DEVELOPER’S GUIDE
to small-scale LNG terminals
Do you know why you need LNG?

So you are interested in one of the coolest fuels on earth and would like help how to go from an idea to a successful project? In this booklet, we will list the things that need to be considered, common stumbling blocks and pointers that will guide you towards your ultimate goal: a small-scale liquified natural gas (LNG) terminal.

Natural gas is a better choice than other fossil fuels from an environmental point-of-view as its use results in lower greenhouse gas emissions and a better air and water quality. Some see LNG as a means of diversifying their energy mix and lessening their dependence on existing supply sources. Since natural gas is cleaner than other hydrocarbons, switching over to it generally results in lower process and maintenance costs. But the most common reason for contemplating LNG is that there is an abundant supply and prices are therefore expected to be affordable and fairly stable for many years to come.

What made you become interested in LNG?

“LNG has a tremendous potential to provide the world with cleaner, lower cost fuel. As it spreads to new industries and consumers, we have realized that there is a need to explain the small-scale LNG value chain and the things to consider when developing these kinds of projects. We hope this booklet will start some great discussions among the players that will make this energy transition happen!”

Alexandre Eykerman
Executive Vice President, LNG Solutions at Wärtsilä
Wärtsilä has the expertise, experience and offering you need. Our offering covers integrated solutions, EPC turnkey delivery, services and products for all phases of the LNG lifecycle. Let Wärtsilä connect the dots that make your life both more profitable – and relaxing. Read more at www.wartsila.com.
The realization of an LNG terminal project might be more complicated than believed at the outset. Usually, several stakeholders need to be committed and must move forward in parallel. Somebody needs to be the leader and take the first step in order for the rest to follow. The more credible the leader, the faster the project will progress. This guide provides a preliminary project development plan and timeline for thinking about different areas of the project. However, due to interdependencies, taking a step forward most often means that you will need to revisit and check if earlier decisions still make sense.

The very first thing that needs to be planned is what your role in the project will be and how you intend to make money from it. Depending on your financial strength, the skills and resources available in your organization, your knowledge about LNG technology and contacts to LNG suppliers and gas consumers, you need to make a decision if you have the stamina to carry out a potentially lengthy project development phase yourself. Also contemplate in which areas you would need to partner up with others in order to take the project to the finish line.

As a reward for your efforts there needs to be a solid business case for you and all the other stakeholders in the project. Whether your interest in the project is that you need natural gas for your industrial operations, power generation or if you will be the operator of the terminal and sell gas and LNG on a tolling basis, the project development steps will be roughly the same.

Project development is essentially all about “bankability” – can the project be financed? An LNG terminal project can be financed by the owner itself if the company has a strong balance sheet. The most common, however, is project financing by lenders. In project financing, allocation of risks is the central issue. Through proper analysis and allocation and mitigation of risks, the developer’s task is to make the risk profile acceptable to the lenders. In many places of the world, it is also possible to apply for subsidies in case the project contributes positively to a country’s energy mix, improves the environment or opens new business opportunities. Such subsidies might come with terms and conditions that impact the setup of the project.

After having built a solid business case and secured financing, you are ready for a final investment decision. Designing and building an LNG terminal that performs as intended also presents many challenges that need to be addressed in order to make the project come to life. Through professional Operations & Maintenance you ensure that the promised value is delivered to the stakeholders over the entire projected lifetime of the facility.
PROJECT DEVELOPMENT

PROJECT CONCEPT
- Project economics
- Business concept
- Site selection
- Technical & commercial feasibility study (several phases)
- Political viability

ENABLING FRAMEWORK
- Select partners
- Negotiate risk allocation
- Onshore and offshore site investigations
- Obtain key agreements
  - Concession
  - Offtake
  - LNG supply
  - LNG vessel
  - Site lease
- Verify project economics
- Preliminary financing plan

PROJECT DEVELOPMENT & NEGOTIATION
- Preliminary engineering (onshore and offshore)
- Obtain permits
- Finalize financing plan and select lenders
- Execute major contracts
  (Offtake, LNG sale and purchase, vessel charter, EPC, O&M, shareholder agreements)

FINANCING
- Issue info memo to lenders
- Finalize term sheet
- Due diligence by lenders
- Finalize loan documentation

CONSTRUCTION & COMMISSIONING
- Site preparation
- Detailed engineering
- Project management
- Equipment delivery and installation
- Commissioning and testing

FINANCIAL CLOSING
- Financial close and Notice To Proceed to EPC contractor

PROJECT OWNERSHIP
- Asset management

OPERATIONS & MAINTENANCE
- Operations management
- Spare parts deliveries and plant maintenance

PROJECT CONSTRUCTION AND OPERATION
Liquefying natural gas is not a new invention. It was done for the first time in 1820 by Michael Faraday. It took until 1941 until the first commercial LNG plant was built in the US. In 1959, LNG was first transported by ship from the US to the UK. Another five years on, there was regular shipping between Algeria and the UK. LNG demand surpassed 100 MTPA in the year 2000 and is now approaching 300 MTPA. LNG is not yet a commodity, but with the speed at which the industry is developing, we are getting closer and closer.

Drivers for LNG

There are three key drivers for LNG:

1. **Energy security considerations and lower energy costs**
   
   Even if gas is accessible through pipelines, many countries and companies diversify into LNG in order to avoid dependency on a single supplier. This flexibility has the potential of lowering energy costs. Also where pipelines are not available and LNG is a substitute for liquid fuels, reducing energy costs is the number one reason for investing in LNG infrastructure.

2. **Requirements for emission reduction in power generation, industry and shipping**
   
   Many countries are implementing legislation to combat climate change and improve air and water quality. Beijing has shut down its coal power plants, the International Maritime Organization has implemented Emission Control Areas for the shipping industry and the EU and the US have strict requirements for power plant emissions. LNG allows companies in many industries to comply with existing and future legislation.

3. **Rapid growth of intermittent renewable power generation and escalating demand fluctuation**

   Renewables are great, but when the sun isn’t shining and the wind isn’t blowing, other power generation assets need to step in. LNG/natural gas is a perfect balancing fuel. In fact, without power plants that can quickly ramp up and ramp down, it isn’t possible to introduce as much renewable energy into the power system as one might like.

The drivers above are just as relevant for small-scale LNG as for large-scale, but the current assumed oversupply of LNG, in combination with innovative new solutions and increased awareness, has boosted interest in small-scale LNG across industries.
Emission Control Areas (ECAs)

Emission reduction with gas

- 25%
- 90%
- 100% - 100%

Particulates
CO₂
NO₂
SO₂

GAS ENGINE
HFO ENGINE

NEGATIVE EFFECTS
CO₂ = Global warming
NO₂ = Smog, acid rain and eutrophication
SO₂ = Acid rain
Particulates = Respiratory problems

Figures are indicative. The exact air pollutant emission reduction potential depends on a range of factors.
Identifying offtakers

The first thing you need to do is to estimate how large the consumption of LNG/gas will be during different parts of the year to come up with a low, normal and high scenario. If the terminal will be utilized only for your own purposes, for example for industrial processes or power generation, this will be a rather straightforward exercise that will produce a fairly exact number. However, if there will be multiple offtakers and LNG/gas demand doesn’t exist immediately, but will develop over time, the process will take longer to finish. Selling the idea of switching fuel to LNG/gas requires many discussions, assisting the potential offtakers in estimating their demand and yourself checking whether the projected demand figures are realistic.

It makes sense to build the project around an anchor customer that can bring large volumes to the table. Energy producers that have gas turbines or engine power plants, mines, refineries, fertilizer plants or metal processing plants are excellent candidates. Additional volumes can be found by investigating any other manufacturing industries requiring large amounts of heat or steam and surveying the local interest in gas driven transportation. While LNG as a fuel for ships, heavy vehicles and high-horsepower equipment currently doesn’t have a large market share, the future potential is expected to be substantial.

While the project developer progresses with trying to figure out what the delivered LNG/gas price will be, the potential offtakers need to calculate what LNG/gas conversion would require from them and how it translates into investments needed and potential gains in operational expenditure. Once the facts are on the table, they can calculate whether LNG/gas would make sense for them and commit to a certain amount of offtake. This is usually an iterative process as potential offtakers abandon or join the project at different stages, which in turn affects the size of the facility, logistics, LNG price and hence, gas price.

Tariffs are set by seeking Net Present Value = 0 (from equity) at the desired Return On Equity (ROE) at slightly lower offtake levels than projected. If the actual levels are higher or lower than expected, there is an upside or downside to the investors’ ROE. If actual offtake levels are considerably higher than expected and best case financial project return conditions are met, there is room for a proportional decrease in tariff for the consumers. It is the downside, however, that needs to be mitigated.

Offtake is usually guaranteed through take-or-pay agreements. This means that consumers commit to a volume, somewhat lower than their planned volume, that they will pay for regardless if they choose to consume it or not. This downside volume that the take-or-pay threshold guarantees, represents the worst case financial project return conditions that will still make the project feasible to investors.

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Forecast demand for small-scale LNG by segment, 2030

<table>
<thead>
<tr>
<th>Tons/year (in millions)</th>
<th>LNG trucks</th>
<th>Marine LNG</th>
<th>LNG power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total demand 2030</td>
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Source: Strategy& “Why small-scale LNG may be the next big wave”, 2017
It makes sense to build the project around an anchor customer that can bring large volumes to the table.
Even though involving multiple parties usually complicates the project, it is often your only way to make it feasible. The reason is that although there is an assumed oversupply of LNG for the near future, options are still few if you need volumes that have to be transported by something smaller than a conventional LNG carrier, but larger than trucks or ISO containers. Large liquefaction plants generally rather serve large customers than small and many large-scale terminals are not compatible with small-scale carriers.

With the saturation of the large-scale market and the growth of the small-scale market, several terminals are seriously looking into reloading or building dedicated break-bulk facilities to cater to small-scale needs. Another option is to contract LNG from small-scale liquefaction plants. However, outside of Europe and Japan, finding a supplier can remain a challenge for the foreseeable future, which is why this has to be addressed at an early stage of a project before going into other details. Another reason why this should be one of the first actions is that the potential limitations set by the LNG supplier may have a considerable impact on the logistics and sizing of the terminal. Often they will specify the size range and configuration of LNG carriers that they can accept at their facility, how often you will be allowed to load a carrier there and the minimum quantity of LNG that they are willing to sell.
DID YOU KNOW?
SMALL-SCALE LNG STILL UNDER DEVELOPMENT

That there are 20 small-scale LNG carriers currently transporting LNG.

That there are only 2 places in Africa that can load LNG tanker trucks or tank containers.

That only two FSRUs have done commercial ship-to-ship transfers to small-scale LNG carriers.

That there are currently less than 30 onshore LNG terminals in the world that can load LNG carriers smaller than 20,000 m³?
Pricing and contracts

Price of LNG is obviously one of the most important points when negotiating an LNG sales contract. The principles of a fair agreement should be that the price provides an acceptable return of investment for both parties' facilities. The seller wants the price to reflect the market value of the gas, while the buyer wants an advantage over competing fuels. Buyers also want the price to mirror the price risk in the sales of their products or services (e.g. electricity). In case of a new market with poor credit ratings, the seller would also require a premium in order to cover the credit risk.

LNG prices are linked to different indexes in different parts of the world and generally small-scale LNG is influenced by large-scale LNG. Most often in Southeast Asia, prices are directly or indirectly linked to Brent crude oil, in Northern Europe to TTF (Title Transfer Facility / Netherlands) or NBP (National Balancing Point / UK) hub prices and in the western hemisphere to Henry Hub (USA). This is understandable as LNG suppliers don’t want to absorb the price risk of buying according to one index and selling according to another. But ideally, the buyer wants to make sure that his fuel costs are lower than the competitor’s. For the buyer whose competitor is using Heavy Fuel Oil (HFO) or Light Fuel Oil (LFO), it would be ideal if the price would be linked to a local index for this fuel, but as they seldom have sufficient liquidity, the seller probably insists on an international index. Brent crude is commonly used as an index, which is beneficial since it is easy to hedge, but there is no guarantee that the price of crude oil and refined products cannot diverge in the future.

Other, more experimental indexing can be considered if the buyer can use other fuels (e.g. a dual-fuel power plant). Then a different index can be chosen, e.g. Henry Hub or NBP, so that one can play with price differences and produce using the fuel that is currently most affordable. Such a strategy might, however, be difficult to align with the Annual Contract Quantities (ACQ).

Gas hubs and oil indexes relevant for the LNG industry

What can be seen in reality is that suppliers of small-scale LNG offer a hub or oil products index plus a fixed component. The fixed component comprises the logistical costs in a Delivered Ex-Ship (DES) contract, but also reduces the transparency of the pricing mechanism. By coincidence or not, the final price often ends up close to the cost of the competing fuel.

The figure on page 13 illustrates the significance of a discount on the Free On Board (FOB) LNG price compared to a reduction in total infrastructure costs for a generic LNG terminal (including marine infrastructure) designed to supply gas to two types of power plants located at a distance of 300 and 600 nautical miles respectively from the LNG supplier. A few cents per MMBTU might sound trivial, but it is apparent that even a minor discount on the LNG price has the same impact as reducing CAPEX spent on the LNG terminal by several million US dollars. Whereas spending less on the LNG terminal will result in lower performance, reliability and perhaps safety, the properties of LNG will not change when lowering the price. The savings also remain
Discount on LNG FOB price compared to a reduction of LNG terminal CAPEX

more or less the same in both low and high price environments.

In addition to price and delivery terms, one also has to pay attention to clauses in the LNG supply agreement relating to duration and quantities. The contract length is often determined by the financing needs of the parties as lenders would like to see the risk of LNG unavailability being mitigated through back-to-back contracts. The trend in large-scale LNG is towards shorter contracts and spot deliveries, but in small-scale LNG one wants to make sure that supply of fuel is guaranteed for a longer time. However, if one expects that the number of suppliers in the region will increase, it might be a good idea with a shorter contract, so that a new contract can be negotiated when the buyer’s bargaining position is better.

One challenge with a long-term supply contract is that the LNG demand may change considerably over the long-term. There are seldom other takers for a small-scale cargo, so the seller wants to make sure that the buyer takes the cargoes that have been assigned to him. Therefore, the contract specifies an Annual Contract Quantity (ACQ). These clauses generally allow for some downward flexibility. The buyer has to pay for the cargoes whether he takes them or not (Take-or-Pay), but the outstanding cargoes should be taken the following year, in addition to the normal ACQ. Strict ACQs and Take-or-Pay work fairly well for national gas grids and baseload electricity production since they can add flexibility through spot purchases, but in small-scale LNG a spot market has not yet really developed. So for example a terminal providing gas for power plants running peak loads would like considerable flexibility when it comes to annual quantities.
Finding and evaluating a location

One thing in small-scale projects that is frequently overlooked are the costs related to site development. There are major differences when comparing large-scale projects with small-scale projects.

Building a large-scale LNG terminal is a major investment of national importance and therefore these projects have often had the luxury of choosing the best possible site. They have either been accompanied by the construction of new power generation facilities or connected to a regional or national gas grid. Moreover, large-scale terminals have enough throughput to be able to absorb the costs of considerable marine infrastructure in order to improve a site and still maintain bankability of the project.

Small-scale LNG terminals are more sensitive to infrastructure development costs due to smaller project size. Although the footprint of the site and the LNG carriers that will deliver to it are smaller, similar safety and availability requirements as for large-scale terminals apply. Construction of a breakwater to protect the facility from the open sea might in some cases be more expensive than the terminal itself. Therefore, the ideal places for a small-scale terminal are for example an existing, low-traffic port or a naturally sheltered location. In some cases, the solution might be the use of new, innovative technology to replace much of the marine infrastructure.

However, often a small-scale LNG terminal is built to serve an existing customer facility of sorts, meaning it needs to be next to that facility, despite that not being the best possible site for the LNG terminal.

If marine infrastructure needs to be constructed, there are many additional things that need to be taken into account:

- Is it possible to navigate a vessel to and from the terminal safely?
- Do the wind and wave conditions allow a vessel to moor and unload safely at all times?
- Can the LNG terminal reasonably absorb the costs of constructing and maintaining the marine infrastructure and approach channel without making the project unfeasible?
- How does the marine infrastructure affect the environment and can we limit or mitigate the impacts so that regulators are satisfied?
Designing the terminal size correctly

When planning the size of the LNG terminal, the current and forecasted offtake provides a natural starting point. There are, however, more things that need to be taken into consideration. The theoretical capacity of a terminal is to a large extent determined by how frequent and how large LNG shipments can be accepted. In order to optimize the value chain, one has to include the supplier, logistics and availability requirements into the equation.

As small-scale LNG supply is still very much in an early phase, one has to be aware of potential limitations regarding the size of vessel that can load at the supplier’s facilities. The supplier may also want to regulate the frequency of how often the small-scale carrier comes to load a cargo in order to minimize disruptions or delay to the large-scale loading/unloading operations.

Given the limited availability of <50,000 m³ LNG carriers in the world, it is not always possible to get the ideal size carrier unless you choose a newbuilding. Having to settle for an existing carrier that is not the optimal size, means that the terminal’s size should be adjusted so that it allows the carrier to transport and unload full cargoes.

Availability requirements also affect the design of the terminal greatly. It is therefore important to know the customer’s operations and their tolerance for the LNG terminal not being able to supply gas. Some have dual-fuel capabilities, which allows for downtime, while others may face huge losses if their industrial processes are dependent on the gas supply. In case there are doubts about the reliability of the supply chain or berthing availability, larger tank capacity is required. Higher availability requirements will increase costs as redundancy of equipment is needed. It will also affect the choice of operations & maintenance philosophy and require more spares at site.

### Tank dimensioning philosophy

<table>
<thead>
<tr>
<th>Function</th>
<th>Criteria</th>
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<tbody>
<tr>
<td>Storage capacity</td>
<td>Send-out rate</td>
</tr>
<tr>
<td></td>
<td>Reserve requirement</td>
</tr>
<tr>
<td></td>
<td>Heel requirement</td>
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</table>

- Optimization of the logistic chain might show that choosing a higher investment in CAPEX leads to lower costs of delivered LNG
- Is the most optimal solution available to you?
- Do you trust the logistical chain to perform as planned?
Land-based or floating?

Floating storage and regasification units (FSRU) were first introduced in the mid-2000s. Nowadays, FSRUs are in many cases the preferred option for new countries looking to import LNG. Does that mean that floating is better than land-based? Not necessarily. If that were the case, then surely strong shipbuilding nations and major LNG importers like Japan, South Korea and China would have chosen FSRUs instead of building onshore terminals. The decision always depends on priorities and site specific conditions.

In small-scale LNG, one needs to consider partly the same drivers. Small-scale onshore terminals are of course much less expensive to build compared to large-scale terminals and floating storage and regasification barges (FSRB) are not as readily available as FSRUs to charter.

Onshore vs floating

Benefits of onshore terminals

- Competitive lifecycle costs for long-term operation
- Permanent asset with high availability
- Local job creation during construction
- Possibility to expand to any size if site permits

Benefits of floating terminals

- Fast track solution that can fill sudden need of gas
- Competitive costs for temporary, shorter-term operation
- Overcome onshore site limitations
- Chartering concept reduces the size of the initial investment

FSRU vs FSRB

Benefits of FSRU

- Suitable for large demand
- More developed market than for FSRB
- Can take a full delivery from a standard size LNG carrier
- Capable of sailing

Benefits of FSRB

- Suitable where demand cannot justify an FSRU
- For shallow waters
- Unmanned, which lowers operating costs
- No need for drydocking
FSRU
Floating storage & regas unit

FSRB
Floating storage & regas barge

FSRU vs FSRB
CAPEX comparison

-40%

M EURO

STORAGE SIZE (M³)

0 50000 100000 150000

0 50 100 150 200 250 300 350

0 50000 100000 150000

FSRU

FSRB
One very basic thing that sets LNG apart from most other fuels is that it is, essentially, a fresh produce. It is a cryogenic liquid that is constantly boiling, with lighter hydrocarbons evaporating first. If left standing for a long time, the LNG will gradually heat up causing ever increasing boil-off rates and the composition and properties of the LNG will change. Because of these traits, LNG tanks need refilling on a regular basis, unlike liquid fuels or propane that can be stored almost indefinitely. Because of this, logistical planning is a key ingredient in developing a successful project.

While LNG can be shipped to the four corners of the world in large-scale LNG carriers, this is not feasible with small-scale carriers. Due to smaller volumes transported; port costs, chartering of ships and other expenses can be significantly more expensive on a per unit basis. Most often, the distances are less than 1500 nautical miles. Transportation using tank containers, tanker trucks and rail cars is also possible. LNG can be stored in these theoretically up to 6-8 weeks, but most often the transportation time is less than two days.

What’s the best way of arranging sea transport for a small-scale project? Most suppliers will offer Delivered Ex-Ship (DES) contracts, which means that the seller bears not only the cost of transportation, but also risk and title until the LNG has been unloaded at the buyer’s facility. This is the preferred option for suppliers partly because it allows them to combine transportation to several offtakers in a milk run and partly because it will camouflage the actual price of LNG.

If your volumes are sufficient and match vessels that are available on the market, you can compare DES prices to a Free On Board (FOB) contract. Under FOB terms, the buyer assumes risk and title after the LNG has been loaded unto the designated LNG carrier and therefore pays for marine transportation, insurance and other fees. Generally speaking, as a newcomer to LNG, the low-risk alternative would be to let the supplier assume responsibility for deliveries.
DID YOU KNOW?
SMALL-SCALE LNG STILL UNDER DEVELOPMENT

In 2018, the number of <40,000 m³ LNG carriers will exceed 40.

A 100 MW baseload power plant needs to be supplied by 21 average size tanker trucks per day.

LNG is regularly transported in tanker trucks in distances up to 2500 km.

The cargoes of the 27 smallest LNG carriers would fit in the cargo tanks of a Q-Max, the world’s largest LNG carrier.
Studies & permitting

There are stringent standards and regulations that cover the construction and operation of LNG facilities. High environmental standards are demanded by local, national and supranational authorities who require extensive environmental assessments of design and operation before granting their approval to construct and operate.

It is of utmost importance to identify the regulatory bodies and to identify the regulatory requirements where the project will take place, in order to structure a realistic and prudent plan for project development. In case of absence of a clear regulatory framework, this is an additional project risk that needs to be considered.

Also, the relevant permits require a series of rigorous safety studies and risk assessments. The main objective is a safe, reliable and operable LNG facility based on a simple and effective design that meets the latest international safety and environmental codes and standards.

Europe employs a risk based regulation where there is freedom to make design choices as long as it can be proven that the risk level is acceptable. US on the other hand has traditionally been relying on prescriptive regulation, but is now also moving towards risk based regulation. Nowadays, the authorities have the option of choosing either of the methods. Other countries employ one or the other of these methods.

Risks to public, personnel and property must be closely examined through:

- Documentation of conditions at the project site and in the vicinity
- Staged design development and engineering phases
- Risk assessments
  - QRA – Quantitative Risk Analysis – simulation of worst case scenarios based on design data and scenarios from other safety studies
  - FERA – Fire and Explosion Risk Assessment
  - HAZID – Hazard Identification
  - HAZOP – Hazard and Operability study
  - SIL – Safety Integrity Level study.
- Siting – establishing safety distances for the operation
- Verification – confirmation that design is in accordance with requirements & recognised standards and that agreed safeguards are implemented
“It is of utmost importance to identify the regulatory bodies and to identify the regulatory requirements where the project will take place, in order to structure a realistic and prudent plan for project development. In case of absence of a clear regulatory framework, this is an additional project risk that needs to be considered.”

Jarno Jussila
Senior Application Manager
Managing project construction

Companies that are developing an LNG terminal project eventually need to make a decision how to manage the construction of the project. Does the developer have own capacity and capability of conducting project management, procurement and legal contracting? If there aren’t enough competences to do everything themselves, there are two basic options; EPC (engineering, procurement, construction) or EPCM (engineering, procurement and construction management).

EPC means that a company is contracted by the owner to provide engineering, procurement and construction services, normally for a lump sum, to deliver the solution defined in scope of work and minimum technical specifications. The EPC contractor guarantees schedule, cost and performance and is the owner’s single point of contact as it is the EPC contractor that has direct contracts with the construction contractors.

EPCM means that a construction management (CM) or project management (PM) company manages the project on behalf of the owner, but the EPCM contractor is not directly involved in the building and construction of the project. The PM/CM company is compensated with a CM fee which may contain a reimbursable element and an incentive for meeting targets. The EPCM contractor has a duty to ensure that the engineering and design of the project is in compliance with the project’s technical and functional specifications. Supervision, management and co-ordination of construction interfaces in accordance
with a detailed schedule is the key responsibility of the EPCM contractor. However, in this model, it is the owner, not the EPCM contractor, that has a contractual relationship with the trade contractors and other sub-suppliers. The EPCM contractor does not account for liability to any risks related to cost, schedule or performance in excess of its CM fee.

In theory, an EPCM contract can show lower investment cost if the owner is capable of assuming the risks. That, however, only materializes if all the risks have been identified and if the owner has sufficient know-how and resources to mitigate those risks. For investors and financing institutions it is a prerequisite that someone is taking construction risk (i.e. guaranteed price, guaranteed time schedule and guaranteed performance) and also O&M risk of ensuring continued plant performance and asset management. Since mitigation of those risks are included, investment cost of an EPC contract with guarantees are comparably higher than the initial estimate of investment cost for an EPCM contract. In addition to the guarantees, the benefits of the EPC contract include access to better project financing arrangements.

### Comparison between EPC and EPCM

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<thead>
<tr>
<th></th>
<th>EPC</th>
<th>EPCM</th>
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</thead>
<tbody>
<tr>
<td><strong>PRICE</strong></td>
<td>Fixed price / Lump sum contract</td>
<td>Rate based / Cost plus</td>
</tr>
<tr>
<td><strong>TIME SCHEDULE</strong></td>
<td>Fixed date for completion</td>
<td>No fixed completion schedule</td>
</tr>
<tr>
<td><strong>RISK</strong></td>
<td>EPC contractor holds risk</td>
<td>Owner holds risk</td>
</tr>
<tr>
<td><strong>ACCOUNTABILITY</strong></td>
<td>EPC contractor accountable</td>
<td>Multiple parties accountable for their own scope</td>
</tr>
<tr>
<td><strong>PROCUREMENT</strong></td>
<td>EPC contractor’s responsibility</td>
<td>EPCM contractor only acts as agent for the owner</td>
</tr>
<tr>
<td><strong>QUALITY / PERFORMANCE GUARANTEE</strong></td>
<td>EPC contractor responsible for the performance of the complete LNG terminal</td>
<td>EPCM contractor does not provide performance guarantees</td>
</tr>
<tr>
<td><strong>DEFECTS</strong></td>
<td>EPC contractor’s responsibility to fix</td>
<td>EPCM contractor assists owner to manage fixing of defects</td>
</tr>
</tbody>
</table>
Operations & Maintenance

Developing and building an LNG terminal presents many interesting challenges, but the work is not done when the facility is built. The single most important task once the LNG terminal has been commissioned is to ensure that it operates safely at all times. What owners and lenders are looking for is primarily predictability of operations and maintenance costs over medium to long term. Customers are expecting a high availability with minimized unplanned downtime.

In order to meet all of these expectations, there needs to be an appropriate operations & maintenance philosophy. The owner should decide whether to operate the facility themselves, outsource operations or a hybrid version where operators are trained on the job by an external company that later transfers responsibility. In any case, it is very valuable to be able to utilize experienced professionals in whatever role is needed, as consequences of poor performance or failing safety are likely to have serious consequences.
“In this booklet, we have outlined the major considerations for successfully developing a small-scale LNG project. The main point that I would like to convey is to focus more on the value chain than on the technology of the terminal itself. Therefore, we have compiled a list of common pitfalls that we want to share with everyone.”

John Reinlund
Business Analyst

COMMON PITFALLS

COSTS
- Lack of willingness to invest the money needed upfront for the development process.
- Project costs make the project unfeasible - especially the marine infrastructure can be too expensive for a small-scale project

LACK OF KNOWLEDGE
- LNG is new to authorities, so it takes time to identify requirements for FEED study & tender
- Lack of understanding leads to poor tenders that need to be retendered
- Believing that there is a good, cheap and safe “miracle technology” that can solve all problems. Having too little knowledge about what an LNG project actually costs often leads developers to ask for second opinions from consultants and suppliers which can delay a project indefinitely.
- Failure to sign up customers with sufficient demand
- Failure to arrange financing due to not having access to the right financing channels
- Poor understanding of the requirements, lack of options or the need to be near existing assets leads to the choice of a poor site

LNG PRICE AND SUPPLY OPTIONS
- Difficulty to estimate what the small-scale LNG price will be makes the project risk too big
- There is no supplier of LNG in small quantities nearby
- Small-scale logistics drive up the LNG price so that the project isn’t feasible
Wärtsilä can take either a supporting or a leading role in the customer’s LNG project development process. In a supporting role, we provide technical and commercial input to our customers or the customer’s design consultant for their traditional conceptual and feasibility study. If Wärtsilä participates in a LNG project as a co- or lead developer under a joint development agreement, development costs and responsibilities can be shared between the developers.

**PROJECT DEVELOPMENT**
Wärtsilä Development & Financial Services is the development and project finance arm of Wärtsilä. WDFS develops independent power producer (IPP) and LNG terminal projects employing Wärtsilä technologies and know-how. Over the years, the professionals at WDFS have proven their ability to mobilise capital from multilateral and bilateral institutions, local and international commercial banks and equity investors, affording low cost of capital and positive project benefits. With a proven track record since 1991, WDFS continues to successfully develop green field LNG and IPP project opportunities worldwide.

The primary business focus of WDFS is to create and structure investment opportunities using Wärtsilä technologies. The WDFS objective is to pursue strategic project opportunities where the involvement of Wärtsilä is required beyond the sale of equipment and services. Such additional involvement includes:

- Comprehensive project development services
- LNG or power sales and related contract negotiations
- Project permitting, including environmental approval
- Equity participations in IPPs
- Securing non-recourse or limited recourse project financing
Front-end work services

Choosing Wärtsilä’s collaborative front-end work services over a traditional Conceptual – Feasibility – Pre-FEED – FEED – Tendering process offers valuable benefits:

- A collaborative approach to the project definition phase shortens time to Final Investment Decision (FID), allowing the customer to act on business opportunities first and make money sooner.
- A collaborative approach leads to fewer uncertainties regarding the scope of work and therefore lowers both the project risk and cost.
- A good project definition that takes Wärtsilä’s technological and organisational strengths into account ensures constructability and solutions fit for the purpose of small-scale LNG at lower CAPEX and OPEX without compromising sustainability, functionality and safety.

The outcomes of the pre-study, conceptual study and FEED support study will support the investor’s feasibility study.

PRE-STUDY
The pre-study defines the project frame and gives an understanding of possible solutions to be further evaluated in a Conceptual Study. The result of the pre-study engineering service is a cost indication and project requirement overview.

CONCEPTUAL STUDY
The conceptual study is a project specific study with clear deliverables. Wärtsilä offers and executes the Conceptual study on contract basis. This is an extended study focusing on defining and evaluating 1–2 concepts identified in pre-study.

The result of the study is to initially define the most feasible solution. Tolerances of project cost estimate depend on how much pre-work and information is available, and agreed scope of the conceptual study. Project cost tolerances are in the range of –15% to +30% of total project cost. Tolerances can be less if more information is available.

FEED SUPPORT STUDY
The FEED support study is also based on a project-specific offer and it is executed under contract with clear deliverables. This FEED support is done together or in parallel with our customer and provides a basic design and engineering study of the complete project, including project-specific inputs for permits required for the project. The result of the FEED support study is a firm EPC proposal without tolerances for a Final Investment Decision (FID). Wärtsilä offers its customers a guaranteed price and schedule that eliminate the risk of cost overrun and ensures bankability of the project.
# Front-end work services by Wärtsilä

<table>
<thead>
<tr>
<th>IDEA</th>
<th>PRE-STUDY</th>
<th>CONCEPTUAL STUDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>MUTUAL UNDERSTANDING OF THE PROJECT</td>
<td>DEVELOP THE BEST CONCEPT</td>
<td></td>
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<table>
<thead>
<tr>
<th>TARGET</th>
<th>ACTIVITY BY WÄRTSILÄ</th>
<th>DESCRIPTION</th>
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</thead>
<tbody>
<tr>
<td>MUTUAL UNDERSTANDING</td>
<td>Wärtsilä provides an order of magnitude capital cost estimate range.</td>
<td>Desktop study where Wärtsilä identifies possible technologies (1 - 5 options) and major equipment. Based on that an order of magnitude capital cost estimate is generated.</td>
</tr>
<tr>
<td>DEVELOP THE BEST CONCEPT</td>
<td>Wärtsilä conducts further assessment of the alternatives, risks, and uncertainties. The most promising development concepts will be the base for the FEED support study.</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>DELIVERABLES</th>
<th>30</th>
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<tbody>
<tr>
<td>BROCHURES &amp; PRESENTATIONS</td>
<td>Pre-study report (4 - 6 pages)</td>
</tr>
<tr>
<td>CONCEPTUAL STUDY REPORT</td>
<td>Conceptual study report (6 - 10 pages)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>DELIVERY TIME</th>
<th>30</th>
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<tbody>
<tr>
<td>1 – 3 days</td>
<td>1 – 3 weeks</td>
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<tr>
<td>3 – 12 weeks</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>PRICE ACCURACY</th>
<th>30</th>
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</thead>
<tbody>
<tr>
<td>PROJECT COST INDICATION</td>
<td>CLASS 4 (-20 to +40%)</td>
</tr>
<tr>
<td>CLASS 3</td>
<td>(-15 to +30%)</td>
</tr>
</tbody>
</table>
The FEED support study and basic engineering will establish the specific set of process operating conditions and equipment necessary to achieve the level of reliability, efficiency and safety required.

All costs incurred through performed studies to be deducted from contract price when the EPC contract is signed.

FEED support study report (20 - 100 pages)

16 – 30 weeks

CLASS 2 ( -10 to +10%)
CLASS 1 ( ±0% )
Wärtsilä’s Project Management organisation plans, leads, manages and executes projects for customers. We support our customers with cost estimates, scheduling and project planning.

The Project Management process at Wärtsilä Energy Solutions is based on the Project Management Institute’s (PMI) standards, the PMBOK® Guide, ISO 21500, ISO 10005 and Wärtsilä best practice and experience.

Each project will be assigned a dedicated Project Management Team led by a Project Manager. The Project Manager is fully responsible for achieving the agreed objectives and requirements and is empowered to represent Wärtsilä as EPC contractor. Wärtsilä Project Management Teams have executed thousands of projects over the last three decades with acknowledged track record. More than 500 projects have been executed including infrastructures, civil works and building structures on EPC basis. The challenging project locations have varied from Siberian tundra to African rain forest, or from the Caribbean shores to Himalayan mountains. Our aim is not only to deliver the project on time, but work sustainably as well as enhance safety and offer the best possible working conditions both during construction and for the facility operators.

**CAPABILITIES**

- Inter-disciplinary team of more than 200 Project Managers and Project Engineers with 100+ PMI certified professionals
- Project control and planning team
- Certified HSE Management System OHSAS 18001 & ISO 14001. Lost Time Injury Frequency (LTIF) ≈ 1.0 (EPC construction sites)
- Quality Management System ISO9001
- Efficient sourcing process and well-managed supplier base
- Experienced construction management team of 400+ engineers
- Established network of partners, engineering, manpower etc.
- Sustainable construction strategy utilising qualified subcontractors with positive local socioeconomic impact

**INFORMATION SYSTEMS**

- Project Portfolio Management (Clarity)
- Schedule Management (built on MS Project)
- Document Control Management (DCM365) to manage collaboration, submittals and interfaces between project stakeholders
- Digital Document Repository (IDM) for document management
- Project Quality Management Plan (PQMP) Configurator
- HSSE Incident Investigation and Reporting tool (We-Care)
- Management of Construction Site Information (Site 365)
- Commissioning Management (SQAD) to generate and configure projects’ Quality Assurance / Control Documentation
- Project Logistics and Material Management (LOGWIS)
**DELIVERY METHODS**

Wärtsilä believes that complete Engineering, Procurement, Construction (EPC) is the delivery method that provides the best value to customers. With EPC, the customer does not need to commit as much time and resources to administration, legal consultations and contractual setup. More importantly, it also significantly reduces the customer’s risk by offering a guaranteed price, delivery date and performance. Having eliminated these risks is often a pre-requisite for the bankability of the project.

The following variations are offered:
- EPC turnkey (Wärtsilä-developed project)
- EPC including front-end work done by Wärtsilä on a reimbursable basis
- EPC based on front-end work done by the customer’s design consultant
- EPC / EPCIC excluding civil works, based on front-end work done by the customer’s design consultant

**Project management value proposition**

- Pre-fabricated product minimizing site work
- Global network of proven partners and suppliers
- Earlier access to market
- 25 years of EPC construction experience in 90 countries
- Quality assured, professional project management
- Experienced personnel and partners
- Access to all Wärtsilä experts and resources
- Risk reduction
- Improved bankability

- Early involvement enables proactive and collaborative project approach
- Listening to customer needs
- Open communication
- Customer Relation On-Line process CROL®
- Clear and managed contractual interfaces
- Reduced project complexity
- Optimal scope of supply through several scope packages
We ensure your LNG facility operate in the most energy-efficient way and that your LNG facility is operated in accordance with regulations.

We agree on performance targets based on measured data. We guarantee that your performance targets are reached and that the target level is maintained. Our holistic approach goes beyond maintenance and operations. We combine remote services and advanced analytics to support on-site activities and to help match maintenance to your operating profile.

**MAXIMISE THE PRODUCTIVITY THROUGH A MAINTENANCE SOLUTION**

With a maintenance solution you can ensure the certainty of operations by transferring responsibility for maintenance of your LNG facility to Wärtsilä. This is a proven way of keeping your LNG facility productive and profitable throughout the asset lifecycle. With this lifecycle solution you can maximise the lifetime for your LNG facility and optimise maintenance costs in a safe, reliable, and environmentally sustainable way.

**ONLINE REMOTE OPERATIONS SUPPORT**

With online connection, we can remotely log into the plant control system and review operations. The operational data is retrieved for trend analysis which enables us to provide recommendations for fine-tuning of operation as well as maintaining and upgrading your equipment.

**MAINTENANCE MANAGEMENT**

This service covers maintenance planning, parts logistics, manpower coordination and maintenance reporting. In order to perform maintenance efficiently and reliably, we ensure that required manpower and spare parts are available for planned maintenance.

**TECHNICAL SUPPORT**

Technical support to resolve your operational problems is available by telephone and email, within agreed response times. Further, we visit your installation to perform technical evaluations. By reviewing trends, we can recommend improvements which can be implemented separately, as agreed.

**SAFETY & CAPITAL SPARE PARTS**

We recommend that you maintain a stock of critical spare parts, especially for parts with long lead times for delivery. If you require, we can manage these stocks for you.

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**Scope of supply**

- Online remote operations support
- Maintenance management & planning
- Technical evaluation
- Operational data analysis
- Technical support
- Spare parts for planned maintenance
- Manpower for planned maintenance
- Inventory management
- Safety stock & onsite tools
- Capital spare parts
Benefits of Wärtsilä’s lifecycle services:

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

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