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SPECIAL FOCUS: OFFSHORE TECHNOLOGY / SUSTAINABILITY

Solutions for decarbonizing offshore power generation

Reducing reliance on hydrocarbons for power is critical to achieving near- and long-term sustainability targets. Siemens Energy is collaborating with major offshore operators to implement decarbonization strategies for electrification, automation and digitalization. This article highlights successful implementation of technologies at several projects and discusses other promising concepts under development.

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Fuel combustion for power generation represents the majority of Scope 1 and Scope 2 carbon emissions in the offshore oil and gas sector. On the UK Continental Shelf, offshore platforms produce an estimated 18 million tonnes of CO_2 emissions per year. It is estimated that 75% of this is associated with power generation (13.5 million tonnes).[1] Similarly, in the Gulf of Mexico during 2022, fuel gas combustion accounted for 76% of total emissions (diesel combustion represented an additional 9%).[2]

HARNESSING FLOATING OFFSHORE WIND: HYWIND TAMPEN

Offsetting conventional power generation with clean electricity from renewables—particularly offshore floating wind—is a key lever in decarbonizing offshore oil and gas. DNV predicts that by 2050, global installed floating wind capacity could reach over 250 gigawatts (GW). For areas where oil and gas infrastructure exists, like the North Sea and Gulf of Mexico (GOM), wind parks represent an opportunity to reduce the carbon intensity of hydrocarbon production.

Hywind Tampen in the Norwegian North Sea is the world's first floating wind farm built explicitly to power offshore oil and gas installations. With a system capacity of 88 MW, it is also the world's largest floating offshore wind farm.

The wind park offsets the need for power from gas turbine generators in Equinor's Snorre and Gullfaks offshore fields, helping avoid 200,000 tonnes of CO_2 and 1,000 tonnes of NO_x per year. It meets about 35% of the annual electricity power demand of the five Snorre A and B and Gullfaks A, B and C platforms.[3]

Siemens Energy provided all 11 of the 8-MW wind turbine generators for Hywind Tampen. The company's scope of supply also included a 36-kV tie-in to the electrical distribution system, providing power to the Snorre and Gullfaks facilities, along with the power management system (PMS), for the wind generation interfacing with the PMS of the platforms. This plays a crucial role in balancing power production (i.e., load sharing) between the wind turbines and the gas turbines. This was accompanied by a digital twin simulator, with an electrical network model for the entire power system, which allows Equinor to test and validate certain conditions in a risk-free, virtual environment.

Hywind Tampen became fully operational in August 2023. The project is a landmark achievement expected to pave the way for additional North Sea floating wind developments in the coming years.

POWER FROM SHORE: TROLL WEST ELECTRIFICATION

Power from shore represents a more economical electrification strategy for assets closer to land. This is particularly true in countries like Norway, where over 95% of grid electricity is generated via clean hydropower.

Siemens Energy has played a significant role in some of the world's largest power-from-shore electrification projects, including Johan Sverdrup, Martin Linge, and Goliat. More recently, the company was awarded the contract for electrification of the Troll West development, which consists of two oil-producing installations in the Norwegian North Sea.

A key objective of the project is to reduce NOx and CO_2 emissions, by replacing existing gas turbine-driven generators and compressors on the Troll C facility with electricity and partially electrifying Troll B. In total, roughly 116 MW of electrical power are being supplied to Equinor's Troll B (30MW) and Troll C (86MW) semisubmersibles with a subsea transmission cable from the Kollsnes natural gas processing plant northwest of the city of Bergen. The cable route goes from Kollsnes to Troll B (79 km) and from Troll B to Troll C (17 km). While Siemens Energy spearheaded the electrical system design and its execution, Aker Solutions handled the EPCI of the project, with Equinor serving as the operator and project owner of the field.

It is estimated that partial electrification of the Troll B platform and full electrification of Troll C will lower annual carbon emissions by approximately 500,000 tonnes—equivalent to about 1% of all emissions from Norway. In addition, NOx emissions from the field will be reduced by an estimated 1,700 tonnes per year.[4]

Siemens Energy is designing, installing and commissioning the complete transmission system for the project, including transformers, reactors, switchgears and the static frequency converter systems. This enables voltage stabilization and frequency conversion from 50 Hz to 60 Hz and large-scale drive trains for the compressor motors at Troll C.

The PMS provided by Siemens Energy will help maintain a safe balance between power demand and consumption, ensuring overall grid stability. It is integrated into the existing onshore and offshore automation systems, including control of compressor trains at Troll C.

TEMPORARY OFFSHORE MICROGRIDS: BLUEWIND

Using power from shore or permanent offshore wind resources to decarbonize is not an option for many field developments. This is particularly the case for aging production and drilling assets that may only have a limited number of service years remaining, or ones far from land.

The Siemens Energy BlueWind concept allows these facilities to decarbonize, using fully independent microgrids, comprising one or more temporary offshore floating wind units (OFWUs) equipped with dedicated battery energy storage and grid converters, **Fig. 1.**



Fig. 1. Siemens Energy's BlueWind Concept.

Siemens Energy's BlueVault lithium-ion battery solution and PMS form a core part of the microgrid system in that, together, they guarantee the design for peak shaving and spinning reserve. Each floating wind unit is designed to make energy storage highly redundant, ensuring black-out avoidance and service continuity despite single temporary failures. BlueVault batteries have been installed in more than 60 marine and offshore applications, including the world's first diesel-electric drilling rig (*West Mira*), and countless passenger ferries, fishing boats and PSVs.

The renewables-based microgrid can be connected to any production (fixed or floating) or drilling installation via a subsea cable, up to 2 km in length (or longer, if required).

The concept is scalable and can be deployed to match the host facility's load profile and power needs. With simple interfaces and robust control topology, there is minimal need for adaptations to the asset's PMS. Stable power provided by the microgrid enables a reduction in localized electricity generation from existing onboard diesel or gas turbine generators. The improved energy mix with wind and energy storage, combined, can reduce carbon emissions by an estimated 60% to 70%, compared to conventional generation with gas turbines. Siemens Energy is working with multiple offshore operators to deploy the BlueWind concept.

Microgrids also can be beneficial, even without renewables or energy storage, though the potential for decarbonization is reduced.

One typical scenario for a microgrid use case involves an operator—with multiple assets in relative proximity—facing a challenge with a power deficit on each asset. This requires all assets to run the spare backup gas turbine to cover the deficit. In case of maintenance or failure on one gas turbine, load shedding must take place, reducing the operational efficiency of that asset.

Tying the assets together in a microgrid enables the integrated power system to run more efficiently, allowing one or two gas turbines to be turned off. The microgrid can be established with traditional power equipment (i.e., transformers and switchgear), or subsea transformers and switchgear, to minimize disruption on the topside.

COMBINING CONVENTIONAL GENERATION WITH CARBON CAPTURE AND STORAGE (CCS)

Today, Siemens Energy is working with several partners to develop a turnkey, offshore power solution that leverages conventional gas-fired, combined cycle power generation with carbon capture and storage (CCS).

There are several concepts currently under development, both for fixed and floating installations. Typical power outputs will be in the range of 100 MW to 750 MW. Electricity production is based on combined cycle power plants provided by Siemens Energy. Amine-based carbon capture is employed to capture up to 90% of the CO_2 coming from the combined cycle plant. The CO_2 can then be compressed and injected into a nearby geological formation or liquefied to be transported to a nearby CO_2 terminal.

The power hub concepts cover a wide range of potential locations and utilizations:

- Being centrally located offshore, close to production facilities, enabling decarbonization of several platforms (instead of power from shore)
- Utilizing stranded gas reserves offshore to provide electricity to shore
- Being near-shore/quay-side, to provide electricity in bottlenecked areas with high energy demand.

One of the potential floating power hub concepts is based on Sevan's SSP's geostationary hull design. This hull design does not require a turret or swivel and can accommodate many risers and dynamic cables, allowing for low-cost provisional tie-ins. The hull also has a high load-carrying capacity and favorable motion characteristics, and it can be easily re-deployed to other locations, Fig. 2.

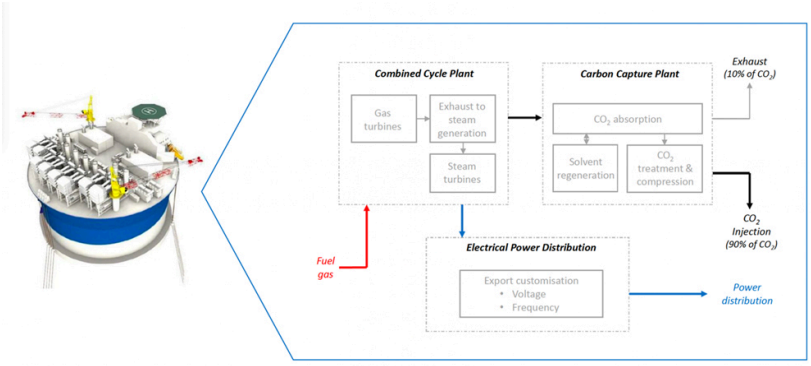


Fig. 2. Floating Power Hub Concept.

In addition to the combined cycle power plant, Siemens Energy is providing the electrical distribution system for the concept. Power from the hub can be supplied to multiple platforms via subsea cables. The combined cycle plant can also be combined with a nearby wind park or power from shore to further reduce emissions.

MARINE DECARBONIZATION

Decarbonizing maritime operations is an area that will play a vital role in driving a successful energy transition. This is particularly true with international shipping, which accounted for approximately 2% of global energy-related CO_2 emissions in 2022.[5]

The technical applicability of decarbonization technologies varies significantly for different ship types and trades. Options for short-sea vessels include several alternative power sources. The shorter distances and highly variable power demands for these ships often make electric or hybrid-electric power and propulsion systems (including diesel/gas-electric) more efficient than mechanical drives. Since its introduction in 2013, Siemens Energy's DC Grid concept, "BlueDrive Plus C," has become the preferred solution for electrical power plants up to 30 MW, due to its high efficiency, low emissions and prolonged service intervals for auxiliary engines.

Over the last decade, Siemens Energy has installed electric propulsion systems on more than 70 marine vessels. This includes some of the world's largest car and passenger ferries, fishing boats, and PSVs. The company also has implemented variations of these systems (in combination with battery energy storage) on drilling rigs to improve efficiency and reduce emissions from diesel gensets. Siemens Energy has collaborated with class authorities, such as DNV, to develop and supply advanced electrical systems for dynamic positioned vessels, allowing the vessels' power plants to operate in closed-ring mode, while in DP3 mode.

Unlike smaller transport and operational support vessels, long-haul, deep-sea ocean-going ships have fewer options for decarbonization, as they need to store substantial amounts of energy for propulsion. Transitioning away from heavy fuel oil (HFO) to cleaner alternatives (e.g., LNG, LPG, green methanol, green ammonia, etc.) is currently considered the best path forward for emissions reductions for these vessels.

In 2022, Siemens Energy partnered with DNV, Fearnleys, and Moss Maritime to develop the Ocean Green concept, a novel low-emission power and propulsion system for deep-sea shipping—particularly LNG carriers. The Ocean Green is a hybrid, combined cycle power and propulsion plant that utilizes an SGT-400 gas turbine as the main engine, in combination with a steam turbine and battery energy storage, Fig. 3.

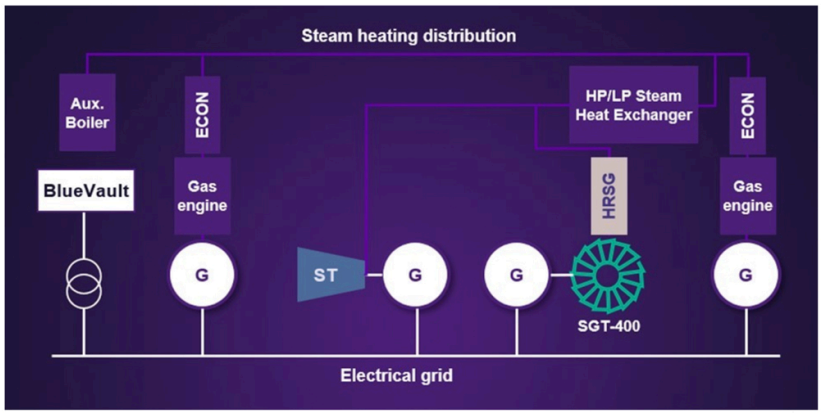


Fig. 3. Ocean Green Hybrid Power Plant.

The compact engine room layout, enabled by the gas turbine, allows for 7% to 10% increased cargo capacity. Combined with reduced maintenance requirements, this results in up to a 17% decrease in unit freight costs, compared to a conventional long-haul carrier powered by HFO. GHG emissions, including methane, are also reduced 18%. Other advantages include lower noise and vibrations, improved maneuvering capabilities, lower OPEX and lower energy consumption during waiting operations. The Ocean Green concept is future-proof, as the gas turbine is prepared to burn a variety of e-fuels including hydrogen.

LOOKING AHEAD

Decarbonizing the oil and gas industry is essential to driving a successful energy transition. Today, oil and gas operations generate the equivalent of 5.1 billion tonnes of GHG emissions, approximately 15% of total energy-related emissions globally. In the IEA's Net Zero Emissions (NZE) by 2050 Scenario, the emission intensity of these activities falls 50% by the end of the decade.[6]

Operators and equipment manufacturers are making considerable progress in addressing emissions from offshore power generation. Although some of the concepts discussed in this article may be relatively new to the marketplace, they are based on proven technologies that have been used for decades.

In the end, no singular solution will solve the offshore emissions puzzle. A diverse range of technologies and solutions will be needed to cover the different conditions and applications. WO

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