



**Liquefied Natural Gas Emissions
Reduction Opportunities**

Lessons Learned
from Natural Gas STAR

Producers and Processors
Technology Transfer Workshop

ConocoPhillips and
EPA's Natural Gas STAR Program
Kenai, AK
May 25, 2006

 EPA



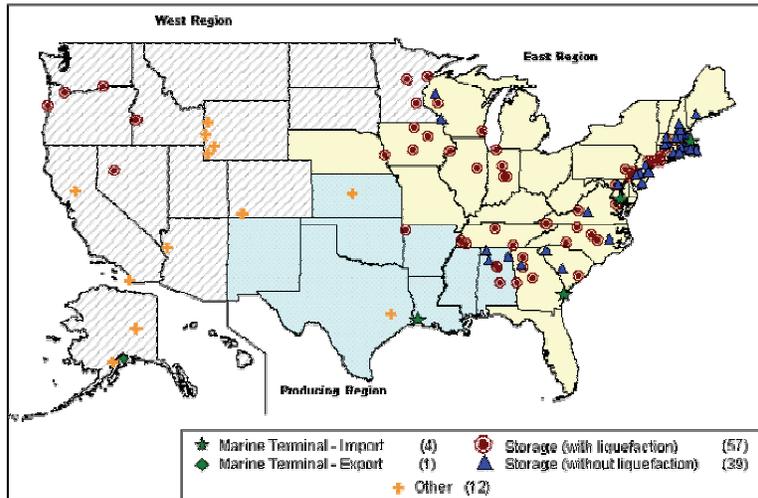


Liquefied Natural Gas (LNG): Agenda

LNG Sources of Emissions

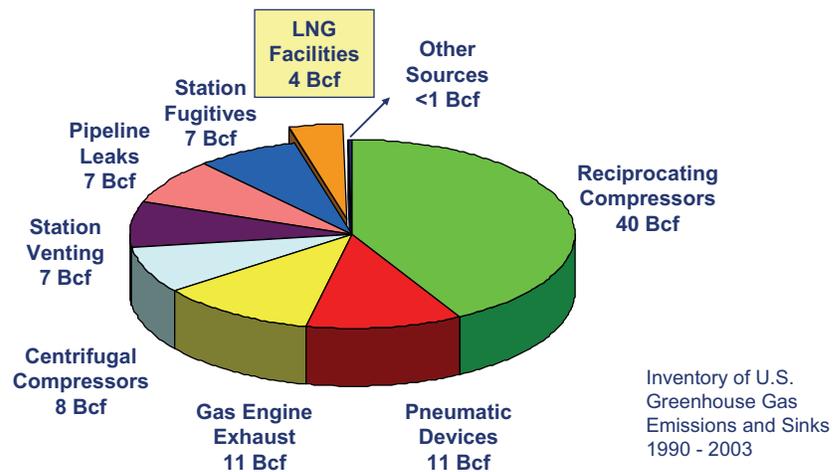
- 🔥 Methane Losses
- 🔥 Methane Recovery
- 🔥 Is Recovery Profitable?
- 🔥 Industry Experience
- 🔥 Discussion Questions

US LNG Facilities



Source: EIA, "US LNG Markets and Uses: June 2004 Update"

Methane Losses: LNG Facilities





Emission Sources

LNG Emission Sources (Combined Sources by Type)				
	Export Terminal	Import Terminal	Storage	Trucking
Ship in Transit	X	X		
Ship Unloading		X		
Ship Loading	X			
Terminal Operations	X	X		X
Storage Tanks	X	X	X	
Boiloff Gas Recovery	X	X	X	
Sendout (pumps, vaporizers)		X	X	
Liquefaction	X		X	
Vehicle Fuel			X	X



LNG Operations

- ⚡ Natural gas liquefaction
 - ⚡ Compression and cryogenic cooling
- ⚡ LNG storage tanks
- ⚡ LNG marine terminals
 - ⚡ Loading and unloading LNG from large tankers
- ⚡ LNG tankers
 - ⚡ Vessels for import and export of LNG
- ⚡ LNG send-out
 - ⚡ Vaporization and injection into pipelines

Liquefaction Equipment

🔥 Description

- 🔥 Progressively lower temperature refrigeration loops
- 🔥 Phillips cascade (3 refrigerants)
- 🔥 Mixed refrigerants

🔥 Possible sources of methane emissions

- 🔥 Compressor seals
- 🔥 CO₂ removal systems
- 🔥 Dehydration systems
- 🔥 Tank overpressure
- 🔥 Ship loading displacement vapors
- 🔥 Loading arm disconnection

LNG Storage tanks

🔥 Tank vapors

- 🔥 99+% methane
- 🔥 Near atmospheric pressure
- 🔥 Cold - visible leaks

🔥 Possible emission sources - venting of vapors

- 🔥 Tank overpressure venting
- 🔥 Leaks from pressure relief valves
- 🔥 Vapor recovery compressors



Source: FERC

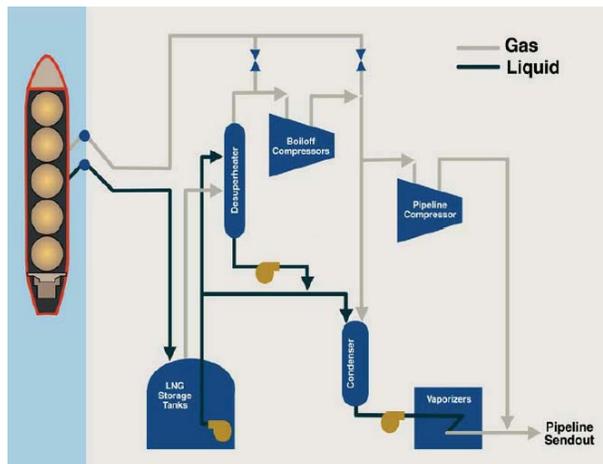
LNG Marine Terminals

- ⚡ Special equipment beyond an LNG storage facility
 - ⚡ Vessel loading arms
 - ⚡ Vapor return blowers
- ⚡ Possible emissions sources
 - ⚡ Fugitives
 - ⚡ Venting, if boil-off vapor can not be consumed as fuel



Source: ConocoPhillips

LNG Marine Terminals



Source: EIA. "US LNG Markets and Uses: June 2004 Update"



LNG Tankers

- ⦿ Long distance transport of LNG
 - ⦿ Fleet approaching 200
 - ⦿ Kenai, AK exports LNG to Pacific rim, Japan (1969)
 - ⦿ Cargos to US in 2005: 197
 - ⦿ 5 existing US terminals
 - ⦿ 1 new terminal every 2 years starting 2008
- ⦿ Possible emissions sources
 - ⦿ Flange and fitting leaks during cool down
 - ⦿ Leaking vapor recovery systems, not operating
 - ⦿ Leaking cargo tank relief valves
 - ⦿ Cargo tank venting during delays



LNG Sendout

- ⦿ LNG from tanks is pumped to pipeline pressure and then vaporized
- ⦿ Possible emission sources
 - ⦿ Vaporizer fuel system leaks
 - ⦿ Pressure relief valves



Methane Savings from Compressors

- 💧 Centrifugal compressor seals
 - 💧 Wet seal oil degassing vents methane to the atmosphere
 - 💧 Typical wet seal emissions of 40 cf/min to 200 cf/min
 - 💧 Dry seals pump gas between the seal rings creating a high pressure barrier to leakage
 - 💧 Typical dry seal emissions of 0.5 cf/min to 3.0 cf/min
 - 💧 Gas savings translate to approximately \$112,000 to \$651,000 per year at \$7/Mcf



Methane Savings from DI&M

- 💧 Fugitive losses can be dramatically reduced by implementing a DI&M program
 - 💧 Voluntary program to identify and fix leaks that are cost effective to repair
 - 💧 Survey cost typically pay out in the first year
 - 💧 Provides valuable data on leakers with information of where to look



Is Recovery through DI&M Profitable?

Repair the Cost Effective Components			
Component	Value of Lost Gas ¹ (\$)	Estimated Repair Cost (\$)	Payback (Months)
Plug Valve: Valve Body	29,496	200	0.1
Union: Fuel Gas Line	28,362	100	0.0
Threaded Connection	24,374	10	0.0
Open-Ended Line	16,238	60	0.0
Compressor Seals	13,493	2,000	1.8
Gate Valve	11,034	60	0.1

¹Based on \$7/Mcf gas price



LNG Emission Prevention Opportunities

- 🔥 Improved connect/disconnect practices
- 🔥 Improved tank pressure management
- 🔥 Improved vapor recovery system maintenance and availability
- 🔥 Strict enforcement of ship venting rules



Summary

LNG Sources of Emissions - *Operations and equipment*

- 🔥 Methane Losses – *Compressor seals and leaks*
- 🔥 Methane Recovery – *Alternative seals and DI&M*
- 🔥 Is Recovery Profitable? - *Probably*
- 🔥 Industry Experience – *ConocoPhillips Presentation*
- 🔥 Time for Discussion & Questions