



LNG Solutions in Action



Innovation. Experience. Performance.®

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Access to reliable energy means empowerment and increased living standards. With energy demand forecast to increase by 30% between today and 2030 and with society committed to transitioning to a low carbon future, natural gas is fundamental to meeting the challenge of significantly increased global energy without worsening air quality conditions.

Liquefied Natural Gas (LNG) is simply natural gas that has been refrigerated to its liquid form so that it can be economically stored and transported. Traditionally it would be produced and distributed on a massive scale but Chart is a key player in the development of small-scale models that are revolutionizing its usage and bringing power to off-grid locations, providing back-up power for peak shaving and supply curtailment events and fueling road, marine and even rail transportation.

It's an exciting and transient landscape where decisions in different parts of the value chain are highly interdependent. Therefore, it's important to select a project partner that understands this. From the earliest feasibility study right through to after-sales service and maintenance packages, Chart will accompany you through the entire project lifecycle.



By choosing Chart you gain a reliable and trustworthy ally, with a proven, solution driven track record. We have provided the industry's highest rate of functionally successful systems from day one and, as a result, the most financially successful projects. We are delighted to present a small sample of them drawn from our experience across the globe.



LNG Production and Trailer Loading Facility at Gas Processing Plant



Highlights:

Location — Hawkins, Texas

Scope of Project:

- Engineering and Project Managed to support the design, manufacture, installation, startup, and commissioning for LNG truck load facility
- Project Completion Late 2015
- Pre-Engineered, Factory Fabricated Modules

Application:

Cryogenic gas processing (Nitrogen Rejection Unit) produces LNG as part of the process, providing low cost LNG for the merchant market.

Project Background:

Chart Industries developed an LNG storage and truck loading system, as part of an existing natural gas processing plant, located in Hawkins, Texas.

System Configuration:

Pre-engineered, factory pre-tested modules accelerated the system installation, so the commissioning process took only two weeks to complete. The existing gas compression equipment enabled vapor recovery of the truck filling process, eliminating the need for cryogenic pumps. The system design eliminated the need to vent natural gas vapor to the atmosphere during the desaturation of the LNG and the truck filling process. The excess gas was compressed and injected into the natural gas pipeline.

The fully automated truck filling process is designed to fill trailers with LNG to comply with DOT load limits for tractor trailer combinations of 80,000 lb gross vehicle weight. Once the hose connections are made, the computer controlled system takes over and performs all the necessary functions from start to finish, including a purge process that forces any remaining LNG from the hose into the trailer by use of a small volume of inert nitrogen gas.

Significant Accomplishments:

Chart had developed pre-engineered truck loading modules, including 50,000 gallon storage tanks, and automation control systems that were instrumental in shortening the time from order to installation.

The automated truck loading system eliminated driver filling errors and reduced filling time.

LNG was required to traverse 2,500 feet, and in some cases 3 stories above ground to fit within the existing site constraints. To minimize installation cost and provide a safer installation, prefabricated vacuum insulated pipe was chosen.





Small-Scale LNG Liquefaction



Highlights:

Location — George West, Texas

Scope of Project:

- Liquefaction of pipeline gas providing fuel for high-horsepower engines used in the oilfield and in the regional transportation and industrial sectors
- Strategically located in the Eagle Ford Shale
- Plant started up in March 2015

Significant Accomplishments:

- Two truck loading racks that can load two transport trailers simultaneously in less than an hour
- Complete integrated control system allows for remote monitoring of LNG production, storage and flow on the site
- Energy efficient turndown and restart capabilities on production, allowing for market flexibility
- Configured to incorporate second production train for planned future expansion

Application:

Dedicated LNG production facility open for business 24/7 throughout the year. Principally committed to providing LNG as an alternative fuel to diesel for high-horsepower engines operating in the oilfield; the plant also offers high quality LNG for growing local merchant use.

Project Background:

Chart provided the complete production plant package including liquefaction, storage and loading.

Plant Features:

- Chart C100N standard LNG plant
- Natural gas liquefaction capacity of 100,000 gallons per day (165 tons per day)
- Chart scope includes proprietary nitrogen cycle process technology, pre-treatment, plate fin heat exchangers, cold box, air cooled heat exchangers, storage tanks and load-out facility
- Standardized 'off-the-shelf' designs built at multiple U.S. Chart manufacturing facilities
- Maximized shop fabrication, minimized field construction
- Simple plant operation





Small Scale Multi-functional LNG Receiving Terminal



Highlights:

Location — Klaipėda, Lithuania

Scope of Project:

- Complete cryogenic section comprising 5,000 m³ of LNG storage, 10 ambient vaporizers for local gas delivery, 2 trailer loading bays, bunkering skid mainly used for filling the terminal from LNG carrier and utilized also for LNG ship fueling
- Shop built standard, field proven equipment for minimized engineering and production costs, schedule and risk
- Solution that incorporates a planned facility expansion that doubles the storage capacity is already built into the base design
- Evaporation capacity up to 6000 Nm³/hr
- The terminal received its first LNG in 2017

Application:

To create a small-scale LNG infrastructure and establish the port of Klaipėda as an LNG hub for the Baltic countries and northeastern Poland through creating a single value chain from LNG delivered from the floating storage and regasification unit (FSRU) Independence.

Project Background:

The facility demonstrates the economic and technological viability of small-scale LNG storage and distribution. Although unable to provide the same economies of scale as the mega-terminals, Klaipėda was built in a significantly shorter time frame and provides operational flexibility. This creates an attractive business model for terminal operators and owners to quickly address the growing demand for LNG as a fuel for transportation and energy and take advantage of new supply.

System Configuration:

LNG offloaded and stored at Klaipėda can be loaded into road tankers for virtual pipeline distribution to off-grid users. It is utilized for ship fueling, bunkering, as well as vaporized as a source of energy for the local community. Catering for all eventualities enables the terminal to make the best use of landed LNG and immediately respond to fluctuations in application demands. The cryogenic section of the terminal comprises five identical horizontal vacuum insulated storage tanks, each with a capacity of 1,000 m³, ten ambient air vaporizers for gas delivery, twin trailer loading bays, which can simultaneously fill two trailers, four cryogenic submerged pumps for truck filling and bunkering, interconnecting pipework, emergency flare and all associated control and safety systems. All equipment is shop built, standard production and already proven in the field, which minimizes engineering and production costs, schedule and risk.

Standardization and modularization are crucial elements in the reduction of cost and schedule. Modularization also means that the planned facility expansion; doubling the storage capacity from the current 5,000 m³ to 10,000 m³ is already built into the base design.

Significant Accomplishments:

Chart provided single point accountability for project execution and collaborated closely with partners to minimize cost and schedule. The facility was delivered on time and according to budget. Within Chart's overall control, each stakeholder focused on their area of expertise, which avoided duplication of effort and allowed the project to be optimized as a whole, rather than by section.





LNG Storage & Trailer Loadout



Highlights:

Location — Northern Canada

Scope of Project:

- Engineering and manufacture of turnkey system to receive and store Liquefied Natural Gas (LNG) from micro liquefier and load into trailers
- (2) 20,000 gal LNG storage tanks
- Single Bay Loadout skid
- Pressure build and transfer system
- Safety system
- Startup and commissioning support onsite
- Completed Dec. 2016

Application:

Liquefied Natural Gas storage and trailer loadout project to be located in area of subzero winter atmospheric conditions. Fully rated for $-40^{\circ}\text{F}/\text{C}$.

Project Background:

Original scope was for 40,000 gallons (151 m³) of on-site storage. This was subsequently expanded to include the single bay load out and ancillary equipment according to customer requirements.

System Configuration:

The horizontal LNG storage vessels are rated to $-40^{\circ}\text{F}/\text{C}$. The LNG Loading Station operates through pressure transfer from bulk tanks to the trailers and is designed to fill an LNG trailer at 300 gpm flowrate. The load system is equipped with safety features and interlocks to meet NFPA 59A & CSA Z276-15 requirements. A PLC system controls the actuated valves on load out and has the ability to tie into the existing DCS system. Chart Vacuum Insulated Pipe 3" ID interconnecting piping is used throughout the system.

Significant Accomplishments:

- Chart provided a total turnkey equipment package with U.S. factory built equipment and skids for easy site installation
- Prebuilt skids reduced onsite weather delays to near zero hours
- As a single supplier, Chart was responsible for the successful project integration, ensuring compatibility of all components and overall design function
- Storage tanks equipped with valves and level transmitters that allow for the least amount of maintenance and interaction from site personnel
- Automated pressure building system sized for the specific project flows and environmental demands
- Automated safety system ensures safe operation in the event of an unexpected shutdown
- KLAW break-aways designed to shut down trailer fills in the event of a drive-away scenario





Natural Gas Fueling Stations



Highlights:

Locations — China, Europe & North America

Scope of Projects:

- Custom engineered fueling stations for natural gas vehicles (NGVs)
- Stations can be privately owned and operated for a dedicated fleet or open to the general public
- Stations comprise Chart Vacuum Technology® and proprietary, best in class equipment

Application:

Safely and reliably deliver fuel for natural gas powered vehicles. Because of its increased driving range, LNG is typically used for heavy duty vehicles, including trucks, buses and special handling vehicles. CNG is utilized for passenger cars and vans. Chart has built small standardized, single pump, temporary (or relocatable) units through to fully customized facilities with multiple dispensers. Stations are both privately owned and operated by companies to fuel their own fleet, or communal and available to all fleet operators and the general public.

System Configuration:

- Structurally, a Chart LNG/LCNG fueling station is similar to its gasoline and diesel counterpart as both deliver liquid fuel. However, because LNG is stored and dispensed as a super-cooled liquid, it requires special cryogenic equipment
- Chart Vacuum Technology® keeps operating costs to a minimum
- Fully modular design means that stations can be expanded quickly, easily and economically to keep pace with demand
- Full turnkey scope including engineering, equipment manufacture, delivery to site, installation and commissioning
- All stations feature fully automated operation, remote control access, ergonomic design and are loaded with our latest technology for maximum safety, accuracy, efficiency and operational comfort

Significant Accomplishments:

- PetroChina station in Changzhou fuels over 240 buses every day
- Station in Warsaw, Poland fuelled its 2,000th bus in 2015 and has continued to fuel 35 more each day since
- Chart stations in Finland are actively contributing to the country's stated intention to reduce greenhouse gases and harmful diesel emissions
- Designed and built equipment for the first 20 Shell fuel stations in the US





LNG Orca™ – The Versatile Mobile Fueler & MicroBulk Delivery System



Highlights:

Location — Washington, U.S.A.

- Chassis mounted LNG fueling station
- Minimum permitting needed to have onsite LNG fueling
- Zero fill losses, no vent system
- 30 to 50 GPM fill speeds
- All equipment built in the USA

Scope of Project:

- Factory built & tested Mobile Fueler
- Three year project that would include three mobile fuelers and 150+ vehicles in the program
- Vehicles included bucket trucks, dump trucks, line trucks and one ton trucks

Application:

Washington State Utility fleet approached Chart to provide a temporary LNG station for factory built LNG dedicated trucks (25). The unit would need to be flexible on refilling, either by transport trailer on site or taken to a nearby LNG fueling station. The first unit and subsequent ones would be placed at operations across Washington to provide fleet access to LNG as needed.

System Configuration:

- Chassis mounted unit
- Minimal power requirement
- 3000 gal onboard storage capacity
- Designed with single-hose quick disconnect
- Integrated saturation fuel allowed for pump filling spark ignited engine type as well as high pressure direct injection engine platform from single Orca™ unit
- Integrated safety system

Significant Accomplishments:

- Single LNG Orca truck expanded to fleet of three, providing LNG fuel for 150 service vehicles
- System approach has automatic switching, operations thru PLC (Programmable Logic Computer) panels
- LNG system has gone from three months operation support to year round
- Over three year ramp up to fleet conversion – zero accident rate (as of 08/2018)

See Orca LNG Spec Sheet (PN 14901969)





LNG/LCNG Compact Vehicle Fueling Stations



Highlights:

Location — Pan European
Includes stations in France & Scandinavia.
Stations are typically sited close to major transport hubs, such as ports and arterial traffic routes.

Scope of Project:

- Complete stations including build and install
- Comprehensive after-sales support options including training, servicing and on-line maintenance support
- Public access and provision to serve all NGVs – LNG, CNG and LBG
- Designed for 24/7 operation
- Zero emissions to atmosphere

Application:

Chart is typically working with national gas operators to expand the fueling infrastructure for natural gas vehicles in support of the host country's environmental objectives of reducing greenhouse gas emissions, together with those of NOx, SOx and particulates. The main targets are heavy goods vehicles fueled by LNG, and the stations are capable of seamlessly fueling those fitted with the most recently introduced Euro VI engines, as well as older fleets. Chart also works closely with vehicle OEMs and hence installed stations are already future proofed for the next generation of engines. Natural gas from composted organic waste is increasingly used in its liquefied state (LBG) for vehicle fueling and Chart stations are fully compatible with both LNG and LBG. They are also typically equipped with CNG modules and available to fuel all NGVs.

System Configuration:

- Compact assembly comprising 3-in-1 vertical LNG storage tank, pump skid and Saturation on the Fly (SoF) system
- The compact design reduces overall footprint by 2/3 versus conventional NGV fueling stations
- Range of LNG storage capacities from 50 to 108 m³
- Full factory assembly and modularization minimizes CAPEX, civil work activities, transportation cost and on-site installation time
- Fully CE marked (European compliance standard)
- Proprietary SoF technology eliminates the cool down process to deliver an immediate fueling response, which means reduced filling time for drivers
- Equipped to serve all types of vehicles with saturated or cold liquid
- MID certified Dynaflo 3000 LNG dispenser facilitates venting and fueling through one liquid line
- Fully automated driver operated fueling process
- Cellular remote monitoring with control and diagnostics via smart devices
- Payment terminal incorporated into station design – Fill & Pay
- 24/7 operator support help desk and troubleshooting service
- Relevant for all NGV fleet sizes

Significant Accomplishments:

- Minimum overall station footprint of just 3.8 x 3.8 m
- Stations installed, commissioned and fully operational within days of arriving at site
- Very positive operator feedback regarding fast access and ease of use
- Fueling times consistent with those for diesel fueled vehicles





Vacuum Insulated Pipe (VIP) for LNG Fueling Stations



Highlights:

Location — 20 Fueling Stations across the US

Scope of Project:

- Factory built & tested VIP skids
- Installed on LNG fueling stations designed to fill up to 150 trucks per day

Customer Quote:

"The VIP bolted right up and the fit was right on the money. I was impressed with the knowledge of the Chart team and the quality and accuracy of the installation."

Application:

VIP for LNG use on multiple fueling stations that was easy to install, economical to maintain, and could be easily replicated on future stations.

Project Background:

Major Energy Company wanted to design and build a select number of LNG fueling stations across the US. In order to mitigate risk and ensure profitability for the venture, they needed a way to distribute and dispense LNG in the most reliable and cost-effective manner possible, which could be easily replicated at new fueling station sites as needed. The piping system would need the lowest maintenance solution available in the industry.

Solution:

The energy company contracted Chart Inc. to design, manufacture and commission 20 LNG fueling stations, the first of which opened in May 2014 in California. The stations are built in a phased approach based on the success of the first few locations, with each station designed to fill up to 150 trucks per day.

As part of applying its 50+ years of experience toward ensuring a safe, dependable and profitable configuration, Chart recommended using vacuum insulated pipe (VIP) instead of mechanically insulated pipe (MIP) to distribute LNG from the onsite storage vessel to the LNG dispensers.

Chart VIP incorporates several advantages that greatly reduce total cost of ownership versus MIP. Those include a double-wall design that decreases heat leakage by 90% and acts as a secondary barrier for safety, while preserving the maximum amount of energy per volume of LNG to ensure superior MPG performance for end-users. The typical VIP installation also offers a functional life up to 10 times longer than that of MIP.

System Configuration:

- 200 ft of 2" ID VIP
- Connecting manifolds
- VIP skids installation and onsite testing includes in the start-up and commissioning support of the total LNG fueling station(s)

Significant Accomplishments:

- Low heat leak and low pressure drop
- Reduced transport costs, ease of installation and ease of service
- Full system includes design for efficient recovery & reuse of vented LNG
- Minimal vibration between the pumps and distribution system
- Maximum temperature expansion and contraction compensation





Rail – LNG Tender Car



Highlights:

Location — Jacksonville to Miami
Rail Lines

Scope of Project:

- Full diesel horse power and operating characteristics are maintained in the locomotives with LNG
- All equipment built in the USA
- Designed to displace up to 80% of the diesel fuel required to power the locomotive
- US Factory built & tested rail tender car for class 1 railroad
- LNG rail tender car for original pilot project
- Designed with ability to support locomotives built by various manufacturers

Application:

With a 20+ year history of engineering and manufacturing LNG rail equipment for various US and Canadian pilot projects, Chart was approached to design and supply the full LNG tender car. The tender car would need to support one to two locomotives that could displace 80% of the diesel fuel and meet or exceed the current FRA and AAR requirements. It was designed with the ability to refill with minimal effort.

Tender Car Configuration:

- Designed to fuel 1 to 2 locomotives
- PLC manages the supply mode from the tender
- On-the-tender LNG storage provides ~5,900 DGE (diesel gallon equivalents; 10,000 gallons LNG)
- Gas transfer from the tender can be by liquid pump transfer, liquid pressure transfer or gas pressure
- 130 psig at the tender end plate
- 119,000 lbs (~53,977 kg) tare weight

Significant Accomplishments:

- 12 additional Chart manufactured LNG tenders put into service
- Extremely robust safety features
- Design withstands the longitudinal and side impact crash scenarios as specified in Section 10 of the March 31, 2015 NGFT Draft Standard
- Includes custom, purpose built, platform car per end user specifications
- Gas supply from either end of tender and liquid fill and vapor return connections can be accessed from either side of the unit
- Connections located at center of the unit; meets the side impact requirements
- Initial conversion from diesel to LNG occurred November 2014 on GE ES44C4 440 HP 'dual fuel' locomotive
- These locomotives, together with the LNG fuel, meet Tier 3 emissions





LNG Bunkering Terminal with Integrated Gas Feed for Factory Boilers



Highlights:

Location — Oksvoll, Norway

Scope of Project:

- Complete bunkering solution incorporating in-house design and manufacture of principal equipment
- LNG evaporation system provides natural gas for the boiler operation at the adjacent fish processing factory
- Bunkering capability @ 1700 liters/min.
- Evaporation capability @ 2000 Nm³/hr (for 20MW boiler consumption)
- 24/7 operation
- Zero emissions to atmosphere
- Commissioning and start-up support with training
- Operations started March 2014

Application:

The bunkering station was commissioned to support Marine Harvest's ability to fuel LNG powered fish farm feeder vessels serving 40 offshore farms. An integral evaporation plant re-gasifies LNG to provide a source of natural gas for nearby fish feed processing facility's boiler system. The LNG storage tanks are designed to be supplied with LNG by ship but also have the facility to unload LNG by road tankers.

Environmental concerns were top of the list. The complete system is designed and built to ensure no loss or venting of product to atmosphere under normal operations.

System Configuration:

- Supply vessels are connected to the terminal via a jetty module
- Solution comprising three perlite vacuum insulated horizontal storage tanks
- Three tanks provide 750 m³ of LNG storage (approx. 500 m³ for bunkering and 250 m³ for the boiler)
- Both the bunkering and boiler feed sections were designed for low and high operational modes
- Designed and built fully in accordance with relevant compliance standards and local legislation
- Chart engineered and supplied 945 ft (290 m) of vacuum insulated pipe (VIP) with 6" inner diameter / 8" outer diameter in 12 m sections for optimal transport
- Outer pipe SS316L/316
- Reduced cost of install with field welded joints and no insulating of pipe needed on site
- Residual gas from the bunkering line is returned to the boiler tank or direct to the boiler itself to eliminate any gas being vented to atmosphere

Significant Accomplishments:

- Bunkering station and boiler feed support Marine Harvest's initiative to minimize their environmental impact
- The bunkering station fuels the vessels for a 55 hour round trip around the fish farms
- Chart proprietary VIP decreases heat leakage by 90% and provides a functional life up to 10 times longer than conventional mechanically insulated pipe





LNG Fueled River Barges



Highlights:

Location — Yangtze River, China

Scope of Project:

- Engineered, built and delivered complete LNG fueling solution for Weichai 155 kW gas fueled marine engines
- Local design and manufacture
- Prestigious Chinese customers
- Compliance with Chinese marine classification
- Chart Vacuum Technology®
- Minimized footprint
- First vessels operational since 2015

Application:

400 million people depend on China's Yangtze River. Before exiting to the sea in Shanghai, the Yangtze passes through some of China's major industrial cities in its lower reaches and is the world's busiest inland shipping corridor. The Chinese government is committed to its environmental recovery, and transitioning to green energy to power marine vessels is just one of the many initiatives being pursued.

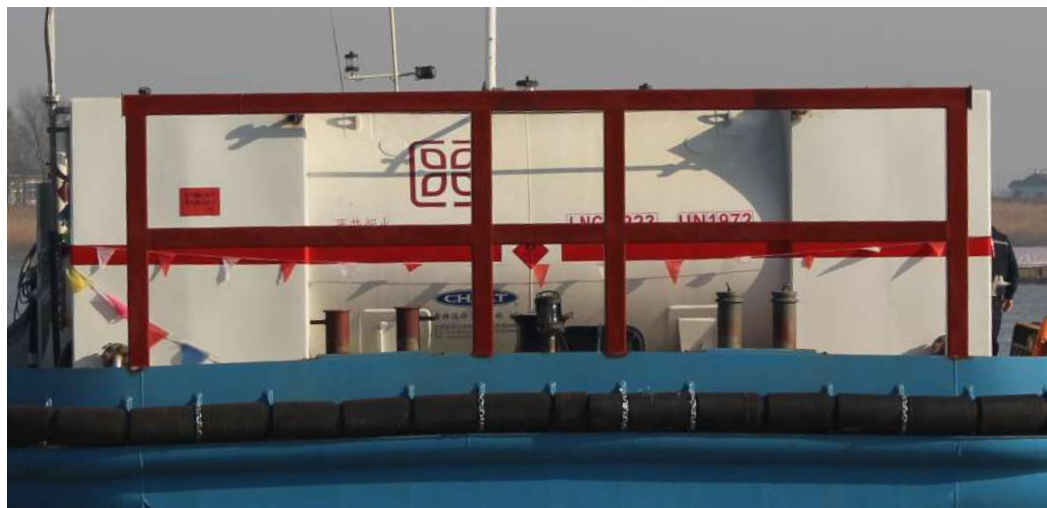
Chart was approached by two acclaimed Chinese companies operating on the waterway to provide the complete fueling solution, including storage and delivery systems for new natural gas fueled vessels they building. All the craft are powered by Weichai 155 kW marine engines but Chart had to cater for different tank capacities and piping arrangements associated with the tank connection spaces (TCS and also known as cold boxes) that are called by marine rules to house the valves, vaporizers, plumbing and instrumentation.

System Configuration:

- 5.6 m³ horizontal cryogenic storage tank with dual drip tray
- 5.6 m³ horizontal cryogenic storage tank with twin TCS
- 11 m³ horizontal cryogenic storage tank with twin TCS
- Tanks can be supplied with LNG through marine bunkering or road tanker

Significant Accomplishments:

- 4 systems for a fleet of 30 TEU household garbage ships were delivered in 2017
- Fully engineered, built and tested in our Changzhou facility
- Equipment is fully in accordance with China Classification Society (CCS) standards





Marine Fueling – High Speed Catamaran



Highlights:

Location — Argentina / Uruguay

Scope of Project:

- World's fastest, cleanest and most efficient high speed ferry
- First high speed ferry built according to High Speed Craft (HSC) Code to be powered by LNG fuelled turbines
- Lightweight, compact solution
- Heat recovered from the turbine exhaust gas is used to evaporate LNG
- Enhanced safety functions

Application:

The Francisco, designed and built by Incat and owned and operated by Buquebus, operates twice daily between Montevideo and Buenos Aires with an each way transit time of just 2 hours and 15 minutes. It is equipped to carry 1000 passengers and 150 cars, in comfort, and can maintain a speed of 50 knots when fully laden.

Chart's project scope was to design, manufacture and commission the first of its kind fuel system that stores LNG and converts it to gaseous methane (natural gas) for power.

Solution:

Power to the catamaran's two General Electric LM2500 gas turbines is provided by twin 43m³ DNV approved cryogenic tanks, engineered and manufactured in Chart's Decin facility. Although identical, the LNG fueling systems are housed in separate hulls and are therefore designed to operate independently. Other items comprising the complete system include a pump, vaporizer, valves, instrumentation, engine feed line, water/glycol heating circuit, bunkering lines, controls and nitrogen system.

Size, weight and safety were three fundamental prerequisites for this best in class vessel and Chart's innovative stainless steel 'cold box', engineered to house the control system, cryogenic pump and vaporization system, accomplishes all of them. Constructed from 316L grade stainless steel with A-60 insulation, the cold box is equipped with a CO₂ fire extinguishing system, two gas detectors that monitor constantly for leaks and two flame detectors. In addition, the cold box is ventilated with 30 air changes each hour.





LNG Industrial Regasification / Vehicle Fueling



Highlights: Location — Florence, VT

Phase 1 (Fall 2013):

- Eight (8) 15,000 gallon LNG tanks; total storage volume of 120,000 gallons
- Ambient vaporization
- Final line pressure control and trim heating
- Odorization
- Complete system instrumentation and control package

Phase 2 (Fall 2014):

- Added 3,000 storage tank (filled from on-site storage) for vehicle fueling application
- Added pump skid and dispenser
- Updated controls integration to support added fueling application

Both Phases Included:

- Startup, commissioning and on-site training of system equipment

Application:

Dedicated LNG regasification system operating 24/7/365 for a Minerals Processing Facility. First LNG application in the state of Vermont. System installed and operational in the fall of 2013. A phase two project included adding a truck fueling station to the existing design to support fueling over a dozen mining trucks that support the movement of raw mineral materials from the quarries to the various processing areas in and around the site. A "plug and play" solution for phase two was incorporated into the initial design so that it could be installed with minimal downtime to the regasification portion of the system. Phase two was completed in the fall of 2014.

Project Background:

Chart provided a complete turnkey equipment solution to provide LNG as an alternate fuel for the customer's energy intense manufacturing processes. They were held hostage to using only No. 2 fuel oil and wanted to have another, greener, option that would save them money and provide them with fuel diversification. Other possible, greener, solutions like wind and solar were also evaluated but deemed impractical for the application the customer serves. Availability of LNG from various sources within reasonable distance from the site made the project feasible.

System Configuration:

Phase 1 (Regasification)

- Eight (8) 15,000 gallon storage tanks for a total storage volume of 120,000 gallons. Provides a week's worth of total storage in the event of supply disruption (e.g. inclement weather)
- Offloading skid: Allows for filling storage tanks while system is supplying gas to the plant
- Ambient vaporization
- Final line pressure regulation along with odorization of gas
- Complete controls integration of the LNG Regasification plant

Phase 2 (Truck Fueling)

- Added 3,000 gallon storage tank for vehicle fueling
- Added pump skid and dispenser for vehicle fueling
- RFID identification of each tractor during a fill
- Updated PLC controls

Significant Accomplishments:

- First LNG installation in state of Vermont
- First ever integration of truck fueling application into an existing regasification facility, making this a dual use site



Vehicle Fueling Dispenser



Dual Electric Trim Heaters



LNG Truck Offload



LNG Storage & Regasification Conversion from Propane to LNG for Burner Supply



Highlights:

Location — Gujarat, India

Scope of Project:

- Proprietary major equipment engineered and built by Chart for a turn-key solution.
- LNG bulk storage (VT 105 m³/12 bar) and pre-manufactured assemblies
- Chart guaranteed the system operated & functioned as designed to deliver 26,000 SCM/day to sustain consumption & operate between 30-75 PSIG on the final line
- System designed for automatic operation with provision for manual intervention

Application:

Replacement of existing propane system to more cost-effective natural gas to feed the burners of a copper smelter.

Project Background:

Chart developed a full equipment package solution, which takes LNG from trailers through to the final line.

System Configuration:

Engineering, project management and skid-mounted equipment modules were provided by Chart's New Prague, MN technical center. The 105m³ storage tank was built at the Chart facility in the Czech Republic and shipped direct to site. The vaporizers were sourced locally from Chart's indigenous business partner Shell-N-Tube.

System operation controlled from a remote panel containing both PLC (Programmable Logic Computer) using pneumatic logic and HMI user interface. The air-actuated valves in the system select the various operating modes and also serve as an emergency shutoff device. The system was completely instrumented, with pressure, level, and temperature transmitters feeding the Control System.

The system allows for automated switching of liquid flow between two ambient air vaporizers allowing time to defrost in between cycle and not affect the system flow rate during continuous use requirement.

Pressure regulation completely automated by utilizing a Proportional Integral Derivative (PID) control loop and a flow control valve sized for this specific application. Provisions are provided to mechanically control the system without the Control System, if needed.

Significant Accomplishments:

Chart managed the entire project. System included automatic switch of liquid flow between two ambient air vaporizers to guarantee steady flow rate during continuous use. System operation controlled from a remote panel containing both PLC (Programmable Logic Computer) using pneumatic logic and HMI User Interface.





Power Generation at Secluded Diamond Mine



Highlights:

Location — Northern Quebec

Scope of Project:

- Engineering & Project Managed to support the design, manufacture, installation, startup, & commissioning for LNG storage system for plant power generation
- Project completed in early 2016
- (6) 80,000 gallon LNG storage tanks (MAWP: 101 psi / 7 bar)

Application:

Liquid Natural Gas (LNG) is used as the primary fuel source for power generation (seven 2.1MW gen sets) at a diamond mine, located in far north Quebec Canada, off the electric and natural gas pipeline grid.

Project Background:

Chart Industries was requested to provide LNG storage equipment, design and commissioning within a tight time line, in an extreme climate location.

System Configuration:

The LNG system is designed to unload LNG trailers into the storage tanks, rapidly without venting natural gas. The six 80,000 gallon tanks are interconnected with 300 feet of vacuum jacketed piping and feed the regasification vaporizers. The tanks are equipped with pressure building heat exchangers to maintain required tank pressure during high flow rates (193,000 SCFH / 5,466 Nm³/H). The control system is housed in a 20 foot ISO container for ease of transporting to the site.

Significant Accomplishments:

LNG Storage tanks were designed, manufactured and shipped within six months of receipt of order, delivered on time. Supply included control system design.

Installation and commissioning took place in far north of Quebec in January, in sub-zero conditions with limited light. The tank commissioning on site was accomplished in two weeks.

The tank cooldown process utilizes liquid nitrogen, which is inert and colder than LNG. Due to the remote location of the installation site, it was important to minimize the volume of liquid nitrogen used for this process. Clever commissioning engineering developed a cascade cooldown process, reducing the volume of required liquid nitrogen by 50%.





LNG Storage & Regasification



Highlights:

Location — Northern Territories, Canada

Scope of Project:

- Regasification application to support local power utility
- Peak gas supply of 1800 m³/h
- Reduced emissions

Application:

Dedicated LNG regasification system operating 24/7/365 in a power generation application for a local utility located in the Northwest Territories, Canada. System was installed and operational in late winter of 2014.

Project Background:

Customer has two power plants, one designed to run on diesel and one designed to run on natural gas. The plant that operated on natural gas received its supply from a well in the Mackenzie Delta, which powered the gas plant from 1999 to 2012, until the well stopped flowing. The diesel plant, normally used as standby power for the town, generated the town's power in 2013, while the customer looked for solutions.

Chart was requested to provide a complete turnkey equipment solution to provide LNG as an alternate gas supply for the power plant that was originally fed from the well. This was the Northern Canada's first LNG vaporization system. Peak gas output would need to be in the neighborhood of 1,800 m³/h of natural gas.

System Configuration:

- Two (2) 18,000 gallon storage tanks for a total storage volume of 36,000 gallons; system was designed to "drop in" a future third tank
- Offloading skid: Allows for filling storage tanks while system is supplying gas to the plant
- Waterbath vaporization (using waste hot water from power plant)
- Final line pressure regulation
- Complete controls integration of the LNG Regasification plant
- Startup and commissioning support

Significant Accomplishments:

- First LNG installation in Northwest Territories, Canada
- Chart was able to provide a turnkey equipment package with factory built modular components (tanks, pump skid, vaporizer, pressure regulation skid)
- Utilized pre-fabricated interconnecting piping spools that minimized field welding





LNG Virtual Pipeline

**Highlights:**

Location — Madeira, Portugal

Scope of Project:

- Chart worked in close collaboration with Gaslink and other Grupo Sousa companies
- Transport of LNG from mainland terminal to island power station in less than 1 week
- Power station provides the island with 240 to 450 GW/h of energy
- Equipment engineered and built at Chart Ferox facility in Czech Republic
- ISO-based system affords flexible solution that can be adapted to meet Madeira's future power demand

Application:

Supply LNG to Madeira's natural gas fired power station operating 24/7/365. Madeira is an autonomous, archipelago of Portugal located off the northwest coast of Africa and not connected to the natural gas pipeline grid. LNG is loaded into ISO units at the import terminal in Sines, transported over-the-road to the port and then by vessel to Madeira where it is offloaded into an LNG tank farm and regasified on demand.

Project Background:

Provide a transport solution in accordance with the following criteria:

- Maximum LNG payload within worldwide 40 ft container envelope
- Road and ocean transport in accordance with ADR, RID, IMDG, ISO 1496-3 and EN 13530-2 codes
- Fill rate of 1200 litres per minute
- Discharge rate of 600 litres per minute
- Aggressive delivery schedule

System Configuration:

55 units TVS-43-PB-10 ISO intermodal cryogenic containers with Chart Vacuum Technology®:

- Gross capacity: 43500 litres
- Tare weight: 11300 kg
- Max. gross weight: 34000 kg
- Design pressure: 10 barg/145 psig
- Hold time: 65+ days before reaching RV pressures
- Approvals: CSC, UN T75



SCAN CODE
TO SEE LNG
VIRTUAL
PIPELINE
IN ACTION





LNG Regasification System Conversion from Diesel to LNG for Power Generation



Highlights:

Location — Caribbean

Scope of Project:

- 1,764,000 gallons total onsite storage
- LNG ship offloading
- All-inclusive high capacity LNG pump and vaporization system, designed for no venting
- Trailer loading
- Future vehicle fueling system from same bulk storage
- Complete engineering, control and site safety systems

Application:

Enabling a 115MW power station in the Caribbean to convert from diesel to natural gas and use imported LNG as its primary fuel source.

Project Background:

The tight project timeline and requirement for minimal site civil work eliminated the site erected LNG storage tank as an option. Seven 1,000 cubic meter (252,000 gal) shop-built storage tanks were globally sourced from multiple manufacturing sites. LNG was initially planned to be transported to the island by 40 foot ISO containers; however, to further reduce costs, it was decided to transport by LNG tanker and off-load directly into the on-site storage tanks.

System Configuration:

Ship offload designed to interface with the tank farm. Thermax® (A Chart Industries Company) heat exchangers utilize sea water for high-capacity vaporization of LNG to gas. Cryogenic pumps boost pressure to 450 psig at a maximum flow rate of 6.08 kg/s. Boil off gas compression equipment captures any excess gas, sending it downstream, eliminating vent losses. The entire control system, designed by Chart, allows the system to operate automatically 24/7, through the entire demand profile with minimal operator interaction.

Significant Accomplishments:

Chart engineers designed the entire system, including storage tanks and manifold, tank loading, vaporization, boost pumps, boil off gas compression, and the operational control system. Safety and environmental objectives were of paramount importance. The entire system is designed in accordance with NFPA guidelines. The site operates normally without venting natural gas to the atmosphere.





Mobile LNG Regas System at Coal Fueled Power Plant



Highlights:

Location — West Virginia

Scope of Project:

- LNG in mobile format provided a quick solution to meet required timeline
- Minimum permitting
- Increased power plant equipment reliability
- One of the most efficient and cleanest coal-fired plants in the US using LNG as backup
- All equipment built in the USA
- Factory built & tested mobile equipment
- Total of 181,500 gal LNG storage
- Full regasification system included, for instant 'on' capability for burner supply
- Allowed for guaranteed start up and run when called
- Safety features installed on the system
- Peak flows of 1.8 million scfh
- Project Completion: June 2015

See LNG Mobile Regasification Spec Sheet
(PN 15089669)



Application:

The original layout was designed to support the startup of a new coal fueled power plant located in West Virginia. The mobile onsite equipment configuration guaranteed capacity for two full starts. The LNG system morphed from three month operational support to year round. It was developed into support for winter and summer performance risks, meeting the latest PJM Capacity Performance requirements.

System Configuration:

- 12 Chart regasification/Queen LNG storage units with on-board pumps
- E-stops at all egress locations
- Operations coordination with plant processes
- 1mw 480v electric power supply from plant

Significant Accomplishments:

- Full integrated mobile system operated as a single source of natural gas at pressures of up to 100 psig
- System approach has automatic switching, operations thru PLC panels
- LNG system has gone from three months of operation support to year round (no Chart equipment is currently on site)
- Mobile system gave winter peak or pipeline outage coverage

Customer Quote:

"Utilizing Chart LNG equipment in this application allowed Thigpen Energy to run the temporary LNG system at the extreme volumes of 1,800,000 scf per hour. That is an operation that not many in the world can put on their resume and Chart's equipment performed as promised."

James T. Schauer, CEO & Managing Director, Thigpen Energy





LNG Regasification Plant as Primary Backup to Natural Gas Pipeline



Highlights:

Location — Northeast United States

Scope of Project:

- Engineering and manufacture of turnkey system to store Liquefied Natural Gas (LNG) and supply in gaseous form to a central heating plant
- (3) 18,000 gallon LNG tanks
- (1) Indirect Fired Water Bath (IFWB) Thermax® vaporizer
- (1) Ambient air vaporizer sized to accommodate Boil-off Gas (BOG) from the storage tanks during periods of non-use
- Truck offload station with dual pumps
- Allow for two modes of operation – full manual and full automatic
- Startup, commissioning, and onsite training on system equipment
- Project Completion: October 2016

Application:

University campus – LNG regasification plant to be the primary, stationary backup to natural gas pipeline supply during times of high use, or allows for interruptible pipeline service. Converting from ultra-low sulfur diesel is expected to save the university millions of dollars over the next few years, as well as reducing their carbon footprint.

Project Background:

The University campus had previously used LNG in trailers (as a trial mode change from diesel) during peak season and desired a permanent solution. The LNG supply had to be in place for the start of the 2016/17 heating season. Both fully automatic and manual modes were required. System was required to accommodate flow rates fluctuating between 10,000 and 175,000 standard cubic feet per hour of natural gas.

System Configuration:

LNG facility station includes onsite storage totalling 54,000 gallons gross capacity in vertical cryogenic tanks. Other components in the total system approach – VIP (between vessels & vaporizer), pump offload skid, waterbath vaporizer, and BOG heat exchanger. The multiple manifolds included an LNG CGA connection, both upstream and downstream BOG valving, upstream and downstream water bath valving, and the Final Line Pressure Control with metering skid and vent stack. All components were factory tested and designed for ease of installation. Chart's personnel managed the project installation.

Significant Accomplishments:

- Chart was able to provide a total turnkey package with U.S. factory built equipment and skid designed for easy installation at site
- Designed to operate in two modes: automatic mode puts the equipment into standby/backup mode between November 1st and April 15th – winter heating season; manual operations, or summer mode, is used for the balance of the year
- To eliminate the venting of natural gas, Boil-off Gas (BOG) is managed through economizer circuits on each tank. Plant operators monitor the pressure in each tank, utilizing BOG valves as needed. This causes the line pressure in the supply line to drop below the supply pressure and opens valves on the final line pressure regulator to flow gas from the tank(s) to the University Central Heating Plant mixed with the natural gas pipeline supply. The end result is the system does not vent any natural gas to atmosphere throughout the entire year
- Integrated the controls and screens with remote view and run capability to the existing system.
- Onsite commissioning with operation and safety training in three days



3 tanks, vaporizer,
IFWB and manifolds



Final Line Manifold



LNG Power Barge



Highlights:

Location — Hamburg, Germany

Scope of Project:

- Close collaboration with Becker marine and other project partners
- Commercial operations began in spring 2015
- Application of good engineering practice
- Engineered and built at Chart Ferox facility in the Czech Republic
- Chart Vacuum Technology®
- Proven cryogenic tank design incorporates stainless steel inner and outer vessels for enhanced safety

Application:

LNG fueling system for Hummel, a hybrid power barge and the world's first environmentally-friendly floating power plant providing energy to cruise ships during layovers in the port of Hamburg, Germany. In accordance with MARPOL regulations, using LNG instead of distillate fuel significantly reduces harmful gas emissions, including sulphur and other soot particles, nitrogen oxide and carbon dioxide. The barge was built by Becker Marine Systems who partnered AIDA cruises; the AIDAsof being the first cruise ship to be supplied with electricity from the LNG fuelled power plant. Hummel's environmental footprint is further enhanced through being outfitted with equipment to supply electricity during peak times and to other ships during winter.

Project Background:

Provide the LNG fueling solution in accordance with the following criteria

- Maximum LNG payload within standard intermodal container envelope
- Demonstrate enhanced safety (first of its kind)
- Eliminate the need for a bunkering station (for the initial phase)
- Minimize footprint
- Quick and efficient change over

Significant Accomplishments:

Chart's LNG fueling system is housed in two 40' ISO containers complete with a skid mounted gas processing unit, interconnecting pipe work, control and safety appliances. The system provides cryogenic storage of almost 23,000 gallons of LNG capable of powering two CAT3516 generator sets (rated at 1555kW each).

- Compact, lightweight design to minimize valuable real estate
- Fully modular
- Full for empty swap basis
- Incorporates option to fill from bunkering station (at a later date)
- High-pressure fueling system for optimum engine feed
- Docking station





LNG Solutions in Action

Chart holds the following international HSE and quality accreditations:

Quality Management System in accordance with ISO 9001:2008

Environmental Management System in accordance with ISO 14001:2004

Occupational Health & Safety Management System in accordance with BSOHSAS 18001:2007



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