Not Your Father’s LNG Production Facility
By: Jeffrey P. Beale, CH·IV International
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Agenda

- Review the history of LNG peakshaving in the U.S.
- Discuss the status of these LNG facilities.
- Describe how these old plants can be optimized for continued operation.
- In what ways are new, purpose-built liquefiers different than the historical plants?

The presentation has been modified from this point on as you will find out!
Speaker Information

- Jeffrey P. (Jeff) Beale, President of CH·IV International
  - LNG system design, operations and safety since 1974.
  - Member of NFPA 59A LNG Committee since 1994
- CH·IV International, founded in 2001
  - Engineering / Consulting firm specializing in LNG
    - “The LNG Specialists”
  - Focusing on LNG Import/Export Projects and Small-Scale LNG Production Facilities
  - Offices in Hanover, Maryland and Houston, Texas
What Led to Need for Natural Gas Peakshavers?

- Natural gas consumption greatly increased in the post WWII era.
- Gas pipelines were serving heavy year-round industrial loads.
- Interstate/intrastate pipeline capacities were often exceeded during very cold periods due to high commercial and residential heating loads.
Winter Peakshaving

- To meet these “peak” demands gas utilities incorporated different methods:
  - Where available, gas was injected into underground gas storage fields during low demand periods such that it could be extracted from storage during the peak periods;
  - Industrial gas loads were shifted to alternative fuels leaving more gas availability in the system;
  - Propane was vaporized and mixed with air to deliver a similar burning “gas,” Propane-Air; and
  - LNG Peakshaving
LNG Peakshaving

- Liquefy natural gas at a continuous, low rate from March through October.

- Stockpile the LNG in large, low pressure, flat-bottom, LNG storage tanks.

- On the peak days/hours during winter, the LNG is pumped to pipeline pressure, vaporized and fed into the pipeline.
LNG Peakshaving

- The “200/20” Rule
  - Liquefy for 200 days in order to peakshave for 20 days.
  - For example, assume peaking demand was 100 mmscfd for 20 days (2,000 mmcf).
  - The LNG production would provide $\frac{1}{200}$th of total storage every day, i.e., 10 mmscfd.
  - A lot of “200/20” facilities were built in the 1965 to 1978 period.
Number of U.S LNG Peakshavers Built per Year in the Period of 1965 to 1978

- 1965: 4
- 1966: 0
- 1967: 1
- 1968: 4
- 1969: 4
- 1970: 2
- 1971: 4
- 1972: 11
- 1973: 5
- 1974: 4
- 1975: 6
- 1976: 1
- 1977: 4
- 1978: 2
LNG Peakshaving

There was also a lack of consistency in design of LNG peakshavers.

<table>
<thead>
<tr>
<th>Basic Liquefaction Technology</th>
<th>Number Built</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed Refrigerant (multiple “recipes”)</td>
<td>26</td>
</tr>
<tr>
<td>Cascade (many variations)</td>
<td>11</td>
</tr>
<tr>
<td>Let Down Expansion</td>
<td>9</td>
</tr>
<tr>
<td>Nitrogen Expansion</td>
<td>7</td>
</tr>
<tr>
<td>“Other”</td>
<td>3</td>
</tr>
</tbody>
</table>
What Has Happened Since 1978?

- A few new LNG peakshavers were built after the initial 52.
- The original 52 have quite old, very small-scale LNG production facilities with very large LNG storage tanks.
  - A few liquefaction units have been upgraded over the intervening years.
- These original LNG peakshavers rarely see the peakshaving demand for which they were designed as new interstate gas transmission pipelines were built increasing winter gas delivery.
  - Consider . . .
Pipeline Expansion from Canada

Office of the Federal Coordinator, Alaska Natural Gas Transportation Projects - May 2011
**Impact**

- Many LNG peaker’s liquefaction units are operated on a minimal basis, if at all.
  - Only a fraction of total storage is typically needed during winter.
  - Many liquefaction systems were operated only to keep in “Rate Base” and/or replenish boil off losses.
  - Often the LNG in storage ages (methane boils off) forcing operators to sendout LNG prior to gas quality becoming incompatible with pipeline gas composition tariffs.
- As a result, these facilities have . . .
Old, Minimally Maintained Pretreatment and Liquefaction Equipment
Out-Dated, Rarely Used LNG Trailer Loading Stations
Yet All Have

- Underutilized LNG storage tanks averaging over 14 million gallons.
- Take for example . . .
There’s a lot of underutilized LNG storage out there!
Development of Vehicular LNG (VLNG) Supply

- Consider now “economics of scale,” which more or less follows the simple formula:

\[
\text{Cost}_2 = \text{Cost}_1 \times \left(\frac{\text{Size}_2}{\text{Size}_1}\right)^{0.60}
\]

If a 5 mmscfd (60,000 gpd) liquefier cost “X,” then a liquefier 5 times larger only cost 2.6 X.

- What historically was the largest single cost item, i.e., the LNG storage tank, already exists.
The Major Market Force for VLNG

- The “Shale Gas Delta” – $4.00/gallon diesel = $28/mmBtu
  Henry Hub ≈ $4/mmBtu!
- Over-the-Road Heavy Duty Vehicles

From ngvglobal.com
The Major Market Force for VLNG

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- Off-Road Applications? Locomotives?
Development of Vehicular LNG Supply

- Other considerations for upgrading existing “LNG Peakers.”
  - New liquefaction systems can be designed and operated year-round.
    - Liquefaction plants actually have better performance during the colder months.
  - Add or upgrade LNG trailer loading stations to minimize the impact of loading on the day-to-day operation of the LNG facility.
    - Design such that driver handles total LNG transfer operation.
      (This could be a separate presentation.)
Then, a Funny Thing Happened on the Way to LNG 17 that Caused Me to Divert from my Original Paper!
The North American Emissions Control Area

(http://www.epa.gov/oms/oceanvessels.htm)

“ECA,” for ships operating within 200 nautical miles (370 km) of the U.S. and Canada.

Requiring much stricter controls on emissions of sulfur oxide (SOx), nitrogen oxide (NOx) and particulate matter for these ships.
The 200 NM NAECA ("ECA")
Options to Address ECA:

- Burn much more expensive fuel oil with a lower sulfur content (**increased costs**)
- Use an apparatus to reduce emissions, e.g., selective catalytic reduction, “SCR” (**increased costs**)
- Burn low a emission fuel, i.e., natural gas, i.e., LNG. (**DECREASED COSTS**)
Calling all Potential LNG Fuel Suppliers –

Fueling One Container Ship $\cong$ Fueling 3,500 Class 8 Trucks

Please let me repeat that –
Fueling One Container Ship $\cong$ Fueling 3,500 Class 8 Trucks
Orca Conversion

- Built for Alaska Trade
- 33,000 MMBTU of LNG needed per week, per ship
- Dual fuel capable
- Bunker in Tacoma or Anchorage
- Minimal out of service time during conversion

From toteinc.com
To Complete the Picture, There is a New Need for LNG Bunker Ships and/or Bunkering Ports

- LNG Bunker Ships

Example: White Smoke
2,800 m³ (740,000 gallon)
“WS₃ LNG Bunker Vessel”

From whitesmoke.se
New Need for LNG Bunker Ships or Bunkering Ports

- LNG Bunker Ships
- LNG Bunkering Ports (miniature “LNG Export Facilities”)
  - Load LNG-Powered Ships
  - Load Bunker Vessels
    - Self-powered like the WS3
    - Articulated Tug Barges
There are Possibly 20 Existing U.S. LNG Peakshavers That Have Marine Access

- Most have room to add new, larger liquefaction units.
- All have large LNG tanks, minimum 3 million gallons.
- All are “LNG trailer loading capable”
- Many have rail access, as well.
Summary

- The paper associated with this presentation focused on providing over-the-road vehicular LNG using underutilized LNG peakers.
- The rapidly evolving LNG bunkering market changed the focus for this presentation.
- ECA is currently the major driver, but the positive economics of LNG-powered marine vessels are hard to ignore, with or without ECA.
- Starting with an existing LNG facility with a large storage tank and marine access is one way to “kick start” this LNG bunkering industry.
Thank You!

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Rendering courtesy of Freeport LNG Development, L.P. for whom CH-IV provided Balance of Plant (BOP) FEED and FERC filing.