Siemens PTI Report

PREPA Fuel Delivery Option Assessment

Prepared for

Puerto Rico Electric Power Authority (PREPA)

Submitted by:
Siemens Industry

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Section 1

Executive Summary

Siemens Industry, Inc. for its Siemens Power Technologies International (Siemens PTI), and its Pace Global Energy Business Advisory (collectively Siemens) conducted fuel delivery option assessment as per request of Puerto Rico Electric Power Authority (PREPA). This feasibility study assesses the practicality and competitiveness of delivering sufficient volumes of containerized liquefied natural gas (LNG) or compressed natural gas (CNG) to displace diesel and No. 6 fuel oil as a potential interim or long-term solution. The assessment includes Aguirre absent Aguirre Offshore Gas Port (AOGP), as well as San Juan and Palo Seco. Exhibit 1 outlines the four delivery options and required gas demand in this study.

Exhibit 1: Fuel Delivery Options and Required Daily Delivery

	Gas Demand MMBTu Per Day	ISO Containers Per Day	CNG Containers Per Day
Containerized LNG to Aguirre absent AOGP	164,299	193	
Containerized LNG to San Juan and Palo Seco	33,167	40	
CNG to Aguirre absent AOGP	164,299		617
CNG to San Juan and Palo Seco	33,167		126

Key conclusions from this fuel delivery option assessment include:

- CNG delivery either as a bridge fuel or long-term solution is not practical due to PREPA's expected demand in the three sites.
- LNG delivery in ISO containers to Aguirre absent AOGP is not practical due to the expected gas demand and the amount of container handling required on a daily basis and vessel deliveries required on an annual basis. In addition, dredging will be required at the Aguirre port, which could be a fatal flaw.
- The costs and operational risks for LNG delivery in ISO containers to San Juan are prohibitively high.
- Recommendations to PREPA:

  (1) In the South, continue the development of AOGP, which will afford the earliest MATS compliance for the Aguirre 1&2 steam electric units while reducing the fuel cost for the existing Aguirre CC 1&2 units and for future generation at Aguirre.

(2) In the North, evaluate the feasibility of bulk LNG delivery and onsite tank storage to improve the cost competitiveness of LNG to San Juan and Palo Seco. Said option was the most favorable of the ones studied in the Galway report[1].

[1] Galway Energy Advisors LLC, LNG and Natural Gas Import and Delivery Options Evaluation for PREPA's Northern Power Plants – Feasibility Study & Fatal Flaw Analysis, June 1, 2015.

Section
2

PREPA Natural Gas Demand Assessment

2.1 Natural Gas Demand at Aguirre without AOGP

Should AOGP not materialize, and natural gas could be delivered to Aguirre, by way of CNG or containerized LNG, Siemens estimated the gas consumption at the Aguirre site based on the resource decision schedules in the Portfolio 3 Modified Future 1 Modified (P3MF1M), which considers a reduction on the demand due to energy efficiency and full RPS compliance by 2035. The estimated gas demand at Aguirre is approximately 164,299 MMBtu per day. This demand requires approximately 193 standard, intermodal, 40-foot ISO containers per day.

LNG ISO containers are designed to be stacked and secured as cargo on sea-going container vessels and barges, or mounted on truck/train frames for transport. These ISO containers can be marine-shipped, trucked, handled, and stored. Each 40-foot LNG ISO container is a self-contained, independent storage system with about 10,800 gallon capacity and can remain in service for between 50 and 60 days, depending on the model's pressure ratings.

If using CNG 40 foot ISO containers, the gas demand at Aguirre entails approximately 617 CNG ISO containers on a daily basis. Given the exceptional pressure requirements, CNG is not stored in a single large container like LNG. Rather CNG ISO containers are a series of small tubes combined within the same footprint as an ISO container. As a result, a typical LNG 40-foot ISO container holds 855 MMBtus of energy, while commercially available CNG ISO container holds 267 MMBtus. Exhibit 2 shows the required LNG and CNG containers per day to serve the gas demand at Aguirre site.

Exhibit 2: Aguirre Site Gas Demand

Max. Gas Demand at Aguirre	
LNG Containers per Day	193
CNG Containers per Day	617
Gas Demand (MMBtu/day)	164,299

2.2 Natural Gas Demand at Palo Seco

The Supplemental IRP allows the flexibility of building one to three smaller units depending on the magnitude of the reduced demand due to energy efficiency. Siemens estimated natural gas demand at Palo Seco based on a 72 MW gas fired SCC-800 combined cycle unit at 35 percent capacity factor and 8,031 Btu/KWh heat rate. The gas demand at Palo Seco is approximately 4,859 MMBtu per day, which entails approximately 6 LNG ISO containers per day or 19 CNG containers per day as shown in Exhibit 3.

Exhibit 3: Palo Seco Site Gas Demand

Max. Gas Demand at Palo Seco	
LNG Containers per Day	6
CNG Containers per Day	19
Gas Demand (MMBtu/day)	4,859

2.3 Natural Gas Demand at San Juan

In all Supplemental IRP portfolios and scenarios, there are no new generation resources at San Juan. As such, Siemens estimated the natural gas demand by assuming same volume as the diesel consumption (on an MMBTU basis) by the existing San Juan combined cycle units. The gas demand at San Juan is approximately 28,308 MMBtu per day, which entails approximately 33 LNG ISO containers per day or 107 CNG containers per day as shown in Exhibit 4.

Exhibit 4: San Juan Site Gas Demand

Max. Gas Demand San Juan	
LNG Containers per Day	34
CNG Containers per Day	107
Gas Demand (MMBtu/day)	28,308

2.4 Natural Gas Demand at San Juan and Palo Seco

Because it is not feasible for LNG or CNG container ships to access Palo Seco due to its considerably shallow access, all the volumes need to be unloaded at San Juan. To deliver sufficient gas to meet demand at the two sites 40 LNG containers or 126 CNG containers are required each day. Exhibit 5 shows the required LNG and CNG containers per day to serve the gas demand at San Juan and Palo Seco.

Exhibit 5: San Juan and Palo Seco LNG Containers and CNG Trailers per Day

Max. Gas Demand at Palo Seco and San Juan	
LNG Containers per Day	40
CNG Containers per Day	126
Gas Demand (MMBtu/day)	33,167

Section
3

LNG via ISO Containers

3.1 LNG via ISO Containers by Crowley and New Fortress Energy

3.1.1 LNG ISO Containers by Crowley to Coca-Cola in Puerto Rico

Delivery of LNG via ISO containers to Puerto Rico has been executed by Crowley's Carib Energy subsidiary, which was awarded a multi-year contract with Coca-Cola Bottlers of Puerto Rico to supply U.S.-sourced containerized LNG to the plants in Cayey and Club Caribe in Cidra, Puerto Rico. It utilizes standard, intermodal, 40 foot ISO containers.

The LNG ISO containers are shipped from Jacksonville, Florida via Crowley's vessels departing for Puerto Rico. Upon arrival on the island, Crowley's Puerto Rico-based logistics team delivers the LNG to the local Coca-Cola bottling facilities. The LNG is re-gasified into pipeline natural gas.

3.1.2 LNG ISO Containers by New Fortress Energy to Jamaica

New Fortress Energy, an energy service provider and a subsidiary of the American based Fortress Investment Group, entered into fuel supply agreement with Jamaica Public Service Company Limited (JPS) in August 2015. New Fortress planned to deliver LNG in ISO containers from Florida to Jamaica for the 120 MW Bogue power plant at Montego Bay. In addition, JPS and New Fortress Energy signed an agreement to extend the supply of gas to Jamaica to the new 190 MW power plant at Old Harbour Bay, St. Catherine.

For the Bogue plant deliveries, New Fortress later dropped the idea of delivery via LNG ISO containers in favor of ship-to-ship transfers of bulk LNG. At present, the *Athena Vender*, a small LNG vessel, is loaded at sea from larger scale LNG carriers and brings LNG into Montego Bay. These deliveries are ongoing. LNG is stored in seven storage tanks and regasified on site.

For the Old Harbor deliveries, New Fortress selected a Floating Storage Unit (FSU) which would take LNG deliveries directly from larger LNG vessels. The infrastructure for this supply chain is expected to be complete by mid-April permitting gas delivery.

According to the Environmental Impact Assessment filed in September 2016, the gas infrastructure for Old Harbor includes a marine terminal facility comprising a vessel berth and offshore offloading and regasification platform in the Portland Bight area approved by the Port Authority of Jamaica. The facility accommodates a FSU vessel for LNG storage and LNG carrier delivering to the FSU. The FSU is an LNG carrier refitted for use as a storage vessel. New Fortress Energy chartered the Golar Arctic from Golar LNG under a two-year deal. The 2003-built, 138,500 cubic meters Golar Arctic serves as the FSU.

It is expected that the liquid gas from the FSU will be regasified and the gas would then be released into an undersea pipeline in a straight line from the platform to the vicinity of the JPS plant. The berths are designed for LNG vessel sizes ranging from 140,000 cubic meters up to 175,000 cubic meters capacity with an approximate vessel length of 280 to 300 meters and draft of 12.5 meters. Such structures are designed to resist mooring and berthing loads under operational conditions, as well as seismic and hurricane/tropical storm conditions. The platform is sized to include the critical components of an LNG offloading and regasification facility: an unloading area, control room, power distribution center, boil-off-gas compressor skid, LNG pump skid, vaporizer and process skid, flare skid including drain tank and igniter, flare, nitrogen generator skid, seawater pumps, mixing tank, air burst system, crane, and launcher area.

New Fortress Energy assumes the costs for delivering gas to the burner tip and is responsible for all the fuel delivery and regasification infrastructures. New Fortress Energy has agreed to privately finance and develop the infrastructure, while JPS will have no stake in the gas infrastructure.

3.2 Vessels for LNG ISO Containers

In the past few years, Crowley and TOTE, major shippers to Puerto Rico, have developed and built new vessels dedicated to their regular Puerto Rico trade. Both companies developed vessels designed to carry both container and roll-on roll-off (RoRo) cargo. Crowley's Commitment Class vessels carry 2,400 Twenty Unit Equivalent (TEU), and TOTE's Marlin Class carries 3,100 TEU. Since a 40-foot container is twice the size of a TEU, the Crowley vessels can carry 1,200 40-foot ISO containers in each trip and the TOTE vessels can carry 1,550 40-foot ISO containers in each trip. Exhibit 6 and Exhibit 7 show the vessel dimensions by Crowley and TOTE separately.

Exhibit 6: Crowley's Commitment Class Vessel - El Coqui

Deadweight	DWT	26,500t
Capacity	TEUs	2,400
Length Overall x Breadth Extreme	Meters	219.5 x 32.2
Speed	knots	22
Draft	Meters	10

Source: Crowley

Exhibit 7: Tote Marlin Class Vessel

Length Overall	764 feet
Breadth	106' 00" (Panamax)
Depth	60' 00"
Design Draft	34' 00"/ 10.36 meter
Main Engine	Dual Fuel Slow Speed
Engine Model	MAN8L70ME-C8.2GI
Speed	22 knots
Container Size	40', 45' & 53'
Capacity	3,100 TEU

Source: TOTE

However, an important question is whether these vessels can dedicate the required space for containerized and liquefied natural gas required by PREPA. This space may already be committed to other customers. If they cannot, additional vessel(s) will be required to provide continuous service of LNG ISO containers. Since PREPA would have to commit to a long-term natural gas supply contract in this scenario, new vessels would likely be designed to meet PREPA's ISO container carriage needs and draft limitations.

3.3 Containerized LNG to San Juan and Palo Seco

PREPA's gas demand at San Juan and Palo Seco requires a daily delivery of 40 ISO containers of 40-foot each to San Juan, which would provide container storage for both power plants. The ISO containers would be delivered to the neighboring container terminal, loaded on flatbed trailers for delivery the San Juan storage yard or placed in short-term storage at the port. From there containers serving San Juan would be positioned at San Juan's fuel manifold, and containers intended to serve Palo Seco would be placed on flatbeds and towed to the plant. Empty ISO containers would be returned on flatbeds to either the San Juan storage facility or port. Empty ISO containers from San Juan would be re-positioned into an empty storage area either on-site or at the port.

Earlier LNG studies indicated that PREPA could gain access to an existing warehouse complex at San Juan to provide an estimated 138,000 square meters of fuel storage and regasification facility. However, PREPA does not own the warehouse property and such operation is subject to Port Authority approvals or forced acquisition if permitted. Containers intended to serve San Juan would be connected to an LNG manifold to ensure continuous fuel supply, which would feed a regasification unit from which a compressor station would raise the natural gas pressure to that required by the units. This would reduce container handling costs and lower operational risks. Empty containers would be removed to the San Juan storage yard for return to the gas supply location.

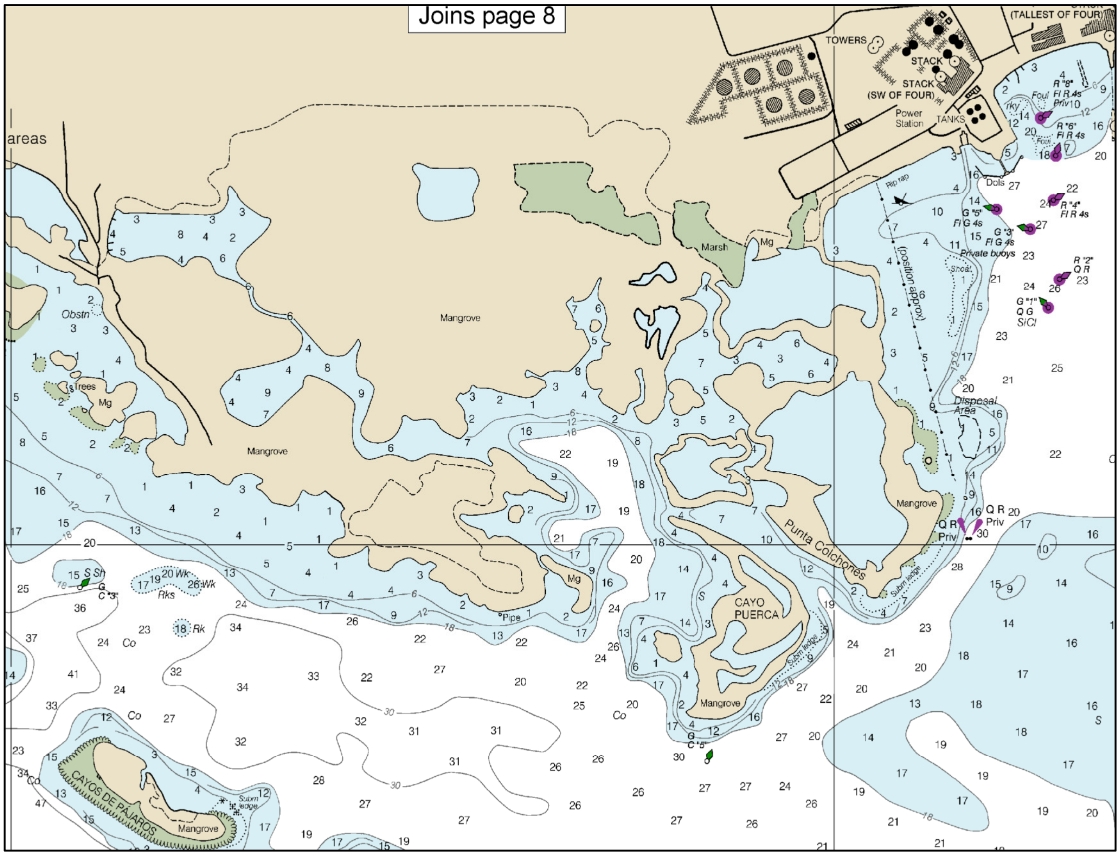
At Palo Seco, a similar storage and regasification location would also be developed to continuously supply appropriately pressurized natural gas to those units. ISO containers would be trucked directly from the port to Palo Seco so long as available space remained. Any containers that could not be immediately placed on site would be stored at San Juan.

3.4 Containerized LNG to Aguirre

PREPA's gas demand at the Aguirre would require a daily delivery of 193 40-foot ISO containers to Aguirre Port in Salinas, where both cargo and fuel delivered by barge interconnect with rail and road networks. ISO containers would be delivered by barge and offloaded to awaiting flatbed trailers and/or short term storage for transshipment to the Aguirre plant. National Oceanic and Atmospheric Administration (NOAA) Chart 25687 indicates water depths at the Aguirre power station docks of 27 feet at mean low water (MLW), though water depths of approximately 20 feet in the approach channel may prove more limiting as shown in Exhibit 8.

At Aguirre, a dedicated fueling yard would be established in which to store fuel and connect containers to a similar fuel manifold and regasification system as that discussed above. Empty containers would be stored either on-site or at Aguirre Port for return to the gas supply location.

Exhibit 8: NOAA Chart 25687



Source: National Oceanic and Atmospheric Administration

Section
4

CNG via ISO Containers

4.1 CNG Containers

Unlike LNG, CNG would be shipped as a compressed gas rather than a liquid. To increase energy density in an ISO container, natural gas is compressed to very high pressures, which could reach 5,000 psi in the most modern CNG trailers.

Given the exceptional pressure requirements, CNG is not stored in a single large container like LNG. Rather CNG ISO containers are a series of small tubes combined within the same footprint as an ISO container. As a result, a typical LNG 40-foot ISO container holds 858 MMBtus of energy at 3,600 psi, while commercially available CNG ISO containers hold 267 MMBtus. Exhibit 9 shows the picture of a CNG ISO container.

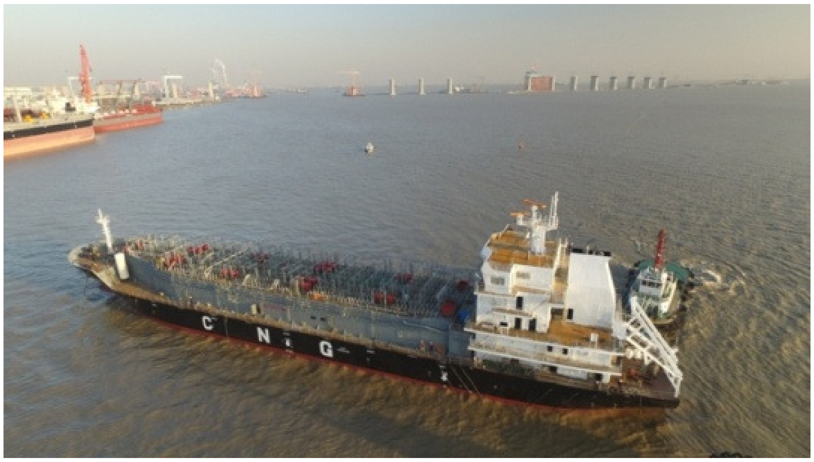
Exhibit 9: CNG ISO Container

4.2 CNG Vessels

For delivery of CNG in ISO containers, same ships as discussed in section 3.1 could be utilized. Siemens conducted the CNG shipping analysis based on the specifications of TOTE's Marlin Class which is capable of carrying 3,100 TEU. However, there are no precedent practices that such delivery option has been carried out through long haul ocean voyage and delivered on land through trucks with hundreds of containers each day.

In terms of bulk CNG carrying ships, unlike LNG carrying vessels, which have been in operation worldwide for many years, ships capable of carrying CNG are very new. In fact, in January 2016 the Jayanti Baruna became the first operational CNG carrier. It was developed by Indonesia's power company (PT PLN) and classified by the American Bureau of Shipping (ABS). It is 110 meter in length and has a CNG transport capacity of 2,200 cubic meters and focuses on transport between islands in Southeast Asia. Exhibit 10 shows the picture of the CNG ship.

Exhibit 10: CNG Ship



Sea NG, another CNG vessels developer created several carrier designs of differing capacities. Although their designs are not currently operational, they are available for construction with design criteria shown below.

Exhibit 11: Sea NG Ship Specifications

Ship	C16	C20	C25	C30	C36	C42	C49	C84	C112	C128
Coselles	16	20	25	30	36	42	49	84	112	128
Net Capacity* (million scf)	66	83	104	125	149	174	203	349	465	531
(million scm)	1.8	2.3	2.8	3.4	4.1	4.8	5.8	9.9	13.2	15
Length OA (m)	137	137	160	160	180	201	201	234	257	278
Breadth (m)	23.5	23.5	23.5	28.5	28.5	29.5	31.0	46.0	46.0	48.0
Loaded Draft (m)	7.3	7.5	8.0	7.9	8.2	8.3	8.8	8.7	10.5	10.5

* Net Capacity is net of heel gas and assumes lean gas at 27 °C

Source: Sea NG

4.3 CNG Delivery to Puerto Rico

PREPA's gas demand at the three sites (Aguirre, San Juan and Palo Seco) requires a daily delivery of 126 CNG containers to San Juan and 617 CNG containers to Aguirre. In comparison of LNG and CNG delivery, LNG generally excels for larger-scale projects that deliver over longer distances, while CNG competes when storage requirements are small and delivery distances are short. Exhibit 12 shows the comparison of LNG and CNG in terms of safety, scale and storage.

Exhibit 12: LNG and CNG Delivery Comparison

	CNG	LNG
Safety	• Long history in vehicle applications and truck deliveries. • CNG is lighter than air, so if it escapes, it evaporates rather than forming a puddle. • CNG can be highly volatile, even explosive, if the gas escapes a pressurized storage tank. • Lack of operating history means technical and operating regulations are uncertain for CNG carriers and bulk operations as Sea NG envisions.	• Long history of LNG carrier and bulk delivery operations makes for tried, tested, and improved operating rules and regulations. • Cryogenic hazard to flesh and steel are real, but are effectively managed in the bulk industry. • Damages from spills are rare. LNG is heavier than air, but only briefly during a release as liquid flashes to gas and is dispersed almost instantly. • Double-walled construction of tanks is inherently robust so explosion is highly unlikely.
Scale	• Relatively low energy density inhibits bulk delivery of large quantities. • Requires large numbers of relatively small-capacity equipment to transport larger volumes, impacting economies of scale. • For smaller containers (e.g., tankers), new composite materials lower cost and increase capacity, which increases competition with LNG under certain conditions.	• Energy density facilitates economic delivery of large quantities over relatively long distances. • Recent developments in small-scale LNG production, transport, and storage have lowered costs, making many projects economically viable. • Increased production results in economies of scale further enhancing performance and lowering unit costs.
Storage	• High-pressure tanks required to contain at pressure. • At larger capacities, tanks become massive, increasing cost and visibility, which can drive pushback from local inhabitants.	• Double-walled cryogenic tanks required to maintain temperature. • Initial costs can be high, but there are low maintenance costs and inspections are generally only required every five years. • Energy density results in storage that requires relatively little physical space.

Section 5

Fatal Flaw Analysis

5.1 CNG Container Delivery Not Practical

Based on the gas demand estimated at the three sites, 617 containers are required at Aguirre absent AOGP and 126 containers are required at San Juan (including demand at Palo Seco) as shown in Exhibit 12. There are no existing CNG production facilities of the scale required to satisfy PREPA's volume requirements. The sheer volume in comparison to LNG ISO containers rules out CNG containers as a viable option. Exhibit 13 and Exhibit 14 show the logistic calculation of CNG containers to San Juan and Aguirre separately.

In addition, no CNG projects in the U.S. had been presented to the Federal Energy Regulatory Commission (FERC) or U.S. Coast Guard (USCG). As a result, no explicit rules existed with regards to safety zones for CNG ships transiting through U.S. ports or navigable waterways. Establishing the first set of CNG bulk transport rules may prove challenging since some industry experts raise concerns about the potential size of an exclusion zone extending around a 3,600 psig pressure vessel.

Exhibit 13: CNG Containers Delivery Requirements to San Juan

CNG in ISO Containers to San Juan and Palo Seco		
Containers per Ship	number	1,550
Annual Demand at San Juan and Palo Seco	containers	45,990
Daily CNG Demand at San Juan and Palo Seco	containers	126
Onsite Storage	days of supply	7
Onsite Storage	containers	882
Required Trips per Year	**trips/ year**	**31**
Jackson FL to San Juan	nm	1121
Speed	kn	16
Round Trip Transit Time	hours	70
Loading + Unloading + Filling Time	hours	100
Total Transit Time	hours	240
Total Transit Time	days	10
Driving Distance from San Juan to Palo Seco	miles	5
Daily CNG Demand at Palo Seco	containers	19
Daily CNG ISO Container Trucks to Palo Seco	**trucks**	**19**

Exhibit 14: CNG Containers Delivery Requirements at San Juan

CNG in ISO Containers to Aguirre		
Containers per Ship	number	1,550
Annual Demand at Aguirre	containers	225,205
Daily CNG Demand at Aguirre	containers	617
Onsite Storage	days of supply	7
Onsite Storage	containers	4,319
Required Trips per Year	**trips/ year**	**149**
Jackson FL to Philex	nm	1158
Speed	kn	16
Round Trip Transit Time	hours	72
Loading + Unloading + Filling Time	hours	100
Total Transit Time	hours	245
Total Transit Time	days	10
Driving Distance from Philex to Aguirre	miles	4
Daily CNG Demand at Aguirre	containers	617
Daily CNG ISO Container Trucks to Aguirre	**trucks**	**617**

5.2 LNG Container Delivery to Aguirre Not Practical

Even though the delivery of LNG via ISO containers to Puerto Rico has been executed by Crowley's Carib Energy subsidiary to Coca-Cola in smaller volume, the volume required at Aguirre of 193 containers per day and 47 vessel deliveries per year makes it impractical from a logistic point of view. Exhibit 15 displays the logistic calculations regarding delivery of LNG containers to Aguirre.

It is important to note that the waterway access to the Aguirre site is an environmentally protected area, which cannot be disturbed. Thus the waterway depth and condition cannot be altered to accommodate larger vessels, so access is limited to vessels with loaded depths of probably less than twenty feet.

The around the clock ISO container transport and on-site logistics would entail significant material handling challenges and potential safety hazards. ISO containers would be continually offloaded from ships by crane to awaiting flatbed trailers as they arrive, to be removed to a fuel storage area. Containers already in service would be disconnected from fueling manifolds and lifted or towed to areas designated for empty containers, while full containers would be attached to the fuel manifold. Since cranes of sufficient capacity are not currently available at the site, several new cranes would need to be acquired to enable this operation. Empty containers would be loaded on trucks to be returned to the port for storage before being lifted on to cargo ships to return the empties for refill. This would be a continuous heavy lifting operation requiring several additional cranes to lift containers, trucks to tow ISO containers on trailers, flatbed trailers for transport, and significant trained manpower to manipulate the equipment. In an operation this complex, errors would have to be expected and could be hazardous to both staff and equipment. The frequency of small accidents would certain higher than might be expected with a bulk storage design.

Exhibit 15: LNG Containers Delivery Requirements at Aguirre

LNG in ISO Containers to Aguirre		
Containers per Ship	number	1,550
Annual Demand at Aguirre	containers	70,080
Daily LNG Demand at Aguirre	containers	192
Onsite Storage	days of supply	7
Onsite Storage	containers	1,344
Required Trips per Year	**trips/ year**	**47**
Jackson FL to Las Mareas (using Ponce as proxy)	nm	1,158
Speed	kn	16
Round Trip Transit Time	hours	72
Loading + Unloading + Filling Time	hours	100
Total Transit Time	hours	245
Total Transit Time	days	10
Driving Distance from Las Mareas to Aguirre	miles	4
Daily LNG Demand at Aguirre	containers	192
Daily LNG ISO Container Trucks to Aguirre	**trucks**	**192**

5.3 LNG Container Delivery to San Juan

LNG supply in ISO containers to San Juan requires 40 LNG containers per day and 10 vessel deliveries per year. Exhibit 16 shows the LNG container delivery to San Juan. According to the Galway report, the most favored LNG option, which is bulk LNG storage in full containment LNG thermal tanks, does not appear limited by either vapor dispersion or thermal limits that might result from an accident at the proposed pier. That analysis was based on a few large deliveries of LNG per year, arriving via ocean going vessel, in order for the project to be positively receptive to regulatory agencies such as the USCG. Delivery via ISO container will be far more frequent and in much smaller volumes, thus the hazards resulting from an accident would be smaller than those presented by CHV in the Galway report. Even though the delivery of LNG in containers is expected to be able to pass environmental and safety evaluation, the frequent handling of the LNG containers present safety concerns that would be taken into consideration by regulatory agencies.

However, the option of LNG container delivery requires adequate storage at San Juan to accommodate the 3,100 ISO containers - 1,550 containers filled with LNG unloaded with each port call and 1,550 empty containers waiting to be loaded in the return voyage. The warehouse location could be a potential site for this purpose, however, the land is owned by the Ports Authority, and significant inducements may be required to gain access. Further, given the substantial materials handling requirements of an ISO container based operation, the Ports Authority may certainly require their staff to provide that service. Note, a bulk inland LNG storage facility would not only require far less property making it more feasible, but such a facility would also require less staff and moving equipment to operate. The EcoElectrica LNG facility is operated with only three to four staff members.

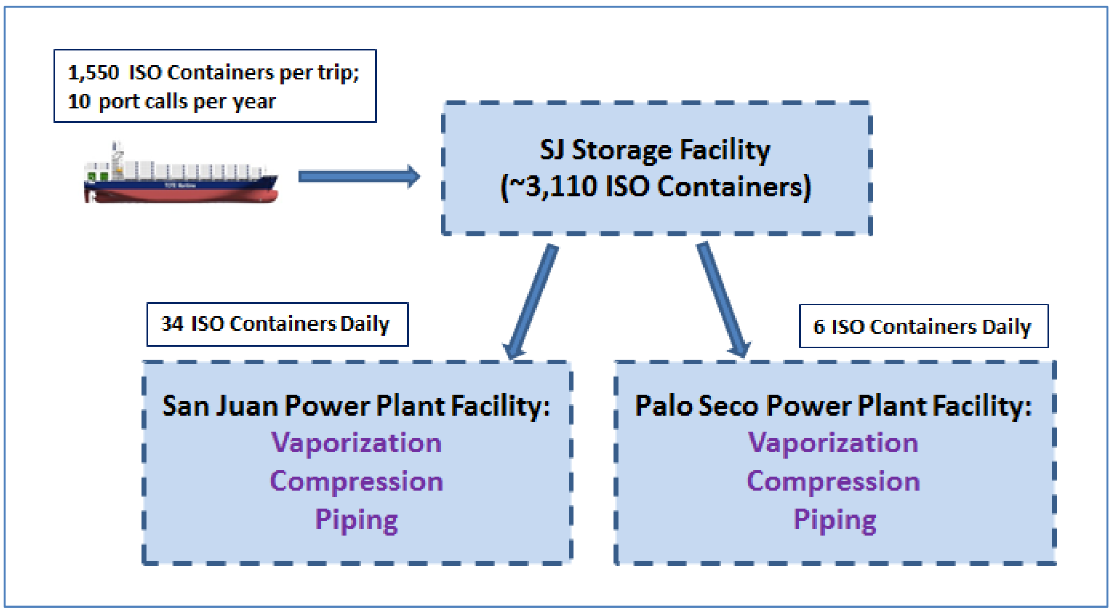
The logistics calculations for ISO container delivery to San Juan are displayed in Exhibit 16, and Exhibit 17 shows the on shore delivery plan.

This option requires significant infrastructures including order of a new vessel, potentially new unloading terminal, 3,100 ISO containers, two to three trucks, LNG regasification system at San Juan and Palo Seco power plants separately.

Exhibit 16: LNG Containers Delivery Requirements at San Juan

LNG in ISO Containers to San Juan and Palo Seco		
Containers per Ship	number	1,550
Annual Demand at San Juan and Palo Seco	containers	14,235
Daily LNG Demand at San Juan and Palo Seco	containers	39
Onsite Storage	days of supply	7
Onsite Storage	containers	273
Required Trips per Year	**trips/ year**	**10**
Jackson FL to San Juan	nm	1121
Speed	kn	16
Round Trip Transit Time	hours	70
Loading + Unloading + Filling Time	hours	100
Total Transit Time	hours	240
Total Transit Time	days	10
Driving Distance from San Juan to Palo Seco	miles	5
Daily LNG Demand at Palo Seco	containers	6
Daily LNG ISO Container Trucks to Palo Seco	**trucks**	**6**

Exhibit 17: LNG Containers Delivery to San Juan and Palo Seco



Section
6

LNG Containers to San Juan Cost Prohibitively High

The costs to deliver sufficient LNG are based on the estimated natural gas consumption of the plants. The amount and rate at which fuel will be consumed establish a foundational number of 3,100 LNG ISO containers required to support operations at San Juan and Palo Seco. These containers are required to not only contain the fuel, provide adequate storage capacity, but to also return as empty containers to be refilled for the next delivery cycle as well as the ones in transit. The containers could be delivered by a ship with the approximate container capacity of TOTE's new marlin class duel-fueled vessel now bringing cargo to Puerto Rico. Recently both Crowley and TOTE developed duel-fueled vessels specifically for the Puerto Rico liner trade. Since these vessels were sized to support traditional cargo requirements, they are not expected to have sufficient space aboard to carry the 1,550 ISO containers required each 40 days, so it is expected that a new ECA compliant vessel of similar capacity will be required to support the delivery of LNG ISO containers.

Recent ISO container demand, much resulting from Chinese LNG mandates, has driven the development of new more automated vessel assembly capabilities allowing for much lower ISO container costs. While unit costs for such containers have declined, the number of containers is significant; consequently, ISO containers are expected to be the single most costly item.

ISO LNG containers are standard sizes and can be transported on flatbed trailers within or between sites. These loads can be moved with day-cab tractors at the approximate cost of $125,000 each.

The expected storage site will require some modifications. At San Juan, existing warehouses would be demolished and operations transferred to make space to store ISO containers and to establish a fueling system. That fueling system will be an LNG liquid manifold to which at least three ISO containers can be connected simultaneously, though depending upon consumption rates, more ISO containers may need to be connected. The fueling system would also contain two vaporizers to convert LNG back into natural gas, and two gas compressors to raise the natural gas pressure to sufficient operating pressure for the power generation equipment. If existing port infrastructure such as cranes are found inadequate for the service or are not sufficient for the rest of the container handling demand, new port infrastructure with cranes would need to be invested in.

Since under this delivery arrangement, LNG would be delivered in ISO containers, no special permits are anticipated for the seaborne delivery. However, the port may certainly require special permission to handle a cryogenic fuel, and the storage and fueling system are expected to require permits.

Estimated total costs to set up an LNG ISO containers delivery option is prohibitively expensive as shown in Exhibit 18.

In addition to high upfront capital costs, ongoing operating costs are expect to be higher than bulk LNG option due to inefficient logistics and handling.

Exhibit 18: LNG Containers Delivery to San Juan Capital Costs

LNG ISO Container to San Juan Project Capital Cost	Unit Costs	Required Units	Amount ($2016)
Custom-build Special Purpose Vessel	$187,000,000	1	$187,000,000
40 foot ISO Cryogenic LNG Container	$70,000	3,100	$217,000,000
New Tractor (day Cab)	$125,000	3	$375,000
San Juan Storage Facility	$20,000,000	1	$20,000,000
Cranes	$500,000	4	$2,000,000
Onsite Regasification, Compression and Piping	$2,000,000	4	$8,000,000
PREPA Permits, Approvals	$160,000	1	$160,000
Contingency at 20%			$86,907,000
Total			$521,442,000

Financing Summary	Amount ($2016)
Equity Portion	20%
Debt Portion	80%
Financing Costs	2%
Annual Interest Rate	6.86%
Construction Period (months)	36
Equity Amount	$104,288,400
Debt Amount	$417,153,600
Financing Costs	$8,343,072
Interest During Construction	$45,017,826
Total Project Cost	$574,802,898

Section
7

Risks and Schedules

7.1 Risk Assessment of LNG ISO Containers to San Juan and Palo Seco

For LNG containers delivery to San Juan and Palo Seco, the market risk is the supply and price for delivered LNG fuel. As there is adequate natural gas supply in the market and at present an excess of LNG liquefaction capacity worldwide, the risk that the fuel becomes unavailable is minimal. However, the complexity of the supply chain relative to more traditional means of moving large LNG volumes adds delivered price risk. The complex supply chain involves many moving parts, requires tight coordination, and good working relationships with supply and delivery partners. One approach is for PREPA to contract for long-term delivered LNG at burner tip like JPS's approach in Jamaica. Alternatively, PREPA would likely own the ISO containers, while the shipping, loading and unloading containers, and transportation to and from PREPA locations would likely be accomplished with third party support. While others might be responsible for these actions, PREPA would be accountable and pay the price should fuel not available or not be available at the expected delivered price.

Physically manipulating 40 containers every day entails significant operational risk resulting from increased costs of switching to diesel in the event of shortage, environmental exceedances from over consumption of diesel or LNG leaks/ spills, and physical injuries. We assume containers would be manipulated by PREPA staff while on PREPA property, and third parties would be responsible to safely transport containers beyond PREPA's boundaries.

As mentioned above, successful operation of this complex supply chain will require the well-coordinated efforts of several third parties including the fuel supplier loading LNG into containers, the port authority loading containers, the shipper delivering the cargo, the Puerto Rico port unloading and delivering containers to San Juan, the San Juan staff manipulating the fuel storage container both full and empty, and a trucking service to deliver containers to other locations. The health of any one partner could place the delivery at risk, so mitigating plans must be prepared to be executed upon. Exhibit 19 outlines the major risk categories.

Exhibit 19: Risks Assessment of LNG Containers Delivery to San Juan and Palo Seco

Permitting	Environmental	Fuel Supply
Moderate	Moderate	Low to Moderate
Both port and land-based operations will have exclusion zones ruling apply	Leaks and spills	Competitive pricing from several potential sources
Port Handling	**Container Handling**	**Trucking**
Moderate to High	Moderate to High	Moderate to High
1,550 containers per port call and 10 port calls per year added to busy San Juan port		Continuous truck movement on public high way to Palo Seco and near San Juan plant

7.1 Estimated Schedules of LNG Containers to San Juan

Establishing an LNG container delivery system to San Juan will require gaining permits and other approvals, deployment of U.S.-built, U.S. owned, U.S.-flagged, and U.S.-crewed ship, procurement of the required ISO containers, conversion of the existing warehouse space to fuel storage and regasification functionality, procurement of flatbed trailers and tractors, and construction of the storage facilities. To accelerate development, many, though not all, of these activities could be conducted in parallel. While some design and planning activities could start immediately, it is unlikely significant capital would be spent before permit approvals are gained, and since no similar facility has been permitted on Puerto Rico, the timing of required construction and operating permits is a significant risk.

With permits in hand, the contract for vessel construction, which will likely set the critical path for project completion, and procurement of other long lead items can begin. It is likely the ISO containers would be procured in China where a significant government mandated LNG fuel expansion is underway, which has driven container production capacity and quality up, and cost necessarily down.

In total, developing the envisioned ISO container based delivery system would likely require approximately 12 months to permit and an additional 24-30 months to construct resulting in a total development schedule of approximately 42 months.

Exhibit 20: Estimated Schedules of LNG Containers Delivery

Items	Lead Time (months)
Permit and Approvals	~12
Customized Ship Building	24-30
ISO Containers Procurement	12-24
San Juan Storage Facility	12-18
San Juan and Palo Seco Facility (vaporization, compression, piping, testing, and commissioning)	3-6
Fuel Supply and Negotiation	6-12

Section
8

Conclusion

The combination of reduced natural gas price expectations and the demand for cleaner fuels has dramatically increased the interest in LNG. While LNG was once only delivered by large scale LNG carriers to be re-gasified into large pipeline systems, new smaller scale technologies have been developed to serve small market needs.

LNG distribution, storage infrastructure and logistics are key factors for the competitiveness of this fuel. Advances in delivery technology, particularly in small-scale LNG shipping and floating regasification units, are making natural gas a more economical option for small markets, like Caribbean islands. For example, since 2006, the global fleet of ships with a capacity of 25,000 cubic meters or less has increased from 5 to 24. As a result, the technologies for delivering LNG fuel are technically mature, though they await broader commercial acceptance to lower costs.

While several Caribbean nations are considering LNG fuel, Jamaica has made the first significant move. LNG fuel was first delivered to JPS's 120 MW Bogue plant in fall 2016. Initial planning suggested the supplier would use LNG ISO containers, however, it was later decided to transfer LNG at sea from a larger LNG carrier and brought directly to the plant.

Despite this success, many challenges remain. The capital cost for natural gas transportation infrastructure remains high. Guarantees are required to finance projects to procure natural gas, often including long-term contracts, credit worthy buyers, and sovereign support. Natural gas projects benefit from economies of scale, suggesting the potential for greater returns from larger markets than from smaller ones. As such, some suppliers may charge a premium for delivering natural gas in small quantities, as might be required in Bermuda where the local power utility is consider switching to LNG.

Key conclusions from this fuel delivery option assessment include:

- CNG delivery either as a bridge fuel or long-term solution is not practical due to PREPA's expected demand at Aguirre, San Juan and Palo Seco.
- LNG delivery in ISO containers to Aguirre absent AOGP is not practical due to the expected gas demand and the amount of container handling required on a daily basis and vessel deliveries required on an annual basis.
- The costs and operational risks for LNG delivery in ISO containers to San Juan are prohibitively high.
- In the South, continue the development of AOGP, which will afford the earliest MATS compliance for the Aguirre 1&2 steam electric units while reducing the fuel cost for the existing Aguirre CC 1&2 units and for future generation at Aguirre.
- In the North, evaluate the feasibility of bulk LNG delivery and onsite tank storage to improve the cost competitiveness of LNG to San Juan and Palo Seco. Said option was the most favorable of the ones studied in the Galway report.

Appendix

A

Glossary of Terms

Aguirre Offshore GasPort (AOGP): A floating offshore liquefied natural gas regasification facility off the southern coast of Puerto Rico. It will consist of three main components: an offshore berthing platform; an offshore marine LNG receiving facility consisting of an FSRU moored at the offshore berthing platform; and a subsea pipeline connecting the platform to the Aguirre Power Complex, which will run across the Jobos Bay.

British Thermal Unit (Btu): A unit of energy measure that indicates the amount of heat required to raise the temperature of one pound of water by 1oF at a constant atmospheric pressure.

Combined Cycle (CC): A form of power generation that captures exhaust heat often from a CT (or multiple CTs) to create additional electric power beyond that created by the simple CT and enhance the overall efficiency of the unit by producing more output for the same level of input.

Capital Cost: The cost of various sources of funds used in a financing an entity's operations.

Engineering, Procurement and Construction (EPC): EPC is a prominent form of contracting agreement in the construction industry. The engineering and construction contractor will carry out the detailed engineering design of the project, procure all the equipment and materials necessary, and then construct to deliver a functioning facility or asset to their clients.

Federal Energy Regulatory Commission (FERC): FERC is the United States federal agency with jurisdiction over interstate electricity sales, wholesale electric rates, hydroelectric licensing, natural gas pricing, and oil pipeline rates. FERC also reviews and authorizes liquefied natural gas (LNG) terminals, interstate natural gas pipelines and non-federal hydropower projects.

Floating Storage and Regasification Unit (FSRU): A Floating Storage Regasification Unit (FSRU) is the vital component required while transiting and transferring Liquefied Natural Gas (LNG) through the oceanic channels.

Liquefied natural gas (LNG): Natural gas that has been converted to liquid form for ease of transport and/or storage.

Mercury and Air Toxics Standards (MATS): MATS is an environmental regulation proposed by the US Environmental Protection Agency (EPA) in 2011 to reduce the emissions of hazardous air pollutants, such as mercury and acid gases, from coal-and-oil fired power plants.

Megawatt (MW): One million watts or 1,000 kilowatts.

Megawatt-hour (MWh): One million watts (or 1,000 kilowatts) produced for one hour of time.

MMBtu: One million Btus.

MMcf: Million cubic feet

MMscf/d: One million standard cubic feet per day.