Biological Technologies for Methane-to-Liquid Fuels

ARPA-E Workshop

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Advanced Research Projects Agency – Energy
U.S. Department of Energy

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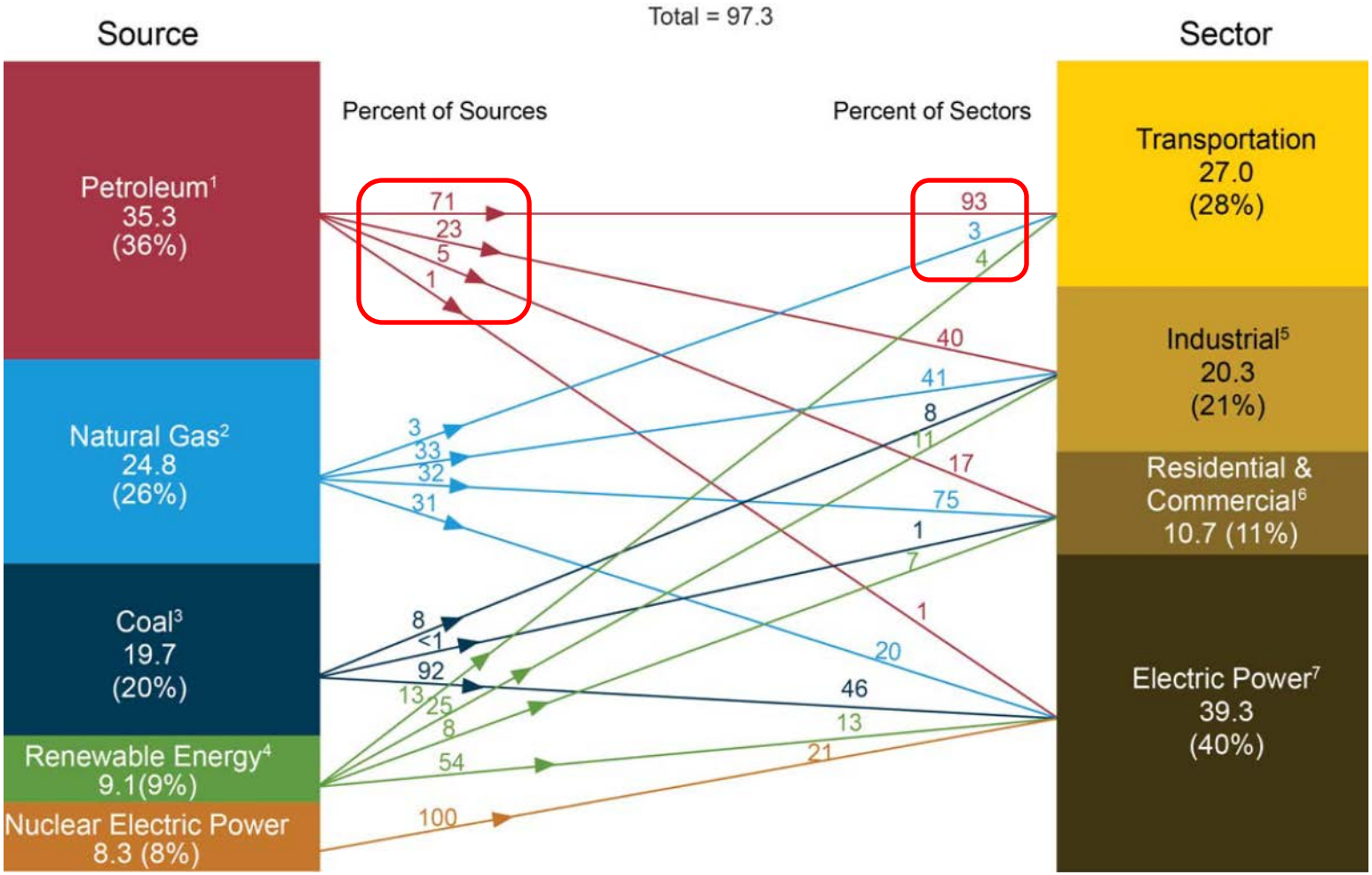
www.arpa-e.energy.gov

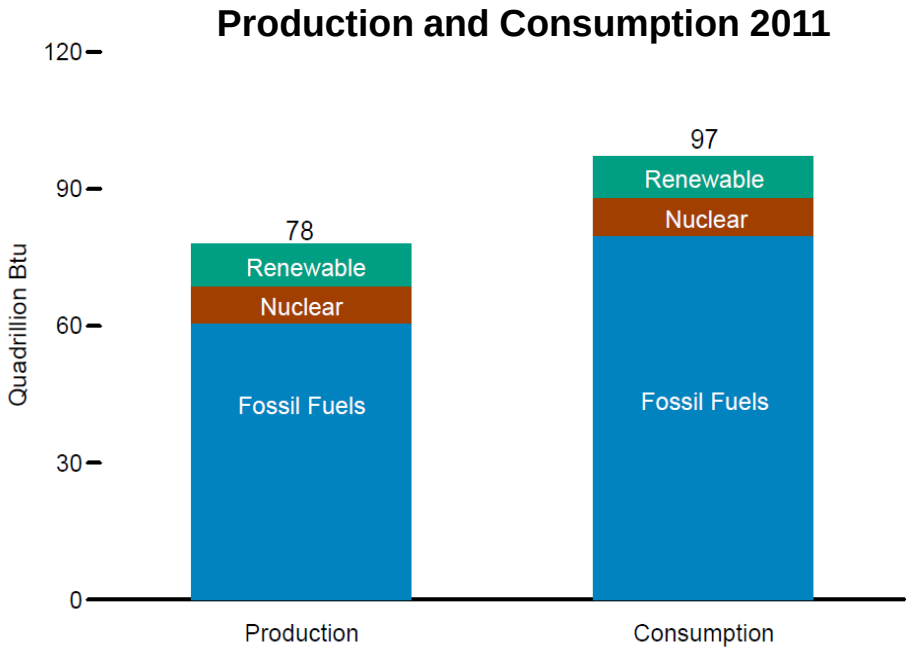
>90% of the nation's transportation sector is powered by petroleum

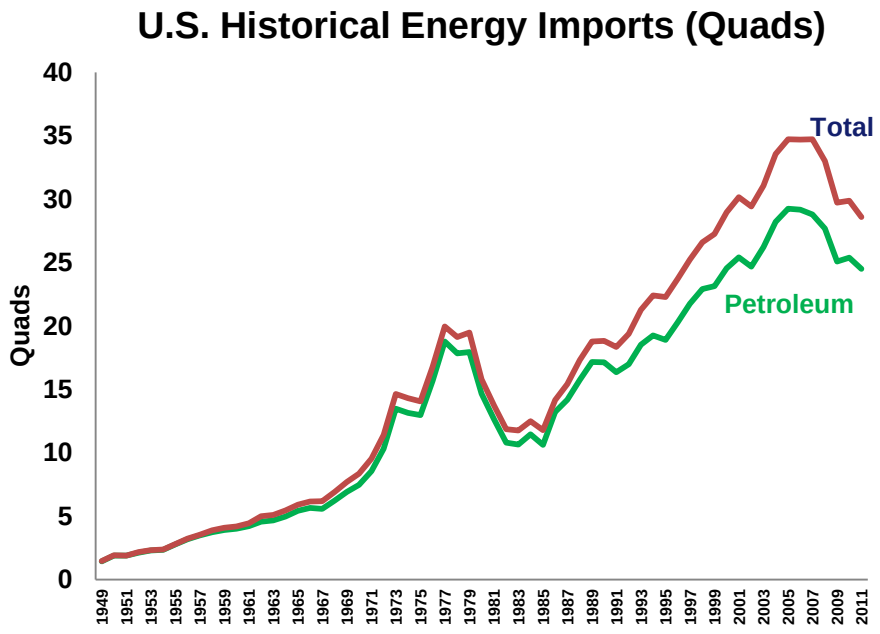


Primary energy consumption by source and sector (Quadrillion Btu)

U.S. Energy Information Administration / Annual Energy Review 2011

The U.S. relies on imported petroleum to meet the nation's full energy demand



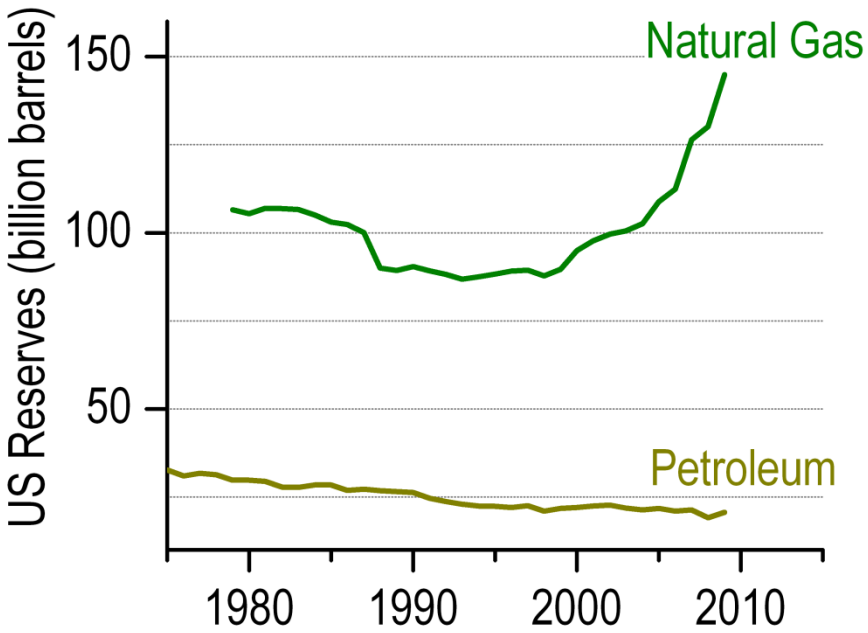


Current cost of U.S. petroleum imports accounts for nearly 50% of the nation's trade deficit

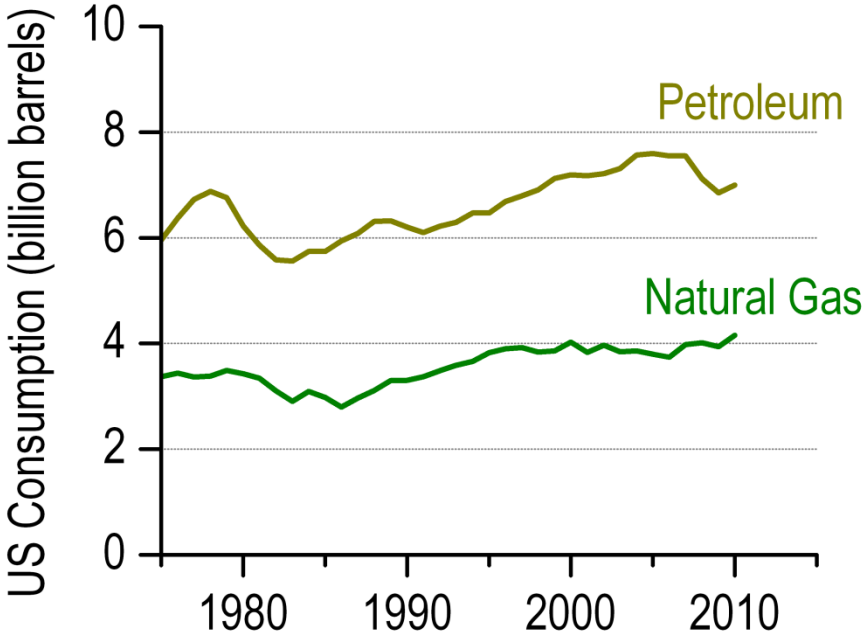
U.S. Energy Information Administration / Annual Energy Review 2011

Proven U.S. natural gas supplies have increased substantially over the last decade

U.S. Proven Reserves



U.S. Annual Consumption



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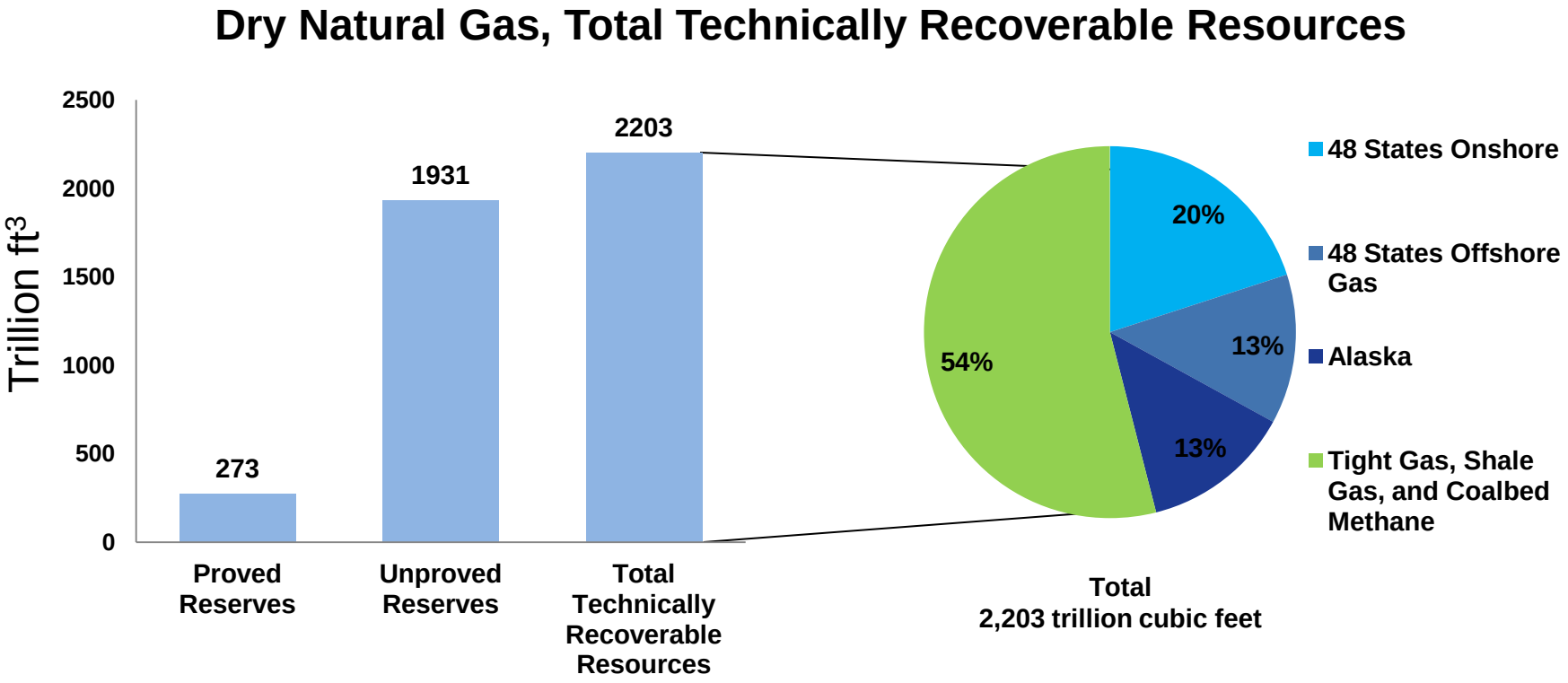
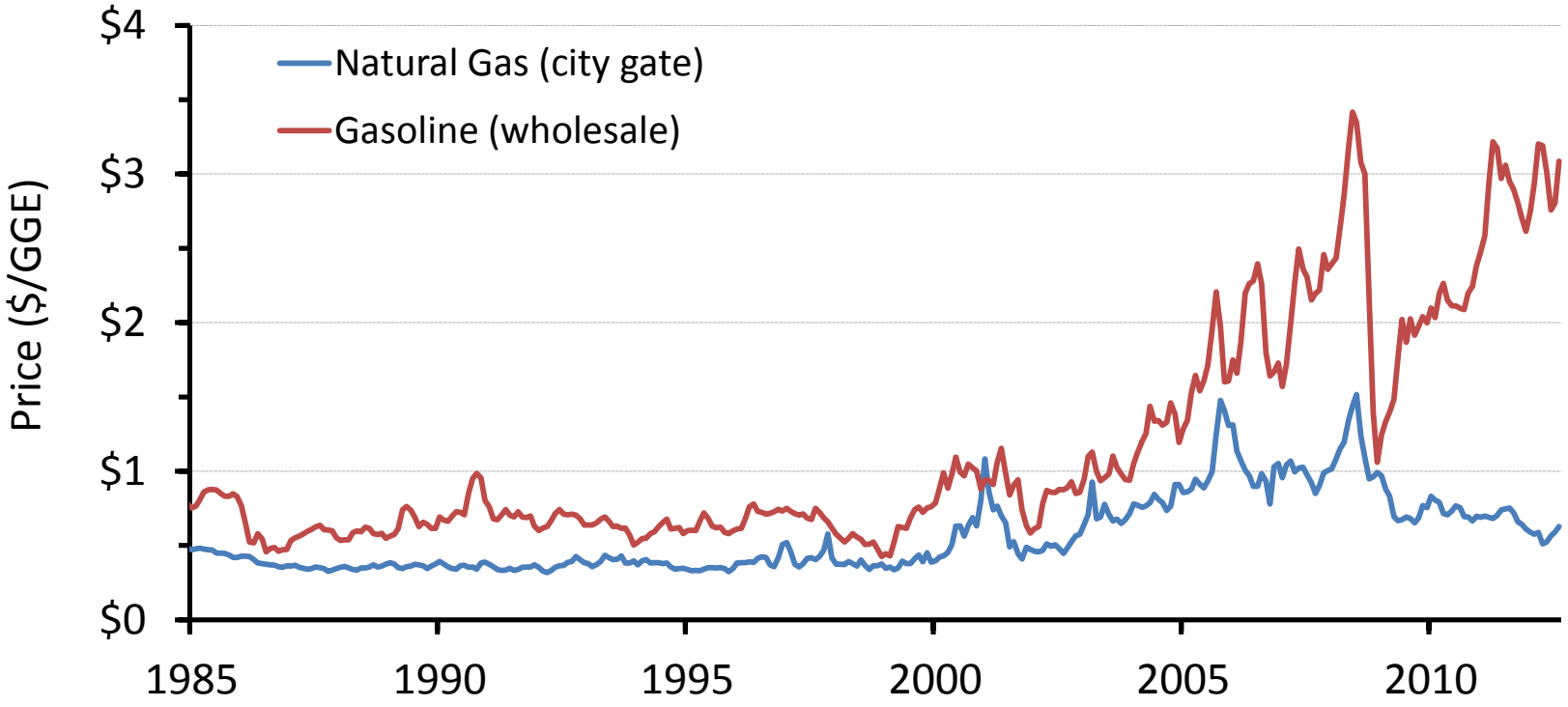
Technically recoverable estimates suggest a resource abundance poised for new markets



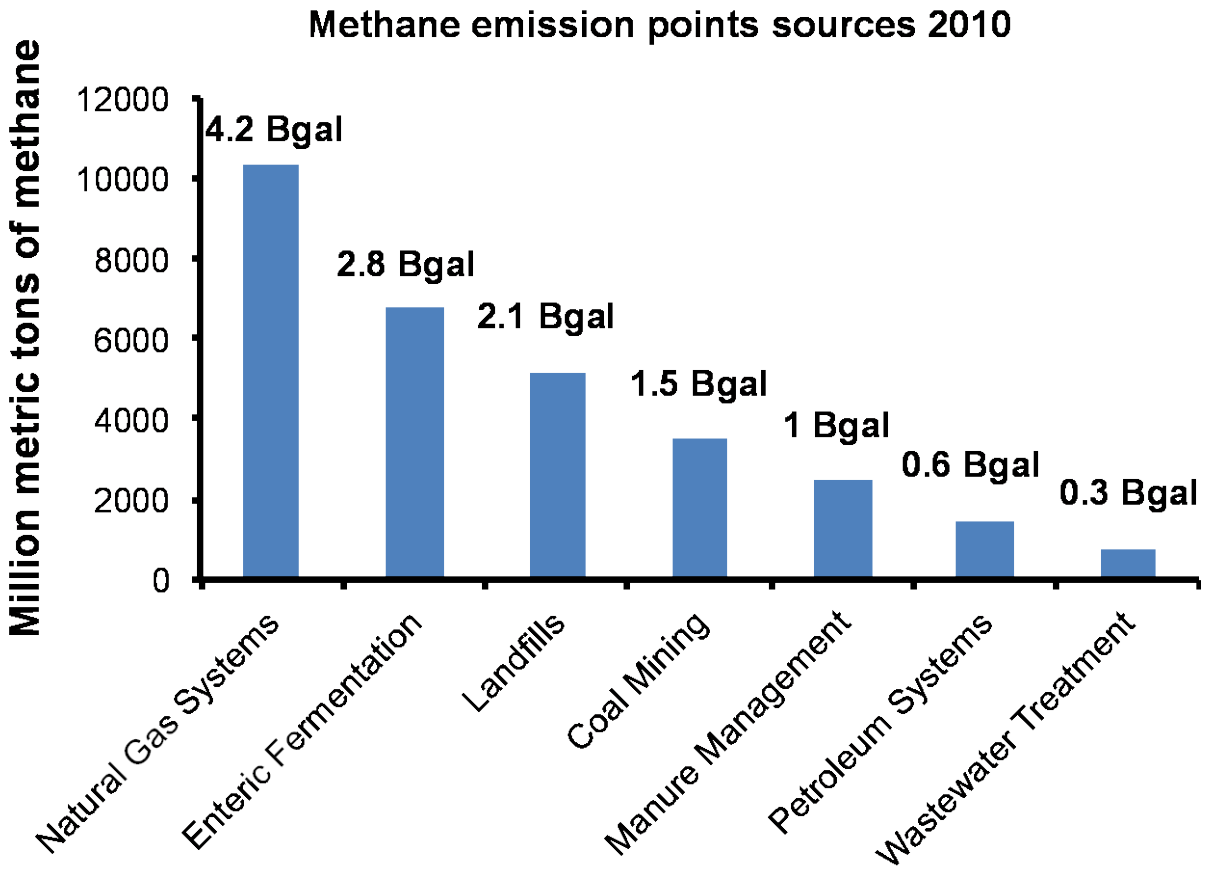
At current annual consumption rates (~ 25 tcf), technically recoverable reserves (~ 2,500 tcf) would last for ~ 100 years

U.S. Energy Information Administration / Annual Energy Review 2011

U.S. annual natural gas and petroleum prices have lately diverged from historical trends



Methane is a potent greenhouse gas and is emitted from numerous anthropogenic sources



Potential to produce up to 12 billion gallons of butanol per year from methane emissions alone

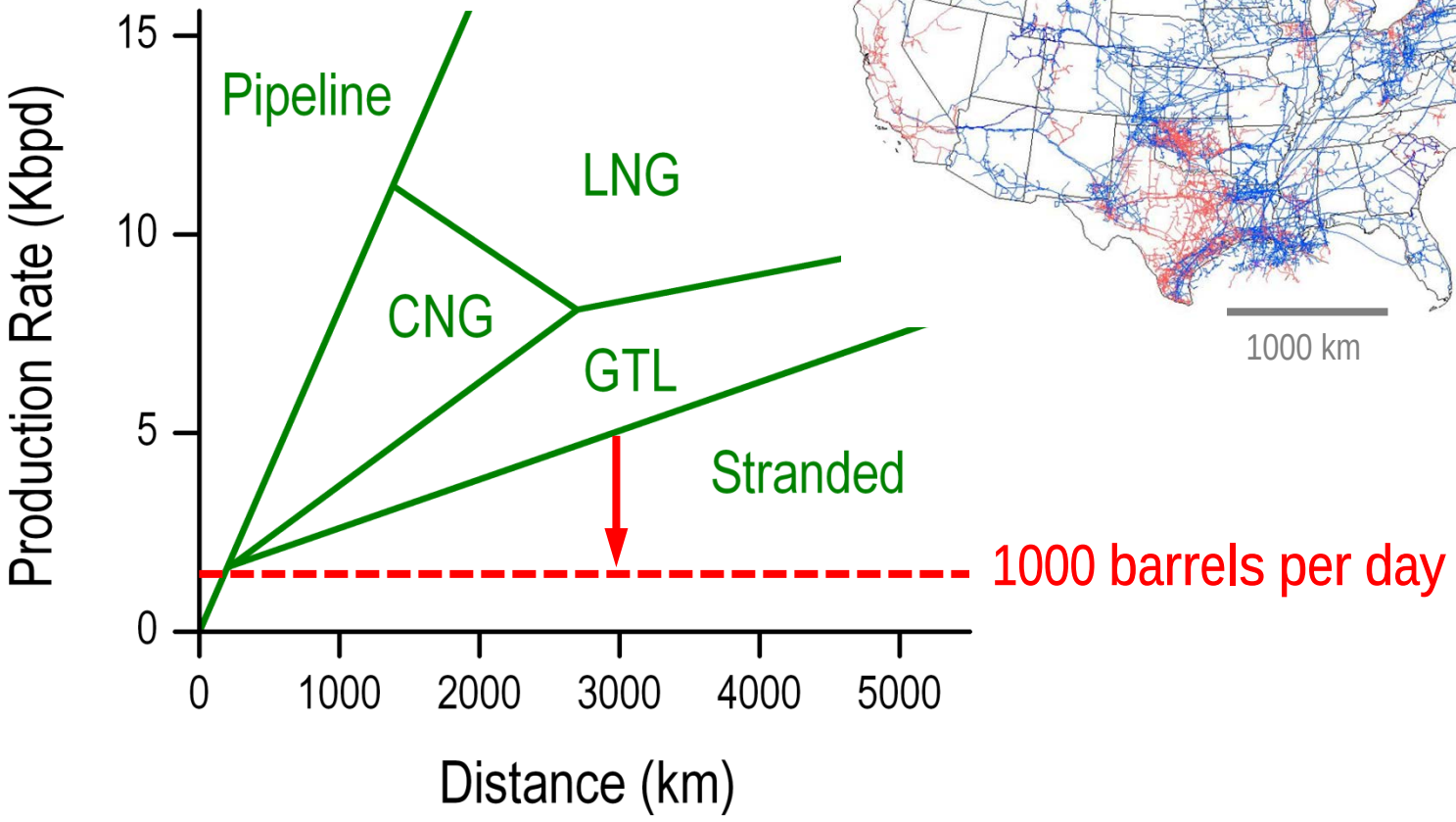
(Assumed stoichiometry requirements of 170 ft^3 to 1 gallon butanol via anaerobic methanotrophy)

U.S. Energy Information Administration / Annual Energy Review 2011
And http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2012-ES.pdf

Now is the time for natural gas technologies…

- Vast majority of the nation's imported energy is for liquid fuels for transportation
- New production technologies have pushed US natural gas resources available in excess of current and future needs (50-100 years)
- Significant, long-term spread between natural gas and petroleum/oil prices expected
- Opportunity to convert natural gas to liquid fuels and reduce US oil imports/trade deficit

Yet profitability of bringing natural gas to market depends on both production rate and distance



Hawkins, D. TransOcean,Global, Gas Flaring Reduction Conference, Paris Dec 13-15, 2006

Economically attractive low feedstock costs are driving new gas-to-liquids project development

South African Company to Build U.S. Plant to Convert Gas to Liquid Fuels

By CLIFFORD KRAUSS
Published: December 3, 2012

WESTLAKE, La. — In an ambitious bet that the glut of cheap natural gas in the United States will last for many years, a South African energy company announced on Monday that it would build America's first commercial plant to convert natural gas to diesel and other liquid fuels.

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Michael Stravato for The New York Times

Sasol's chief executive, David Constable, left, and Gov. Bobby Jindal announced the deal for the new plant on Monday in Westlake, La.

The company, Sasol, which is based in Johannesburg, has been a pioneer in a technology that has tantalized energy scientists for decades over its potential to produce liquid fuels without using oil, which has historically cost far more than natural gas.

Having already built smaller plants in South Africa and Qatar, Sasol has designed its new Louisiana plant to produce 96,000 barrels of fuel a day using its "gas to liquids," or G.T.L., technology. It will be the second-largest plant of its kind in the world, after Royal Dutch Shell's Pearl plant in Qatar, and will cost $11 billion to $14 billion to build.

Green

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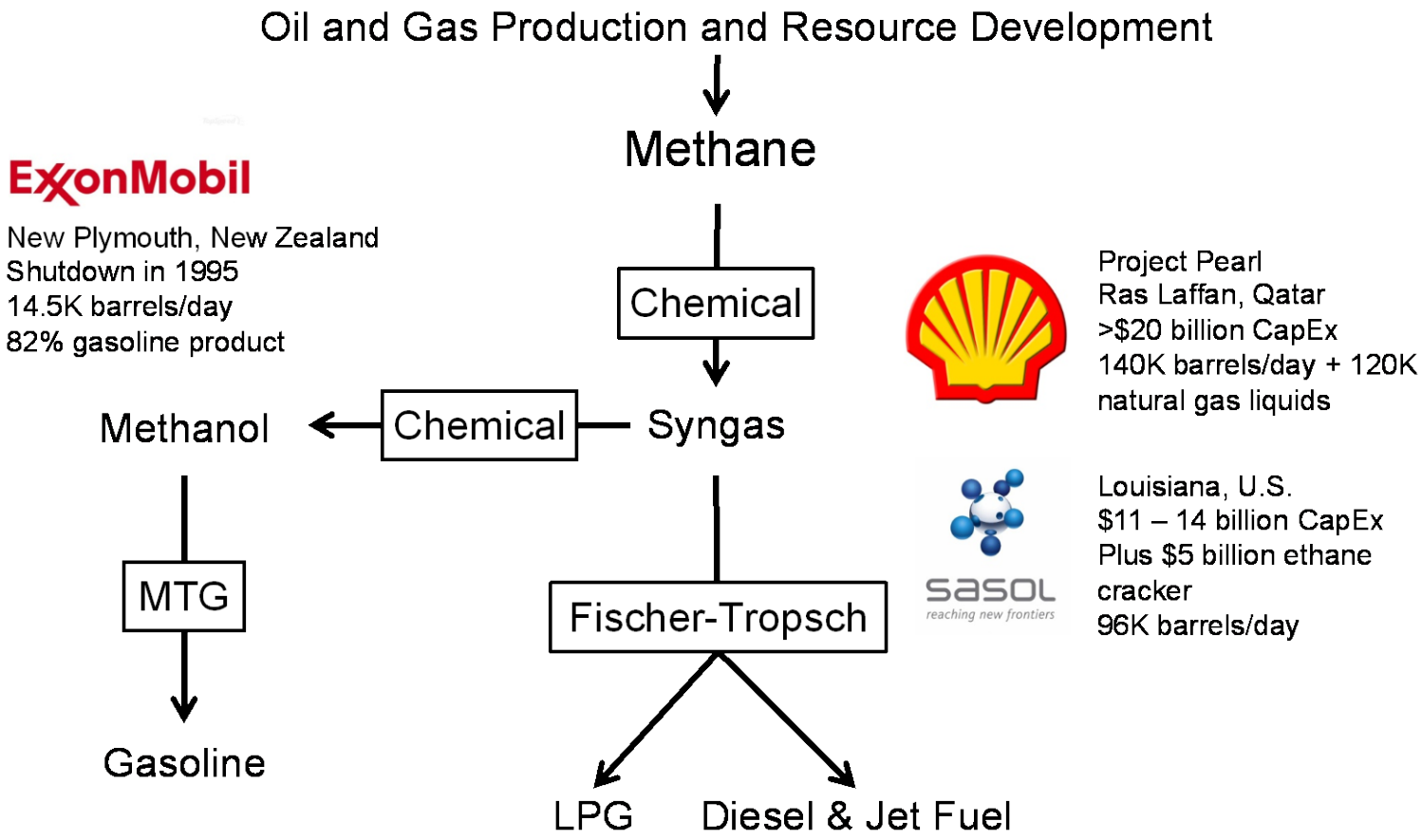
sasol
reaching new frontiers

Announced Monday in NY Times:

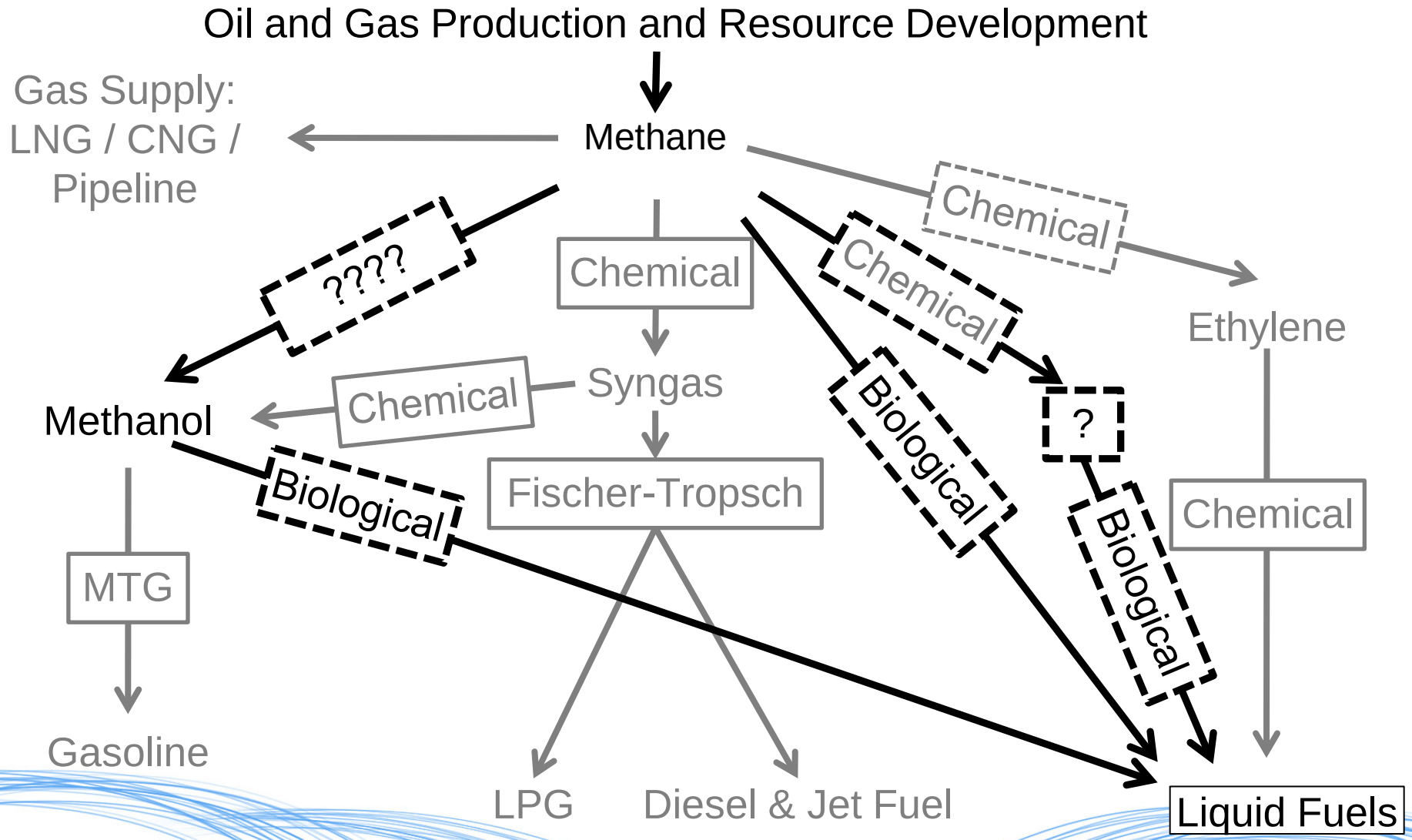
- 1st US commercial plant in LA
- 96 K barrels/day
- $11 – 14 billion CapEx
- Plus $5 billion ethane cracker

GTL projects deployed/to be deployed utilize methane indirectly through synthesis gas



- **Low efficiency (low 40's) & selectivity**
- **Very large CapEx.**
- **Very large scale required for "cost-effective" process.**

Direct conversion is needed to avoid syngas, lower CapEx, and increase profits at smaller scale



Why methane bio-conversion to liquid transportation fuels?

Efficiency	Carbon- and energy-efficient conversion • 66-100% carbon efficiency, 53-79% energy efficiency for conversion of methane to drop-in "designer" (C ≥ 4) products.
Opportunity	Decentralized model for technology deployment • Small-scale facilities allow access to remote/stranded gas
Process Integration	Reduction in conversion steps of natural gas to liquid fuels • Most/all of reactions takes place within engineered microorganism
Monetization	Cost-effective production of liquid transportation fuels from domestic energy source • Higher yield, lower pressure, lower temperature, lower CapEx

Workshop agenda, morning

8:30-8:40	Eric Toone, Principal Deputy Director ARPA-E
8:40-9:00	Ramon Gonzalez, Program Director ARPA-E
9:00-9:30	Doug Cameron, Co-President & Director First Green Partners
9:30-10:00	Greg Stephanopoulos, W.H. Dow Professor of Chemical Engineering and Biotechnology MIT
10:00-10:05	Agenda & Breakout Expectations
10:05-10:20	Break & Room Change
10:20-12:15	Breakout Session A (Franklin)
	Breakout Session B (Edison)
	Breakout Session C (Carver)
12:15-1:00	Lunch

Speakers

Doug Cameron
Co-President & Director
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Greg Stephanopoulos
W.H. Dow Professor of Chemical Engineering and Biotechnology
MIT