SIEMENS energy

Floating Power Plants

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The Siemens Energy SeaFloat power plants use the company's proven and reliable equipment that is been modified for application on floating devices. While the majority of the market requests are for the successful SGT-800 gas turbine, solutions based on the e.g. SGT-8000H series have also been developed to address a variety of market needs.

The most obvious characteristics of Seafloat Power plants that distinguish them from conventional land-based equivalents are:

- **Mobility:** The entire power plant can be moved to any site that is accessible by sea or major rivers.
- **Land consumption:** Almost no investment for land acquisition is required; SeaFloat has been designed to be as small as possible, and it has defined a new standard in power density.
- **Construction in controlled environments:** Because the plants' construction and a large portion of commissioning are performed using standardized equipment under strictly controlled conditions in the world's leading shipyards, a short lead time can be realized. Construction of the plant also doesn't interfere with any infrastructure work that might be required onshore: for example, installation of substation, transmission line, and access roads. This allows the total time required for these kinds of infrastructure projects to be significantly reduced.

Typical applications include:

- Powering up of remote areas like islands
- Development of industrial areas on shorelines or major rivers (for example, chemical and desalination plants)
- Brownfield applications, in other words, the replacement of outdated plants like coal-fired power plants: The existing plant can continue to operate until the new one is in place and ready to be connected to the grid.
- Short-term provision of power to the grid in the event of an urgent need: for example, by leasing a SeaFloat power plant.

Due on the unique advantages of floating power plants, Siemens sees more compelling applications and projects that we are looking forward to developing with trusted partners. The option to install efficient combined cycle power plants on floating devices creates a wide range of project applications.

Examples from the oil and gas business

SeaFloat power plants can be installed on a shared power hub that serves several Floating Production Storage and Offloading Units (FPSO) instead of each FPSO needing its own power supply unit. The additional space gained on the FPSO can be utilized to increase its oil storage capacity. Existing platforms with inefficient open cycle power generation units can be extended with a bottoming cycle, resulting in a reduced CO_2 footprint.

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1. Introduction

The idea of putting power plants out to sea is not new. Floating power plants with Westinghouse gas turbines can be found dating back to the 1990s. Floating plants that use inefficient and costly reciprocating engines are available under leasing contracts. Because mobility, flexibility, and population growth are all pressing concerns today, a dedicated and agile team at Siemens worked to develop the floating power plant using the Siemens Energy latest-generation highly efficient gas turbine frames on floating devices – and they succeeded in creating a new class of floating power plants.

The SeaFloat technology combines state-of-the-art combined cyle power plant technology with the mobility and flexibility required by the current and future energy market. Our vision is a future with access to affordable but clean electricity and clean water for everyone. A tough challenge to achieve, but a necessity in light of climate change and the need to provide electrical energy for the world's growing population.

SeaFloat power plants can be used as an emergency backup for existing power plants during peak loads or outages and to provide a power supply in the event of a humanitarian disaster. SeaFloat power plants can even be supplemented with a desalination plant to provide clean potable water and help prevent disease. A wide range of gas turbine frames and combined cycle configurations are available so that an appropriate solution that meets specific requirements can be developed jointly by the SeaFloat team and our customers:

> **"SeaFloat applications provide the right answers to all the flexibility and mobility needs of the future power market."**
>
> Hamed Hossain, Business Owner SeaFloat

2. The benefits of SeaFloat

When first discussing floating power plants – being on a vessel, barge or platform it brings along a lot of questions. What would I need it for? How well does it work? How is the electricity transported to land? How is fuel delivered to the plant? Why did you develop this, what are the advantages? There are many positive and encouraging answers to these questions, both in terms of the technical factors as well as the "whys" and "what fors." While the technical aspects stimulate the curiosity of engineers and trigger their can-do mentality, the important question is whether it is worthwhile to invest in a floating power plant. The simple answer is "Yes." Of course, all of these questions deserve more detailed answers, and they need to be considered from two angles. There is the economic view, and there are also social and environmental factors to bear in mind. These factors are connected, but in the following section we'll be taking a detailed look at each one individually.

2.1 Global awareness

With SeaFloat applications, it is possible to electrify remote areas and areas with limited space, as well as sites where the land is unsuitable for construction or industrial applications. SeaFloat enables deployment and development that drives economic growth in areas that are inaccessible by road or that lack HV transmission lines to import power. In countries that are hit hard by catastrophes like hurricanes, earthquakes, or tsunamis, immediate power from SeaFloat power plants allows the recovery process to begin as soon as possible. When there is extensive damaged or destroyed infrastructure, mobile power plants can bring power and hope to people and financial security to banks and lenders.

2.2 Space requirements

The SeaFloat's enhanced power density enables installation on a floating hull. Compared with typical land-based applications, the power supply footprint can be reduced up to 50 percent.

Types of SeaFloat plants	Length (m)	Width (m)	Area (m^2)
SCC-800 2x1	~55	~30	~1.650
SCC-800 3x1	~65	~40	~2.600
SCC-800 4x1	~75	~40	~3.000
SCC5-8000H 1x1	~170	~60	~10.200
SCC5-8000H 2x1	~170	~90	~15.300

2.3 Shorter schedule

Construction time can be cut by up to 20 percent by building the power plants in the controlled environment of a ship yard. Needless to say, this also results in lower construction costs.

The shorter timeframe for installing a SeaFloat power plant is due to optimized construction sequences and capabilities which can be realized at shipyards. High lifting capabilities and the design of SeaFloat equipment as single lift frame allows the modules to be easily lifted onto a barge in one piece. Space and access constraints as well as a lack of heavy-lift cranes are typical limiting factors at land-based sites. Not so at shipyards: There are sufficient crane lifting capabilities available, and the infrastructure at large ship yards also provides sufficient space and transport capabilities. Construction at a shipyard includes HRSG cleaning and cold-commissioning activities up to the very moment when the equipment is ready for first fire and grid connection. Of course, these final hot commissioning activities need to be executed under real grid conditions at the place of final operation. But with cold commissioning being mostly completed at the shipyard, the required activities at the final destination are limited: The SeaFloat power plant is

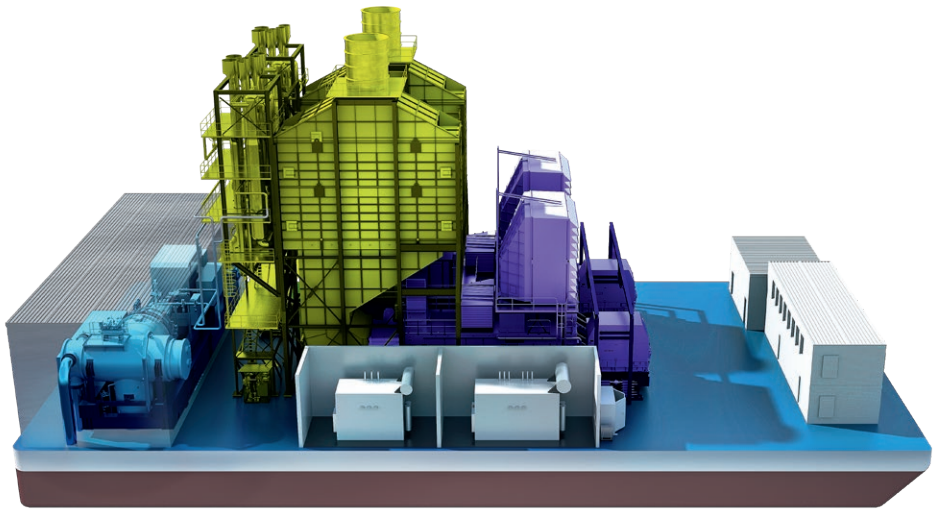
ready to inject power to the grid in the shortest possible time once it has arrived at its final destination. This is especially attractive when old power plants are being replaced. The switch to the new plant can be accomplished with minimum disruption to the power supply.

2.4 Eco-friendliness

Gas turbine power plants on land are as eco-friendly as those on a floating device. The difference is seen in the unique features of the floating plants. Economic advantages and eco-friendliness are no longer mutually exclusive. Encouraging investors to replace inefficient power plants or coal-fired power plants will help fight CO_2 emissions and climate change. Existing land-based assets can still be commercially operated during off-site construction of the new and efficient SeaFloat plant.

The off-site manufacture of the new platform prevents major interference during site activities compared with the typical brownfield substitution system used for land-based power plants. Serving remote areas with highly efficient and clean natural gas or LNG-driven power plants eliminates the use of inefficient, outdated diesel generators. This reduces CO_2 and other greenhouse-gas emissions as well as local pollutants like dust and noise, enhancing the quality of life for the local population. Environmental considerations are becoming more and more important, and many countries are planning a phase-out of coal-fired power plants.

SeaFloat power plants can even use existing structures like cooling water in- and outlet structures and HV grid connections and provide large-scale combined cycle power plants as a replacement. SeaFloat power plants can be an interesting approach for international companies that are looking for opportunities to reduce their CO_2 footprint, especially under the umbrella of the Paris Climate Agreement.



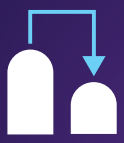
3. The business case

The economic advantages of SeaFloat power plants need to be assessed holistically, taking into account not only the cost of the barge but also all project requirements and risk contingencies, which often have a major impact on the business case evaluation of conventional land-based power plants.

- Labor availability in remote areas
- Cost of land acquisition
- Soil risks and typical brownfield risks with possible impact on project schedule and costs
- Required site preparation work (including leveling)
- Demolition work and required relocation of existing facilities: for example, sea water intake and outfall facilities and high-voltage switchgear
- Interference with existing plants and required shutdown of existing asset due to construction activities
- Limited accessibility by road

Substituting a brownfield land-based power plant for a SeaFloat application – taking into account demolition work and relocation of existing site infrastructure – may result in a 20 percent shorter project schedule. SeaFloat has the potential to reduce CAPEX by 20 percent and yield a 25 percent better net present value (NPV), a five percent better IRR, and a 45 percent faster payback.

Replacing reciprocating engines with Siemens Energies gas turbines-based SeaFloat power plants can result in the following benefits:

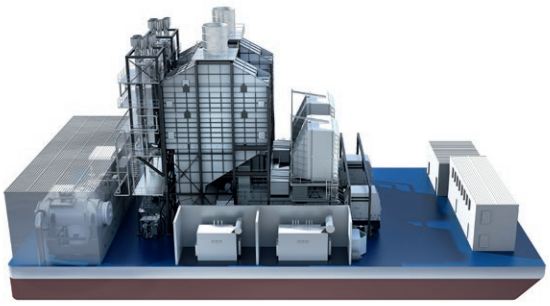


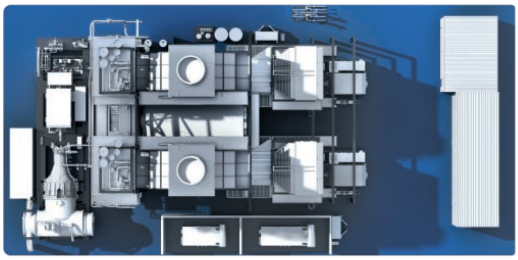
- Increased efficiency of gas turbine-based combined cycle plant
- Fuel flexibility with focus on LNG, natural gas, ethane, propane, and diesel
- Part-load capability and efficiency of steam turbine design
- Fewer emissions (such as COi, NOx, and noise), which is important in the context of the Paris Climate Agreement as well as for financial reasons
- Lower space requirements due to higher power density
- Long maintenance intervals resulting in fewer required maintenance staff and significantly greater availability

Based on project-specific requirements, a SeaFloat combined cycle power plants can provide major benefits of up to 20 percent better Levelized Costs of Electricity (LCoE) compared with reciprocating engines.

4. SeaFloat power plants: Optimization of proven technology

After carefully screening market and customer requirements, Siemens Energy now offers seaworthy power plants based on SGT-800 technology and on the SGT-8000H series, each addressing specific market needs. When modifying the land-based equipment, the characteristic requirements of floating devices – primarily motion ("roll and pitch"), acceleration, and deflection – were accomodated in the design to make the equipment seaworthy.





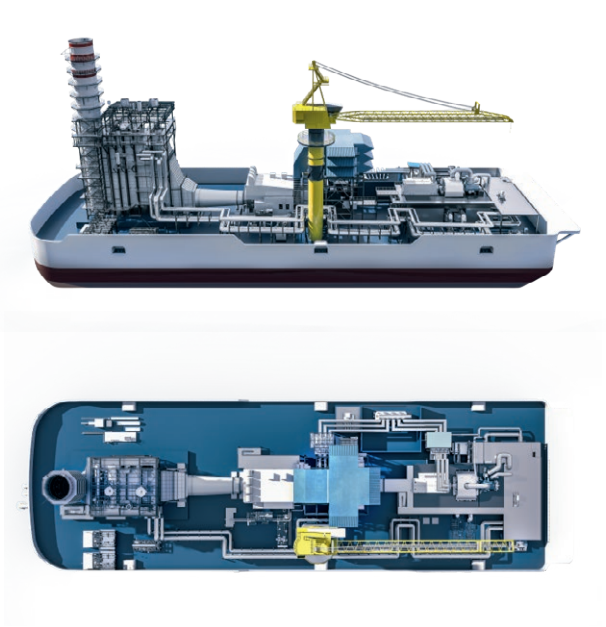
SGT-800

Development of remote areas

SeaFloat applications based on the SGT-800 are the front-runners in developing remote coastal areas. A reliable supply of electrical energy strengthens the economy and opens the door to new investments. Eventually it improves the social and economic circumstances of local residents. With solutions available from 150 MW in a SCC-800 2+1 configuration to 450 MW in a SCC 800 6+1 configuration, a wide range of power demands can be addressed.

The SGT-800 gas turbine provides:

- Plug-and-play concept with high degree of automation
- Modularized application for high degree of standardization and flexible installation
- Flexible power plant solution with high efficiency at plant part load



SGT-8000H series

The high performer of large gas turbines

Even the world champion of heavy-duty gas turbines – Siemens' high-end SGT-8000H – has been enhanced for SeaFloat application. It is available in SCC-8000H 2x1 and SCC-8000H 1x1 combined cycle configurations and delivers up to 1,330 MW with a plant efficiency higher than 61 percent. This highly efficient and reliable large-scale power plant is primarily intended to replace older plants like nuclear power plants and coal-fired power plants.

The SCC5-8000H SeaFloat power plant consists of a single-lift gas-turbine generator package and a single-lift package for the steam-turbine generator package with condenser. Within the HRSG's steel structure, flexible elements absorb deflections while a compensator decouples the gas turbine from the HRSG.

5. Conclusion/outlook

Mobility and flexibility are becoming more and more important in today's world. The prospects for SeaFloat power plants based on state-of-the-art combined cycle technology are diverse and promise wealth and development in many areas. Because it is equipped with the latest highly efficient combined cycle technology, SeaFloat can also play an important role in replacing outdated technology and therefore can support the achievement of national and global climate goals (like the Paris Climate Agreement).

SeaFloat power plants are more competitive than comparable power plants with reciprocating engines, and depending on the project requirements, they're also more cost-efficient than traditional land-based power plants.

SeaFloat applications currently use but are not limited to machines in the SGT-800 and SGT-8000H series.

Siemens Energy is looking forward to supplying equipment for floating power plants – and is also seeking partners to realize extended, forward-looking applications like floating storage regasification and power units (FSRPU), where the power plant is mounted on an FSRU or combined with floating desalination units. Our vision is to provide access to clean water and energy to everyone.

6. Disclaimer

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