Case study

From massive to mega: the Qatargas LNG trains that changed the industry

We have a heritage of LNG breakthroughs that spans more than 30 years, with core equipment in most LNG plants around the world. Our evolutionary approach combines field-proven technologies with experience and innovative ideas—always making the largest possible leap forward while maintaining optimal risk and safety standards at every step.

We've consistently helped customers drive economies of scale, increasing liquefaction train sizes with milestone projects from 2.3 mtpa in Australia in the early 1990s, to 3.3 mtpa in Oman, 3.8 mtpa in Malaysia, 4.8 mtpa and 7.8 mtpa in Qatar as covered in this case history.

Challenge

Our relationship with Qatar's LNG industry began with the supply of three LNG liquefaction trains driven by 12 Frame 5 gas turbines for Qatargas 1, which delivered its first LNG to market in 1997. A few years later, we were asked to support Qatargas 2 (QG2), the first of several major expansion projects we eventually collaborated on in Ras Laffan Industrial City that decade.

QG2 was the world's first project to fully integrate the entire LNG value chain including production wells, liquefaction and processing plants, a dedicated fleet of massive new ships, and new receiving terminals in Europe. Every aspect of the project was ambitious and astounding, and overall success depended on the ability to achieve unprecedented economies of scale.

Solution

We supplied two game-changing liquefaction "megatrains" with an unprecedented LNG capacity of 7.8 mtpa each—making QG2 the world's largest by a long shot.

Turbines

The project required significantly more power per compression train than QG1—even more than our Frame 6 and 7 turbines were producing at other large liquefaction sites around the world. Therefore, our Frame 9E turbine was selected. Rated for 130 MW of mechanical-drive power at ISO conditions, it was already well proven for hybrid mechanical drive and power generation applications in steel mills.

Turbine installation in 2006

Each string also included a 45-MW starter generator with 60-MW peak power to enable flat LNG production over the year, and electricity supply to the grid in case of surplus turbine power. The various refrigeration cycles required total power in the range of 300 MW. By using the Frame 9E, qualified for continuous duty at 96-102% speed, the power requirement was achieved with a minimum number of turbines.

The turbines were equipped with an innovative DLN combustion system to maintain NOx emission below 25 ppm, and they could burn fuel gas with high nitrogen content. Our strong DLN experience came from Frame 7 models operating at other LNG plants with high levels of inert gases in the fuel gas.

Compressors

Compressor installation in 2006

Since the Frame 9E's nominal rotating speed was 3,000 rpm, larger compressors were needed to handle higher capacity with lower speed than previous LNG trains driven by our Frame 7 turbine at 3600 rpm. That required unprecedented casing and impeller sizes up to 1,800 mm—well within the capabilities of our Florence manufacturing facility that can machine compressor casings with internal diameters up to 12.4 ft (3,800 mm), and 3D shrouded impellers with diameters exceeding 6.5 ft. (2,000 mm) from a single forging. Dry gas seals with internal diameters of 1.14 ft (350 mm) were also qualified. Each QG2 megatrain included six of our centrifugal compressors:

- Propane cycle: 3MCL1403 + MCL1402
- Mixed refrigerant cycle: MCL1805 + 2BCL1006
- Nitrogen cycle: MCL1402 + BCL1003

Benefits

The inauguration of QG2 (Trains 4 and 5) in April and September 2009 more than doubled the production capacity available from the three older trains at QG1. The technologies developed and installation lessons learned on the project enhanced our efficiency and capabilities for the subsequent expansion projects:

Qatargas 3
- Train 6 with 7.8 mtpa LNG capacity
- Completed November 2010

Qatargas 4
- Train 7 with 7.8 mtpa LNG capacity
- Completed January 2011

Ras Laffan 3
- Trains 6 and 7 with 7.8 mtpa LNG capacity each
- Completed November 2009 and July 2010 respectively

All told, our six new megatrains propelled Ras Laffan Industrial City's LNG production to over 77 mtpa.

Continuous evolution

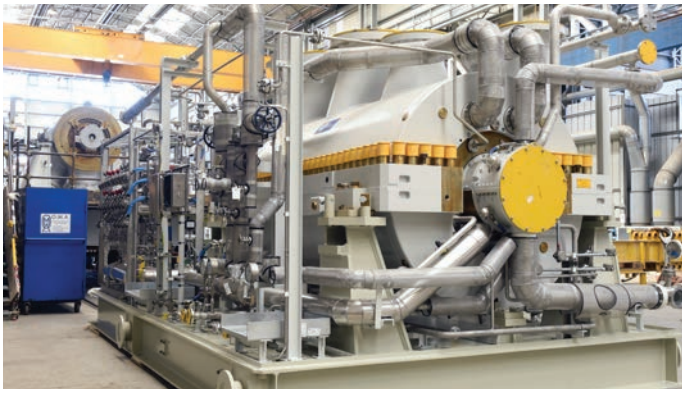
132 MW, 50 Hz Frame 9/1E in 2020

Something truly exceptional was achieved through our collaborations with Qatargas, but it's hardly the end of the story for the technologies used. Since QG2, our Frame 9/1E turbine design has been enhanced to increase component durability, improve cooling and sealing, and increase performance in both simple-cycle and combined cycle applications. Its latest specifications include:

- 132 MW power
- 34.6% simple-cycle efficiency
- 544°C exhaust gas temperature
- 419 kg/s exhaust gas mass flow
- Up to 5 ppm NOx emissions @ base load

Our centrifugal compressors have seen similar improvements. With thousands of running references, Baker Hughes can ensure the highest availability at best performance. Advanced technologies and optimization have enabled single-stage efficiency to be increased up to 6% since QG2. New robotic welding techniques guarantee lower cost, highest quality, and shorter manufacturing lead times.

Our Power Density program enhanced rotor dynamics and reduced casing sizes. Leveraging the latest manufacturing technologies, our new compression trains weigh less, and require less raw materials, which reduces CO_2 emissions during production by up to 10%. Design improvements also optimize HSE aspects, simplify maintenance, while the machines' smaller footprint and diameter facilitates installation and maintenance ergonomics.



MCL horizontally split compressor in 2017

New impellers for high-mach, high-capacity compressors

By continually investing to evolve technologies, our solutions have also improved the feasibility of remote natural gas fields and more marginal stranded gas resources. This enables commercialization of otherwise flared natural gas associated with the production of oil, and benefits the environment by displacing other more environmentally intrusive fuels with clean-burning natural gas.

Beyond our equipment, another key differentiator is our ability to provide customized, expert service for the entire life of a plant—from regular maintenance to complex troubleshooting, upgrades, and technology injections that improve performance and productivity over time.

Service capabilities are key to the value that Baker Hughes provides to Qatargas, and to the long, mutually beneficial relationship we've enjoyed. Our commitment was clearly defined from the start in a Contractual Service Agreement (CSA)—specifically designed to deliver availability and productivity guarantees over the full asset lifecycle. We've provided comprehensive operational decision support, maintenance management, and outage excellence. Through the years, our contribution has evolved to include a suite of digital services including advanced remote monitoring and diagnostics, event analysis, and component lifecycle evaluations.

Everything we do—from designing a turbine to deploying field-service engineers and parts—is rooted in an appreciation of the challenges our customers face every day. Long-term relationships with visionary companies like Qatargas greatly impact our ability to push technological boundaries and ensure that all our activities are driving customer success.

Baker Hughes