

Alternative Natural Gas Applications Workshop Creating a Prosperous Demand Market

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Figure 1.1 Primary Energy Overview (Quadrillion Btu)



EIA Monthly Energy Review 9/2014 http://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf



Natural gas production

million cubic feet/day



• US Shale Gas Production

• Production quadrupled 2 years

Ref: http://www.eia.gov/petroleum/drilling/pdf/marcellus.pdf

PENNSTATE Estimated US Energy Use 2013

1855

Lawrence Livermore National Laboratory Estimated U.S. Energy Use in 2013: ~97.4 Quads Net Electricity 0.179 Imports 0.0849 Solar 0.320 8.27 12.4 25.8 Electricity Nuclear 8.34 Generation 8.27 Rejected 38.2 2.53 16.5 Energy Hydro 59.0[°] 2.56 3.98 4.75 1.59 Wind Residential 1.60 0.157 11.4 0.232 0.0197 Geothermal 0.893 0.420 0.201 5.05 3.01 4.57 0.0197 Natural Commercial Gas 8.59 26.6 Energy 3.36 0.477 Services 0.0320 38.4 0.0454 4.94 3.26 0.112 9.08 Coal Industrial 19.8 18.0 24.7 8.58 1.50 2.25 0.465 Biomass 21.3 4.49 1.24 0.79 0.262 Transportation 24.9 27.0 Petroleum 5.66 35.1

Source: LLNL 2014. Data is based on DOE/EIA-0035(2014-03), March, 2014. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential and commercial sectors 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

PENNSTATE **Estimated US Carbon Emissions 2013**

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Estimated U.S. Carbon Emissions in 2013: ~5,390 Million Metric Tons



Source: LLNL 2014. Data is based on DOE/EIA-0035(2014-03), March, 2014. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Carbon emissions are attributed to their physical source, and are not allocated to end use for electricity consumption in the residential, commercial, industrial and transportation sectors. Petroleum consumption in the electric power sector includes the non-renewable portion of municipal solid waste. Combusition of biologically derived fuels is assumed to have zero net carbon emissions - the lifecycle emissions associated with producing biofuels are included in commercial and industrial emissions. Totals may not equal sum of components due to independent rounding errors. LLNL-MI-410527





*Cost of fossil fuels at electricity generating plant 2013, U.S. Energy Information Administration / Monthly Energy Review September 2014 page 129

PENNSTATE Public Policy ... New Boundary Conditions

Air Pollution and the Clean Air Act





Clean Water Act

Increases in the Energy Efficiency of Household Appliances, 1981 to 2012



Sustainability

Source: Professor Roland Clift, Centre for Environmental Strategy (CES), University of Surrey; www.surrey.ac.uk



Which is More "Sustainable" ?





Paper Bag (Recycled Content) Plastic Bag



Impact Summary of Various Bag Types (Carrying Capacity Equivalent to 1000 Paper Bags)	Paper (30% Recycled Fiber)	Polyethylene
Total Energy Usage (MJ)	2,622	763
Fossil Fuel Use (kg)	23.2	14.9
Municipal Solid Waste (kg)	33.9	7.0
Greenhouse Gas Emissions (CO ₂ Equiv. Tons)	0.08	0.04
Fresh Water Usage (Gal)	1,004	58
Landfill Half-Life	Short	Ś

Sources:

• "Bag fact sheet", American Chemistry Council

• "Life Cycle Assessment for Three Types of Grocery Bags - Recyclable Plastic; Compostable, Biodegradable Plastic; and Recycled, Recyclable Paper ", Boustead Consulting & Associates Ltd





Source: EPA, http://www.epa.gov/statelocalclimate/images/flow_chart_life_cycle_big.jpg



- "Shale Gas new major investments, environmental improvement
- Sustainability an evolving change to boundary conditions for solution
- Innovation push for the box ; technology (solution) <-> Need (market)



Chemicals – Shell Cracker



NOVEMBER 19, 2013 | 5:30 PM BY KATIE COLANERI

Comment Tweet 3

Royal Dutch Shell's decision about whether to build a multibillion dollar ethane cracker in Beaver County could still be several years off, but the Associated Press has found that the company is actively taking steps to explore the site.

More from the Associated Press:



PENNSYLVANIA Energy. Environment. Economy.

REGULATION -ECONOMY - INFLUENCE -IMPACT -

Shell's proposed ethane cracker could be a big emitter

JUNE 23, 2014 | 12:45 PM BY KATIE COLANERI

7 Comments Tweet 5

The Pittsburgh Tribune-Review reports Shell's proposed ethane cracker in

western Pennsylvania could be a significant new source of air pollution.

The company has not yet committed to building the multi-billion dollar petrochemical plant, but has applied to the Department of Environmental Protection for an air quality permit for the site in Monaca, Beaver County.



🔀 Email

Recommend

\$ 54

MARIE CUSICK/STATEIMPACT PENNSYLVANIA Shell construction manager Ken Conly talks about the ethane cracker project at a public meeting.

Potential New **Chemicals Investment**

Local / Global









Delta Airlines' Trainer, Pennsylvania Refinery

TRANSPORTATION

Savings ~ 300 MM\$

• System savings

Invest ~150 MM\$

More: Airlines Delta Airlines Fuel Costs Transportation 🗸

How Delta Bought A Refinery And Wound Up Saving Its Rivals A Ton Of Cash

🛛 BENJAMIN ZHANG 🛛 🗹

Delta sources Bakken crude for Pa. refinery

Deal accounts for one third of refinery's capacity.

By Daniel J. Graeber | July 21, 2014 at 10:19 AM | 0 Comments (Leave a comment)

Ref: <u>http://www.businessinsider.com/delta-airlines-fuel-prices-2014-8</u> http://www.upi.com/Business_News/Energy-Resources/2014/07/21/Delta-sources-Bakken-crude-for-Parefinery/5281405951764/

Transportation Fuel – Natural Gas



Ref: http://www.pickensplan.com

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Technology

<u>Network</u>

- Compressed Natural Gas (CNG)
- Liquefied Natural Gas (LNG)
- Dimethyl Ether (DME)
- Hydrogen

Natural

Gas

• Gas to Liquids

Ref: http://www.linde-gas.com/en/innovations/hydrogen_energy/index.html

- Production, distribution
- Fueling stations
- Vehicles: car, rail, marine ...



Technology

Network



Infrastructure, standards



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- Projects that have direct financial return
- Power generation
- Novel supply chain investments
- Residential and industrial conversion

Network

- Need coordinated supply chain investment
- Transportation fuels infrastructure
- H2, CNG, LNG, DME
- GTL

Risk, Unknown

- Long term price of natural gas
- Sustainability regulation, emissions, water
- High capital risk



- System Level Benefits
- Operating Expense
- Capital Expense



- Technology create new opportunity
- System level thinking
- Profitability and <u>Sustainability</u>



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Thank You!