Floating storage and regasification barges

BRINGING LNG TO AREAS WITH SITE LIMITATIONS

A FLEXIBLE AND MOVABLE SOLUTION

CONCEPTS ADAPTABLE TO CUSTOMER NEEDS
Bringing LNG to locations not served by the established infrastructure

The global trend towards replacement of conventional liquid fossil fuels with liquefied natural gas (LNG) in the energy and marine markets is accelerating. This trend is driving investments in the development of the LNG supply infrastructure to serve the increasing demand.
Nevertheless, there are locations that simply cannot be served by conventional land-based facilities. Similarly, there are locations that require a short-term supply solution pending the installation of more permanent facilities. It is to fill these requirements that Wärtsilä has developed the floating storage & regasification barge (FSRB).

Wärtsilä has extensive experience in providing products, systems and integrated solutions for all links along the LNG value chain. We have also in-house expertise in barge-mounted solutions, and our impressive reference list of floating power plant installations can be seen on page 14.

Leading technologies and innovative solutions are the hallmarks of the Wärtsilä brand. These characteristics and the company’s in-house capabilities are the basis upon which the Wärtsilä FSRB has been developed. In providing a practical and efficient means of supplying LNG to smaller, remotely located demand centres, we are speeding the global adoption of LNG as an environmentally friendly fuel for the energy and marine markets.
Wärtsilä’s flexible barge-mounted storage and regasification solution has storage capacities ranging from 7500 to 30,000 m³. It has been developed to serve a new market by bringing smaller volumes of LNG to areas that are not possible to reach with floating storage and regasification units (FSRUs), or where the building of an onshore facility is not economically viable. For example:

- Where an onshore tank facility is difficult to build
- Where the regulatory permits to build onshore are difficult to obtain
- Where the water is too shallow for FSRUs and large-scale LNG carriers
- Where a temporary solution is needed while more permanent facilities are being developed
- Where limited demand cannot support a large fixed facility or a conventional large-scale FSRU
- Where the demand is temporary, and a solution that can later be relocated or sold elsewhere is preferred
- Where flexibility for adapting to changing market conditions is essential. Capacity can quickly be increased by adding an additional barge.

The Wärtsilä FSRB can be utilised to supply gas for power production or other consumers, to provide LNG bunkering for ships, or for distribution via tanker trucks.
A flexible concept that overcomes infrastructure limitations

The Wärtsilä FSRB is an economically viable, fast delivery solution for providing LNG storage and regasification facilities to areas where the conventional infrastructure is limited, or entirely absent. Consider the advantages that the barge offers:

- It saves time in obtaining regulatory approvals needed by land-based terminals
- It is a high quality solution with a relatively low capital investment, especially for remote locations and islands where local materials and labour may be limited or unavailable
- Since the FSRB is unmanned, operating costs are low
- Delivery time is short, typically one year
- Financing can be easier to obtain since it is a flexible re-sellable asset
Adaptability is a central feature of the Wärtsilä FSRB. Each individual location where an FSRB might be needed is different. It might be on a river or inland waterway, or adjacent to a busy commercial harbour, or within a quiet, low traffic port. It can be in a shallow sea water location or moored in a landlocked lagoon. In all cases, the local weather conditions have to be taken into consideration. While extreme conditions can be handled if the site selection is carefully made, such decisions need to be made on a project specific basis.

Because each location has its own characteristics, Wärtsilä develops different mooring concepts to suit the particular situation. The following five concepts represent typical solutions:

1. **FSRB mooring at shore concept**
   This covers situations where no existing jetty or quay is available. Wärtsilä constructs an appropriate mooring facility to provide a physical connection to dry land.

2. **FSRB mooring at a quay concept**
   In this case, there is an existing quay where both the barge and the visiting LNG carrier can be moored. It is not, therefore, necessary to construct an expensive mooring structure where simple modifications are sufficient.

3. **FSRB mooring at a jetty concept**
   If it is necessary to construct a jetty, its length depends on the local bathymetric water depths. The jetty must be at a depth where small-scale LNG carriers can safely berth and offload their cargo. The FSRB is permanently moored at the jetty and the LNG carrier can dock either next to the barge for ship-to-barge transfer, or can deliver the LNG via cross-jetty transfer.

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1. **FSRB mooring at shore concept.**

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2. FSRB mooring at a quay concept.

3. FSRB mooring at a jetty concept.
4. FSRB as a landlocked concept
Where the local geotechnical conditions are poor, excavations can be carried out to create a small pond or lagoon with an access canal to the open water. When the barge has been floated into the lagoon, the canal is filled in and the barge is ‘landlocked’. It can be moored by ropes to bollards on the land. This is a solution particularly suited to swamps and very low, wet land. A connection will be necessary to transfer LNG from the supplying carrier to the barge. This can be made either by a jetty or by using a floating LNG hose that can be connected to the carrier.

5. Jettyless LNG transfer concept
This solution is applicable when the visiting LNG carrier is conventionally spread moored near shore. The hoses are floated from an on-shore hose reel and the barge is towed out to the LNG carrier for unloading. The barge’s own unloading arm is then attached to the carrier with mooring ropes. This solution enables small-scale LNG transfers to the LNG storage on shore or to the landlocked FSRBs.

We recommend evaluating a combination of options on a case by case basis. For example, the unloading barge and floating hoses can be used also if the existing mooring structures, such as a ready quay or jetty, allow space only for the FSRB. Combining existing installations with low-cost spread mooring can open up new possibilities to transfer LNG ashore.

The illustrations on the right hand page represent examples of ways by which the visiting LNG carrier can be connected to the on-shore storage without a jetty.
5. Barge at shore and LNG connection by floating hoses to barrier.

5. Bullet tanks and LNG connection by floating hoses.
The Wärtsilä FSRB features LNG storage, with capacities from 7500 to 30,000 m³, and a regasification unit. Storage of the LNG is in a number of independent Type-C tanks. When liquefied gas is stored for longer periods, heat flux from the surroundings will increase the temperature inside the tank, thus causing the liquid to evaporate. The generated gas from this is known as boil-off gas (BOG). The BOG has a larger volume than the LNG from which it was created, which in turn increases the pressure inside the tank. The Type-C tanks can handle internal pressures up to 6 bar, which allows them to store the BOG for longer periods, whereas membrane or land-based atmospheric tanks require the BOG to be handled much sooner.

Where the FSRB is supplying gas to a nearby electricity generating power plant, the BOG can be fed easily via a low-pressure pipeline to the plant. This represents a cost-efficient means of handling the BOG. Similarly, waste heat generated by the power plant can be fed back to the barge to be utilised in the regasification process.

Wärtsilä’s regasification technologies are notable for their energy efficiency, robustness, and operational flexibility. We have delivered and commissioned numerous floating LNG regasification system modules based on either closed-loop regasification technology, using steam with water/glycol as the intermediate heating medium, or open loop regasification technology using sea water with propane as the intermediate heating medium. The regasification systems used on the FSRB utilise either the water/glycol system, taking heat from a nearby source such as a power plant, or ambient air vaporisers. Ambient air vaporisers use the heat in the surrounding air to vaporise the LNG into gaseous form.

Examples of FSRBs with different storage capacities:

- Storage volume: 7500-15,000 m³
- Width: < 32 m
- Length: 40-100 m
- Max draught: 4-5 m
Unloading system
LNG storage
Regasification
Electrical and control system
Gas send-out

FSRB with a 15,000 m³ LNG storage.

Storage volume: 15,000-30,000 m³
Width: < 32 m
Length: 80-150 m
Max draught: 5-6 m
The Wärtsilä FSRB opens exciting new opportunities for providing LNG to areas where such supply has not previously been possible or economically viable. It is a solution that is flexible in its application and available in various combinations.

The barge is equipped with similar processes as those on land-based satellite and bunkering facilities. The processes can also be split between the barge and land. This can be achieved, for example, by locating the LNG storage tanks on the barge and the process equipment and support facilities onshore.

Once the FSRB is in position, Wärtsilä undertakes any necessary onshore infrastructure work on a complete turnkey EPC (engineering, procurement and construction) basis. Wärtsilä has extensive experience in such projects having constructed power barges and land-based power plants around the world. Furthermore, our global service network provides maintenance support wherever and whenever needed.

The barge-mounted solution is convenient. It can be delivered on a relatively fast-track schedule and relocated at any time. The modular design of both the barge hull and the onboard storage tanks makes scaling up or down easy, and there is always the option of adding a second barge if one alone cannot provide sufficient storage capacity. The essential point in providing storage and regasification facilities is that the use of natural gas in power generation and maritime applications is increasing at a rapid rate, and the gas needs to be made available where needed. The central question related to this development is which comes first; the supply infrastructure or end-user demand? The Wärtsilä FSRB provides a convenient interim solution until such time as the fixed infrastructure and local demand are in balance.

Furthermore, the overall concept is a cost-effective alternative to the conventional means of bringing LNG to challenging locations. The FSRB costs are competitive since all the engineering and infrastructure arrangements are included in the solution. Furthermore, Wärtsilä offers Operations and Maintenance (O&M) services for the facility. The barge is unmanned during normal operations and because it is unpropelled, there are no special demands or restrictions by the marine authorities. It retains its value well because it can be sold and relocated when no longer required.

By having a floating solution, the safety aspects are enhanced since the barge can be moored at distances away from population centres. Personnel and equipment safety is central to all Wärtsilä’s design and development activities. In ensuring safe and efficient solutions, Wärtsilä has the advantage of deep in-house knowledge and years of experience in serving the LNG needs of the energy and marine markets. We are very much involved throughout the entire gas value chain, from production to end-user applications. We have delivered both floating and onshore receiving and storage facilities, mini and small-scale liquefaction solutions, storage tanks, boil-off gas (BOG) handling systems, tank control systems and regasification units to customers around the world.
Why Wärtsilä?

We make it possible to switch over to LNG, a cleaner and more affordable fuel, in locations where the conventional infrastructure is limited, or entirely absent. Wärtsilä helps you to develop the project rapidly and with lower risk. With us as a partner, you will have a well-functioning asset for years to come.

Projects are customised for customer needs based on a set of pre-defined scopes and proven designs to provide a high quality asset at a competitive price. The scope and quality of our services sets Wärtsilä apart from its competitors, and our range of capabilities is unique. We offer:

- Advice and assistance in deal structuring and financing, including financial modelling and feasibility studies.
- Proven LNG infrastructure solutions supported by LNG Solutions Design team.
- Support in project development by performing pre studies, conceptual studies and FEED study support.
- Complete EPC deliveries with guaranteed pricing, delivery schedules and performance, as well as process solution deliveries.
- The use of professional project management methodology and best practices.
- Operations & Maintenance solutions for guaranteed performance and predictable maintenance costs.
- EPC packages combining both terminals and power plants that create potentially considerable synergistic benefits.

Wärtsilä is proud to serve each customer with the same high level of quality and excellence to ensure that all expectations and priorities are fully understood and met.

Support throughout the entire lifecycle

Wärtsilä’s service network reaches almost all corners of the world. This extensive coverage ensures that plant operators receive fast and effective response to their maintenance needs.

Wärtsilä can also support plant owners with O&M solutions that offer the following benefits:

- **Ensured productivity** throughout the lifecycle of the asset
- **High availability** with minimised unplanned downtime
- **Predictability** of maintenance costs over the medium to long term
- **Attention to safety** and environmental aspects.
Experience and successes

The power barges delivered by Wärtsilä produce over 1 GW of electricity in 8 countries. Below you find some of examples of our experience. Read more about the references at www.wartsila.com.

Santo Domingo, Dominican Republic.

**SEABOARD FLEXICYCLE BARGE**
- Customer: Seaboard Corporation
- Type: Flexicycle 50DF multi-fuel floating power plant
- Operating mode: Flexible baseload
- Gensets: 6 x Wärtsilä 18V50DF
- Total output: 106 MW
- Fuel: Natural gas, HFO
- Scope: Engineering, procurement, and construction (EPC)
- Delivery: 2012

Liir, Papua New Guinea.

**LIHIR GOLD LIMITED POWER UPGRADE**
- Customer: Lihir Gold Limited
- Type: Floating power plant
- Operating mode: Baseload
- Gensets: 8 x Wärtsilä 20V32
- Total output: 71 MW
- Fuel: HFO
- Scope: Engineering, procurement, and construction (EPC)
- Delivery: 2011

San Pedro de Macoris, Dominican Republic.

**SULTANA DEL ESTE (HAINA) POWER BARGE**
- Customer: Empresa Generado de Electricidad Haina, S.A.
- Type: Floating power plant
- Operating mode: Baseload
- Gensets: 9 x Wärtsilä 18V46
- Total output: 158 MW
- Fuel: HFO
- Scope: Engineering, procurement, and construction (EPC)
- Delivery: 2001
DOCTOR BIRD I & II POWER BARGES
Customer: Jamaica Energy Partners
Type: Floating power plants
Operating mode: Baseload
Gensets: 8 x Wärtsilä 12V46 & 3 x Wärtsilä 18V46
Total output: 74 MW & 50 MW
Fuel: HFO
Scope: Engineering, procurement, and construction (EPC)
Delivery: 1994 & 2005

HARIPUR POWER BARGE
Customer: NEPC Haripur Ltd.
Type: Floating power plant
Operating mode: Baseload
Gensets: 8 x Wärtsilä 18V46GD
Total output: 120 MW
Fuel: Natural gas, HFO
Scope: Engineering, procurement, and construction (EPC)
Delivery: 1999

KHULNA TIGER I & III POWER BARGES
Customer: Khulna Power Company Ltd.
Type: Floating power plants
Operating mode: Baseload
Gensets: 9 and 10 x Wärtsilä 18V32
Total output: 110 MW
Fuel: HFO
Scope: Engineering, procurement, and construction (EPC)
Delivery: 1998
Wärtsilä is a global leader in advanced technologies and complete lifecycle solutions for the marine and energy markets. By emphasising sustainable innovation and total efficiency, Wärtsilä maximises the environmental and economic performance of the vessels, power plants and LNG infrastructure of its customers.