Presentation Slides: Synergies in Natural Gas and Hydrogen Fuels

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SYNERGIES IN NATURAL GAS AND HYDROGEN FUELS

Department of Energy – Argonne National Laboratory
Natural Gas and Hydrogen Infrastructure Opportunities Workshop

Brian Bonner
October 18, 2011

AIR PRODUCTS

Who Is Air Products?

- $9 Billion global company in atmospheric, process and specialty gases, performance materials, equipment and services provider
- Serving industrial, energy, technology and healthcare markets worldwide
- Fortune 500 company
- Operations in over 40 countries
- 18,300 employees worldwide
- Known for our innovative culture and operational excellence
- Recognized industry leader in safety

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World's Leader in Hydrogen

- World's largest merchant supplier
- H_2 production equivalent to fueling ~8 Million cars/day
- Bulk, liquid and pipeline distribution
- More than 500 H_2 customers
- H_2 Energy projects since 1993
  - >130 hydrogen station projects
  - >350,000 fuellings/yr
- Parlayed MHE, cell tower, DOD experiences
- Stations in 19 countries
- Broad IP estate

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Air Products' Role in the LNG Industry

- World's foremost provider of Natural Gas Liquefaction technology and Equipment
  - Full range of process options: from small plants to the world's largest LNG process trains: 6 AP-X® Units On-Stream in Qatar
  - Awarded equipment supply for the world's 1st floating LNG (FLNG) project: Shell Prelude FLNG
  - Majority of the world's LNG production employs Air Products' processes and equipment (main cryogenic heat exchangers)
  - Main cryogenic heat exchangers manufactured by Air Products in the United States and exported worldwide

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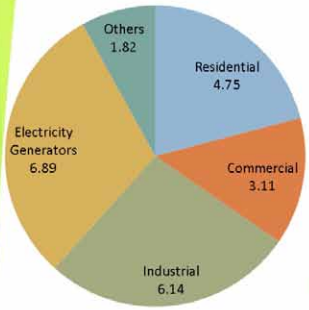
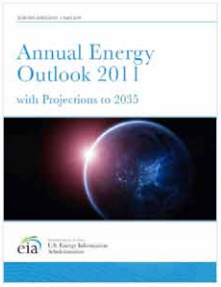
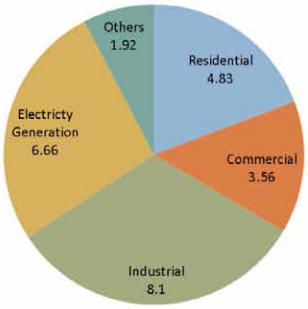
Natural Gas in US

2009 Consumption 22.71 Tcf





AEO 2011 Reference Case
2025 Consumption 25.07 Tcf



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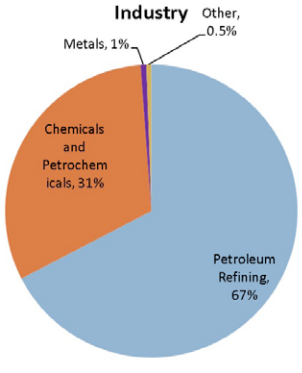
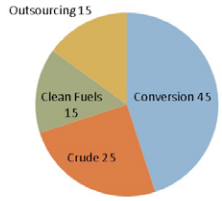
US Consumes ~3.2 Tcf of hydrogen annually



Source: SRI Consulting 2010 Chemical Economics Handbook

Refining Hydrogen and Energy Driving Hydrogen Growth



- Transportation fuels growth
- More heavy, sour crude
- Clean fuels legislation
- Increased outsourcing trend

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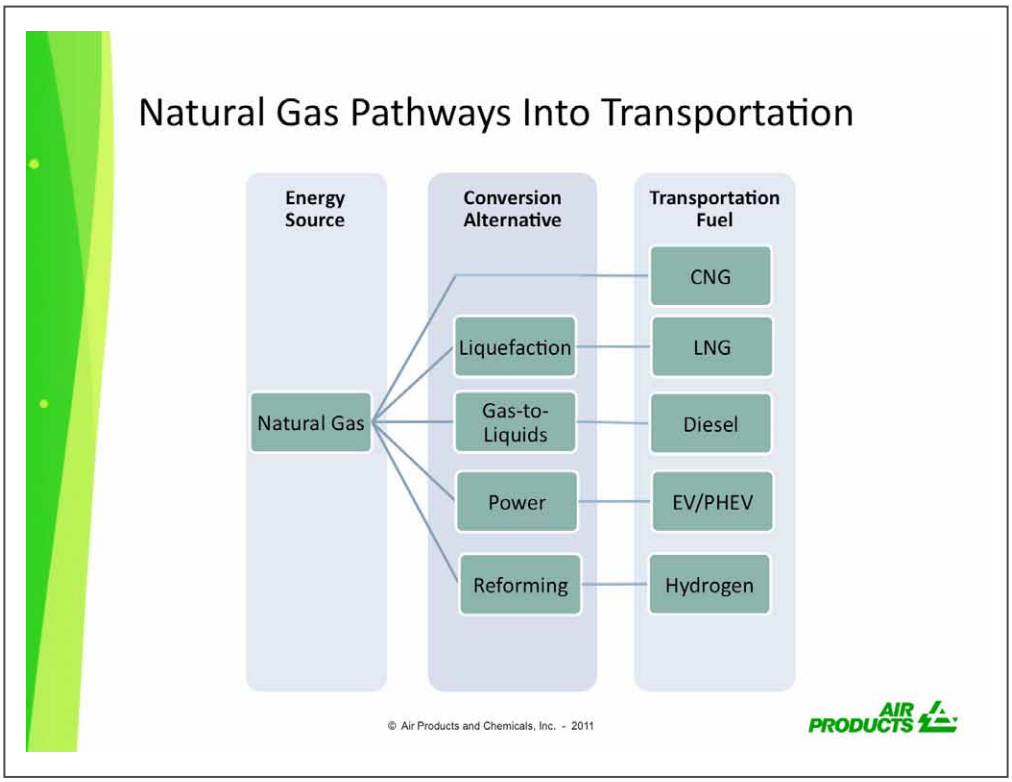
Natural Gas Pathways Into Transportation
Energy Source
Conversion Alternative
Transportation Fuel
Natural Gas
Liquefaction
Gas-to-Liquids
Power
Reforming
CNG
LNG
Diesel
EV/PHEV
Hydrogen
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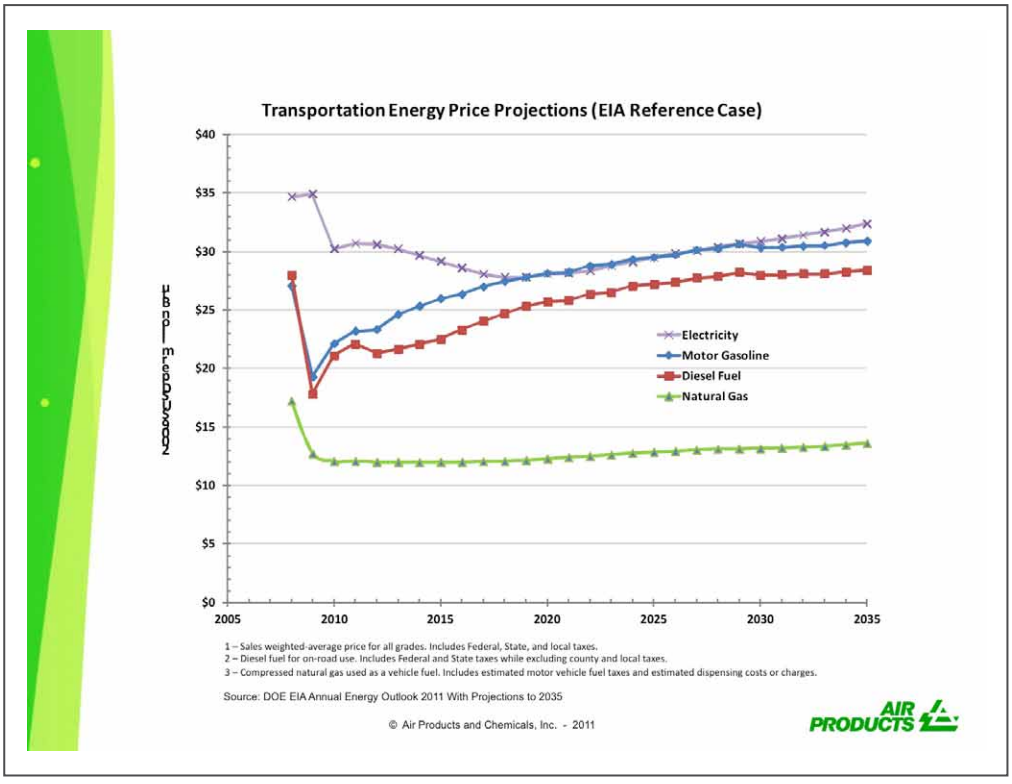
Transportation Energy Price Projections (EIA Reference Case)
$40
$35
$30
$25
$20
$15
$10
$5
$0
2005
2010
2015
2020
2025
2030
2035
Electricity
Motor Gasoline
Diesel Fuel
Natural Gas
1 – Sales weighted-average price for all grades. Includes Federal, State, and local taxes.
2 – Diesel fuel for on-road use. Includes Federal and State taxes while excluding county and local taxes.
3 – Compressed natural gas used as a vehicle fuel. Includes estimated motor vehicle fuel taxes and estimated dispensing costs or charges.
Source: DOE EIA Annual Energy Outlook 2011 With Projections to 2035
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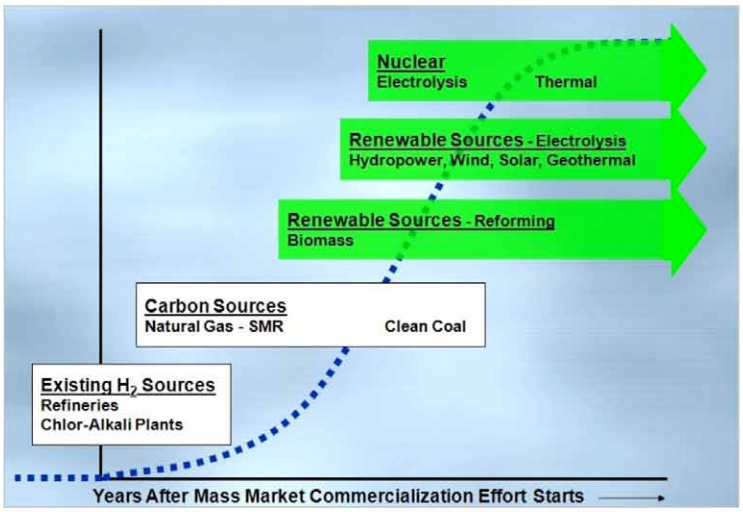
Hydrogen Feedstock Evolution



- Hydrogen from natural gas is today's starting point
- Biomass is first logical step for large-scale renewable hydrogen
- Hydrogen from renewable electricity is regional / long-term

Source: GM, Air Products

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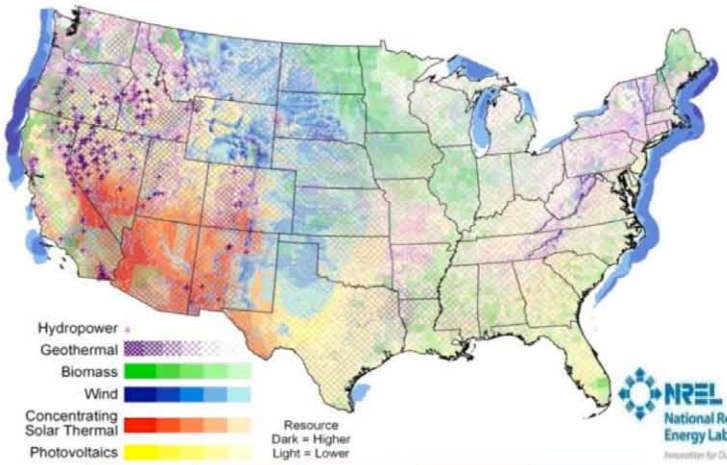
Renewable Hydrogen Potential



Resource	Biomass	Solar PV/CSP)	Wind	Geothermal
Theoretical Potential	395 Million H2 cars	21 Billion H2 Cars	1,251 Million H2 Cars	270 Million H2 Cars

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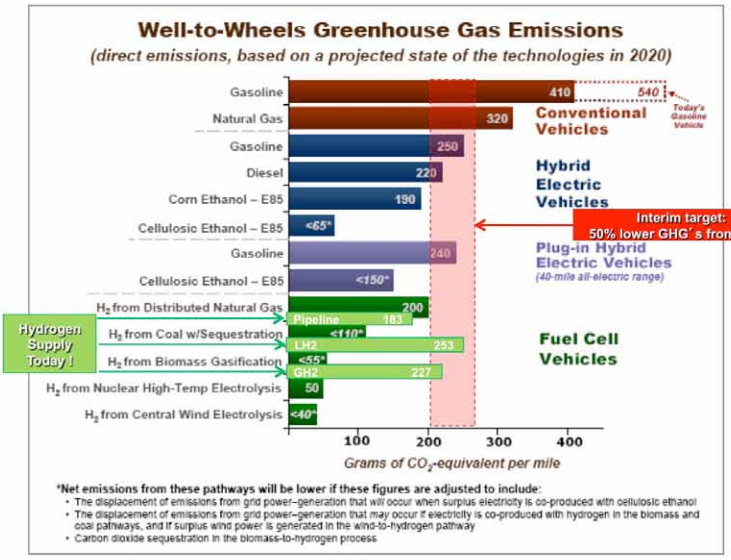
Significant GHG Reduction with Today's Supply



Adapted from DOE hydrogen program record #9002

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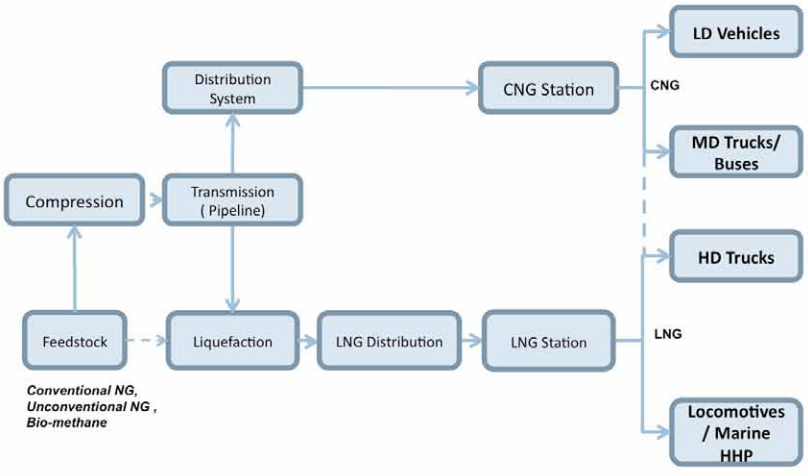
CNG/LNG Supply Chain



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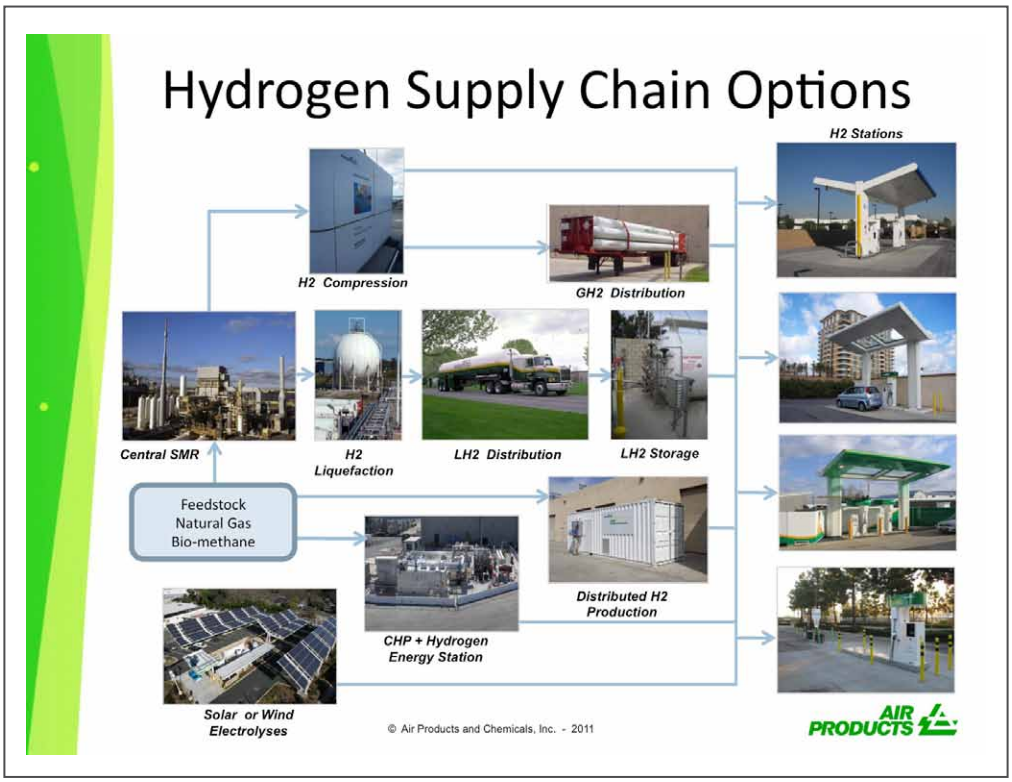
Hydrogen Supply Chain Options
H2 Stations
H2 Compression
GH2 Distribution
Central SMR
H2 Liquefaction
LH2 Distribution
LH2 Storage
Feedstock
Natural Gas
Bio-methane
Distributed H2 Production
CHP + Hydrogen Energy Station
Solar or Wind Electrolyses
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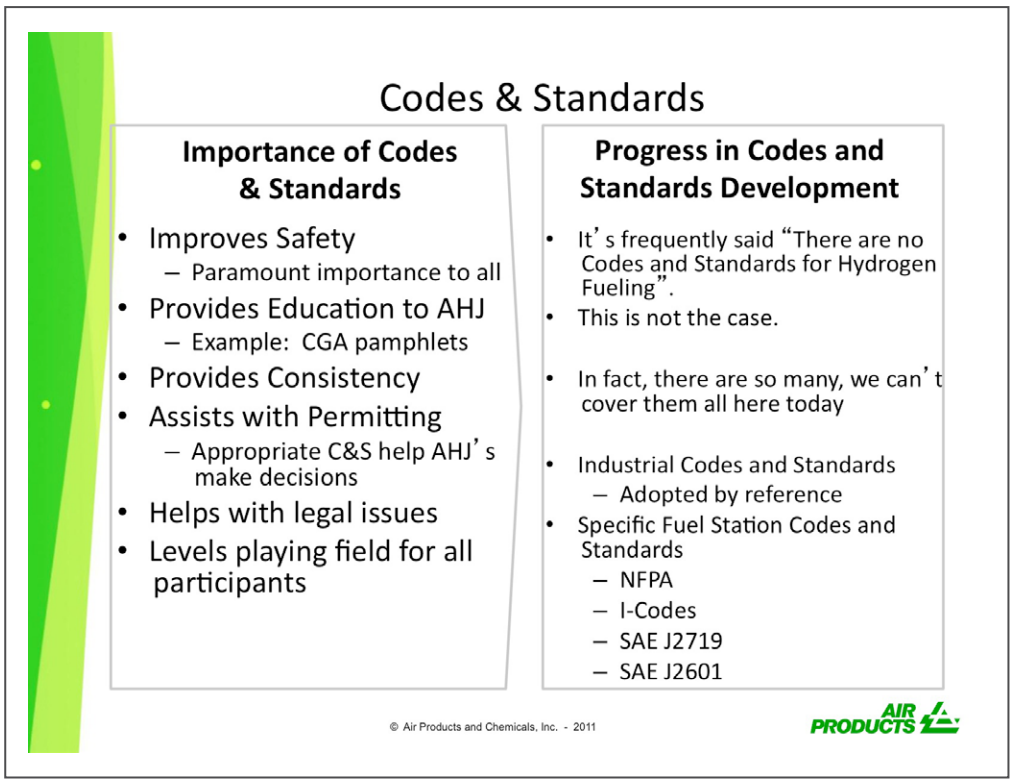
Codes & Standards
Importance of Codes & Standards
• Improves Safety
– Paramount importance to all
• Provides Education to AHJ
– Example: CGA pamphlets
• Provides Consistency
• Assists with Permitting
– Appropriate C&S help AHJ's make decisions
• Helps with legal issues
• Levels playing field for all participants
Progress in Codes and Standards Development
• It's frequently said "There are no Codes and Standards for Hydrogen Fueling".
• This is not the case.
• In fact, there are so many, we can't cover them all here today
• Industrial Codes and Standards
– Adopted by reference
• Specific Fuel Station Codes and Standards
– NFPA
– I-Codes
– SAE J2719
– SAE J2601
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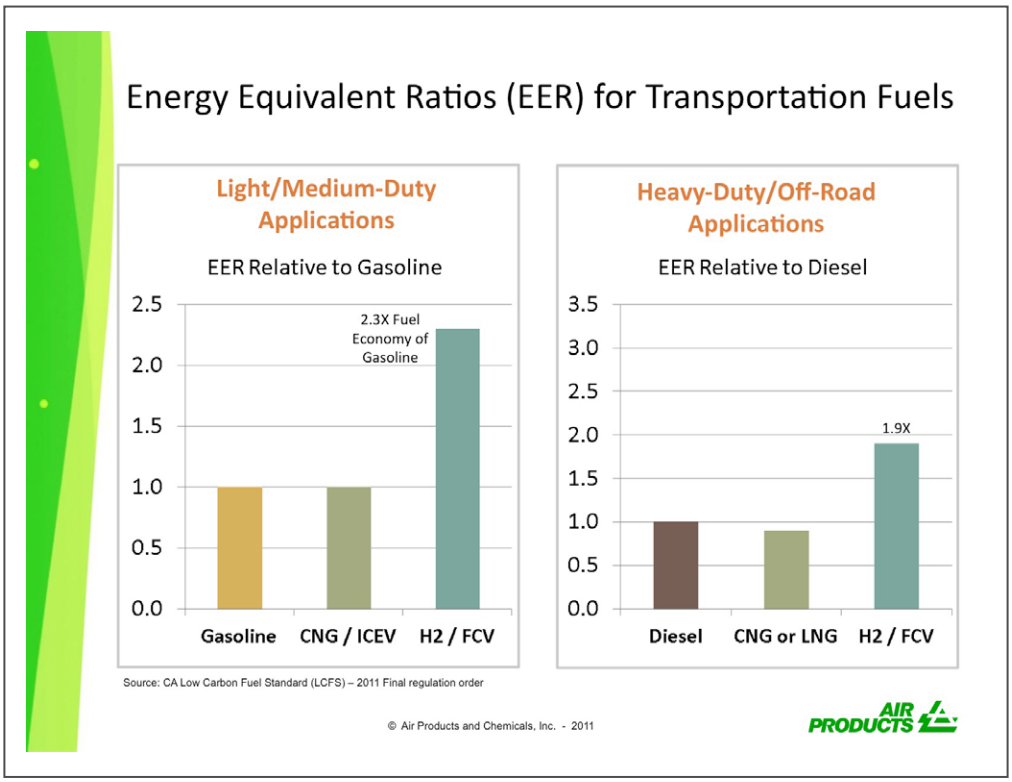
Energy Equivalent Ratios (EER) for Transportation Fuels
Light/Medium-Duty Applications
EER Relative to Gasoline
2.5
2.0
1.5
1.0
0.5
0.0
2.3X Fuel Economy of Gasoline
Gasoline
CNG / ICEV
H2 / FCV
Heavy-Duty/Off-Road Applications
EER Relative to Diesel
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.9X
Diesel
CNG or LNG
H2 / FCV
Source: CA Low Carbon Fuel Standard (LCFS) – 2011 Final regulation order
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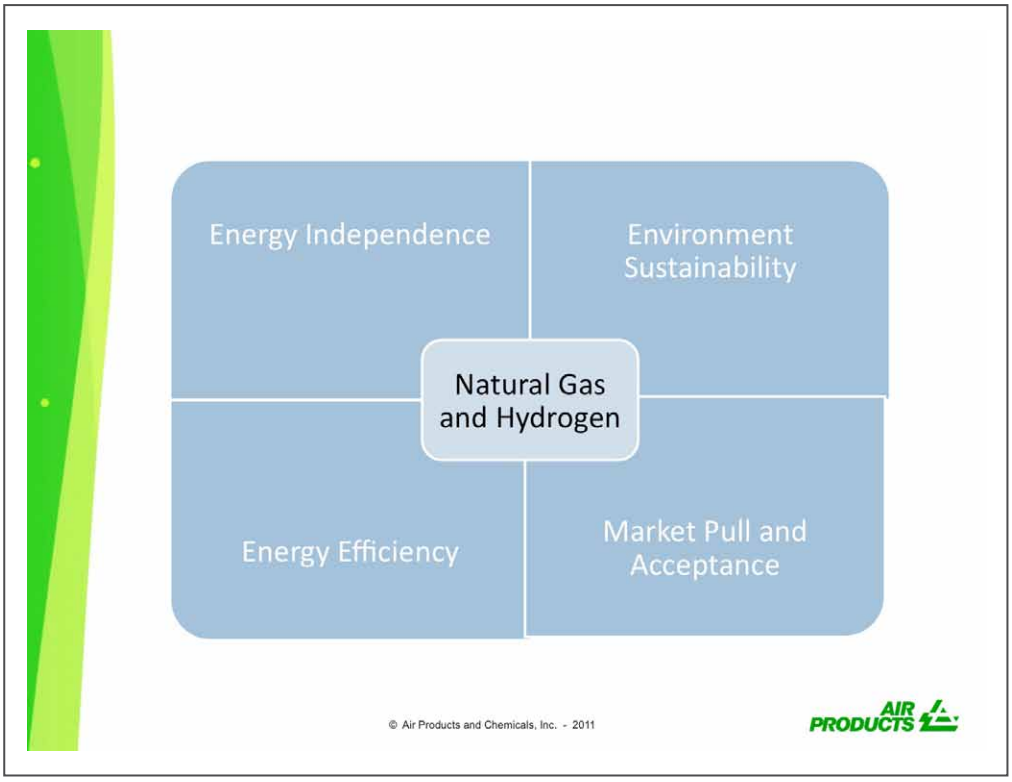
Energy Independence
Environment Sustainability
Natural Gas and Hydrogen
Energy Efficiency
Market Pull and Acceptance
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Summary

- US has an abundant amount of natural gas that's expect to be developed at low cost
- The substantially lower carbon footprint for natural gas and hydrogen produced from natural gas makes natural gas a bridge to a low carbon future
- US renewable energy supply is also abundant and important in developing the long-term solution
- Natural Gas and Hydrogen supply chain infrastructure continue to lower cost and expand in targeted markets
- End market Total Cost of Ownership of vehicle and fuel will influence market acceptance and market scale of alternative fuels

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Thank You!
www.airproducts.com/h2energy

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