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Base load floating regasification

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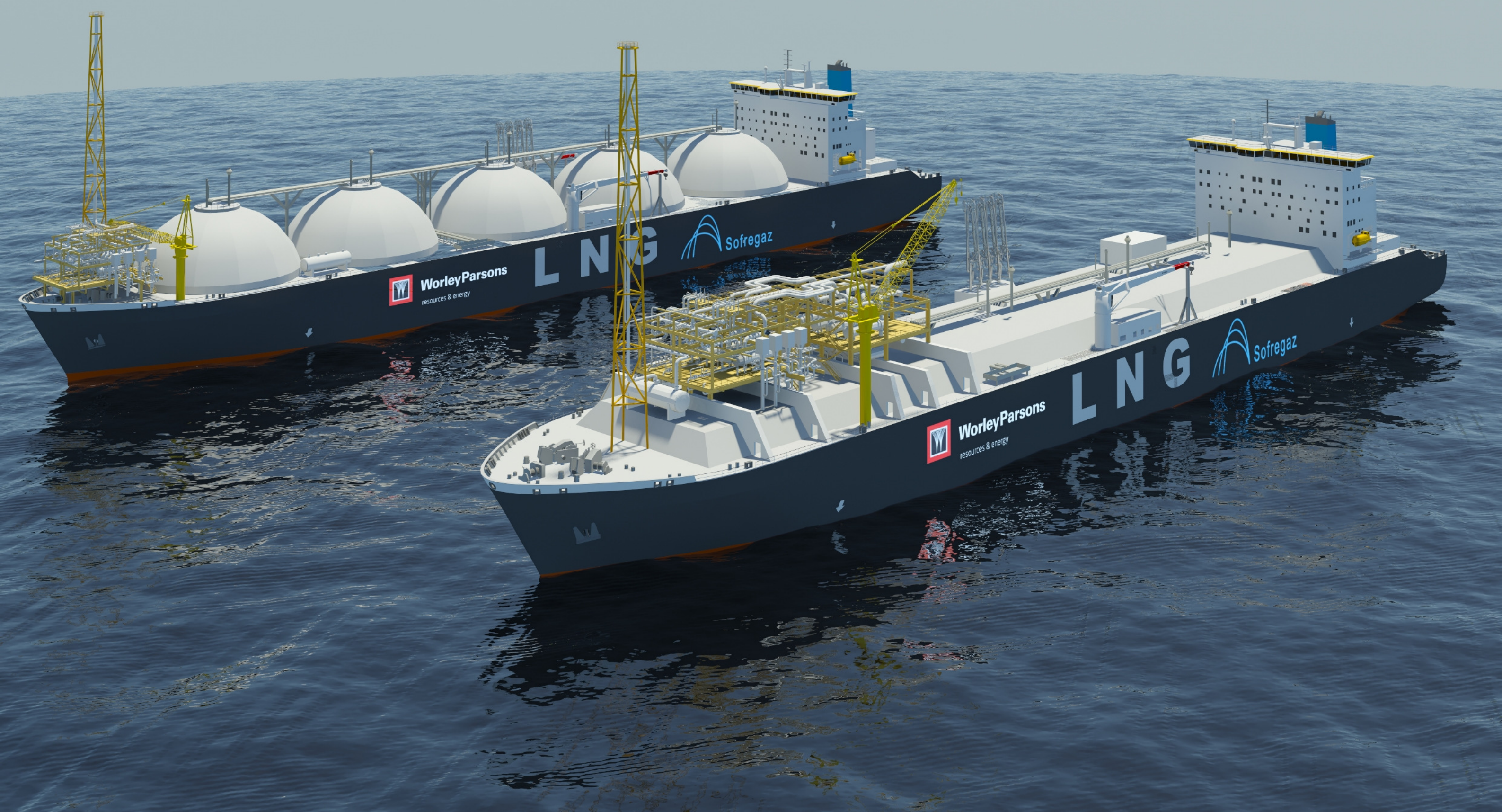
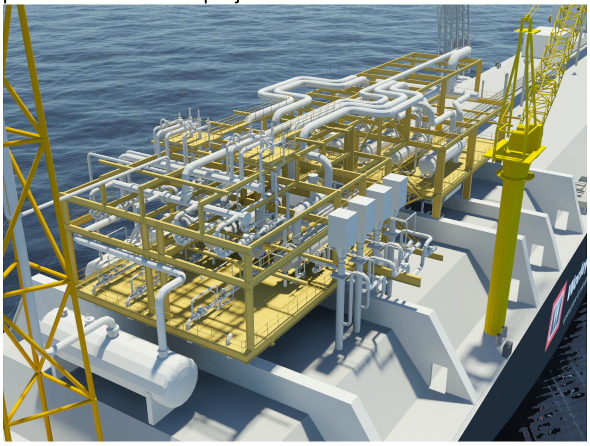
In the context of rising global energy demand and the need to diversify the fuel mix to better compensate for fluctuations in the market in highly populated areas where space for shore facilities is scarce, floating regasification developments are on the rise. Indonesia is currently planning to build three floating regasification terminals. Pertamina will build a floating terminal in East Java; PGN will build another near Medan in North Sumatra, and the two companies have teamed up for a floating terminal near Jakarta in West Java. In the northern hemisphere (Europe and North America), the majority of floating regasification import terminals provide for seasonal demand. In equatorial countries such as Indonesia, where the natural gas is predominately used for power generations, the need for a constant gas flow requires base load facilities to achieve annual availability of gas delivered of better than 98%. This places high demand on operability and maintainability of the equipment, and the regasification unit design.



WorleyParsons-SOFREGAZ alliance floating regasification system

Background

WorleyParsons gained significant experience in floating regasification technology from a number of projects, most notably during front end engineering work performed for BHP Billiton's Cabrillo Port floating storage and regasification unit (FSRU), and through the co-operation with SOFREGAZ on the shore-based Singapore LNG terminal. Following of from the Singapore LNG terminal project, WorleyParsons and SOFREGAZ formed an alliance to develop floating regasification systems. The alliance brings together SOFREGAZ's shore based experience from over 800 LNG regasification projects and WorleyParsons experience from over 70 floating production offshore projects for Oil and Gas.



WorleyParsons-SOFREGAZ alliance floating IFV regasification system with propane cycle.

WorleyParsons are in the process of completing it's scope on the Jakarta Bay (West Java) regasification project, where the company was contracted to undertake feasibility studies for the floating regasification terminal including the design of the mooring system, the subsea and riser systems, pipeline to shore and on shore receiver. The scope also included the preparation of the ITB package, for the first base load floating regasification development in Asia. This activity and the formation of the alliance led to the review of base load floating regasification requirements, and the development of a floating regasification system by the WorleyParsons-SOFREGAZ alliance that could be utilised on other floating regasification projects.

Markets

The design of floating regasification terminals are driven by the types of markets they serve and there are generally two distinct types of markets:

- Seasonal load markets, typically located in the northern hemisphere (Europe and North America).
- Base load markets, typical of equatorial countries.

In seasonal load markets, the regasification terminals are generally designed to provide gas during periods where there is an increase in energy demand as a result of seasonal changes, such as the increased energy demand for heating during colder seasons. In these markets, gas is generally provided by a main supply source (such as gas via pipelines), with the floating regasification terminal providing the supplemental gas supply to cater for peaks in the seasonal demand. In contrast to seasonal load markets, gas demand in base load markets is characterised by a constant base loading with routine daily fluctuations as a result of human activities. It is further expected that, as the local economy grows, the base loading would grow in parallel with the economy in order to satisfy its energy demands.

To gain some insight on the potential growth of base loading gas demand and its impact on the design of base load regasification terminals, WorleyParsons recently carried out a study on energy demand in Indonesia. This study indicates a 10% power demand increase in Jakarta over 2008 - 2009, and that this trend (10% annual power demand increase) is expected to continue in the short to medium term over the Java-Madura-Bali region. With floating regasification terminals typically having a 20 - 40 year life cycle, a 10% annual power demand increase would mean a doubling of power demand approximately every seven to eight years. If additional gas supplies are not sourced to meet this demand, it is likely that the regasification terminal serving the Indonesian market will require at least a doubling of its regasification capacity over a 20 year life cycle. In some cases this could mean that the regasification capacity needs to increase from a nominal 1.5 million tpa of LNG during the initial years of operation, to 3.5 million tpa over a 20 year life cycle. The design of base load regasification terminals therefore needs to consider not only the potential doubling of regasification capacity, and to cater for this change in demand in an economically prudent way, but also needs to meet the daily demand fluctuations by having the ability to ramp-up and ramp-down gas production, caused by the power plant duty cycles and the lack of a wider natural gas grid smoothing the sharp peaks in the demand curve. These challenges can be addressed by careful consideration of the following:

- Terminal flexibility.
- Terminal availability.
- Economic viability.

Terminal flexibility

Designing for terminal flexibility addresses the challenge of keeping up with annual base load demand growth, as well as the routine daily demand fluctuations. Catering for future base load demands during the design of floating regasification terminals is not only capital intensive, it is also operationally inefficient as the regasification equipment is operated below capacity (at least during the initial years of operation), not to mention the higher maintenance expense that will be incurred in the meantime. To provide an economically attractive solution and to cater for the increased demand, a flexible design that allows the terminal regasification capacity to be staggered is required. This not only provides savings during the initial capital works, but the flexible design allows the terminal to keep up with actual market demands (as opposed to projected market demands).

To design for daily demand fluctuations, detailed knowledge of the nature of fluctuations is required. This allows correct sizing of key regasification components (such as pumps and vapourisers) and the development of operational philosophies to provide ramp-up and ramp-down capability.

Terminal availability

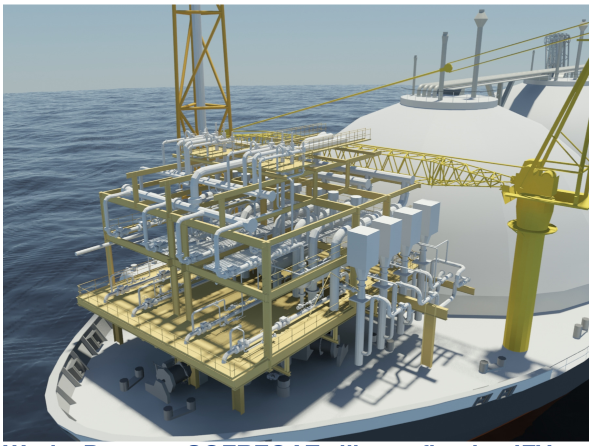
Terminal availability is a measure of the time where the terminal is online and supplying gas to the onshore power plants/gas distribution grid. Availability is commonly expressed as a percentage on an annual basis. For example, a terminal with 98% availability annually will mean that the terminal is supplying gas approximately 358 days of the year. For base load regasification terminals, high availability is driven by market demands and is a strict requirement (generally above 98%). This high availability means that the terminal either has to be permanently moored or the facility has to utilise two regasification vessels that can be alternated; the latter solution would incur significantly higher capital expenditure and operational cost. In contrast, the availability for seasonal load markets would only have to be 40 - 60% annually (market dependent) to satisfy the seasonal demands and for these markets, a permanently moored facility is therefore not required.

The requirement of a permanently moored terminal means that it is not possible to remove the facility for lengthy service periods in a dock/shipyard. This necessitates careful consideration during the design process, especially in the design of the regasification (process) equipment and LNG storage tanks. The challenges in designing regasification equipment lie in the marinisation process (adapting land based regasification technology for the offshore environment) and in ensuring high availability of the equipment. Both of these challenges can be addressed by a design centred on minimising downtime (via designing for operational flexibility that allows continuous operation during partial equipment failure) and minimising maintenance/repair operations offshore. Another challenge is the selection of the appropriate LNG cargo storage system. The challenges associated with LNG storage tanks are not only sloshing related, but also relate to the maintainability/routine inspection of the storage tanks without bringing the facility into a dock/shipyard. Some LNG tanks technologies such as IMO type B and C tanks are better equipped to overcome those issues than integrated tank systems.

Economic viability

The third challenge deals with the economic viability of the regasification terminal. Economic viability assessments not only need to consider capital expenses (CAPEX) and operating expenses (OPEX), but also need to consider life cycle costs associated with sourcing and delivery of LNG to the regasification terminal, to ensure that supply of LNG maintains a high availability and to ensure that the increasing base load demands are met.

Evaluation of the life cycle cost can be carried out in two stages. The first stage is to identify LNG supply terminals that would provide gas matching the specification requirements of the local power plants and terminals that would provide the required volume of LNG to meet the gas demand. Gas specifications would include gas molecular composition and heat values. Where the gas specifications do not match the requirements of the power plants, additional process equipment could be added to the regasification terminal or the power plants to ensure compatibility, although this would be at an additional cost. Having identified suitable LNG supply terminals, the next stage is to manage the logistics of delivering LNG to the



WorleyParsons-SOFREGAZ alliance floating IFV regasification system with glycol cycle.

regasification terminal. To achieve an optimised logistics chain, a large number of factors need to be considered, including the size and type of LNG carriers, storage capacity of the regasification terminal, route selection and so on. This would typically entail a large number of scenarios to be considered during the initial planning stages, in order to fully understand and identify the key drivers of the life cycle costs. To study large numbers of sensitivity scenarios, WorleyParsons developed in-house software tools which can carry out economic feasibility assessment for floating regasification terminals, including logistic chain optimisations, LNG carrier and regasification terminal sizing optimisations and economic assessment. The three cost factors (CAPEX, OPEX and life cycle costs) are evaluated over the lifetime of the terminal including the projected growth in gas demand.

These challenges will need to be addressed at a high level from the initial phases of such projects, with emphasis on establishing viability, availability and reliability of the terminal. This can be achieved by carrying out a number of studies, including:

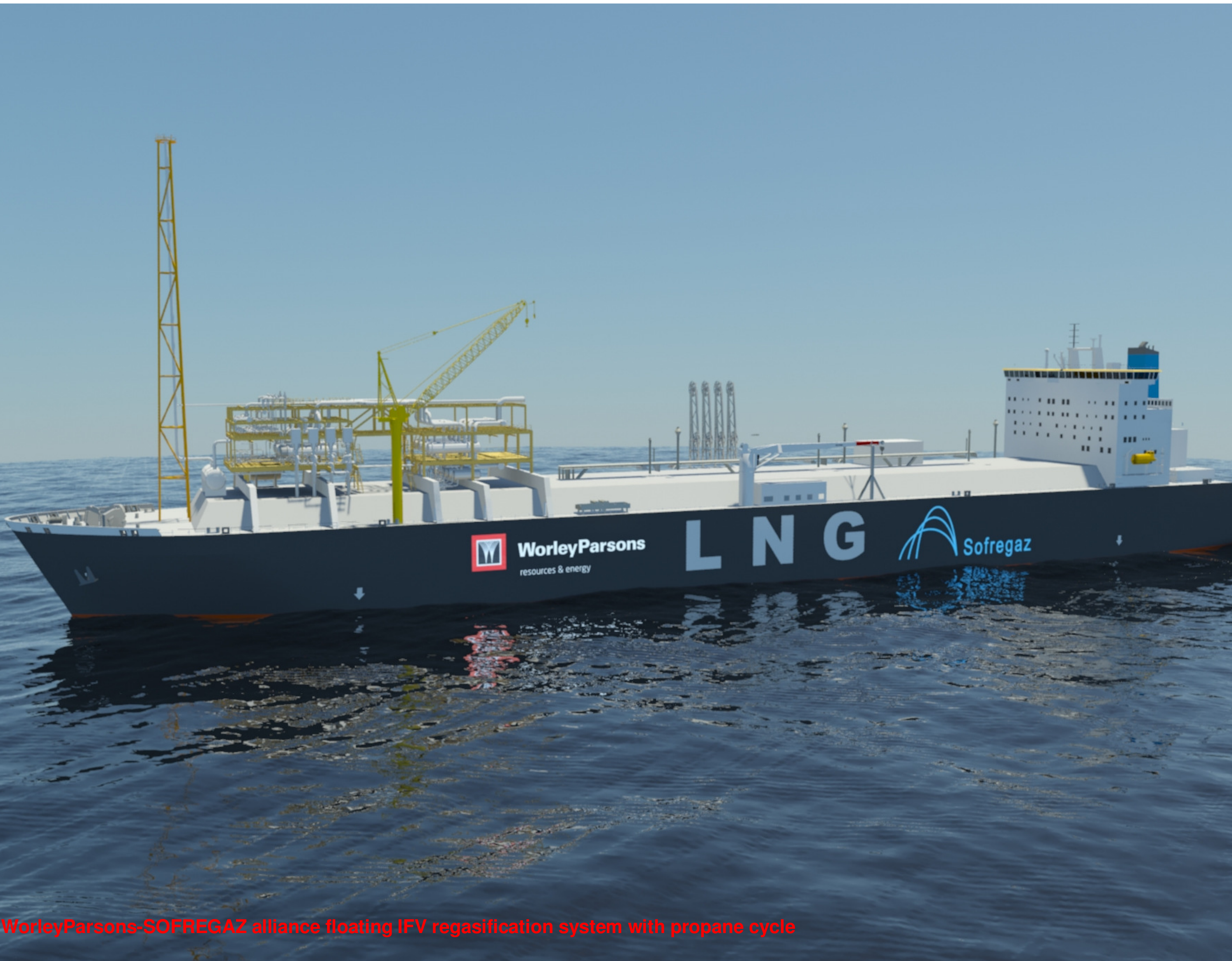
- Market study: to establish the base loading characteristics and growth;
- Environmental study: to establish suitable regasification equipment and terminal locations;
- Regasification technology selection; and
- Economics study: to consider the terminal cost and projected revenues, and to provide preliminary refining of LNG supply logistics.

Regasification technology development

For the Jakarta Bay floating terminal (West Java), WorleyParsons carried out a regasification concept selection (where existing shore based regasification technologies were evaluated against their marinisation ability and offshore operability) and carried out preliminary designs for intermediate fluid vapourisers (IFV) and ambient air vapourisers (AAV). The review also revealed that some of the systems currently in use on floating regasification units limit the ability to maintain the systems offshore. Based on this experience, the WorleyParsons-SOFREGAZ alliance developed an 800 million standard ft^3/d IFV vapourisation system, in which glycol or propane is used as intermediate fluid and seawater as primary heating medium. Both systems (glycol or propane) can be used for newbuild FSRUs or converted LNGC to FSRU facilities. The system makes use of offshore oil and gas standards to provide the reliability and maintainability required for greater than 20 year lifetime on station. In addition, the system is highly flexible, allowing for the fluctuation of the power plant loads and also the ability to increase the regasification capacity over the life of the facility as demand increases, i.e. “a fit for but not with” philosophy was adopted, to minimise the initial capital expenditure and to keep the operational cost as low as possible, by avoiding the need to maintain equipment that is not required in the early life of the facility. The IFV system was chosen for its compactness, the ability to marinise the system, the track record of comparable systems in the industry and in the floating production industry. At the core of the system is a shell and tube vapouriser through which the high pressure LNG is vapourised into natural gas using glycol or propane as a heating medium. This type of system was also chosen because it is considerably more environmentally friendly than closed loop systems which require gas to be burned to heat the LNG. Depending on the power generation the system provides a 75% CO_2 emission reduction compared to a system that uses submerged combustion vapourisers (SCV) of similar capacity.

Moving forward

Whilst this article focuses on base load terminals, the less onerous design challenges associated with seasonal load terminals make base load terminals ideal for use in both types of markets. With energy demands in major South East Asian hubs set to increase over the foreseeable future, floating regasification terminals represent an economically and technically attractive solution to meet their energy and gas supply requirements. Recognising this future demand, the WorleyParsons- SOFREGAZ alliance are currently engaged in discussions with several regasification terminal owners, operators and local government bodies to progress the development of floating regasification terminals into the next phase, and to explore world wide opportunities for its floating regasification systems.



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