

Natural Gas

“Infrastructure as Momentum”



Dr. Fred Beach

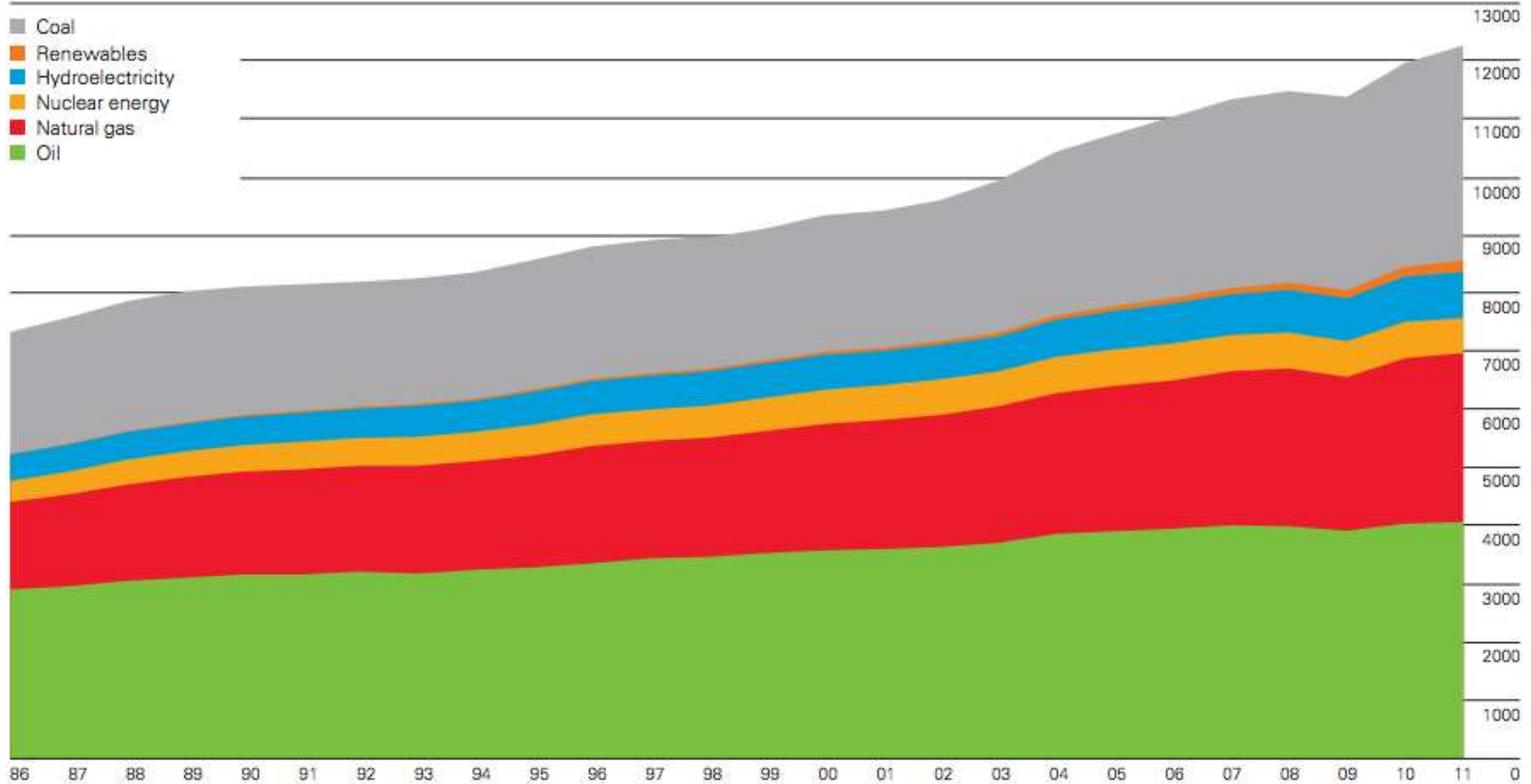
Energy Institute
The University of Texas at Austin

Fossil Fuels Supply 87% of All Energy Consumption in the World

World consumption

Million tonnes oil equivalent

- Coal
- Renewables
- Hydroelectricity
- Nuclear energy
- Natural gas
- Oil



World primary energy consumption grew by 2.5% in 2011, less than half the growth rate experienced in 2010 but close to the historical average. Growth decelerated for all regions and for all fuels. Oil remains the world's leading fuel, accounting for 33.1% of global energy consumption, but this figure is the lowest share on record. Coal's market share of 30.3% was the highest since 1969.

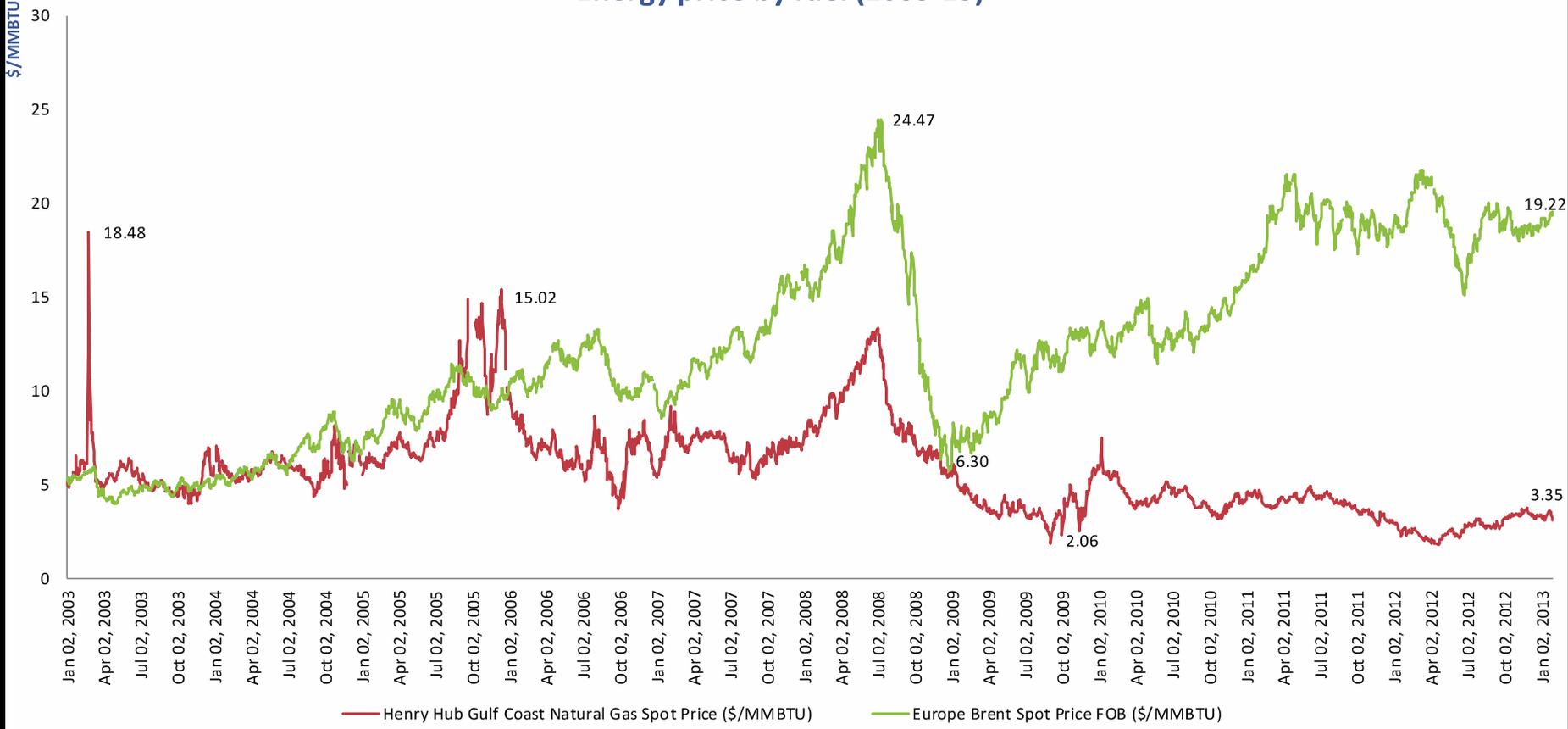
Global Consumption Trends 2011

- Energy Consumption, + 2.5%
 OECD, Down
 Non-OECD, Up
- Oil Consumption, + 0.7%
 OECD, -1.2%
 Non-OECD, +2.8%
- Natural Gas Consumption, +2.2%
 EU, -9.9%
 China, +21.5%
- Coal Consumption, +5.4%
 OECD, -1.1%
 Non-OECD, +8.4%

World's 10 Largest Energy Projects in \$'s

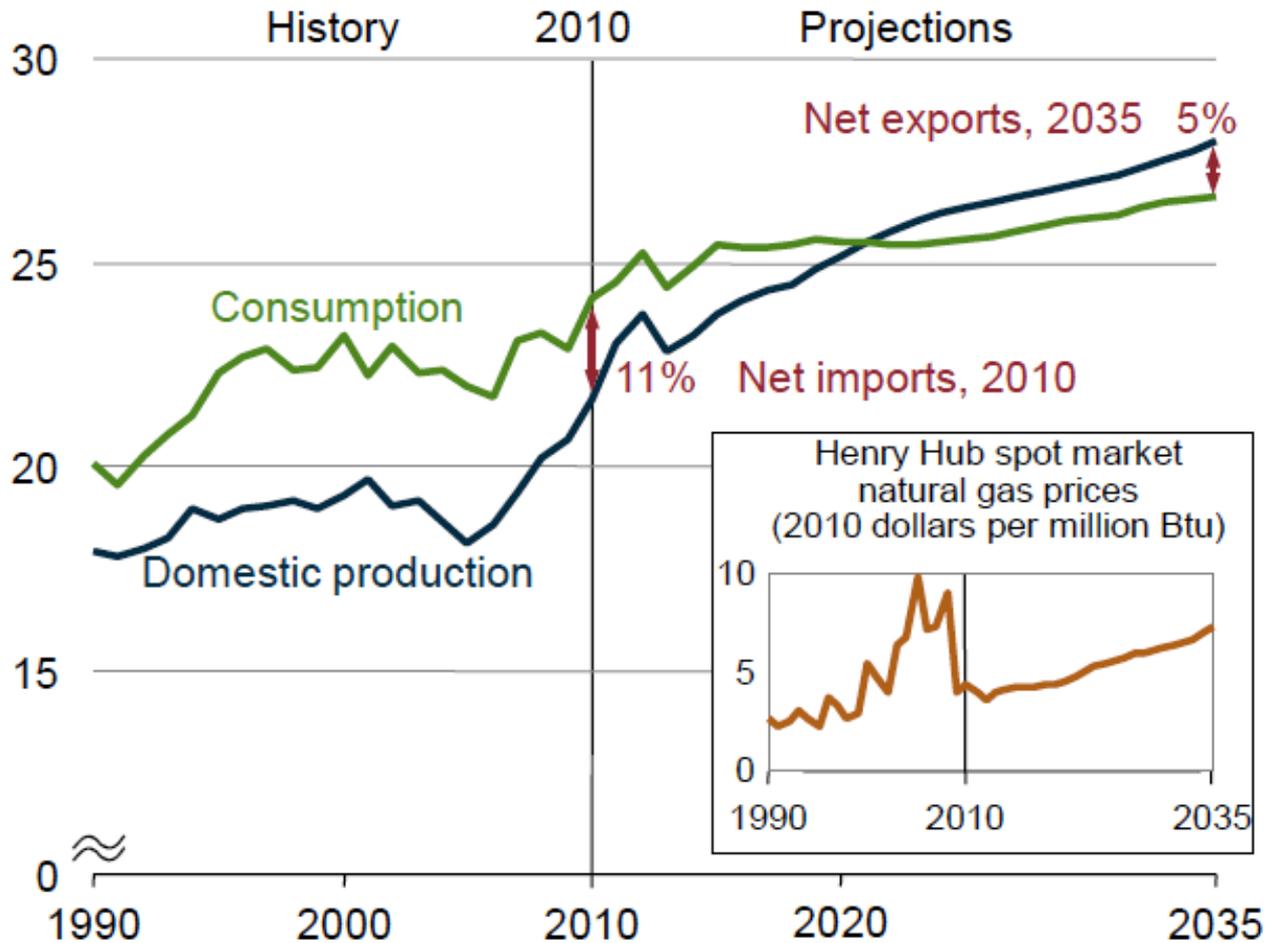
Rank	Name	Energy	Country	Cost (\$ Billion)
10	Three Gorges Dam	Hydro	China	\$28
9	Gladstone (Santos, Petronas, Total)	Gas	Australia	\$30
8	Kearl (Imperial & Exxon Mobile)	Oil	Canada	\$33
7	Queensland Curtis (BP)	Gas	Australia	\$34
6	Wheatstone (Chevron, Apache, TEPCO, Kuwait Foreign Petroleum)	Gas	Australia	\$35
5	Australia Pacific (Origin, ConPhil, Sinopec)	Gas	Australia	\$37
4	Bovanenkovskoye (Gazprom)	Gas	Russia	\$41
3	Ichthys (Inpex & Total)	Gas	Australia	\$43
2	Gorgon (Chevron, Exxon & Shell)	Gas	Australia	\$57
1	Kashagan (KazMunayGas, ENI, Shell, Exxon, Total, ConPhil, INPEX)	Oil	Kazakhstan	\$116

Energy price by fuel (2003-13)



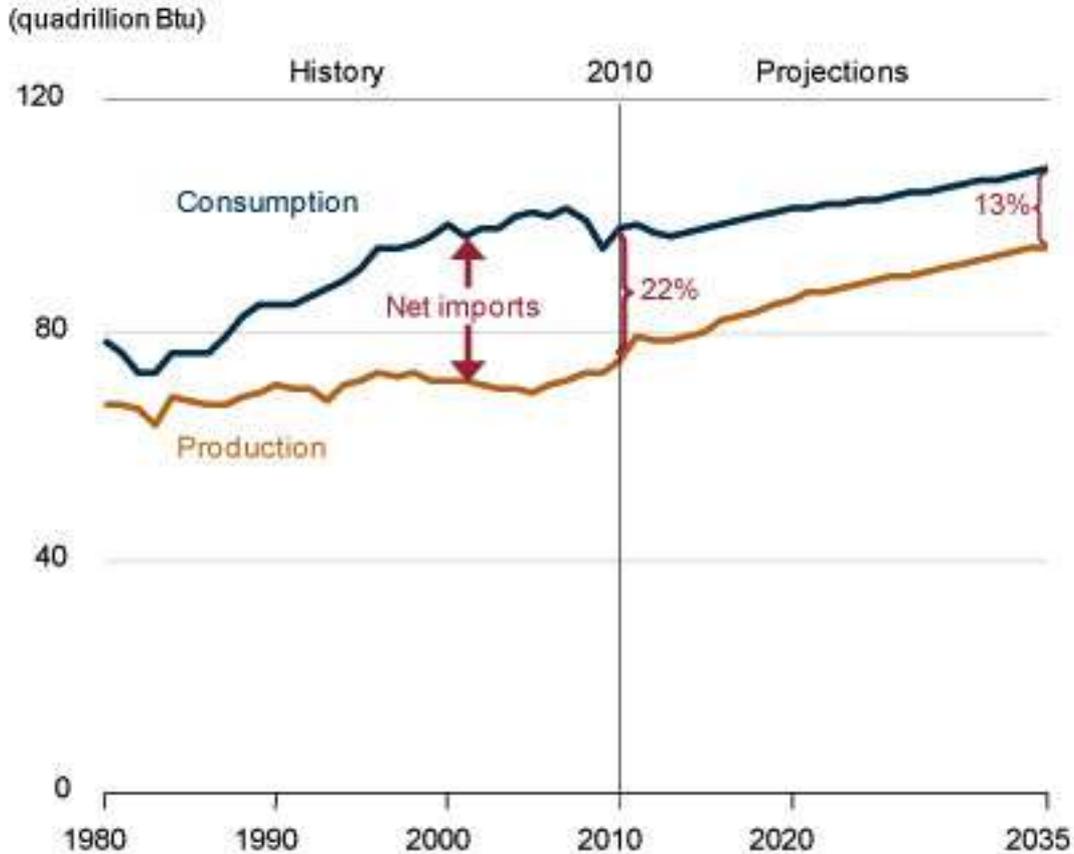
U.S. Natural Gas Production

Figure 4. Total U.S. natural gas production, consumption, and net imports, 1990-2035 (trillion cubic feet)



U.S. Energy Independence Trend

Figure 11. Total energy production and consumption, 1980-2035
(quadrillion Btu)



US for 2012
(Quads)

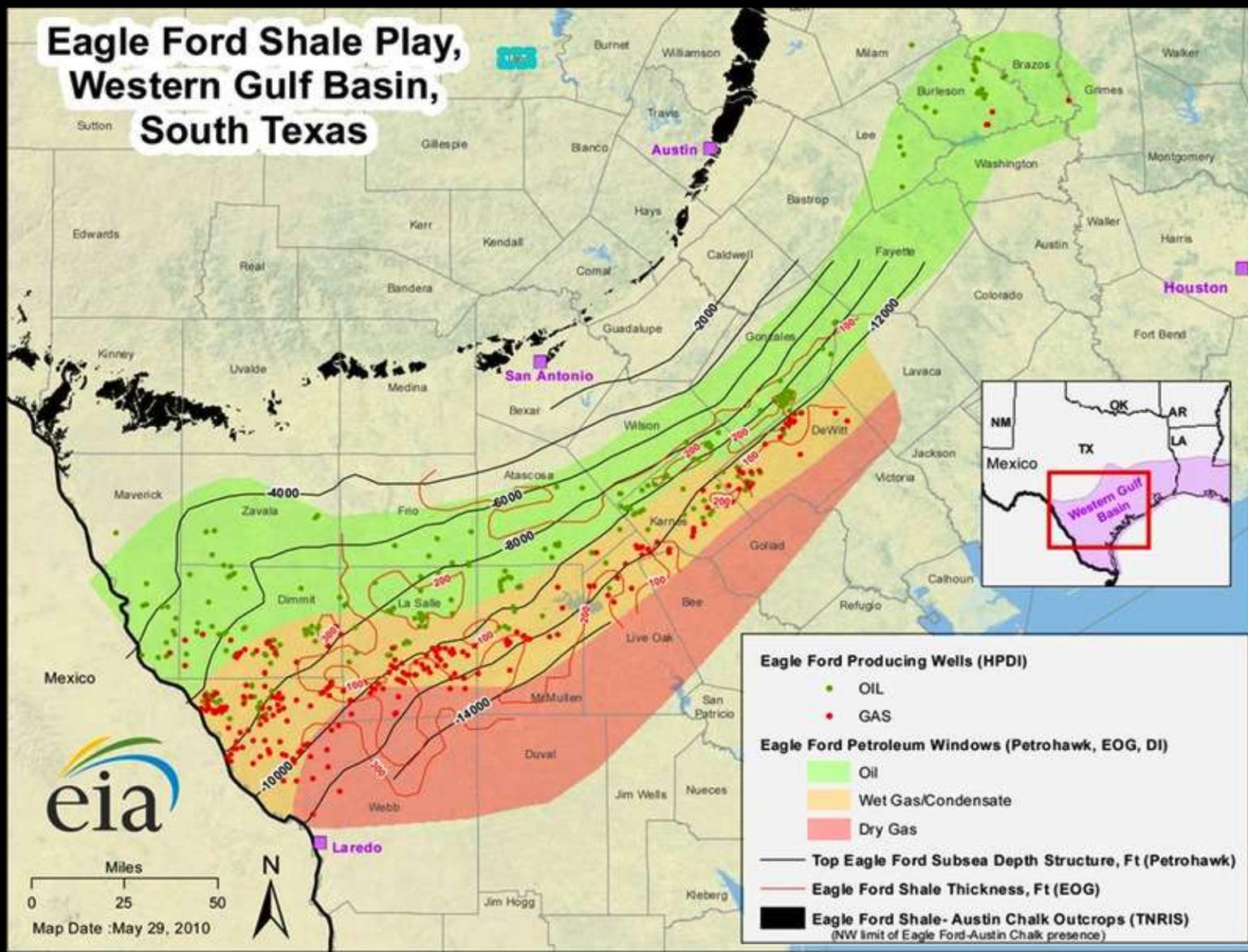
Consumption = 95
Production = 80

Imports = 15.8%
2013 (to date)
12.9%

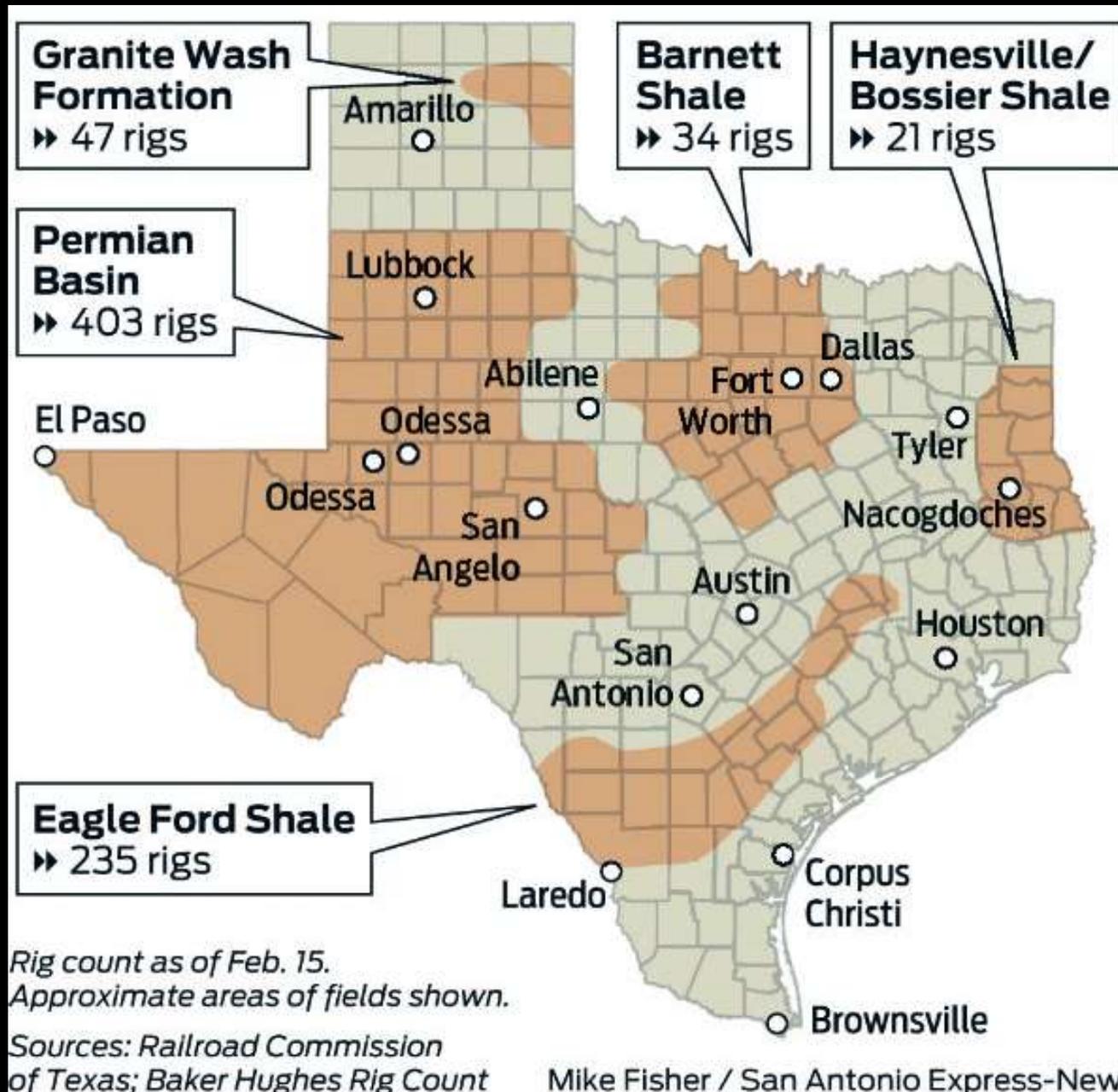
“Physical Trends Have Momentum”



Eagle Ford Oil, Gas, & Liquids Production

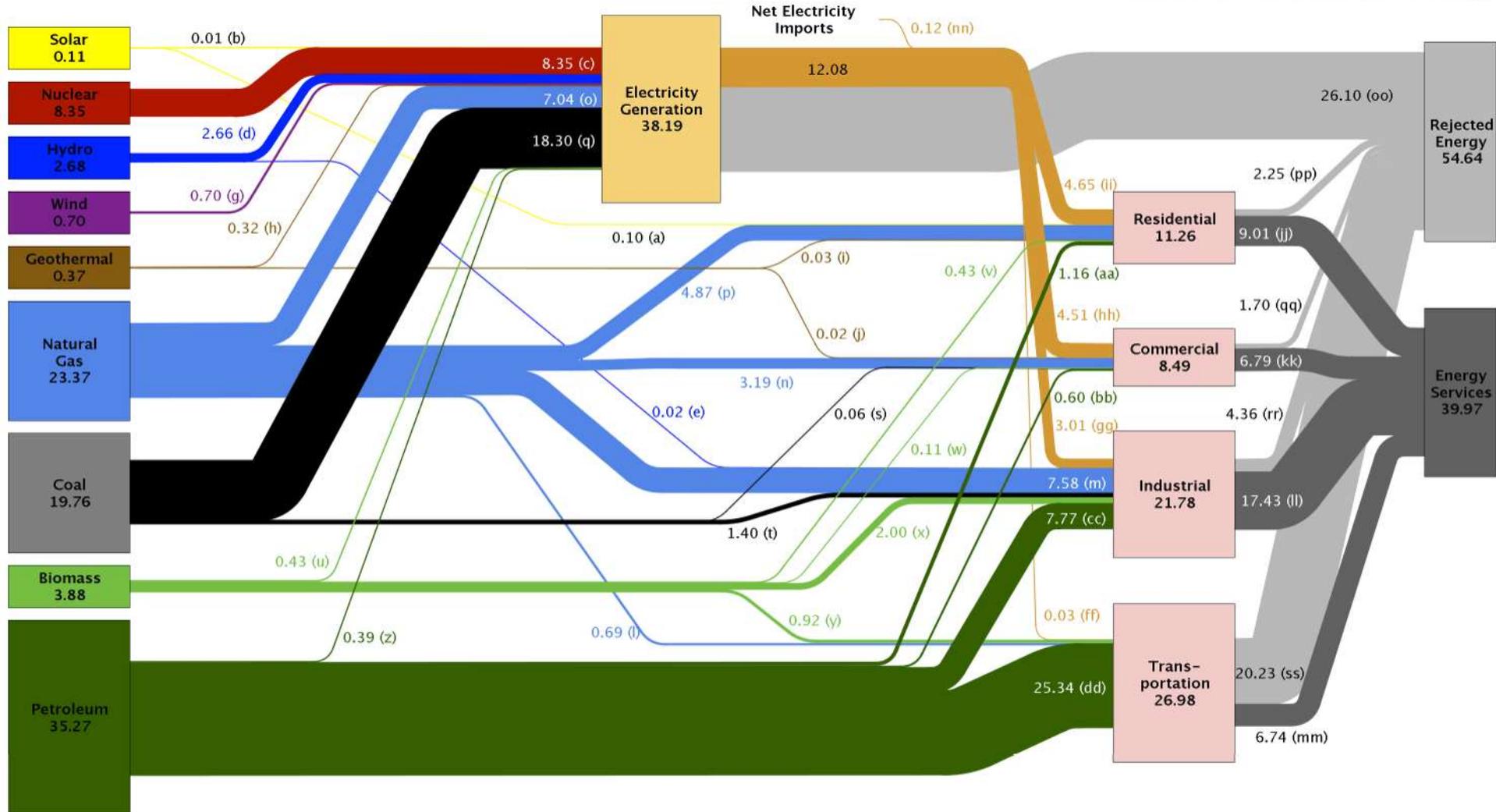


Texas Rig Count Feb 2013



U.S. Energy Use

Estimated U.S. Energy Use in 2009: ~94.6 Quads



Natural Gas Demand Growth Potential

Demand options	Example users	Potential impact (Bcf/day)
Transportation	CNG/LNG transportation	0.92
Generate	Power plants	5
Export	LNG	5.4
Convert	F-T liquids/methanol/DME	1.3
Refine	NSPS-compliant process fuel	2
Manufacture	Process fuel or feedstock	2.16
Incremental demand: 17.1 Bcf/day by 2018 (13 Bcf/day beyond current power fuel switching)		
Total consumption: 73.1 Bcf/day by 2018		

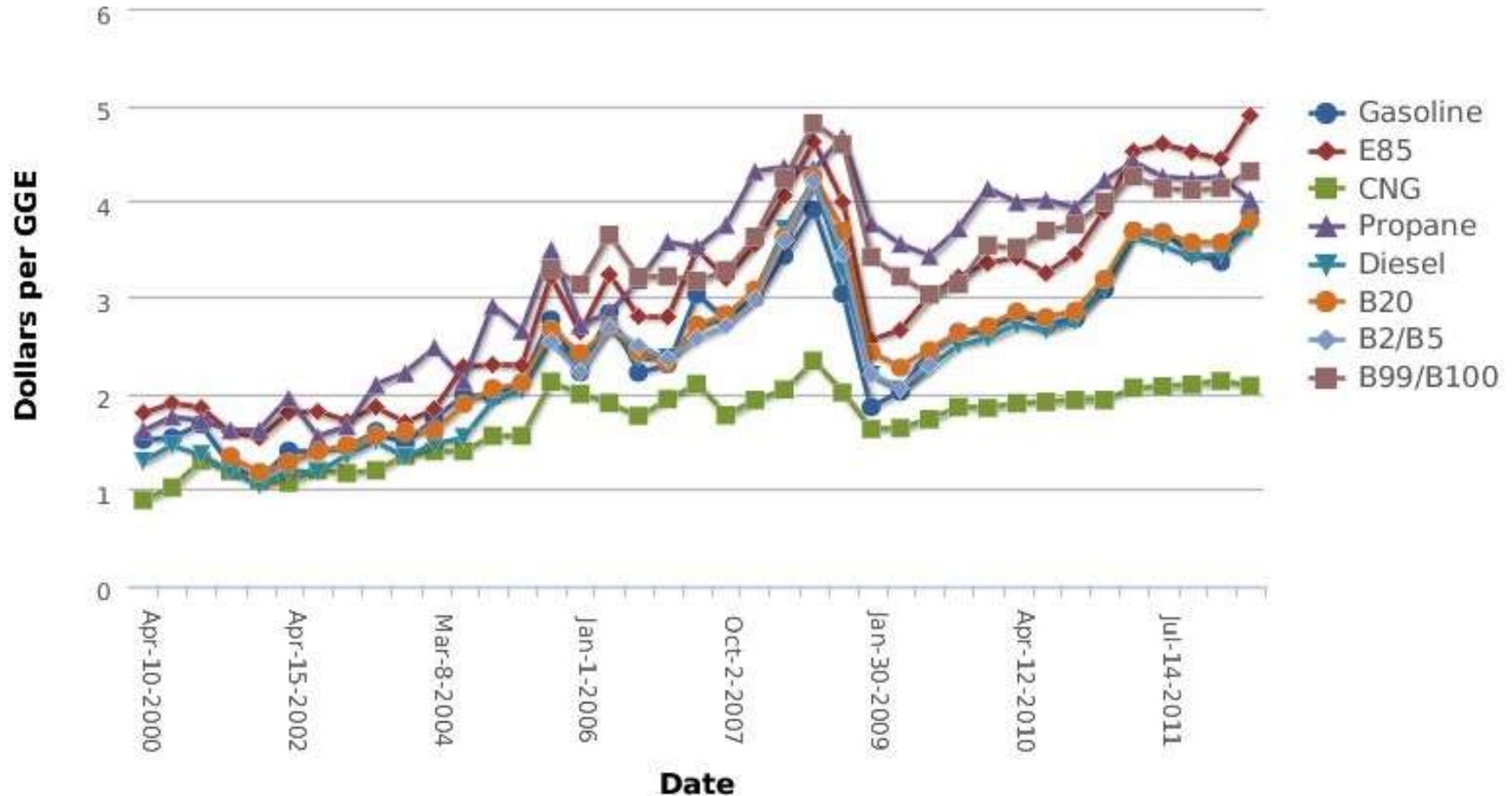
Source: Project on Realizing the Potential of Unconventional Gas, Workshop #3: Policy Pathway Forward, December 13, 2012, CSIS.

Note: CNG = compressed natural gas; LNG = liquefied natural gas; F-T = Fischer-Tropsch; DME = dimethyl ether; NSPS = New Source Performance Standards; Bcf = billion cubic feet.

2012 US Consumption was 69.7 Bcf/day

U.S. Ground Transportation Fuel Market

Average Retail Fuel Prices in the U.S.



Gas Cost Versus GGE Cost



CNG Sales Profitability

On January 20, 2012 the NYMEX spot price for natural gas closed at \$2.26/MMBtu, the lowest point in a decade. These low commodity prices are a boon for CNG retail profit margins.

Pump price of \$1.99/gge

INPUT	COST
Natural Gas (divide by 8.0)	\$0.28
Transport Costs & Fees	\$0.25
Electricity Costs per GGE	\$0.15
Maintenance per GGE	\$0.26
Federal and State Taxes	\$0.25
Fuel Card Fees per GGE	\$0.05
Retailer Profit Margin	\$0.75
CNG at the Pump	\$1.99

Pump price of \$2.45/gge

INPUT	COST
Natural Gas (divide by 8.0)	\$0.28
Transport Costs & Fees	\$0.25
Electricity Costs per GGE	\$0.15
Maintenance per GGE	\$0.26
Federal and State Taxes	\$0.25
Fuel Card Fees per GGE	\$0.05
Retailer Profit Margin	\$1.21
CNG at the Pump	\$2.45

Transportation



Transportation



Coast-to-Coast and Border-to-Border LNG Truck Fueling

The Honda Civic GX is the only Natural Gas LDV for Sale in the U.S.

- Cleaner air at tailpipe than coming in the vents
- Extensive residential fueling infrastructure
 - fill up with home compressor



• (~\$4000)



\$25,190

Why Not NatGas PHEVs?

- **There are 78 million single family homes in the US**
- **99.99% have electricity service**
- **50 million have natural gas service**
- **That is a lot of fueling stations.....But**
- **NFPA is Working to Ban Natural Gas Home Refueling Through Building Code Restrictions**

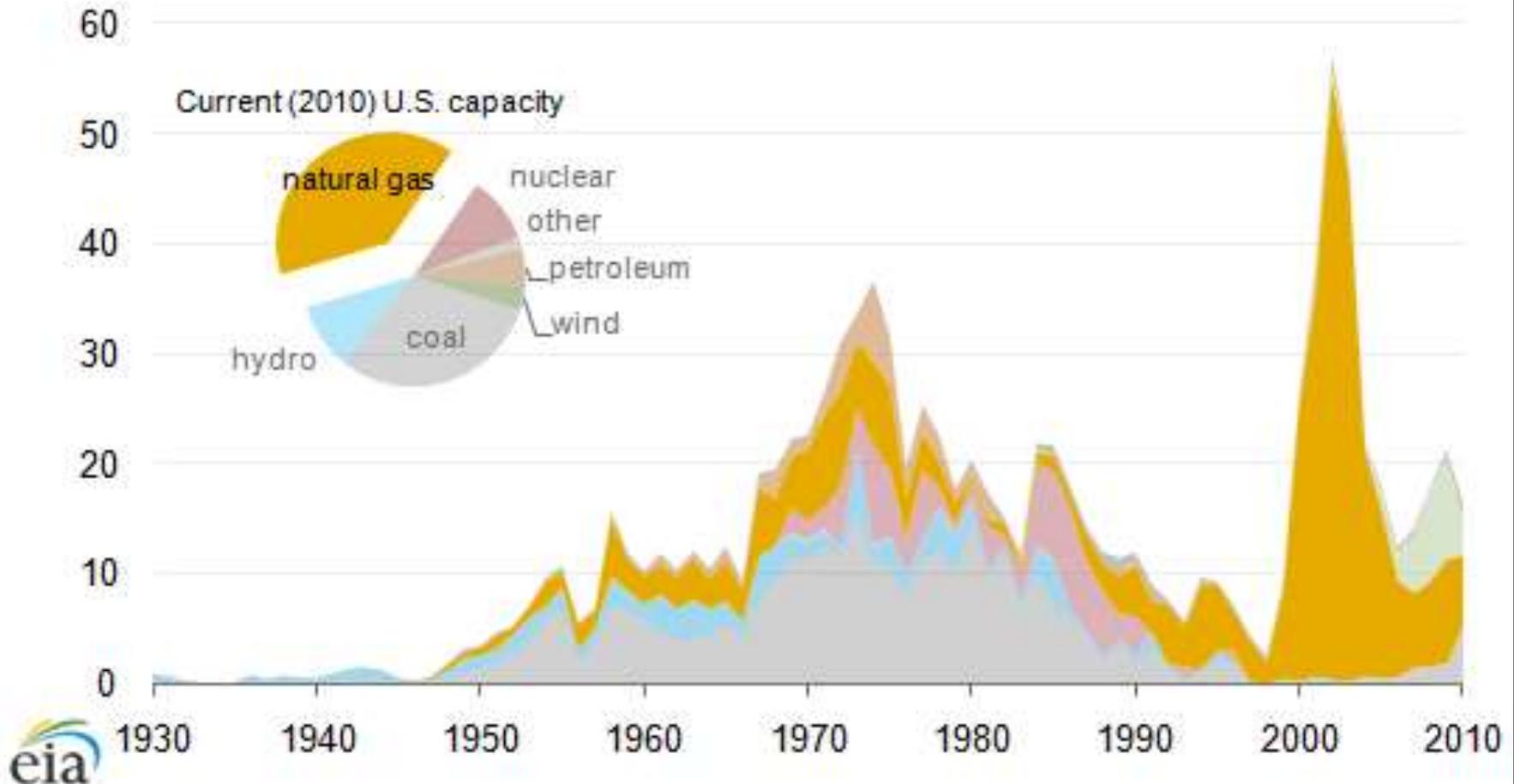
Power Generation



Combined Cycle Natural Gas Plants Have High Efficiency
50%-60% versus ~30% National Power Plant Average

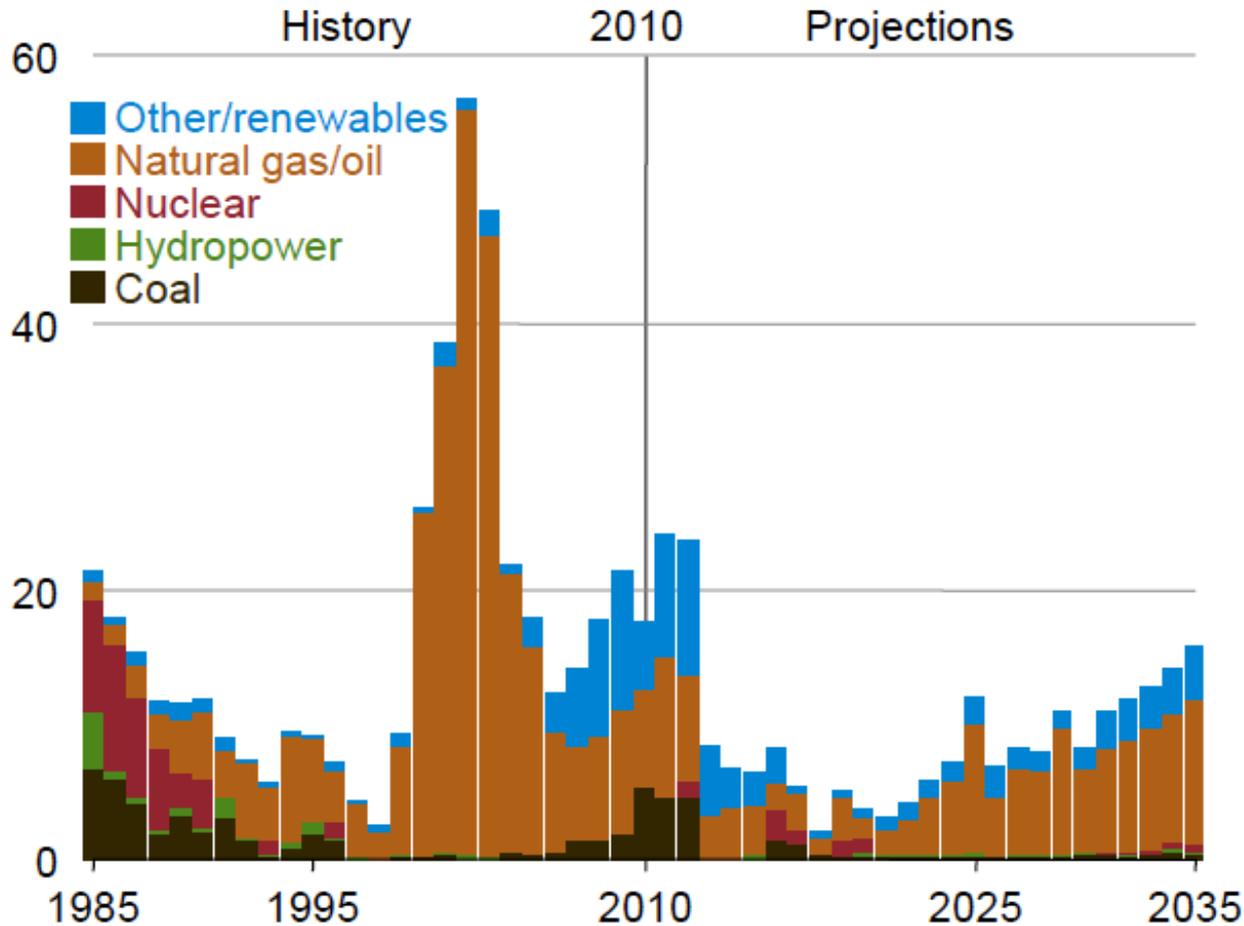
FUA (Nat Gas) 1978-1987

Current (2010) capacity by initial year of operation and fuel type
gigawatts



Generation Investment Mix

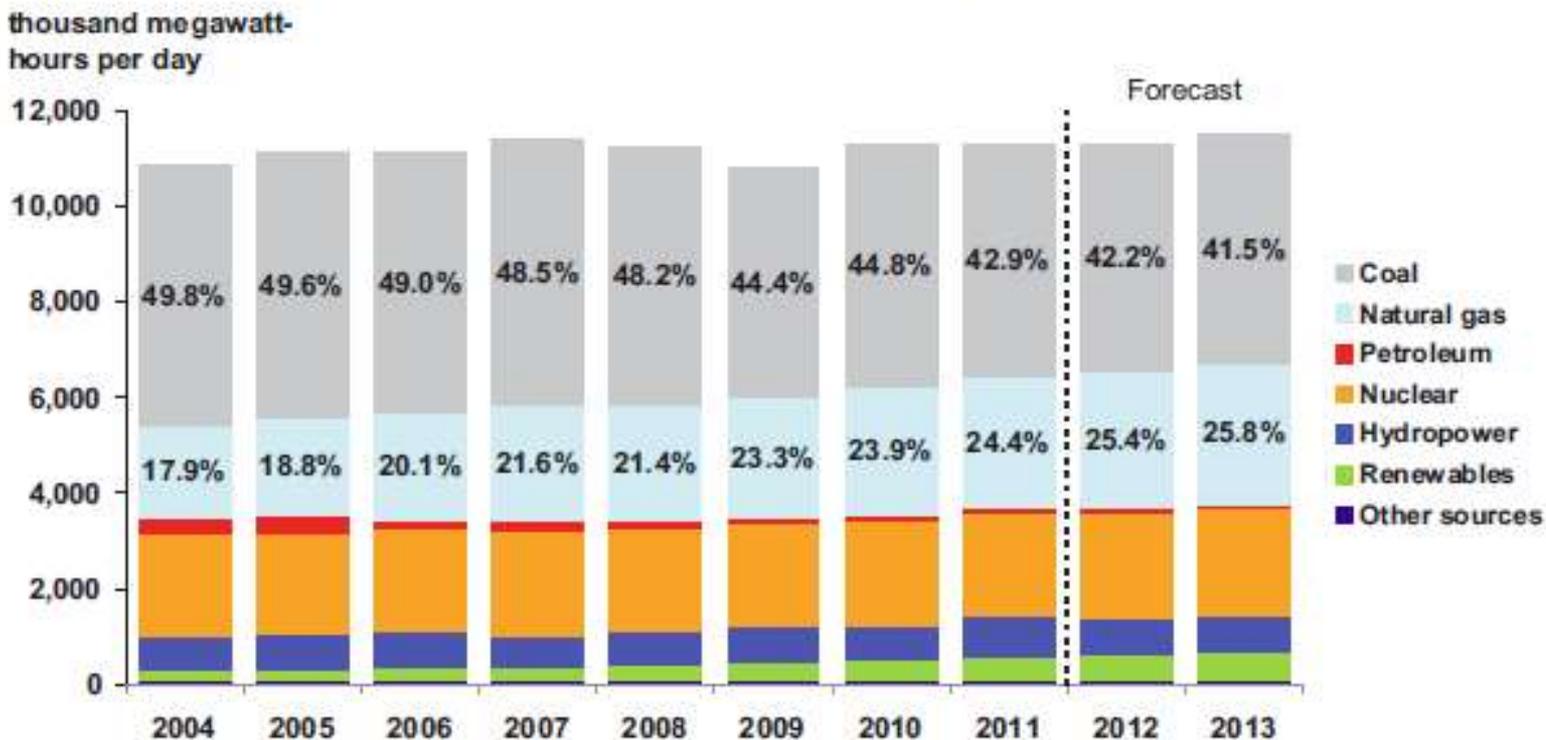
Figure 96. Additions to electricity generating capacity, 1985-2035 (gigawatts)



Are We Building a Less Resilient Generation Portfolio?

Fuel Switching in Electricity Generation

U.S. Electricity Generation by Fuel, All Sectors

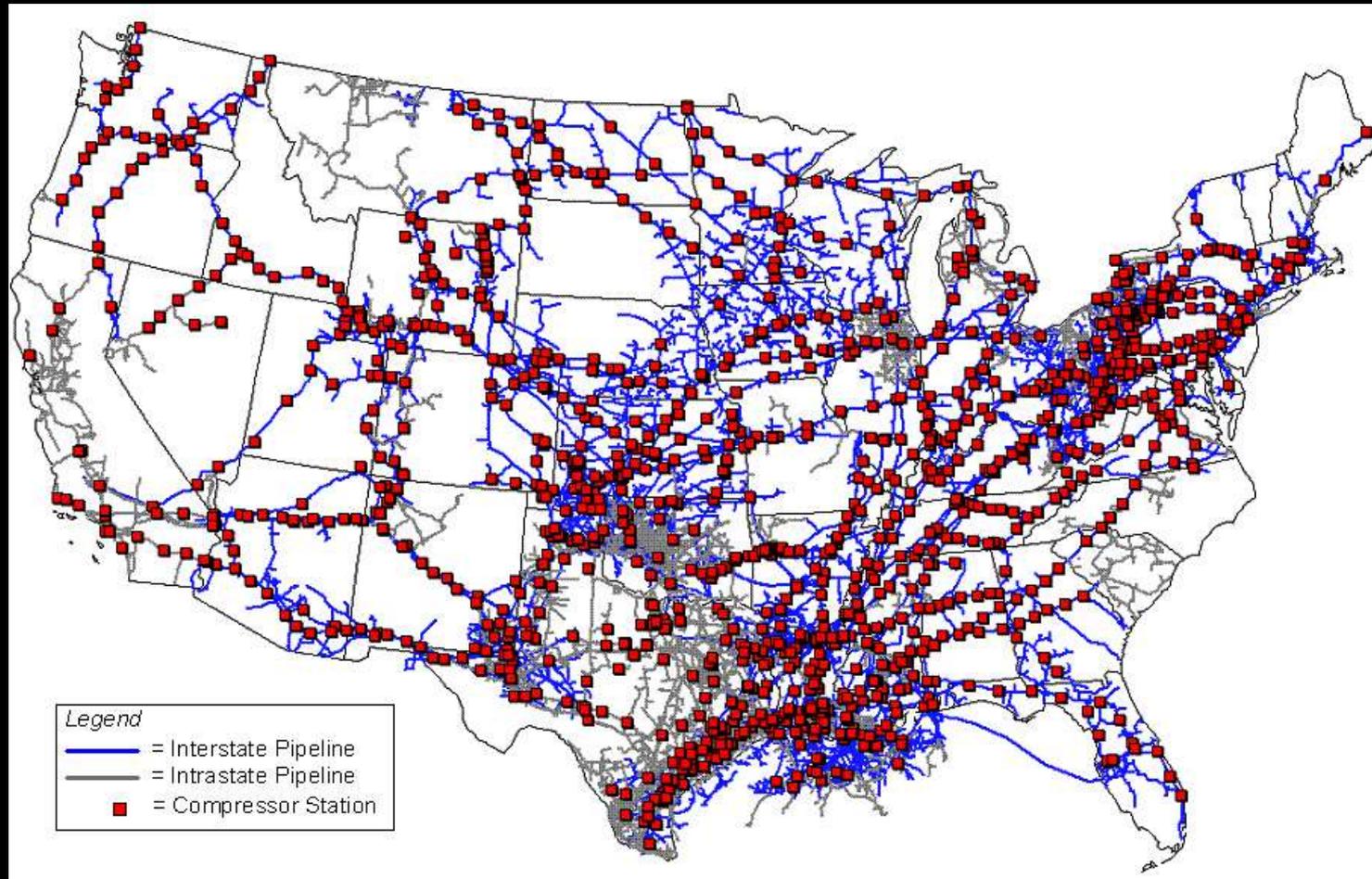


Note: Labels show percentage share of total generation provided by coal and natural gas.

Source: Short-Term Energy Outlook, January 2012



Pipeline Network



LNG Market

World LNG Estimated May 2013 Landed Prices

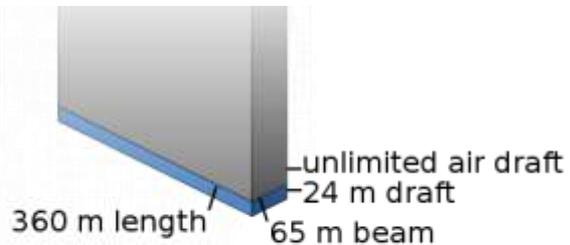


Export

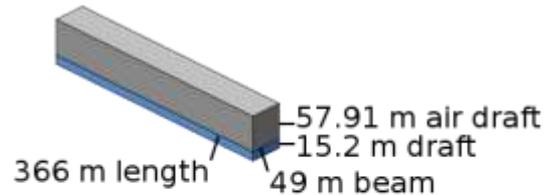


Qmax LNG Tankers, 5.7 Bcf capacity (9.4 Mcf Liquid)

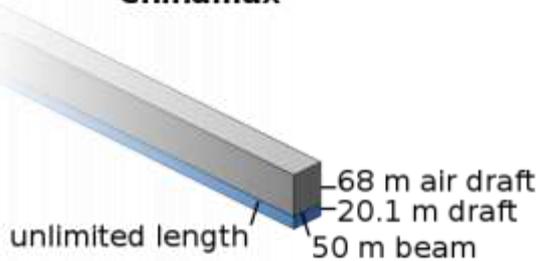
Q-max Ships are Market Tailored



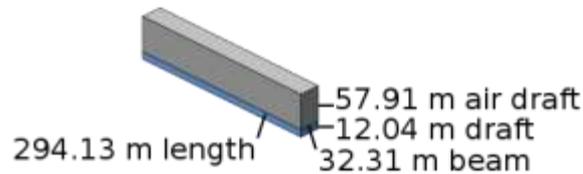
Chinamax



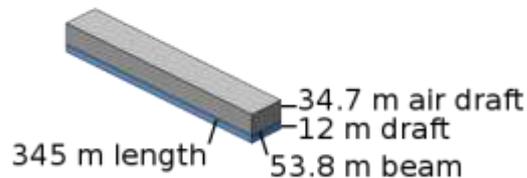
New Panamax



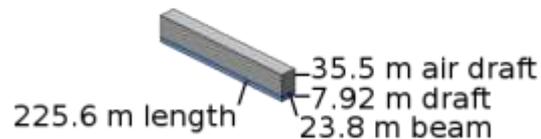
Suezmax



Panamax



Q-max



Seawaymax

Qmax Ships are tailored for the Arabian Gulf and Australia to Asia Market

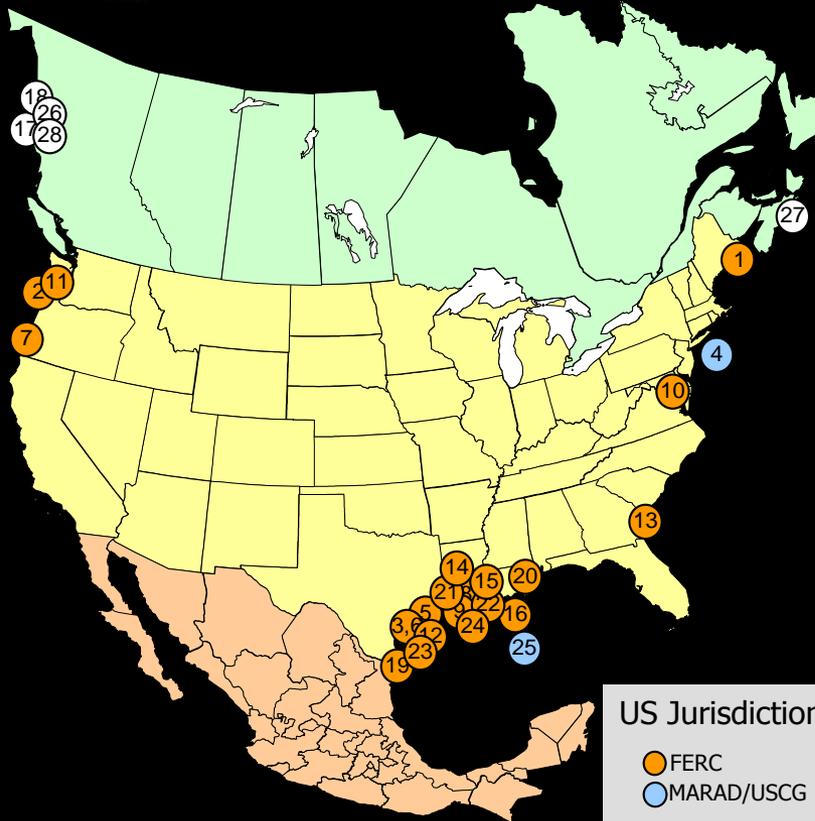
LNG Export Terminals



LNG Terminals Can Cost Several Billion \$ to Construct

LNG Export Terminals

Proposed/Potential



Import Terminal PROPOSED TO FERC

1. **Robbinston, ME:** 0.5 Bcfd (Kestrel Energy - Downeast LNG)
 2. **Astoria, OR:** 1.5 Bcfd (Oregon LNG)
 3. **Corpus Christi, TX:** 0.4 Bcfd (Cheniere – Corpus Christi LNG)
- POTENTIAL U.S. SITES IDENTIFIED BY PROJECT SPONSORS**
4. **Offshore New York:** 0.4 Bcfd (Liberty Natural Gas)

Export Terminal PROPOSED TO FERC

5. **Freeport, TX:** 1.8 Bcfd (Freeport LNG Dev/Freeport LNG Expansion/FLNG Liquefaction)*
6. **Corpus Christi, TX:** 2.1 Bcfd (Cheniere – Corpus Christi LNG)*
7. **Coos Bay, OR:** 0.9 Bcfd (Jordan Cove Energy Project)
8. **Lake Charles, LA:** 2.4 Bcfd (Southern Union - Trunkline LNG)
9. **Hackberry, LA:** 1.7 Bcfd (Sempra – Cameron LNG)*
10. **Cove Point, MD:** 0.82 Bcfd (Dominion – Cove Point LNG)*
11. **Astoria, OR:** 1.30 Bcfd (Oregon LNG)
12. **Lavaca Bay, TX:** 1.38 Bcfd (Excelerate Liquefaction)
13. **Elba Island, GA:** 0.35 Bcfd (Southern LNG Company)
14. **Sabine Pass; LA:** 1.3 Bcfd (Sabine Pass Liquefaction)
15. **Lake Charles, LA:** 1.07 Bcfd (Magnolia LNG)
16. **Plaquemines Parish, LA:** 1.07 Bcfd (CE FLNG)

PROPOSED CANADIAN SITES IDENTIFIED BY PROJECT SPONSORS

17. **Kitimat, BC:** 0.7 Bcfd (Apache Canada Ltd.)
18. **Douglas Island, BC:** 0.25 Bcfd (BC LNG Export Cooperative)

POTENTIAL U.S. SITES IDENTIFIED BY PROJECT SPONSORS

19. **Brownsville, TX:** 2.8 Bcfd (Gulf Coast LNG Export)
20. **Pascagoula, MS:** 1.5 Bcfd (Gulf LNG Liquefaction)
21. **Sabine Pass, TX:** 2.6 Bcfd (ExxonMobil – Golden Pass)
22. **Cameron Parish, LA:** 0.16 Bcfd (Waller LNG Services)
23. **Ingleside, TX:** 1.09 Bcfd (Pangea LNG (North America))
24. **Cameron Parish, LA:** 0.20 Bcfd (Gasfin Development)

U.S. – MARAD/COAST GUARD

25. **Gulf of Mexico:** 3.22 Bcfd (Main Pass - Freeport-McMoRan)

POTENTIAL CANADIAN SITES IDENTIFIED BY PROJECT SPONSORS

26. **Prince Rupert Island, BC:** 1.0 Bcfd (Shell Canada)
27. **Goldboro, NS:** 0.67 Bcfd (Pieridae Energy Canada)
28. **Kitimat, BC:** 2.0 Bcfd (LNG Canada)

Office of Energy Projects

So What is the US Policy for NatGas?

- NatGas for Transportation?
- NatGas for Electricity Generation?
- NatGas for Export?
- NatGas for Economic (Manufacturing) Advantage?
- NatGas for Carbon Reduction?
- NatGas for Energy Transition (A Bridge to ...)?
- NatGas for Revenue Generation?

Governing Federal Statutes

- National Environmental Policy Act (NEPA) Requires EIA on Federal lands
- Clean Air Act (CAA) Requires Permitting for Drilling and Production
- Clean Water Act (CWA) Regulates Surface Water Discharge of All Liquids Related to Drilling and Production
- Safe Drinking Water Act (SDWA) Regulates Underground Injection of Waste Fluids
- Emergency Planning and Right-to-Know Act (EPCRA) Requires Emergency Plans and Notification Procedures
- Endangered Species Act (ESA)
- Toxic Substances Control Act (TSCA) Regulates Manufacturing and Use of Certain Chemicals
- Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Regulates the Handling of Drilling Waste

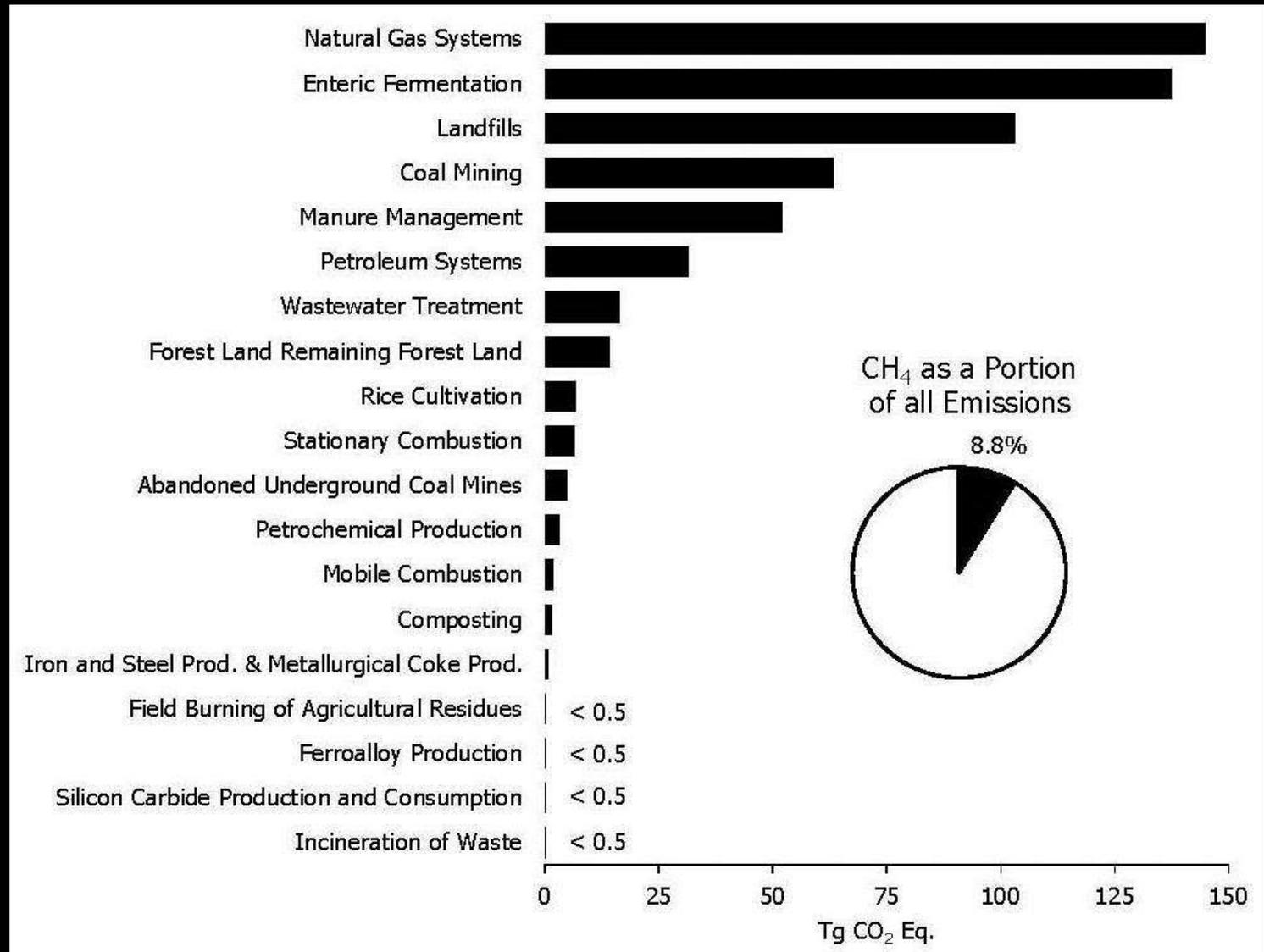
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THE UNIVERSITY OF TEXAS AT AUSTIN

Fugitive Methane Emissions



Fugitive Methane Emissions

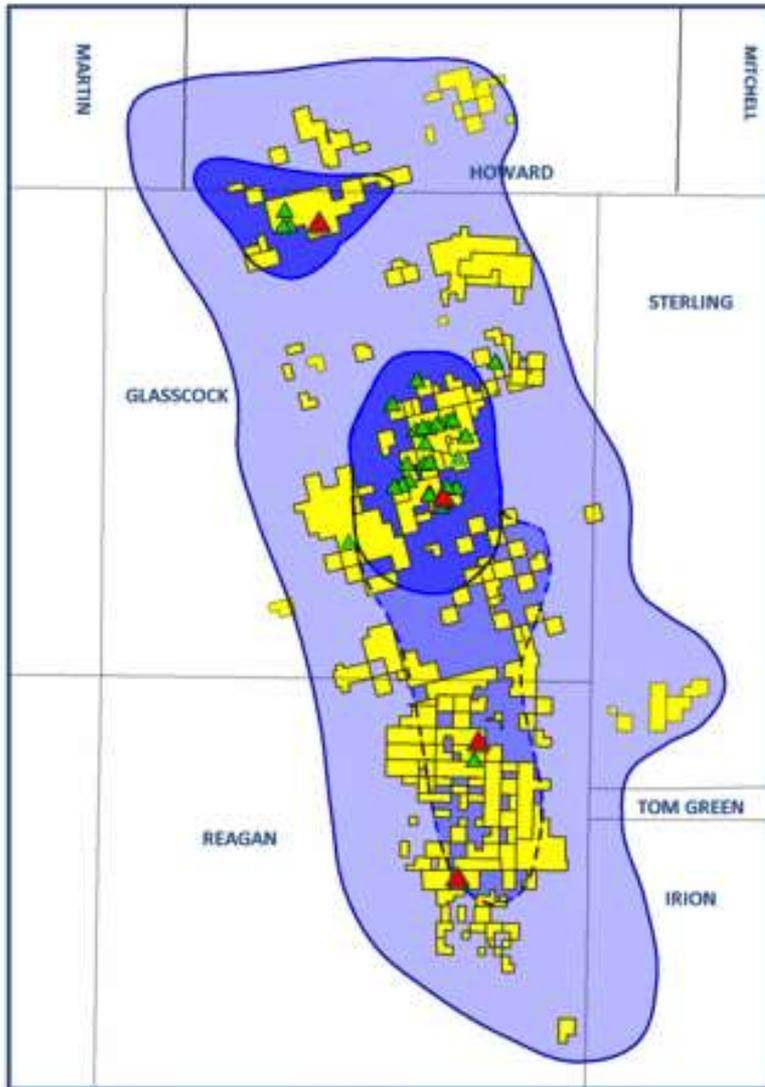
Table 2 Fugitive methane emissions associated with development of natural gas from conventional wells and from shale formations (expressed as the percentage of methane produced over the lifecycle of a well)

	Conventional gas	Shale gas
Emissions during well completion	0.01%	1.9%
Routine venting and equipment leaks at well site	0.3 to 1.9%	0.3 to 1.9%
Emissions during liquid unloading	0 to 0.26%	0 to 0.26%
Emissions during gas processing	0 to 0.19%	0 to 0.19%
Emissions during transport, storage, and distribution	1.4 to 3.6%	1.4 to 3.6%
Total emissions	1.7 to 6.0%	3.6 to 7.9%

See text for derivation of estimates and supporting information

Howarth, Santoro, & Ingraffea, "Methane and greenhouse-gas footprint of natural gas from shale formations" Climate Change, June 2011

Laredo Petroleum's Cline Shale Play

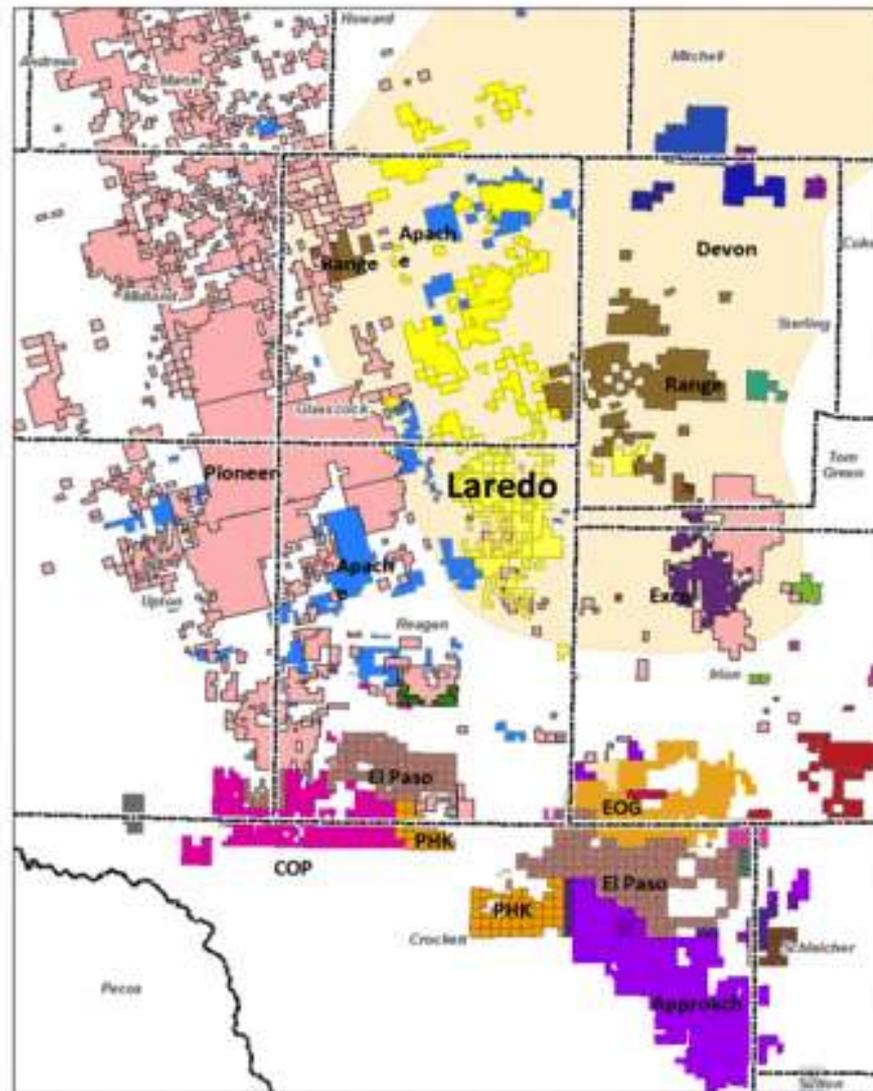


- Repeatable horizontal resource play in the Cline Shale
- Laredo has been drilling and gathering data on Cline Shale since 2008
- 26 horizontal wells drilled and completed in the Cline Shale, a baseline of historical well performance ¹
- Cline Shale has been identified across Laredo's entire Permian acreage position
- Laredo has gathered extensive petrophysical data on the Cline Shale that is currently proprietary

943 Horizontal Cline Shale Identified Potential Locations

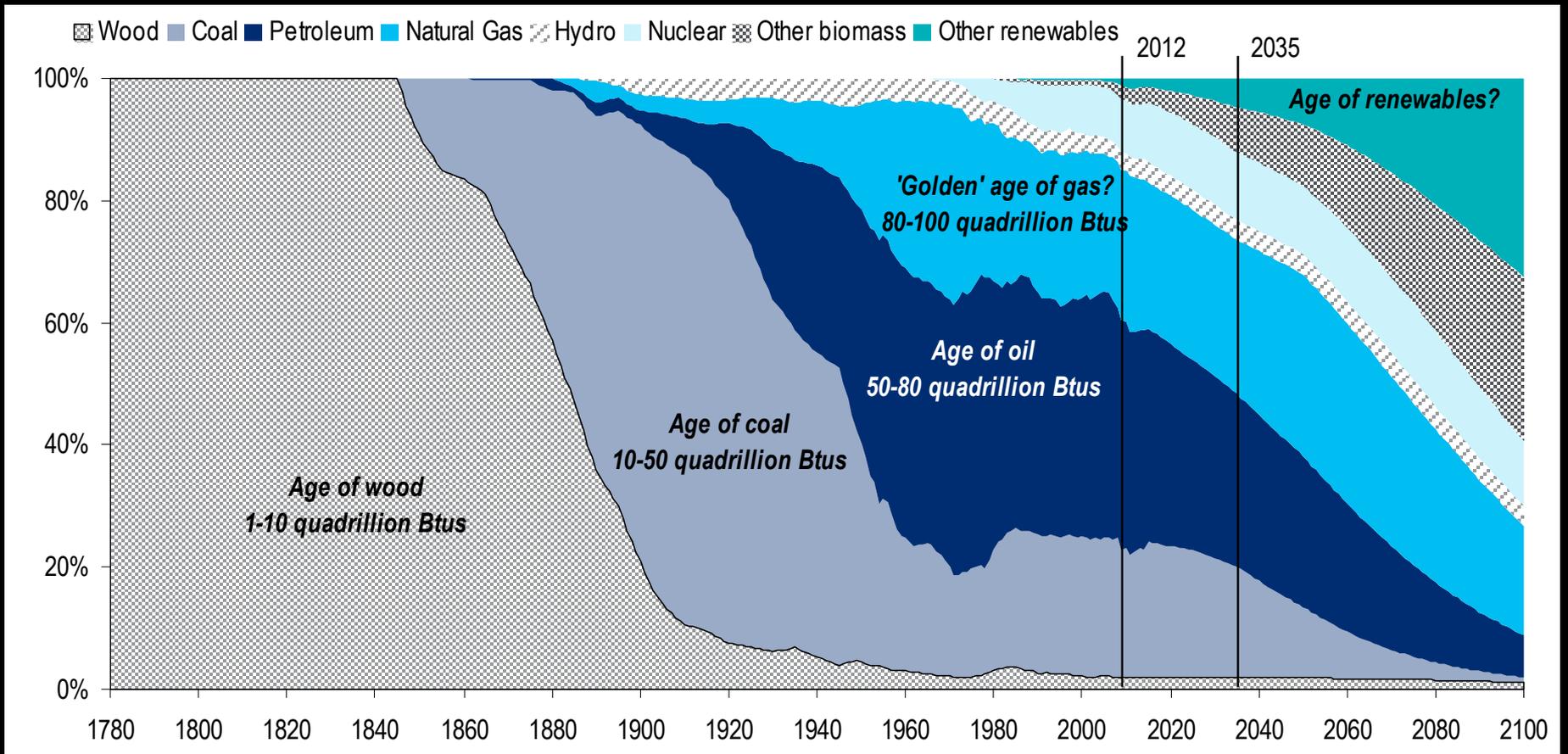
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|--|---------------------------|---|-------------------------|
|  | Laredo Cline hz well (26) |  | Late stage exploration |
|  | LPI acreage |  | Early stage development |
|  | Early stage exploration |  | Cline whole core |

But It's Not Just Laredo



- Current target intervals include **Vertical Wolfberry, Horizontal Wolfcamp Shale (Upper, Middle, Lower) and Horizontal Cline Shale**
- Interest in over 300 sections with ~135,000 net acres concentrated in Glasscock and Reagan Counties
- ~96% average working interest





Bakken Shale



Miles

Minot

Bismarck

Australia 2001



Australia 2012



Northern Russia 2001



Northern Russia 2012



Export



Qmax LNG Tankers, 5.7 Bcf capacity (9.4 Mcf Liquid)