

The Dominican Republic LNG Import Terminal: Challenges in Engineering, Procurement and Construction

Brian Eisentrout, Tim McKinney, Jeff Sipes, and Barbara Weber, CB&I, USA

CB&I describe the engineering and construction of the AES Andres LNG import terminal in the Dominican Republic, and how they dealt with the challenges associated with the site, the integration with a new power plant, and the need for cost savings.

As energy deficient countries continue to seek environmentally friendly fuel sources to feed new power generation, opportunities have emerged to couple LNG import terminals with the construction of new power plants. A recent project in the Dominican Republic provides a successful example of this strategic combination. The power plant and the terminal, the first LNG facilities in the Dominican Republic, were planned in such a way that they could be operated efficiently together, despite the fact that each was designed by a different company. A number of innovative features were included in the design to optimize the integration. The LNG that is now imported into the Dominican Republic for use in the new power plant is also available as a fuel source for older existing power plants in this small island Caribbean country. One of the country's older plants has already been retrofitted to be able to use natural gas as its fuel source, with other plants looking at the viability of making this same alteration.

The Dominican Republic comprises the eastern two-thirds of Hispaniola, an island located between the Caribbean Sea and the North Atlantic Ocean just to the southeast of Cuba. A site for the LNG import terminal and power plant was selected along the shoreline, 30 km east of the Dominican Republic's capital city of Santo Domingo. The sea is rough in this area, and the land is pelted with salt spray. Since the island sits atop a large coral reef, the shoreline is dominated by porous limestone (see Figure 1). Over time, the sea and the spray have created numerous cavities in the limestone. The area is seismically active and located in the middle of the path many hurricanes follow as they move through the Caribbean corridor.

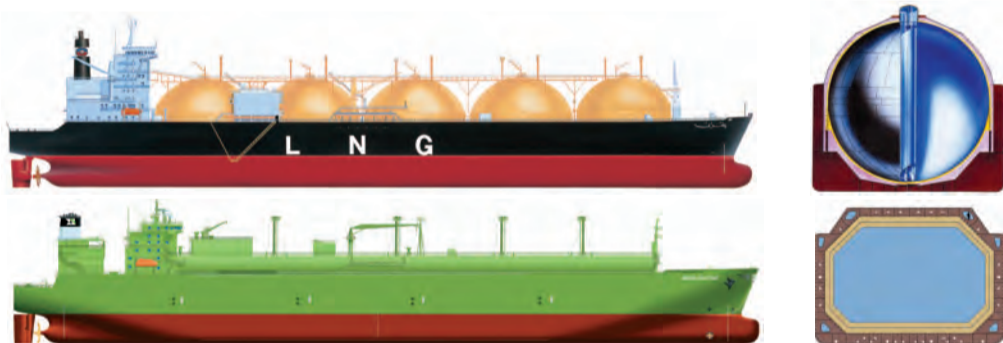
These are the conditions that AES Corporation encountered when they initiated the AES Andres project in the Dominican Republic. This project consisted of three contracts: the power plant, the jetty, and the LNG import terminal. AES selected CB&I to deliver the LNG import terminal portion of this project on a lump-sum



Figure 1: Aerial view of completed AES Andres LNG Import Terminal

on your risk agenda:

LNG Transportation



Large LNG ships, partial filling of cargo tanks, longevity, fatigue, coating, increased corrosion margins, alternative propulsion arrangements, cold climate, emissions are all subjects now on the agenda within the LNG shipping community. DNV was actively involved in the pioneering work to develop both membrane and spherical cargo containment systems more than 40 years ago, and all cargo containment systems have been approved by DNV. Experience gained, accumulated competence combined with state-of-the-art software for structural analysis makes DNV the ideal classification partner for successful ship design, construction and operation.

We can help you manage the new risk reality. Visit www.dnv.com to find out how.

new perspectives	
technological edge	
efficient delivery	
solution orientation	

State-of-the-art technology, the right tools, and the ability to make the most of it. At DNV, we base our offering on our leading maritime technology and expertise. It's technology that gives you an edge.



MANAGING RISK

turnkey basis. The import terminal included a receiving system to unload the LNG from the ship, a storage tank with enough capacity to hold the entire cargo of a 145,000 m³ LNG ship, a vapor handling system, and a send-out system, all fully integrated with the associated power plant (see Figure 2). CB&I's work included project development support, process design, civil and structural design, detail engineering, material supply, fabrication, project management, construction, pre-commissioning, startup and operator training for the import terminal.

CB&I faced numerous challenges in both the design and the construction of this facility, including:

- building an LNG facility on a location with harsh site conditions, subjected to frequent seismic events and also with high exposure to hurricane winds common in the Caribbean
- a design requirement to optimize the efficiency of the adjoining power plant through a unique system for thermal integration with the LNG terminal, and
- a need to balance capital expenditures against operating costs to make the terminal as capital efficient as possible

The terminal is designed for the typical one-day LNG ship unloading turnaround. The unloading time including LNG transfer arm cool-down and ship cargo pump ramp up and ramp down will not exceed this one-day allowance. These design challenges were intensified by an aggressive schedule aimed at expediting the completion of the entire project as quickly as possible to meet the Dominican Republic's critical need for power. This article describes the notable engineering, procurement, and construction challenges encountered in building the first LNG import terminal in the Dominican Republic.

Engineering Challenges

AES and CB&I worked closely together to develop a design concept for the terminal that would not only be cost-efficient to operate stand-alone, but would also provide operational efficiencies when used in conjunction with the power plant.

Site Conditions: The porous limestone topography presented a variety of challenges to the design of the import terminal and associated storage tank. A ringwall was designed to provide a suit-

able foundation for the storage tank. As the preliminary excavation work for the ringwall was being performed, it was discovered that the limestone in that area contained solution cavities where the mineral in the rock had leached out over time. Some of these cavities could not be avoided and required remediation. To strengthen the limestone beneath the tank, bore-

holes were drilled into the limestone under the tank and under parts of the process area, and then the boreholes and any cavities encountered were pumped full of grout. Approximately 2,000 cubic yards (1600 m³) of grout was pumped into the limestone beneath the tank through these holes.

The use of locally available materials for

construction of the earthen secondary containment structure was convenient; however, these materials required stabilization when used in the earthen dike (see Figure 1). To improve the soil's structural properties and reduce its permeability, the soil in the outer five feet of the dike was mixed with cement and compacted to form soil cement. Both the walls and the bottom of



FCX Orton MV Series triple eccentric metal-seated valves for use in the Atlantic LNG project in Trinidad



FCX manufactured Truflo ball valves; Rona gate, globe and check valves and Royal butterfly valves were supplied to the Korean Gas Corporation's LNG terminals at Incheon and Pyeong Taek.
Photo courtesy Korean Gas Corporation



Specialist valves for performance critical LNG applications

Orton MV Royal Series BW, top entry, triple eccentric, metal seated valves



FCX offers products for every application, from hazardous chemicals to abrasive powders at a range of temperatures and pressures.



Truflo top-entry cryogenic ball valve

The Power to Perform

www.fcx-orton.com
www.fcx-truflo-rona.com

FCX Europe Head Office
Gaetano Martinolaan 95
6229 GS Maastricht
The Netherlands
Tel: +31 43 35 66 901
Fax: +31 43 35 66 903
email: info@fcx-europe.com
website: www.fc-x.com

FCX Orton
Via Grilli, 2/A San Nicolo A Trebbia
29010-Rottofreno-(PC)
Italy
tel:+39 0523 762 511
fax:+39 0523 762 512
email: sales@fcx-orton.com
web:www.fcx-orton.com

FCX Truflo Rona
Parc Industriel des Hauts Sarts 4040 Herstal
Belgium
tel:+32 (0) 4 240 6886
fax:+32 (0) 4 248 0246
email:sales@fcx-truflo-rona.com
web:www.fcx-truflo-rona.com

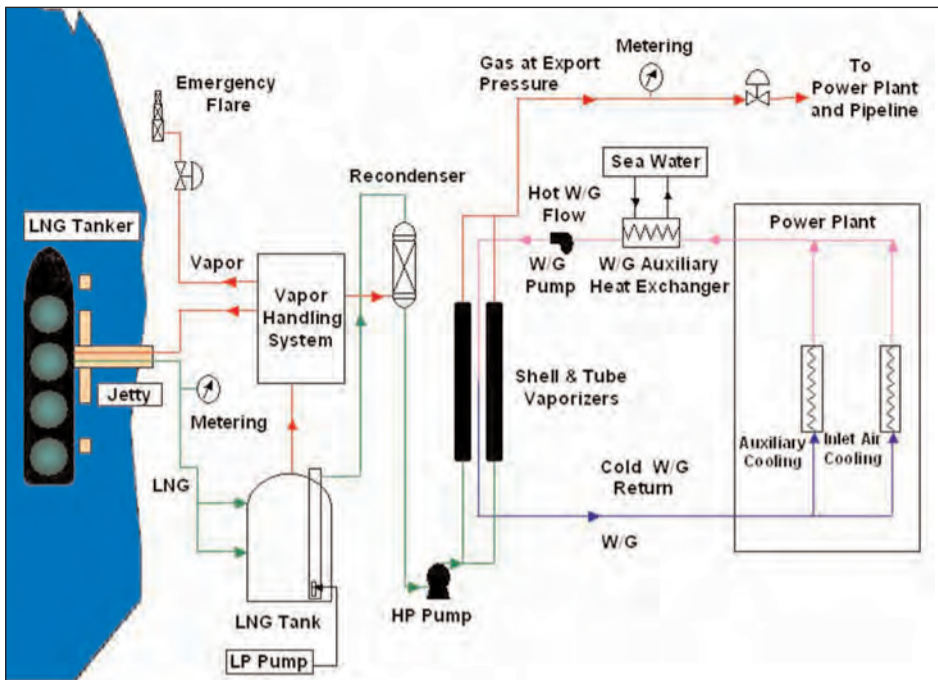


Figure 2 Schematic for the LNG Import Terminal

the containment structure were constructed of this soil/cement mixture. Additionally, a concrete revetment mat was constructed over the ocean-side surface of the dike to protect the dike from wave-action damage during severe storms.

Seismic studies of the site were conducted and analyzed to ascertain specific data about the location. This data was used to determine the requirements for building structures that might experience an earthquake of the magnitude and duration that could occur at the site. U.S. engineering codes were followed to develop a structural design for the storage tank that

would withstand a horizontal peak ground acceleration of 0.857g (Safe Shutdown Earthquake -SSE horizontal as defined by NFPA 59A 1996) as well as 150 mile an hour wind gusts.

Thermal Integration: The desire to optimize the efficiency of the power plant through a thermal system integrated with the terminal presented yet another set of challenges. A heat transfer system, using a water/glycol heat transfer fluid, facilitated the use of waste heat and turbine combustion air as a heat source for vaporization. On the terminal end, the warm water/glycol mixture was designed to

vaporize and superheat the LNG from a liquid at -260 °F (-162 °C) to a vapor at 40 °F (4 °C). During this process of vaporizing and heating, the water/glycol is cooled and then sent to the power plant, providing cooling for the utilities and cooling for the inlet air for the gas turbine, both of which make the power plant operate more efficiently. The heated water/glycol is returned to the terminal. This closed-loop cycle is then repeated. While the power plant is operating, the temperature of the water/glycol sent to the power plant is maintained by an integrated control system. Both the LNG terminal and the power plant are responsible for maintaining this temperature as well as the heat balance. Common pumps located in the import terminal area circulate the water/glycol to the power plant and back to the import terminal. No additional water/glycol pumps are required in the power plant to circulate the mixture. This design improves the operating efficiency and the output capacity of the plant with no additional capital investment.


A heat exchanger in the water/glycol loop uses seawater as a back-up heating system for vaporization so natural gas send-out may occur when the power plant is not operating. The power plant cooling water pumps provide the seawater to the import terminal so a separate import terminal seawater intake is not required.

LNG Reception, Storage and Send-Out: The terminal was designed to unload a ship at a rate of 10,500 m³ per hour. In this case, three unloading arms provide the

necessary capacity. As the LNG is unloaded into the storage tank, some residual vapor is released. The vapor load may be handled in several different ways depending on the options available to the import terminal at the time of ship unloading. Conventional non-cryogenic blowers and compressors handle this vapor load by returning vapor to the ship and sending it to the recondenser. Vapor may also be flared on an emergency basis.

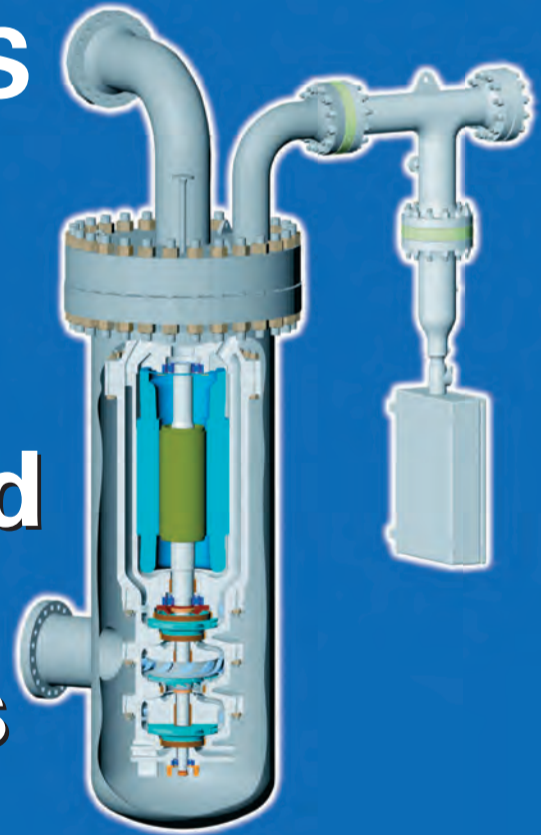
The unloaded LNG is sent to a double-wall, steel, flat-bottom tank (see Figure 3). The storage tank design capacity is 160,000 m³, allowing the entire capacity of a 145,000 m³ LNG tanker to be unloaded while maintaining adequate inventory to allow for shipping schedule variations. The outer tank is carbon steel, the inner tank that holds the LNG is 9%-nickel steel, and the suspended deck is aluminum. Insulation on the internal suspended deck and in the annular space between the inner and outer tank walls is expanded perlite. The load bearing bottom insulation is cellular glass.

In many LNG import terminals, the vapor handling system compresses the boil-off and unloading vapor to the line pressure of the pipeline. In contrast, the vapor handling system designed for this project was made more economical to operate by using efficient pump energy instead of gas compression to do the majority of the work in handling the boil-off and unloading vapor. The vapor handling system compresses the boil-off and excess ship unloading vapor and sends it

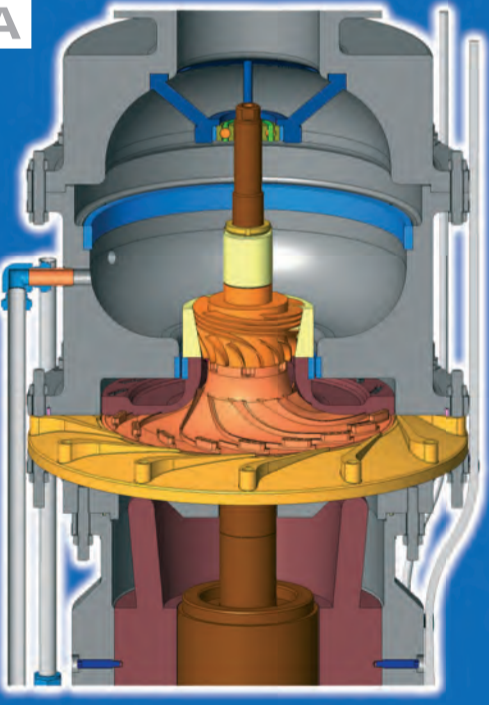


EBARA CRYODYNAMICS

Turbine Expanders for Liquid and Two Phase Applications



Liquid Turbine Expander



Medium and High Volumetric Two Phase Turbine Expander

Headquarters
EBARA International Corporation
 Cryodynamics Division
 350 Salomom Circle, Sparks,
 Nevada 89434, USA
 Tel: +1 (775)356 2796
 Fax: +1 (775)356 2884
 Email: Sales@Ebaraintl.com

Representative Office, Europe, Middle East and Africa
EBARA International Corporation
 Cryodynamics Division
 The Pavilions, 1 Weston Road, Kiln Lane,
 Epsom, Surrey KT17 1JG UK
 Tel: +44 (0)1372 739666 Fax: +44 (0)1372 748290
 Email: London@eicuk.com

Asian Office
EBARA International Corporation
 Cryodynamics Division
 1-6-27 Konan Minato-Ku, Tokyo 108-8480,
 JAPAN
 Tel: +81 (3) 5461 5285
 Fax: +81 (3) 5796 0369
 Email: tanaka.hiroshi@ebaracom

Visit our web site www.ebaracryo.com



Figure 3: The storage tank and send-out system

to the reconder, operating at low pressure. The LNG flowing through the reconder condenses the vapor, which then becomes liquid and is added to the send-out volume. Second stage pumps are used to increase the pressure of the liquid to pipeline pressure. The liquid then goes through a vaporizer, where it is warmed to 40°F and sent into the pipeline. This design, using a reconder, reduces both capital and operating costs by minimizing the size of the compression equipment, as the vapor is compressed only to reconder pressure, which is a small fraction of pipeline pressure.

Procurement Challenges

Procurement also presented significant challenges. Materials and equipment were purchased from over 15 different countries. The international effort of identifying qualified suppliers, monitoring their progress, inspecting the suppliers' finished products, and ensuring on-time delivery to the jobsite required a diverse project team with worldwide coverage. The logistics of coordinating shipping through various U.S. ports for consolidation with materials shipped direct to the Dominican Republic challenged the most experienced managers.

Construction Challenges

The construction of the LNG import terminal presented its own set of unique challenges. Most of these were driven by the accelerated project schedule created to address critical power shortages in the Dominican Republic. AES wanted the import terminal completed and operational in 26 months to meet this need. Construction was completed in a record 24 months, beating this deadline.

AES worked with CB&I to develop a construction schedule that would bring up the facility in phases. The first phase began when AES granted CB&I early release of the engineering. This allowed CB&I to do all the preliminary work in preparation for the construction startup while AES was still securing the necessary permits. As a result, once all the permits were received and AES gave CB&I the Notice to Proceed, CB&I was able to mobilize and begin construction within one week, with subcontractors hired and on location. Purchase orders were established and long-lead items could be ordered quickly. Foundation and site

engineering had been completed, and tank materials could be ordered. The early release of engineering shaved three to four months from the construction schedule.

The scope of the project grew during the construction process. One of the first modifications to the project involved a request to complete the send-out system so that it could be used stand-alone, if necessary, while the storage tank was being built. According to the original schedule, the power plant would be operational before the storage tank was completed. The intent of the modification was to send LNG directly to the power plant from a ship without waiting for the completion of the storage tank. The send-out system was built first and connected directly to the receiving system. LNG could then be unloaded from the ship at a low flow rate and sent directly through the send-out system to the plant. While not cost-effective for normal operations since the time required for the ship to remain at the facility was greatly increased, this design provided flexibility for the import terminal operators during the construction process. Although subsequent construction delays with the power plant rendered it unnecessary to use the send-out system stand-alone, it was successfully built with the capability to be operated in this manner.

Other modifications that were added to the scope of the work involved the civil work at the site. CB&I was up and running on location so quickly that it made sense for them to handle much of the work that was originally included in another part of the project, including the building of roads, drainage systems, and site remediation. They were able to subcontract and oversee this work and complete it along with the import terminal.

Because of its long history of constructing facilities in the Dominican Republic, CB&I was able to hire and train the construction crew in an expedited timeframe. The construction crew was predominantly staffed with labor resources from the Dominican Republic. Including subcontractors, about 90% of the construction crew members were Dominican Republic nationals (exceeding the local labor requirement). Of the CB&I employees on the crew, at least half were nationals, many of whom had worked for CB&I on other projects in the Dominican Republic. This experience greatly reduced the amount of training time required and facilitated the fast-track construction pace. CB&I was able to select skilled supervisors from their extensive labor pool in neighboring Central and South America, as well as the Caribbean. These individuals played key roles in field supervision and created a team of talented professionals who were adept at handling local, as well as global, construction problems. This approach not only helped shorten the project schedule, but it also helped in resolving other location-specific issues that were encountered.

Once the crews were hired and on the ground, training became the next priority, especially safety training. Safety was never compromised in the interest of completing the project quickly. Crew members were trained to follow the safety practices required on all CB&I's construction projects. As a result, the project team com-

pleted the project without incurring a recordable injury or lost-time accident.

The ability to accomplish this significant result required a total team effort. The commitment of every member of the construction crew to work safely and to work smart, along with the outstanding leadership of the safety manager, the superintendent, the construction manager, and all the field supervisors, contributed to the remarkable success of this project. The spirit of the Dominican Republic nationals, whose friendly attitude and strong work ethic created the atmosphere in which the work was

fuel the Los Mina power plant, an older power plant owned and operated by AES in the neighboring city of Haina. The Los Mina plant was retooled to use natural gas as a fuel source, and a pipeline was constructed to carry the natural gas from the import terminal to the plant.

In December, the new power plant was completed and the LNG import terminal was fully tested. During this testing, all of the systems were operated and monitored to ensure that all design specifications were met, including the rate and pressure at which the ship was unloaded and the

The spirit of the Dominican Republic nationals, whose friendly attitude and strong work ethic created the atmosphere in which the work was performed, helped AES and CB&I find solutions for all the challenges encountered in the construction process.

performed, helped AES and CB&I find solutions for all the challenges encountered in the construction process and led to the safe and successful completion of the project two months ahead of schedule.

Commissioning

The AES Andres LNG import terminal, the first in the Dominican Republic, was commissioned on February 20, 2003. The facility achieved mechanical completion the preceding September, but the power plant at the site was not ready to receive LNG at that time. In February, the first ship docked at the terminal site and successfully unloaded LNG into the terminal. Although the associated power plant was still not operational, the LNG was used to

rate and pressure of the send-out system. Adjustments were made as necessary to ensure optimal performance.

Conclusion

The power plant and LNG import terminal are now fully operational, and LNG imported at the terminal is being used to fuel both the new AES Andres power plant and the older Los Mina power plant. While the Dominican Republic continues to seek solutions to meet its power needs, LNG is already bringing some relief to the problem by providing a new fuel source for power generation in the Santo Domingo area, with tremendous potential for transporting the fuel to other locations throughout the country. ■

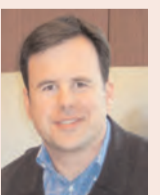
Tim McKinney is a Project Manager with CB&I Company Ltd. With over 20 years of engineering and construction experience, he has worked 14 years as a Project Manager in locations around the world. He has overseen the construction of several LNG facilities and has specific expertise in grassroots turnkey project development. He is a licensed professional engineer and received a Bachelor of Engineering degree in Civil Engineering from Louisiana State University.



Brian Eisentrout is a Process Engineering Supervisor with CB&I Technical Services Co. He has more than 15 years experience as a supervisor of CB&I engineering projects and has led teams in the design of a number of domestic and international LNG facilities, including liquefaction, storage, pump-out and import facilities. He is a licensed professional engineer and received a Bachelor of Science degree in Civil Engineering from Washington State University.



Jeff Sipes is Vice President, LNG Business Development, Asia and The Americas at CB&I Company Ltd. With over 14 years experience with CB&I, he specializes in business development for LNG facilities. He has focused on project development opportunities in Venezuela, then throughout Central and South America, and he is currently pursuing opportunities in Asia as well. He received a Bachelor of Science degree in Civil Engineering from Texas Tech University.



Barbara Weber is a Marketing Analyst with CB&I. She has 20 years experience in the oil and gas industry, working primarily in public relations and marketing. In this capacity, she has worked on various LNG projects. She has a Bachelor of Arts degree from the University of Texas at El Paso, a Master of Arts degree from New Mexico State University, and an MBA from the University of Phoenix.

