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Natural Gas in Transportation

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Key Points to be Covered

- **How sustainable is the shale gas revolution in the United States?**
- **What is the potential for natural gas as a direct or indirect transportation fuel in California in light of the shale revolution?**
- **What does initial ITS scenarios analysis, as well as other sources, show about the potential for natural gas to displace petroleum and reduce greenhouse gas emissions and improve air quality in CA and the U.S.?**

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Over ten U.S. shale plays have high liquids potential



Source: Deutsche Bank, Integrated Oil & Gas for Beginners

- U.S. shale oil and shale gas potential is widely distributed geographically
- Increasingly, natural gas is being produced as associated gas by product of shale oil production
- U.S. natural gas surpluses expected to be extended and large

Price Forecasts

Figure 5. Average annual Brent spot crude oil prices in three cases, 1980-2040 (2011 dollars per barrel)

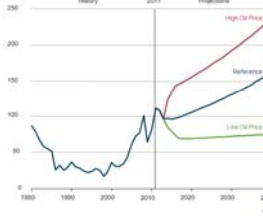
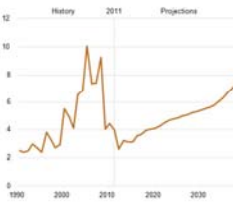
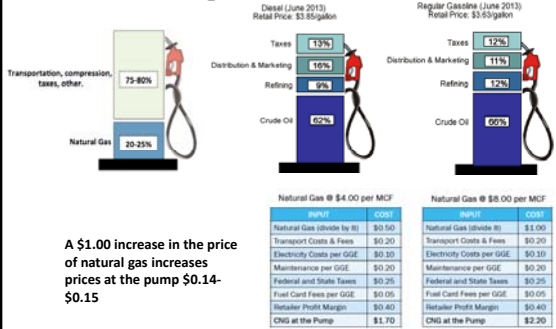


Figure 86. Annual average Henry Hub spot natural gas prices, 1990-2040 (2011 dollars per million Btu)



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NG commodity price is a small part of retail price of CNG/LNG.



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Natural Gas for Transportation: Lessons from Oklahoma

- Natural gas producers increasingly focused on creating new demand markets for natural gas including transportation
- State of Oklahoma initiative – multi-state RFP for the purchase of CNG vehicles resulted in major cost savings for direct purchases from OEMs, combined with simultaneous station provider commitments. Incentives 75% cost of filling stations, 50% home refueling costs, funded via 0.25 GGE surcharge
- Transportation demand in US could top 1 Bcf/d to 3Bcf/d if oil-gas price ratio holds
- Oklahoma model an example for future initiatives in NGVs where natural gas production is high

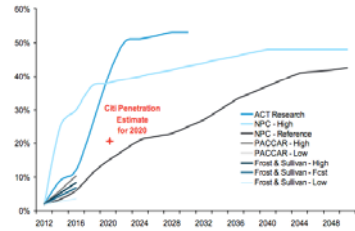
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**Projections NGV Class 8 Truck Adoption:
Penetration Likely limited Over Next 5
Years, but Could Scale by 2020**

Figure 34. Long-Term Class 8 Natural Gas Penetration Forecasts



Source: Citi Research

relegated to large fleets that can leverage existing natural gas infrastructure

CA is heavy traffic zone

Figure 30. Heavy Traffic Truck Corridors



Source: US Department of Transportation

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**Greenhouse gas emissions
reductions: Key factors,
circumstances and
assumptions.**

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Social Costs TOP model

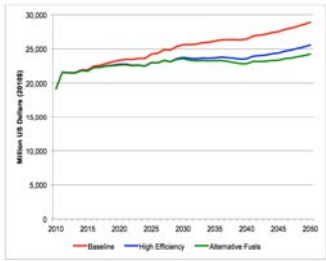


Figure 5-70: Total lifecycle costs of the Alternative Fuels, High Efficiency, and Baseline scenarios

Include both the direct costs incurred by HD vehicle users as well as the monetized externality costs imposed by HD vehicles, including air pollution, climate change, noise, and the military expenditures required to secure energy resources abroad.

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Ongoing research issues

- Consequential LCA
- Rebound effect
- Time horizon to calculate GWP (20 or 100 years)
- Only difference between shale gas and conventional natural gas is production phase. Distribution infrastructure is the same as conventional gas.
- Part of the problem is that price of natural gas is low:
 - Lots of venting (LOTS)
 - New Federal EPA regs in 2015 will require green completions that greatly reduce methane leakage at wellhead

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Sources

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- Delucchi, M.A. **The Social-Cost Calculator (SCC): Documentation of Methods and Data, and Case Study of Sacramento 2006.** Institute of Transportation Studies, University of California, Davis: Davis, CA. (2013 update)

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