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Australian operational focus leads to successful GLNG performance

GLNG is a joint venture between Santos of Australia, PETRONAS of Malaysia, Total of France and KOGAS of South Korea. The joint venture extracts gas from coal seams in the Surat and Bowen basins of Queensland which is transported by high pressure pipeline to Curtis Island, off the coast from Gladstone, for conversion to LNG.

The Curtis Island facility comprises a two-train LNG plant - each train with nameplate capacity of 3.9 million tonnes per annum, two 140,000 cubic metres capacity LNG storage tanks and a product loading jetty.

GLNG awarded Bechtel the front-end engineering and design contract for the Curtis Island facility way back in December 2008, followed by the engineering, procurement and construction contract in January 2011. A proven lump-sum, turn-key (LSTK) contractual approach was implemented, where the contractor maintained responsibility for commissioning and start-up (CSU) and operations until the performance test and other turnover criteria were met.

**Strategy**

This strategy integrates owner and licensor personnel into the contractor’s CSU team and enables a smooth transition from contractor to owner at the turnover of an operational plant that meets production targets.

GLNG resourced the project with a strong owner’s project team and from the earliest stages of design, incorporated key members of the operations team to maintain a focus on start-up and operations throughout all project stages.

A fully integrated CSU team from GLNG, Bechtel and ConocoPhillips was formed in the earlier stages of the project. This team worked together throughout the different phases of CSU and through operation of the LNG plant.

Bechtel and ConocoPhillips also developed an intensive operations training program, which was provided prior to CSU and supplemented with “on the job” training throughout the CSU process. This ensured that at plant handover the GLNG team was fully proficient in the operation of the facility.

As with any large project, a few issues occurred during start-up and the first year of operation, which required resolution.

Nevertheless, the facility’s performance and relatively limited occurrence of serious operational problems are positive testament to the liquefaction technology selected and the collaborative operations team’s focus throughout all project phases.

Once installed, the technology is simple and easy to operate. Additionally, it allows for faster commissioning and startup, since commissioning can progress in some sections of the plant while construction continues in the remaining sections.

First LNG production from GLNG’s Trains 1 and 2 was achieved in September 2015 and May 2016, respectively. Train 1 achieved sustainable nameplate production capacity 135 days from introduction of feed gas, and Train 2 achieved the same in only 80 days.

In addition, the production from both trains exceeds nameplate capacity as confirmed through formal performance tests. These were impressive accomplishments and this article will share insights into how they were achieved.

**GLNG’s vision**

GLNG’s vision was to build and operate an efficient LNG production facility well suited to the unique characteristics of gas produced from coal seams.

Some of the key characteristics of coal seam gas (CSG) include a gradual ramp up to full production and a sensitivity to the wells being fully shut-in (in some
cases CSG wells can require work-over after being shut-in to recover production).

Good facility turndown, high plant availability and minimization of full LNG train outages are important requirements to achieve when operating a plant to convert CSG to LNG.

After a thorough review, GLNG selected the Optimized Cascade® Process as the technology, together with the Global LNG Collaboration between ConocoPhillips and Bechtel to design, construct and commission the two train, 7.8 MTPA LNG facility.

The technology delivers high availability and thermal efficiency throughout a wide range of feed gas compositions without the need to adjust refrigerant compositions.

**Approach**

The two-trains-in-one approach, where one train of highly reliable heat exchangers and other process equipment is served by two parallel refrigeration turbine/compressor sets, prevents total train downtime in the event of any single turbine/compressor string trip.

In such an event, the design allows operators to quickly and easily rebalance refrigerant loads and maintain production in excess of 60 percent. Another highly desirable feature of the Optimized Cascade® Process is the ability to re-start a tripped turbine/compressor with little or no flaring.

However, even in the event of a total plant trip, liquefaction process temperatures, pressures, and liquid levels, due to the design of the liquefaction unit facilities, are maintained for prolonged periods, enabling a rapid restart of the plant.

The infrequency of plant trips, combined with the ability to restart quickly when a total plant trip does occur, help maximize the overall facility availability and production efficiency, which are key elements in meeting GLNG’s stringent requirements. The technology also provides for stable operation at low throughput, supporting a ramp up to full production while minimizing the risk of well shut in.

The schematic below provides a simplified depiction of the Optimized Cascade® Process. The raw gas is first treated to remove carbon dioxide (CO2), hydrogen sulfide (H2S) and other sulfur compounds, water (H2O), organometallics, mercury compounds, particulates, and other contaminants before routing to the liquefaction section of the plant.

**Heat exchangers**

The treated gas is then chilled and condensed in successively colder heat exchangers, using pure propane, ethylene, and methane refrigerants until LNG is produced.

The design for GLNG includes an integrated nitrogen rejection unit (NRU) configured to achieve optimal LNG plant performance and maximize the net present value of the facility.

The LNG product is then pumped into insulated storage tanks in preparation for shipment. Boil off gas and ship return vapors are captured and recycled through the Optimized Cascade® Process for efficient re-liquefaction and maximum output.

**Engineering**

For example, some detailed engineering activities can begin during the early phases of FEED since the plant layout, vessel sizing criteria, and other critical considerations are already well known. Schedule reducing synergies exist throughout all phases of the project, from pre-FEED through commissioning and startup.

**Key to success: fully integrated commissioning and start-up team:** With the chosen contracting strategy (EPC-LSTK), both ConocoPhillips and Bechtel were incentivized to complete the project with fully operational trains meeting production and efficiency targets, as demonstrated through formal 72-hr performance tests.

This structure was beneficial to GLNG because at turnover of care custody, and control (TCCC) of the plant, GLNG did not have to pursue the contractor for assistance with work items during the commissioning and start-up phases, as such items remained within the contractor’s area of responsibility.

Becthel also benefitted from this structure because at the time of TCCC they would have resolved the majority of “punch list” items, thereby allowing a definitive schedule for demobilization of their personnel and equipment.

There can be no question that operations excellence begins in design.[2] One of the advantages of the ConocoPhillips and Bechtel LNG collaboration is that each bring complimentary perspectives. ConocoPhillips’ focus on technology, engineering, and operations complements Bechtel’s focus on engineering, procurement, construction, and overall project management capabilities.
Who developed the world’s first LNG tanker?

Who opened up the Asia-Pacific market by exporting LNG from Alaska to Japan?

Whose Optimized Cascade® Process technology was selected for four of the last seven LNG projects in Australia?

Whose technology is expected to produce 25% of the world’s LNG by 2020?

Answer: ConocoPhillips

With all that expertise and experience in LNG, shouldn’t you be talking to ConocoPhillips, too?

To learn more, visit lnglicensing.conocophillips.com.
One key to achieving GLNG’s vision was their strategic decision to embed and involve experienced operations personnel into the project from the earliest project phases through TCCC and during subsequent operations, as well.

**Collaboration**

The ConocoPhillips and Bechtel collaborative relationship also brought operational expertise and lessons learned from a large installed base of licensed Optimized Cascade® facilities. Due to the significant industrial base in Australia, a good selection of experienced operations candidates with applicable LNG experience was available.

GLNG recruited personnel early in the process to front end load the project with appropriate operations resources. Operators assisted throughout the Pre-Feed, FEED and EPC phases.

They were an integral part of the team for HAZID, HAZOP, SIL Studies, FATS and SATs and Module Yard activities.

Since Bechtel was responsible for starting up the plant and the initial operations until plant TCCC, the GLNG operations workforce was incorporated into the Bechtel CSU team, which ensured a seamless transfer from the Bechtel controlled CSU phase to stable operations.

ConocoPhillips operations specialists were incorporated into the CSU team as well, such that all three parties worked together as an integrated team.

**Training**

The plant operations staff supplied by GLNG sufficiently early in the project to receive training prior to commissioning and start-up activities. This allowed training of the operators in hydrocarbon fundamentals and on the ConocoPhillips Optimized Cascade® Process early enough to allow them to assist on various CSU work.

Bechtel and ConocoPhillips were responsible for providing classroom training that consisted of equipment theory, plant functions and layout, the Optimized Cascade® Process, mechanical design, safety matters, plant start-up and operation, and facility troubleshooting. Personnel with operating and engineering experience from ConocoPhillips provided training based on first-hand experience and knowledge. Critical equipment vendors provided additional operations training.

Once the classroom training was completed, GLNG operations staff were incorporated into Bechtel’s CSU team. This arrangement provided Bechtel with additional staff for commissioning and start-up activities and provided GLNG with staff trained in the operation of the LNG facility. Thus fully integrated team continued throughout commissioning, start-up, and operation of the LNG plant.

Bechtel, ConocoPhillips and the GLNG operations team worked together to build, test and commission a high fidelity Operations Training Simulator (OTS). The utilization of the OTS allowed the GLNG operations team to write/validation procedures, familiarize themselves with plant and equipment start-ups and shutdowns, and understand “all of LNG Train” dynamics, optimization techniques, troubleshooting and tuning of control loops prior to start-up.

ConocoPhillips completed higher fidelity dynamic simulations during the design phase, complete with hydrailics and much more detailed equipment modeling and integration, to select the proper valve trim as well as to develop and test many of the control algorithms.

This effort proved greatly beneficial in validating and testing the OTS, which ultimately matched plant performance very well. After start-up the OTS was As-Built by Bechtel, leading to a simulator that provides a good match to plant performance.

**Milestones**

With the EPC contract being awarded in January 2011, early work began at the facility in May, 2011. Most of Train 1’s utilities were commissioned by early July 2015 to support pressuring up the inlet pretreatment area with hydrocarbons on 7 August 2015 (initial Start-up).

For Train 2, initial start-up of the power generators used fuel gas from Train 1 until Train 2 fuel systems were up and running. Train 2’s initial start-up took place on 17 April 2016.

The Optimized Cascade® Process is designed for rapid chill down and ramp up to full production. The combination of closed loop refrigerant circuits and ability to route the feed sequentially through each refrigerant stage allows for rapid chill down without undue concern over thermal rate of change limitations.

It is also possible to operate and control the plant at very low rates, since no difficult refrigerant phase transitions occur within any of the equipment. Also, with controllable LNG production at very low rates, there is no need to chill the LNG Tanks with an external source, such as an LNG cargo.

Barring the time to cool down the LNG Tanks, which takes approximately three days per tank, chill-down and ramp up to full production can often proceed within a day and GLNG achieved first drop of LNG within 33 hours of the start of cooldown of either Train 1 or Train 2.

Ramp up to full production was slowed by residual debris on the propane system as well as by ongoing commissioning activities such as gas turbine performance mapping.

Nevertheless, Train 1 completed its performance test within 65 days of producing its first LNG cargo and Train 2 completed its performance test within 33 days of producing its first LNG cargo.

The nature of the CSU collaboration allowed lessons learned from Train 1 to be applied to Train 2 as follows:

- QA focus areas for construction
- Optimization of construction as well as CSU sequence
- Application of Train 1 tuning parameters to Train 2

**Commissioning Tests (process and utility):** Commissioning tests were required for all systems, all package units, various special items such as metering skids, firewater pumps, utility systems and of course, all control systems, alarm systems and shutdown systems.

The purpose of the commissioning tests was to demonstrate that individual systems within the facility performed to design specifications provided for in the EPC contract. There were 36 individual tests each with a procedure and a report documenting the results and individually signed off by Bechtel and signed off and witnessed by the owner.

**Performance Test:** Once all of the equipment and system acceptance tests were completed, formal 72-hr performance tests were completed for each train to demonstrate that production and thermal efficiency targets met or exceeded the guarantee rates.

The production result achieved for Train 1 was 15.5 percent above guarantee.

The production result for Train 2 improved, with a demonstrated production 18.1 percent above guarantee.

By successfully completing the formal 72-hour performance tests, sustainable production capacity at design production or above was achieved in 135 days from initial start-up for Train 1 and 80 days for Train 2.

Efficiency targets were also met in a similar fashion for each train.

**Conclusions**

By engaging the ConocoPhillips and Bechtel LNG collaboration, and applying its preferred contracting strategy, GLNG selected an LNG liquefaction technology suitable for operating a plant that can convert CSG to LNG and a contractor motivated to deliver a completed, tested and operating LNG plant.

Key to the successful start-up of the operation were:

- Having an LNG liquefaction plant that can be rapidly chilled down and ramped up to full production, and quickly adjusted to changing conditions;
- Integration of experienced operations staff in the earliest phases of design and construction throughout the project stages and with owner’s project team focused on plant operability;
- Structured training of operations personnel through classroom, vendor and simulator training; and
- Integration of operations personnel into the Bechtel CSU team to provide hands on training and the opportunity for experienced operations personnel to optimize the commissioning and start-up of the facility.

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