Staff Update on Liquefied Natural Gas

David Maul, Manager
Natural Gas and Special Projects Office
California Energy Commission
February 24, 2004
Overview

- State energy policy
- LNG and its properties
- Safety and environmental issues
Why the interest lately in liquefied natural gas?

- The U.S. is relying more on natural gas for cleaner power generation.
- Canadian and Lower 48 states’ gas production is declining.
- LNG links U.S. consumers to transoceanic gas supplies from many countries.
- LNG delivery costs have declined.
California’s Energy Policies

• **Energy Action Plan**
  – Evaluate new supply options, such as LNG imports

• **Integrated Energy Policy Report**
  – Encourage LNG facilities in California or Baja California, Mexico
  – Ensure new facilities protect the environment and public safety
  – Coordinate permit reviews and address local concerns
What is LNG?
LNG is natural gas in liquid form.

- Primarily methane
- Cryogenic liquid (-260°F)
- 1/600th volume of natural gas
- Non-toxic and non-corrosive
- Colorless and odorless
- Can not ignite
- Contact is hazardous due to extremely cold temperature.
As a liquid, LNG:

- Is stored as a liquid in well-insulated tanks at near-atmospheric pressure
- Floats on water, then vaporizes
- Large spills on water may produce a rapid phase transition (non-combustion explosion)
LNG Vapor Cloud Characteristics

- Looks like fog
- Lighter than air once above -160°F
- Leaves no residue on land or water
LNG Vapor Cloud Characteristics, continued

- Highly flammable within cloud, where gas volume is between 5% and 15%.
- Cloud remains flammable until gas volume <5%.
- Not explosive, unless ignited in an enclosed space.
How is LNG Used?

• As natural gas:
  For heating, cooking, electricity generation, industrial feedstock (e.g., making fertilizer, chemicals)

• As LNG:
  For vehicle fuel, storage supplement to gas utility’s inventories
The LNG “Supply Chain”

- Gas Exploration and Production
- Gathering and Processing
- Liquefaction
- Shipping
- Importation
- Regasification
- Distribution via Pipelines
The LNG Industry

• Approximately 30 years old

• Atlantic Basin buyers:
  – Belgium, France, Greece, Italy, Portugal, Spain, Turkey, and the United States

• Pacific Rim buyers:
  – Japan, South Korea, and Taiwan

• More than 40 receiving terminals worldwide
Worldwide LNG Facilities

Source: CH·IV International
Current LNG Producers

Algeria
Australia
Brunei
Indonesia
Libya
Malaysia
Nigeria
Qatar
Oman
Trinidad
United Arab Emirates
United States
LNG Potential Supply and Demand 2010

(totals in million tons per year)
U.S. LNG Import Facilities

Everett, Massachusetts
Built 1971

Cove Point, Maryland
Built 1974

Lake Charles, Louisiana
Built 1981

Elba Island, Georgia
Built 1978

Plus, Puerto Rico
All U.S. import facilities are adding capacity.

<table>
<thead>
<tr>
<th>Location</th>
<th>Now</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>Everett, Massachusetts</td>
<td>435 MMcf/d</td>
<td>700 MMcf/d</td>
</tr>
<tr>
<td>Cove Point, Maryland</td>
<td>430 MMcf/d</td>
<td>1 Bcf/d</td>
</tr>
<tr>
<td>Elba Island, Georgia</td>
<td>600 MMcf/d</td>
<td>1.2 Bcf/d</td>
</tr>
<tr>
<td>Lake Charles, Louisiana</td>
<td>750 MMcf/d</td>
<td>1 Bcf/d</td>
</tr>
</tbody>
</table>

Total: 2,215 MMcf/d ➤ 3.9 Bcf/d

(MMcf/d = million cubic feet per day; Bcf/d = billion cubic feet per day)
Trends in LNG Imports – relative to natural gas prices

SOURCE: U.S. Energy Information Administration
Current U.S. Sources of LNG

506.5 Bcf in 2003

Current U.S. Sources of LNG

- Algeria
- Nigeria
- Oman
- Qatar
- Trinidad
LNG Deliveries in 2003

- Elba Island, Georgia: 44 Bcf (9%)
- Cove Point, Maryland: 66.1 Bcf (13%)
- Everett, Massachusetts: 158.2 Bcf (31%)
- Lake Charles, Louisiana: 238.2 Bcf (47%)

Total: 506.5 Bcf, excluding Puerto Rico
Projected Net LNG Imports 2000-2025

SOURCE: U.S. Energy Information Administration
## Potential LNG Sources for the West Coast

<table>
<thead>
<tr>
<th>Source Country</th>
<th>Distance (One-way, @ 18.5 knot ship speed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oman</td>
<td>25 days</td>
</tr>
<tr>
<td>Australia</td>
<td>18 days</td>
</tr>
<tr>
<td>Malaysia</td>
<td>17 days</td>
</tr>
<tr>
<td>Indonesia</td>
<td>16 days</td>
</tr>
<tr>
<td>Brunei</td>
<td>16 days</td>
</tr>
<tr>
<td>Russia</td>
<td>11 days</td>
</tr>
<tr>
<td>Alaska</td>
<td>5 days</td>
</tr>
</tbody>
</table>
Transporting LNG
LNG is transported in specially designed ships.

- Most carriers are 900 feet long, 140 feet wide, 40 feet high
- Carry ≈ 35 million gallons of LNG, 3 Bcf
LNG Carriers

- Double-hulled and well-insulated (not refrigerated)
- Store LNG at near-atmospheric pressure (not pressurized)
- Use “boil off” gas as on-board fuel
- Many safety features for cargo containment and fire prevention
LNG Terminal Components

- Berth and jetty
- Unloading arms
- Storage tanks
- Vaporizers
- Control room
- Connection to utility-pipe network
LNG Facility Site Choices

Onshore
  - Existing port
  - Remote coastline
LNG Facility Site Choices

Offshore

Technology Options:
• Attached to platform
• Attached to pipeline with vaporization on carrier
• Artificial island
• Floating, moored to seabed
LNG Terminal Siting
“Best Practices”

- Adequate acreage for safety exclusion zones
- Compatibility with other maritime traffic
LNG Terminal Siting
“Best Practices” (cont.)

- Access to pipeline infrastructure
- Local community acceptance
- Consistent with current land-use zoning
- Coordinated federal, state, and local environmental approvals
- Use of latest storage and transfer-system technologies
LNG Safety Concerns

• A fire from a large release of LNG will burn intensely. Little smoke.
  – Potential harm to plant employees
  – Potential damage to LNG marine terminal and offsite facilities
  – Large fires must burn themselves out.

• LNG firefighting is like fighting any hydrocarbon fire.
  – Firefighters attend hands-on training.
  – Fire detection sensors trigger alarm and shutdown.
  – Special dry chemicals, expansion foam control small fires, not water.
LNG facilities must have buffer zones for public safety

- *Thermal exclusion zones* are designed to prevent public exposure to thermal radiation from a fire.

- *Vapor dispersion zones* are designed to prevent public exposure to unlit vapor clouds that could ignite later.

- *Security zones* are designated to prevent ship collisions with LNG carriers.
LNG Carrier Safety Record

- No LNG cargo spills due to ship collisions, groundings, fires, explosions, or hull failures
- No damage to land-based property or the environment due to LNG releases from carriers
- No fatalities

SOURCE: Lloyd’s Register
Two Fatal Accidents at LNG Plants

- 1944 - Cleveland, Ohio (peak-shaving plant)
  Storage tank failed. LNG spilled into the sewer. Underground explosion killed 128 people.

- 1979 - Cove Point, Maryland
  Valve leaked LNG along an electrical conduit and into an equipment room. Explosion killed a plant employee.
Safety Risk Assessments

Postulated “Worst Case” Scenario (example)

- Carrier collides with another ship, rapid release of a large amount of LNG

- Spill spreads on water. Vapor cloud forms.

- Cloud drifts to urban area, then ignites.

- Fire kills people, destroys property.
Safety Risk Assessments

• Reasonable assumptions for “worst case” scenario:
  – Where could a carrier-damaging collision occur?
  – What is the spill rate? Would spill be instantaneous?
  – Will the collision start a fire? Or, is ignition delayed?

• Site-specific data on facility layout & design, topography, waves, humidity, wind speed, etc.
Safety Risk Assessments

Dense cloud dispersion models predict:

- thermal radiation heat flux
- distance traveled while still flammable

Using the same assumptions and data, all such models predict similar results.
Quest Model Controversy

• Performed shortly after 9-11 for U.S. DOE
• Assumed:
  – Collision occurred outside of Boston Harbor
  – Rapid, but not instantaneous, LNG release
  – Waves hasten LNG vaporization
  – No ignition until cloud is biggest size while still flammable
Comparison of Results

Distance that a 25,000 m$^3$ LNG spill spreads:
- 470 feet (Quest)
- 1,411 feet (James Fay)
- 1,239 to 1,539 (Others)

No scenario assumed the collision starts a fire.

Other’s analyses yielded bigger numbers, because:
- Collisions occur inside Boston Harbor.
- LNG release is instantaneous.
Pipeline Safety

• Ownership of pipelines determines state or federal safety jurisdiction.

• Federal pipeline safety regulated by US Department of Transportation under 49 CFR 192

• The CPUC has adopted the federal pipeline safety regulations under General Order 112E, and enforces these regulations on operators under its jurisdiction.
Potential Environmental Impacts

LNG projects are subject to environmental review and regulation.

Environmental impact evaluations cover:
• Air quality
• Water resources
• Biological resources
• Land use
• Visual impacts
• And more
Potential air quality impacts from LNG facilities

Emission sources include:

- Natural gas burned for LNG vaporization
- Diesel-fuel emissions:
  - Emergency generators
  - On-ship power supply
  - Tug boat engines

LNG facilities do not routinely flare or vent natural gas, only in emergencies.
LNG plants do not consume large amounts of water or produce a lot of waste water.

If seawater were the heat source for vaporization, large quantities of sea water would flow through the system.

- Cold-temperature seawater would be discharged.
- Marine life could be entrained.
Biological Resources

LNG ships don’t discharge ballast after arriving at an import terminal.

Ports may need to dredge and fill ship waterway.

Pipeline routes may:
• Cross critical marine habitat, streams, or wetlands
• Require plant life removal, replacement
Visual Resource Impacts

Terminals are industrial facilities.
West Coast LNG Projects

Past and Proposed
Past proposals to build terminals in California

- Point Conception (1970s)
- Mare Island (2002)
Point Conception project history

• Proposed by California gas utilities
• Multiple sites considered, Point Conception selected
• Despite public opposition and lawsuits, project eventually approved
• Change in U.S. gas regulations boosted domestic supplies, hurting LNG market
• Project never built

Photo Credit: Kenneth Adelman
Mare Island project history

- LNG project proposed by Bechtel & Shell in 2002

- Site was a former naval shipyard within San Francisco Bay

- Citizens opposed the project

- Shell, then Bechtel, withdrew proposal

(Artist’s Rendition)
## Proposed LNG projects under consideration for California

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Beach LNG Facility</td>
<td>Port of Long Beach</td>
<td>Joint EIS/EIR by FERC and Port of Long Beach.</td>
</tr>
<tr>
<td>Sound Energy Solutions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabrillo Deepwater Port</td>
<td>~12 miles off shore of Ventura County</td>
<td>Joint EIS/EIR by Coast Guard and State Lands Commission.</td>
</tr>
<tr>
<td>BHP Billiton</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crystal Clearwater Port</td>
<td>~11 miles off shore of Ventura County</td>
<td>Filed application with Coast Guard and State Lands Commission.</td>
</tr>
<tr>
<td>Crystal Energy LLC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Port of Long Beach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crystal Clearwater Port</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crystal Energy LLC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sound Energy Solutions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long Beach LNG Facility</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samo Point Energy Center</td>
<td>Humboldt Bay</td>
<td>Announced project.</td>
</tr>
<tr>
<td>Calpine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Port Penguin</td>
<td>To be determined</td>
<td>Announced project.</td>
</tr>
<tr>
<td>ChevronTexaco</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Proposed LNG projects under consideration for Baja California

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal GNL Mar Adentro de Baja CA ChevronTexaco</td>
<td>Offshore, Tijuana</td>
<td>Project Announced</td>
</tr>
<tr>
<td>Tijuana Regional Energy Center Marathon</td>
<td>Tijuana</td>
<td>Obtaining permits</td>
</tr>
<tr>
<td>Energia Costa Azul Sempra and Shell</td>
<td>Ensenada</td>
<td>Permits suspended by Mexican Court</td>
</tr>
</tbody>
</table>
Is LNG a near-term supply source for the West Coast?

- Earliest estimate ~ 2006
- Siting process could take ~ 4 to 7 years
Federal, State and Local Authorities involved with LNG
Federal Agencies with Review or Permit Authority over California LNG Facilities

**Onshore Terminals**
- Federal Energy Regulatory Commission
- Department of Transportation
- Coast Guard

**Offshore Terminals**
- Coast Guard
- Maritime Administration

**Other Key Regulators**
- Department of Energy
- Fish and Wildlife Service and NOAA Fisheries
- Minerals Management Service
- Army Corps of Engineers
State Agencies with LNG Review or Permit Authority

- State Lands Commission
- Department of Fish and Game
- Coastal Commission or San Francisco Bay Area Conservation and Development Commission
- California Public Utilities Commission
- Governor’s Office (offshore terminals)
Local Jurisdictions

- City or county government
- Port authority or harbor district

Photo Credit: Kenneth Adelman
Unresolved Issues

- Extent of safety risks
- Public perception of safety risks
- Scope of LNG terminal regulation
- Price competitiveness of LNG
- Gas-quality standards
- Jones Act barrier to Alaskan imports
- Interstate competition for Mexican LNG