMO) 2020 regulations which came into effect this year are making these types of novel power solutions more attractive and cost-effective.

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