*RFF's Center for Energy Economics and Policy*

# The Effect of the Shale Gas Boom on Electricity and Transport Sectors in the U.S.

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Director, Center for Energy Economics and Policy
Shale Gas Forum, sponsored by CSEP
Beijing, November 14, 2012

# Outline

- The role natural gas plays in our economic system
- The effect on Electricity
- The effect on Transportation
- Other sectors

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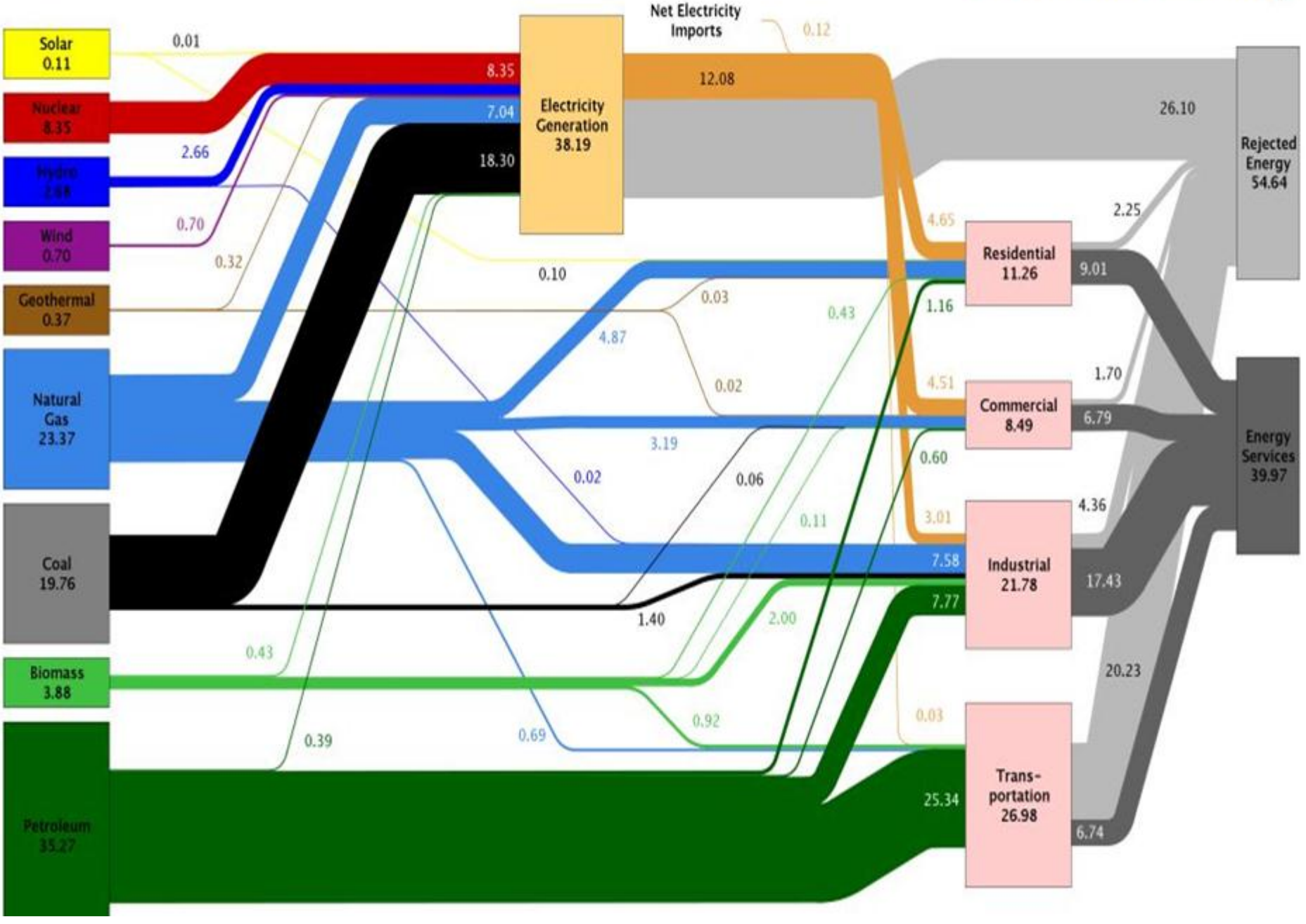
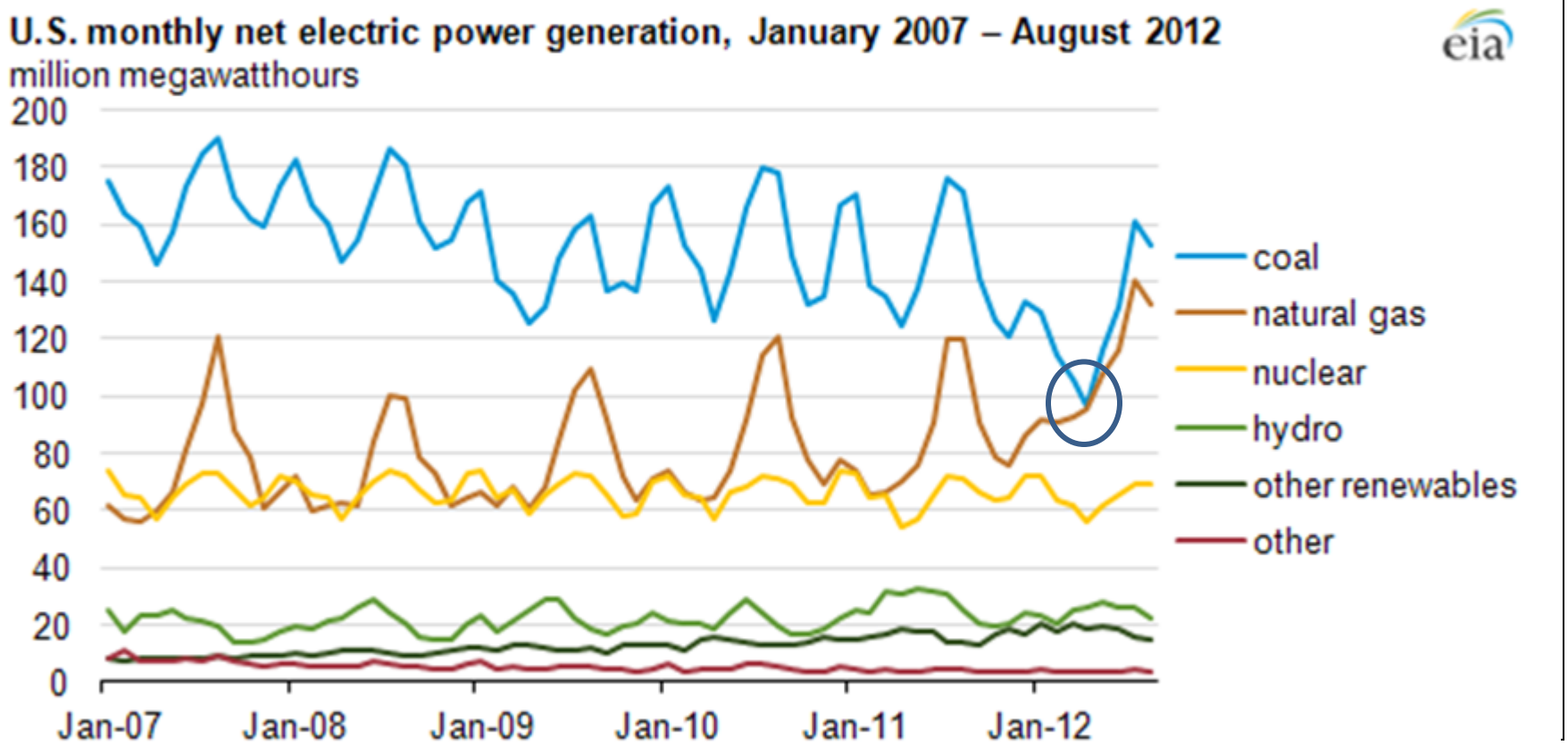
# Estimated U.S. Energy Use in 2009: ~94.6 Quads

Lawrence Livermore National Laboratory



# Electricity generation by fuel, Jan. 2007 – Aug. 2012

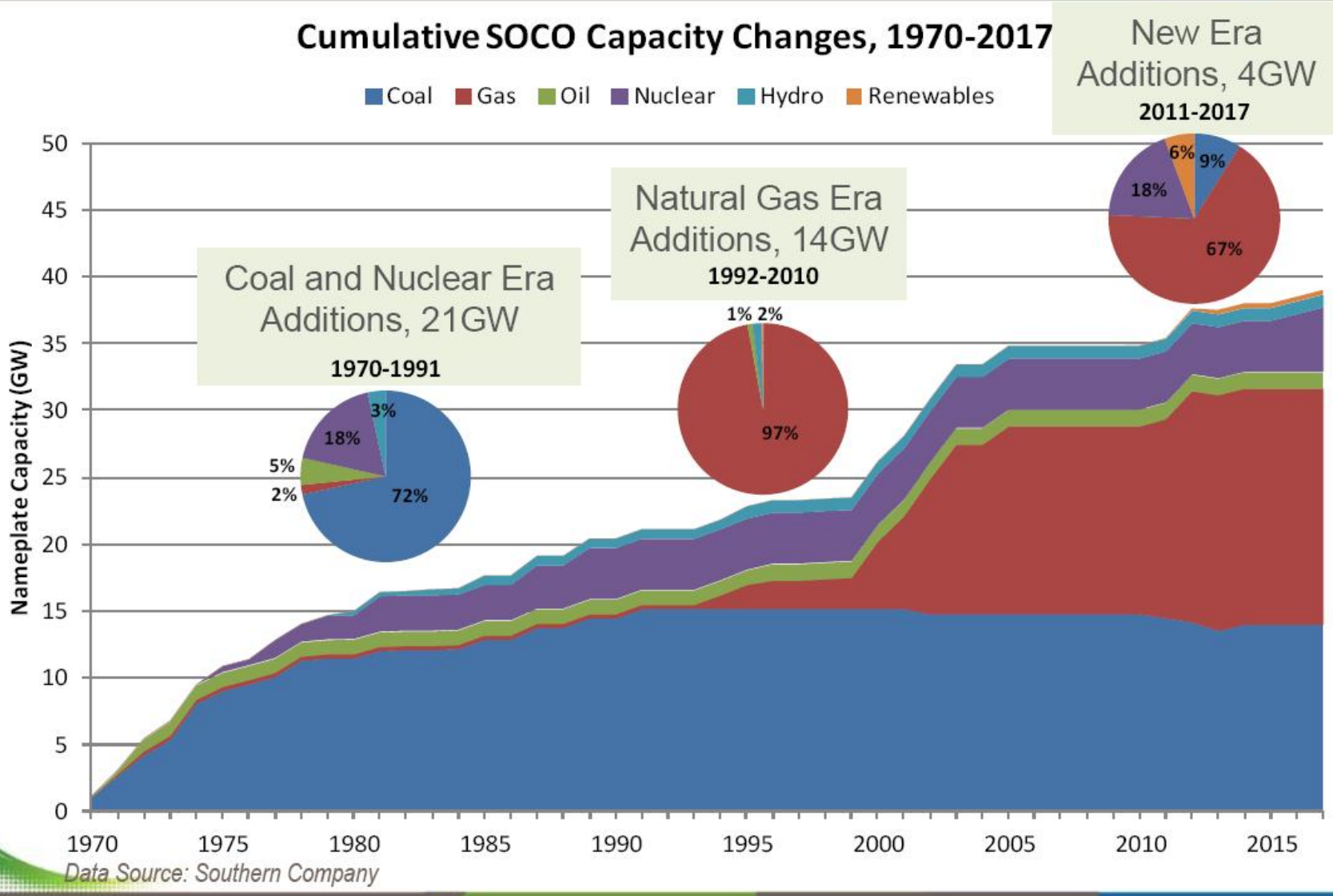
## Electricity generation from coal and natural gas both increased with summer heat




**Source:** U.S. Energy Information Administration, Electric Power Monthly. The next issue of Electric Power Monthly will be releas week of October 22.

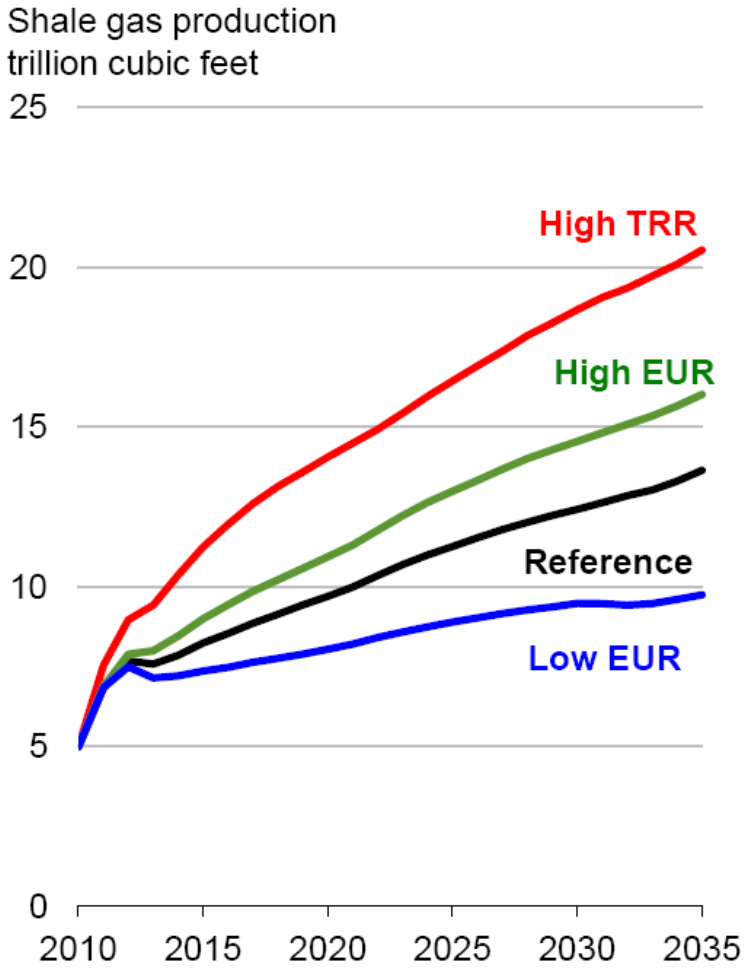
**Note:** Data for 2011 and 2012 are preliminary. Chart includes generation from the electric power sector only, excluding commer and industrial generators.

# Southern Company Construction Eras




Data Source: Southern Company

# Shale gas resource potential, costs remain highly uncertain




*Source: EIA, Annual Energy Outlook 2012*

## Three alternate cases

**High Technically Recoverable Resource (TRR) case** assumes High EUR case with wells closer together (80 acres per well), and it could represent finding more plays.

**High Estimate Ultimate Recovery (EUR) case** assumes an EUR per shale gas well set 50% higher than in the Reference case. Results in lower per Mcf costs.

**Low EUR** case is like High EUR but lower.

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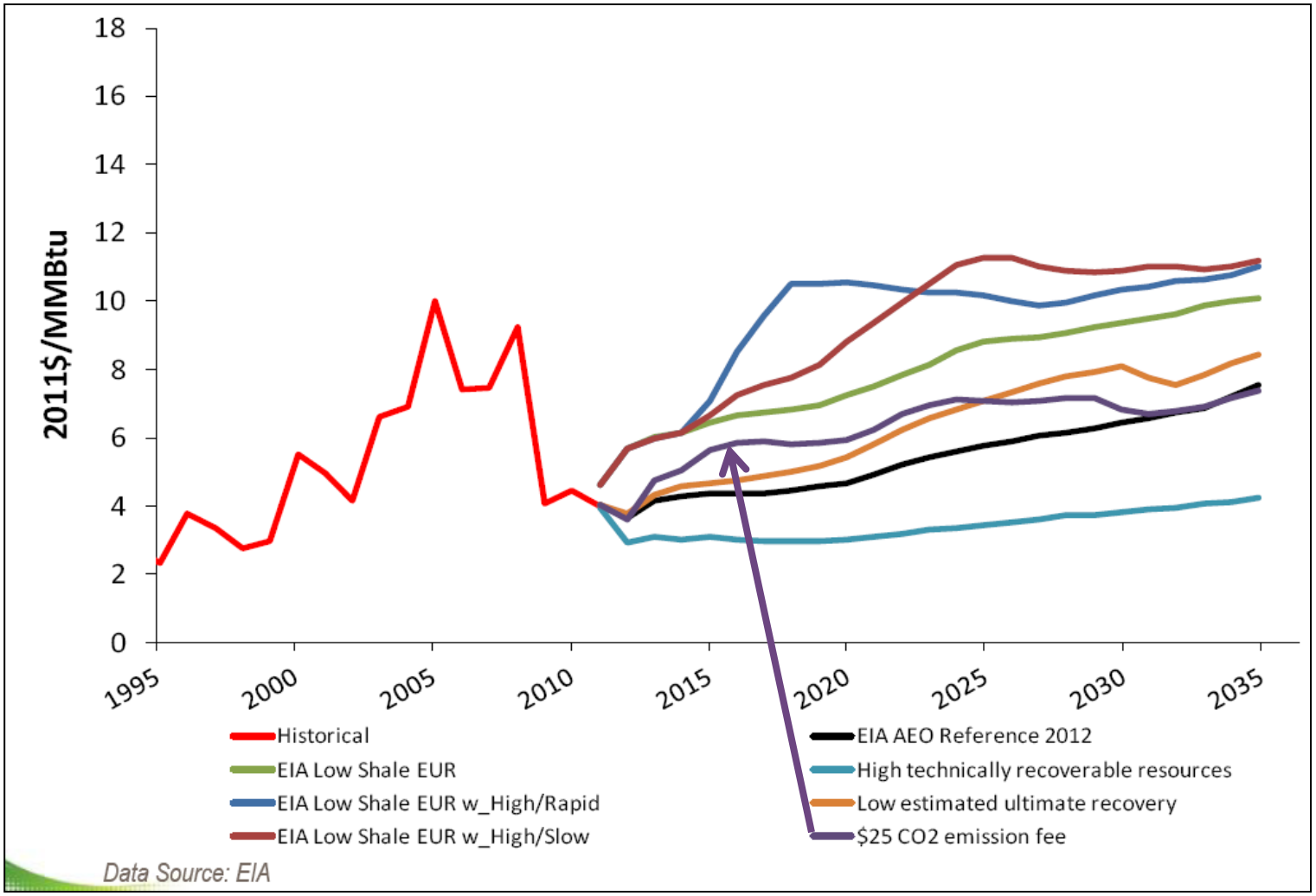
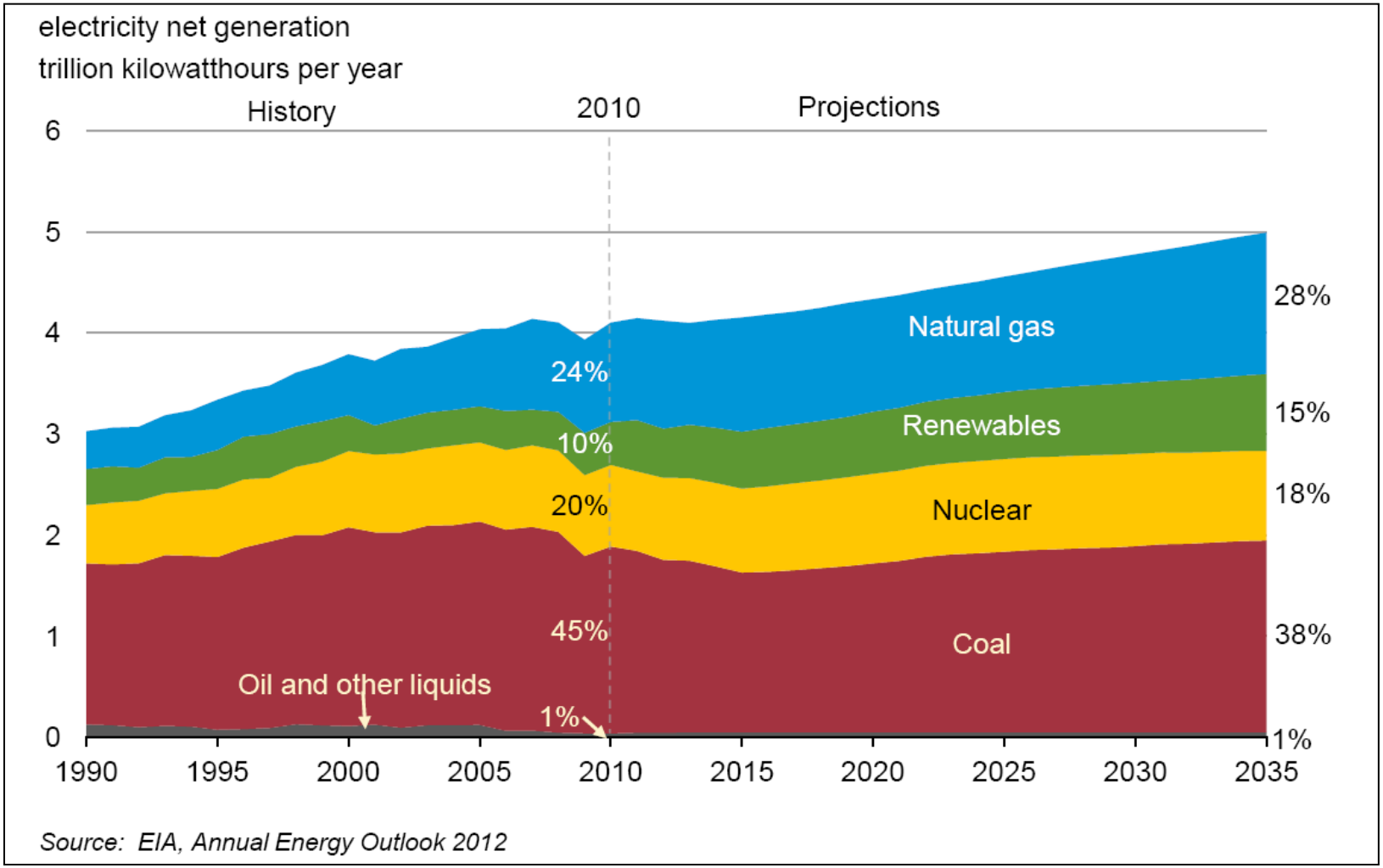
# EIA Henry Hub Natural Gas Prices



# EIA's reference case electricity mix gradually shifts to lower-carbon options, led by growth in renewables and natural gas




*Source: EIA, Annual Energy Outlook 2012*

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# Electricity sector simulations with RFF's HAIKU model

**Table 2. Natural Gas Prices**

| Natural Gas Prices | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Baseline | | | 2011Demand_ 2009NatGas | | | 2009Demand_ 2009NatGas | | |
| | 2013 | 2016 | 2020 | 2013 | 2016 | 2020 | 2013 | 2016 | 2020 |
| Delivered natural gas ($/MMBtu) | 4.6 | 4.6 | 4.9 | 5.4 | 5.9 | 6.6 | 5.5 | 5.9 | 6.8 |
| *Percentage difference* | | | | *17.4%* | *28.3%* | *34.7%* | *19.6%* | *28.3%* | *38.8%* |
| Wellhead natural gas ($/billion cubic feet) | 4.0 | 4.2 | 4.4 | 5.1 | 5.6 | 6.4 | 5.1 | 5.7 | 6.6 |
| *Percentage difference* | | | | *27.5%* | *33.3%* | *45.5%* | *27.5%* | *35.7%* | *50.0%* |

With cheap gas  Without cheap gas With 2011 elec demand  Without cheap gas With 2009 demand

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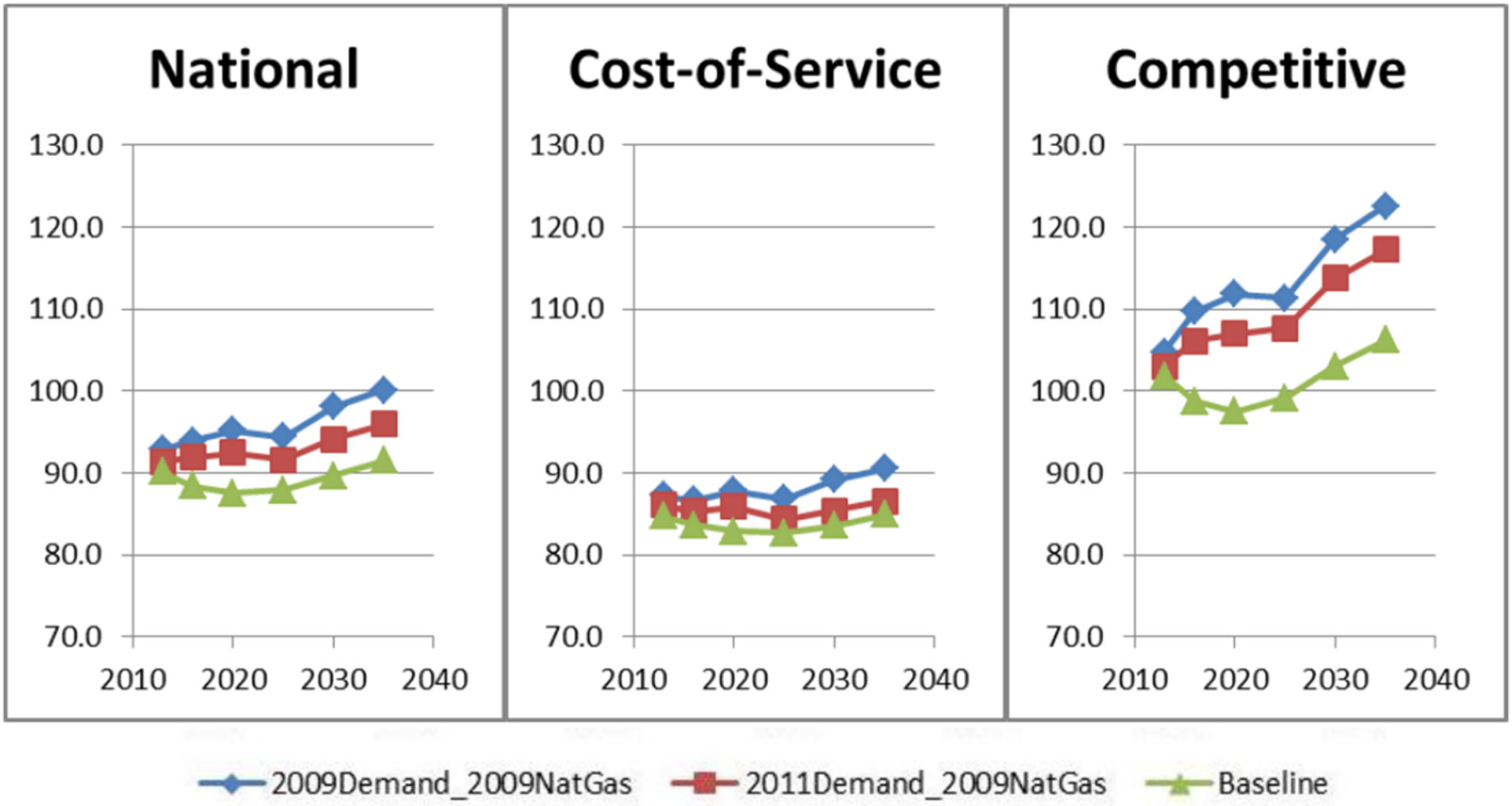
## Figure 1. Electricity Prices ($/MWh)

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## Table 5. Cumulative Savings in the Baseline (Billion $2009)

| National Cumulative Savings in the Baseline (Billion $2009) | | | | | | |
|---|---|---|---|---|---|---|
| | Compared to 2011Demand_2009NatGas | | | | | |
| | Real Dollars | | | Discounted Value | | |
| | 2013 | 2016 | 2020 | 2013 | 2016 | 2020 |
| Total | 3.5 | 26.2 | 70.8 | 3.5 | 2.4 | 57.4 |
| Residential | 0.8 | 8.6 | 25.8 | 0.8 | 7.8 | 20.7 |
| Commercial | 2.2 | 13.3 | 33.9 | 2.2 | 1.2 | 27.7 |
| Industrial | 0.6 | 4.1 | 10.5 | 0.6 | 3.7 | 8.6 |
| | Compared to 2009Demand_2009NatGas | | | | | |
| | Real Dollars | | | Discounted Value | | |
| | 2013 | 2016 | 2020 | 2013 | 2016 | 2020 |
| Total | 9.9 | 67.1 | 203.4 | 9.9 | 61.2 | 163.3 |
| Residential | 5.3 | 34.1 | 100.6 | 5.3 | 31.1 | 80.9 |
| Commercial | 7.9 | 43.2 | 111.6 | 7.9 | 39.7 | 91.0 |
| Industrial | –3.4 | –10.8 | 86.9 | –3.4 | –10.1 | 61.7 |

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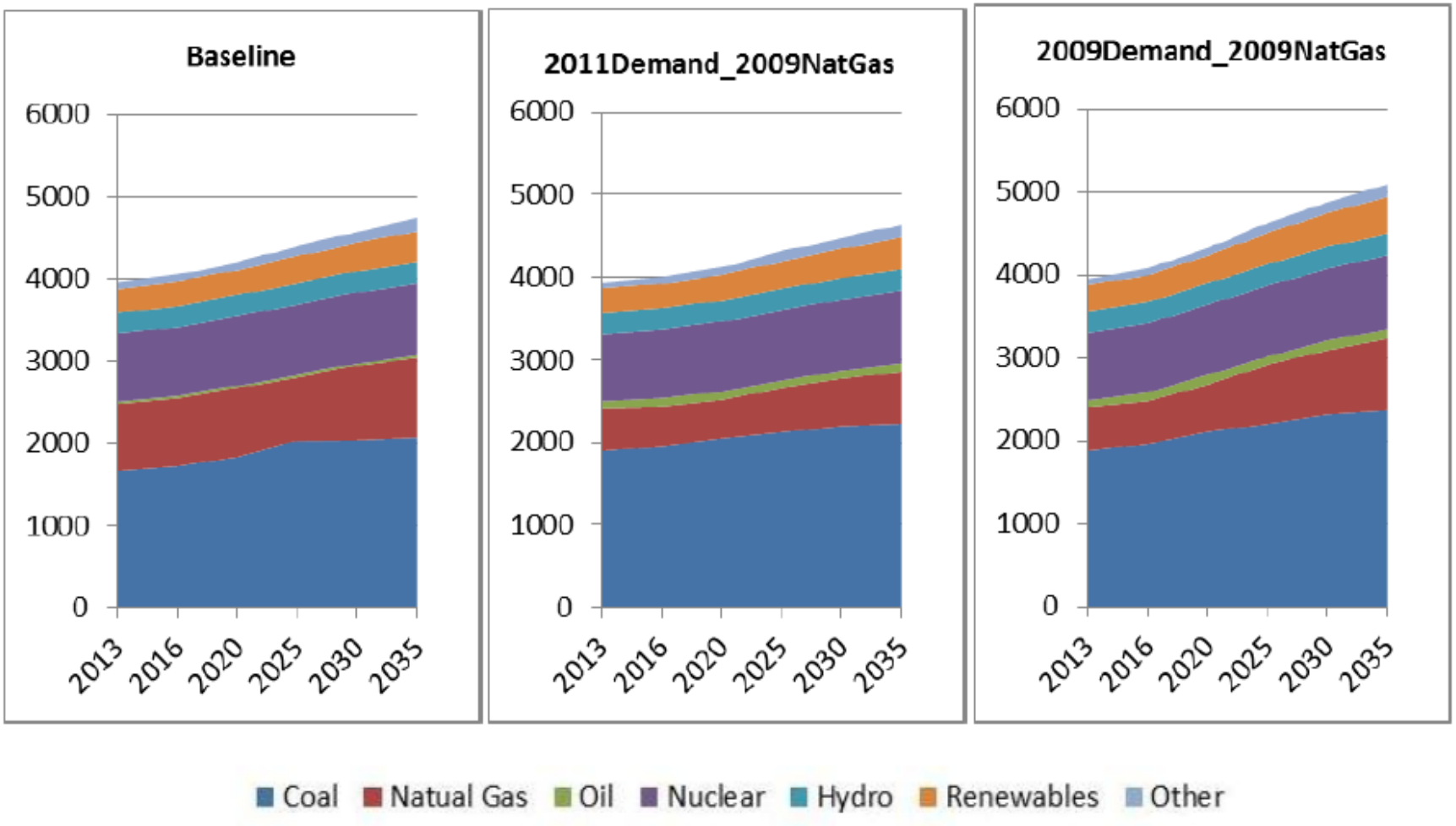
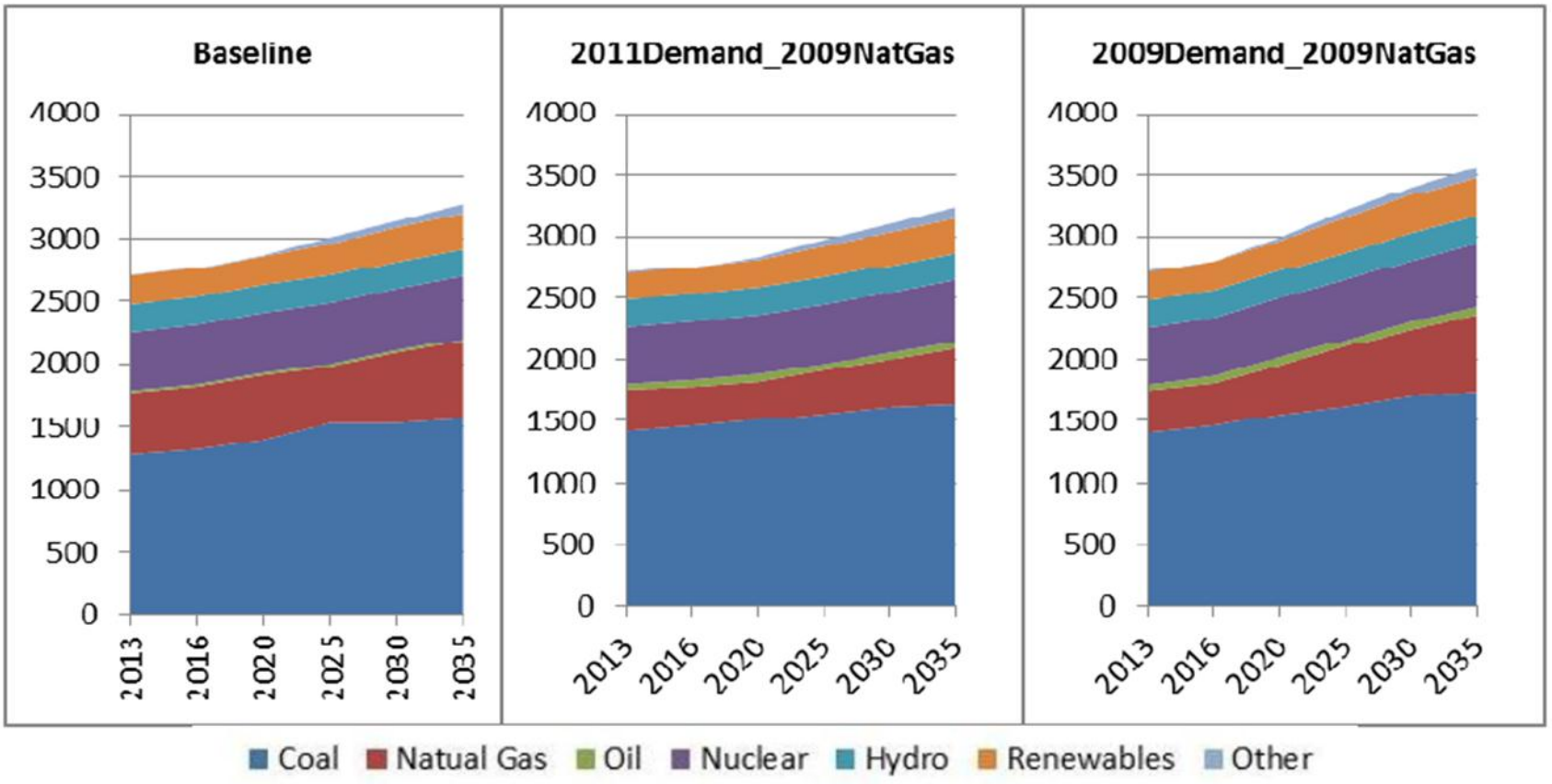
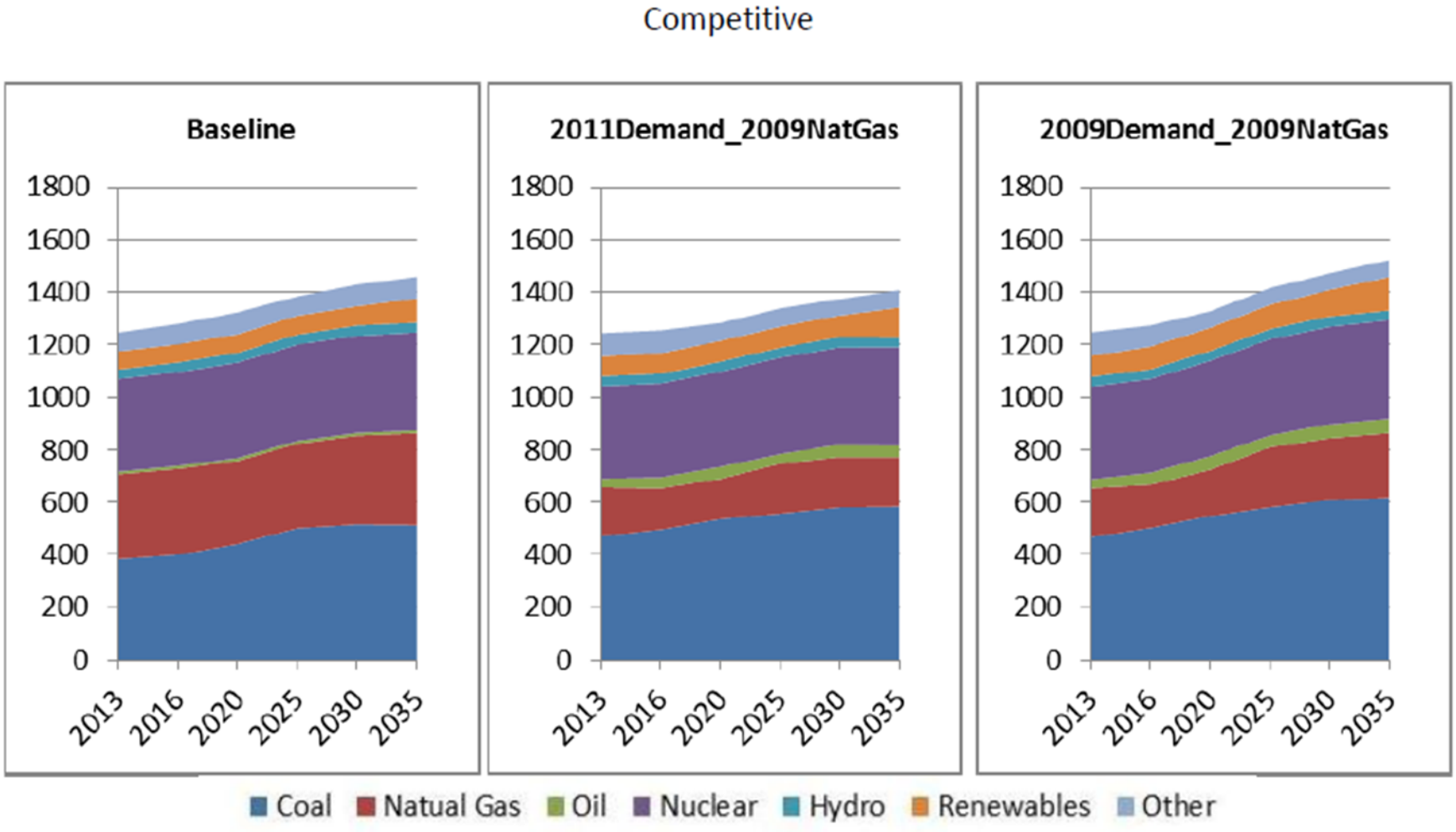
## Figure 2. Generation Mix

National

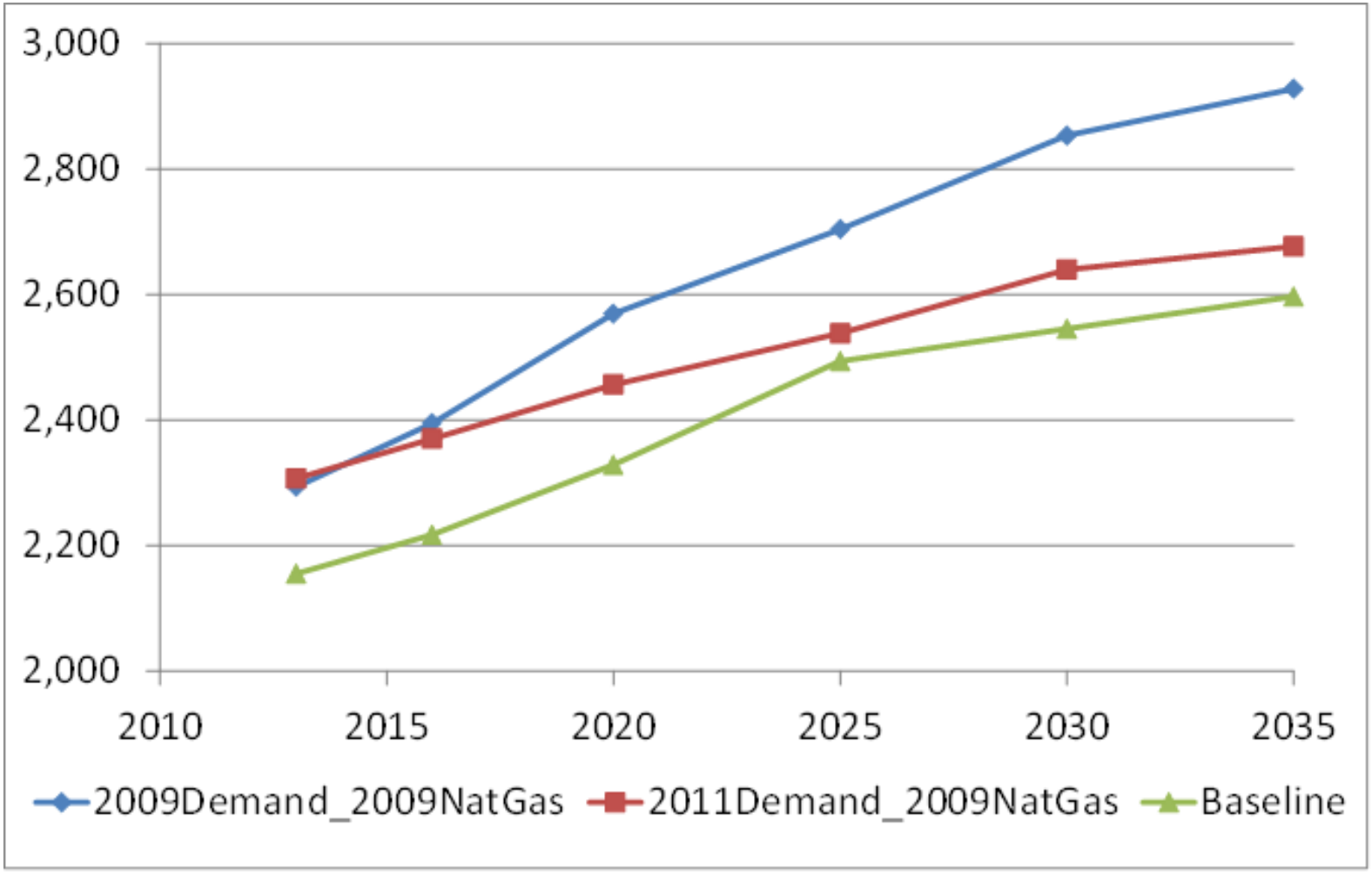


Cost-of-Service




Competitive
Baseline
2011Demand_2009NatGas
2009Demand_2009NatGas
1800
1600
1400
1200
1000
800
600
400
200
0
2013
2016
2020
2025
2030
2035
Coal
Natual Gas
Oil
Nuclear
Hydro
Renewables
Other

# CO2 Emissions (millions of tons)

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# Conclusions on Electricity Sector Impacts

- Natural gas makes big inroads against coal
- But slows growth in renewables
- Net effect is slower growth in CO2 emissions than without shale gas
- But CO2 emissions still grow with increasing demand.
- In a competitive market, electricity prices are about 10-15% lower by 2035 with versus without shale gas.

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The President at a UPS facility in Las Vegas after his State of the Union speech

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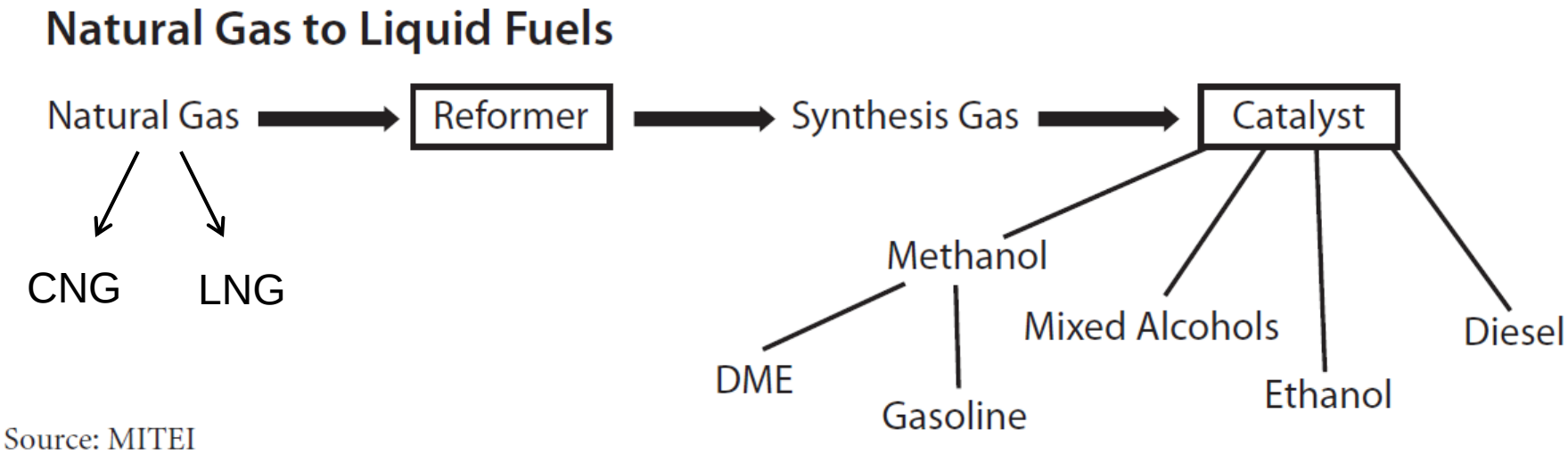
## Figure 5.9 Conversion of Natural Gas to Liquid Fuels



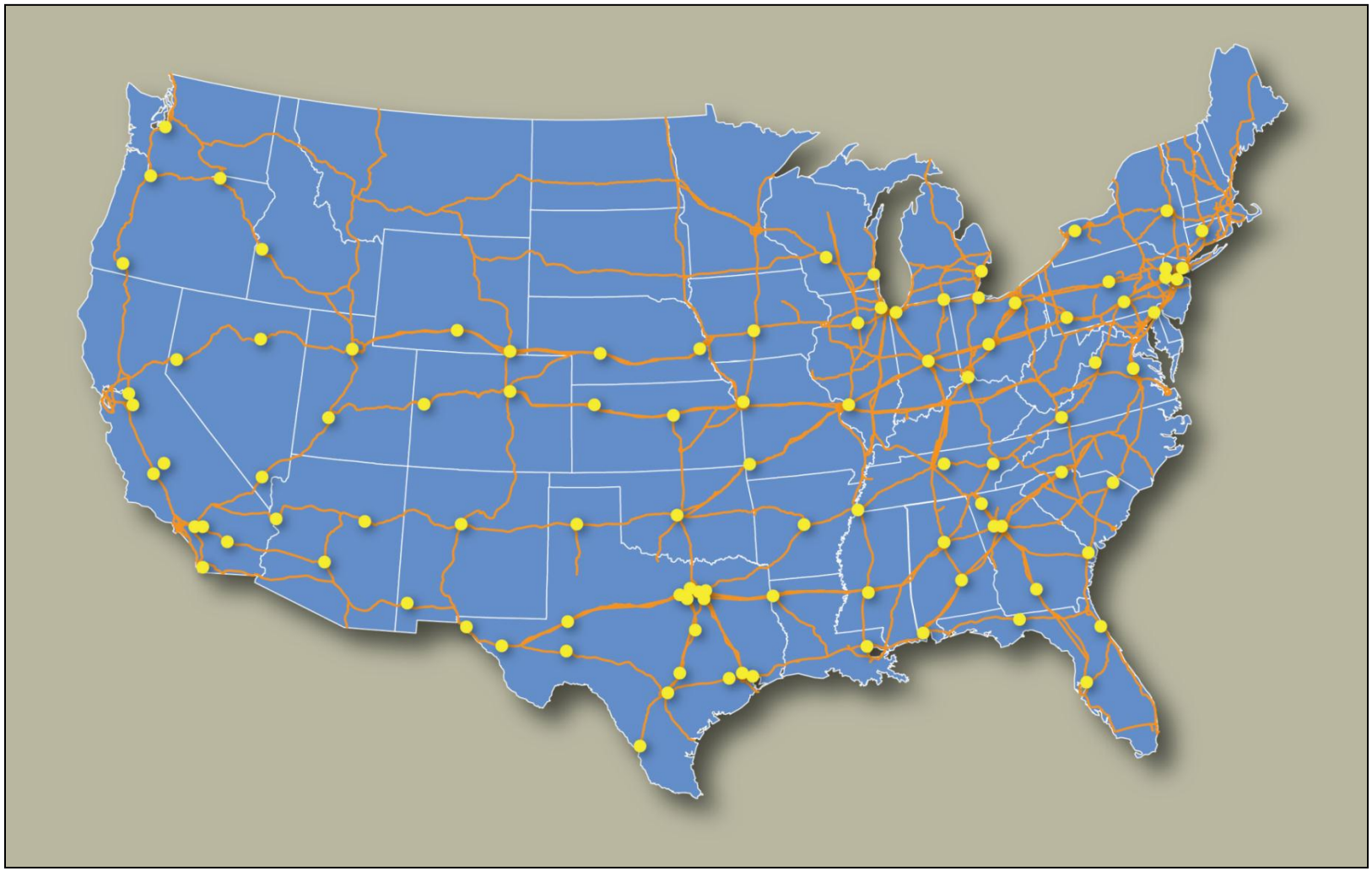

Source: MITEI

# Natural Gas Vehicles in the US

- US is 12th-14th globally (behind Argentina, Brazil, India) with 110,000 NGVs
- US fueling stations: 840 for CNG, 39 for LNG (28 in CA) vs. 4,000 diesel truck stops
- US fleet composition: almost all CNG, mostly buses, taxis, delivery and refuse trucks, and other fleet vehicles; Honda Civic; bi-fuel trucks (F-250)
- Port of LA/Westport/Clean Fuels and others

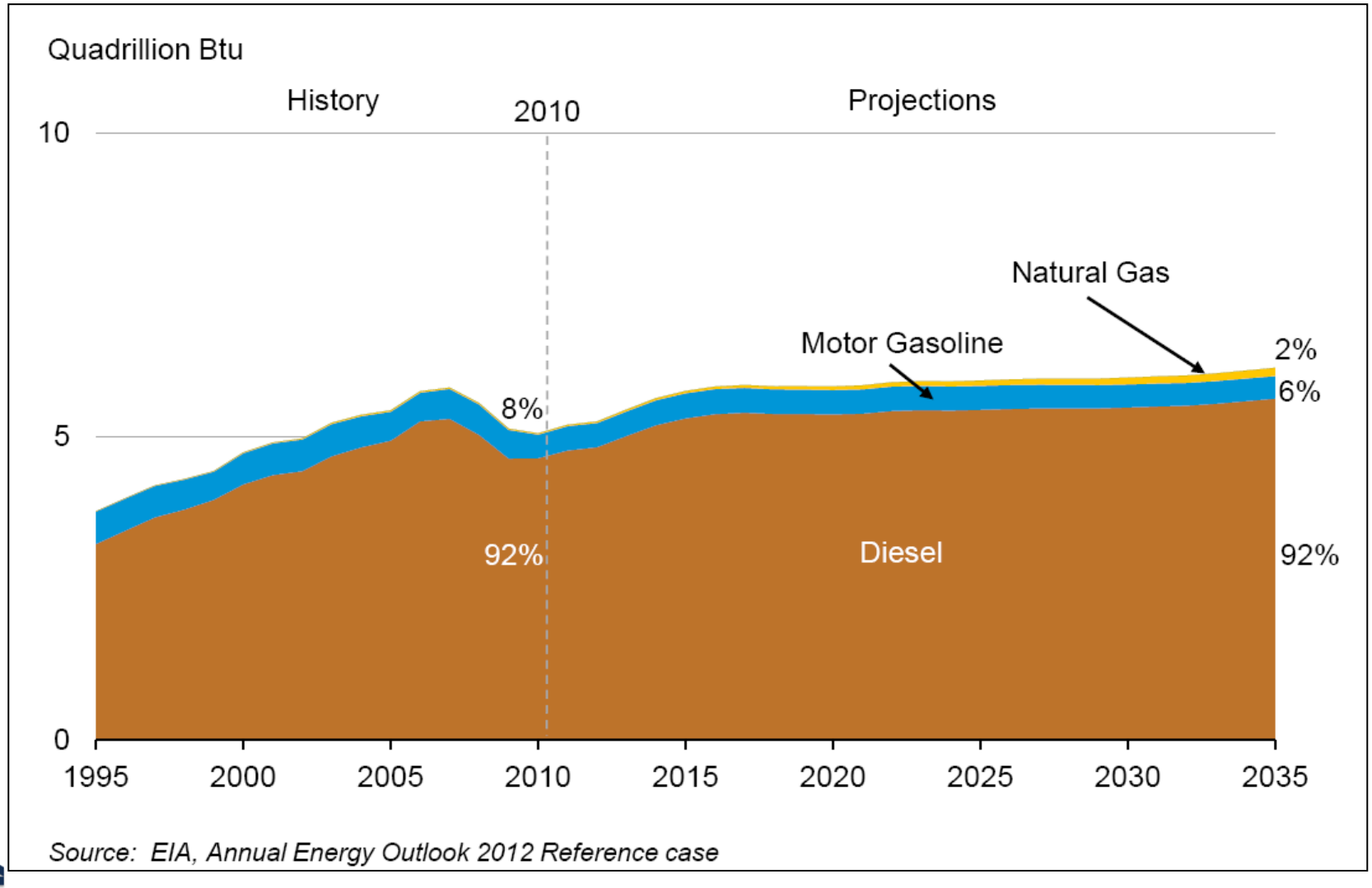
# Infrastructure “corridors”

- Utah: Built infrastructure (24 => 41 public stations) for NGVs, making I-15 a “natural gas corridor”
- New deal with Shell and Westport and trucking companies for “oil sands route” (Fort McMurray to Vancouver): LNG
- UPS long-haul LNG trucks: Salt Lake - Las Vegas - LA corridor
- Chesapeake Energy, Clean Energy Fuel Corp. and Pilot Flying J for CNG/LNG stations: $150 mil.



*Source:* http://www.cleanenergyfuels.com/pdf/CE-OS.ANGH.012412.pdf

# Heavy-duty vehicle energy consumption grows due to rising VMT; mainly met by diesel consumption




*Source: EIA, Annual Energy Outlook 2012 Reference case*

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# Heavy-Duty Vehicles: Economics

- 18-wheelers travel 125,000 miles/year @ ~5 miles/gallon diesel
- LNG for range (energy density: 0.67 of diesel; CNG 0.21 of diesel)
- ~ $70,000 more expensive investment, but historically lower fuel costs
- BUT: observed impatience (31% interest rate)

# Sensitivity of Payback Periods to Assumptions

| Vehicle Cost Differential: | | $35,000 | | | $70,000 | | |
|---|---|---|---|---|---|---|---|
| Fuel Economy: | | 5.6 mpg | 5.1 mpg | 4.6 mpg | 5.1 mpg | | |
| Vehicle Miles Traveled: | | 70,000 | | | 125,000 | 90,000 | 70,000 |
| Interest Rate= 0.05 | Fuel Price Diff. = $1.50 | 1.62 | 1.82 | 2.14 | 2.05 | 2.91 | 3.82 |
| | $0.75 | 3.04 | 3.82 | 5.54 | 4.33 | 6.29 | 8.52 |
| | $0.50 | 4.3 | 6.03 | 11.98 | 6.89 | 10.36 | 14.62 |
| 0.10 | $1.50 | 1.73 | 1.95 | 2.31 | 2.22 | 3.22 | 4.36 |
| | $0.75 | 3.39 | 4.36 | 6.74 | 5.03 | 7.9 | 11.96 |
| | $0.50 | 4.99 | 7.48 | 22.72 | 8.88 | 16.54 | - |
| 0.31 | $1.50 | 12.09 | - | - | 3.3 | 6.35 | - |
| | $0.75 | - | - | - | - | - | - |
| | $0.50 | - | - | - | - | - | - |

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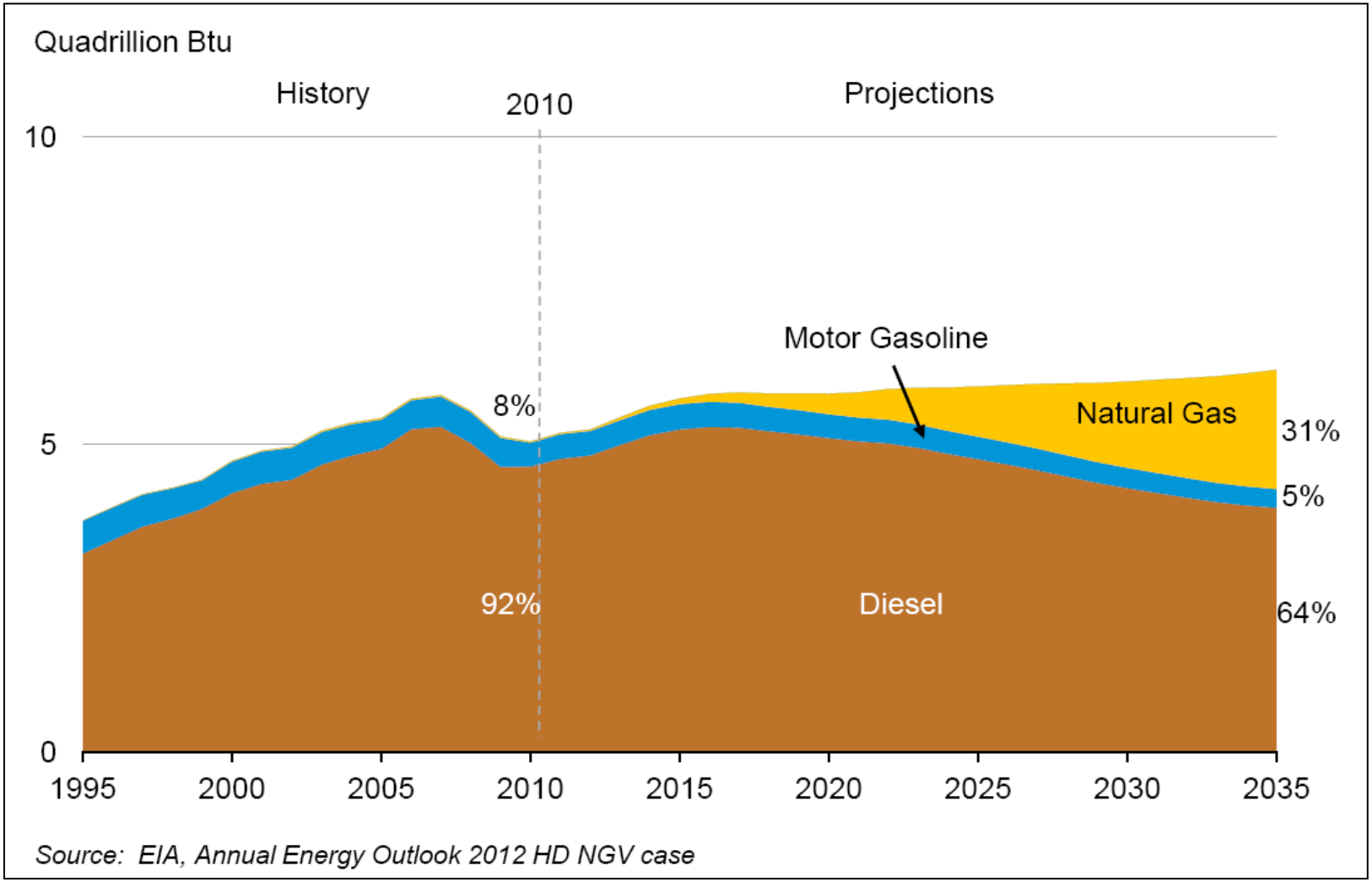
# Heavy-duty vehicle natural gas consumption grows substantially in the HD NGV case




*Source: EIA, Annual Energy Outlook 2012 HD NGV case*

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# What's "green" about natural gas?

Reductions in conventional pollutants vs. diesel*:

- Carbon monoxide 20 percent – 40 percent lower
- VOCs 10 percent lower
- Particulate matter 80 percent lower

No oil spills/leaks

Energy security benefits if oil backed out

Safety issues with natural gas

Lifecycle GHGe emissions:

- Conventional wisdom: 20% cleaner than diesel (including boil off of LNG)
- May be 30% cleaner than diesel from oil sands
- Critical role of fugitive methane and global warming potential

*http://www.afdc.energy.gov/afdc/vehicles/emissions_natural_gas.html

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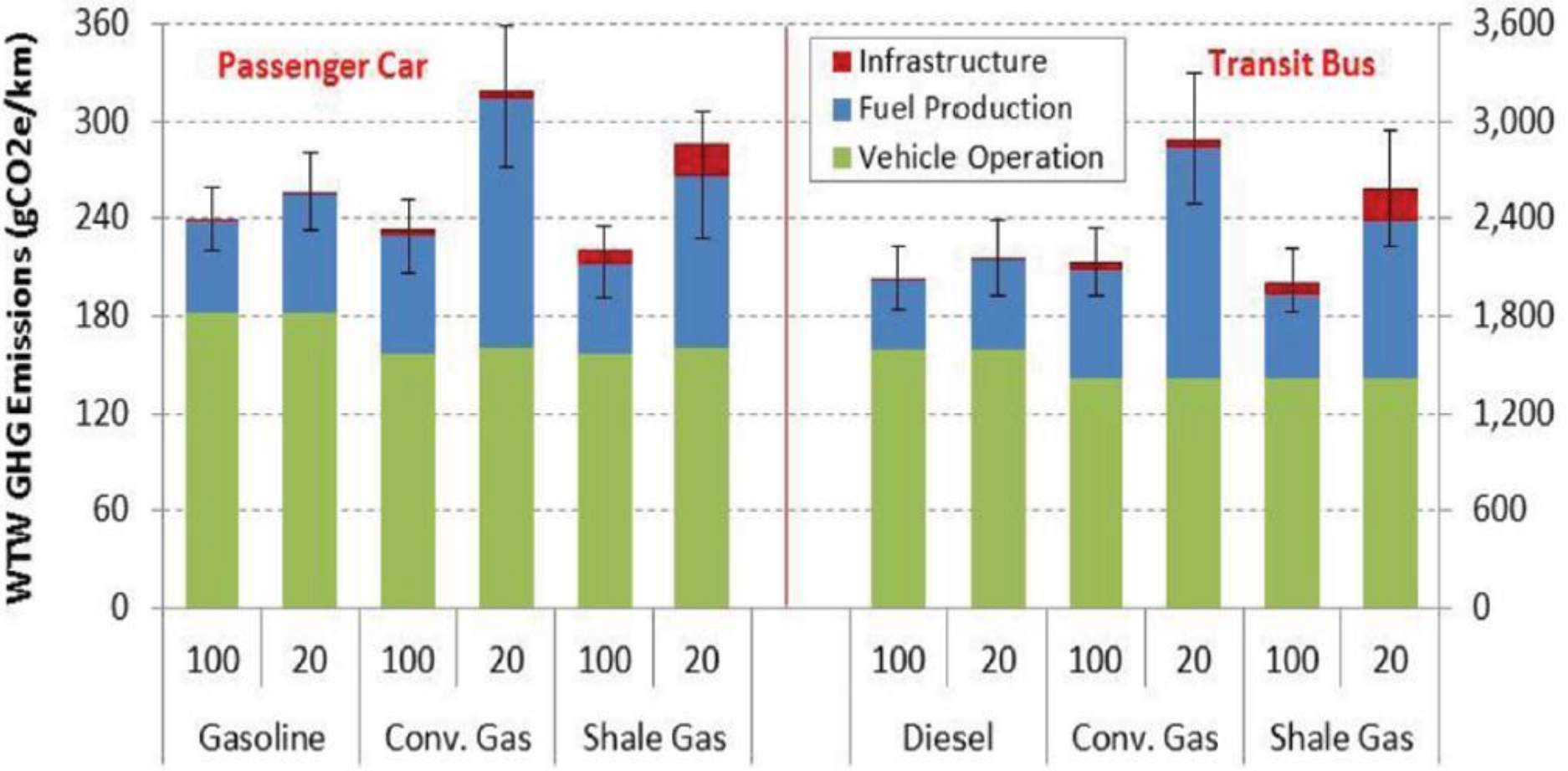


**Life-cycle GHG emissions per vehicle kilometer traveled passenger car and transit bus for both 100-year and 20-year time horizons.**

Life-Cycle Greenhouse Gas Emissions of Shale Gas, Natural Gas, Coal, and Petroleum, Andrew Burnham,* Jeongwoo Han, Corrie E. Clark, Michael Wang, Jennifer B. Dunn, and Ignasi Palou-Riveradx.doi.org/10.1021/es201942m |Environ. Sci. Technol. 2012, 46, 619–627

# Alverez et al PNAS, 2012

Fugitive methane below 1.6% of production to provide GHG benefits backing out gasoline vehicle

Fugitive methane below 1.0% of production to provide GHG benefits backing out diesel HD vehicle

Their estimate: 3% leakage rate: highly uncertain

# Conclusions on economics

## Very Heavy-Duty

- Now: Niche market for LNG-fueled heavy-duty trucks. Much upside potential. Chicken and egg problem being addressed by shale gas companies. Secondary market needs study.

## Light-Duty

- Tougher case for CNG-fueled light-duty vehicles: lots of competition with alternate fuels and GVs; range and cost issues
- European NGVs overcome one issue by mounting tanks under the back seat and luggage compartment, thereby leaving more trunk space

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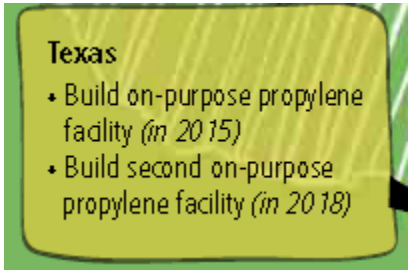
# Policy conclusion

- HD truck market working to add LNG.
- O&Gs need to monetize their gas
- Externality differential with diesel exists but not large and significant uncertainty with respect to global warming potential

➔ Not the best candidate for subsidies

# Other sectors

- Residential and commercial uses:  Limited opportunities for substitution; slow growth
- Industrial: natural gas use had been declining, but now reversed
  - “Companies like fertilizer and chemical makers, which use gas as a raw material, are suddenly finding that the United States is an attractive place to put new factories, compared with, say, Asia, where gas is four times the price.
  - Dow Chemical, which uses natural gas as a material for producing plastics, has assembled a list of 91 new manufacturing projects, representing $70 billion in potential investment, that various companies have proposed or begun because of cheap gas.”  (NYTimes)



Source: Dow’s Annual Report (2011)

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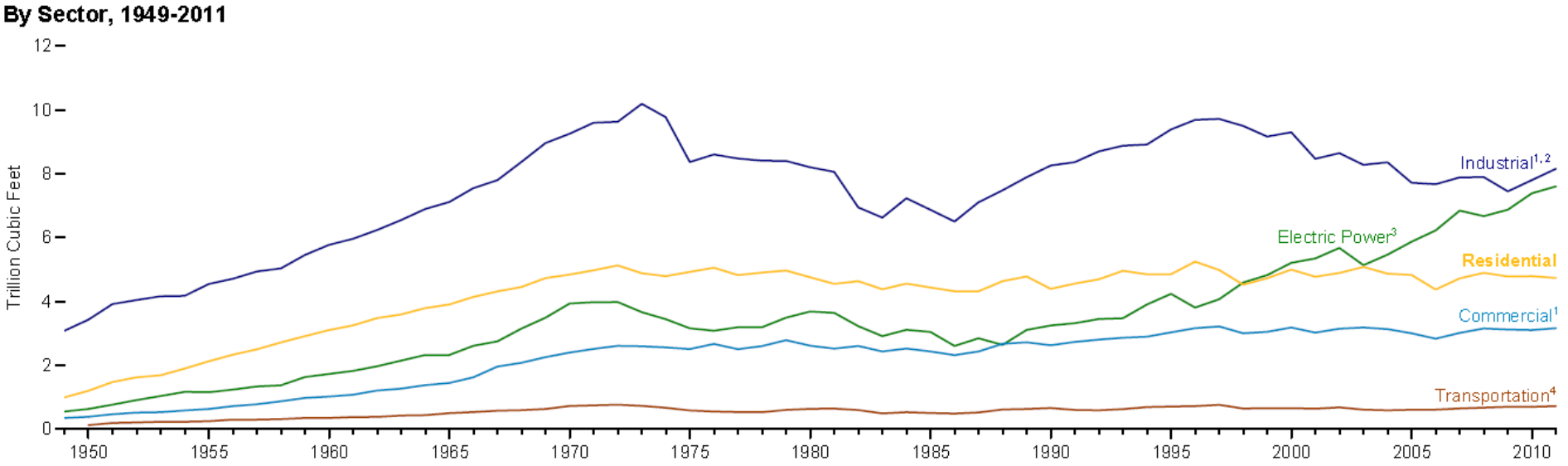
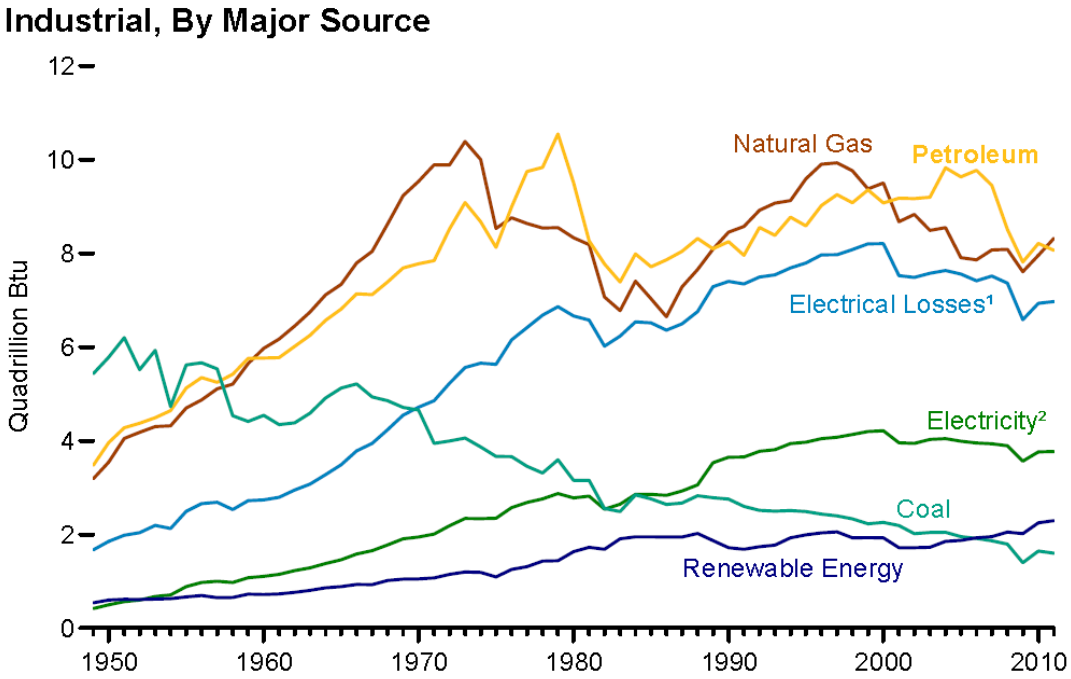



Source: Annual Energy Review 2011 (EIA, 2012)




Source: Annual Energy Review 2011 (EIA, 2012)

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# From Natural Gas to Manufactured Products


Source: PwC and TopLine Analytics; Wiki

# Thank You!

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