



Converting LFG Into Liquefied Natural Gas (LNG) For Vehicle Fuel

2008 SWANA Northwest Regional Symposium

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What is Liquefied Natural Gas ?

- LNG is natural gas in its liquid state at -260 F
- As it warms it becomes natural gas and will rise
- 1 liquid unit = 600 gas units



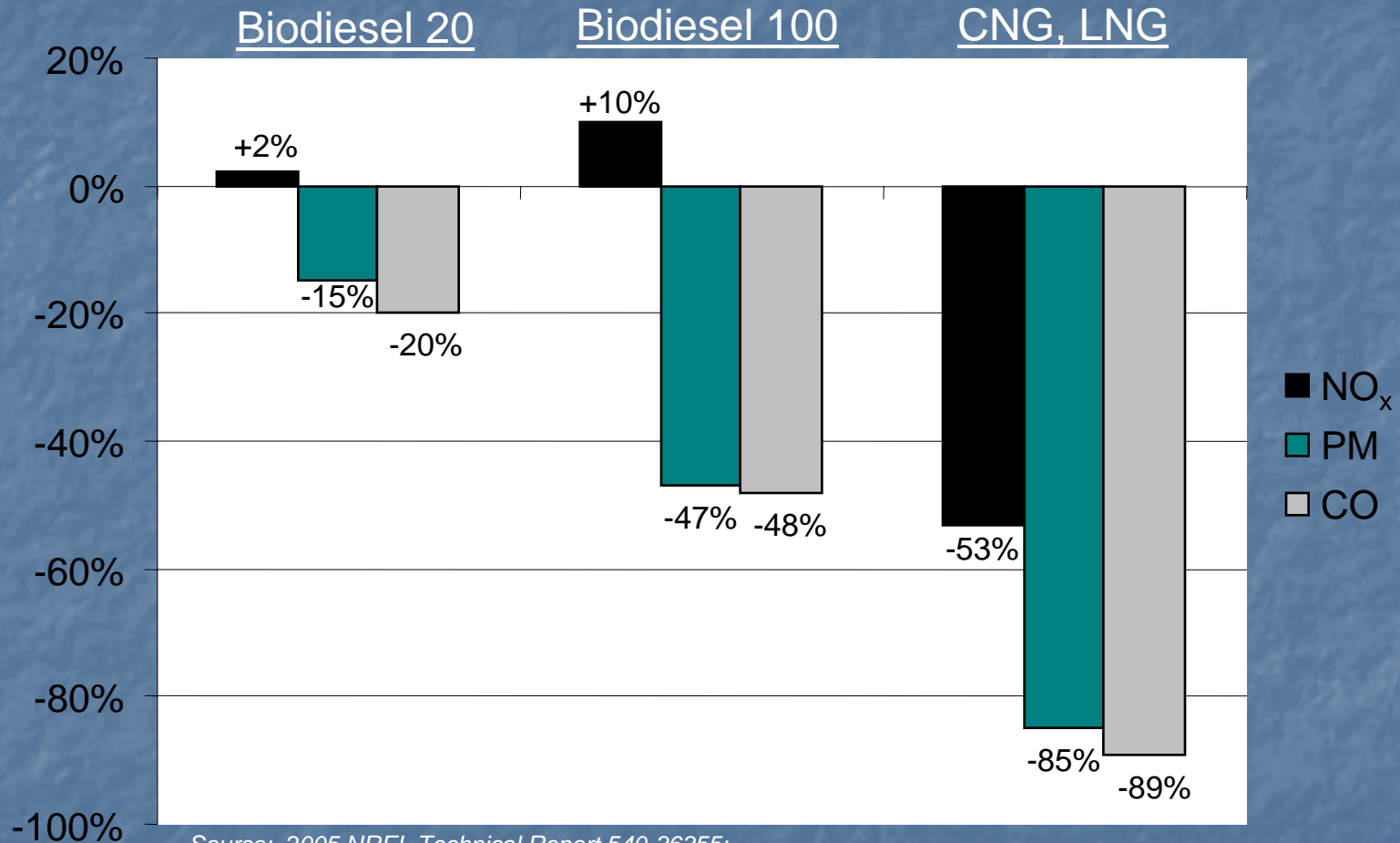
Emerging LNG Use – Market Drivers

- Clean transportation fuel (diesel displacement)
 - Diesel exhaust identified as health threat
 - Port expansions require emission reductions
 - Focus on climate change
- High price of diesel over LNG



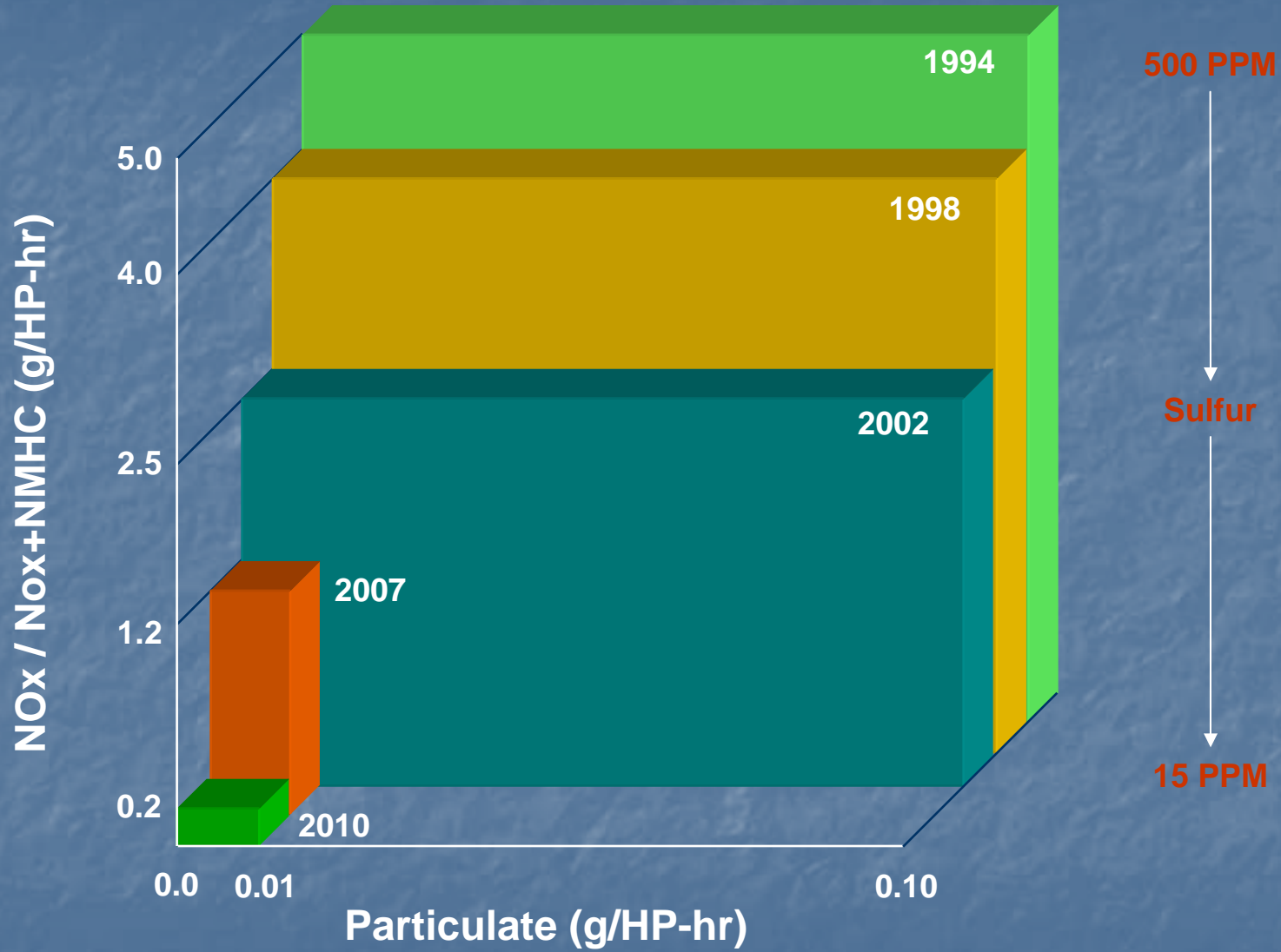
Air Quality Benefits of Alternative Fuel Use

Emission Reduction % by Fuel Type and Pollutant



Source: 2005 NREL Technical Report 540-36355;
Puget Sound Clean Air Agency Biodiesel Fact Sheet

US Emission Standards



LNG Fueling Station

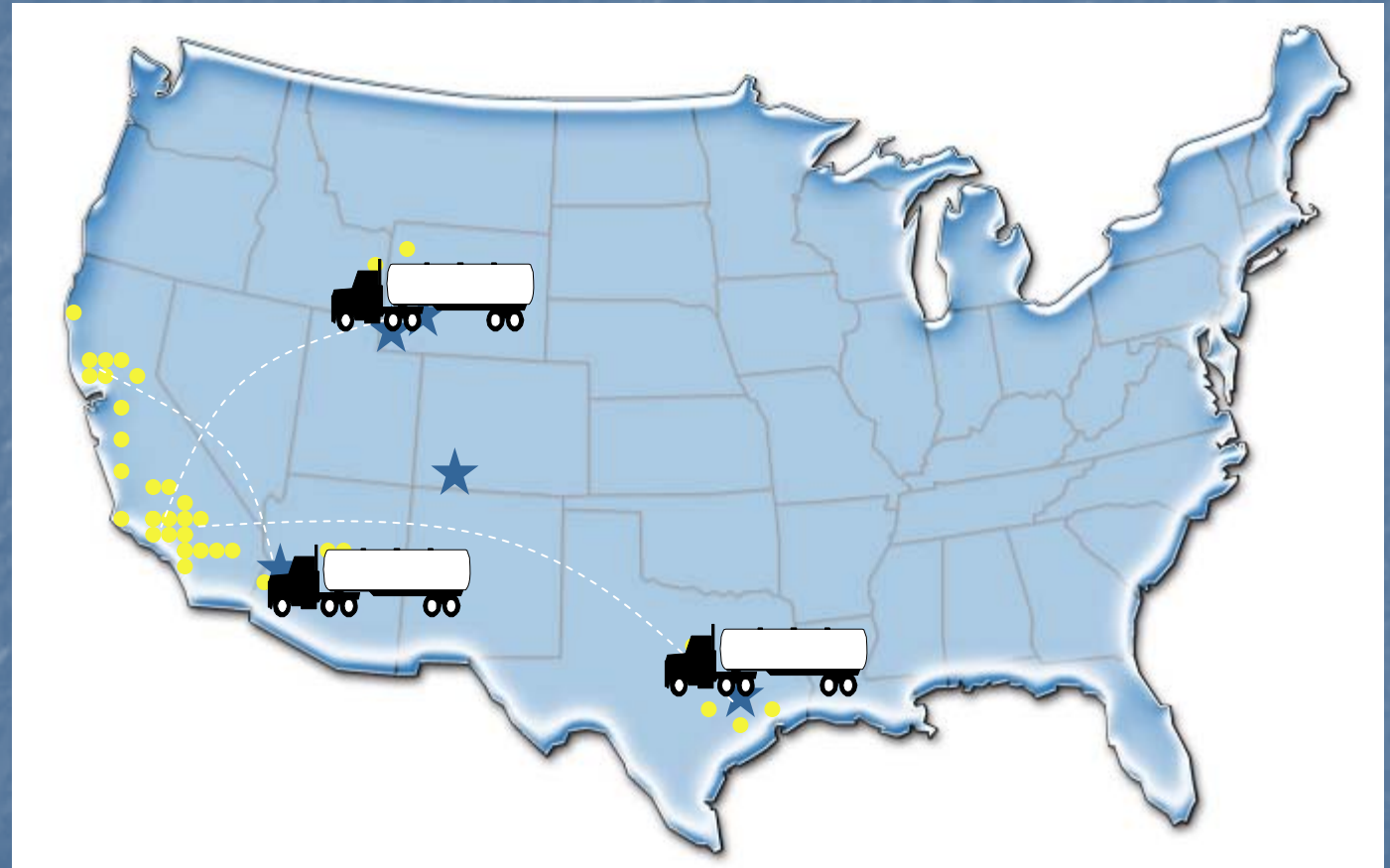
Sacramento County, CA



US LNG Vehicle Fuel Distribution Market

5 LNG facilities currently supply the West Coast

Existing LNG vehicle fuel market consumes 180,000 gallons per day



Source: Prometheus Energy

Typical Landfill Gas Composition

- Methane 40-55%
- CO₂ 35-45%
- Nitrogen 5-15%
- Oxygen 1-3%
- H₂O Saturated
- H₂S 60 ppm

LFG to LNG Process

- Similar to High-Btu or pipeline gas projects
- Remove:
 - Moisture
 - Sulfur compounds
 - Volatile organic compounds
 - Siloxanes
 - Carbon dioxide
 - Nitrogen
- Refrigeration and liquefaction

Prometheus Energy Bowerman LFG to LNG Facility



- Orange County was flaring all LFG
- Target capacity 5,000 gallons per day of LNG
- Montauk Energy was partner

Prometheus Energy Bowerman LFG to LNG System



Bowerman Project End Use



LFG to LNG for Orange County Transit

California Integrated Waste Management Board LNG From LFG - Grant Award (2007)

- Waste Management/Linde/GTI
- Altamont Landfill, Livermore, CA
- Plan to supply Waste Management fleet and others
- Plan to produce 13,000 gallons per day of LNG
- Displace 2.8 million gallons of diesel per year

Recent Industry Developments

- Ports of LA and Long Beach announce plans to invest \$1.6 Billion (over 5 years) in natural gas and other clean fuels for 17,000 trucks
- Kenworth announces plans to sell LNG powered trucks
- Wall-Mart to demo LNG trucks
- Clean Energy building more LNG fueling stations and liquefaction plants

Seattle Airport

- All taxis, shuttles and buses are CNG
- CNG was environmental mitigation for expansion
- LNG would provide faster fill times and increased storage



LNG/CNG Infrastructure



Source: Northstar Industries

North Star – South Korea

China LNG Distribution

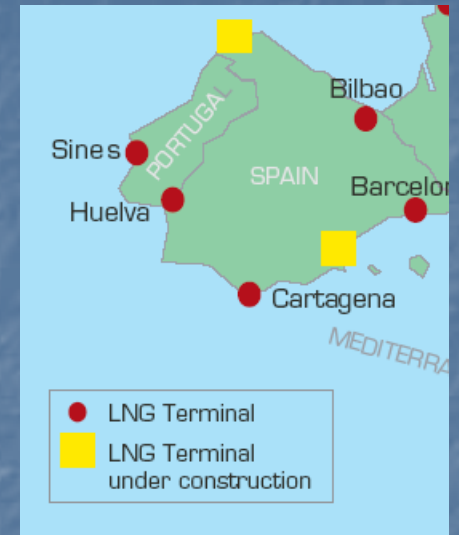
- Shanghai running 40,000 taxis on CNG (from LNG)
- 500 trailers travel 4000 km
- Building 5 liquefaction facilities
- Import terminal loading bays



Source: Max Universal, Inc.

Import LNG Distribution, Spain

- LNG is transshipped from import terminals to small tanks inland
- Delivers 40,000 trailer loads per year



Source: Energy Information Administration

Chive LNG Trailers moving from Spain to England



Conclusions

- LFG to LNG is technically possible, challenge is to make it cost effective
- Increasing focus on being “green”
- Improving economics
- Other parties working to build LFG to LNG systems
- How large will LNG vehicle market get?

Questions ?



Innovative natural gas distribution system

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Satellite Industrial LNG Facility

- Replaced propane to fuel sawmill
- 15,000 gallon tank
- LNG from Utility peak shaver



Terasen/Clean Energy – British Columbia

Small Peak-Load Shaving Facility

Puget Sound Energy - Gig Harbor WA

- Supports constrained distribution system
- No liquefaction
- Served by LNG trailers



Portable LNG Vaporization

- LNG trailer capacity 10,000 gallons (830,000 cubic feet)
- Maximum injection rate 500,000 cubic feet/hour



Puget Sound Energy

LNG Remote Service

- Serves 700 commercial and residential customers
- Uses over 20,000 gpd
- LNG from pipeline gas
- Served by LNG trailers



Fairbanks Natural Gas, Alaska

Norway LNG Distribution

- Small ship delivery
- Remote base load
- Aluminum foundry
- Three 130,000 gallon tanks



Source: Chart Industries

Inter-Modal LNG Tank (Temporary Service)

