



AN EXCEPTIONAL ENERGY CASE STUDY

LPG FUELLED POWER AS FLEXIBLE GRID RESPONSE TO RENEWABLE ENERGY VARIABILITY

TENO POWER PLANT (45MW) IN CENTRAL CHILE – A MODEL FOR THE ENERGY TRANSITION

As many countries around the globe are struggling with the energy transition from fossil fuels to renewables, the Teno Power Plant in Central Chile is an ideal case study for an environmentally friendly dispatchable power solution. This Exceptional Energy case study demonstrates fast execution from planning to first power, rapid response to grid power requirements (up time in less than five minutes) and a practical approach to sourcing affordable feedstock (LPG) that meets environmental standards unlike many other fuels.

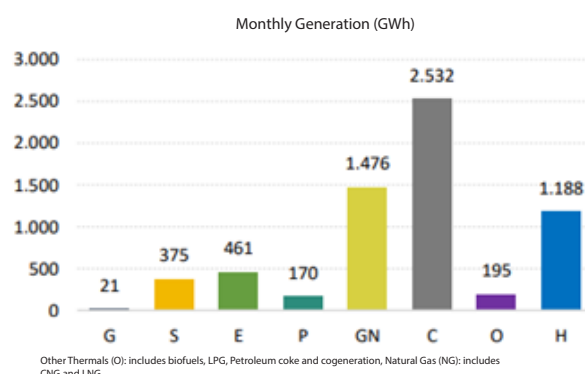
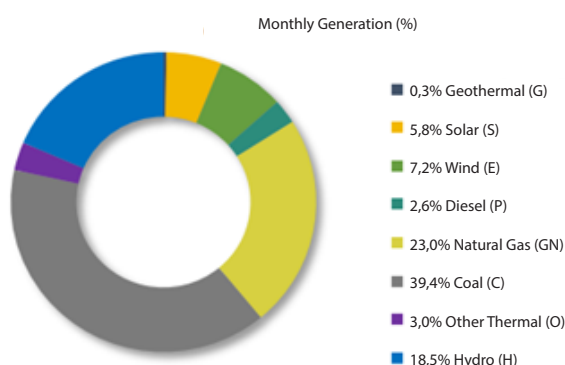
1. The Challenge

Chile has set a national objective of achieving 60% of power generation from renewable sources by 2035 and 70% by 2050. As a country with a growing portion of intermittent and non-dispatchable power sources Chile is scaling back coal-fired power and will be required to develop flexible power solutions which can be quickly deployed, are environmentally friendly, affordable and will be able to provide strategically important dispatchable electricity support. The Teno LPG to Power Plant meets these key criteria – it allows for quick start-ups, is functional, price competitive, and will run without interruptions.

The LPG to Power model used for the Teno Power Project applies a technology also suitable for off-grid power generation facilities in more remote areas that do not benefit from access to the national or regional power grids. In Chile and other countries, the concept is particularly attractive for remote mining facilities as well as off-grid solar projects.



LPG to Power projects can enable the start of early-stage operations without the need for an electricity distribution network, can be constructed fast, reduce CO2 emissions and virtually eliminate SOx and PM emissions compared to traditional liquid fuels used for such sites, ensuring a 24-hour clean energy supply.



2. The Solution

Chile's Innovación Energía S.A. (INERSA), a joint venture of Energía Latina S.A. (ENLASA) and fuel provider GASCO, was created in December 2016 to install and operate power plants using gas (LPG or natural gas) to provide price competitive back-up power for the grid.

INERSA built its first power plant in Teno, central Chile, to back-up the grid whenever renewable sources of electricity cannot meet the required electricity demand.

In January 2018 the construction of a 45MW electric power plant began in the town of Teno, Maule Region, in central Chile. The plant design is based on 26 x 1,7MW gas-engines by MWM, a Caterpillar subsidiary. These engines operate at an efficiency of 43%, substantially higher than the standard diesel engine, providing an additional competitive advantage to this business model.

Within two years, in February 2020, the power plant began commercial operations feeding electricity into the National Electrical System (SEN). During the first year of operation, the grid requested from the Teno Power Plant more electricity than expected, achieving a plant factor of near 10% - a high value for a back-up plant in Chile.



3. Why LPG?

There are several reasons why LPG is an attractive feedstock for a back-up plant. All of those are key factors that sustain the INERSA on grid and off grid business model.

1. Logistics/Storage

LPG is a feedstock that is relatively easy to transport. Road haulage is the main means of forwarding in Chile, and the transportation of LPG is similar to that of liquid fuels.

LPG's transportation advantages in comparison to natural gas and other forms of gas is detailed below.

- *Natural Gas*
Delivery of natural gas requires pipelines which, if not in place, are expensive and time consuming to deploy.
- *Compressed Natural Gas (CNG)*
Alternatively, natural gas can be compressed and transported. However, due to the modest compression ratio, CNG is only suitable to be transported over short distances.
- *Liquefied Natural Gas (LNG)*
Lastly natural gas can be refrigerated to become LNG which becomes very costly as transport and storage require refrigeration at -160°C requiring special cryogenic equipment.

2. Teno Benefits from Alternative LPG Sourcing Options

Teno Power Plant is conveniently located where it can source LPG from four storage facilities in Chile. Two of the storage sites are primary sources. The first being the LPG Terminal in Quintero being 325km from the power plant, offers the cheapest feedstock and good road connection to Teno. The second supply option is from the San Fernando storage facility at a close distance of 50km from the power plant. Should both of these LPG facilities fail to provide supply there are further options sourcing from either a LPG storage facility in Santiago at a distance of 220km or from a storage site in Talca which is 80km from the Teno power plant.

These multiple sourcing options provide a clear advantage over LNG which only has a single source in Quintero and no back-up options should poor weather or other circumstances create sourcing issues.

Local on-site storage at the power plant is provided through mounded storage tanks with a capacity of 200 tonnes. Furthermore, a vaporizer supplies 9 tonnes of LPG vapor per hour, along with a loading island that can unload two 22 ton-trucks simultaneously, allowing autonomy of 24-hours for a continuous operation without logistical stress.

3. Environmental Benefit

LPG is a suitable feedstock for power generation providing similar performance for engines and gas turbines when compared with natural gas. Emissions are also comparable to those when using natural gas. However, CO₂ and NO_x as well as noise emissions are significantly lower by 20% and 95% respectively when compared to operating on liquid fuels such as Heavy Fuel Oil (HFO).

4. Summary

The attractions of using LPG as a feedstock become apparent for various reasons:

- Broad application – LPG is an efficient feedstock that works with a broad range of power generation equipment be it gas turbines or internal combustion engines.
- Logistical advantages – more than 140 countries globally command LPG infrastructure – mostly to distribute LPG as a cooking or heating fuel. The broad experience of handling LPG and moving it even to remote inland locations make LPG an attractive feedstock.
- Environmental benefits – with comparable emissions to natural gas, LPG is an attractive feedstock that serves as a bridge solution to replace highly pollutant fuels such as coal, diesel or HFO.
- Energy transition – as the Teno Power Plant demonstrates LPG can play an important role as a flexible fuel to provide nearly instant dispatchable power particularly for decentralised power stations.
- Hybrid power plants – LPG powered plants should be considered in combination with wind and solar projects to guarantee uninterrupted, dispatchable power especially for remote or off-grid installations.

5. The Project Sponsors

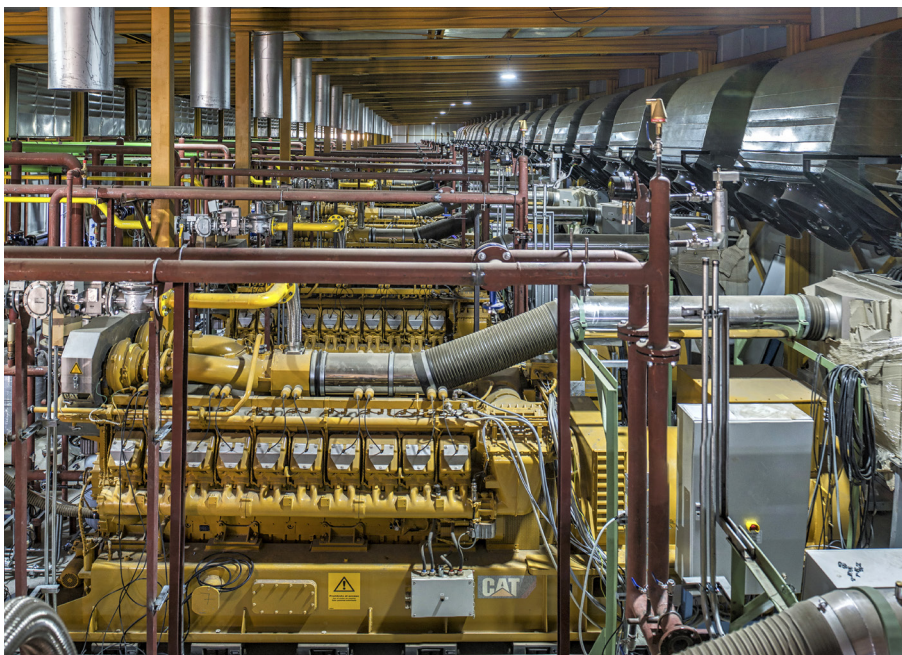
In recent years, WLPGA and Industry Council member GASCO has promoted different energy solutions with the goal of achieving greater energy efficiency, economic benefits, operational continuity, and positive environmental impact. One of the solutions the company has promoted, together with its partner ENLASA, is the development and implementation of LPG for power generation as a complement to systems of Variable Renewable Energy (VRE), either for new projects or existing facilities.

With more than 160 years of history, Empresas GASCO offers a business model that integrates different activities to deliver energy solutions via feedstock supply, logistics management, and marketing of gas in a sustainable and responsible manner, all based on innovation, excellence, and commitment to the community. GASCO is developing a series of projects based on clean energies that offer efficient and environmentally friendly energy solutions, with the aim of contributing to a better

quality of life for people as well as the sustainable development of industries, companies, and SMEs (small and medium sized enterprises).

“As a company, we seek to position power generation based on liquefied gas as an efficient, economical and environmentally friendly alternative to that based on diesel or other liquid fuels. We are actively participating in the design and development of initiatives that complement the generation of VREs, which by their nature do not have the capacity to supply a continuous demand, aiming at energy cogeneration for sustainability,” said Juan Andres Mendez, Energy Solutions Manager at GASCO.

GASCO also offers the following solutions: Dual Electric Generation, Cogeneration, Photovoltaic Solar Generation, Thermal Energy, Off Shore Power Generation in Aquaculture Platforms meeting various diverging customer needs.



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