

**NYS Liquefied Natural Gas (LNG) 6 NYCRR Part 570
Promulgation Support Study**

By

David Vandor, Managing Director & Chief Technology Officer, Expansion Energy LLC
Jeremy Dockter, Managing Director, Expansion Energy LLC

For

Joseph Tario, Project Manager, New York State Energy Research and Development
Authority

Contract No. 21361 09/20/2011

Notice

This report was prepared by Expansion Energy LLC in the course of performing work contracted for and sponsored by the New York State Energy Research and Development Authority (hereafter “NYSERDA”). The opinions expressed in this report do not necessarily reflect those of NYSERDA or the State of New York, and the contractor makes no warranties or representation, expressed or implied, as to the fitness for particular purpose or merchantability of any product, apparatus, or service or the usefulness, completeness, or accuracy of any processes, methods, or other information contained, described, or referred to in this report. NYSERDA, the State of New York, and the contractor make no representation that the use of any product, apparatus, process, method, or other information will not infringe privately owned rights and will assume no liability for any loss, injury, or damage resulting from, or occurring in connection with, the use of information contained, described, disclosed, or referred to in this report.

Table of Contents

Introduction	1
Task 1: Defining the “State-of-the-Art”	
1A. LNG –Definition and Brief History	2
1B. Regulatory Protocols	
1B1. Controlling the Location of LNG Storage Facilities	4
1B2. Controlling the Site Plan of LNG Storage Facilities	8
1B3. Design and Operation of LNG Production, Storage and Dispensing Facilities	10
1B4. Transportation of LNG in Bulk	13
1B5. Safety of LNG Facilities	15
1B6. Security of LNG Facilities	18
1B7. Emergency Response Procedures	19
1B8. Inspection of LNG Facilities and Enforcement of Applicable Rules and Regulations	20
1C. Regulatory Relief	23
1D. LNG-Related Incidents / Accidents	23
1D1. Explosions and Fires	24
1D2. Spills and Leaks	25
Task 2: Facility, Job, and Cost Projections	
2A. LNG Facility Projection Methodologies	27
2B. Interviews with Experts	27
2C. Projections Using a Historic Perspective	29
2C1. Historic Review of LNG Facilities in California	32
2C2. Historic Review of LNG Facilities in the U.S.	34
2C3. Historic Review of CNG Facilities in New York	34
2C4. Historic Barriers to LNG	36
2D. Projections of LNG Facilities Using a Functional Perspective	38
2D1. Import / Export Terminals	39
2D2. Peak-Shaving Plants	40
2D3. Regional Production Facilities	40
2D4. Production at Gas and/or Oil Wells	41
2D5. On-Pipeline Production at AFV Fleets	43
2D6. Dispensing to AFV Fleets, With No On-Site Production	44
2E. Summary of Projections for LNG Facilities in NYS	45
2F. Jobs Projections	46
2G. Summary of Projected New Jobs by User Category	48

2H. Cost Projections	49
Conclusions	51
Appendix A: Scope of Work	52
Appendix B: Tabulation of Topics Covered by Various LNG Codes	53
Tables	
Table 1: 49 CFR Part 193 References	6
Table 2: Approximate Inventory of U.S. LNG Facilities	30
Table 3: Projected LNG Facilities in NYS by Function and Use	46
Table 4: Projected LNG Facility Jobs in NYS by Function and Use	48
Table 5: Costs to LNG Facilities, Related to Part 570	49

Introduction

Expansion Energy LLC (XE) has been retained by the New York State Energy Research and Development Authority (NYSERDA) to provide supporting information and analysis to NYSEDA and the New York State Department of Environmental Conservation (DEC) in DEC's ongoing efforts to promulgate rules (6 NYCRR Part 570 [Part 570]) to regulate liquefied natural gas (LNG) facilities pursuant to Article 23, Title 17 of the New York State Environmental Conservation Law (ECL). A summary of XE's scope of work can be found in Appendix A. The primary goals of this project are to: 1) document the regulatory approach to regulating the storage of LNG taken by several representative states; 2) project the number of LNG facilities that may be built in New York State (NYS) after promulgation of Part 570; 3) project the number of jobs that would be created to own and operate regulated LNG facilities; and 4) project the costs associated with complying with Part 570. These various projections will be used by DEC to complete the support documents for the rulemaking process as required by the State Administrative Procedures Act.

The purpose of Part 570 is to require owners of LNG facilities to obtain a permit from DEC for the siting, construction, and operations of LNG facilities. Additionally, the rules will provide inspection criteria for such facilities and more generally, requirements to protect the public health, safety and welfare, the lands, waters, air and the environment of New York State. The ECL charges the NYS Department of Transportation with creating certified routes and criteria for the safe transportation of LNG.

According to a representative of the Clean Vehicle Education Foundation, most states in the United States (U.S.), including those bordering NYS, use legislatively empowered "code committees" to select LNG-related codes to be enforced, but in some instances allowing a degree of "flexibility" by local jurisdictions. With only Texas (TX) as the exception, all U.S. jurisdictions use codes developed by the National Fire Protection Association (NFPA). In contrast to the widely used "code committee" format, California (CA) is the only state XE found that has adopted NFPA standards by reference. TX has adopted codes similar to those in NFPA but promulgated within its own legislative framework rather than by reference to NFPA. The TX codes are essentially the same as the NFPA codes and will be mentioned throughout this report but not analyzed in detail. In summary, NFPA 52 and 59A are consistently ("universally") used throughout the U.S.

The promulgation of Part 570 will establish protocols in NYS for the deployment of LNG facilities, based on NFPA codes, following the code enforcement standards found in most jurisdictions nationwide, but specifically following the CA model of "referencing" NFPA codes by a statewide statute. Those NFPA codes represent a detailed, rigorous, and comprehensive set of standards for the construction and operation of LNG facilities.

The first part of this report defines LNG and offers a brief history of LNG facility deployments; defines the "state of the art;" and reviews the history of LNG incidents. The second part uses several methodologies to project the number of LNG facilities that are likely to be deployed in NYS during the first five years after the promulgation of Part 570. Part Two also projects the number of new jobs that will likely be created by the LNG industry during those first five years, and analyzes the costs to prospective LNG facilities for complying with the rules promulgated by Part 570.

Task 1: Defining the “State-of-the-Art”

1A. LNG –Definition and Brief History

LNG is a dense, low-pressure, cryogenic, liquid phase of natural gas, mostly consisting of methane. It is distinct from liquid petroleum gas (LPG, generally called “propane”), which consists mostly of heavier hydrocarbons (rather than methane) and which is stored and transported in pressurized vessels as an ambient temperature liquid. The DEC draft rules do not include LPG.

“LNG facility” is defined in DEC’s draft rules as “any structure or facility used to store liquefied natural gas in a tank, vault or other storage device, to dispense liquefied natural gas, or to convert liquefied natural gas into natural gas.” (Emphasis added by XE.) The definition excludes on-vehicle LNG fuel tanks. Every LNG production plant that will follow the promulgation of Part 570 and every LNG dispensing site will constitute an LNG facility because they will all have some amount of on-site storage capacity.

The phrase “tank, vault or other storage device” in the above quoted DEC draft rules can be construed to be included by the word “container” defined in Section 3.3.9 of NFPA 52, as “a pressure vessel, cylinder, or cylinder(s) permanently manifolded together used to store CNG [Compressed Natural Gas], GH2 [Gaseous Hydrogen], LNG or LH2 [Liquid Hydrogen]” and which includes the following container types:

3.3.9.1 Cargo Transport Container – (A mobile unit designed to transport LNG...)

3.3.9.2 Composite Container

3.3.9.3 Fuel Supply Container – (A container mounted on a vehicle to store LNG, but which is not defined as an “LNG facility” in the DEC draft rules)

3.3.9.4 Fueling Facility Container – (“Primary storage for vehicular fueling,” also known as LNG storage “tanks.”)

Throughout NFPA 52, the terms “tank” and “container” are used interchangeably.

Similarly, NFPA 59A defines Cargo Tank Vehicle as “a tank truck or trailer designed to transport liquid cargo,” and defines Container as “a vessel for storing liquefied natural gas.” Another term used commonly in the industry is “storage vessel.”

Natural Gas in any form (compressed as CNG or liquefied as LNG) is one of the cleanest burning hydrocarbon fuels, producing lower levels of carbon dioxide (CO₂), oxides of nitrogen (NO_x), and particulate matter than heavier hydrocarbon fuels such as diesel. The commercial use of LNG can be traced back to the mid-20th century. LNG’s primary attribute, compared to the natural gas routinely delivered by the nation’s extensive natural gas pipeline system, or compared to the CNG carried on the roof of municipal bus fleets, is LNG’s density. LNG at a pressure of only 65 pounds per square inch, absolute (psia), but chilled to -245° F, has a density of 25.6 pounds per cubic foot. Colder LNG at -260° F will have a density of more than 26 pounds per cubic foot. Those densities are more than twice the 10.65 pounds per cubic foot density of CNG contained in high-pressure (up to 3,600 psia) tanks, at ambient temperatures. Thus, the purpose of liquefying natural gas is to increase its density in comparison to CNG, reducing its volume and the size and weight of the container it is stored in. In other words, a given volume of LNG will contain more than twice the heating value of the same volume of CNG.

The first commercial use of LNG began in the 1950s, mainly for the international shipping of LNG from gas producing regions to gas consuming regions. Within the U.S., LNG was used as a means to “peak-shave” natural gas use. Peak-shaving consists of liquefying and storing natural gas during the off-season

(summer), vaporizing and releasing it back into the pipeline during the peak demand (winter) periods. Also in the 1950s the San Diego Gas and Electric Company began to research the use of LNG for vehicle use.

During the 1960s, the international use of LNG expanded, as did the industry's technical understanding of the safe production, storage, transport and dispensing of LNG. By the 1970s, in response to oil shortages, LNG was seen as a viable alternative to diesel fuel. By the 1980s, heavy-duty vehicle engine technology was advancing, allowing for a wider range of vehicular options that could utilize LNG as a vehicle fuel.

During the 1990s U.S. reserves of natural gas increased, as did the import of oil from non-U.S. sources. As a result, after the 1990s, the historically tandem price fluctuations of oil and gas began to diverge, making natural gas (CNG and LNG) more competitive with standard fuels. That trend of increasing U.S. gas reserves (and increasing rates of production), and a growing gap between the price of natural gas and an equivalent "energy-containing" amount of diesel and gasoline, is likely to continue the growing use of LNG as a heavy-duty vehicle fuel.

On a worldwide scale, the most common reason for producing LNG is to allow it to be shipped in ocean-going tankers from production sources served by LNG export terminals (such as in Qatar) to import terminals in receiving countries (such as Japan), where the LNG is re-vaporized for insertion into local natural gas pipelines. Without liquefaction, such international trade and transport of natural gas, outside of pipelines, would not be possible. Nearby examples of LNG import terminal locations include Everett, Massachusetts; Elba Island, Georgia; and Cove Point, Maryland.

On the national scale, the U.S. has several LNG import terminals, which receive LNG from various "base load" production facilities throughout the world. The likelihood of new U.S. import terminal proposals has recently been substantially diminished because of increases in domestic natural gas reserves. New import terminals will have difficulty delivering LNG at prices that can compete with an abundance of lower priced north-American natural gas. Some existing import terminals and those that are in the planning stage are considering their options as export terminals. To the extent that exporting LNG from U.S. natural gas reserves is viable, it will likely first occur at existing terminals with amortized equipment rather than at newly built export facilities in NYS or in nearby states. In any event, any future proposal for LNG import or export terminals will require Federal Energy Regulatory Commission (FERC) review. That review will be the primary "permitting" process, rather than Part 570.

NYS has three peak-shaving plants that predate ECL Article 23, Title 17, two in New York City (NYC) and one on Long Island. Those facilities are "non-conforming facilities" and subject to requirements in DEC orders issued on January 19, 1979. Throughout the U.S. there are some 40 peak-shaving plants, including in Baltimore and Philadelphia.

Moving down in scale, and focusing on U.S. LNG facilities, there are several LNG production facilities (for example, in CA, AZ and TX) that produce LNG for use by vehicles based throughout the west and southwest. In terms of the total number of facilities, the most prevalent purpose for U.S. LNG facilities is the production and dispensing of vehicle-grade fuel. Forty-five to 50 U.S. LNG production and dispensing facilities serve that market, mostly in the western U.S. In almost every instance, the production-to-dispensing model relies on centralized LNG plants from which the LNG is distributed in specialized trailers to local storage and dispensing sites. At those dispensing sites, the LNG can be dispensed to heavy-duty vehicles as LNG, or to light-duty vehicles as CNG. XE knows of no example of an LNG production facility serving an individual fleet, "on site," at the home base of the fleet.

Several factors have accelerated the growth of LNG production and use in the U.S., including the following:

- The price of oil and the fuels derived from oil (diesel and gasoline) have begun to diverge from the price of natural gas, with natural gas being less costly, when the fuel costs are compared on an energy equivalent basis.
- The natural gas industry, including the LNG production and distribution portion, and the “alternative fuel vehicle” (AFV) industry have developed advanced engines, transport and storage equipment and cost-effective production systems to respond to a growing demand for AFVs.
- Public policies have been adopted on the federal and state levels to encourage the use of alternative fuels, especially domestic fuels, such as natural gas; and especially those fuels, including natural gas, that have a reduce emission profile.

Those factors will likely continue the growth of LNG production, transport, storage, and dispensing, especially for use as a vehicle fuel. DEC’s proposed adoption of Part 570 coincides with the growth of LNG as a vehicle fuel throughout the U.S. In order for vehicle-grade LNG to continue that market growth into NYS, DEC will need to adopt Part 570, which like all States (except TX) will rely on nationally recognized protocols for the regulation of LNG facilities.

1B. Regulatory Protocols

1B1. Controlling the Location of LNG Storage Facilities

Most U.S. jurisdictions rely on the NFPA codes for the regulation of LNG facilities, as they do for a variety of fire prevention codes, from electrical codes to the codes related to the storage and distribution of oxygen at hospitals. A member of the NFPA Technical Committee on Vehicular Alternative Fuel Systems (which wrote NFPA 52) stated that most states have established, by legislation, expert “code committees,” assigning the review and adoption of fire and building codes to the legislatively empowered code committee, thus avoiding the need for legislative action on each individual code to be adopted. By contrast, CA specifically incorporates NFPA standards, by reference, into its laws. For example, the CA Code of Regulations, Title 8, Section 455 incorporates NFPA 59A by reference.

The DEC draft rules follow the CA example by explicitly referencing NFPA 52 and NFPA 59A as the applicable codes that each LNG facility must comply with. Those codes will not replace, but rather add to local zoning controls, building codes and other codes (including other NFPA codes) related to electrical systems, pressure vessels, and the like. It should be noted that all existing CNG stations in NYS were almost certainly designed, deployed, and approved per NFPA 52, because that document covers all gaseous fuels, not just LNG, and because NFPA 52 is referenced by the International Construction Code.

Appendix B of this report is a summary table of the NFPA, federal, and TX rules and regulations for LNG facilities. That table is organized to mirror Section 1B of this report, with the key topics listed on the left, from 1) Site Planning through 6) Inspection & Enforcement.

NFPA 52, “Vehicular Gaseous Fuel Systems Code,” and NFPA 59A, “Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG),” are the de-facto “national” standards used by local jurisdictions in all states, except TX, for regulating the deployment and operations of all LNG facilities. TX has adopted specific legislation for the siting and operation of LNG facilities. The Texas Railroad Commission (RRC) administers the rules and regulations for the construction and operation of LNG facilities. Those rules and regulations are similar in scope to NFPA 52 and 59A. DEC draft rules

adopt NFPA 52 and NFPA 59A by reference, which is consistent with LNG rules in all other states in the U.S. The most current edition of NFPA 52 was issued in 2010, and the most current edition of NFPA 59A was issued in 2009.

A detailed review of the comprehensive scopes of NFPA 52 and NFPA 59A (see below) will show that the two codes are mutually supportive, often covering similar topics and prescribing the same standards, with NFPA 52 focusing on LNG related to vehicles and NFPA 59A focusing on LNG production, storage and handling. For most LNG facilities, the two NFPA codes will overlap, providing a comprehensive set of standards. Additionally, both NFPA 52 and 59A require compliance with other referenced NFPA codes and with standards by other entities. The following is a list of industry groups, outside of fire prevention, whose standards are referenced by NFPA 52 and 59A:

- American Gas Association (AGA)
- American Petroleum Institute (API)
- American Society of Civil Engineers (ASCE)
- American Society of Mechanical Engineers (ASME)
- American Society for Testing and Materials (ASTM)
- American Welding Society (AWS)
- Canadian General Standards Board (CGSB)
- Canadian Geotechnical Society
- Compressed Gas Association (CGA)
- Gas Research Institute (GRI)
- Gas Technology Institute (GTI)
- International Code Council (ICC)
- International Standards Organization (ISO)
- National Association of Corrosion Engineers (NACE)
- National Board of Boiler and Pressure Vessel Inspectors (NBBI)
- Society of Automotive Engineers (SAE)
- Steel Structures Painting Council (SSPC)
- U.S. Department of Transportation (USDOT)

Part 570, by requiring compliance with both NFPA 52 and 59A, will fully establish a comprehensive set of requirements, no matter what the “function” or scope of service provided at any LNG facility. As such, Part 570 incorporates, by way of NFPA 52 and 59A, the manufacturing, testing, maintenance and operating standards adopted by the expert groups listed above.

Part 570 will require a “statement of compliance,” signed by the owner of a proposed LNG facility and a NYS Professional Engineer, that the proposed facility “meets the provisions of the Federal Pipeline Safety standards, applicable provisions of the Public Commission’s regulations 16 NYCRR, and the Uniform Fire Prevention and Building Code of the State.”

The Federal Energy Regulatory Commission (FERC) has exclusive authority under the Natural Gas Act to authorize the siting of LNG import or export facilities. However, that authorization is conditioned on the applicant’s satisfaction of other statutory requirements. For example, substantial authority exists through current federal statutes for the states in which LNG import or export facilities are to be located to authorize or block (and “veto”) the development of LNG facilities. Examples of such authority held by the states include the Clean Water Act, the Clean Air Act and the National Environmental Policy Act (NEPA), which allows the states to contribute to the environmental review of any LNG proposal brought

to FERC. A more detailed outline of FERC’s LNG review role and how it interacts with the states can be found at FERC’s web site at <http://www.ferc.gov/industries/gas/indus-act/lng/state-rights.asp>.

For LNG facilities located on interstate natural gas pipelines, and which include certain operating characteristics, such as on-site LNG production, storage and re-vaporization of the LNG for re-insertion into the pipeline, the federal pipeline standards found at 49 CFR Part 193 and 33 CFR Part 127 apply. CFR stands for Code of Federal Regulations. 49 CFR Part 193 does not apply to: (1) “ultimate consumers of LNG;” (2) production facilities which do not store LNG; or (3) any LNG facility located in navigable waters. 49 CFR Part 193 incorporates a variety of standards by reference, as tabulated in Table 1 below.

Table 1: 49 CFR Part 193 References

Source and name of referenced material	49 CFR Reference
A. American Gas Association (AGA):	
(1) “Purging Principles and Practices” (3rd edition, 2001)	§§193.2513; 193.2517; 193.2615.
B. American Petroleum Institute (API):	
(1) API Standard 620 “Design and Construction of Large, Welded, Low-Pressure Storage Tanks” (11th edition February 2008, addendum 1, March 2009)	§§193.2101(b); 193.2321(b)(2).
C. American Society of Civil Engineers (ASCE):	
(1) ASCE/SEI 7–05 “Minimum Design Loads for Buildings and Other Structures” (2005 edition, includes supplement No. 1 and Errata)	§193.2067(b)(1).
D. ASME International (ASME):	
(1) 2007 ASME Boiler & Pressure Vessel Code, Section VIII, Division 1, “Rules for Construction of Pressure Vessels” (2007 edition, July 1, 2007)	§193.2321(a).
(2) 2007 ASME Boiler & Pressure Vessel Code, Section VIII, Division 2, “Alternative Rules, Rules for Construction of Pressure Vessels” (2007 edition, July 1, 2007)	§193.2321(a).
E. Gas Technology Institute (GTI) formerly the Gas Research Institute (GRI):	
(1) GTI–04/0032 LNGFIRE3: A Thermal Radiation Model for LNG Fires (March 2004)	§193.2057(a).
(2) GTI–04/0049 (April 2004) “LNG Vapor Dispersion Prediction with the DEGADIS 2.1: Dense Gas Dispersion Model For LNG Vapor Dispersion”	§193.2059.
(3) GRI–96/0396.5 “Evaluation of Mitigation Methods for Accidental LNG Releases, Volume 5: Using FEM3A for LNG Accident Consequence Analyses” (April 1997)	§193.2059.
F. National Fire Protection Association (NFPA):	
(1) NFPA 59A, (2001) “Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)”	§§193.2019; 193.2051; 193.2057; 193.2059; 193.2101(a); 193.2301; 193.2303; 193.2401; 193.2521; 193.2639; 193.2801.
(2) NFPA 59A, “Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)” (2006 edition, Approved August 18, 2005)	§§193.2101(b); 193.2321(b).

Note that Section E of the table above deals with Thermal Radiation Modeling, Vapor Dispersion, and the “Evaluation of Mitigation Methods for Accidental LNG Releases, Volume 5: Using FEMA3A for LNG Accident Consequence Analyses.” FEMA stands for Federal Emergency Management Agency. Those referenced models all deal with siting controls.

Also note that NFPA 59A is incorporated by reference in 49 CFR Part 193. In turn, DEC's draft Part 570 regulations incorporate 49 CFR Part 193 for LNG "facilities that produce and transfer LNG to trucks or rail cars or both and store 70,000 gallons or more of LNG in aggregate." 33 CFR Part 127 controls LNG facilities at the waterfront. Chapter I, subchapter D concerns pipeline safety. Section 193 is titled "Liquefied Natural Gas Facilities: Federal Safety Standards." DEC's draft of Part 570 incorporates 33 CFR Part 127 by reference for "the installation, operation and maintenance of facilities that transfer LNG to and from marine vessels."

Thus, all of the codes and standards available to federal and state regulators (including to DEC), are derived from a vast library of continuously updated research by independent entities, and all are cross-referenced in the NFPA and CFR codes that will be promulgated by Part 570.

When it comes to site planning, NFPA 52, NFPA 59A (as well as 49 CFR Part 193, and 33 CFR Part 127) focus on the arrangement of buildings, storage tanks and other equipment on the site of an LNG facility, but not on the site selection process for where an LNG "use" can be located. This "limitation" on the scope of those regulations is accepted by all the U.S. states that rely on the NFPA codes to regulate LNG facilities, because the question of "where" an LNG facility (or any other use) may locate is the purview of local land use controls (zoning regulations) which are the most commonly enforced administrative code in all jurisdictions (with the exception of TX), and stem from the police power of the state.

In the context of zoning controls, LNG facilities fit within a list of defined "uses," (or use categories) which include other fuel processing, storage, and dispensing uses, such as gasoline, diesel, propane storage and dispensing, and the like. Generally, such uses are allowed in "industrial" or "manufacturing" districts or in certain "automotive" commercial districts that permit the storage and sale of fuel and the maintenance of vehicles. Such uses are almost always prohibited from locating in residential zones or in districts that permit community facilities, such as schools and hospitals.

The exceptions are "pre-existing" non-conforming uses that were located in a neighborhood prior to the adoption of the current land use controls. Generally, those non-conforming uses can stay, (and be sold to new owners) but cannot expand or increase their "degree" of non-conformity. For example, if a non-conforming gasoline station in or next to a residential district proposed to add LNG dispensing to its services, it would likely be deemed an increase in its degree of non-conformity because more liquid fuel would be proposed for storage, and/or more liquid fuel would be proposed for aboveground storage. As a practical matter, such an addition of LNG storage and dispensing to any existing fuel dispensing site, (even one that conforms with the zoning ordinance), would need to be on a site large enough to allow compliance with the buffer standards in NFPA 52 and 59A, which are reviewed below.

The "edges" between industrial/manufacturing districts and residential and community facility districts most often include "buffers." Buffering techniques might include specific yard and setback requirements in the industrial/manufacturing district, when adjacent to less intensive uses. Buffering can also be achieved by placing light manufacturing and commercial uses between heavier manufacturing and residential districts. In other words, statewide and nationally, the most common and most effective tool for separating fuel processing, storage and dispensing facilities (including LNG facilities) from incompatible land uses is the local zoning ordinance.

Zoning ordinances are routinely amended by localities to respond to evolving land use patterns. Such amendments are undertaken within a predictable and transparent review process (including

environmental assessments of the proposed “land use action”), and are subject to judicial review. The adoption of Part 570 may trigger such amendments.

Based on the research conducted, it is believed that the adoption of Part 570 will not “open the floodgates” to new LNG facilities, especially in locations that are incompatible with existing land uses. First, the role of LNG within the overall energy production, storage and transport industry will continue to be limited to special applications and markets where the extra costs associated with the production, storage, and transport of LNG can be recovered by the “value added” aspects of its increased density. In other words, there are market driven limits to the commercialization of LNG that will, for example, yield much fewer LNG dispensing sites than gasoline stations. Subsequent sections of this report address the projected number of LNG facilities likely to be deployed in NYS during the first five years after the promulgation of Part 570.

As for compatibility with adjoining land uses, any proposed LNG facility will need to comply with existing land use controls, which also control all other fuel processing, storage and dispensing facilities. DEC’s permitting process, per Part 570, including the environmental review of each application, will confirm that the proposed location of an LNG facility complies with local land use controls. Some communities may, as an extra measure of “protection,” seek to amend their local zoning regulations to “zone out” LNG facilities, or to more rigorously restrict the location options available to proposed LNG facilities, compared to the land use restrictions placed on other similar uses. Such “exclusionary” zoning controls are subject to challenge in the courts and are not likely to prevail in jurisdictions that permit other (competing) fuel production, storage and dispensing facilities, but limit or exclude LNG facilities.

1B2. Controlling the Site Plan of LNG Storage Facilities

Instead of controlling where an LNG facility can be located, the NFPA and federal pipeline safety standards regulate the site plan of such facilities, especially with regard to the “buffer zone” between LNG storage tanks and property lines and/or nearby buildings. For example, site planning controls, including the regulations for the required distance between LNG storage tanks and property lines, can be found in Section 16.5.1 of NFPA 52, in Chapter 5 of NFPA 59A, and in Sections 193.2057 and 193.2059 of the federal pipeline safety standards. Similarly, Subchapters B and D of the LNG regulations of the Texas RRC contain site-planning controls as well as regulations related to the design and operation of equipment.

Section 16.5.1 of NFPA 52

Section 16.5.1 of NFPA 52 regulates the distance between LNG storage containers, between storage containers and buildings and between storage containers and a property lines, relative to the capacity of the storage container as measured in gallons. For example, LNG containers with capacities of up to **2,000 gallons** must be placed at least 5 feet apart, with a minimum of **15 feet** from any property line. For facilities with very small storage tanks, the minimum “buffer” zone between a tank and a property line is 10 feet.

Facilities with tanks up to **15,000 gallons** of capacity require a minimum of 5 feet between tanks, and a distance of at least **25 feet** to the property line. Storage tanks up to a capacity of **30,000 gallons** need to be placed at least **50 feet** from a property line, and tanks up to **70,000 gallons** in capacity need to be placed **75 feet** from a property line. Storage containers with capacities larger than 40 gallons are not permitted in buildings.

Thus, the smallest practical “lot area” for an LNG storage facility with straight property lines (a rectangular site, rather than a circular one), and assuming a 5 foot diameter vertical storage tank, is 35

feet by 35 feet. However, the addition of other equipment, such as dispensers, and the NFPA requirements for distancing certain safety equipment from the equipment they serve, will require larger sites. Also, most zoning ordinances include front, rear, and side yard controls, which do not permit (or strictly limit) the deployment of permanent structures / equipment in those yards.

A “typical” LNG fuel dispensing site, with a single 10,000-gallon storage tank, requiring 25 feet between the tank and any property line, and again assuming a vertical tank, will likely need a site that is significantly larger than 100 feet by 100 feet. This is to accommodate (1) the buffer zone between the storage tank and the property lines and any other equipment (or buildings) required for that fuel dispensing function; (2) distances required between safety equipment and the equipment they support; (3) required standards for the safe arrival and departure of vehicles; and (4) yard requirements inherent in the zoning ordinance.

Chapter 5 of NFPA 59A

Chapter 5 of NFPA 59A includes spill and leak control provisions, requiring one of three possible “impoundment” techniques for controlling spills, and preventing spills from reaching buildings, equipment, adjoining properties or waterways. Those impoundment methods can include natural barriers, dikes, walls, excavated “bowls,” or any combination of such techniques.

The volumetric capacity of those impoundment areas must be 100 to 110 percent of the capacity of the storage tanks being impounded, depending on the strength of the impoundment and its height. Chapter 5 specifies the construction standards for various impoundment designs; drainage standards to keep the impoundments free of water and to keep spilled LNG within the impoundment area until it vaporizes; and the distance of the impoundment perimeter from the edge of the tank(s) within the impoundment area.

Chapter 5 also regulates the “Radiant Heat Flux Limits to Property Lines” and to off-site “occupancies,” requiring that the applicant calculate the potential for fire damage to off-site areas in the event of a spill and fire. Mitigation measures, such as water curtains can be included in the site plan. The calculation of a “design spill rate and volume” of a potential LNG release is based on type of LNG container proposed for the site specific deployment and on the location of “container penetrations” (for valves, pipes, and the like), relative to the liquid level within the container.

The minimum distance from the edge of an impoundment area to a property line is **15 feet** for facilities with storage capacities of up to **2,000 gallons**, which is the same requirement as in NFPA 52. For facilities with capacities up to **18,000 gallons**, the required distance from the impoundment area to the property line is **25 feet**. (That standard allows 3,000 more gallons within that 25 feet buffer than the NFPA 52 standard.) For impoundment area capacities of up to **30,000 gallons**, the minimum distance to a property line is **50 feet**, which is consistent with NFPA 52. For capacities up to **70,000 gallons**, the minimum distance to property lines is **75 feet**, which is also consistent with NFPA 52. Facilities with more than 70,000 gallons of storage capacity are required to provide a distance to all property lines that is 0.7 times the diameter of the storage container, but not less than 100 feet.

Section 5.9 of Chapter 5 deals with “portable LNG facilities,” also known as “portable pipelines.” In addition to requiring that vehicles complying with USDOT standards be used as the “supply container,” and requiring trained staff at the site, this section also requires that “provisions shall be made to minimize the possibility of accidental discharge of LNG at containers.” The section allows the use of portable and temporary spill containment methods.

Sections 193.2057 and 193.2059 of federal pipeline safety standards (49 CFR Part 193)

As discussed above, the required thermal exclusion zone and the vapor dispersion zone is to be calculated per NFPA 59, and the modeling for thermal radiation and “vapor-gas dispersion distance” is to be done per the referenced Gas Technology Institute (GTI) standards.

1B3. Design and Operation of LNG Production, Storage and Dispensing Facilities

In addition to each jurisdiction’s zoning ordinance, specific controls relating to the buildings and the equipment that constitute the permitted land use are generally found in local, national, or international building codes that each jurisdiction has adopted. It is those building codes, enforced by local “code enforcement” officials, which contain (explicitly or by reference) standards related to fire safety, explosion prevention, and the general protection of life and property. The purview of local code enforcement officials may cover all applicable building and safety codes, or certain fire and explosion related matters might be delegated to the local fire department. NFPA codes supplement those more general building codes.

Draft Part 570 requires compliance by all proposed LNG facilities with NFPA 52 and NFPA 59A, as well as with 49 CFR Part 193 and 33 CFR Part 127 for certain larger LNG facilities. The design and operation of equipment, including for buildings, storage tanks, vaporization equipment, piping, valves, pumps and electric instruments, are covered in each of those referenced codes. Those design and operation controls are covered in Chapters 11, 12 and 16 in NFPA 52, and Chapters 6-11 and 13 of NFPA 59A, with each chapter’s main topics outlined below.

NFPA 52, Chapters 11, 12, and 16

Chapter 11 of NFPA 52 covers **LNG engine fuel systems** on ground-transport vehicles (with Chapter 17 covering marine vehicles). All safety aspects are addressed, as follows:

- Materials used in LNG equipment;
- The design of vehicular fuel containers;
- Controlling the filling of fuel containers;
- Structural integrity of containers;
- Standards for shut-off valves;
- Various other fuel container standards;
- Standards for pressure relief devices, pressure gauges and pressure regulators;
- Piping tubing and fittings standards;
- Valves; pumps and compressors;
- Vaporizers that convert LNG back to a gas;
- The integration and installation of LNG fuel tanks, piping and other equipment on a vehicle, with the vehicle’s engine and other vehicle components;
- On-vehicle pipes, tubing, fittings, valves, pressure regulators, gauges, electric wiring, labeling;
- On-vehicle fueling receptacle; and
- The testing of on-board LNG systems.

Chapter 12 of NFPA 52 covers **LNG fueling facilities**, where stored LNG is transferred to vehicles.

- General facility design standards, related to safety, security, and operating methods. Facilities that are to be unattended “shall be designed to secure all equipment from tampering,” including storage equipment and transfer equipment;

- Siting standards relative to such topics as overhead electric lines, other-than-LNG hazardous liquids, and the “points of transfer” where, for example, an LNG transfer point must be at least 25 feet from the nearest building not associated with the LNG facility;
- Spill containment;
- The construction of on-site buildings;
- Cargo transport unloading;
- Isolation valves associated with transfer piping;
- Methane detection systems;
- Depressurization of LNG hoses and loading arms for transfer piping and for the vehicle fuel dispensing systems;
- Vehicle fuel dispensing systems;
- Safety valves and relief valves;
- Corrosion control;
- Pumps, compressors and vaporizers;
- LNG-to-CNG (L/CNG) systems;
- Instrumentation and gauges;
- Emergency shutdown devices
- Electrical equipment; and
- Maintenance of equipment.

Chapter 16 of NFPA 52 covers stationary **LNG tanks** with a capacity of 70,000 gallons or less, covering the following topics at LNG fueling facilities. “Tanks” and “containers” are used interchangeably in Chapter 16. For example, the title of the chapter is “Installation Requirements for ASME Tanks for LNG,” but with section 16.1 using the phrase “LNG containers of 70,000 [gallons]”, section 16.3.1 using the phrase “inner and outer containers,” and section 16.3.3 using the phrase “inner tank and outer tank.”

- Securing containers against tampering;
- General standards for tank and container design, with reference to ASME standards, including the requirement that all containers be double walled;
- Standards for the vacuum insulation between the tanks;
- Pressure relief devices;
- Container seismic design standards;
- Container identification standards,
- Container foundation and support standards;
- The installation of containers;
- Automatic, failsafe product retention valves;
- Inspection, testing and purging of containers prior to start up;
- Piping within and to containers;
- Instrumentation, including in the event of power failure; and
- Gauges and pressure control devices.

Section 16.5.1 includes a table that codifies the minimum required distance between storage tanks and the minimum distance between any LNG storage tank and the facility’s property line. That topic was discussed above in Section 1B2.

NFPA 59A Chapters 6, 7, 8, 9, 10, 11 and 13

Chapter 6 of NFPA 59A covers **LNG process equipment** and includes the following topics:

- The installation of process equipment;

- Pumps and compressors;
- Flammable refrigerant and other flammable liquid storage; and
- General standards for the fabrication, pressure limits and other mechanical features of process equipment.

Chapter 7 of NFPA 59A covers **stationary LNG containers** including the following:

- Inspection prior to the operation of a facility;
- General standards related to pressure and cryogenic conditions, piping, gauges and foundations;
- Seismic design for field-erected and shop-fabricated containers;
- Wind, flood, and snow loads on containers;
- Foundations;
- Metal and concrete container standards;
- Construction, inspection and testing standards;
- Pressure relief devices; and
- Exposure to fire.

Chapter 8 of NFPA 59A covers **vaporization equipment and facilities**, which also covers topics related to “portable pipelines.”

- Classification of vaporizers and general design and materials standards;
- Piping and valves; and
- Relief devices.

Chapter 9 of NFPA 59A covers **piping systems and related components**.

- General piping standards;
- Seismic design;
- Materials and methods of construction assembly, including joints, fittings, bends and valves;
- Installation and welding;
- Pipe supports;
- Inspection, testing and record keeping;
- Corrosion control; and
- Operational standards.

Chapter 10 of NFPA 59A covers **instrumentation and electrical systems**.

- Gauges for LNG tanks and for refrigerant tanks, pressure and vacuum gauges;
- Temperature indicators;
- Emergency shutdown instruments;
- Electrical equipment, with reference to NFPA 70; and
- Electrical grounding and bonding.

Chapter 11 of NFPA 59A covers the **transfer of LNG and of refrigerants** used in the production of LNG.

- General standards;
- Piping systems, pumps and compressors;
- Marine shipping and receiving;
- Tank vehicle and tank car loading and unloading;
- Pipeline shipping and receiving;
- Hoses and transfer “arms;” and

- Communication equipment and lighting.

Chapter 13 of NFPA 59A covers **stationary LNG containers**. As mentioned above, the terms “tank” and “container” are used interchangeably.

- General standards;
- Container standards;
- Foundations and supports;
- Installation standards, including minimum standards for the distance between a container and a property line, as codified in Chapter 5;
- Spill containment;
- Inspection and testing of containers;
- Piping integral to containers;
- Instrumentation and gauges;
- Operation requirements and procedures manual;
- Emergency procedures;
- Maintenance and records; and
- Training of personnel.

The federal regulations for the design and operation of LNG equipment can be found in Subparts E and F of 49 CFR Part 193, and in Section 127.101 of 33 CFR Part 127. Those standards reference NFPA 59A, which has been covered above in this report. In the Texas RRC rules, design and operation controls, beyond those in Subchapters B and D, can be found in Subchapters E, F and G. The Texas RRC rules will not be analyzed in this report because TX represents a “special case” of a state adopting its own LNG regulations rather than referencing NFPA standards. CA enforces NFPA 52 and 59A and adds Cal/OSHA Titles 8 and 13, which deal with the safety of workers. Cal/OSHA means the California Occupational Safety and Health Administration.

1B4. Transportation of LNG in Bulk

The transport of Non-Radioactive Hazardous Materials (NRHM) is regulated by Federal Regulations, CFR 49 Part 397, which can be accessed at the following web site: <http://ecfr.gpoaccess.gov/>. The following is the definition of Hazardous Materials per section 397.65:

"A substance or material, including a hazardous substance, which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, or property when transported in commerce, and which has been so designated. "

The term NRHM is defined in 397.65 as follows:

"A non-radioactive hazardous material transported by motor vehicle in types and quantities which require placarding, pursuant to Table 1 or 2 of 49 CFR 172.504. "

The term "Hazardous Materials" includes all of the following: (1) Hazardous Substances, (2) Hazardous Wastes, (3) Marine Pollutants, (4) Elevated Temperature Material, (5) Materials identified in 172.101, and (6) Materials meeting the definitions contained in Part 173. Class 1 covers explosives, Class 2 covers gases (including flammable, non-flammable and toxic), and Class 3 covers flammable liquids. LNG, like all other liquid fuels, fits Class 3, and is covered by the federal codes.

Section 397.3 allows for local jurisdictions to impose stricter rules, but requires that federal standards apply when the federal standards are stricter than local standards. The states establish, maintain and enforce specific NRHM routing designations, but which must comply with federal standards related to the following:

- Enhancement of public safety;
- Public participation in the establishment of such routing standards;
- Consultation with affected political subdivisions;
- “Through routing,” to ensure continuity of movement of goods;
- Agreements of other states, avoiding a burden on commerce;
- Timeliness of the establishment of standards; and
- Reasonableness of routes, terminals and other facilities.

Also, the states must take responsibility for and consider the following:

- Local compliance, ensuring that all political subdivisions comply with the federal standards;
- Population densities exposed to a NRHM release;
- The characteristics of the highways designated for the routing of NRHM;
- The types and quantities of NRHM normally transported along such routes;
- Local emergency response capabilities;
- Comments from the consultation process mentioned above;
- Exposure and other risk factors, including homes, commercial buildings, hospitals, schools, “handicapped facilities,” prisons, stadiums, water sources, parks, wetlands and wildlife reserves;
- Terrain considerations;
- Continuity of routes;
- Effects on commerce;
- Delays in transportation;
- Climatic conditions, such as snow, wind, ice, fog, etc. that could affect safety; and
- Congestion and accident history.

The federal NRHM regulations require the following reporting requirements by states:

- Public information regarding NRHM routing in the form of maps, lists, road signs and the like; and the
- Reporting and publishing of designated NRHM routes.

XE is not aware of any state or any local jurisdiction that has specific LNG transport/routing requirements that separate the routing requirements for LNG from all other liquid fuels and/or from all other NRHMs.

The bulk transport of LNG and its unloading at destination points is covered in Sections 12.3, 12.4, and 12.10 of NFPA 52 and 11.6, 14.6 and 14.7 of NFPA 59A. The federal standards are silent on this issue because it is outside of the area of interest of those codes. The Texas RRC rules cover that topic in Subchapter H. The NFPA codes that deal with the bulk transport of LNG will be listed below, with an outline of each section’s main topics. That will be followed by a discussion of LNG pipelines.

NFPA 52, Sections 12.3, 12.4 and 12.10

Section 12.3 covers **cargo transport unloading**.

- Isolation valves;
- Methane detection; and
- Venting systems.

Section 12.4 covers **vehicle fuel dispensing systems**.

- Collision protection;
- Shut-off valves and pressure regulation; and

- Hoses and transfer “arms.”

Section 12.10 covers **L/CNG systems**.

- Emergency shutdown;
- Location of compressors, vaporizers and CNG storage tanks;
- Transfer piping, pumps and compressors; and
- Standards related to the use of methane odorants.

NFPA 59A, Sections 11.6, 14.6, and 14.7

Section 11.6 covers **loading and unloading facilities**.

- Tank vehicle standards;
- Loading and unloading area standards; and
- Pipes, pumps, compressors, valves, and vents.

Section 14.6 covers **marine shipping and receiving facilities**.

- Standards for controlling possible incidents in the transfer area;
- Mooring standards;
- Transfer procedures and operating standards; and
- Inspection standards.

Section 14.7 covers **LNG product transfer**. Again, tanks and containers are interchangeable.

- Standards for matching the characteristics of the transferred LNG to the contents of the receiving container;
- Prevention of LNG “stratification” and tank roll-over; and
- Elimination of ignition sources from transfer area.

LNG Pipelines

Examples of transporting LNG in short distance pipelines can be found at LNG import and export terminals worldwide, where the on-shore LNG storage tanks are connected to ship-loading (or off-loading) connections. Longer distance (i.e., more than one mile) LNG pipelines are not practical because they are expensive (due to the need for double walled, vacuum insulation), and are difficult to operate because the LNG tends to flow in a two-phase state, with natural gas (NG) vapor mixing with the LNG, causing turbulence and “slug flow.” However, the AZ Administrative Code, Title 14, Chapter 5, Article 2, controls intrastate LNG pipelines. Those regulations reference federal pipeline safety standards, including 49 CFR Parts 40, 191, 192, 193 and 195. XE knows of no examples of such LNG pipelines having been built in AZ or in any other location other than at import/export terminals.

In the remote event that future technical and economic developments will allow for the cost-effective construction and operation of LNG pipelines (of any length) in NYS, the NFPA and other standards discussed in this report (and adopted by the promulgation of Part 570) will regulate such deployments, because each such LNG pipeline will begin and end at two or more points that are regulated by NFPA standards.

1B5. Safety of LNG Facilities

Fire protection safety and security of LNG facilities are dealt with in Chapters 15 and 17 in NFPA 52 and Chapters 12 and 14 in NFPA 59A. Section A.12.2 of Annex A of NFPA 59A (Explanatory Material) lists 21 NFPA documents that deal with fire extinguishing systems. The federal pipeline safety regulations cover fire protection and safety in Chapters G, H and I in 49 CFR Part 193, and Subpart B

and throughout sub-sections of that document. NFPA 59A, in Annex C reprints, for information purposes, all of the Security standards in 49 CFR Part 193. (The Texas RRC regulations cover those topics in Subchapter B.)

NFPA 52, Chapters 15 and 17

Chapter 15 deals with **LNG Fire Protection** and covers a wide range of topics. Items shown in *italics* concern the physical security of LNG facilities. That topic is covered in more detail in Section 1B6 below.

- Fire protection, safety and security, based on standards that include local conditions, vehicle operations, exposure to or from nearby properties, and relative to the size of the LNG containers;
- Guidance factors for the fire protection standards include, the type and location of fire detection and control equipment; methods for protecting vehicles and buildings; integration with the Emergency Shut Down (ESD) system; type and quantity of sensors that initiate the ESD protocols; availability of personnel, and protective equipment and training required for personnel;
- Planning for emergency response coordination with local first responders;
- The establishment of an emergency response plan;
- Ignition source control mechanisms;
- Personnel safety and training protocols including the qualifications of personnel, protective clothing and shielding for LNG dispensing personnel;
- Training protocols must include information on the properties of LNG in its liquid and vapor states, specific instructions related to equipment at each site, information on materials, care of protective equipment, first aid and self-aid methods, emergency response steps, “good housekeeping” practices, review of the emergency response plan, and drills related to fires and evacuations;
- Each operator must provide and implement a written plan for the initial training of personnel;
- *The security of each facility must be established, for example, minimizing unauthorized access;*
- Gas and fire detection equipment must be installed;
- Vehicle parking standards; and
- Warning signs prohibiting smoking, shutting engines, not allowing open flames, and warning about the cryogenic liquid and gas contained on site, about flammability and regarding the absence of “odorizing” additives in the gas.

Chapter 17 deals with the **LNG and CNG on commercial marine vessels and pleasure craft**. At the moment there are very few LNG marine vessels, which are mostly in Europe. However, that may change in the future. The following is an outline of topics covered by Chapter 17 of NFPA 52:

- The location of fuel tanks on the vessel;
- Position of tanks relative to potential collision damage;
- Cradles, racks and mounting systems;
- Installation and pressure gauges;
- Labeling of tanks;
- Operation standards;
- On-board fire protection;
- Ventilation systems;
- Fueling systems;
- Storage and handling of fuels;
- Marine service stations;
- Engine rooms and compartments, including ventilation and natural gas detection systems;

- Engines and engine compartments;
- Fire equipment, systems and fire-fighting equipment and other safety equipment;
- Tank rooms and compartments;
- Lighting and vents;
- Deluge and alarm systems; and
- Safety training, including monthly training drills.

NFPA 59A, Chapters 12 and 14

Chapter 12 deals with **fire protection, safety and security**, and is designed to minimize the consequences from released LNG and other flammable fluids. Chapter 12 augments the leak and spill controls of the other NFPA 59A chapters. The 10 fire protection protocols listed in Chapter 12 are similar to the list above for Chapter 15 of NFPA 52. The following additional topics are also covered, with items in *italics* dealing with site security:

- ESD systems;
- Fire and leak detection, including the detection of gas;
- Fire protection water systems;
- Fire extinguishing and other fire control equipment;
- Maintenance of fire protection equipment;
- Personnel safety;
- *A required “security assessment” that covers LNG storage containers, flammable liquid storage tanks, other hazardous material storage, outdoor process equipment, buildings housing equipment, and onshore loading and unloading facilities; and*
- *Enclosure requirements for the facility, as well as lighting to promote security.*

Chapter 14 concerns the **operating maintenance and personnel training** needed for the safe operation of LNG plants. *Italicized* items below are relevant to the security of LNG facilities, a topic more fully discussed in Section 1B6 below. In addition to the outlined topics that follow, Section 14.4.6.1 requires that the “operation monitoring [of an LNG facility] shall be carried out by an *attended control center* that watches or listens for *warning alarms* and by inspections conducted at least at the intervals set out in the written operating procedures referred to in Section 14.2 and, at a minimum, on a weekly basis.” (Emphasis added by XE.) Annex D of NFPA 59A reprints (for informational purposes) the training requirements of 49 CFR 193.

- The operating company must prepare documented operating, maintenance and training programs and comply with requirements for documenting all procedures, maintaining up-to-date drawings of plant equipment, revising such as information as new equipment is installed, ensuring cool-down of components per 14.4.2, establishing an emergency plan, establishing a *liaison with local police*, fire and other authorities, and analyze and document all safety-related incidents in order to prevent recurrence;
- Manual of operating procedures;
- Inspection records;
- Emergency procedures;
- Maintenance manual;
- Foundations and support systems for each component;
- Emergency power systems;
- Marine shipping and receiving standards including standards for the transfer of LNG and loading and unloading of refrigerants;
- Testing for the oxygen content of containers;
- Purging of containers;

- Site housekeeping;
- Inspection and testing of control systems;
- Corrosion control;
- Records keeping;
- Personnel training; and
- Periodic refresher training (every 2-years for personnel trained per 14.14.1 or 14.14.2).

1B6. Security of LNG Facilities

With regard to “homeland security,” LNG facilities in CA, AZ and TX are generally viewed in a comprehensive manner, along with other uses, including large-scale hazardous material production and storage facilities. In that context, most LNG facilities are too small to receive special attention as a homeland security risk site. However, as noted above, (and highlighted by *italics*) several sections of NFPA 52 and NFPA 59A deal with the security of LNG facilities.

In a February 9, 2011 response to a set of questions posed by XE, the NYS Office of Fire Prevention and Control (OFPC) offered the following regarding “homeland security”:

“Courses [offered by OFPC] considered as Emergency Response to Terrorism deal with intentional acts involving chemicals, explosives, biological and other agents, which are believed to be weapons a terrorist may employ. We recognize the possibility of attacks on these facilities but do not focus training on the possibility.”

On the national level, the Transportation Worker Identification Credential (TWIC™) program is an initiative of the U.S. Transportation Security Administration (TSA) and the U.S. Coast Guards. Information on the program can be found at <https://twicprogram.tsa.dhs.gov/TWICWebApp/AboutTWIC.do>. “The TWIC™ program provides a tamper-resistant biometric credential to maritime workers requiring unescorted access to secure areas of port facilities, outer continental shelf facilities, and vessels regulated under the Maritime Transportation Security Act (MTSA), and all U.S. Coast Guard credentialed merchant mariners,” including workers associated with the transport of LNG by ship.

The program’s goals include the following:

- Positively identify authorized individuals who require unescorted access to secure areas of the nation's maritime transportation system;
- Determine the eligibility of an individual to be authorized unescorted access to secure areas of the maritime transportation system;
- Enhance security by ensuring that unauthorized individuals are denied unescorted access to secure areas of the nation's maritime transportation system; and,
- Identify individuals who fail to maintain their eligibility qualifications after being permitted unescorted access to secure areas of the nation's maritime transportation system and revoke the individual's permissions.

The TSA “Transportation Sector Network Management (TSNM) program, outlined at [http://www.tsa.gov/what we do/tsnm/index.shtm](http://www.tsa.gov/what_we_do/tsnm/index.shtm), covers railroads, highway motor carriers, ports and intermodal facilities, mass transit facilities, pipelines, air cargo, commercial and general aviation. Each transportation mode has specific TSNM protocols. For example, for highway motor carriers, the TSA web site offers a Highway Security Counterterrorism Guide, Hazmat Training updates and Hazmat Motor Carrier Security Training Workshops. (Hazmat, or hazardous materials, includes fuels such as LNG.)

Information on TSA's "HAZMAT Endorsement Threat Assessment Program" can be found at http://www.tsa.gov/what_we_do/layers/hazmat/index.shtm. "The program was implemented to meet the requirements of the USA PATRIOT Act, which prohibits states from issuing a license to transport hazardous materials in commerce unless a determination has been made that the driver does not pose a security risk. The Act further requires that the risk assessment include checks of criminal history records, legal status, and relevant international databases." Other features of the program can be found at the web site cited above.

1B7. Emergency Response Procedures

Emergency response and shutdown procedures are regulated in section 12.11.3 of NFPA 52, which requires an ESD, which will, "in the event of a power or instrumentation failure" cause the system to "go into a fail-safe condition that can be maintained until the operators can take appropriate action to either reactivate or secure the system." Additionally, emergency response procedures are covered in the following sections of NFPA 59A: 10.6, 11.5.4, 12.2.2, 12.3, 13.18.3, 14.4.8 and 14.5.9, each of which is summarized as follows:

- **Section 10.6** replicates the standards of NFPA 52, section 12.11.3, which is quoted above;
- **Section 11.5.4** requires manual ESD systems at marine terminals;
- **Section 12.2.2** outlines a comprehensive set of fire protection standards, including ESD systems, and with a reference to NFPA 600, "Standard on Industrial Fire Brigades;"
- **Section 12.3** outlines standards for automatic ESD systems as well as requiring "manual actuators" to be located at least 50' from the equipment they serve;
- **Section 13.18.3** requires a set of emergency procedures, including the prompt notification of an emergency to local officials;
- **Section 14.4.8** outlines the emergency procedures required as part of the overall operation, maintenance and personnel-training program; and
- **Section 14.5.9** deals with emergency power systems, including their monthly testing.

The federal pipeline safety regulations address emergency response in 49 CFR section 193.2509 and in 33 CFR section 127.205. (The Texas RRC regulations deal with this topic in sections 14.2046, 14.2049 and 14.2510, which are not reviewed here in detail.) The following summarizes the emergency procedure topic covered by 49 CFR and 33 CFR.

49 CFR Section 193.2509

- Identification of potential types and places of future emergencies;
- Establish written manuals for emergency procedures;
- Establish protocols for controllable emergencies;
- Establish protocols for uncontrollable emergencies;
- Coordinating with local officials;
- Cooperating with local officials regarding evacuations; and
- Informing local officials as to the location and types of fire control equipment, potential hazards at the plant, communication and control capabilities, and the status of each emergency.

33 CFR Section 127.205

- Each transfer system must have a manually operated Emergency Shutdown System; and
- The system must operate automatically when LNG concentrations exceed "40% of the lower flammable limit."

In NYS, outside of NYC and to some extent outside of Nassau and Suffolk Counties, the training of firefighters and emergency responders is the responsibility of NYS OFPC, which was recently combined with several other State agencies to form the Division of Homeland Security and Emergency Services. The NYC Fire Department has its own training system, which is fully independent of OFPC. With regard to Nassau and Suffolk Counties, OFPC provides specialized training that supplements each county's local training system.

OFPC provides training courses to first responders in NYS. The courses cover all types of containers at all scales, for all types of flammable, explosive and hazardous liquids and gases. The Flammable Gas workshops, covering propane and natural gas, familiarize students with transport vehicles, and distribution systems. Students at the fire academy are also taught (and practice) proper procedures for dealing with leaks of flammable fluids and fires caused by such fluids. The Flammable Liquids course covers procedures at bulk fuel storage facilities. Spill control and firefighting is covered in the Operations and Technician courses. Cryogenic fluids are also covered, with an emphasis on containers and the hazards associated with super cold fluids. Issues related to rail transport are covered in many of the OFPC courses. The agency is currently developing a Rail Tank Car Specialist course consistent with NFPA 472, Chapter 12.

Firefighters are encouraged to work with local industry specialists to prepare appropriate emergency response plans. The training includes identifying hazardous products, evaluating potential emergencies, and developing tactics to deal with those emergencies that are consistent with safe work practices. In the past, when a local fire department requested help for the planning of a specific facility, OFPC conducted a site visit and worked with the local entities to create the emergency response plan.

NYS's career firefighters must complete 229 hours of basic training, including 16 hours of Hazardous Materials training. After basic training, career firefighters are required to complete 100 hours of "in service" training annually. Details of the minimum training requirements are available at: <http://www.dos.state.ny.us/fire/pdfs/standards/Part426LawBook.pdf>.

Some career departments add training to the "Hazmat Technician" level to the basic program. Others offer it only to individuals who will be assigned hazardous material response duties. Advanced training is usually taken voluntarily, but some departments require it for promotion or assignment to specific duties. Both career and volunteer fire departments must comply with OSHA 1910.120 paragraph q, which requires training to the Operations level, complete refresher training, and annual competency demonstration. OSHA means the federal Occupational Safety and Health Administration.

An entity that has deployed several LNG facilities in TX has informed XE that for "large-scale" LNG projects, applicants for permits have been known to fund the training of first responders. Section 570.3 (c) of the draft Part 570 regulations requires that "each applicant for a permit shall offer an emergency response training program for local enforcement, fire, and hazardous material response personnel of the authority having jurisdiction."

1B8. Inspection of LNG Facilities and Enforcement of Applicable Rules and Regulations

NFPA 52 covers inspection of LNG facilities and the enforcement of applicable rules and regulations in sections 9.9.1.4, 16.7 and 16.8.

Section 9.9.1.4 covers **pipng systems**.

- ASME and other standards are referenced; and
- Standards for manifolds, joints, threading, bends, and fittings are stated.

Section 16.7 covers **inspections**.

- Inspections must occur prior to initial operation; and
- Inspectors must be qualified per NFPA 59A.

Section 16.8 covers **testing and purging of LNG containers**.

- Containers must be leak tested per the ASME Boiler and Pressure Vessel Code;
- Shop-built containers must be tested by the manufacturer, with any intrinsic piping tested per NFPA 59A;
- All containers shall be leak tested prior to filling per NFPA 59A standards;
- Containers shall be shipped with low-pressure inert gas in them;
- No field welding is permitted after testing; and
- Prior to service, all containers must be “inerted” by an approved “inerting” procedure.

NFPA 59A, section 7.5.3, deals with construction inspection, sections 7.7, 7.8, and 13.9 deal with container testing and inspection, and section 9.7 covers testing of piping. Each of those sections is summarized below.

Section 7.5.3 covers **construction, inspection and tests**.

- Concrete LNG containers must meet several American Concrete Institute (ACI) referenced standards, for the use of concrete in structures;
- Inspection regimes for concrete construction are specified; and
- Metal LNG containers must meet referenced API standards for welded, low-pressure storage tanks.

Section 7.7 covers the **testing of containers**.

- Leak testing of containers is required;
- Containers designed for pressures in excess of 15 pounds per square inch (psi) must be tested prior to installation per a set of protocols and per reference standards for boilers and pressure vessels; and
- No field welding of the container is permitted after testing, so as not to cause unintended harm to the containers.

Section 7.8 covers **container purging and cool-down**.

“Before an LNG container is put into service, it shall be purged in accordance with 14.4.2 and 14.9.2 and cooled in accordance with 14.4.2.” That use of “internal” references to standards, within NFPA 59 A, is typical in NFPA codes, requiring one set of protocols in one portion of the code to apply to other, related portions.

Section 13.9 covers **inspections**.

This section reiterates the need for inspections prior to putting a container into service, and calls for inspectors to be appropriately qualified.

Section 9.7 covers the **inspection and testing of piping**.

- Pressure testing per ASME standards must be performed on all piping, and records of such tests shall be kept;

- Longitudinal welded pipes must meet performance standards, or be subjected to “100 percent radiographic [x-ray] or ultrasonic inspection,” and circumferential welds must be fully examined by x-ray or ultrasonic inspection; and
- Inspections per ASME standards are required, and records of inspections must be maintained.

Section 193.2623 and 193.2705, and 127.403 of the federal standards cover this topic.

49 CFR Section 193.2623

“Each LNG storage tank must be inspected or tested to verify that each of the following conditions does not impair the structural integrity or safety of the tank:

- (a) Foundation and tank movement during normal operation and after a major meteorological or geophysical disturbance.
- (b) Inner tank leakage.
- (c) Effectiveness of insulation.
- (d) Frost heave.”

49 CFR Section 193.2705

- (a) “Supervisors and other personnel utilized for construction, installation, inspection, or testing must have demonstrated their capability to perform satisfactorily the assigned function by appropriate training in the methods and equipment to be used or related experience and accomplishments.
- (b) Each operator must periodically determine whether inspectors performing construction, installation, and testing duties required by this part are satisfactorily performing their assigned functions.”

33 CFR Section 127.403

“The operator shall conduct a visual inspection for defects of each pressure-relief device not capable of being tested, at least once each calendar year, with intervals between inspections not exceeding 15 months, and make all repairs in accordance with §127.405.”

(Subchapter A of the Texas RRC LNG regulations deals with inspection and enforcement, and Subchapters B, C and F of the Laws of Texas LNG regulations further offer inspection and enforcement controls.)

In NYS, the enforcement of LNG rules and regulations or the inspection of LNG facilities is not within the mandate of OFPC. Rather, the local code enforcement official is responsible for enforcing the Uniform Fire Prevention and Building Code (UFPBC). In some communities the local fire department and/or Fire Marshall share code enforcement duties with the local “building inspector.” In most jurisdictions (in NYC and elsewhere), code enforcement and inspection are divided into “electrical” and “mechanical” permits, with inspections performed prior to the use of the equipment.

A 2/4/11 e-mail opinion received by XE from a Senior Building Construction Engineer at the NYS Department of State, Division of Code Enforcement and Administration stated:

“Such an inspection would be considered a ‘Special Inspection’ under the 2010 Building Code of New York State (Chapter 17). Therefore a third party inspection agency would be required/needed to inspect the [LNG] facility to the UFPBC [standards] and any reference standard[s] which apply to such a facility.”

It should be noted that the Building Code of New York State, which contains fire prevention standards, does not contain LNG-specific standards. However, the quote above suggests that all LNG facilities, by their special nature, would undergo “Special Inspection” by third party inspection entities.

According to senior staff at Chart Industries, most U.S. jurisdictions with LNG facilities inspect those sites on an annual basis. Those inspections mostly focus on pressure vessels. The codes in place during the time that the facility was deployed are generally used as the standard for the inspection, rather than newer version of the applicable codes.

Section 570.3(a) of the draft Part 570 allows for the unannounced inspection of any LNG facility for permit compliance, at any time, and as often as deemed appropriate by DEC or its designated representative.

1C. Regulatory Relief

The Texas RRC LNG regulations offer exceptions related to LNG safety rules in Section 14.2052. Subsection (h) states the following:

“After [a public] hearing, the Commission may grant exceptions to this chapter if the Commission finds that granting the exception will not adversely affect the safety of the public.”

XE is not aware of any other national or local codes that offer regulatory relief to LNG facilities. As such, no jurisdiction makes a distinction between LNG facilities operated by small businesses, government agencies, or “minor facilities” that might store less than a specified threshold quantity of LNG.

1D. LNG-Related Incidents /Accidents

The LNG industry has an excellent safety record, due to several factors. First, all LNG containers, large and small, stationary or transportable, are required by technical standards related to the vessel’s ability to resist heat gain and by NFPA standards to be double walled. The space between the inner and outer container is insulated to keep the LNG in its liquid state. That universal double-wall design is substantially stronger and more resistant to spills than the standard single-walled design used for all other fuels such as propane, diesel and gasoline. Secondly, the LNG industry, and the codes that regulate it, have continued to evolve technical solutions and protocols for the safe production, storage, transport, and dispensing of LNG. Also, the risks associated with LNG (as distinct from the risks associated with other flammable and explosive fuels and various toxic fluids) are well understood and have been incorporated into the applicable codes that regulate LNG facilities.

There have been many studies undertaken to assess the potential hazards of LNG, some by entities opposed to the deployment of LNG facilities, some by the LNG industry, and others by more “neutral” entities at the behest of public agencies, regulatory authorities, and policy makers, seeking to understand the risks posed by LNG facilities. Sandia National Laboratories prepared two such reports, one in 2004 and a second one in 2008, titled “Breach and Safety Analysis of Spills Over Water from Large Liquefied Natural Gas Carriers,” which can be found at the following site:

http://fossil.energy.gov/programs/oilgas/storage/lng/SANDIA_2008_Report_-_Large_LNG_Vessel_Sa.pdf.

The earlier study looked at LNG tankers that transport from 125,000 to 145,000 cubic meters of LNG in multiple (separated) cargo tanks on a single ship. The 2008 report looked at LNG tankers that can carry

up to 265,000 cubic meters of LNG, also in multiple compartments. The following is one of the noteworthy conclusions of the 2008 Sandia study, which focused on ships carrying up to 265,000 cubic meters of LNG:

“Even with the increase in thermal hazard distances from pool fires for the larger ships, the most significant impacts to public safety and property are still within approximately 500 m of a spill, with lower public health and safety impacts at distances beyond approximately 1600 m.”

A concise (but not comprehensive) history of LNG can be found at the following web site:

<http://www.centreforenergy.com/AboutEnergy/ONG/LiquifiedNaturalGas/History.asp>

A web-based search of LNG incidents and/or accidents yields several sites that compile such information. A fairly comprehensive and neutral compilation of such incidents can be found on the web site of the California Energy Commission (CEC) at <http://www.energy.ca.gov/lng/safety.html>

A review of those incidents indicates that most were related to the operations of export/import terminals and the ships serving those facilities rather than to smaller, more widely deployed LNG facilities. For example, none of the approximately 40 LNG facilities servicing LNG fleets in CA have experienced any explosions, fires, spills or leaks. Also largely absent from the compilation by the CA Energy Commission are incidents related to the transport and transfer of LNG (from transport truck to stationary storage tank). Admittedly, the “volume” of LNG transport, as measured in total gallons or vehicle miles, is very low when compared to the transport of other hydrocarbon fuels, such as gasoline, diesel and propane. Still, the lack of transport-related LNG incidents indicates that the applicable NFPA standards are working and that double-walled tanks are inherently safer than the single-walled tanks that are used to carry other fuels.

The CA compilation is organized under two categories: 1) **Explosions and Fires**; and 2) **Spills and Leaks**. Rather than reproduce here that compilation’s nineteen events with the narrative that describes each event, the following is the date and place/name of the eleven “Explosions/Fires” and the 8 “Spills/Leaks” that have occurred worldwide since 1944, which are described more fully on the above-referenced CEC web site. Note that LNG spills and leaks can happen without causing an explosion or fire, and that explosions and fires can occur at LNG facilities even in the absence of LNG, as they can at any natural gas facility; fuel production, storage and transfer facility; and industrial site or large-scale construction site.

1D1. Explosions and Fires

- October 1944, Cleveland, Ohio: failure of a low-nickel (3.5%) storage tank at a peak-shaving plant
- 1964 and 1965 Methane Progress, Arzew, Algeria: on-board an LNG ship, via lightning strike
- 1969, Portland, Oregon: during the construction of an LNG tank, not yet containing LNG
- January 1972, Montreal East, Quebec, Canada: valve failure at a peak-shaving plant
- February 1973, Staten Island, New York: explosion in empty tank during tank repairs
- October 1979, Cove Point, Maryland: due to natural gas leak
- April 1983, Bontang, Indonesia: at base-load plant due to excess pressurization of heat exchanger
- August 1987, Nevada Test Site, Mercury, Nevada: by accidental ignition during vapor cloud testing
- June 2004, Trinidad, Tobago: due to gas turbine failure
- July 2004, Ghislenghien, Belgium: due to gas pipeline failure, likely caused by contractor
- March 2005, District Heights, Maryland: explosion in house due to difference in chemical composition of NG derived from imported LNG, compared to domestic NG.

The 1973 Staten Island explosion in NYS occurred in tank empty of LNG that was undergoing maintenance. The tank was warmed, purged of the remaining combustible gases with inert nitrogen, and then filled with fresh recirculation air. A construction crew entered the tank to begin repair work in April of 1972. In February 1973, an unknown cause ignited the tank's Mylar liner and polyurethane foam insulation. The rapid rise in temperature caused a rise in pressure, lifting the tank's concrete dome, which then collapsed killing 37 construction workers inside. NYC Fire Department investigation concluded that the accident was a construction accident, not an LNG accident.

1D2. Spills and Leaks

- Early 1965, Methane Princess Spill: during ship-to-shore transfer
- May 1965, Jules Verne Spill, Arzew, Algeria: due to overflow from cargo tank
- 1971, La Spezia, Italy: due to vapor cloud escape
- July 1974, Massachusetts Barge Spill: 40 gallons leaked during a transfer operation
- September 1977, Aquarius Spill: overflow from tank, likely because of gauge failure
- March 1978, Das Island, United Arab Emirates: due to pipe connection failure
- April 1979, Mostafa Ben Bouliad Spill, Cove Point, Maryland: valve failure during transfer resulted in a minor spill
- April 1979, Pollenger Spill, Everett, Massachusetts: due to a valve fracture

Missing from the above CEC list was a 2004 incident at the Skikda, Algeria LNG Export Facility. A description of that incident can be found at <http://www.ch-iv.com/links/history.html>, where several other incidents (on the CEC list) are also described. (The date of the Cleveland incident on the CH-IV web page is shown as 1994, but should be 1944.)

Also missing from the CEC list are several incidents found on a PDF produced by CEC that is available at the following web page:

http://www.slc.ca.gov/division_pages/DEPM/DEPM_Programs_and_Reports/BHP_Deep_Water_Port/RevisedDraftEIR/1aCabTransport/Appendices/C3_Public%20Safety.pdf

It should be noted that the NFPA rules and regulations are regularly updated by expert panels, in response to new technologies, new deployment and operating models, and especially in response to adverse incidents, including those listed above. For example, the 1944 Cleveland incident substantially advanced the industry's (and the regulators') understanding of the need for 9% nickel steel (and other such standards) to combat brittleness in cryogenic storage tanks. Each of the incidents listed above likely generated the next round of code improvements.

For example, the Clean Vehicle Education Foundation (CVEF), which is a member of the NFPA Technical Committee on Vehicular Alternative Fuel Systems, investigates all LNG related incidents and provides information to all of the NFPA 52 committees. A new NFPA 52 is normally issued on a 3 to 4 year cycle, reflecting input by the various committees including from CVEF. However, if a change to NFPA 52 is needed prior to the normal cycle, a Tentative Interim Amendment (TIA) can be issued to address a specific issue. A similar process exists for updating NFPA 59A.

As mentioned above, LNG trailers are double-walled steel containers, which, unlike single-walled vessels used to store or transport other fuels, tend to better withstand collisions and other adverse effects. Over the last 20 years or so, there have been several LNG trailer accidents (collisions), none of which has resulted in loss of life or major property damage. Chart Industries recalls an incident some year ago where an LNG trailer in the U.S. developed a leak in its on-board "plumbing" (valves and pipes), which

caused a fire when a temporary solution to stop the leak was attempted. The fire burnt out safely with no loss of life and no property damage beyond the trailer.

Some entities that have lobbied against the deployment of LNG facilities have suggested that a catastrophic release of LNG will create a “boiling liquid expanding vapor explosion,” or BLEVE. In independent laboratory tests and in open-ocean combustion tests, there have been no documented cases of LNG BLEVEs.

Any catastrophic failure of an LNG containment vessel can result in a “rapid phase transition” (RPT) or the rapid conversion from liquid to vapor, but which will not cause ignition. Instead the RPT will further damage the containment vessel. Any ignition that might occur would need to be initiated by a heat source. Opponents of LNG suggest that LNG tankers (ships and trailers) are potentially explosive “bombs.” The history of LNG transport includes events that have resulted in the loss of containment (spillage) as well as fires, but not the explosion of a containment vessel.

After 9/11/2001, local and state public safety officials commissioned studies to evaluate the fire and explosion risks associated with a potential terrorist attack on LNG ships destined for the Distrigas import terminal at Everett, Massachusetts (near Boston). Those studies concluded that a 5-meter hole in a ship would spill 25,000 cubic meters of LNG, which if ignited, would burn off in 37 minutes, with no explosion.

Task 2: Facility, Job, and Cost Projections

2A. LNG Facility Projection Methodologies

There are several mutually supportive methodologies that can be applied to answer the following: How many LNG facilities will be deployed within the first five years after the promulgation of Part 570?

XE used the following three methodologies for its projections of LNG facilities during the first five years after the promulgation of Part 570:

- **Interviews with Experts**
- **Historic Perspective**
- **Functional Perspective**

The US LNG industry is relatively small, with only a handful of LNG-related equipment and service providers. The number of experts is also small, allowing for an informal interview process that can quickly reach those with the most up-to-date knowledge of the technical and economic issues that advance or thwart the deployment of LNG facilities. However, “expert projections” of the number of LNG facilities that would be deployed after the promulgation of Part 570 may be driven in part by a level of “optimism” that is natural among those in the business of deploying LNG facilities.

A second methodology, using a historic perspective, balances the expert projections by looking back at the history of commercial LNG facility deployments since the 1940s. The historic review uses worldwide and U.S. deployment rates of LNG facilities as models for projecting how many LNG facilities will be built in the near future in NYS.

A third approach, the functional perspective, balances the first two methodologies by looking forward, focusing on the various functional roles and economic drivers of LNG facilities as well as the economic and logistical constraints on their near-future deployment. Each methodology was undertaken independent of the other two, but with the results from all three informing XE’s projections.

2B. Interviews with Experts

There are several entities in (and around) New York that have a history of operating CNG and LNG facilities. Key personnel at those entities constitute a pool of experts that understand the technical constraints and opportunities associated with LNG facilities. XE reached out to those experts, seeking responses to various questions related to the barriers against or opportunities for the future deployment of LNG facilities. XE’s questions were tailored to the entity’s expertise, with the following three questions as the most typically asked:

- 1) Do you see any likelihood of a new peak-shaving plant built in NYS during the first 5-years after new LNG facilities are allowed in NYS?
- 2) If "portable pipelines" were allowed in NYS (where LNG is delivered by truck, pumped to pressure and vaporized into an existing pipeline), would you deploy such equipment in your service area? If so, can you estimate the number of such deployments in any given year during the first 5-years after new LNG facilities are allowed in NYS?
- 3) Do you foresee a market for LNG-fueled heavy-duty vehicles in your service territory?

In addition to routine outreach to NYSERDA and DEC staff during the study, XE contacted various industry leaders and received thoughtful responses from the following entities:

- Chart Industries
- Clean Energy
- Con Edison (Con Ed)
- GDF Suez (Distrigas) Import Terminal
- National Fuel Gas (NFG)
- National Grid
- New York State Bureau of Weights and Measures
- New York State Department of State
- New York State Department of Taxation and Finance
- New York State Department of Transportation
- US DOE, Brookhaven National Laboratory

Chart Industries and Clean Energy were especially helpful with Task 1 of XE’s scope of work, and offered useful feedback on the logistics of future LNG dispensing facilities. Staff at National Grid provided XE with helpful information on the taxes associated with CNG, as well as information on the various U.S. and NYS tax waivers on alternative fuels. (Tax policies, especially those favoring alternative fuels, are “drivers” for new facility deployment.) The NYS Department of Taxation and Finance also provided XE with tax information.

The following are projections by some of the entities listed above for the deployment of LNG facilities in NYS, during the first five years after the promulgation of Part 570.

- Chart Industries estimates **fifteen to twenty** (15-20) LNG facilities will be built in NYS during the first five years after promulgation of Part 570. The most common deployment would be for LNG dispensing, where the LNG would be delivered to the dispensing site in double-walled cryogenic trailers. A few small-scale production facilities would also be among the total 15-20 deployed facilities.
- Clean Energy estimates **ten to fifteen** (10-15) LNG or L/CNG fuel dispensing facilities will be built in NYS during the first five years after promulgation of Part 570, with those facilities serving heavy-duty (Class 8) trucks with trailers (which move goods), as well as natural gas fueled refuse haulers.
- A senior analyst at National Grid foresees the deployment of **two** “semi-permanent” LNG facilities on the north- and south-forks of eastern Long Island, for purposes of pressure maintenance at the eastern end of the Long Island natural gas pipeline network. Deliveries to those re-vaporization facilities would come from the LNG import terminal at Everett, Massachusetts. The National Grid analyst also estimates that in addition to those two semi-permanent deployments, New York State will follow New England’s example where approximately **two** “portable pipelines” are deployed in any given year, for purposes of pipeline maintenance.
- A senior analyst at National Grid’s Gas Supply Group sees no need for peak-shaving plants “in the near-future, based on current supply/demand balance” in the region. The analyst also suggests that exporting of LNG from existing peak-shaving plants, such as National Grid’s Greenpoint and Holtsville facilities, would “require a major revamping to the mission of the facilities,” a process that will not be undertaken lightly and would not likely be completed during the first five years after the promulgation of Part 570.

- A senior staff person at National Fuel Gas (NFG) stated that “NFG does not foresee the need to add LNG for peak-shaving in our service area because of the availability (and lower cost) of pipeline transmission and storage.” NFG operates several large underground CNG storage facilities. NFG staff person also stated that “portable pipelines are not likely to be deployed on the existing system operated by NFG;” and “For heavy truck & fleet operations, a small CNG infrastructure exists in our area. Increased use of gas-fired vehicles has been discussed for a number of years. CNG versus LNG will sort itself out based on costs of supply, facilities, and vehicle conversion.”

In summary, the maximum projected number of LNG facility deployments, based on interviews with industry experts, is 20 dispensing facilities (per Chart’s projection), which would include several small-scale production systems, plus two semi-permanent “portable pipelines” and two such units that would be more mobile, for a total of **24** LNG facilities.

2C. Projections Using a Historic Perspective

Worldwide, there are several very-large-scale LNG production facilities, called “base load” plants, whose purpose is to convert regionally “stranded” NG into LNG for shipment to customers overseas. Examples of such base load plants with export terminals include facilities in Russia, Qatar and Trinidad-Tobago. Examples of importing countries include Japan, South Korea, several European countries and the U.S. One, relatively small US LNG export terminal exists in Alaska, with Japan as its main customer.

Moving down in scale from those large facilities, there are dozens of peak-shaving and satellite LNG storage facilities including in Australia, Canada, Germany, Japan, Norway, Spain, Switzerland, and the United Kingdom. As noted elsewhere in this report, peak-shaving plants produce LNG on a pipeline for re-insertion at a later time. Satellite facilities accept truck (or ship-) delivered LNG for storage and later dispensing, but do not have on-site production capacity.

Outside of the export terminals mentioned above, one is hard pressed to identify any LNG production facilities in Europe, South America, Africa, Australia and South Asia (India and Pakistan), at any scale, that produce LNG for off-site use. Further down the “scale ladder,” XE knows of no existing small-scale LNG production and dispensing facilities (i.e., under 20,000 gallons per day [GPD]), that are analogous to the thousands of CNG production and dispensing networks that are so prevalent in many countries, such as Italy, India and Pakistan. Even in countries that have LNG import terminals, such as the UK and India, XE knows of no LNG distribution facilities beyond the boundaries of the import terminals, peak-shaving and satellite facilities. After some 60 years of LNG technology and market development, and with many countries benefiting from extensive NG pipeline networks and/or LNG import terminals, most of the world’s LNG infrastructure consists of large base-load production facilities, export or import terminals and peak-shaving plants.

The U.S. has, by far, the largest number of LNG facilities in the world. There are three peak-shaving plants in NYS, each of which are “non-conforming facilities” and subject to requirements in DEC orders issued on January 19, 1979. In nearby states, peak-shaving plants exist in Philadelphia, Baltimore, and on the Delmarva Peninsula in Delaware. Connecticut hosts several LNG storage and re-vaporizing facilities. The location, size and function of those facilities is outlined on a web page at <http://www.ct.gov/dpuc/cwp/view.asp?a=3363&q=414306>, which also offers background information on LNG and a concise history of LNG facility deployments in the U.S.

Table 2 is an “approximate” inventory of the many LNG facilities in the U.S. The table was derived from several sources, including from the Zeus Virtual Energy Library Archive, which is at <http://www.zeuslibrary.com/VEL/satellite/index.asp>.

The four columns represent functional categories (the purpose of each facility), which will be discussed in more detail below. The total number of facilities and the numbers in each category are approximations because the source data is not necessarily current, with some facilities having recently closed and new ones coming on line. Still, the table is a snapshot of LNG activity in the U.S.

Column 2 indicates that more than 100 peak-shaving plants are operating in the U.S., with most states hosting at least one such facility. The next largest category of facilities is the more than 50 LNG dispensing sites, most of which are in CA. In total, the U.S. has approximately 183 LNG facilities spread throughout the country.

The functional distinctions in the 4 columns may not be entirely “pure.” For example, the peak-shaving plant operated by Philadelphia Gas Works (PGW) sells some LNG to off-site customers. Each facility is assigned a single position in one column, based on the facility’s predominant function. New York and its neighboring states are shown in bold type.

Table 2: Approximate Inventory of U.S. LNG Facilities

Functional Categories (*)	(1) Import/Export	(2) Peak-Shaving & Satellite Plants	(3) Production For Off-Site	(6) Dispensing (No Production)	Totals
Alabama		5			5
Alaska	1	17			18
Arizona		3	1	7	11
Arkansas		1			1
California		1	1	40	42
Colorado			1		1
Connecticut		6		1	7
Delaware		1			1
Florida					
Georgia	1	4			5
Hawaii					
Idaho		1			1
Illinois					
Indiana		2			2
Iowa		3			3
Kansas			1		1
Kentucky					
Louisiana	3				3
Maine		2			2
Maryland	1	2			3
Massachusetts	1	16			17
Michigan					
Minnesota		2			2
Mississippi					
Missouri					
Montana		1			1
Nebraska		2			2

Functional Categories (*)	(1) Import/Export	(2) Peak-Shaving & Satellite Plants	(3) Production For Off-Site	(6) Dispensing (No Production)	Totals
Nevada		1		1	2
New Hampshire		4			4
New Mexico					
New York		3			3
North Carolina		4			4
North Dakota					
Ohio					
Oklahoma					
Oregon		2			2
Pennsylvania		5		1	6
Rhode Island		3			3
South Carolina		4			4
South Dakota					
Tennessee		5			5
Texas	2		1	4	7
Utah		1			1
Vermont					
Virginia		3			3
Washington		1			1
West Virginia					
Wisconsin		3			3
Wyoming			1		1
TOTAL	9	114	6	54	183

* Functional categories 4 (production at wells) and 5 (on-pipeline production for AFV fleets) are not shown above because, to the best of our knowledge, those functional categories have not yet been deployed anywhere in the U.S.

Based on the table above, one can predict that the U.S. will soon have some 200 LNG facilities, dispersed throughout most of the states. Another (optimistic) reading of the table suggests that the current absence of LNG production facilities on natural gas wells and on pipelines (serving local fleets) will not last. When those markets develop, with entries in columns 4 and 5, the total inventory of U.S. LNG facilities will increase. The projected rate of increase, in NYS during the first five years after the promulgation of Part 570 is discussed below.

All of the import terminals in the U.S. are currently located east of (or just slightly to the west of) the Mississippi River, and include the terminals at Everett, Massachusetts; Elba Island, Georgia; Cove Point, Maryland; Freeport, Texas; Cameron Parish, Louisiana; and Lake Charles, Louisiana. Other import terminals have been proposed for the Atlantic coast in Canada and the U.S and along the Pacific coast, for example in Oregon. Recent proposals for import terminals off the coasts of NYS and New Jersey have not advanced. Indeed, the entire economic framework behind LNG import terminals, especially new ones, is in question because the U.S. now has an abundance of proven natural gas reserves, causing the price of domestic natural gas to be lower than the price needed to justify imported LNG.

Most of the existing, large-scale U.S. LNG facilities are “mature” by industrial development standards, and represent natural gas production, storage and dispensing models that may be difficult to replicate.

(That point is discussed in more detail in the next section of this report.) Recently a new east coast LNG dispensing facility, known as Enviro-Express, has opened in Bridgeport Connecticut. That facility will receive LNG delivered by transport-trailers, with no on-site production.

Together, the large (and generally older) base load facilities and the newly deployed Bridgeport facility constitute all of the U.S. LNG facilities east of the Mississippi River. While LNG facilities can be found in almost every U.S. state, in most states, there are no LNG facilities that serve AFVs.

2C1. Historic Review of LNG Facilities in California

CA is the U.S. leader in LNG facilities, with approximately 41 such facilities operating in 2005/2006. All of those facilities were LNG (or L/CNG, where CNG is dispensed from stored LNG) dispensing sites, with no facility producing LNG in CA at that time. All were serving “return-to-base” (primarily on-site) fleets, and most of them were not providing “public access.” In other words, even in CA, with one of the largest networks of LNG dispensing sites and LNG vehicles, the concept of an “LNG corridor” that would allow LNG vehicles to travel an extended range, with various fueling opportunities along the way, was not yet in place in 2006 and is still not in place in 2011.

In the context of a more than 20-year history of LNG facility deployments, the 41 CA facilities would “average” approximately two new facilities per year. Obviously, the deployment of LNG facilities did not occur at an “even” rate annually. Still, the historic record indicates that with the most LNG facilities in the U.S., with multiple state and federal policies to induce AFVs, with no history of an LNG moratorium, and where natural gas prices are more competitive with diesel than on the east coast, CA has not had an exceptionally rapid rate of LNG facility deployments.

Section 2 of the “California Alternative Fuels Market Assessment 2006,” which can be found at <http://www.energy.ca.gov/2006publications/CEC-600-2006-015/CEC-600-2006-015-D.PDF>, states that CA had 26,700 registered natural gas vehicles (NGVs) in 2006. Those NGVs included approximately 21,269 light-duty vehicles that used CNG and approximately 5,401 heavy-duty vehicles, some (but not all) of which used LNG. Those 26,700 NGVs represented only 0.11% of all on-road vehicles in CA. The CNG vehicles had access to approximately 365 CNG stations statewide, of which 148 were public access stations. Thus, the 41 LNG or L/CNG stations represented approximately 10% of all the natural gas fueling facilities in CA.

Most importantly, until approximately 2008, all the LNG used in the state was “imported” from TX, AZ, Wyoming or Colorado, often traveling many hundreds of miles between the production source and the end-user. Despite the growing market for LNG as a vehicle fuel, it took more than 20 years for the first vehicle-grade LNG production plant to be built in CA.

Beyond the statistics for the CA NGV and CNG/LNG dispensing infrastructure, the report cited above offers its own list of barriers to AFV (and LNG facilities) growth, and examines why prior optimistic growth projections did not materialize. For example, with regard to LNG “barriers,” the following is worth noting:

“Many of the heavy-duty vehicle applications that are good candidates for LNG fueling are Class 8 trucks that require engines in the 400+ horsepower range, (which usually have displacements of 11 liters or more). As of mid-2006, there is a dearth of certified natural gas engines in this category (see Table 2-4). The Mack E7G engine is only available in Mack trucks. The Westport ISXG engine is just now transitioning from the demonstration phase to a commercial product. The lack of high-horsepower natural gas engine products has motivated government agencies such as SCAQMD to

co-fund development programs. If current efforts to develop new high horsepower natural gas engines to meet the 2007-2010 emission standards are not successful, the lack of high-horsepower natural gas engine choices will make it difficult to achieve significant growth in the important high fuel consuming goods movement market sector.”

Despite the above outlined barrier and several others, the report concludes on a positive note with regard to CA’s heavy-duty NGV segment, as follows:

“The heavy duty NGV marketplace is likely to remain active. Most of the natural gas fuel use in the state is in the heavy-duty sector (i.e., displaces diesel), and this is projected to remain the case. Many transit agencies in the state committed to the alternative fuel path, and are satisfying their commitment largely via the purchase and use of CNG buses. The number of agencies moving to this path will increase in the near future to satisfy the requirement that all agencies within SCAQMD embrace the alternative fuel path. School districts will continue to purchase CNG school buses with incentive funding from state and federal sources. Government agency-run shuttle bus fleets will remain under pressure to employ AFVs, and natural gas use in refuse trucks will continue to see increased NGV penetration. All of these are return to base fleets that are best suited for natural gas use.”

“Most of the NGV research and development work is being done as part of the DOE-funded Next Generation Natural Gas Vehicle (NGNGV) program managed by NREL. This R&D work is focused on developing heavy-duty NGV engines with the objective of meeting the 2007 through 2010 EPA and ARB [California Air Resources Board] heavy-duty vehicle emission standards. If successful, heavy duty NGVs will be able to economically compete with diesel fueled vehicles under a variety of potentially likely scenarios.”

A more recent report (dated 3/16/11), titled “Natural Gas Vehicles, Fueling Infrastructure, and Economics,” by Caley Johnson, Transportation Market Analyst at the National Renewable Energy Laboratory (NREL), can be found at the following web site:

www.eesi.org/natural-gas-transportation-fuel-prospects-and-challenges-16-mar-2011.

With regard to LNG vehicles (heavy-duty trucks and buses), the NREL report is mostly about the CA LNG network, because CA has almost all of the vehicle-grade LNG dispensing sites in the U.S.

Slide two of that presentation lists Fuel Prices, Vehicle Attributes and Infrastructure Costs as contributors to the cash flow and economic analysis of NGVs. Slide three illustrates that natural gas pricing is becoming more competitive with diesel and gasoline pricing and tends to be more predictable. (The pricing “delta” between natural gas and diesel is discussed more fully below.) Slide four illustrates a significant barrier to heavy-duty (LNG) vehicle deployment: the lack of equipment options. Slide five illustrates another barrier to the wide deployment of heavy-duty NGVs (LNG vehicles): the \$50,000 incremental extra cost of the vehicle. Slide six shows that CNG stations are widely distributed in the U.S. However, as mentioned above, slide seven shows that LNG dispensing stations are mostly limited to CA.

Slide eight shows another barrier to heavy-duty NGVs, the estimated \$4,500,000 cost of the fuel storage and dispensing infrastructure at a typically sized LNG dispensing facility. Slides eight and ten do not offer an “optimistic” outlook for LNG-fueled, heavy-duty NGVs. For CNG projects, if a 3-year payback is sought, as would be the case for a private sector fleet, the price of diesel fuel needs to be above **\$4.00/gallon**. However, because conventional LNG equipment (storage, dispensing and the vehicles) is more expensive than CNG equipment, and relying on NREL’s analysis, it is hard to see how private

sector LNG-fueled vehicles can be economically viable until diesel prices reach **\$5.00/gallon**, if such vehicle owners build and operate their own LNG fueling station(s) (thus absorbing the capital costs entirely on their own).

2C2. Historic Review of LNG Facilities in the U.S.

Of the approximately 167,000 U.S. service stations (i.e., vehicle fueling facilities open to the public), less than 900 (0.005%) are CNG stations, and less than 45 (0.0002%) are LNG stations. As far as XE knows, none of those 45 or so LNG stations produce LNG on-site. All of them receive LNG from large-scale, off-site production facilities. The figures offered here were found at http://www.afdc.energy.gov/afdc/fuels/stations_counts.html and in the above-cited NERL report. They reflect the culmination of 20-25 years of public-private initiatives to increase the number of NGV facilities in the U.S.

Those efforts have included federal and state tax incentives for AFVs, fuel storage and dispensing systems and for natural gas as a vehicle fuel. However, those incentives have undergone various levels of “uncertainty” as each policy comes up for renewal in Congress or at the state level. That uncertainty constrains the industry’s ability to plan for the deployment of equipment. More significantly, even if a specific deployment manages to be completed before the “hardware-related” tax credits come up for renewal, the uncertainty of fuel tax waivers remains a major barrier to NGV deployments by the private sector. Without the long-term certainty of federal and state tax waivers on natural gas as a vehicle fuel, the competitiveness of NG, relative to diesel, has not been assured. As discussed below, that barrier may soon fall.

2C3. Historic Review of CNG Facilities in New York

The historic deployment rate of CNG facilities in NYS can be looked at as an analog for future LNG facility deployments, because CNG and LNG facilities mostly have the same purpose, providing natural gas for AFVs. The 20-25-year effort to advance NGVs in NYS has resulted in approximately 123 CNG stations in the state. The location of those 123 CNG stations can be found on NYSEDA’s web pages dealing with its Alternative-Fuel Vehicle Program. According to the NYS Bureau of Weights and Measures, the total number of “gas stations” (as in public gasoline fueling facilities) in NYS is 7,281, of which 1,927 also sell diesel fuel. Thus, the 123 CNG stations equal 1.7% of the gasoline (and diesel) fuel dispensing facilities in the state. That percentage is significantly higher than the national average (noted above), but it is still a small portion of the fueling infrastructure, and an even smaller portion of the “retail” infrastructure.

Approximately 50% of those existing CNG stations serve NYS government fleets and almost all of the rest serve utility fleets and Metropolitan Transportation Authority (MTA) busses. Other candidate fleets, such as school buses, trash haulers, food distribution fleets and urban taxis are generally not customers of existing CNG stations. The deployments of non-government owned, retail CNG stations are extremely rare.

Moreover, the state’s several public utilities, which have the best access to the lowest possible cost pipeline-delivered natural gas, have not deemed CNG economic enough to convert their fleets to CNG. For example, Con Edison operates eight CNG stations. Those stations are substantially underutilized as evident by the average output of those stations, which is approximately 30% of their capacity. Con Edison’s sister company, Orange and Rockland, does not operate a single CNG station. Of the many hundreds of light-, medium- and heavy-duty vehicles operated by Con Edison, only 3% are CNG vehicles.

The following is a quote from a senior staff person at Clean Energy, relative to NGVs in utility fleets:

“The utility fleet market is a very difficult to penetrate. I used to work for Southern California Gas Company. We had the same issue with NGVs -- very low vehicle usage and fuel consumption per vehicle. At SoCalGas, our light-duty fleet vehicles (pickup trucks, vans, and passenger cars) drove an average of only 40 or so miles per day. That is only about 10,000 miles per year. Today, that might come out to 350 - 500 gallons per year per vehicle (for LD [light-duty] vehicles). If a utility installed their own fueling infrastructure (which they can do using ratepayer money) and they saved say \$2 per gallon today -- that amounts to fuel cost savings per vehicle of \$740 - \$1,000 per year per vehicle. Utilities normally hold onto their vehicles for 7 years. This means that the breakeven differential cost for NGVs is from \$5,180 to \$7,000. The differential cost for a new Honda Civic GX natural gas vehicle is about \$7,000. So the economic proposition is not obvious.”

With regard to medium-duty vehicles, Clean Energy offered the following:

“Utility fleets like Con Ed also have a significant number of medium duty utility trucks and boom trucks. These vehicles are generally Class 6 vehicles that operate on gasoline or diesel fuel. Years ago, there were no natural gas truck products to fit this market niche. Today, Navistar/International makes a natural gas version, which could be used in utility operations. But again, annual fuel consumption for these types of vehicles is fairly low because they generally drive to a work site, stay there all day, then return to their base. The differential cost of these vehicles is around \$25,000. So the problem remains regarding an economic value proposition to the utility.”

With regard to the requirements of the Energy Policy Act (EPACT), Clean Energy has the following perspective:

“In the mid-late 90s, California utilities had a major push on natural gas vehicles. PG&E and SoCalGas each had about 1,500 - 2,000 LD [light-duty] NGVs. This was in response to the 1992 EPACT legislation that required "fuel providers" to purchase a certain percentage of their vehicles as alternative fuel each year. California utilities bought more than they were required to under EPACT. Federal fleets were also supposed to comply with EPACT. The GAO found over the years that the federal government was the largest violator of EPACT policy. By the late 90s - utilities began using "EPACT credits" to avoid further purchases of NGVs. Today, because of the limited product available in the market - utility purchases of NGVs are only token amounts.”

It is not the absence of Part 570 that has limited the growth of CNG stations in NYS, but the economic and practical “realities” as outlined above. Accounting for the fact that many of the 123 CNG stations in NYS are operating at less than their rated capacity, the role of CNG stations in NYS remains small relative to diesel and gasoline fuel dispensing systems.

One significant historic barrier to CNG (and in the future, LNG) deployments in NYS is the price of pipeline-delivered NG. The following U.S. DOE web site shows that NG pricing in NYS is higher than in many other parts of the country: http://www.eia.doe.gov/dnav/ng/ng_pri_sum_dc_u_SMN_a.htm. For example, the 2009 “industrial” price of NG in Minnesota was \$5.66/thousand cubic feet, \$6.57 in CA, and only \$4.05 in TX. That same amount of NG, also in 2009, for a similar industrial customer in NY, cost \$9.52. The NYS price for pipeline-delivered NG is more than twice the price of the same product in TX. The development of the NG reserves in the Marcellus Shale, in NYS and PA, may help reduce the

regional price of NG. However, in order for that to happen, the hydraulic fracturing methods used in PA, and under strict review in NYS, will need to be confirmed as environmentally benign, or will need to be replaced with other cost-effective and environmentally acceptable methods.

Even if Part 570 would have been in place in NYS during the last ten years, and even accounting for AFV incentives advanced by NYSERDA, there is nothing especially compelling about the NYS market that would have caused more LNG facility deployments in NYS than were deployed during that period in neighboring states. Using the historic perspective, the absence of Part 570 does not explain the lack of LNG facilities in New York. In turn, the promulgation of Part 570 may not generate a significant number of new LNG facilities.

Using history as a guide, and the 123 CNG stations built in NYS over 25 years as a model, one can imagine as many as five LNG facility deployments per year, or 25 during the first five years, after the promulgation of Part 570. However, that “optimistic” projection will only occur if there is substantial progress in overcoming the barriers listed in the NREL report cited above and covered in more detail below. If those barriers are not removed or overcome, then NYS will, at best, see a slow growth in CNG station deployments and virtually no LNG facility deployments, even after the promulgation of Part 570.

2C4. Historic Barriers to LNG

The following is a list of barriers that individually or in combination have limited the deployment of LNG facilities throughout the U.S., especially for supporting AFV fleets. XE believes that each of the barriers listed can be overcome.

- a) **Capital Costs of LNG Plants:** In attempting to match the capital cost of LNG production facilities with a customer base, there is a tension between production scale and product demand. Larger facilities, say, with capacities of 50,000 GPD and more, achieve reasonable economies of scale, but require an existing customer base that is larger than is likely to exist (especially before the LNG plant is built). Very small facilities, say, at less than 5,000 GPD of production, cannot be built cost-effectively with the technologies that have historically been deployed. Slightly larger facilities, in the 5,000 to 20,000 GPD range, have also not been deployed in commercially viable configurations. On the positive side, XE believes that cost-effective LNG plants, located on pipelines/distribution lines or on gas wells, at production scales of 5,000 to 20,000 GPD will soon be available.
- b) **Capital Cost of LNG Vehicles:** The approximately \$50,000 extra cost of a heavy-duty LNG bus or truck is significant, and difficult to amortize over a reasonable period for vehicles that do not travel a large number of miles each day/week. (For long-haul trucks or return-to-base vehicles that accumulate high mileage each day/week, the economics are substantially more favorable.) The \$50,000 estimate is from the above-cited NREL report. In a report dated 3/16/11, by Daniel R. Cohn of the Massachusetts Institute of Technology, titled “Natural Gas for Transportation: Prospects for Security And Environmental Benefits” (available on the Environmental Energy Study Institute’s web site cited above on page 33), the incremental cost of heavy-duty LNG vehicles is \$70,000. The Director of Engineering at Distrigas of Massachusetts estimates the extra cost of heavy-duty LNG vehicles at \$90,000, compared to the diesel counterpart. The \$50,000 to \$90,000 “premium” for LNG trucks and buses is now partially offset by federal tax credits. Moreover, those extra costs are likely to be reduced with increased production volumes and with increased competition in the engine and fuel tank production segments. Also, if the “delta” between the energy-equivalent price of LNG and diesel grows, then the incremental cost of LNG vehicles can be more quickly amortized.

- c) **Engine Options:** LNG is most suitable as a fuel for heavy-duty trucks or buses, where CNG is not a viable option because of the weight of the CNG fuel tanks and/or the lack of travel range. The natural-gas-fired engine industry has been slow to respond to the need for high-horsepower engines, which are necessary for the heaviest long-haul trucks. However, several engine makers are now offering heavy-duty gas-fired engines. An example of progress on that front is found here: <http://www.ngvglobal.com/westport-to-develop-hd-natural-gas-technology-for-high-horsepower-applications-0228#more-13120>.

- d) **Fuel Prices:** As mentioned above, NG prices in NYS tend to be higher than in TX and CA. Still, there can be a gap between the local price of diesel and NG. In order to overcome some or all of the above constraints, the “delta” between diesel fuel and LNG with the equivalent energy content needs to be high enough to induce public and private fleets to substitute LNG for diesel. That barrier is now falling and is likely to mitigate the other historic barriers to LNG facility deployments. In the northeast, the abundance of “local” natural gas in the Marcellus Shale formations (in southern NYS and in PA), will likely lead to the sustained availability of relatively low-priced NG for decades. The economics of some gas wells (particularly proposed wells that are not near an existing pipeline) may favor LNG production over insertion into the pipeline.

The barriers listed in the NREL report and summarized above have contributed to the lack of LNG facility deployment throughout the U.S., and especially in the northeast, where construction costs and natural gas costs tend to be higher than in most other parts of the country. As discussed above, each of the barriers listed can be overcome, but not necessarily fast enough to induce the deployment of a large number of LNG facilities over the first five-year period following the promulgation of Part 570. Nonetheless, the story may be substantially different beyond that period, depending on public policy choices; the introduction of new L/CNG production/dispensing equipment and L/CNG engines; and pricing differentials between NG and diesel fuel.

The most promising and immediate “breakthrough” is likely to occur in the fuel-pricing delta. Most analysts predict that the current (relatively low) price of NG will be the norm for at least the remainder of this decade (and possibly beyond), while the price of diesel fuel and gasoline will likely rise and remain volatile. That set of predicted conditions is in contrast to many previous years, during which the price of natural gas, while lower than oil (and diesel) on an energy-equivalent basis, followed the up and down movements of oil prices. Most analysts predict a future with relatively flat prices for natural gas, but rising and volatile prices for oil and its diesel and gasoline derivatives, increasing the delta between the energy-equivalent price of LNG and diesel.

Slide three of the above-cited NREL presentation illustrates that trend, which began in 2009. An article in February 26, 2011’s *New York Times*, titled “Off The Charts: Two Directions for the Prices of Natural Gas and Oil,” by Floyd Norris, reviews that trend and illustrates it with graphs that show the recently increasing gap between the energy-equivalent price of oil and natural gas. The article is at <http://www.nytimes.com/2011/02/26/business/global/26charts.html?emc=eta1>.

The greater the delta between the energy-equivalent prices of CNG/LNG and diesel, the faster the payback on the incremental extra cost of the NGVs. Similarly, the substantially lower volatility of NG prices versus diesel and gasoline has major benefits for fuel consumers, particularly corporate and government fleets that need to adhere to budgets that are often planned as much as a year or more in advance of the actual dates of purchase/use.

Equally important is the availability of technically viable, “small-scale” LNG production systems, from NG delivered by pipelines or recovered from wells. Such small-scale LNG production systems (from a capacity of 5,000 to 20,000 GPD), which have not yet been commercialized in the U.S. or anywhere else, is essential to the growth of LNG facilities that are based on local demand for LNG (or interstate LNG station “corridors”) as compared to regional demand from “return-to-base”/on-site vehicles (which can be served by large, centralized LNG production plants). The commercialization of small-scale LNG plants requires more than just the “downsizing” of conventional technologies, because most large-scale LNG plants use designs that are not efficient at small scales, and which yield very high capital costs (relative to their GPD output) when built in “miniature.” The commercial breakthrough will come from designs specifically developed for the 5,000 to 20,000 GPD “niche,” which view such plants more like “appliances” rather than custom installations, and which purposefully achieve the highest possible LNG production rates with the lowest possible use of fuel to run each plant.

2D. Projections of LNG Facilities Using a Functional Perspective

LNG facilities can be characterized by three functions/activities—production, storage and dispensing—and by their scale, as measured by the amount of on-site storage. Every known LNG production facility (and every import or export terminal) includes some amount of on-site storage in order to buffer the daily production rate relative to the rate at which the LNG is used or distributed at the production facility or the rate at which it is transferred to LNG tankers for distribution to off-site customers.

Similarly, every LNG dispensing facility (such as at an AFV fleet) requires on-site LNG storage, which provides a buffer between the rate of LNG tanker deliveries (or the on-site LNG production rate) and the rate at which the LNG is dispensed to the AFVs. Thus, every LNG facility will include some amount of on-site LNG storage.

Task 2.1, including subtasks, required that XE project the number of LNG facilities likely to be deployed in NYS during the five year period after the promulgation of Part 570, and that those projections be broken down by the following four categories of **developers/end-users** of newly deployed LNG facilities:

- a) Small Business
- b) Local Government
- c) State Government
- d) Other

In order to complete Task 2.1, XE first needed to define LNG facilities by “functional type,” establishing the likely purposes/functions of newly deployed LNG facilities, and eliminating from further analysis those LNG functions that are not likely to generate any deployments in the five years following promulgation of Part 570. The following is a list of LNG facilities by **function**, arranged by scale of their likely storage capacity, from largest to smallest:

1. Import / Export Terminals
2. Peak-Shaving Plants
3. Regional Production Facilities
4. Production Facilities at Stranded Gas Wells or at Oil Wells with Associated Gas
5. On-Pipeline Production at AFV Fleets
6. Dispensing Facilities with No On-Site Production

Items 1-5 need no further clarification. Item 6 includes storage and dispensing facilities at AFV fleets or at fueling depots that do not produce LNG. Item 6 also includes “portable pipelines” which operate as

follows: LNG from a production or import source is delivered by tractor-trailer to an NG pipeline location; the trailer (say, with a capacity of 10,000 gallons) is disconnected from the tractor, allowing the tractor to leave the site; the contents of the trailer are pumped to pressure with a cryogenic liquid pump and inserted at a steady rate or as needed into an existing NG pipeline; when the trailer is empty, it is removed by a tractor which delivers the replacement LNG trailer. The functions of such LNG delivery and re-vaporization arrangements include: maintaining NG pressure at the remote end of existing pipelines; enhancing the delivery of product to existing and new customers, without requiring near-term pipeline upgrades; and the ability to bypass sections of pipeline that are under repair. As such, the portable pipeline would constitute a “temporary” deployment, without on-site LNG production. The total on-site storage of LNG would be limited (likely to no more than 10,000 G), with LNG delivered periodically to the temporary deployment location.

Some other LNG “functions” are not specifically listed above. For example, there is at least one industrial customer in Massachusetts that receives LNG for on-site storage and dispensing to a “burner tip” as a hedge against the price of pipeline-delivered NG. That LNG-use fits item 6 above, because the LNG is delivered by tractor-trailer, for on-site dispensing, without any on-site production. That model is extremely rare because pipeline NG is generally less costly than imported LNG or LNG produced domestically. However, it is possible that such a model can, in the future, compete with propane (LPG) as an off-pipeline industrial fuel.

A village in a western state also fits functional category 6. It has a local natural gas pipeline network that is supplied entirely by LNG delivered by transport trailers to a storage tank, from which it is vaporized for distribution in the local pipeline. The local pipeline network has no connections to a regional NG pipeline. Such an off-pipeline natural gas grid is extremely rare worldwide, and requires very special economic and political parameters to be viable.

The discussions that follow will examine each of the six functional LNG facility types identified above, relative to their function and as to the likelihood of their deployment in NYS within five years of the promulgation of Part 570. For each functional type that is likely to be deployed, a selection (underlined) is made in the section heading as to which one or more of the developer/user categories might pursue that type of deployment. The “discussion” portion of each category explains the logic of the findings.

2D1. Import / Export Terminals

Storage Capacity: 1,000,000 gallons or more

Projected NYS Deployments: None

Discussion:

Import (and export) terminals come under the jurisdiction of the FERC and not within the scope of Part 570. (See section 1B above for a link to FERC.) Still, if such a facility were built in NYS, it may become a source for locally distributed LNG, transported from such a facility to end users in LNG trailers.

The development of LNG import terminals in the U.S. will likely come to a halt in the coming years because recent advances in domestic natural gas (NG) production have created an abundance of NG and have caused the price of NG to fall. Importing of LNG, for any purpose, has become less economically viable, especially for any newly proposed import terminal that would need to compete with existing import terminals that have been amortized over time.

Several of the existing import terminals and some under construction or in development have announced plans to convert to export facilities. In that context there is no reasonable likelihood that any import or

export terminal will be proposed in or adjacent to the waters off NYS during the five years after the promulgation of Part 570. However, even if such a facility were proposed, the time required to advance that proposal to deployment and operation would be well in excess of five years.

2D2. Peak-Shaving Plants

Storage Capacity: 500,000 gallons or more

Projected NYS Deployments: None

Discussion:

Peak-shaving plants are facilities that serve local NG distribution networks by producing and storing LNG during the off-peak periods of each year, for re-vaporization into the NG network during the peak (generally winter) season. (Their scale, if deployed, would require them to comply with the criteria in the draft rules for facilities that “store 70,000 gallons or more of LNG.”) Examples of peak-shaving plants in NYS include existing facilities in Greenpoint, Brooklyn; Astoria, Queens; and Holtsville, Long Island, all three of which are “non-conforming facilities” as defined by the draft rules. Other examples include a facility in Philadelphia, PA and one in Baltimore, MD. Each of those facilities were built dozens of years ago, prior to the restructuring of the regulatory framework in which NG distribution and local delivery companies operate in, and prior to the recently increased abundance of domestic NG and the fall in NG prices. Within the current and near future regulatory and market contexts, there is no reasonable likelihood of a peak-shaving plant proposal for any locality in NYS.

2D3. Regional Production Facilities

Storage Capacity: 300,000 gallons or more

Projected NYS Deployments: None

Discussion:

Regional LNG production facilities can be found in TX, AZ, Wyoming, Colorado and CA. Their main function is to produce LNG from pipeline NG for tanker-truck delivery to customers, which in those states are almost exclusively LNG and L/CNG fleets. (L/CNG is compressed natural gas dispensed from stored LNG by the pumping of the LNG to pressure and the warming/vaporizing of the high-pressure liquid.)

Until recently, this LNG market segment was served by LNG plants in Topak, AZ; Willis, TX; and several facilities in Wyoming and Colorado that produce LNG as a byproduct of propane and other gas processing. The capacity of those production sources generally matched the slow growth in demand from AFVs.

Clean Energy’s Boron, CA LNG plant, with an on-site storage capacity of approximately 1,800,000 gallons, started production in 2008, and is the only example of a newly constructed regional LNG production facility deployed anywhere in the U.S. over the last ten years. (For more information, see <http://www.cleanenergyfuels.com/pdf/CE-OS.Boron.pdf>.) At a production rate of approximately 160,000 GPD (with the ability to increase production to 240,000 GPD), the Boron plant is likely attracting a combination of new LNG customers and existing customers that were relying on production from Topak, Willis, and the facilities in Wyoming and Colorado. The proximity of the Boron plant to the CA AFV market allows it to displace product from more distant sources.

That regional production model requires an existing (or soon to exist) market for the entire output of the plant; otherwise such a regional LNG plant cannot be financed. For example, Clean Energy’s Boron LNG plant required an approximate investment of \$75,000,000. At the same time, the group of LNG customers that would support the construction of a regional facility cannot be expected to deploy storage and dispensing equipment without the certainty of the long-term availability of LNG at a predictable

price. In other words, the replication on the east coast of the west coast regional LNG production and distribution model may take as many years as it took for the west coast model to evolve.

Note that during the last 15-20 years of AFV deployments in CA, which has more LNG vehicles in service than any other state in the U.S. or any country in the world, only since 2008 has LNG been produced in CA. Prior to that, LNG was trucked to CA from distant production facilities. Also note that the regional LNG production and distribution model prevalent in CA, AZ, TX, and more recently in Utah and Nevada, is based on centralized, larger-scale production facilities, rather than smaller-scale production at the individual customers' facility.

The Clean Energy presentation at the following web address offers one regional LNG production and distribution model, which builds on local public policies and other factors that support that model: [http://www.southeastdiesel.org/Presentations for 3rd Annual Meeting/Day 2/Clean Energy- Shaunt Hartounian.pdf](http://www.southeastdiesel.org/Presentations%20for%203rd%20Annual%20Meeting/Day%202/Clean%20Energy-%20Shaunt%20Hartounian.pdf).

Given the critical mass of end-users required to support a single regional LNG production plant, the cost of such a facility, and the lack of effective, long-term, public policies in NYS and nearby to induce the use of LNG in lieu of diesel, there is no reasonable likelihood that any regional LNG production facility will be proposed in NYS during the five years after the promulgation of Part 570. However, if such a facility were contemplated, the time required to advance that proposal to deployment and operation will likely be in excess of five years because of the need to establish the comprehensive sales/purchase agreements needed to justify such a deployment.

2D4. Production at Gas and/or Oil Wells
Storage Capacity: 15,000 gallons or more
Projected NYS Deployments: One to three
Developer/User Category: Small Business
Discussion:

NYS and nearby Pennsylvania contain underground NG assets that, if near existing NG pipelines, contribute to the domestic production of NG. Alternatively, if the value of LNG were significantly higher than the value of the NG at the pipeline insertion point, the owner of the NG asset might consider developing an LNG production and distribution program. The economics of that model would be based on the fact that the higher value LNG will yield enough revenue in, say, three years to pay for the LNG facility and the supporting distribution network. That model will likely be based on a 15-year amortization period, with some portion of the capital investment coming from outside financing sources at prevailing interest rates.

When underground NG reserves are not close enough to an existing pipeline, or where the NG is not pipeline quality (requiring significant pre-treatment to remove, for example, excess CO₂ or N₂), those reserves can be characterized as "stranded." With no opportunity to sell its NG into an adjacent pipeline, the owner of such stranded reserves and/or well(s) can explore the marketing of the NG as LNG if a forward-looking economic analysis indicates that the business model is viable when the price allocated to the well gas is sufficiently above the cost of developing the well.

For example, if the current value of NG sold into the pipeline is approximately \$4/million BTU (MMBTU) and the development costs for the well are \$2/MMBTU of production, then a stranded well owner might be willing to assign a discounted price of \$3/MMBTU to the NG used in a hypothetical LNG plant, the output of which would be distributed for sale outside the pipeline. That model needs to

pass the same tests as the LNG production model for an on-pipeline facility. Namely, the capital investment needs to yield, say, a three-year return, but based on a lower value for the feed gas.

Economic analyses by XE of the above scenarios suggests that if the cost/value of the feed gas to a small-scale LNG plant is \$4/MMBTU and the price of diesel fuel is above \$3.50/gallon, then LNG sold at \$1.25/gallon might be competitive with diesel on an “energy content” basis, where 1.7 gallons of LNG will move a vehicle as far as 1 gallon of diesel fuel. In order to keep the analysis more manageable, those diesel and LNG prices ignore taxes.

However, in order to achieve a viable LNG production and distribution model, the following approximate conditions must also be attained:

- The minimum capacity of such a plant needs to be at least 5,000 GPD, in order to achieve some degree of “economies of scale;”
- The capital costs for the 5,000 GPD plant, its storage tanks, the truck to distribute the LNG, and the storage and dispensing equipment at the customers’ sites needs to cost no more than approximately \$3,000,000; and
- The maximum number of customers served by that LNG plant should be no more than one or two, in order to avoid excessive distribution and dispensing equipment costs.

Those conditions will be difficult to achieve. The \$3,000,000 capital cost limit is an especially daunting constraint.

A model with a larger LNG plant, say, with a capacity of 10,000 GPD will more easily achieve economies of scale, and the comprehensive cost of the plant and all of the other hardware will cost significantly less than twice the \$3,000,000, perhaps as little as \$4,500,000. However, doubling the required customer base makes the model more difficult (though still feasible) to implement.

For example, if a trash hauler uses 50 gallons of diesel per day, and was replaced by an LNG-fueled truck consuming 85 gallons of LNG per day, then the 10,000 GPD LNG plant would need a customer base of 118 trucks. Also, the doubling of the plant’s size requires twice as much feed gas flow from the well (or group of wells) to the LNG plant. That constraint further limits the number of such networks that might be deployed.

Variations on the gas well LNG production model include production of LNG at landfill gas sites and at other biogas sources, such as sewage treatment plants. A significant technical and economic constraint on such non-standard methane sources is the complexity and cost of the front-end clean up process. Such non-standard methane sources often have a CO₂ content of 50 percent or more, extensive amounts of water and a variety of other volatile organic compounds (VOCs), all of which need to be removed before the methane can be compressed and cooled to produce LNG. As of this writing, XE is aware of only one operating landfill-gas-to-LNG plant in the U.S., located on a large landfill in CA. The technical and economic challenges of such LNG facilities and the need for large flow rates of feed gas (because only about half of the gas is methane) will severely limit the rate of deployments for such facilities. In the context of NYS, the likelihood of such an LNG facility being deployed in the five years after promulgation of Part 570 is very remote.

Based on the need to match the output capacity of an LNG plant on a gas well (stranded or not); the need to locate the plant on a gas field with enough long-term reserves; and the need for a customer base that uses the entire annual output (at a reasonable capacity utilization rate) of the LNG plant, one can

project the deployment of up to **three** such LNG production facilities at gas wells in NYS during the five years after the promulgation of Part 570.

The LNG production plant, and the ancillary LNG transport equipment, would likely be developed/operated by a Small Business. The customer base for the LNG can include any of the other three categories of developers/users, but which fit under functional category 6 below.

2D5. On-Pipeline Production at AFV Fleets

Storage Capacity: 10,000 gallons or more

Projected NYS Deployments: Two to four

Developer/User Category: Small Business and State Government

Discussion:

NYS has an extensive underground NG pipeline network that serves large portions of the state, including most of those parts of the states that host industrial, commercial and population centers. By contrast, the portions of the state that have limited or no access to NG pipelines are rural. (The following counties in NYS have little or no NG pipeline service: Franklin, Essex, Herkimer, Hamilton, Warren, Delaware, and Sullivan.)

From a technology perspective, all locations that are served by an NG pipeline are candidates for on-pipeline production facilities. The simplest model would have an on-pipeline LNG production facility serving a single AFV fleet at the same location, avoiding the need to transport the LNG from the production facility to the customer. Production, storage, and dispensing would occur at each deployment location. However, that “single customer” approach needs to achieve a balance between a viably scaled production plant and the likely limit on the total number of AFVs (and the total daily LNG demand) at that site.

It should be noted that there are no existing, commercially viable, LNG production facilities deployed anywhere in the world that produce less than 20,000 GPD of LNG. Still, with upcoming technology advances, one can optimistically assume that an LNG production system with a capacity as low as 5,000 GPD will soon be available commercially.

A 5,000 GPD production facility would need to serve 50 AFVs at the same site if each vehicle used 100 gallons of LNG per day, or the equivalent of 59 gallons of diesel. That model can be economically viable if the 5,000 GPD plant with two days of on-site storage (and dispensing equipment) can be deployed at a turnkey cost of \$3,000,000 or less; if the delivered price of the pipeline NG is \$9.50 or less (accounting for commodity and pipeline transport costs); and if the local price of diesel fuel that the LNG will compete with is at least \$3.75/gallon. If those technical and economic conditions can be achieved, such a facility will yield an approximately 3-year payback period on the capital investment for the production, storage and dispensing equipment, accounting for the incremental extra cost of the NGVs when compared to diesel versions of the same vehicles.

As mentioned above, the smallest “commercially viable” LNG plant in the U.S. is the 20,000 GPD peak-shaving plant in Delaware. (In reality, the commercial viability of that plant was achieved during an era when peak-shaving plants were built and operated under an entirely different set of business models, where the ratepayers of a local NG distribution entity would fund the peak-shaving plant as a portion of their monthly NG bills.) XE knows of no recently constructed, commercially viable LNG plant other than Clean Energy’s Boron, CA plant, which was discussed above. That plant, costing \$75,000,000, produces 160,000 GPD. XE is not aware of any commercially viable LNG facility that operates in the 5,000 to 20,000 GPD range.

In a March 4th telephone interview with a senior staff person at Coca Cola, the model discussed here, where small-scale, on-site LNG production supplies a centrally fueled fleet, was deemed “plausible.” However, Coca Cola has not yet had enough experience with LNG-fueled trucks to feel comfortable with the performance of LNG vehicles. Moreover, according to Coca Cola, the decision to explore such an on-site fueling option for a local Coca Cola distribution fleet will primarily hinge on the anticipated return on the investment in vehicles, on-site LNG production equipment, storage and dispensing equipment, and such intangibles as “good will.” Coca Cola also mentioned that such an on-site LNG production and dispensing model would need to compete against other options, such as hybrid diesel-electric trucks.

An optimistic view of near-term technical advances in the LNG production industry can foresee the possibility of new production systems that will be commercially viable at only 5,000 GPD of LNG production. If so, a conservative projection for the first five years after the promulgation of Part 570 would envision two facilities serving private sector fleets, and two facilities serving state government fleets (such as the heavy-duty AFVs operated by NYS DOT), for a total of **four** on-pipeline, small-scale LNG facilities.

2D6. Dispensing to AFV Fleets, With No On-Site Production

Storage Capacity: 5,000 gallons or more

Projected NYS Deployments: Five to fourteen

Developer/User Category: Small Business, Local Government, State Government, Other

Discussion:

The most prevalent LNG production and distribution model, used in CA, AZ and TX, relies on regional production facilities that send their product by LNG tractor-trailer to local sites that store and dispense LNG and L/CNG to AFVs. As discussed above, that model is not likely to be replicated in NYS within the first five years after promulgation of Part 570.

Instead, LNG produced at gas wells and/or at modestly sized, on-pipeline LNG plants serving on-site AFV fleets, may send LNG to facilities that do not have on-site production plants. The most likely version of that model was discussed in item 4 above, where an LNG plant on a gas field would serve several off-site LNG fleets.

A variation of that would have an on-pipeline LNG plant, such as the model discussed in item 5 above, and send some of its output to an off-site location. For example, a single LNG production plant operated by NYS DOT at one of its on-pipeline depots, would serve the heavy-duty fleet based at that location, as well as one or more off-site DOT fleets. Those off-site vehicles may be located at “off-pipeline” sites (e.g., in the Adirondacks), thus allowing DOT to increase its use of AFVs even if those vehicles operate beyond the NG pipeline network. Those off-pipeline fleets may be CNG-fueled light-duty vehicles, or LNG-fueled heavy-duty vehicles.

Because this functional category—dispensing of LNG to AFV fleets without on-site production—is dependent on off-site production facilities, the projections for such deployments depend on the projections for well-based and on-pipeline LNG production facilities, as discussed in sections 4 and 5 above. If up to three well-based production facilities are assumed, then XE projects **six to eight** dispensing sites that are customers of those three production sites. If four on-pipeline production facilities that serve fleets at the same location are projected, then XE assumes that several of those facilities can send LNG to, say, up to **four** off-site (and off-pipeline) customer locations.

Adding the possible deployment of, say, **two** portable pipeline arrays would increase the projections for this category to up to **14** LNG dispensing sites in the state within the first five years after the promulgation of Part 570. Those 14 sites would receive, store and dispense product, but would not produce any LNG. Each of those 14 facilities would likely have an on-site storage capacity of 5,000 to 10,000 gallons, and would receive product less frequently than a daily basis, say, once or twice per week.

2E. Summary of Projections for LNG Facilities in NYS

Using the “historical perspective” as a projection methodology, and an optimistic assumption that NG pricing and technology advances will favor the AFV industry, XE projects that the promulgation of Part 570 will cause new LNG facilities to be deployed in NYS. Those deployments will first occur outside of NYC, where the existing moratorium on LNG may stay in place for some period after the promulgation of Part 570. The following summarizes our projections:

- Using the “expert interview” methodology, we can foresee up to **20 LNG facilities** during the first five years after the promulgation of Part 570.
- Using the CA example as projection methodology, where approximately 40 LNG facilities were deployed over an approximately 20-year period, XE expects two deployments per year in NYS, for a total of **10 facilities** during the first five years after the promulgation of Part 570.
- Using the historic deployment rate of CNG facilities in NYS and the LNG facility deployment rate in neighboring states as a projection methodology, up to five new LNG facilities per year might be projected for a total of **25 new LNG facilities** during the five-year period after Part 570 is promulgated.
- Using the “functional analysis” projection methodology, which is less concerned with the history of LNG facility deployments, and focuses on how the technical and business aspects of LNG production, storage, transport and dispensing can respond to an evolving market, XE projects up to **21 new LNG facilities** in NYS during the first five years after the promulgation of Part 570. The two driving forces of that new market will likely be the delta between the price of diesel fuel and the energy equivalent price of LNG, and the availability of cost-effective, small-scale LNG production systems.

XE’s projections, by various methods, range from a low of **10** new LNG facilities to a high of **25** new facilities. For purposes of further analysis, the **21** facility projection arrived at by the functional analysis were selected. It is not expected that NYS will catch up to CA (which would require deploying more than 40 LNG facilities) in the brief five-year period following the promulgation of Part 570.

The draft rules for the promulgation of Part 570 include provisions for “minor facility(s),” which are defined as having an on-site storage capacity of “less than 1,100 gallons of LNG.” XE knows of no such micro-scale LNG deployments and do not foresee any such deployments during the first five years after Part 570 is promulgated.

Table 3 below allocates the 21 projected LNG facilities into the six functional types discussed above and into the four Developer/User Categories called for by the contract for this study. Category “d” is not likely to include rural users, because rural customers will not likely provide an adequate customer base for the few and relatively small LNG production facilities that are projected. Also, the “commercial”

deployment of LNG facilities will likely fit with the SAPA section 102(8) definition that includes entities with up to 100 employees, rather than with the “other” category.

Of the projected 21 facilities, approximately seven will produce LNG, with the remainder only hosting modest amounts of storage to support LNG (or L/CNG) dispensing to AFVs. XE assumes that the 21 facilities will be dispersed throughout the state, but outside of NYC during the initial years when the existing NYC moratorium on LNG facility deployments may still be in place.

An evenly dispersed group of LNG facilities will not likely yield multiple facilities in any single jurisdiction. Thus, most LNG facilities deployed during the first five years after the promulgation of Part 570 will be “new” to the jurisdiction in which they seek a permit and likely to be the “only” facility in any given first responder jurisdiction for some period of time. The initial training of first responders and the annual retraining requirement will likely be the responsibility of a single LNG facility in each jurisdiction. That burden is more fully discussed below. For the purposes of this projection, XE has ignored that burden and assumed that the cost associated with permitting, initial training, and annual retraining, will not dissuade prospective LNG facilities from seeking permits for deployment.

Table 3: Projected LNG Facilities in NYS by Function and Use

Functional Categories	Developer/User Categories				Totals
	a)	b)	c)	d)	
1) Import/Export Terminals	0	0	0	0	0
2) Peak-Shaving Plants	0	0	0	0	0
3) Regional Production	0	0	0	0	0
4) Production at NG Wells	3	0	0	0	3
5) On-Pipeline Production	2	0	2	0	4
6) Dispensing Without Production	6	2	4	2	14
Totals	11	2	6	2	21

Key:

- a) Small Business
- b) Local Government
- c) State Government
- d) Other

Approximately five to seven LNG delivery tankers would link the production facilities to the approximately 14 dispensing-only sites. In other words, the intrastate transport of LNG will not likely constitute a significant increase in the vehicle-miles traveled in the state by “hazardous cargo” vehicles.

2F. Jobs Projections

The promulgation of Part 570 and the deployment of 21 new LNG facilities will not likely cause any workers to lose their jobs. Per the table above, XE does not project any deployments in functional categories 1-3. Each of the a-d developer/user categories will likely be found in the three functional categories (4-6) that will likely be deployed.

User category “a” will likely see the most deployments (11) and the most diverse range of jobs. The other user categories will share the remaining (10) projected deployments. The following are job estimates (with supporting rationale) for each of the applicable functional categories and the users within those functional categories.

Category 4: Production at NG Wells

Small-scale LNG plants, if they are to be cost-effective, require automated operation, including remote monitoring. As such, they require no more than one person on a single daily shift for smooth operation. In some instances, the existing staff that operates/monitors the well(s) and its existing production system (for natural gas and for hydrocarbon liquids recovered from NG), will add the relatively modest tasks of monitoring the LNG plant to their work program, without creating any new jobs. However, to be conservative, XE assumes at least one new job will be created for each new LNG plant deployed on a gas well. Training of staff will likely occur as part of the installation of the plant by the entity that installs and starts-up the plant, and provides equipment warranties. Such training functions will be temporary and will not require the creation of new jobs at the entities that build/deploy LNG facilities.

Off-site monitoring of the LNG plants will be provided by existing entities, without creating additional jobs. Projecting three such well-based facilities, this category will yield **three new technical jobs**, all of which are within user category “a.” In addition, the entity that owns and operates the gas well and the LNG plant will likely create new jobs related to the “administration” (sales, safety compliance, accounting, etc.) activities that are needed to support and grow those efforts. XE foresees up to two such administrative positions at each of the three projected facilities, for a total of **six new administrative positions**. Adding the three technical jobs to the six administrative jobs, this category might yield as many as **nine new jobs**, all in user category “a,” during the first five years after the promulgation of Part 570.

The transport of the LNG product, in LNG trailers, will be accomplished by existing transport companies (some based outside of NYS), which will be able to provide that service without the creation of new jobs.

Category 5: On-Pipeline Production

On-pipeline LNG production, where the gas flow rates, pressures and chemical composition is steadily predictable, will require fewer staff than well-based LNG plants. For example, each on-pipeline production facility will mostly supply a fleet at that location, requiring no marketing efforts. Chart Industries projects that any small-scale LNG plants it might deploy would be automated, and require only an “on call” maintenance person, that would cover up to seven such facilities in a territory. Expansion Energy’s experience with small-scale LNG plant designs confirms Chart’s projection, where one person (on one shift) would be assigned to monitor several LNG production facilities. Therefore, XE projects up to one new job at each such on-pipeline production facility for a total of **four new jobs**, if each facility has a separate owner. Two of those jobs will be in the private sector, fitting under category “a,” and two will be in the public sector, under category “c,” for example NYS DOT.

Category 6: Dispensing Without Production

During the first five years after the promulgation of Part 570, and possibly for some years after that, LNG dispensing will occur entirely at the “fleet level,” rather than on a “retail” level. Thus, each dispensing site will be operated and managed by the existing staff that services the fleet at that site. Thus, no new “fuel dispensing” jobs will be created. However, the entity responsible for the optimal functioning of the storage and dispensing equipment (and possibly the long-term purchase agreements for the LNG), will allocate one staff person to up to seven such dispensing facilities within a “region.” (That figure is from Clean Energy.) Thus, depending on how widespread the projected 14 dispensing sites are in the state, XE foresees **two to four such regional representatives and/or “on call” people** that will periodically visit each dispensing site. Those new jobs will be entirely in user category “a.”

2G. Summary of Projected New Jobs by User Category

Per the above, XE projects **up to 15** new jobs in user category “a” and **two** new jobs in user category “c” for a total of **17** new jobs created by the projected deployment of **21** LNG facilities in NYS during the first five years after the promulgation of Part 570. (Even though the facility projection table above shows two projected deployments under category “d”, those will not create any new jobs.) For the sake of simplicity, XE assumes that any entity that now fuels its own fleets, and elects to add on-site LNG dispensing, will not create new jobs. The existing workload of the staff that now fuels that fleet with, for example, diesel fuel, will shift to LNG fueling. Thus, in the above analysis and the summary table below, we did not account for “fractions” of jobs that might be created as a result of newly deployed LNG facilities.

The table that follows summarizes the job projections by LNG functional types along the left side of the table, per user categories a-d.

Table 4: Projected LNG Facility Jobs in NYS by Function and Use

Functional Categories	Developer/User Categories				Totals
	a)	b)	c)	d)	
1) Import/Export Terminal	0	0	0	0	0
2) Peak-Shaving Plant	0	0	0	0	0
3) Regional Production	0	0	0	0	0
4) Production at NG Well					
Monitoring of Equipment	3				3
Administration	6				6
5) On-Pipeline Production					
Monitoring	2		2		4
6) Dispensing Without Production					
Regional Rep.	4				4
Totals	15	0	2	0	17

Key:

- a) Small Business
- b) Local Government
- c) State Government
- d) Other

Under a most optimistic scenario, if the above 17 new jobs (1.2 per projected LNG facility), is doubled to 2.4 new jobs per facility, and the total number of projected facilities are increased from 21 to 25, then the promulgation of Part 570 might yield as many as **60** new jobs during the first five years after promulgation.

Beyond those “direct” jobs (and outside the scope of this study), the new LNG facilities will create temporary construction jobs related to the installation of the equipment, temporary manufacturing and engineering jobs related to the design and manufacture of specific components (some of which will occur in NYS) as well as other temporary jobs related to the administration of contracts associated with the design, construction, installation and permitting of the new facilities.

In addition, “upstream” gas development/production will likely be increased/enhanced by the new markets created by the newly deployed LNG facilities. Those new jobs (also beyond the scope of this study) may last longer than the temporary jobs outlined in the paragraph above.

2H. Cost Projections

This section of the report focuses on the costs associated with complying with the provisions of Part 570. Table 5 summarizes those costs and is followed by the analysis and assumptions behind Table 5.

Table 5: Costs to LNG Facilities, Related to Part 570

Initial Deployment Costs	
Initial DEC Permit Fee	\$500
SEQRA and Permit Processing Cost	\$10,000
Training of Local First Responders	
Cost Per Attendee at Seminar	\$5,000
Number of Attendees	5
Total Cost of First Responder Training	\$25,000
Total Initial Deployment Cost	\$35,500
Annual Permit Renewal Costs	
DEC Permit Renewal Fee	\$500
Refresher Training of First Responders	
Cost Per Attendee at Seminar	\$3,000
Number of Attendees	5
Total Cost of First Responder Training	\$15,000
Total Renewal Cost	\$15,500

Initial Permit Costs: Draft 6 NYCRR Part 570 calls for a \$500 fee for facilities with 10,000 gallons or less of on-site LNG storage and \$1,000 for facilities with more than 10,000 gallons of LNG storage, but less than 70,000 gallons. Per the discussion above, all LNG facilities projected to be deployed during the first five years after the promulgation of Part 570 will fit within those two size ranges, with most fitting within the 10,000-gallon-and-less category. Thus Table 5 assumes that the typical LNG facility will have an “Initial DEC Permit Fee” and an “Annual Renewal Fee” of \$500.

The State Environmental Quality Review Act (SEQRA) process application fees and the fees to local code enforcement entities (municipal building departments) are not considered additional costs related to Part 570 because SEQRA and local permit procedures would apply under any development review protocols (even in the absence of Part 570), and such “routine” permitting and processing costs are generally included in the capital cost budget of each LNG facility to be deployed.

However, Part 570 will likely create an incremental extra cost burden on the LNG facility by the nature of the technical review of the SEQRA application and the applications for local permits. In other words, each LNG facility will need to navigate SEQRA (presumably with DEC as the “lead agency”) and through local application reviews, where the DEC and the local reviewing staff may not have an extensive record of having reviewed similar applications in the past. To facilitate the review process and respond to the reviewing staff’s request for clarifying information, each LNG facility applicant will need to have a specialized consultant on the applicant’s team. The incremental extra cost of that consultant’s work, and the cost of the “learning curve” involved for all participants is estimated at \$10,000 per typically proposed LNG facility with 10,000 gallons (or less) of on-site LNG storage. That estimate is limited to a “short form” Environmental Assessment, which will be the likely SEQRA “scope” for most small-scale LNG deployment proposals.

If the SEQRA process consists of a more complex and protracted Environmental Impact Statement (EIS), requiring detailed reports on specific topics (such as traffic, historic, or archaeological resources), and requiring public hearings, the cost of complying with SEQRA can be well in excess of \$100,000.

XE does not foresee that the typical proposal for LNG facilities will require long-form Environmental Impact Statements.

Training Costs: Each of the LNG facilities that are likely to be deployed during the first five years after the promulgation of Part 570 will generate very few new jobs, and thus require training of only a few staff people. As standard practice, each deployment will likely include an “owner’s manual,” an automatic and manual start up and shut down regime, and the training of operating/maintenance staff, all which would typically be provided by the entity that installs the equipment. It is likely that some deployments will come with service contracts that provide for maintenance by the installing entity, whose staff is already trained.

The costs associated with each deployment’s initial start up are normally accounted for within the total development costs of each facility. Thus, the promulgation of Part 570 will not result in extra costs associated with the training of the owner/operator(s) and staff of such facilities.

The training of first responders is generally the responsibility of local emergency response entities, such as the local fire department. Those training costs typically include the cost of one-day seminars for each attendee, within a range of \$2,000 to \$5,000 per attendee from each jurisdiction. However, the draft rules for the promulgation of Part 570 call for each applicant for a permit to “offer an emergency response training program” for first responders, prior to operating the LNG facility and annually after start up. It is likely that local first responder entities will accept the “offer,” passing the cost of the first training program and subsequent annual training events to the applicant for a permit.

To be conservative, Table 5 assumes that the initial training cost, per attendee, will be \$5,000, and that each jurisdiction will send an average of 5 attendees to the seminars, for a total initial “training cost” to the applicant of approximately \$25,000. Thus the total costs to the typical LNG facility applicant, attributable to Part 570, will be approximately **\$35,500** as shown on Table 5. That expenditure is not a large percentage of the deployment cost of each typical facility.

For larger (atypical) LNG facility deployments, those costs will increase substantially, especially because an EIS will likely be required. However in the context of the capital costs for larger LNG facilities, even if the Part 570 related costs increase ten-fold, those initial costs will be a small fraction of the total capital cost of such large facilities, and will not be a deterrent to their deployment.

Compliance Maintenance Costs: The typical productive use of an LNG facility, without any significant overhaul or upgrading, is fifteen years. With upgrades and replacement of rotating equipment and other components, a facility may function properly for many decades. During that period, routine inspection and maintenance of moving parts, such as pumps at dispensing facilities and prime movers, compressors and expanders at production facilities, will occur annually. Storage vessels, valves, gauges and piping will also undergo frequent visual inspection. All such inspections are routinely included in the annual maintenance program for any gas processing facility, including LNG facilities, and should not be considered an extra cost that stems from Part 570.

The minimum requirements for administration and enforcement of the Uniform Fire Prevention and Building Code for local municipalities is found in the New York State Codes, Rules and Regulations Title 19, Part 1203. Provided there is no area of public assembly, Part 1203 requires a minimum inspection of once every 3 years. A local jurisdiction may require inspections more frequently within their local law or ordinance, which they have adopted in order to comply with Part 1203, and especially

if the local ordinance includes provisions for the testing / certification of equipment and hazardous fluids storage vessels.

Each facility will likely be required to obtain a local operating permit, which may be issued annually, (or bi-annually), with an inspection prior to the issuance of the permit. Such annual inspections by local code enforcement officials are routinely performed for all types of facilities, including for CNG production/dispensing facilities and other fueling facilities. However, the requirement in the draft rules for annual re-training of local first responders, to be “offered” by the operator of the LNG facility, may constitute an economic burden on the smaller facilities, especially if a facility is the “pioneer” (the only one) in any jurisdiction. Given the likely slow pace of LNG facility deployments, each new facility will likely be the only one (for some years) in the jurisdiction where it is sited. Thus the required annual re-training of first responders will fall fully on a single “pioneer” facility, possibly for many years. That annual renewal cost may be a burden to potential pioneers, especially those seeking to deploy smaller facilities, and may inhibit the deployment rate of LNG facilities.

Permit Renewals: The five-year renewal cycle for LNG facility permits should be less costly than the original permit, because it will not require a SEQRA review. However, an annual refresher-training program may be required by the local code enforcement. If the cost of such a refresher course is less than the initial training, say, only \$3,000 per attendee, and five persons attend, then that annual refresher program will cost the owner of the LNG facility \$15,000. Adding the DEC renewal fee of \$500, the total annual costs associated with Part 570, for a typical LNG facility, will be approximately **\$15,500**.

Cost Projection Conclusions: The projected costs associated with the permitting and start up of each LNG facility, and with permit renewals, will not be significant relative to the total capital cost of deploying each facility. However the required annual re-training of local first responders, at the expense of a single LNG facility within each jurisdiction, may be a burden to smaller facilities, and may cause some potential applicants for permits to hold off until others have “paved the way,” and with whom they can share those annually recurring costs. If a significant number of small-scale LNG facilities wait for others to share those annually recurring re-training costs, then the rate of LNG facility deployments will be slower than the projections above.

Conclusions

Based on the information provided in this report, XE concludes the following:

- States that manage significant amounts of LNG rely in large part on the NFPA standards to regulate the storage and handling of LNG. The draft of Part 570 takes a similar approach.
- Beyond storage and handling requirements, and unique to NYS, the promulgation of Part 570 would establish procedures for permitting LNG facilities, intrastate routing of LNG transport vehicles, and the assessment of emergency response capabilities. We did not observe these requirements in the other states evaluated in this study. Texas does require that individuals with significant responsibilities for the storage and handling of LNG be licensed.
- For the foreseeable future, only a small number of LNG facilities (approximately 21) would be deployed, and they would be focused on delivering fuel for vehicle fleets.
- The job and cost projections show that there would be minor increases in job opportunities as a result of the ability to issue LNG facility permits.
- The cost to most developers and operators of LNG facilities, to comply with the requirements of Part 570, will not be consequential enough to deter potential deployments of LNG facilities.

Appendix A Scope of Work

1. Defining the “State-of-the-Art”

- 1.1. Assemble a compilation of the primary federal and state laws, regulations, policies, and guidance along with national consensus standards (e.g., National Fire Protection Association) regarding the storage and transportation of LNG in the following areas:
 - 1.1.1. Siting of storage facilities with a particular emphasis on buffer zones
 - 1.1.2. Design and operation of storage facilities addressing fire/explosion prevention and operational issues that impact facility safety
 - 1.1.3. Transportation
 - 1.1.4. Security
 - 1.1.5. Emergency response
 - 1.1.6. Inspections and enforcement
- 1.2. The compilation will include federal requirements, national consensus standards, and those of the following states: New York, California, Arizona, and Texas. If any of the states with existing LNG programs provide regulatory relief opportunities for small businesses or local governments, this will be noted and described. The general status of LNG programs, if any, in the states bordering NYS will be provided. The compilation will include a summary that simplifies the comparisons (e.g., tabular).
- 1.3. Incidents: To the extent practicable, compile a list of known incidents/accidents with LNG and categorize them by incident type (e.g., transportation [rail, truck], storage tank system incidents, loading/unloading, etc.). When available, the cause of the incident will be noted.

2. Facility, Job, and Cost Projections

- 2.1. **Facility Projections:** For the following four categories of facility owners, estimate the number of permitted LNG facilities that will exist in NYS within 3-5 years of promulgation of Part 570. For each owner type, also estimate the number of tanks and total facility capacity. Before these estimates are completed, the Consultant will submit the proposed approach and assumptions to NYSERDA for approval.
 - 2.1.1. Small Businesses [Any business, which is resident in NYS, independently owned and operated, and employs 100 or fewer individuals. SAPA section 102(8)]
 - 2.1.2. Local Government [Includes all county, city, town and village governing bodies, all other public corporations, special districts and school districts in the state. EXE section 401(3)]
 - 2.1.3. State Government [Includes any department, division, board, bureau, commission, office, agency, authority or public corporation of the state. EXE section 401(4)]
 - 2.1.4. Other [e.g., rural, commercial]
- 2.2. **Job Projections:** For each of the owner types given in section 2.1, estimate the number of jobs that would be created to own and operate a regulated facility. Identify the types of jobs that would be created (e.g., trainers, operators, etc.).
- 2.3. **Cost Projections:** For each of the owner types given in section 2.1, estimate the following costs of complying with the requirements of Part 570 (initial and annual costs):
 - 2.3.1. Obtaining a permit to operate [initial]
 - 2.3.2. Training requirements
 - 2.3.3. Maintenance costs for compliance [operation, inspections]
 - 2.3.4. Permit renewals [5 year renewal cycle]

Appendix B
Tabulation of Topics Covered by Various LNG Codes

Regulated Topics	NFPA 59A 2009 Edition (1)	NFPA 52 2010 Edition (2)	49 CFR Part 193 (3)	33 CFR Part 127 (4)	R.R.C. of Texas LNG Regulations Oct. 2003 (5)	Laws of Texas LNG Regulations Sept. 2003 (6)
1.1.1 Site Planning	Chapter 5		Subpart B	Subpart B	Subchapters B, D	
Facility design	Chapter 4 Annex E	12.2; 17.10	Subparts C, D		14.2304	
Distance from tanks to property lines	5.3.4.1; 13.6.2	16.5.1	193.2057 193.2059		14.2110	
1.1.2 Design / Operation and Equipment			Subpart F	127.101		
Buildings and structures	4.3; 5.4	12.2.4.1			14.2307	
Process equipment Stationary Storage tanks	5.3.6; Chapter 6 Chapter 7 Chapter 13	Chapters 11, 12 Chapter 16	Subpart E 193.2181 193.2187		14.2107	
Seismic design	7.3.2; 7.3.3; 7.3.7.8; 7.4.2.8 9.2.2; 13.3.7; 13.3.14 Annex B	16.3.15				
Container pressure	7.4.1; 7.4.2; 7.9; 13.15.3.3;	11.12.5-6; 16.11				
Vaporization equipment	Chapter 8	11.10; 12.9	193.2441, 2445			
Piping, valves, pumps...	7.9.5; Chapter 9 11.5.3; 13.1.4; 13.7	8.9.1.5; 9.9.1.4; 11.8; 11.9; 11.12.3; 11.12.4; 12.5; 16.9;			Subchapters E, G	
Instrumentation and electrical	Chapter 10	12.11			Subchapter F	
Transfer of liquids	5.3.7; Chapter 11 14.6.6; 14.7; 14.8;	12.3; 12.4; 12.10;	193.2513	127.319	14.2116; 14.2313 14.2325; 14.2734	
1.1.3 Transport of LNG					Subchapter H	
Cargo transport unloading	11.6; 14.6; 14.7;	12.3			14.2119; 14.2325	
1.1.4 Fire Protection, Safety and Security	Chapter 12	Chapter 15 12.6;	Subpart I 193.2709, 2715, 2717		Subchapter B 14.2131	Subchapter B 116.073
Marine shipping and receiving	11.5; 14.6	Chapter 17		Subpart B		
Personnel safety and training	Chapter 14 Annex D	1.7; 15.4; 17.17	193.2511 Subpart H	127.301 127.503	14.2021 14.2137; 14.2328	Subchapter C
Facility security	Annex C	15.5	Subpart J	127.701, 707		
Maintenance	14.5;	12.13; A.12.13	Subpart G 193.2639, 2707	127.401	14.2113; 14.2140 14.2643	
Enforcement	14.1.1	1.6			14.2013 14.2019	
1.1.5 Emergency Response			193.2509		14.2046	
Emergency procedures and shutdown	10.6; 12.2.2; 12.3 11.5.4; 13.18.3; 14.4.8 14.5.9;	12.11.3		127.205	14.2049 14.2510	
1.1.6 Inspection & Enforcement				127.403	Subchapter A	Subchapters B, C, F
Construction inspection	7.5.3		193.2705		14.2037; 14.2316	116.015
Container testing/inspection	7.7; 7.8; 13.9;	16.7; 16.8	193.2623		14.2140; 14.2707	116.015
Piping testing	9.7	9.9.1.4			14.2428; 14.2431	

NOTES:

- (1) Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)
- (2) Vehicular Gaseous Fuel Systems Code. [Includes LNG and L/CNG fueling facilities.]
- (3) Title 49 -- Transportation, Part 193 -- Liquefied Natural Gas Facilities: Federal Safety Standards
- (4) Title 33 -- Navigation and Navigable Waters, Part 27 -- Waterfront Facilities Handling Liquefied Natural Gas and Liquefied Hazardous Gas
- (5) Liquefied Natural Gas Regulations, Railroad Commission of Texas [No "Subchapter C"]
- (6) Laws of the State of Texas Pertaining to Liquefied Gas Regulations