LNG and CNG replacing diesel as truck fuel

Industrial gas firm Cryostar is partnering with Siemens to help fleet operators upgrade from diesel fuel to LNG and CNG, saving money and cutting emissions.

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A specialist in cryogenic equipment design and manufacturing for more than four decades, Cryostar, part of the Linde Group, has extensive experience in gas handling equipment. Based in France, Cryostar has business centers located worldwide.

Cryostar has developed fueling stations to deliver both liquefied natural gas (LNG) and liquefied compressed natural gas (LCNG), and aims to cover the entire natural gas supply chain. Its natural gas-based fueling stations already operate in Europe and at three locations in the U.S., including one of the largest in the world at the City of Los Angeles Bureau of Sanitation.

Now, Cryostar plans to roll out a new and improved LNG/LCNG fueling station tailored to US customers, and to power and control these stations with Siemens hardware and software. CNG offers slightly greater savings over diesel than LNG, but LNG offers superior range. Other advantages of LNG and CNG over diesel fuel are listed in Table 1.

To win over ‘first adopters’ of this technology, Cryostar needed to find the right partner to automate their LNG/LCNG filling stations. After an exhaustive search, Siemens was selected to provide the required power and control components.

Siemens helped Cryostar to meet its goals for this project by covering all the functions needed to power, control and manage the complete fueling process. Cryostar is dedicated to stocking all necessary parts worldwide to support its installed base of systems, so Siemens’ global technical support and parts stocking was also a good fit in this respect.

Table 1: Advantages of LNG and CNG versus Diesel

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<th>Advantage</th>
<th>Description</th>
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<tr>
<td>1) Less expensive than diesel by about $1.50-$2.00/gallon</td>
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<td>2) Cleaner burning than diesel</td>
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<td>3) Allows use of abundant natural gas instead of scarce oil reserves</td>
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<td>4) Can increase a country’s energy independence</td>
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<td>5) LNG has 20% or greater additional range than CNG</td>
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A Cryostar LNG fueling station is depicted in Diagram 1. The LNG is stored in one or more vacuum insulated storage tanks, usually provided by the customer. LNG is pumped from the storage tank by the pump skid. CNG filling capability can be added by installing a high pressure pump with vaporizer to convert the LNG to CNG.

The new electrical design is based on Siemens Totally Integrated Automation, and the design enabled Cryostar to combine power distribution, controls and fuel management into a single more efficient system with easier operation for its customers. The same Siemens power and control panel is provided for both LNG only and LNG/LCNG fueling stations, with panel-mounted components activated as required, greatly simplifying system design.

On the pump skid (see Image 1), a skid-mounted cryogenic transfer pump (made by Cryostar) pumps LNG from the storage tank to the fleet vehicle via the dispenser. The pump skid has two control loops, both executed within the Siemens PC-based controller, as are most other system control functions.

Image 1: Photo of pump skid. The pump skid precisely controls transfer of LNG from the storage tank to the dispenser via a variable speed cryogenic pump and a continuously modulating control valve.

The first loop controls the pump speed via a Siemens variable frequency drive (VFD), maintaining the desired differential pressure between the pump inlet and outlet; the second regulates LNG flow rate with a control ball valve, giving the desired pump outlet pressure.

The dispenser is fitted with two accurate and reliable Siemens’ pressure transmitters, as well as a Coriolis mass flow meter that measures the LNG liquid as it flows through the dispenser to the vehicle. This meter is connected to the PC-based controller via Modbus RS-485. A custom-designed Cryostar calculator and display module, shown in Image 2, shows the user the exact amount of LNG delivered to the vehicle’s storage tank.

Image 2: Photo of dispenser. Cryostar’s dispenser can deliver saturated or unsaturated LNG fuel by throwing a switch on the front panel. Sophisticated technology internal to the dispenser enables simple operation by the vehicle operator.
The system — incorporating tank, pump skid and dispenser — meets equipment specifications for Class 1 Div. 1, NEC 500, which means it is safe for use with flammable gases, vapors or liquids under normal operating conditions. The power and control panel’s compact design helps Cryostar minimize the overall footprint of the filling station, critical in many installations.

The Siemens power and control panel (Image 3) is designed for installation in an unclassified area, so all connections to the pump skid and the dispenser are intrinsically safe. This provides the required degree of protection, while allowing the panel to be provided with standard NEMA 4 or 12 ratings, depending on the exact location of installation. The system is fully compliant with all relevant national and international standards.

PC-Based Control Offers Advantages

The Siemens power and control system provides a host of benefits as listed in Table 2 and detailed below. The PC-based controller (Image 4) provides the necessary support for sophisticated algorithms, and for tasks such as high-level data handling and storage that are better suited to a PC than a PLC. At the same time, the controller provides deterministic real-time control with high reliability, similar to a PLC.

XP Embedded is the operating system for the PC-based controller, allowing real-time and deterministic simultaneous execution of multiple software programs within the controller.

Required automation is implemented through a variety of programming languages including Ladder Diagram for overall program layout, Structured Control Language for data manipulation and handling, and Statement List for real-time control. These languages run simultaneously, automatically exchanging data as required. This support for multiple programming languages allows for simple and rapid controller programming.

The multi-network capabilities of the Siemens system make it straightforward to interface with a range of external components such as VFDs, smart instruments and third-party controllers.

Connections among the automation system’s components are via PROFINET, the open industrial Ethernet standard, without the need for a PROFINET/Ethernet switch. These connections include links from the PC-based controller to the VFD, the I/O, and the graphic display.

Table 2: Benefit of Siemens Automation for LNG/LCNG Filling Stations

<table>
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<tr>
<th>Benefit</th>
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<tr>
<td>1) One global supplier for all power and control components</td>
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<tr>
<td>2) Worldwide technical support and parts stocking</td>
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<tr>
<td>3) Compliance with all relevant national and international standards</td>
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<tr>
<td>4) Compact design reduces required footprint</td>
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<tr>
<td>5) Support for multiple programming languages speeds and simplifies controller programming</td>
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<tr>
<td>6) PC-based platform provides supports for sophisticated algorithms, and for high-level data handling and storage</td>
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<td>7) High performance Ethernet communications via PROFINET</td>
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<tr>
<td>8) Multi-network capabilities allow interface with wide variety of external components</td>
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<tr>
<td>9) Remote access capabilities including web server built-in</td>
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<td>10) Support for intrinsic safety facilitates operation in classified areas</td>
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Image 3: Photo of power and control panel exterior. The graphics panel allows full-featured control and monitoring of the entire fueling station through simple touch-screen commands.

Image 4: Photo of power and control panel interior. The power and control panel houses a variety of Siemens power and control components. All connections to the pump skid, the dispenser and optional components are intrinsically safe—allowing the panel to be rated NEMA 4 or NEMA 12.
The PC-based controller also hosts an open source SQL database. Process data are stored in the database, and are available for local display and for remote access. Data stored include diagnostic information, the number of hours the pump has been in service, and other key parameters.

The local touch screen changes dynamically during fueling to track the process, and operators can make desired adjustments to fueling station parameters as required.

Remote access connections are typically via the controller’s Ethernet port. The controller contains a full-featured web server, allowing secure access via any web browser. Remote access allows maintenance to be addressed proactively, and expedites routine parts servicing and troubleshooting.

Simple operation, significant savings
Once programmed by Cryostar, the automation system handles all of the complex tasks required to operate and monitor the fueling station, while presenting a simple operator interface to users. This is critical because, unlike many industrial gas handling systems, the LNG/LCNG fueling stations will be operated and maintained by personnel not accustomed to process control. The customer simply inserts payment and fills the vehicle with fuel, as with any other filling station.

A US customer currently investing in the fueling station commented that the Cryostar solution is more user friendly than other LNG or LCNG options currently available. “Some of the other systems are very complicated, one-off custom systems—so we are very excited that this whole skid system is modular—you just add another skid and you’ve expanded the capability of the station without having to start over.”

“The Cryostar dispenser has a lot more smarts to it,” the customer added, praising the ability to use one dispenser for both LNG fuel types. “Right now in the industry that’s very useful, to be able to fuel with both saturated and unsaturated LNG, and it’s a huge advantage over systems that require two stations.” For more information on the two LNG fuel types, see the sidebar “Double the Benefits”.

The fueling station offers customers the long term payback of savings in fuel costs, and the opportunity to participate in an exciting new market for cleaner fuels, independent of international pressures on oil prices or availability.

Environmental regulation is on the increase, and both LNG and CNG offer clear emissions benefits over diesel. The main challenges are providing a fueling station that is simple to operate and maintain, while providing all of the safeguards required for the transfer of these fuels from storage tanks to vehicles.

Cryostar is meeting these challenges through many decades of expertise in handling cryogenic materials, and by partnering with Siemens, a worldwide leader in power and control systems. By working together, the companies are delivering a fueling station that meets all of the needs of LNG and CNG vehicle and fleet operators.

Sidebar: Double the Benefits
Cryostar’s fueling station can deliver saturated or unsaturated LNG to accommodate the two different types of LNG engine.

Vehicles that consume saturated LNG can run on dual-fuel or spark-ignited engines. Spark ignited engines are similar to gasoline engines. Dual fuel engines ignite thanks to diesel fuel injection, much like a diesel engine, and can run on diesel alone, or on diesel plus natural gas. Both of these engines take in LNG fuel at -200 °F, injected downstream of the turbocharger.

Vehicles that consume unsaturated LNG use a high-pressure direct-injection (HPDI) engine, with natural gas injected at very high pressure (e.g. 4500 psi) late in the compression stroke. This engine uses cold LNG delivered at -240 °F, deploying pilot diesel injection in order to create a “liquid spark” to ignite the high pressure natural gas. An HPDI engine must operate on LNG and cannot run on CNG, so these types of vehicles are limited by the shortage of LNG fueling infrastructure at present.

Thanks to the control system and engineering of the dispenser system, the fueling system delivers LNG at either pressure, simply by throwing a switch on the dispenser’s front panel. The fuel is delivered at a pressure ranging from 45 to 115 PSI at the pump, with the nozzle delivering 42.5 gallons per minute.

Summary:
LNG is less expensive than diesel fuel by about $2.00/gallon, and it is cleaner burning. The single biggest obstacle to adoption of LNG vehicles is the inadequacy of the LNG fueling infrastructure, so the industrial gas firm Cryostar partnered with Siemens to build and install LNG/LCNG fueling stations.

For this particular application, Siemens provided a number of unique benefits including the ability to provide all required power and control components, worldwide technical support and parts stocking, and compliance with all relevant national and international standards.

The PC-based Siemens controller provided support for sophisticated algorithms, and for high-level data handling and storage, both required for the fueling stations.