Critical Issues Forum

America's Increasing Reliance on Natural Gas: Benefits and Risks of a Methane Economy

Wifi network: FWC Wireless
Password: (no password needed)

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Session 2:
Forecasts of natural gas demand

american geosciences institute
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Kenneth Medlock
Rice University

AGI american geosciences institute
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center for ENERGY STUDIES
Rice University's Baker Institute

RICE

Natural Gas Demand: Outlooks and Implications

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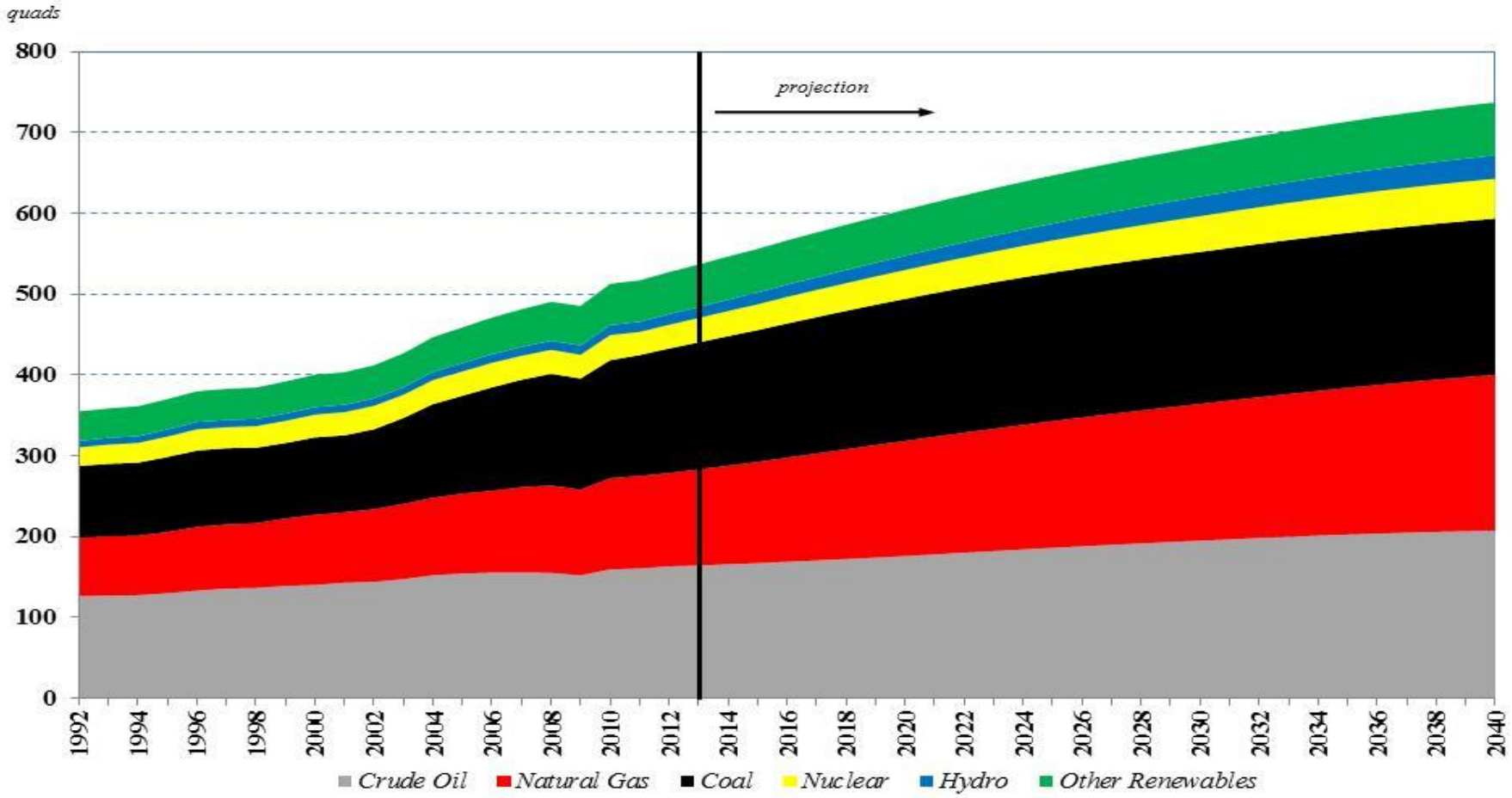
James A Baker III and Susan G Baker Fellow in Energy and Resource Economics, and Senior Director, Center for Energy Studies
Rice University's Baker Institute

November 19, 2014

The Earth at Night and Energy Insights

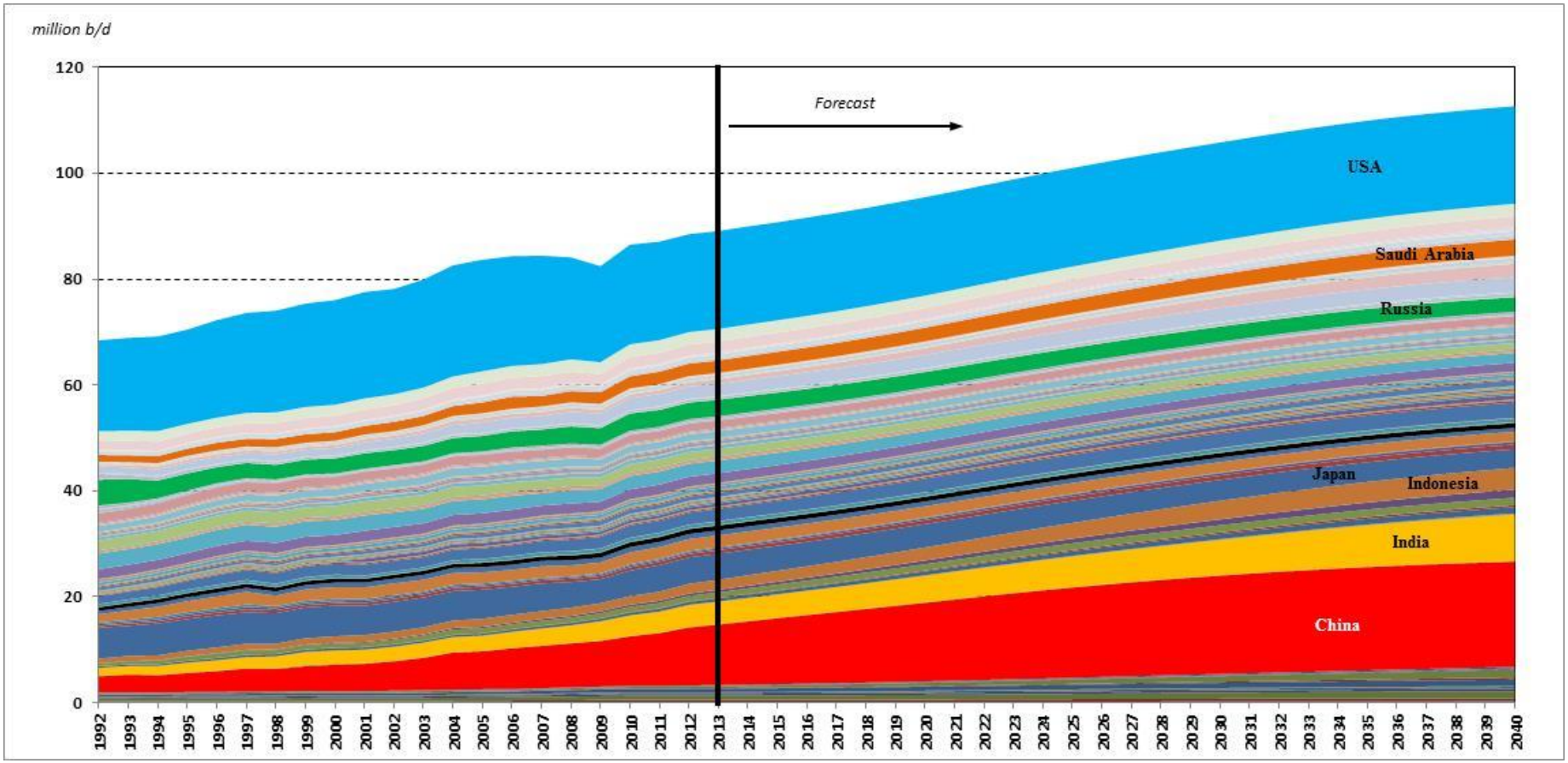
Global Total Primary Energy Requirement

- Baker Institute CES forecast of TPER by fuel, 1992-2040



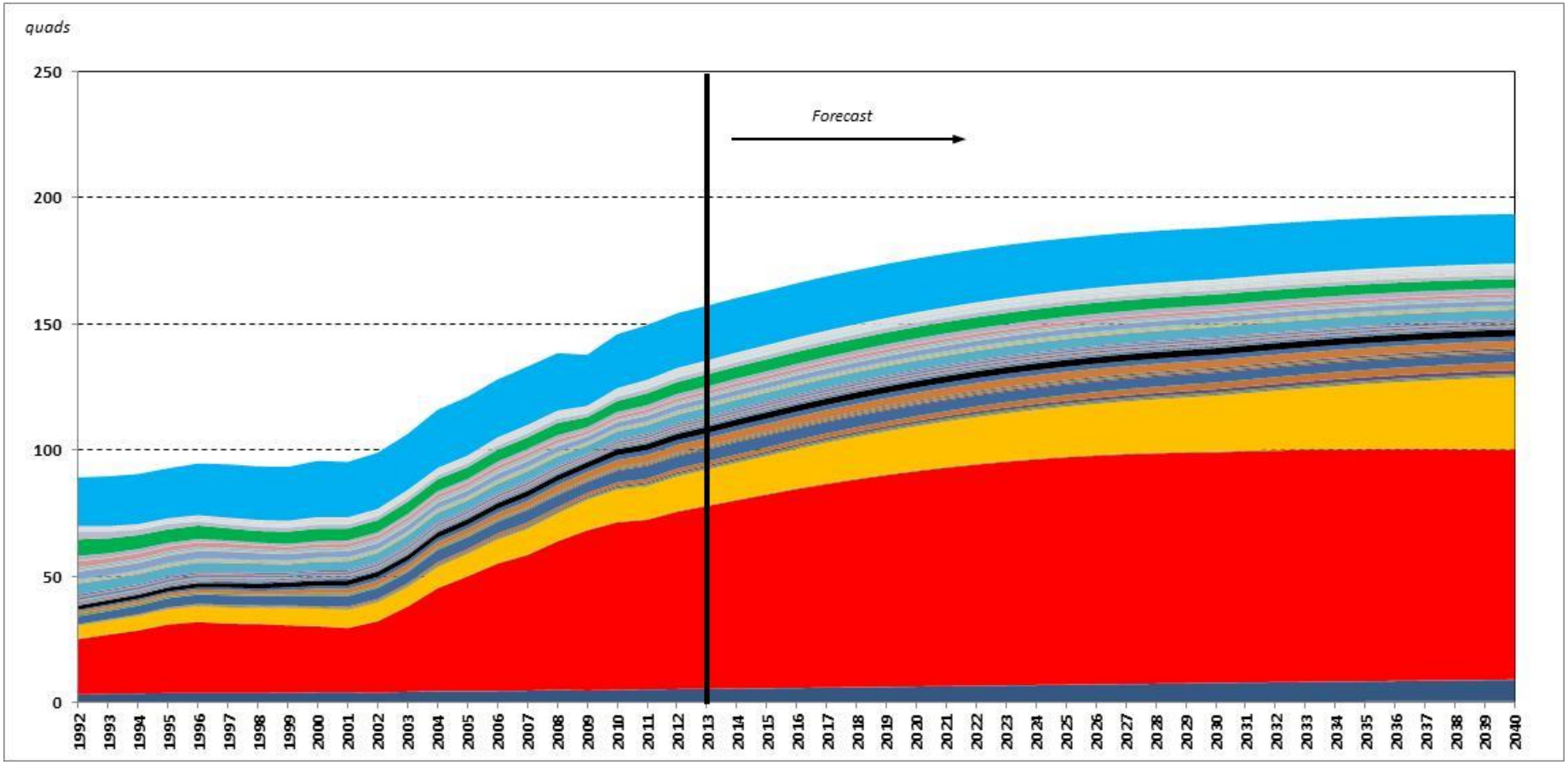
Global Oil Demand

- Baker Institute CES forecast of petroleum demand by country, 1992-2040
  - Demand will continue to grow, driven largely by very populous developing economies such as China and India.



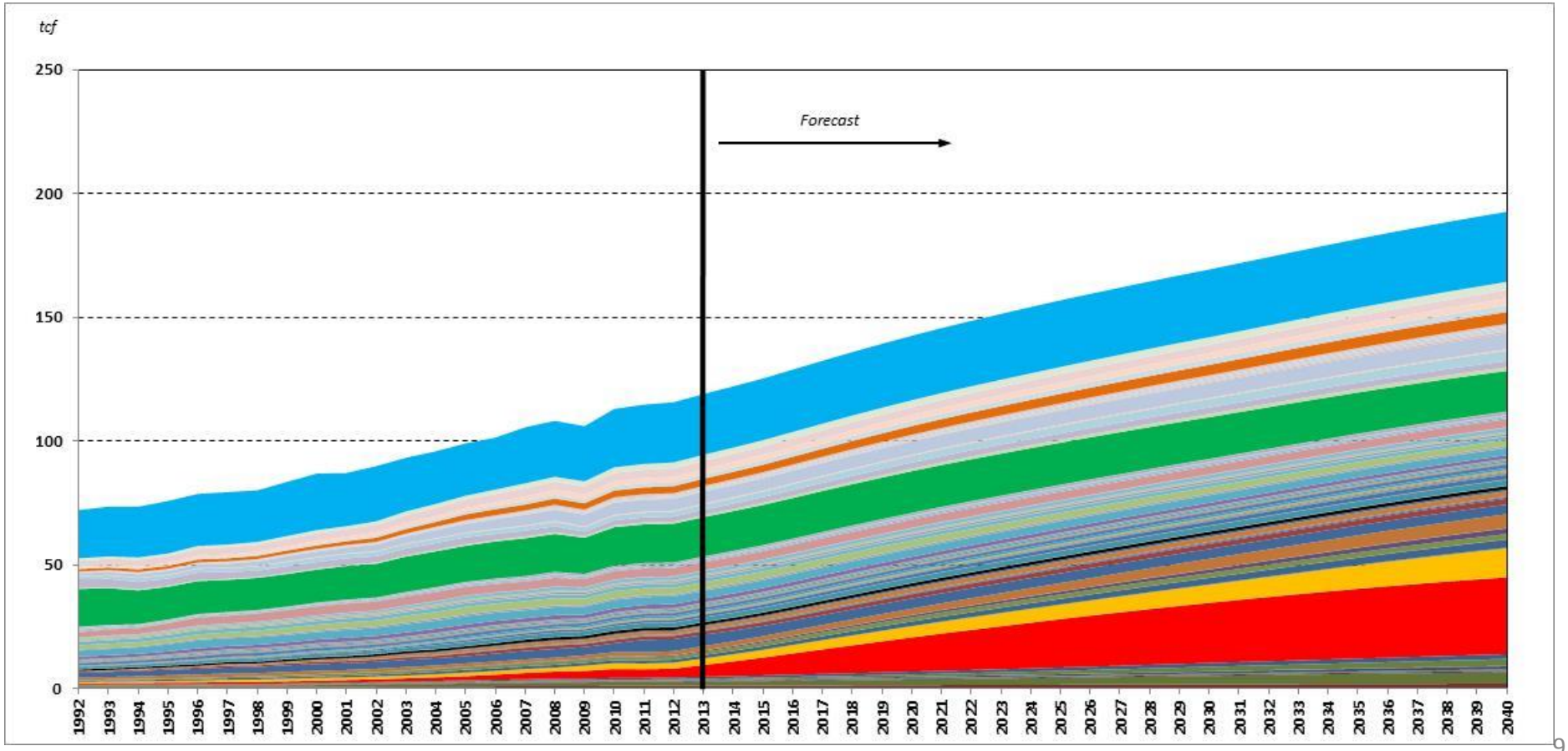
Global Coal Demand

- Baker Institute CES forecast of coal demand by country, 1992-2040
  - Infrastructure in China has been developed around coal… will China switch away, or upgrade environmental controls?



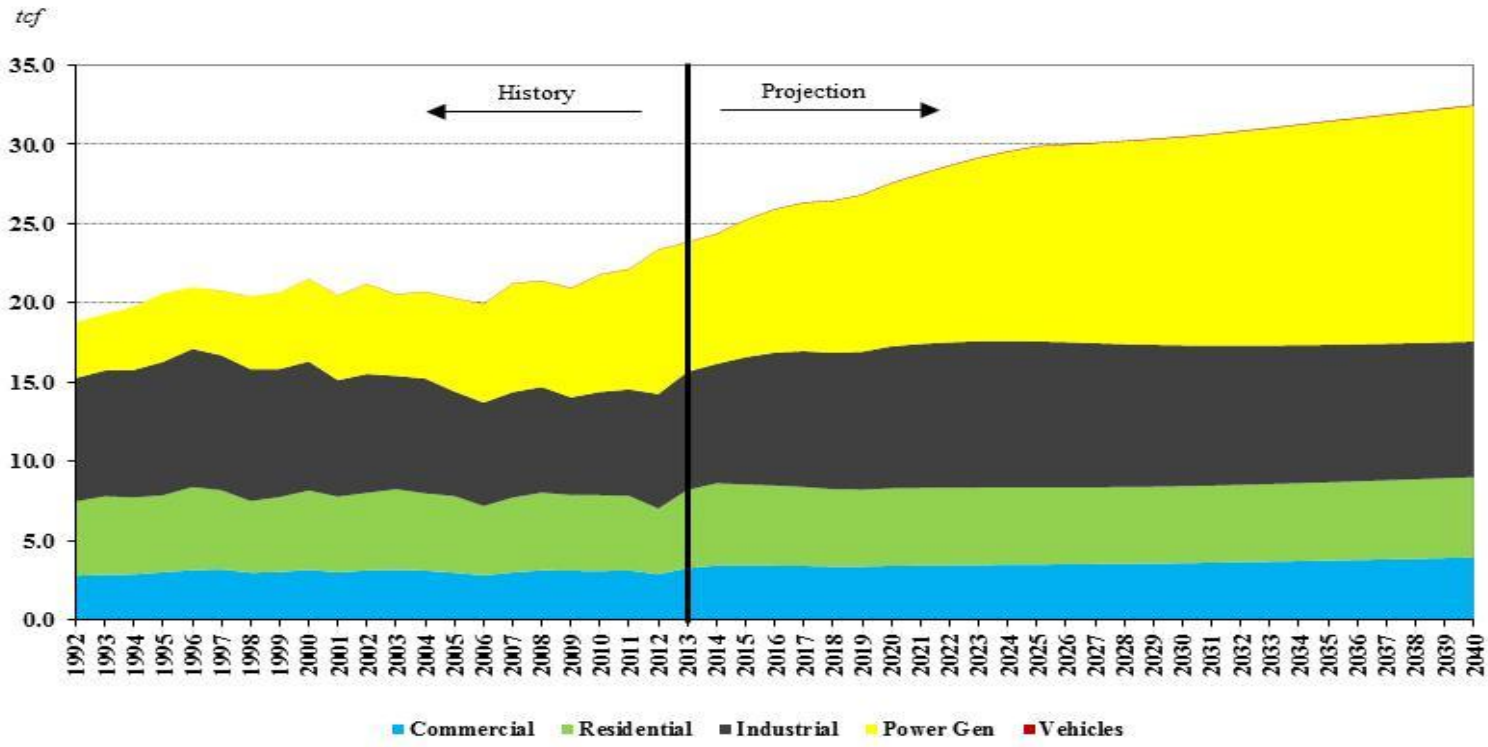
Global Natural Gas Demand

- Baker Institute CES forecast of natural gas demand by country, 1992-2040
  - Similar patterns as with oil… demand driven by Asia



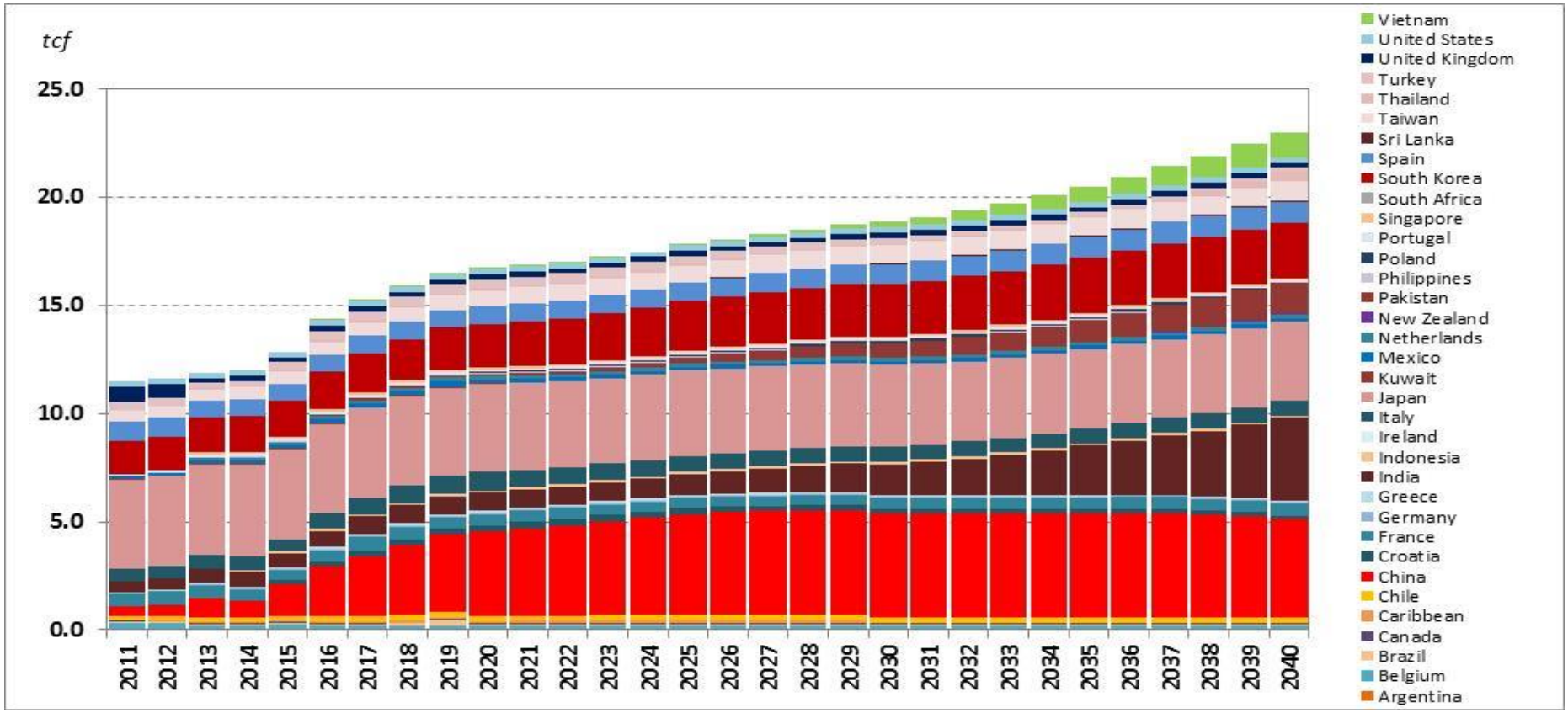
U.S. Natural Gas Demand, 2010-2040

- Natural gas demand is expected to grow by 1.7% p.a. from 2010-2030, largely driven by power generation and industrial demands.
  - Driven by policy, power generation demand grows at 2.9% p.a.
  - Industrial demand grows at 1.6% p.a., largely from 2010 to 2020.



LNG Imports by Country, 2011-2040

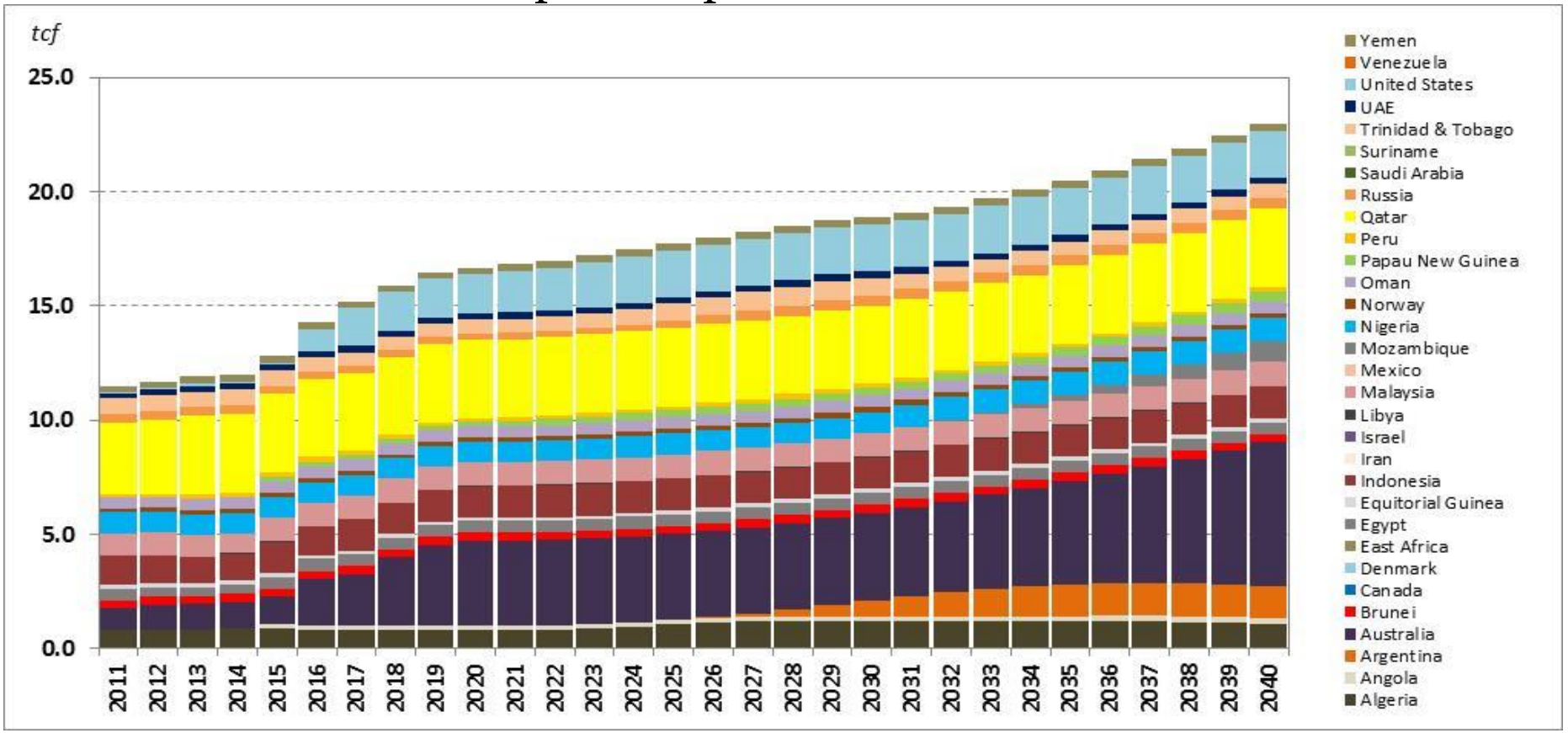
- Diversity in the LNG import picture, with China surpassing Japan in the mid 2020s, and India emerging in the 2030s.



Source: Baker Institute RWGTM February 2014,. The RWGTM was developed by Kenneth Medlock and Peter Hartley of Rice University and utilizes the Deloitte MarketPoint software platform to execute.

LNG Exports by Country, 2011-2040

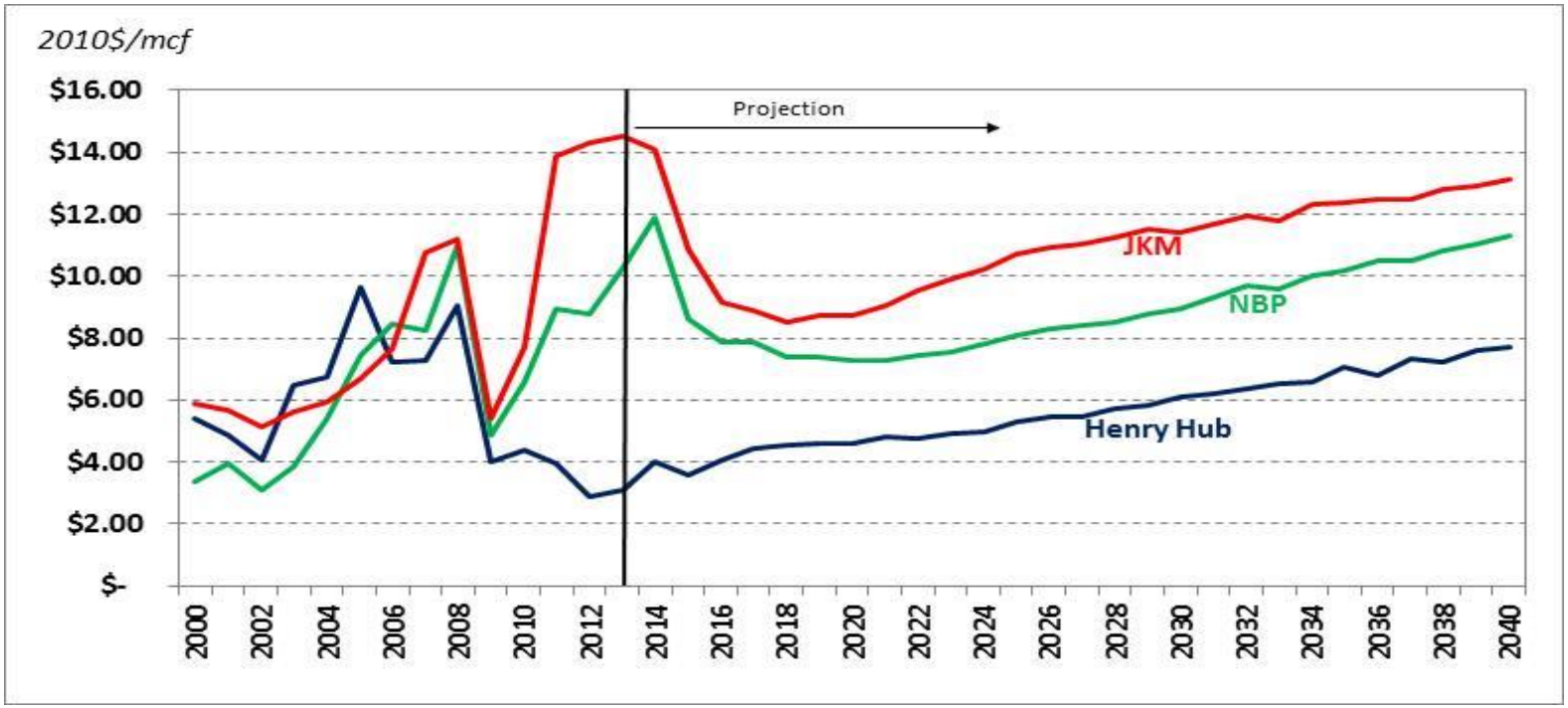
- Qatar and Australia account for over 40% of global *LNG* exports, and the US enters in 2016 which helps drive price decline in Asia.



Source: Baker Institute RWGTM February 2014,. The RWGTM was developed by Kenneth Medlock and Peter Hartley of Rice University and utilizes the Deloitte MarketPoint software platform to execute.

Global Marker Prices, 2011-2040

- The prices indicated are *spot* prices; *contract* prices may be different, but short term trade will continue to expand.
- Global prices remain above the US price, but trade closes the spread.



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center for

ENERGY STUDIES

Rice University's Baker Institute

David Levinson
University of Minnesota

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Futures of Energy for Transportation

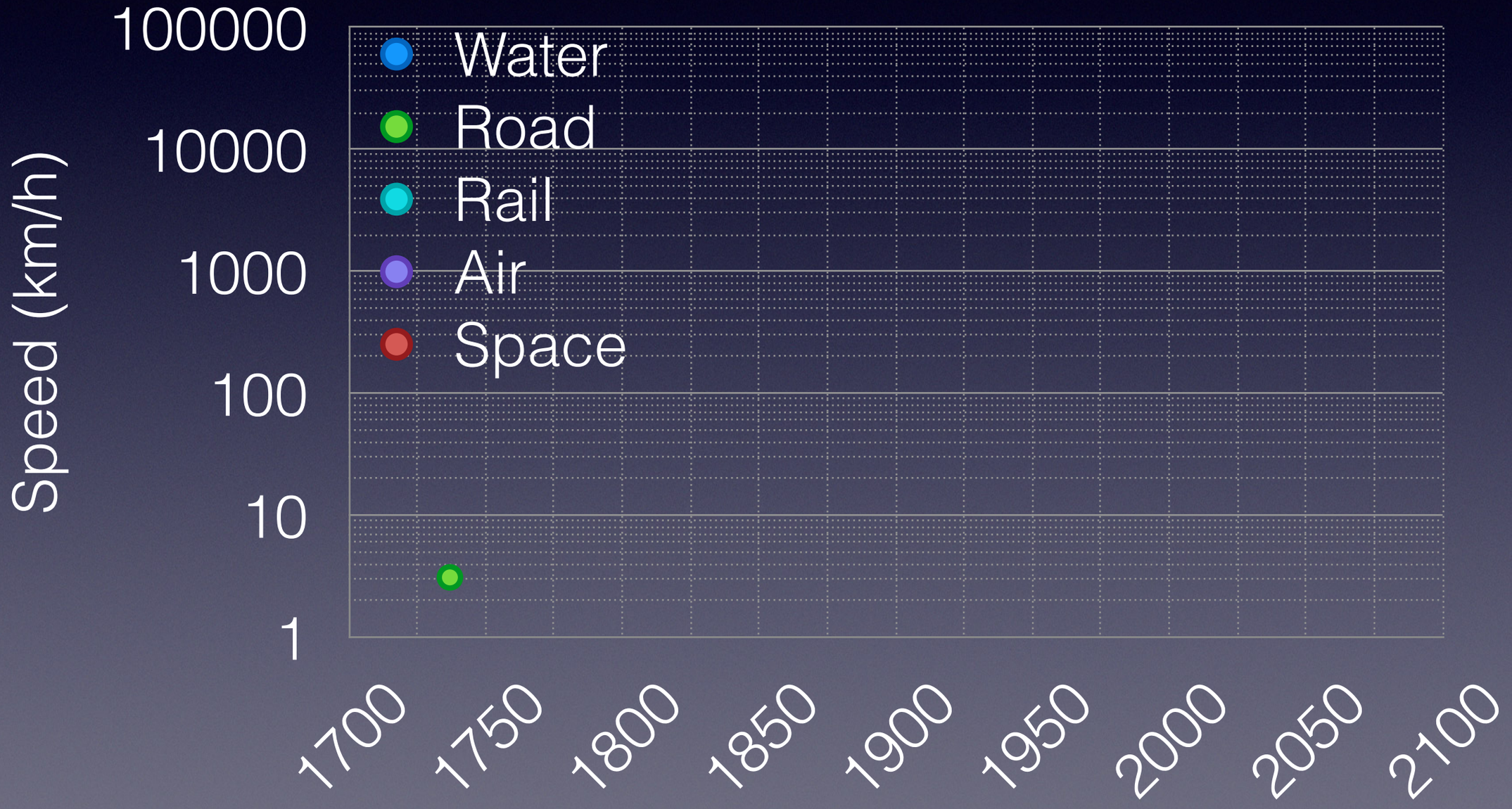
David Levinson
RP Braun/CTS Chair
Department of Civil, Environmental, and Geo- Engineering
University of Minnesota

Abstract:

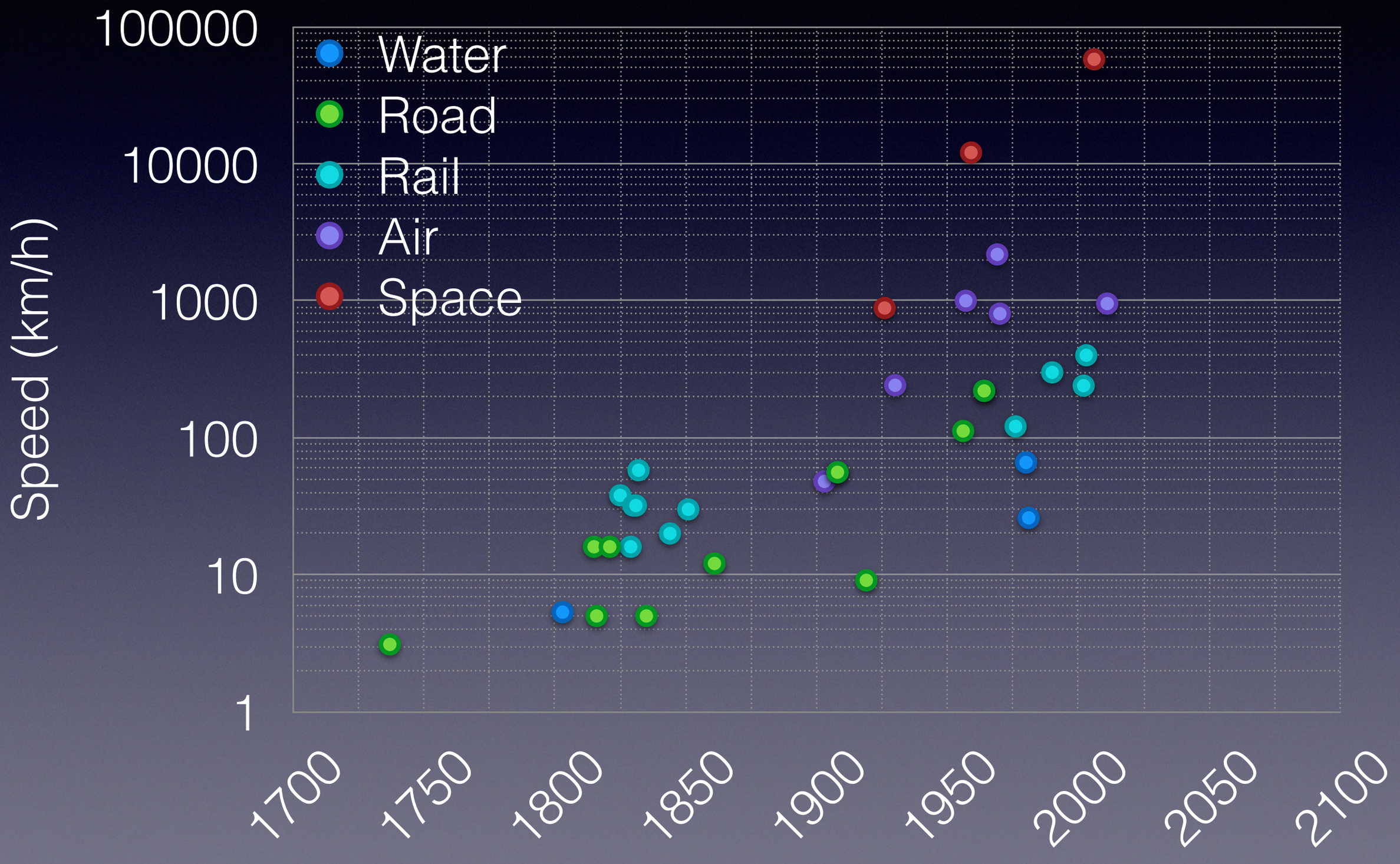
Vehicles powered by electricity or other non-oil-based energy sources will eventually become a mainstay of the American garage. As the market adjusts and early adopters experiment with new vehicles, each energy source, be it electricity, fuel cells, biofuels, natural gas, or something else, may come to temporarily dominate a market niche. But in the end, economies of scale suggest that one technology will win out for a long time. And so the battle for the automobile now looks much like it did at the beginning of the twentieth century.

Context

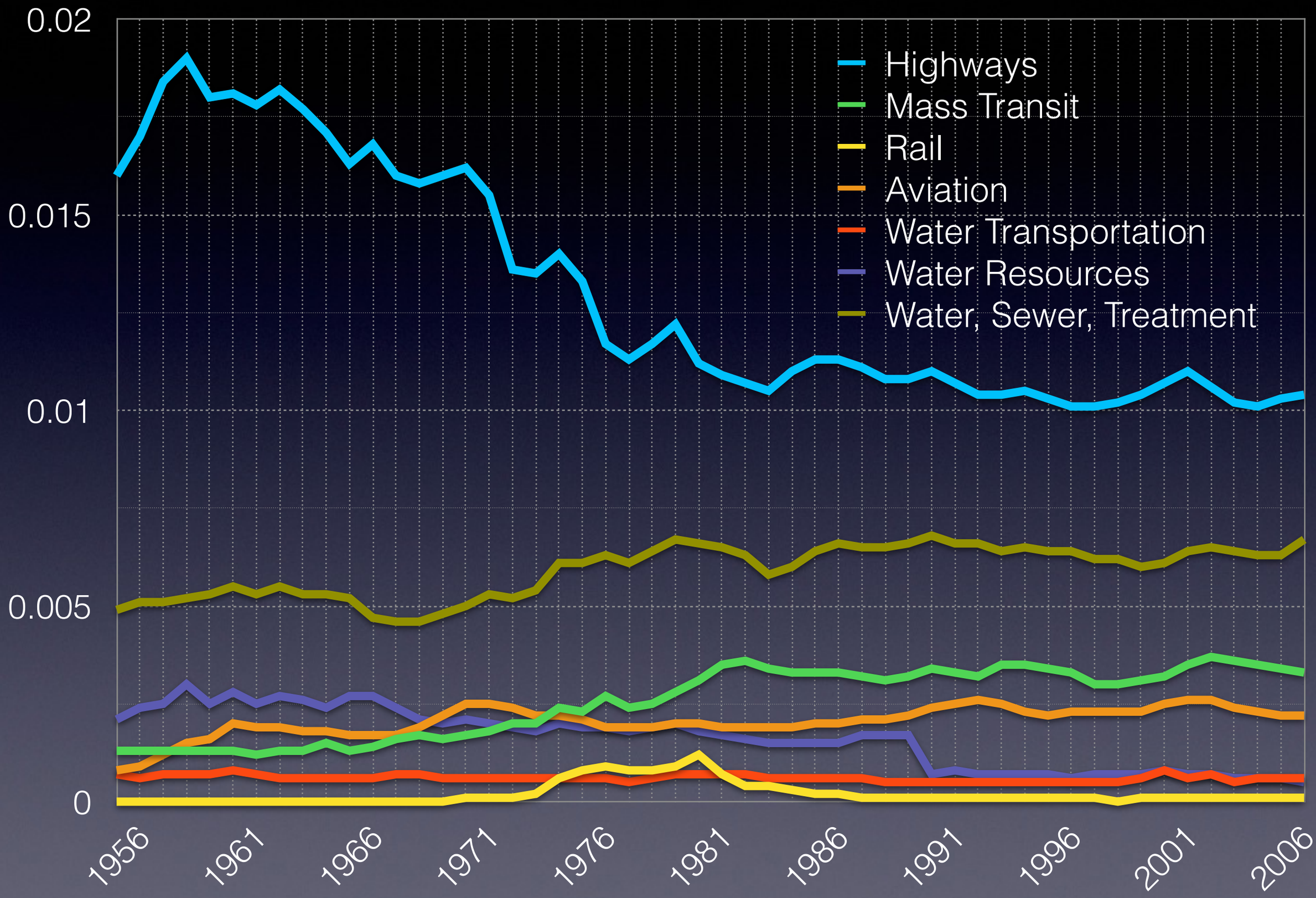
Speed vs. Time (movie)



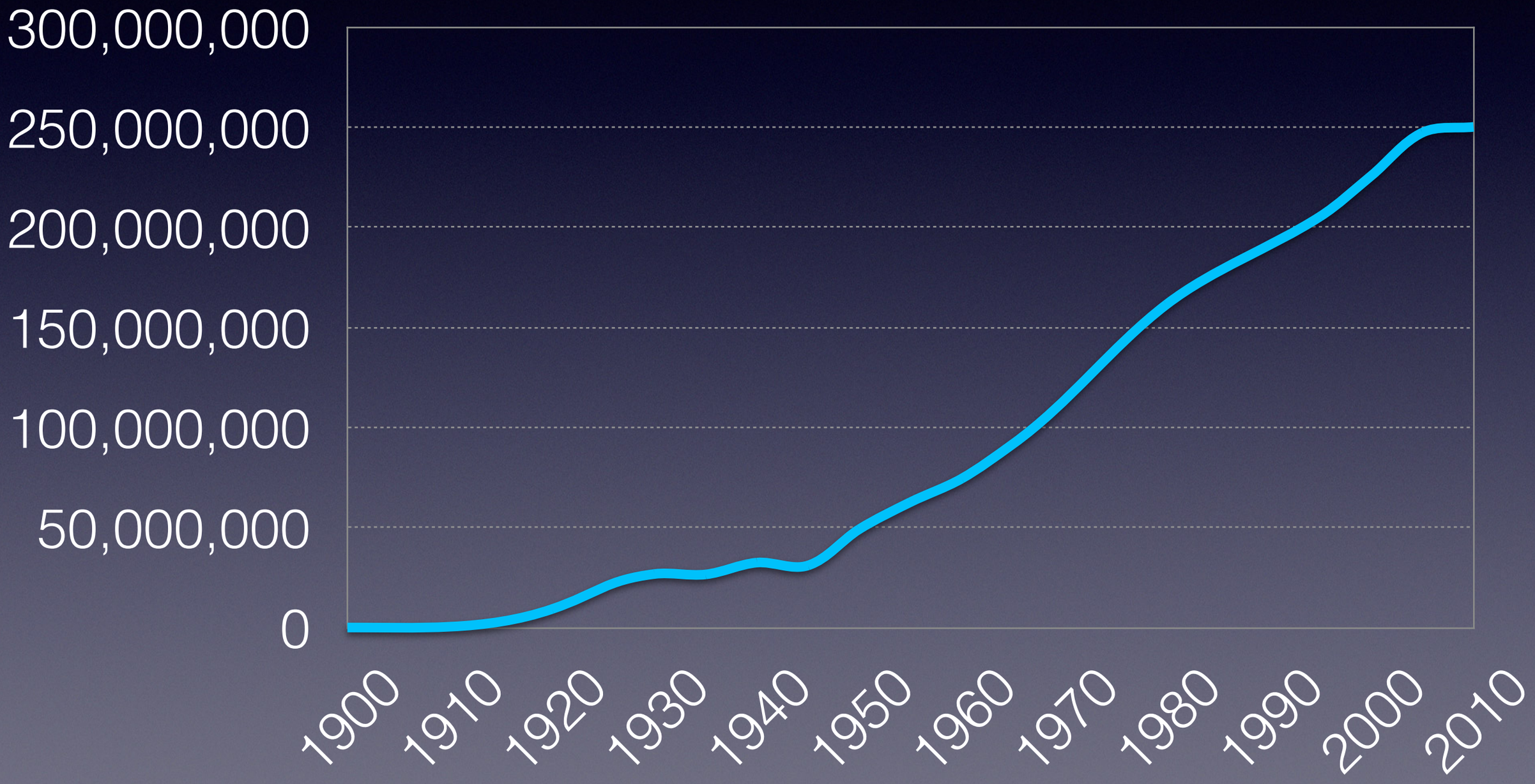
Speed vs. Time

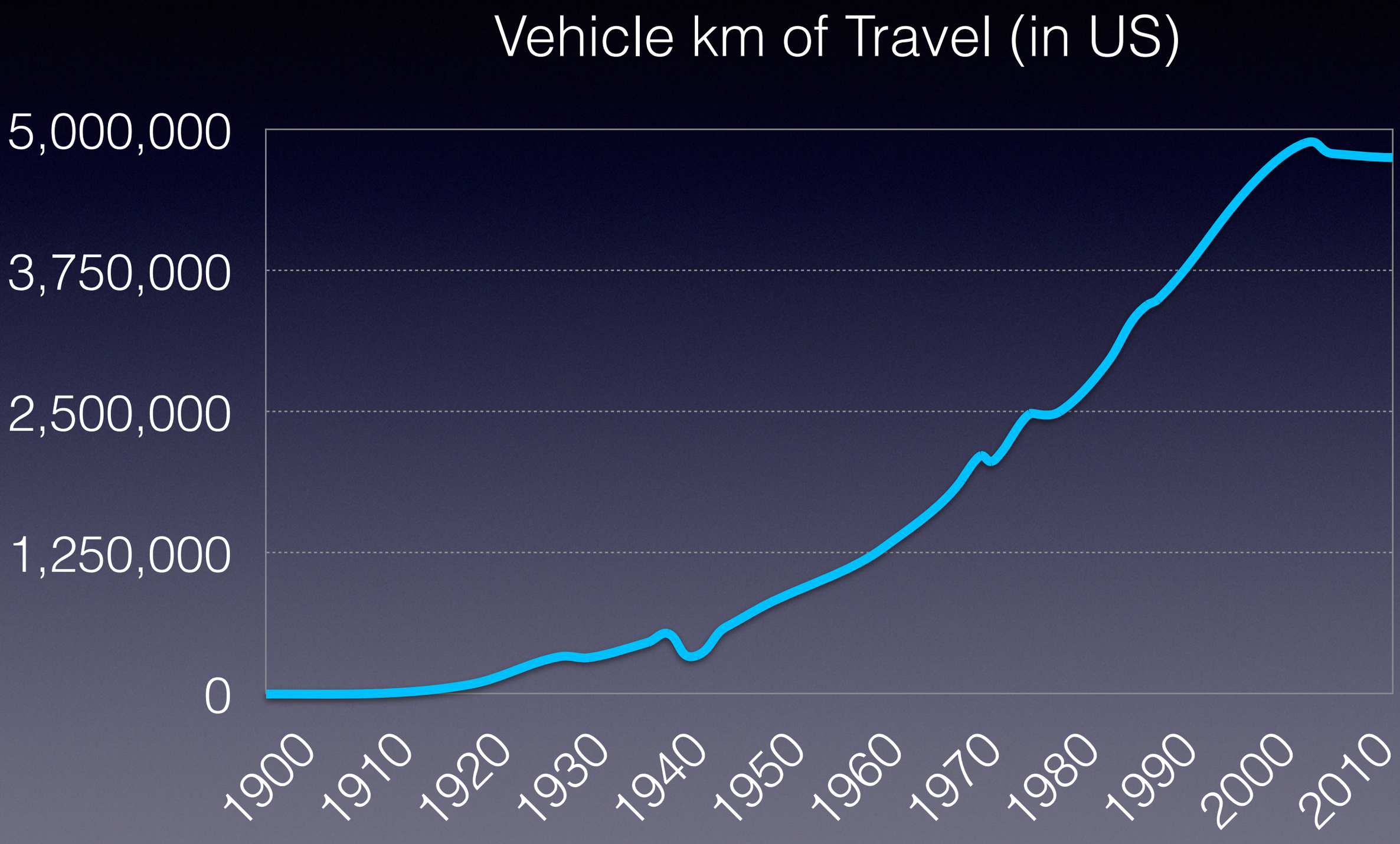


Public Infrastructure Spending as Share of GDP

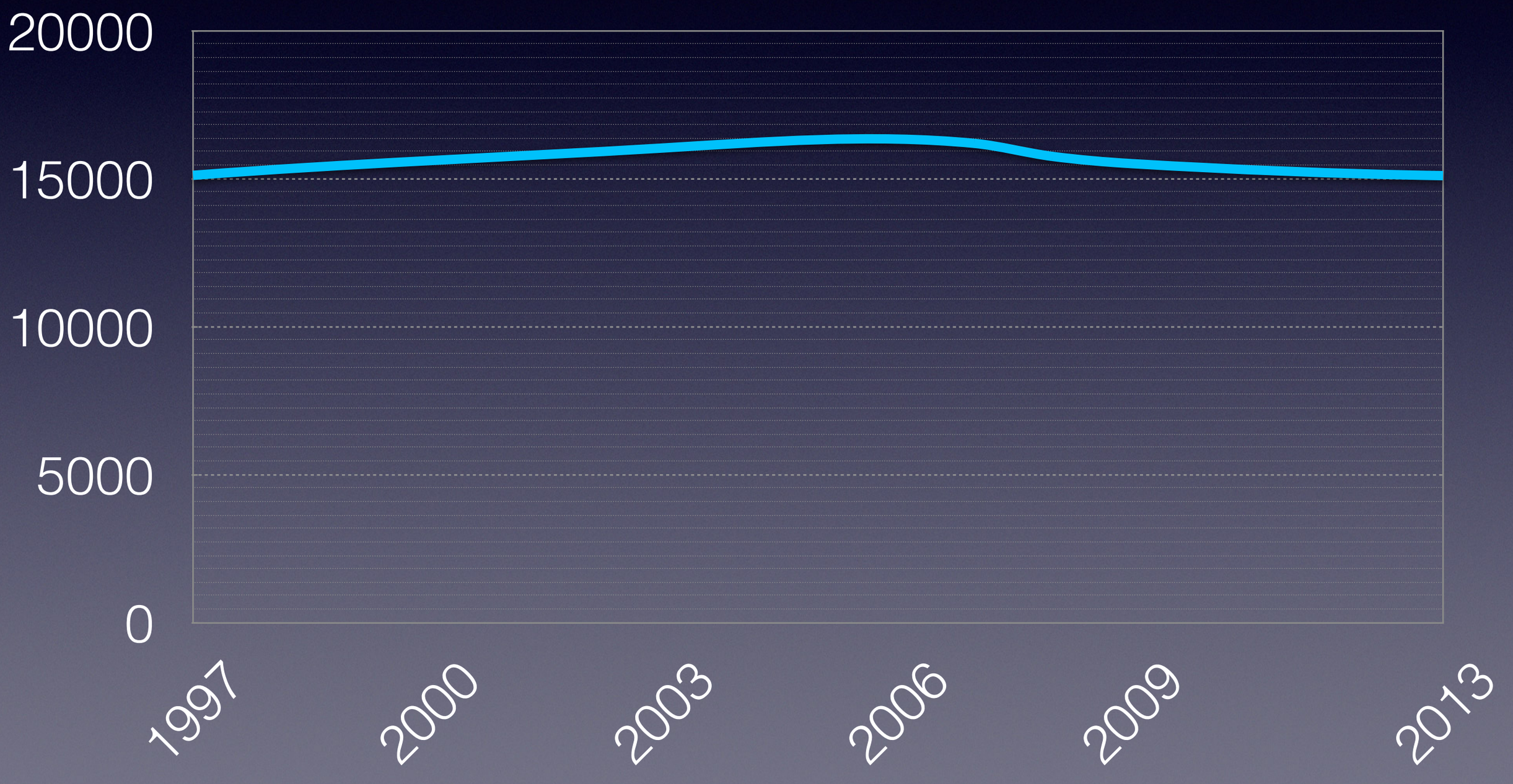


Registered Motor Vehicles (in US)

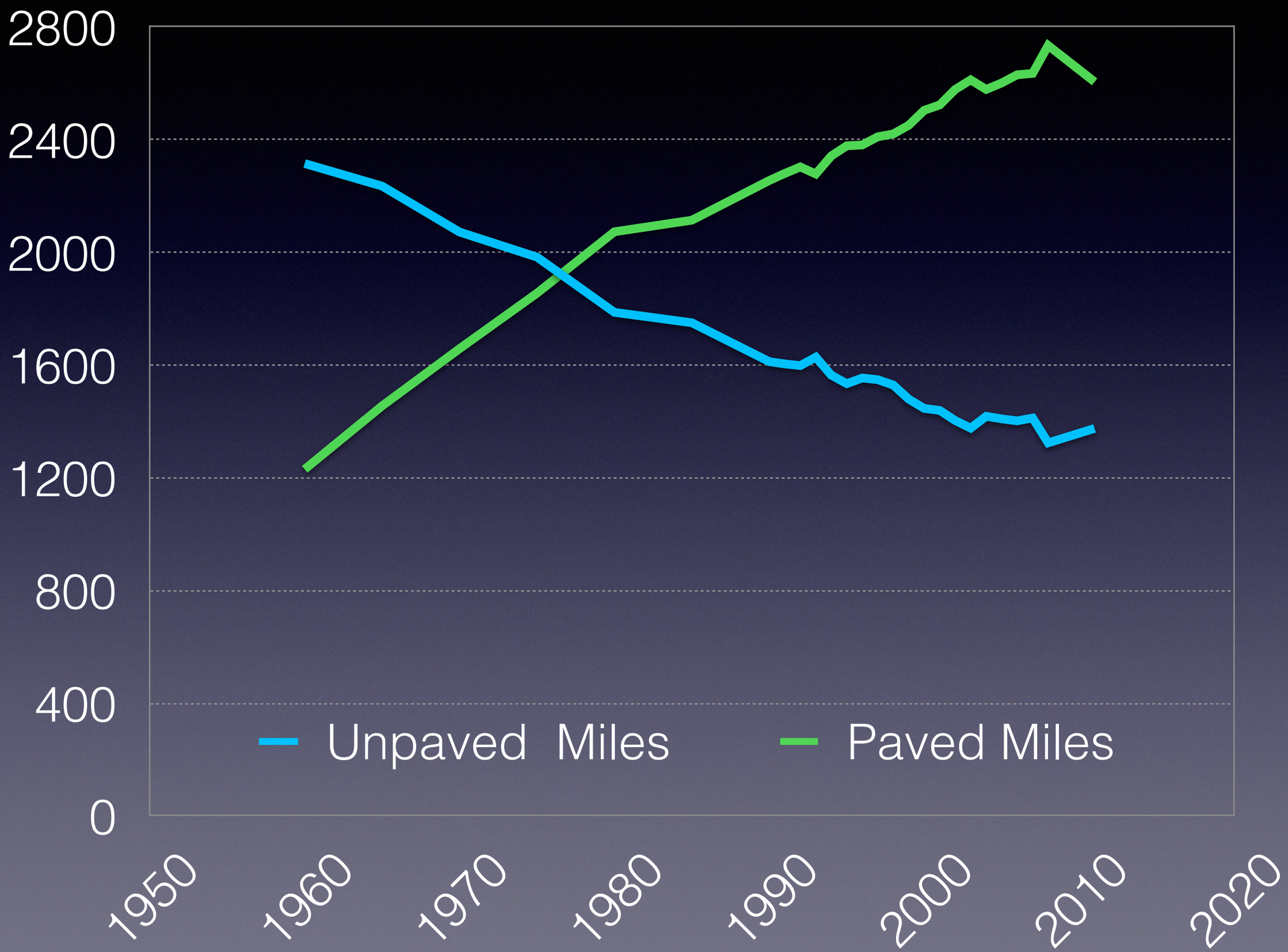


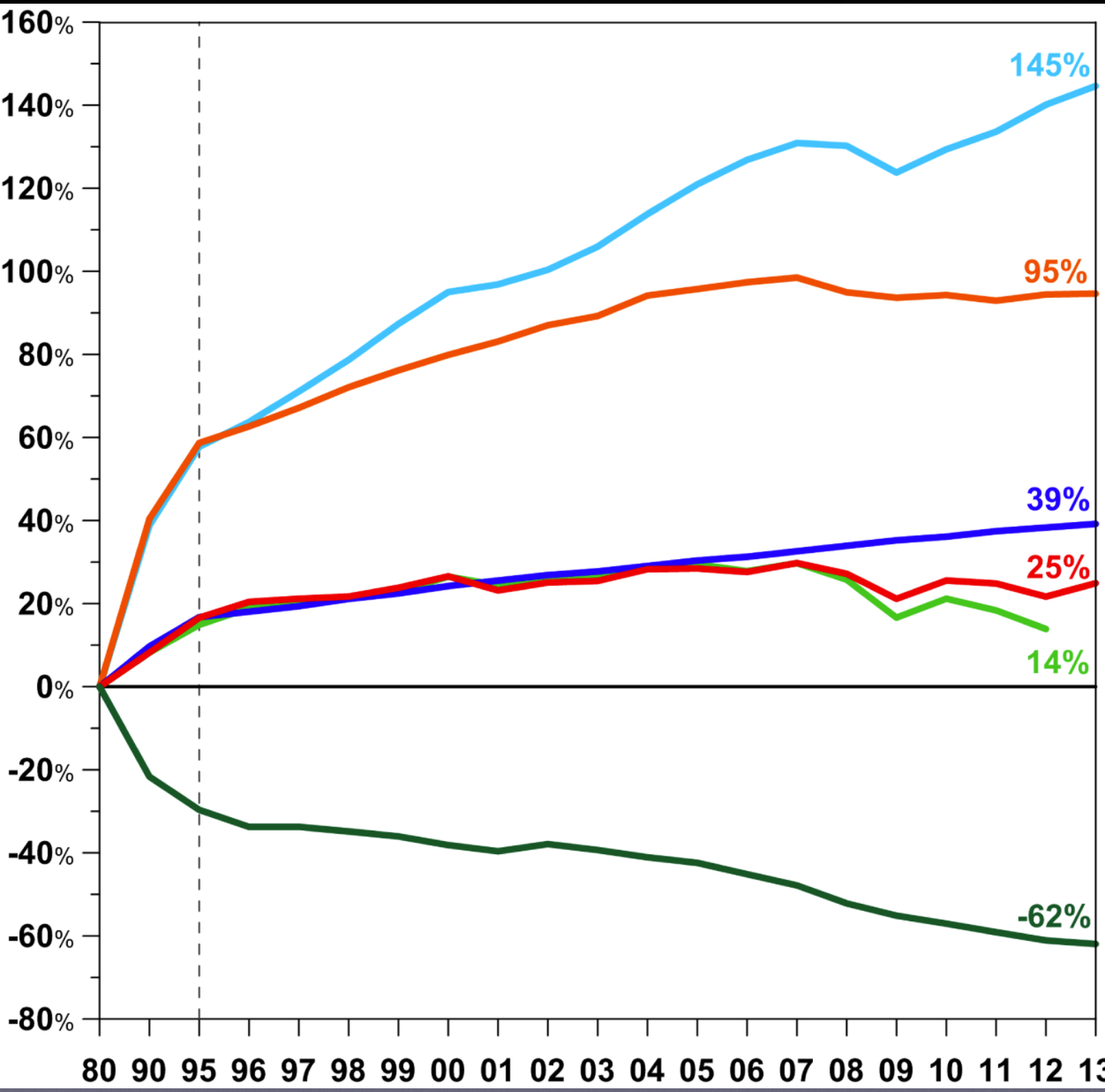

Vehicle km of Travel (in US)
5,000,000
3,750,000
2,500,000
1,250,000
0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

Vehicle km of Travel / Capita (in US)



Miles of Road in US





Gross Domestic Product

Vehicle Miles Traveled

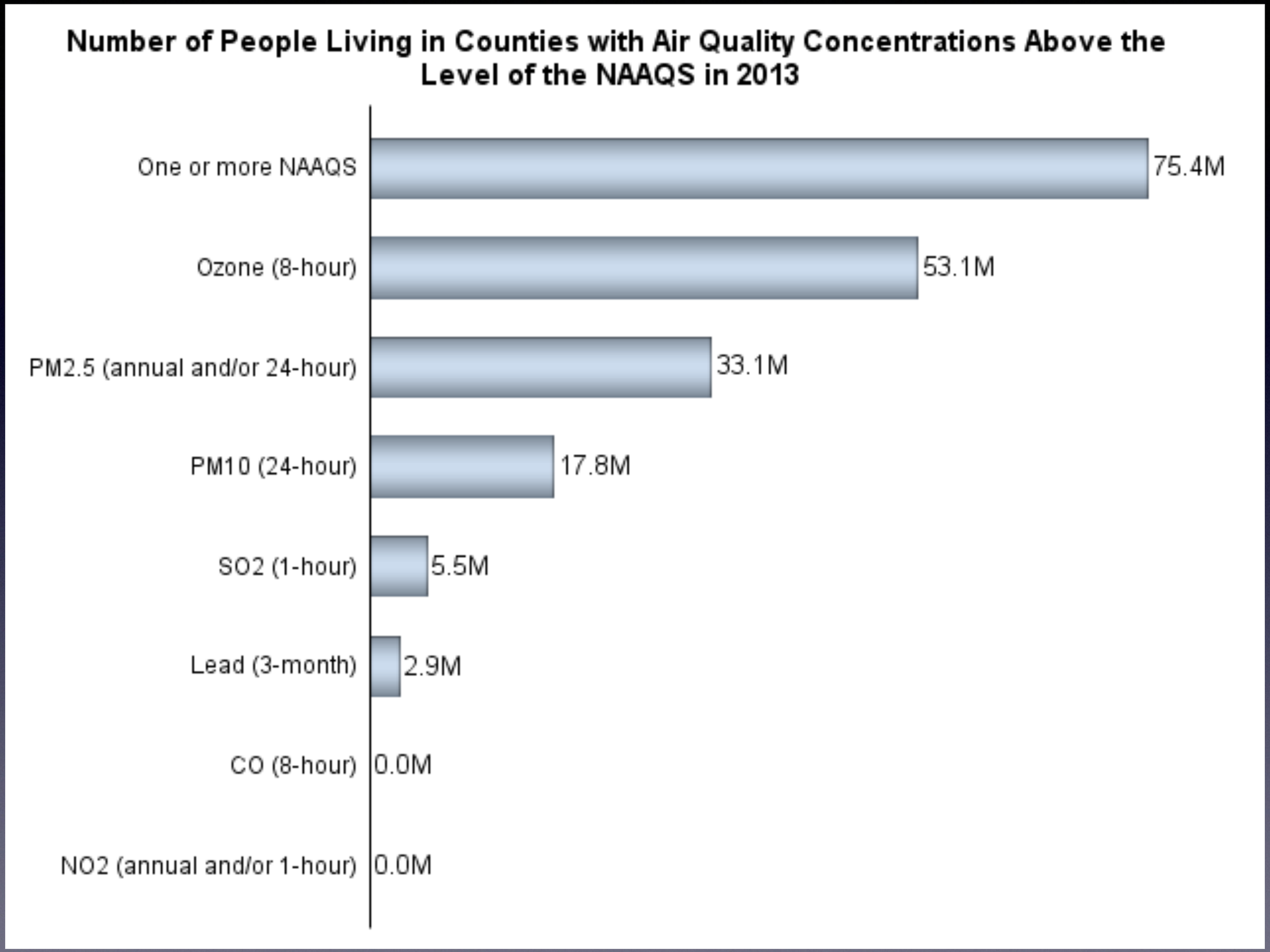
Population

Energy Consumption

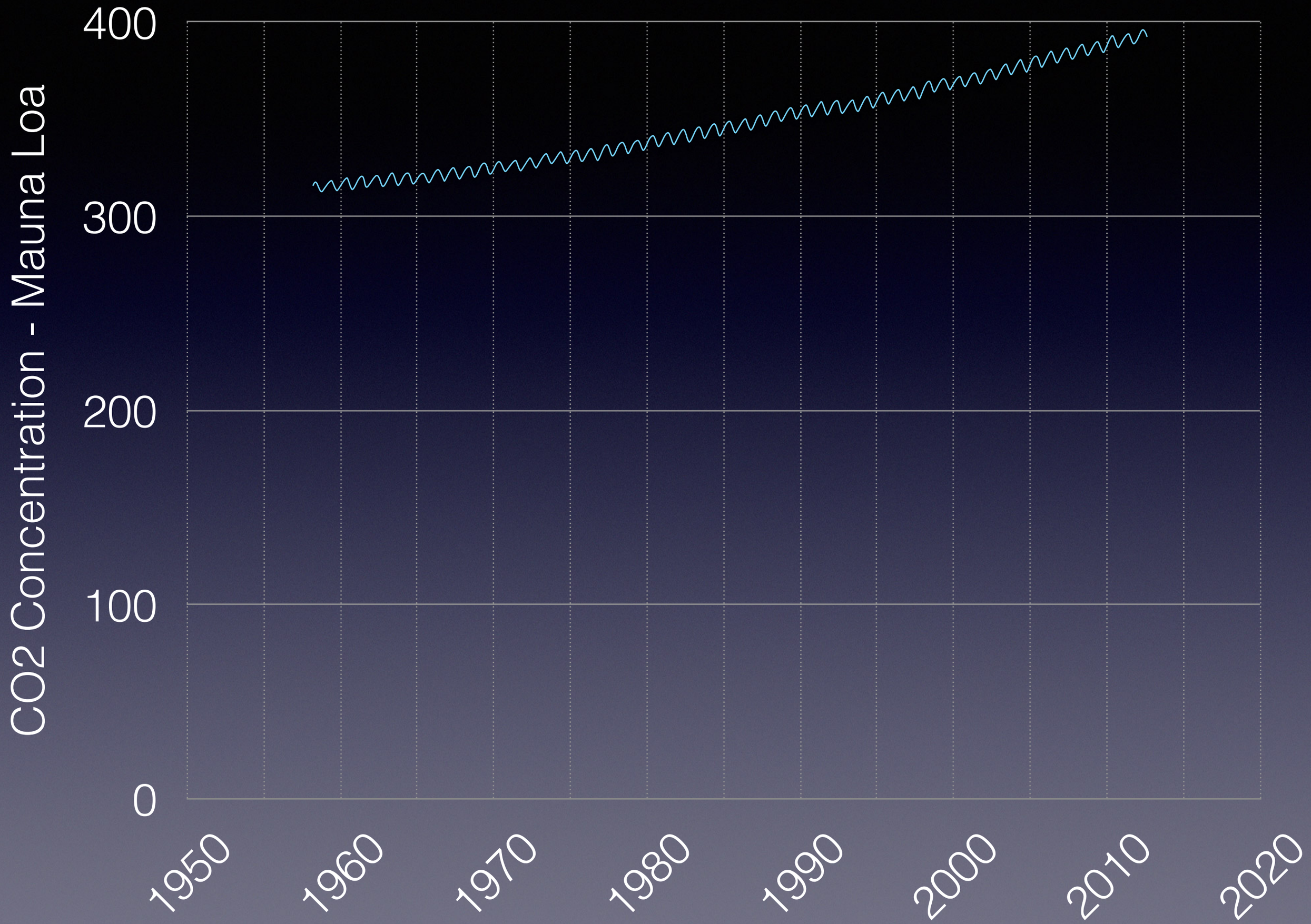
CO_2 Emissions

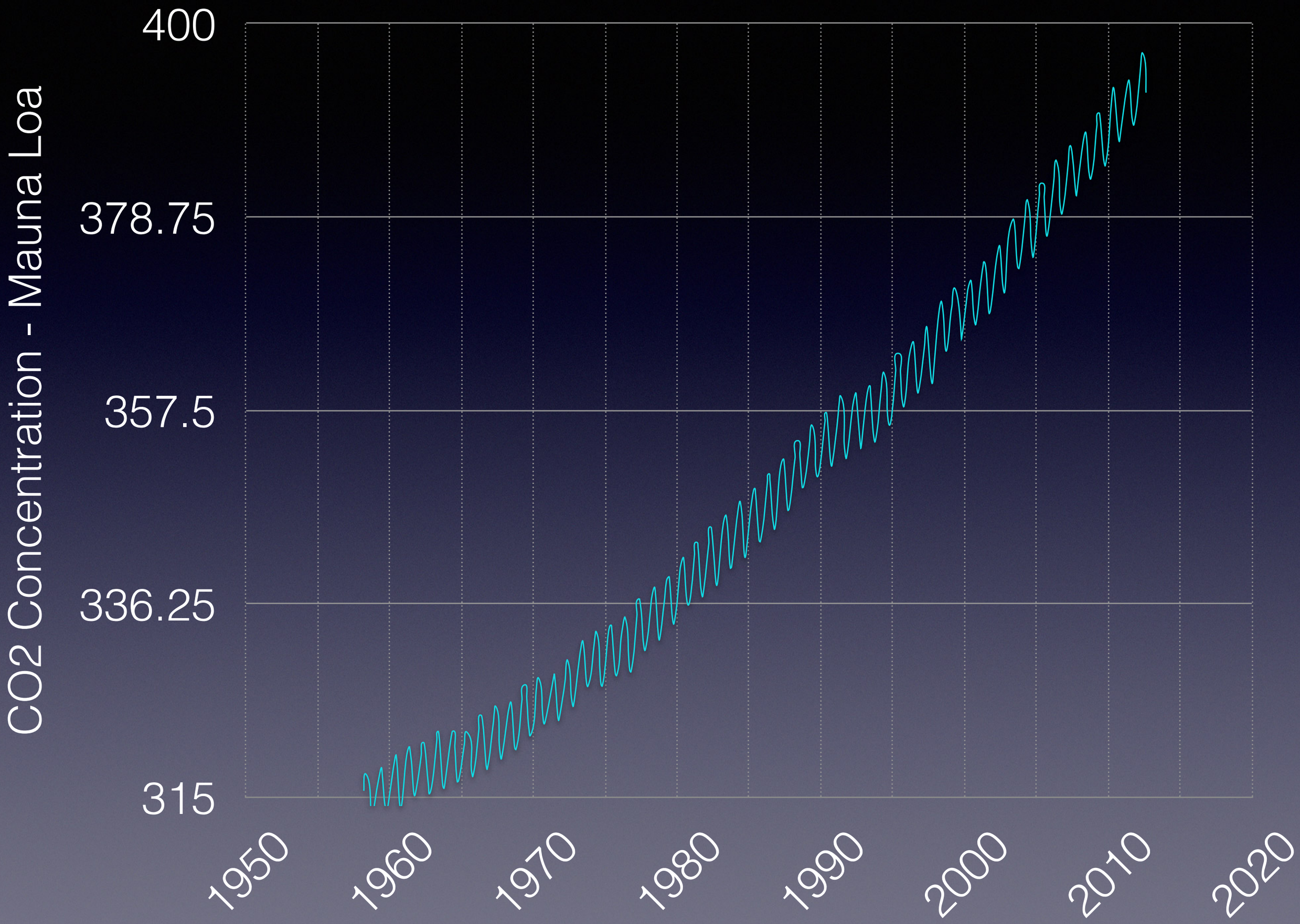
Aggregate Emissions
(Six Common Pollutants)

Source: EPA


Number of People Living in Counties with Air Quality Concentrations Above the Level of the NAAQS in 2013
One or more NAAQS
75.4M
Ozone (8-hour)
53.1M
PM2.5 (annual and/or 24-hour)
33.1M
PM10 (24-hour)
17.8M
SO2 (1-hour)
5.5M
Lead (3-month)
2.9M
CO (8-hour)
0.0M
NO2 (annual and/or 1-hour)
0.0M

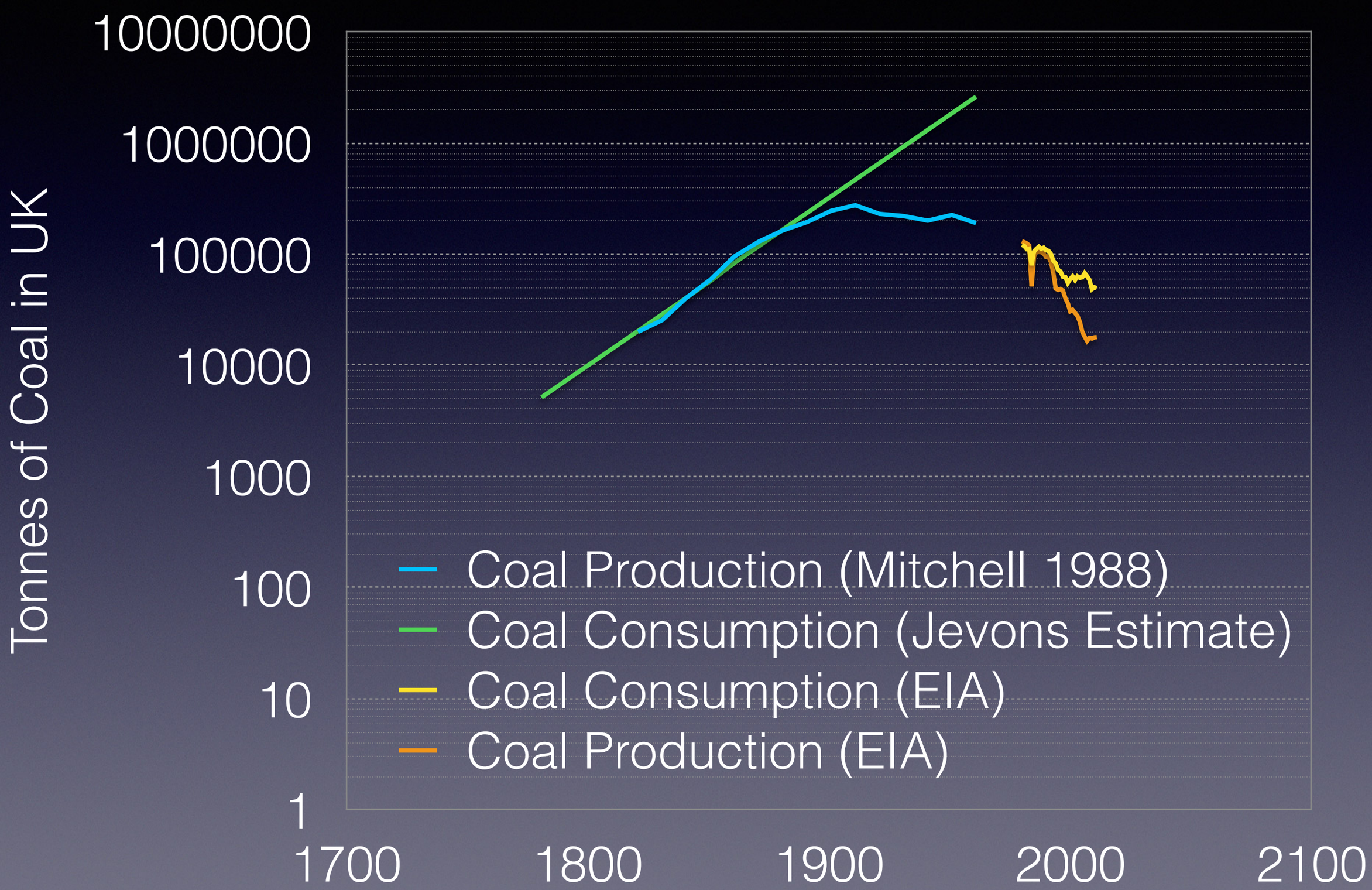
Source: EPA


CO2 Concentration - Mauna Loa
400
300
200
100
0
1950
1960
1970
1980
1990
2000
2010
2020


400
378.75
357.5
336.25
315
CO2 Concentration - Mauna Loa
1950
1960
1970
1980
1990
2000
2010
2020

Forecasting

UK (Jevons prediction vs. actual)

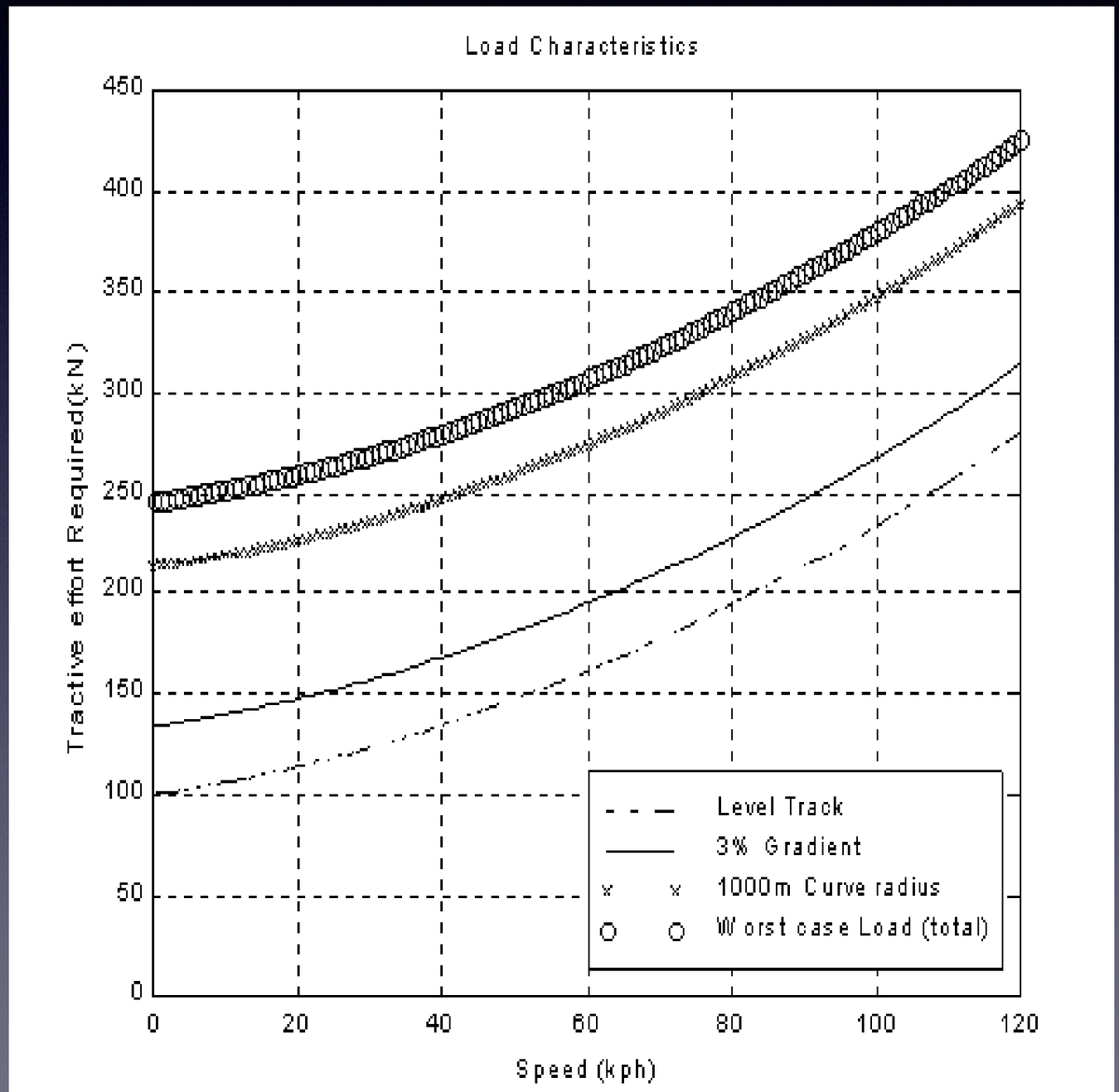


Things that are unsustainable do not sustain

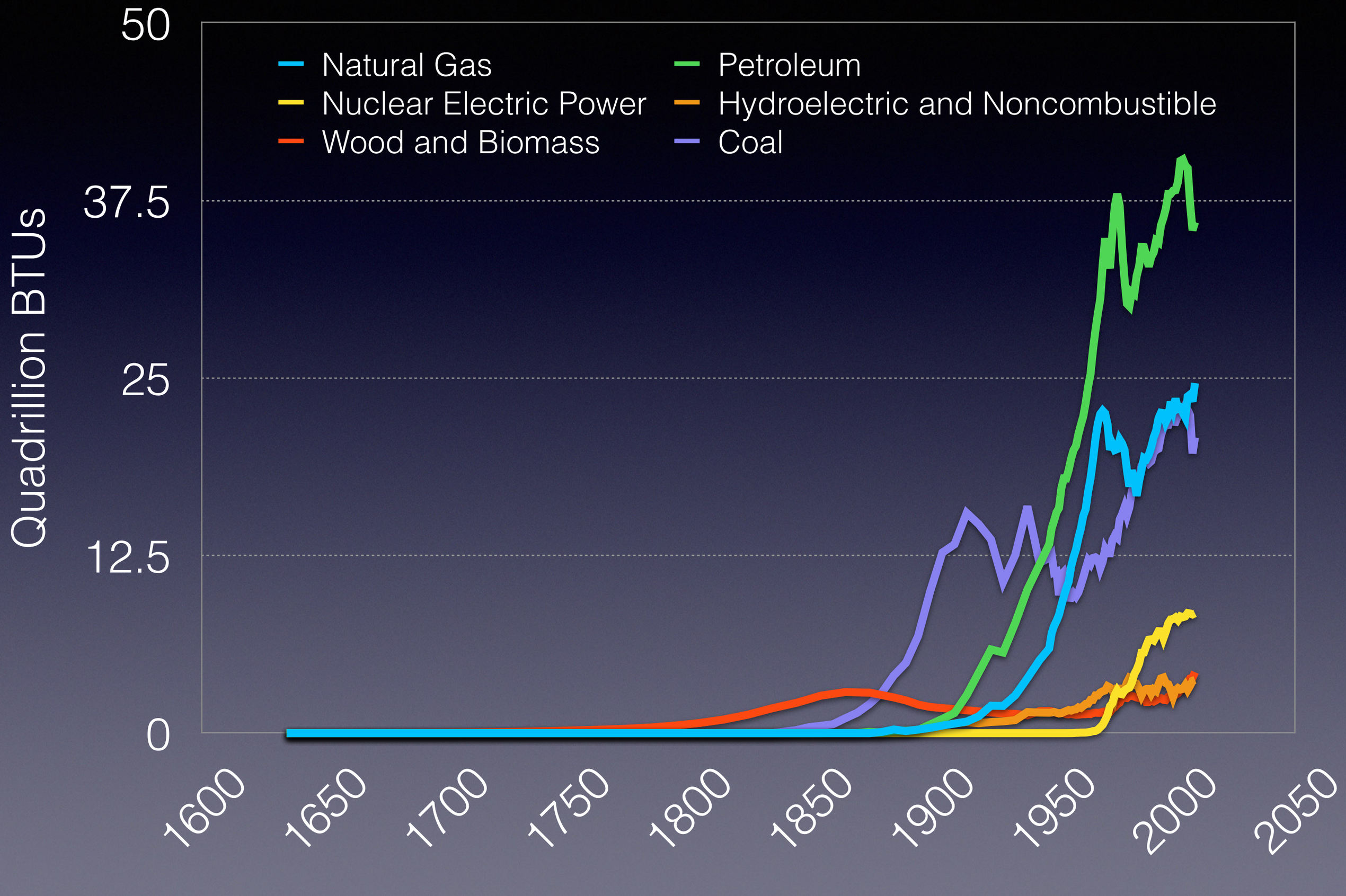
Comparison of Historical Oil Prices and Delphi Forecasts

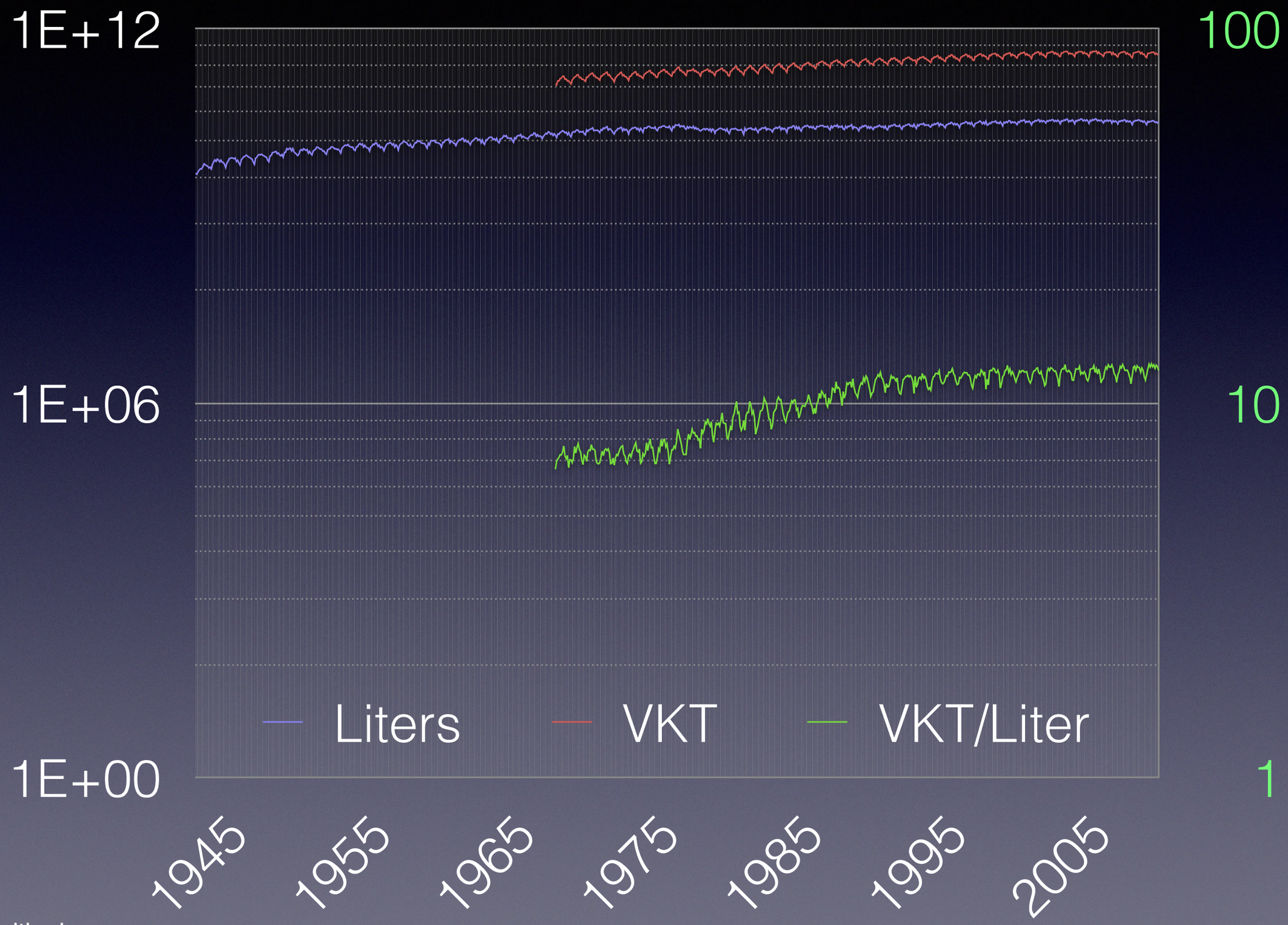
Energy

Energy is Required to Move Mass

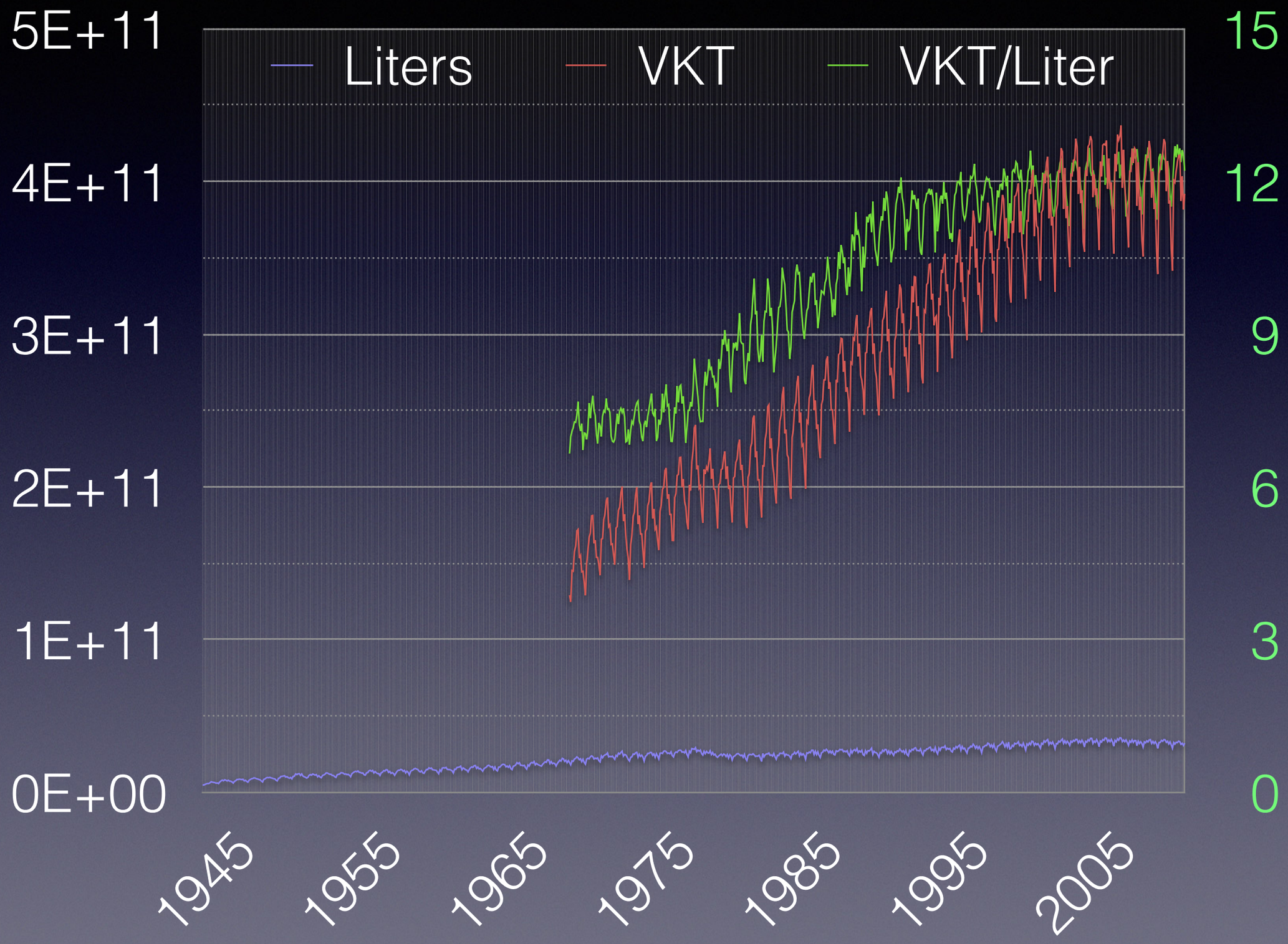


US Energy Use



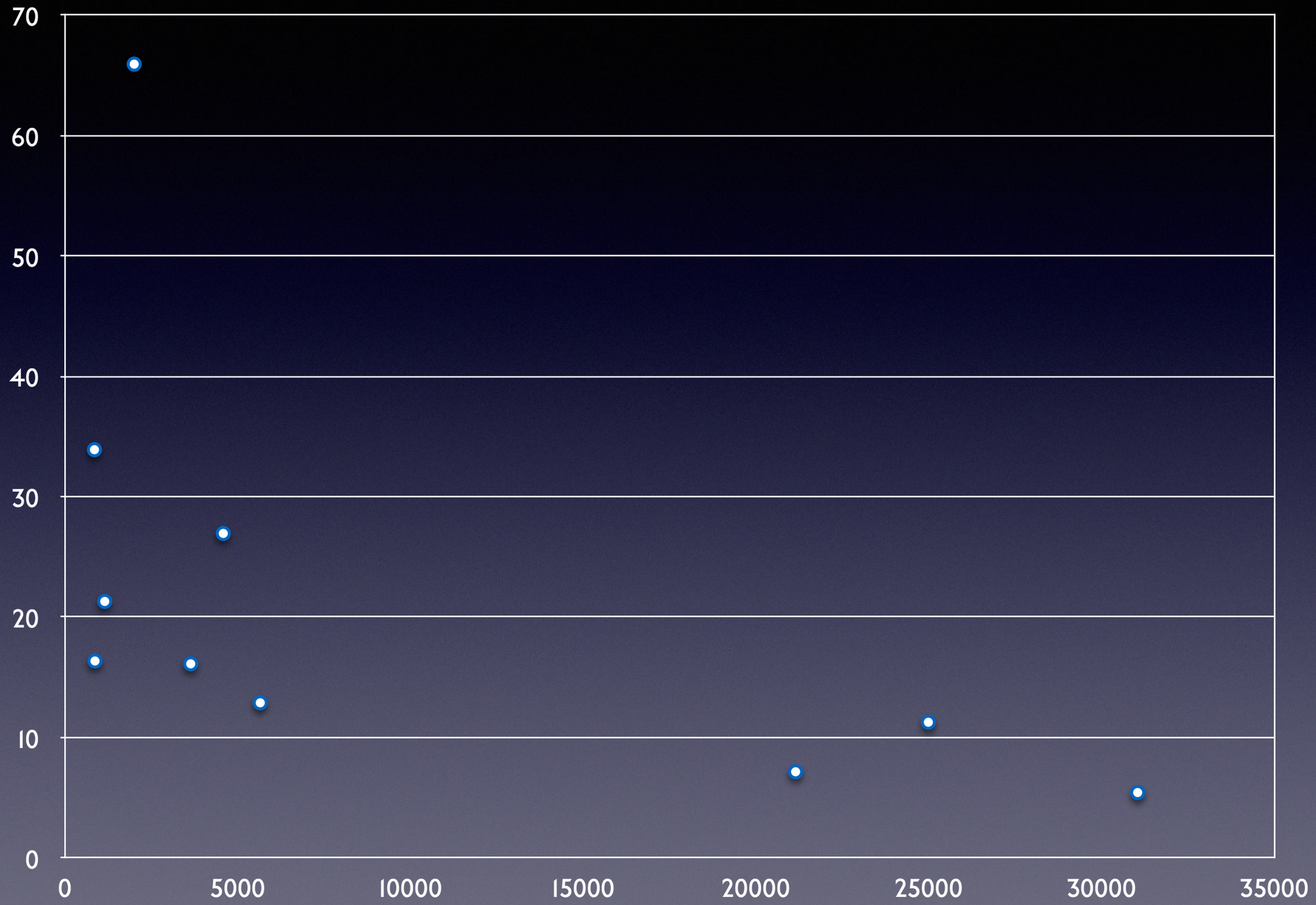


Logarithmic


Liters
VKT
VKT/Liter
5E+11
4E+11
3E+11
2E+11
1E+11
0E+00
15
12
9
6
3
0
1945
1955
1965
1975
1985
1995
2005

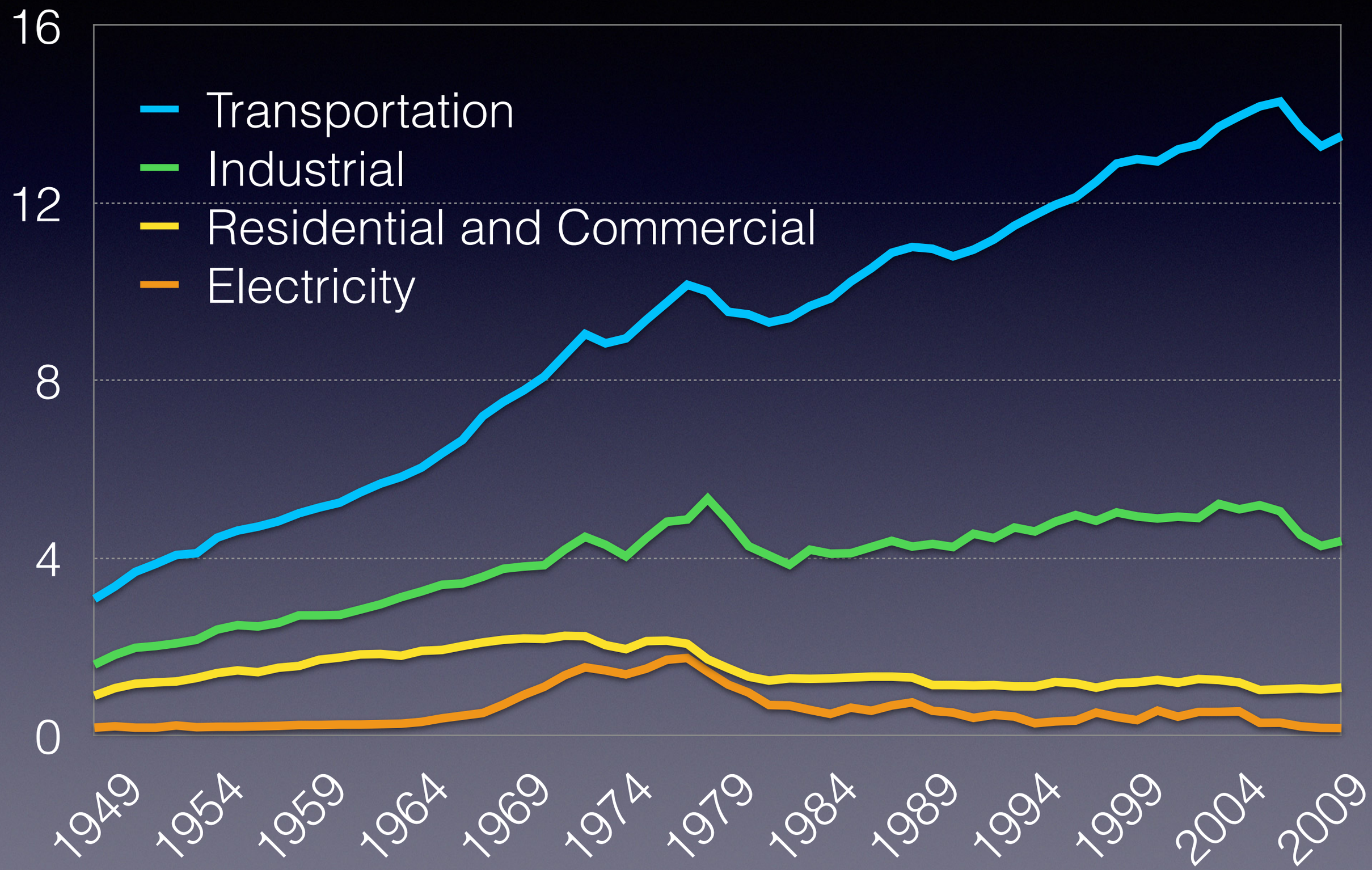
Linear

Thousands of BTU per 1999 $ GDP

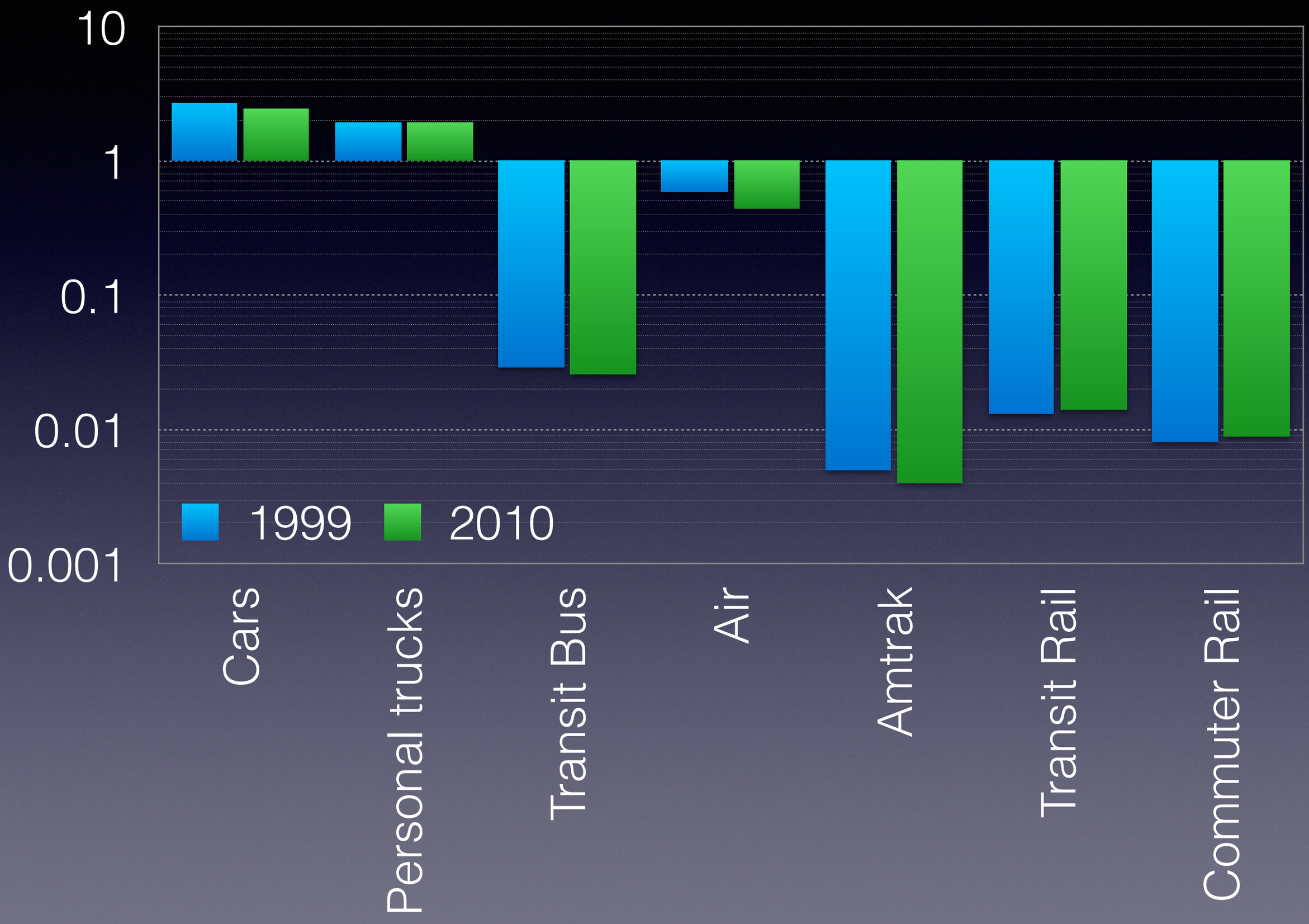


GDP per Capita

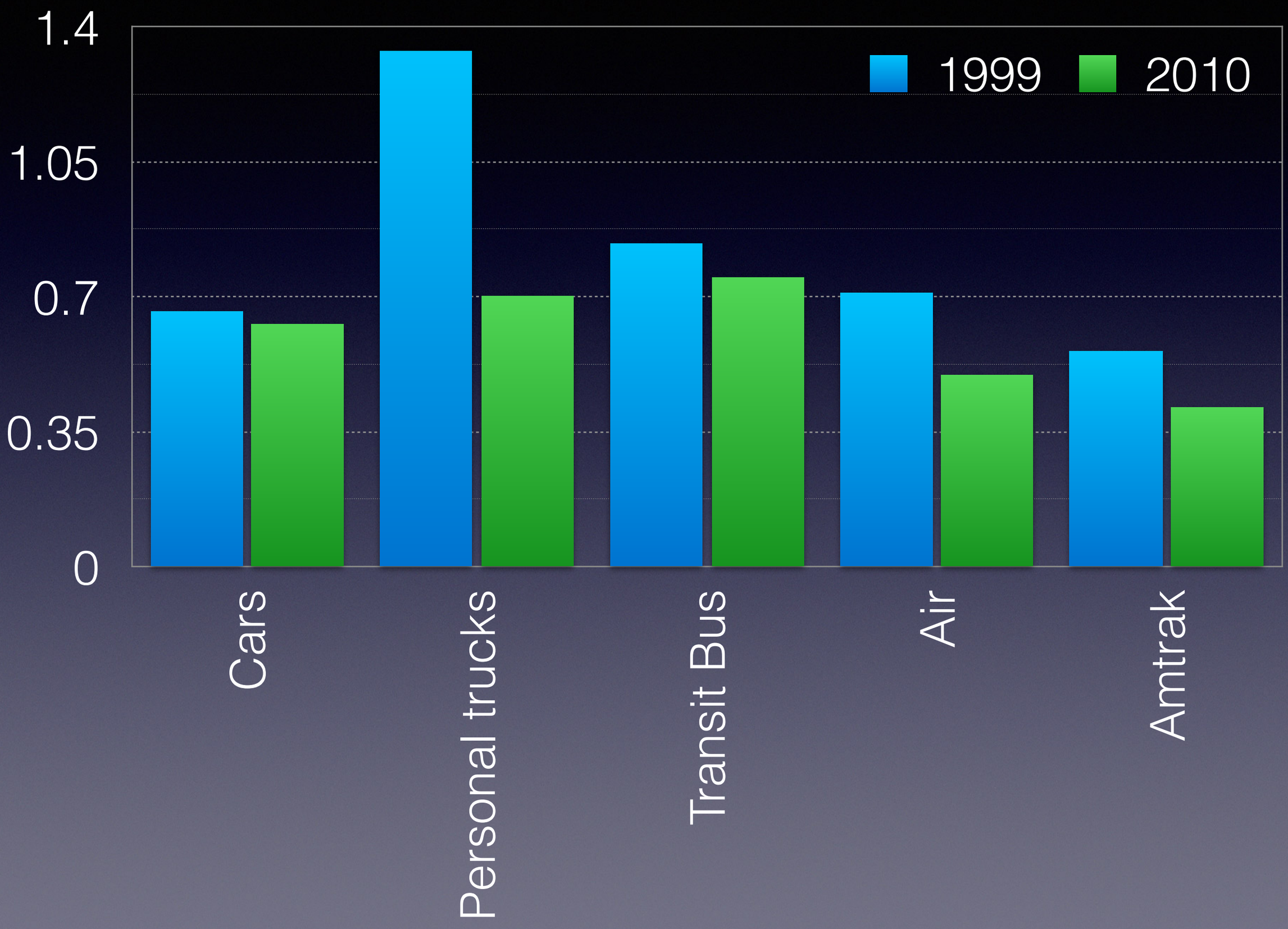
Energy use in United States (Millions of barrels per day)



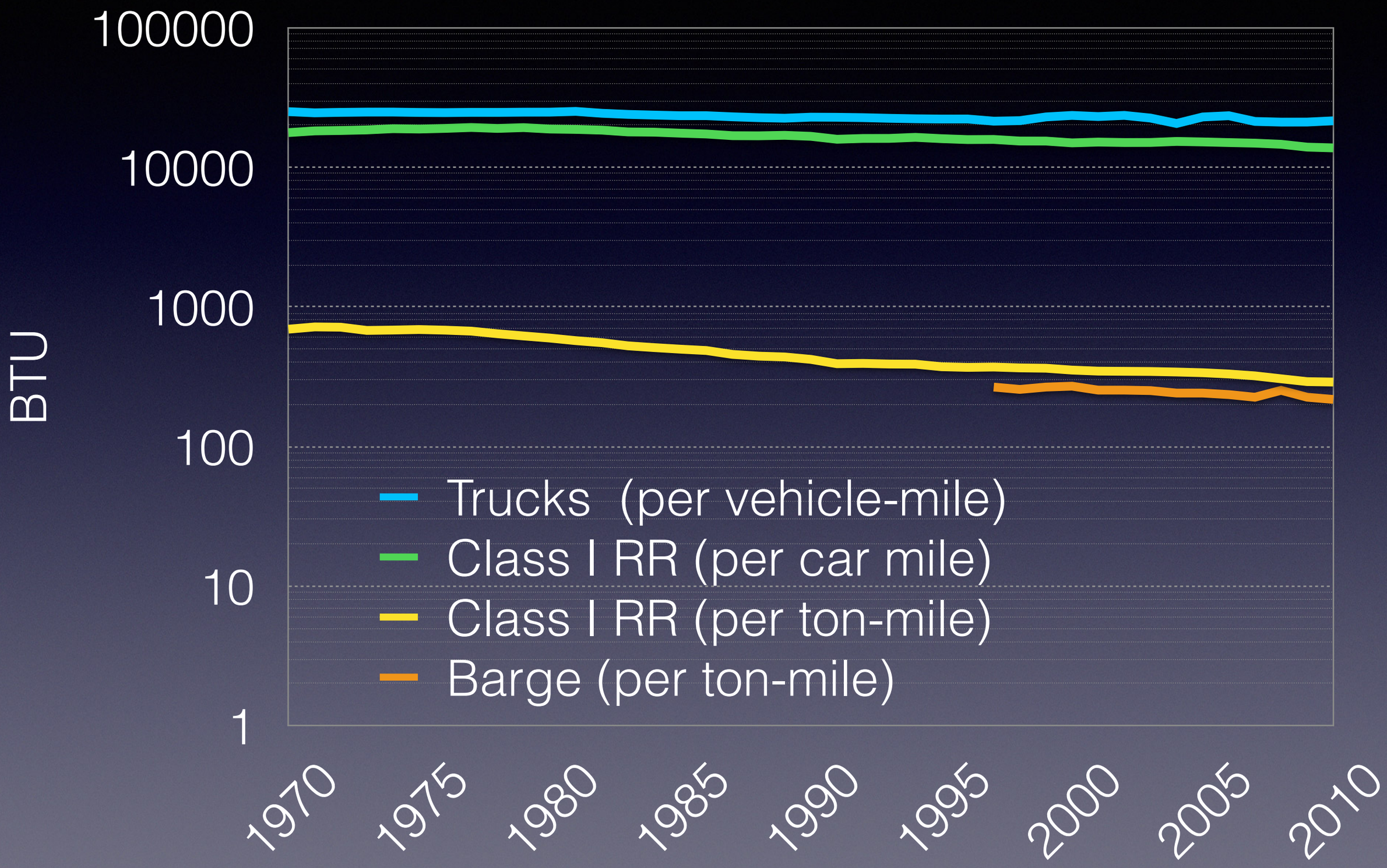
Energy Use (Trillion kWh)



Energy Intensity (kWh/Passenger-km)

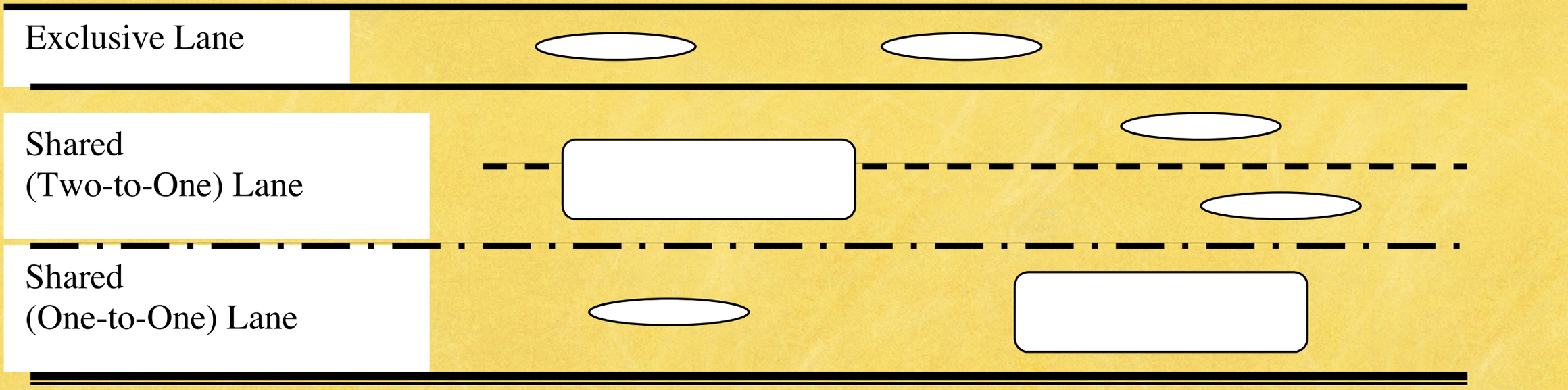


Energy intensity of freight



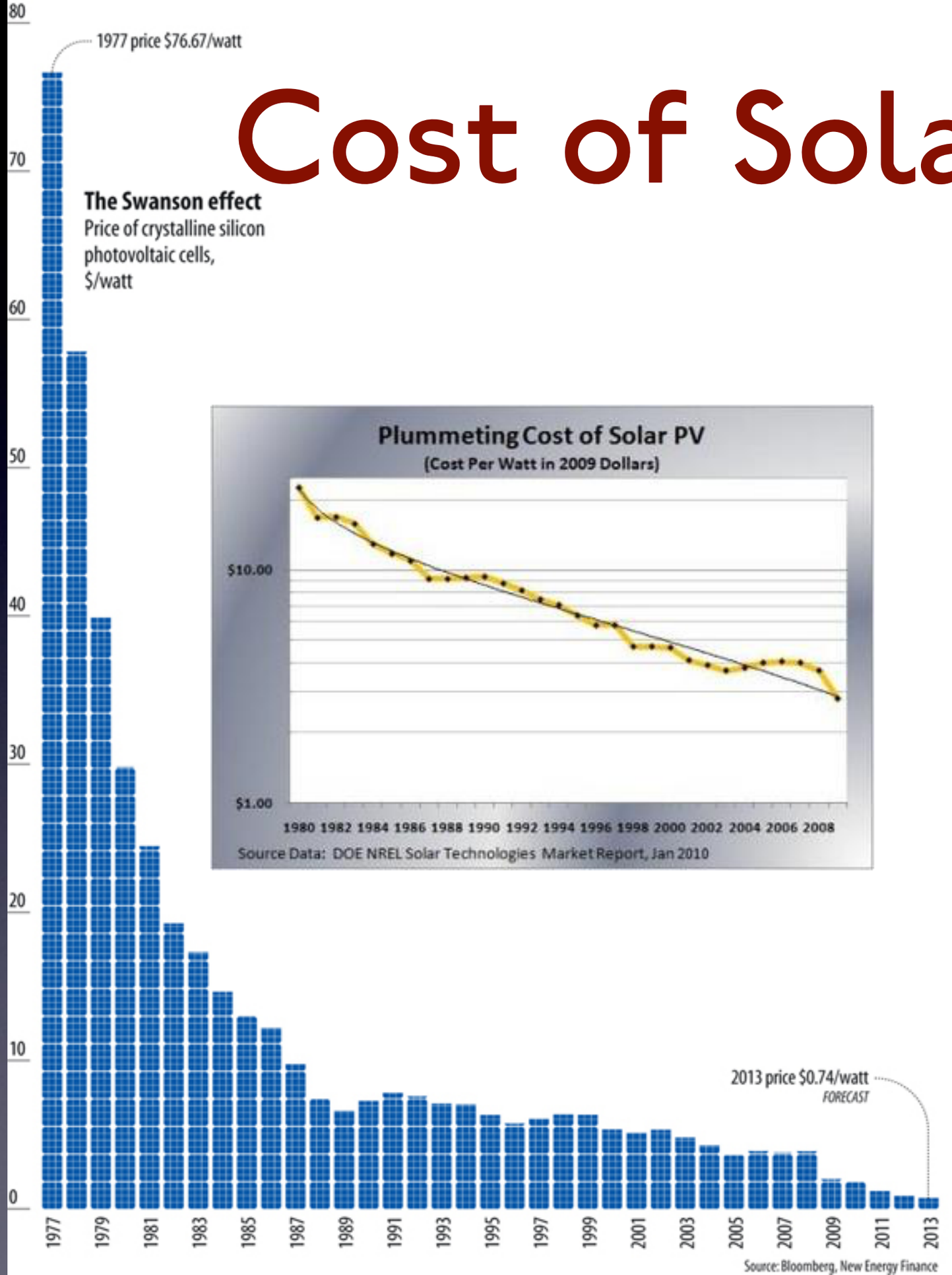
Steam, Electric, Gasoline

- In early years of automobile product (1890s, 1900s) Steam, Electric, and Gasoline power were competing.
- Electrics were backed by significant figures like Thomas Edison, as well as many entrepreneurs. Gasoline engines were backed by future significant individuals like Henry Ford (who had worked at Detroit Edison), and many other entrepreneurs. By 1913, Henry Ford was loaning money to Edison to develop EV.
- Clearly Electric won. Why?
- Electrics had shorter range and lower speed. Could add more batteries, but each additional battery added weight, which reduced the efficiency of other batteries.
- 1909 advent of self-starter in gasoline cars. Note self-starter was electrically (battery) powered. Gasoline-powered vehicles become huge market for batteries.
- This can be thought of as a type of Endo-symbiosis, like the chloroplasts in plants or mitochondria in animals become organelles in cells.

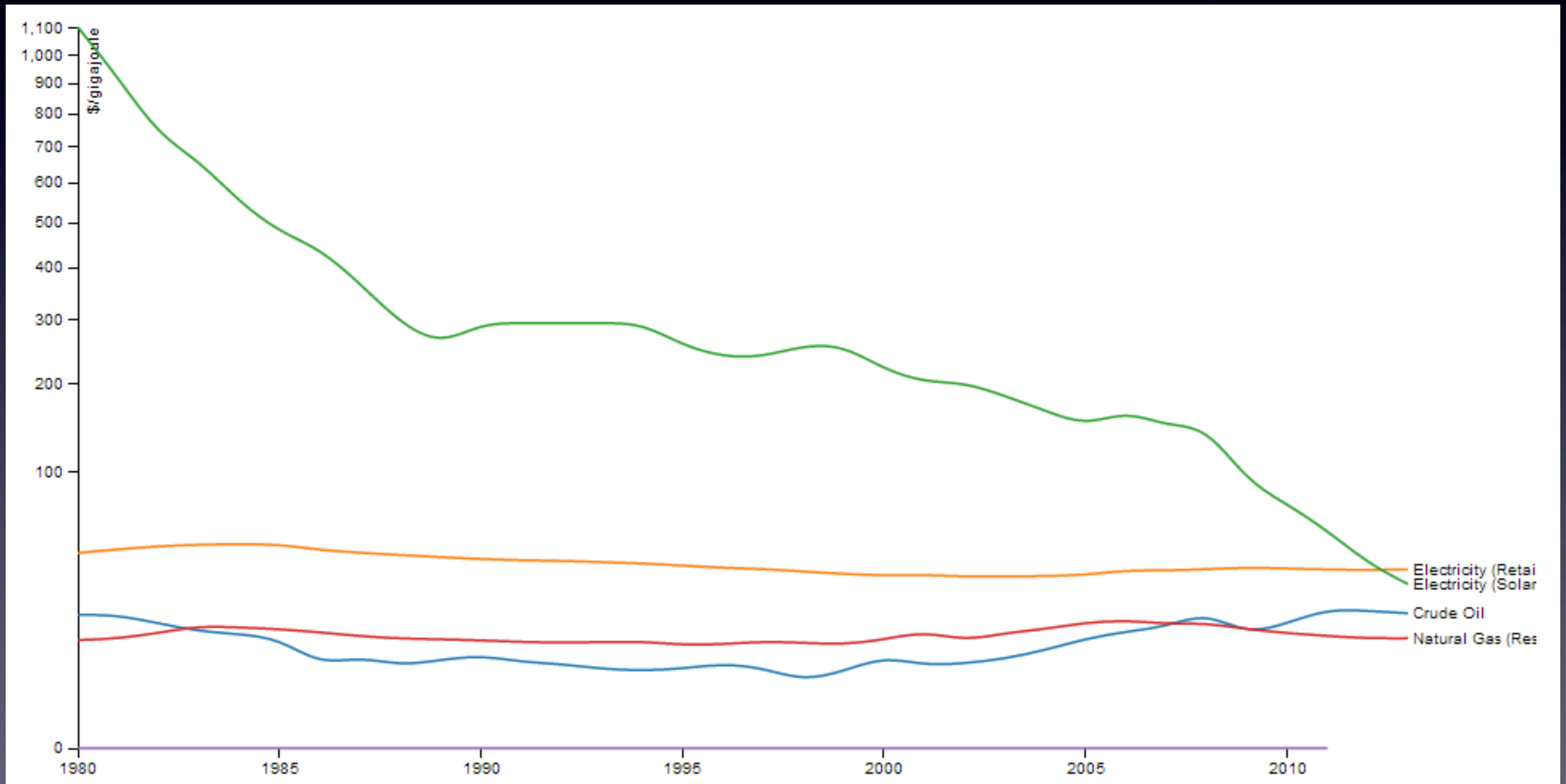


Alternative Vehicles, Alternative Highways

Cost of Solar



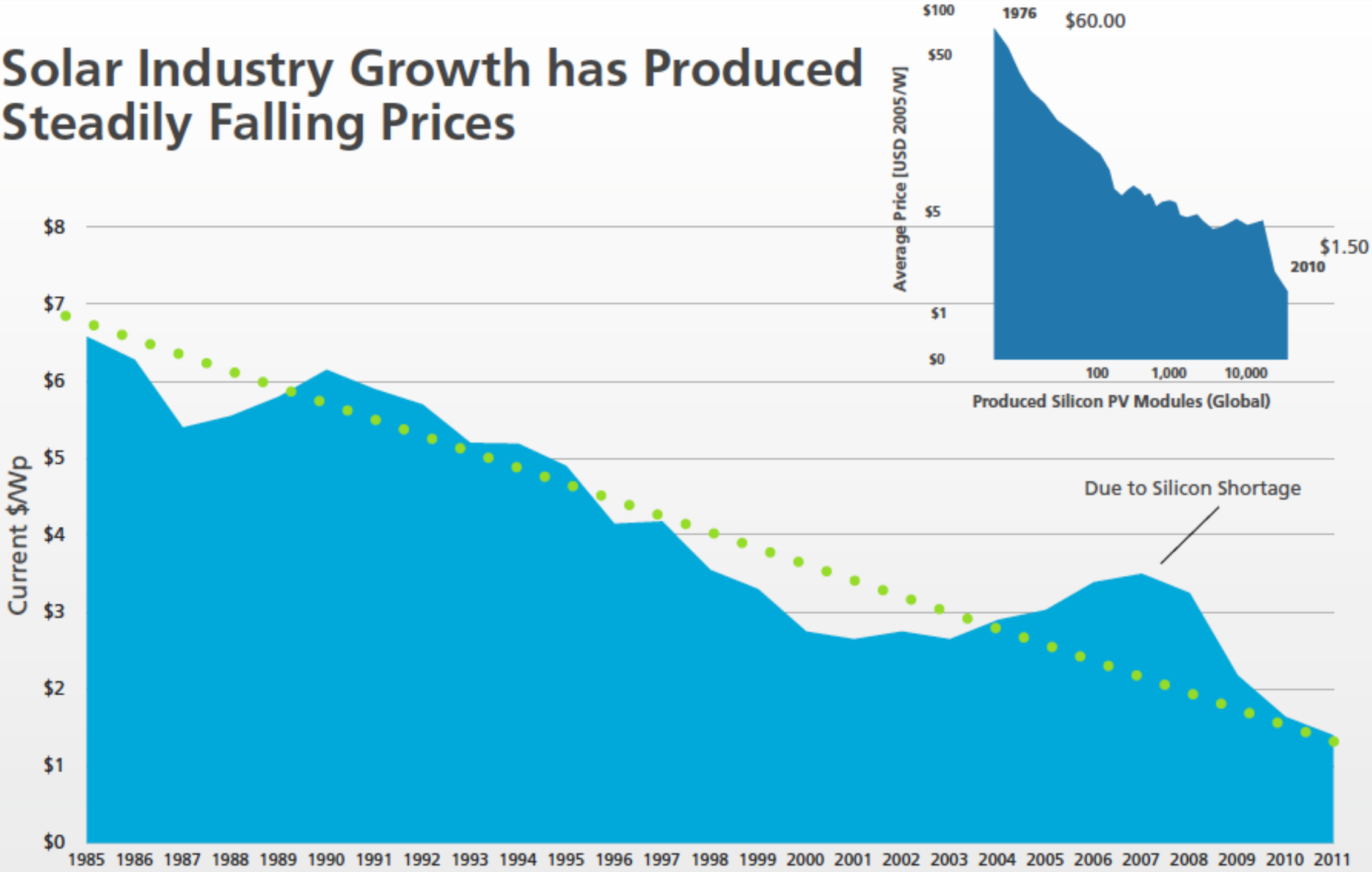
Solar 2



http://cleantechnica.com/2014/09/04/solar-panel-cost-trends-10-charts/

Solar 3

Solar Industry Growth has Produced Steadily Falling Prices

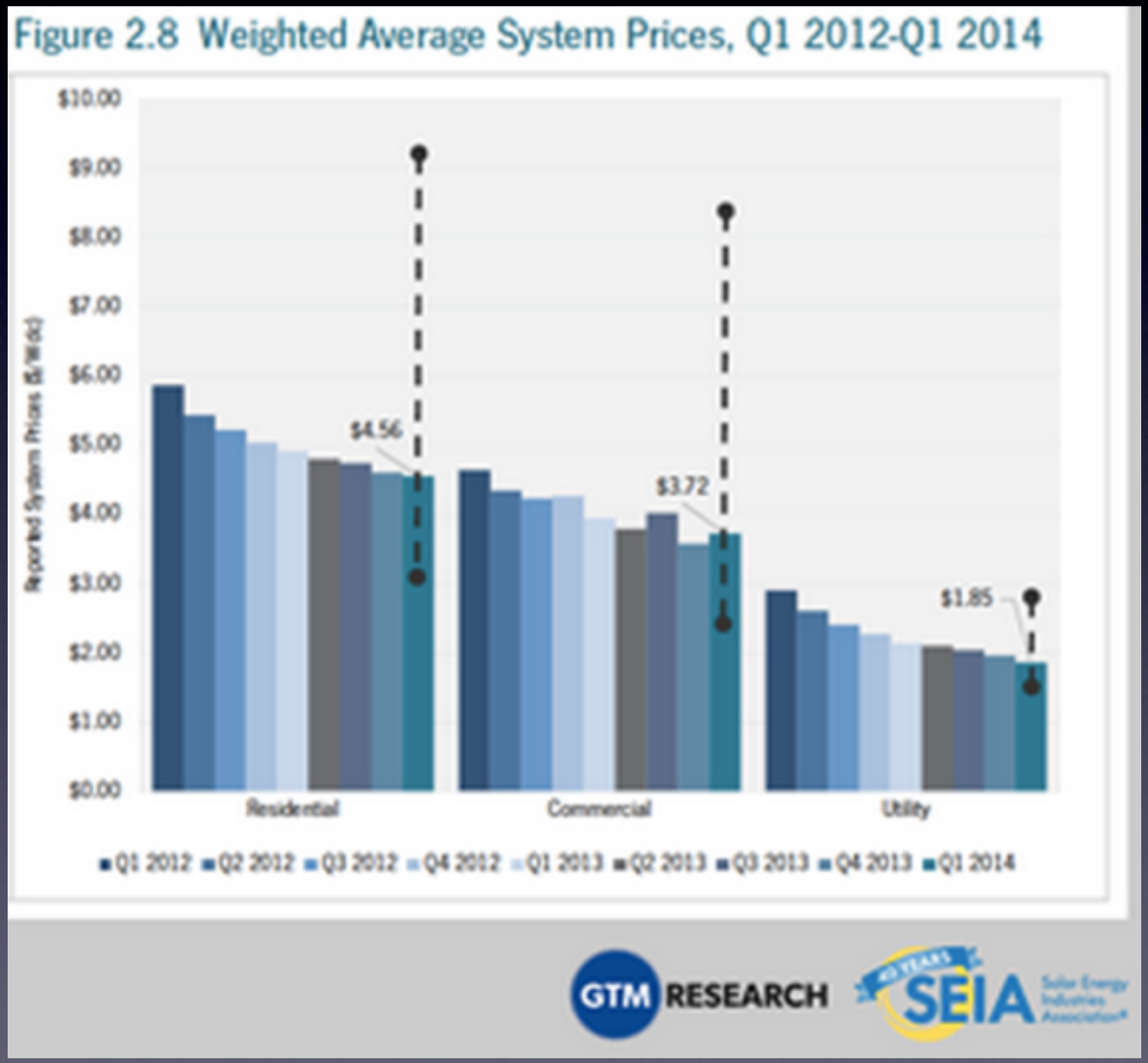


Module Pricing Trends 1985-2011

http://cleantechnica.com/2014/09/04/solar-panel-cost-trends-10-charts/

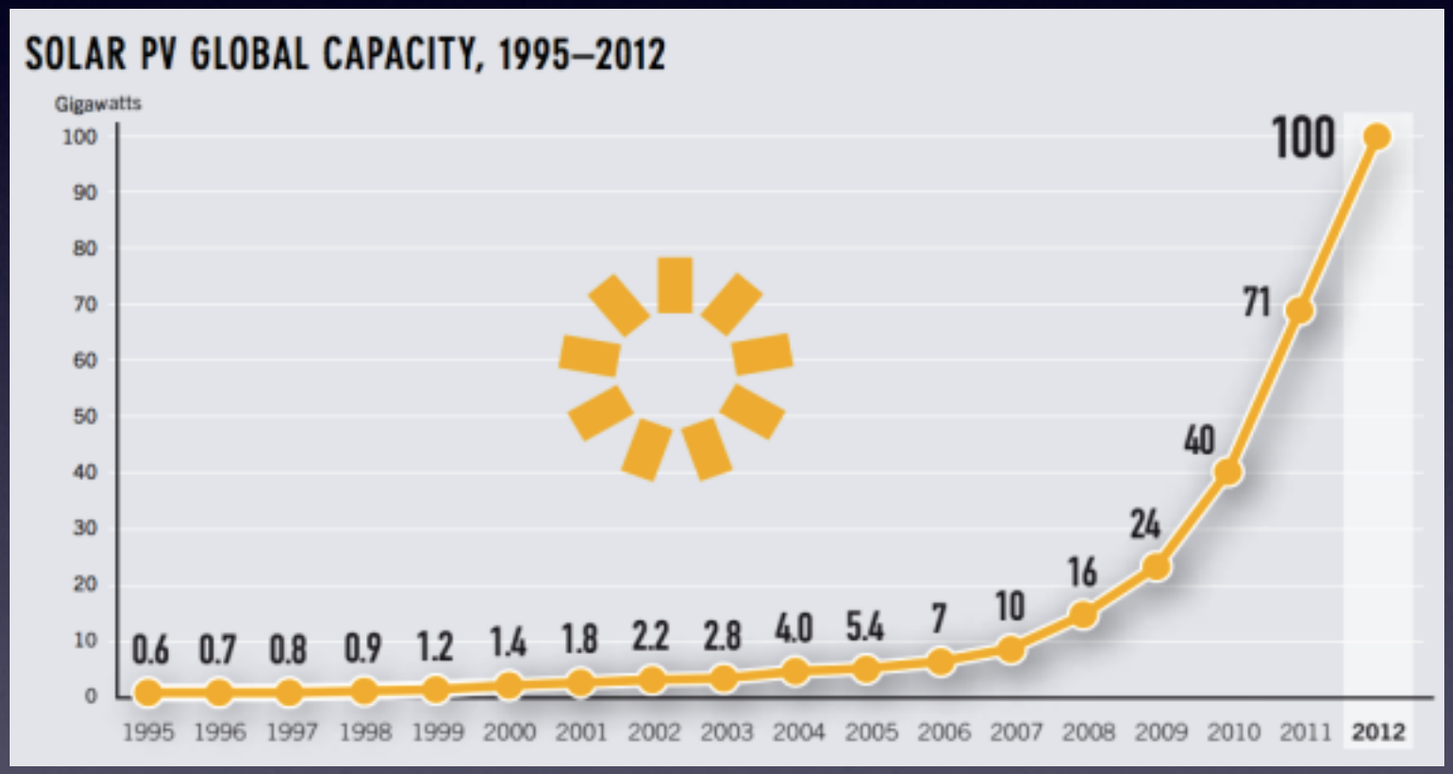
Sources: 1976 -1985 data from IPCC, Final Plenary, Special Report Renewable Energy Sources (SRREN), May 2011; 1985-2010 data from Paula Mints, Principal Analyst, Solar Services Program, Navigant; 2011 numbers based on current market data

Solar 4



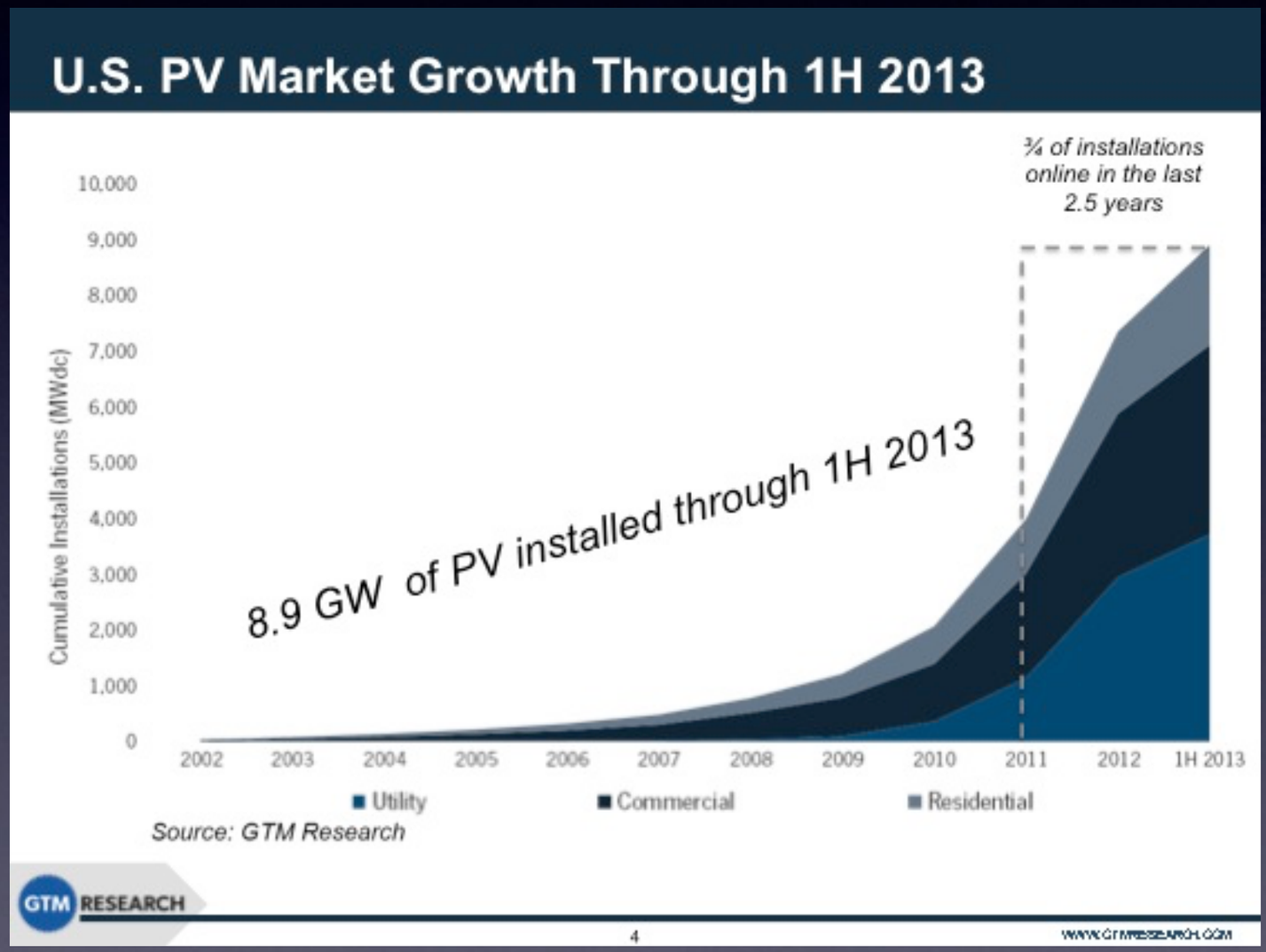
http://cleantechnica.com/2014/09/04/solar-panel-cost-trends-10-charts/

Solar 5



http://cleantechnica.com/2014/09/04/solar-panel-cost-trends-10-charts/

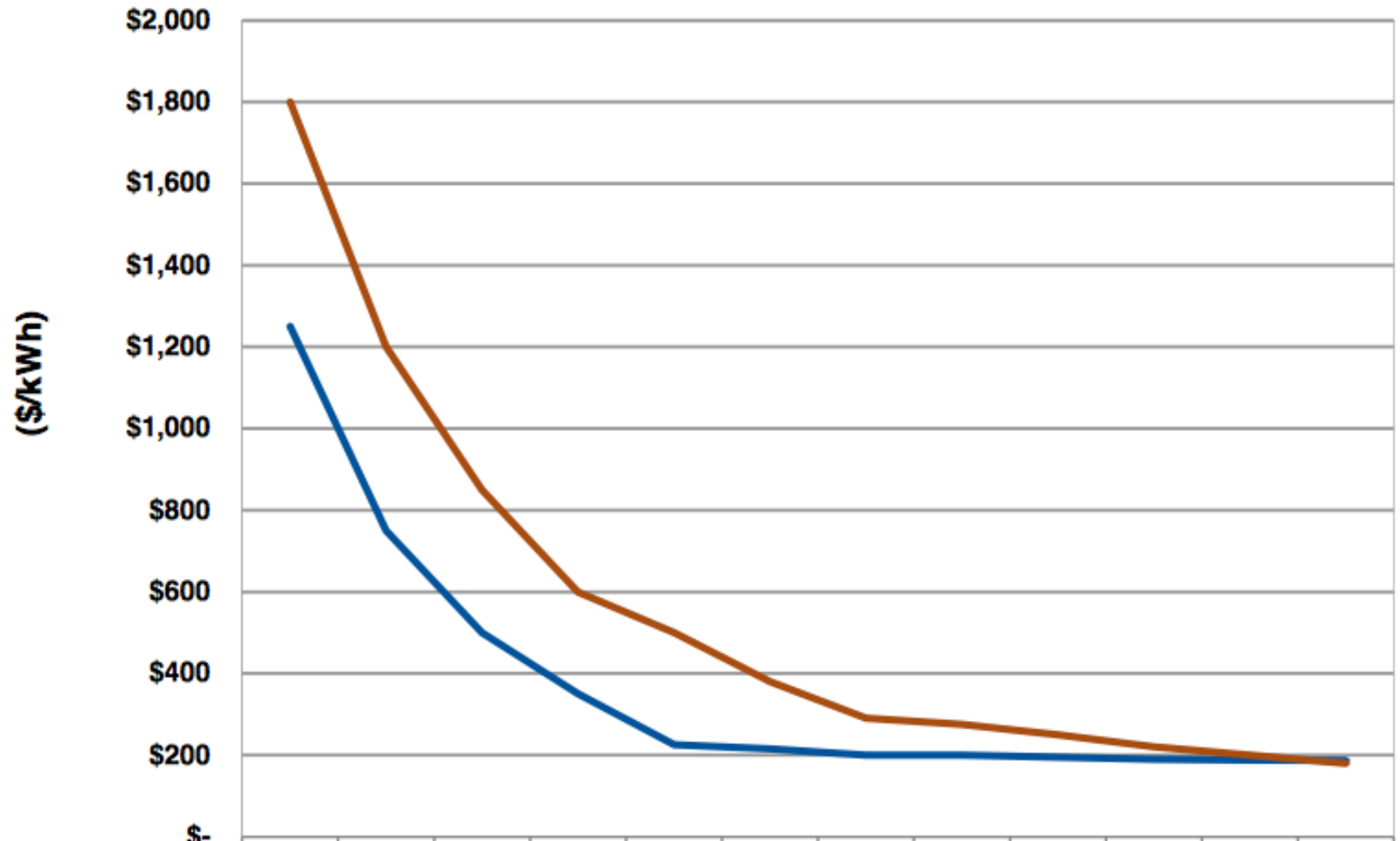
Solar 2



http://cleantechnica.com/2014/09/04/solar-panel-cost-trends-10-charts/

Battery Pricing

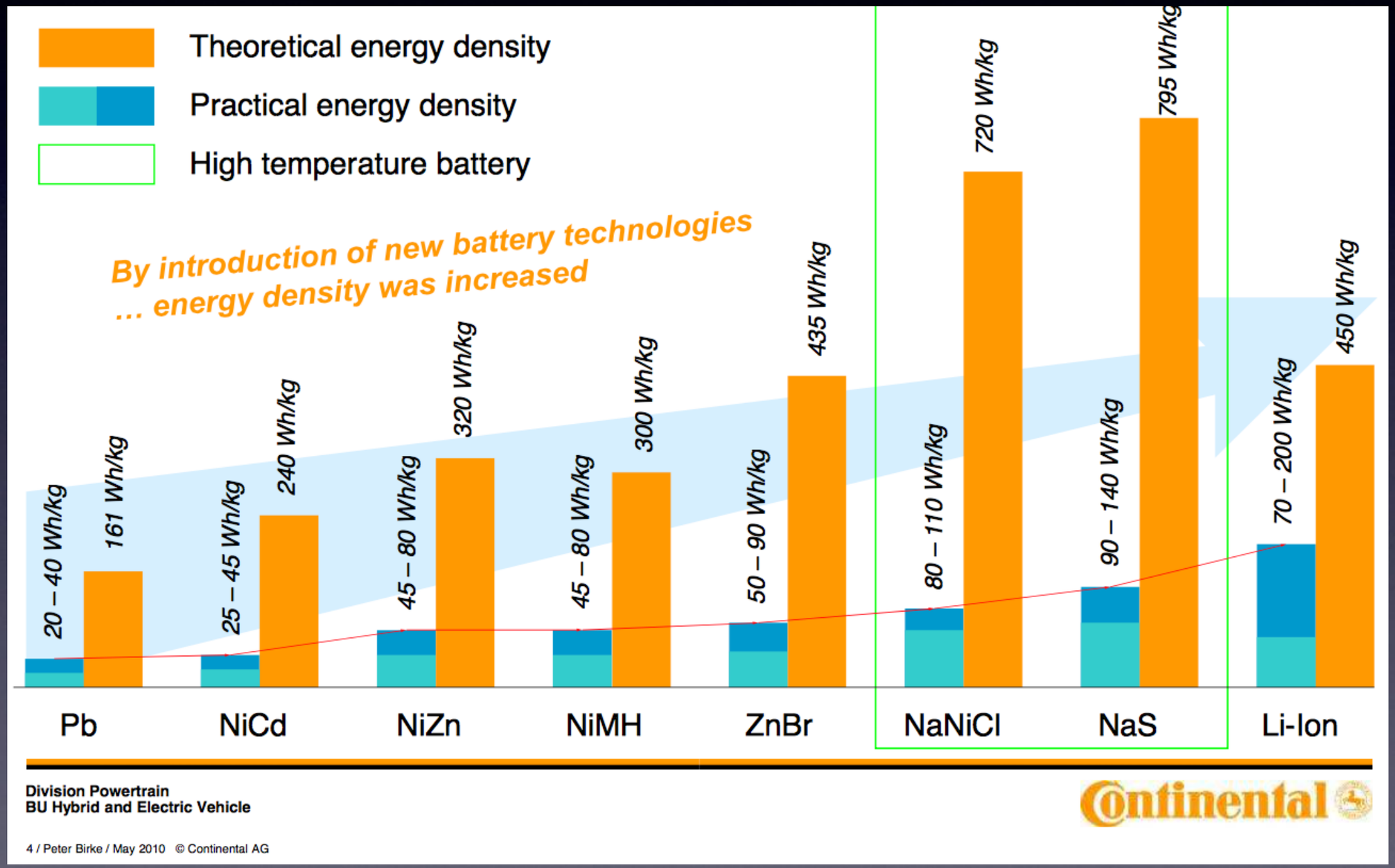
Lithium Ion Battery Pricing by Cell Type: 2009-2020



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Consumer Electronics Li-ion	1,250	750	500	350	225	215	200	200	195	190	188	187
Large Format Li-ion	1,800	1,200	850	600	500	380	290	275	250	220	200	180

(Source: Navigant Research)

Batteries are getting better



http://www.theengineer.co.uk/energy-and-environment/news/breathing-lithium-air-battery-has-higher-energy-density-than-li-ion/1018213.article

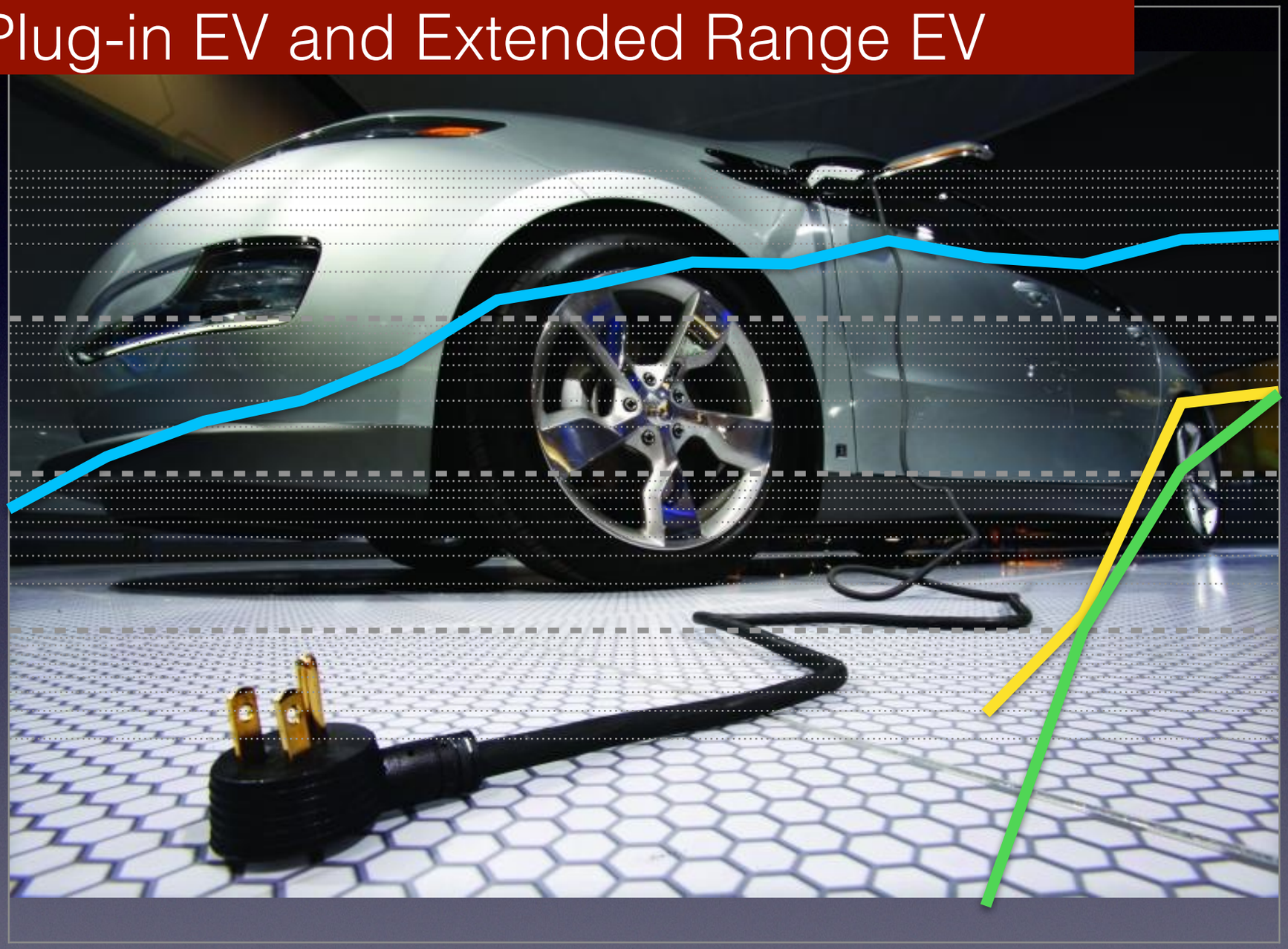
https://en.wikipedia.org/wiki/Lithium–air_battery

http://arstechnica.com/science/2012/06/lithium-air-battery-advance-could-be-jaw-dropping-improvement-over-li-ion/

Car Sharing Can Break Range Anxiety

- Get car you need when you need it.
  Most trips well below EV range NOW.
- Li-Air as supplement to Li-Ion

- Hybrid EV
- Battery EV
- Plug-in EV and Extended Range EV



10.000%

1.000%

0.100%

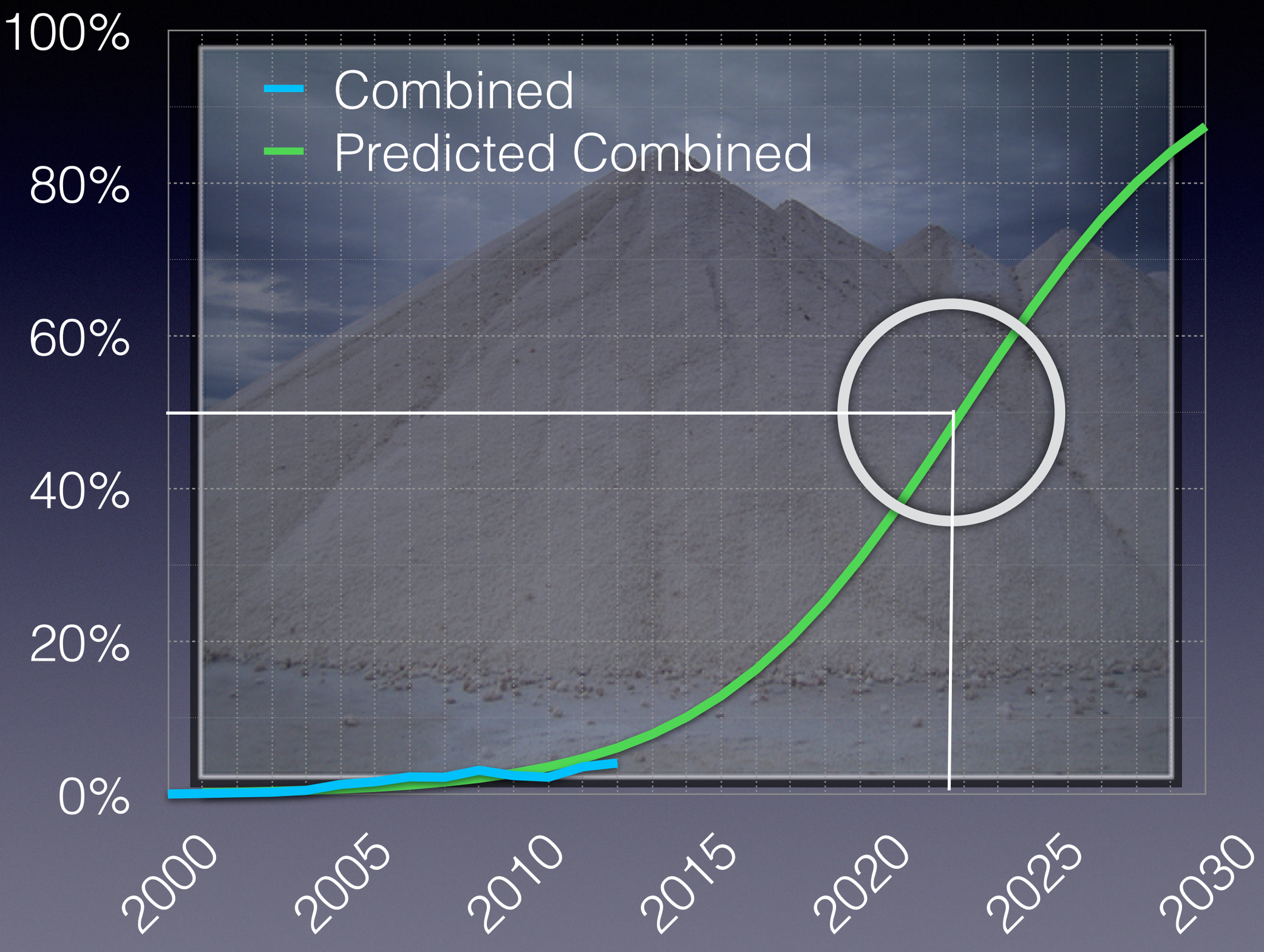
0.010%

0.001%

Log

2000 2002 2004 2006 2008 2010 2012

US EV New Car Market Share: Logistic Growth Curve



Innovation

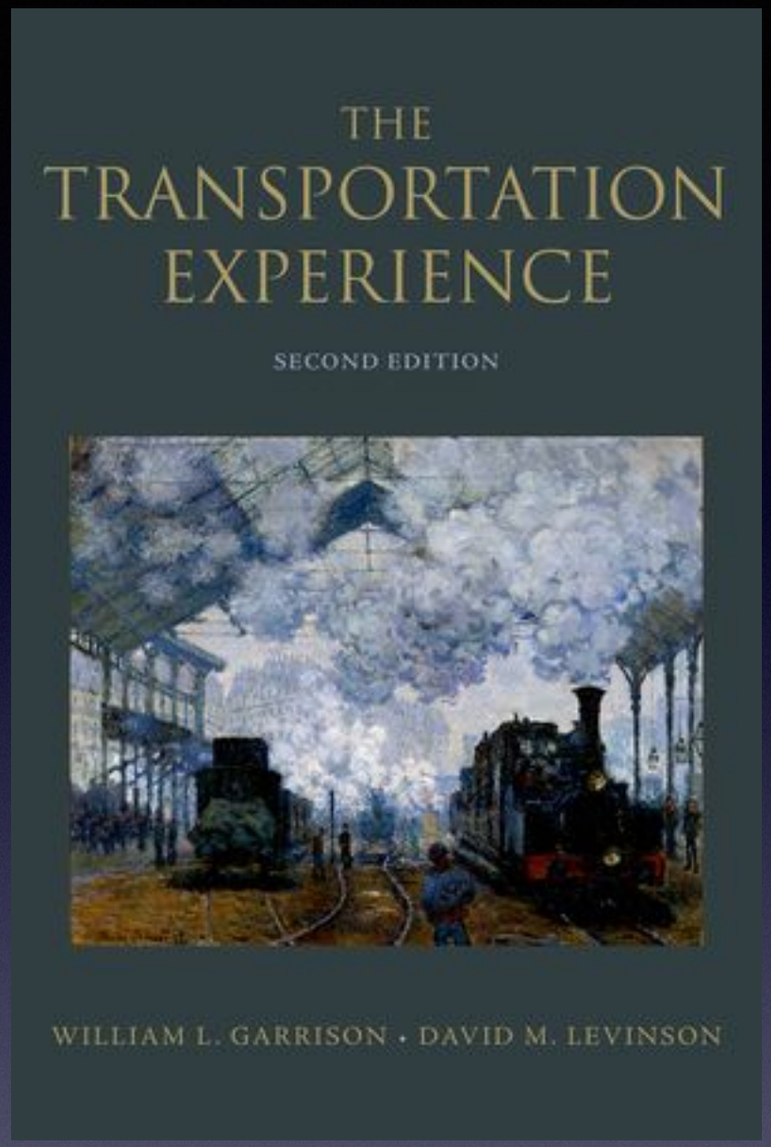
- ~10x improvement on some relevant dimension to justify switching energy platform
- Relevant dimensions: Cost, Speed, Size, Pollution, Comfort, Range

Methanol

- Methanol from drilling etc. doesn't fully address CO2.
- Biofuels are expensive
- Petroleum is abundant and infrastructure exists
- Electricity/batteries are getting steadily better
- Cars are getting more efficient
- Travel demand in US is dropping

Burning Questions

http://www.hclib.org/pub/search/specialcollections/mplshistory/?id=10



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Fuel Freedom Foundation

AGI american geosciences institute
connecting earth, science, and people

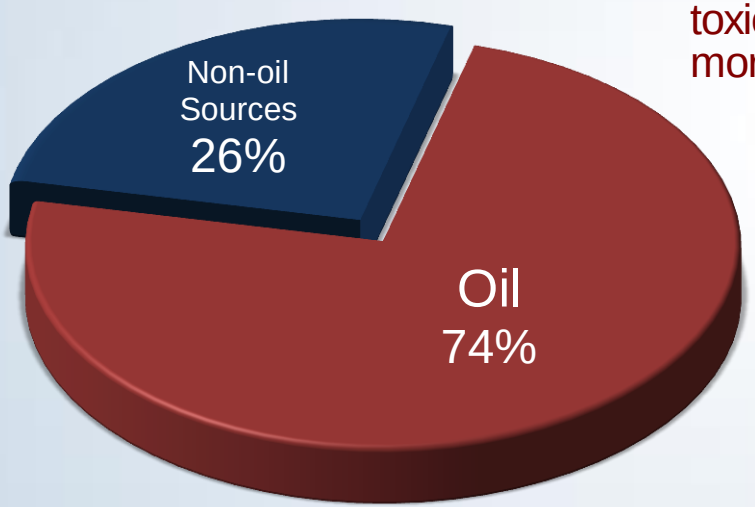
Refueling the future with Alcohol Fuels

EYAL ARONOFF
Co-founder, Fuel Freedom Foundation

June 18, 2014
TEDx Chapman University

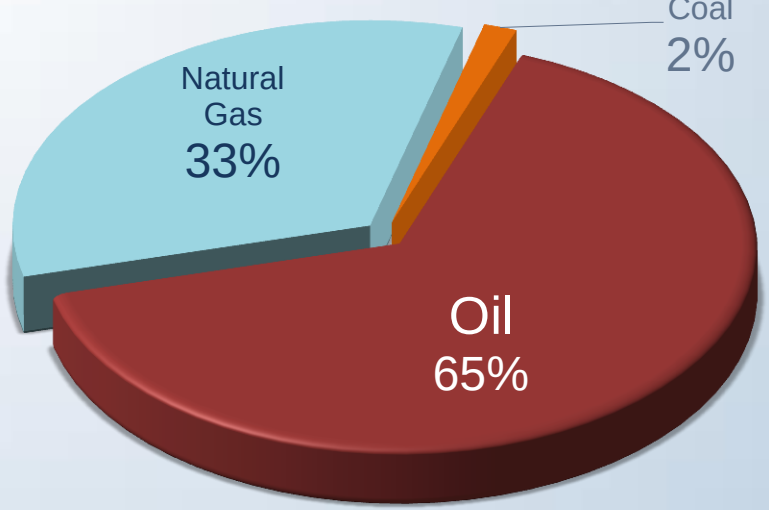
Oil's Impact on California

California Emissions



3/4 of California's emissions (including CO_2, toxic pollutants, ozone forming emissions and more) come from petroleum

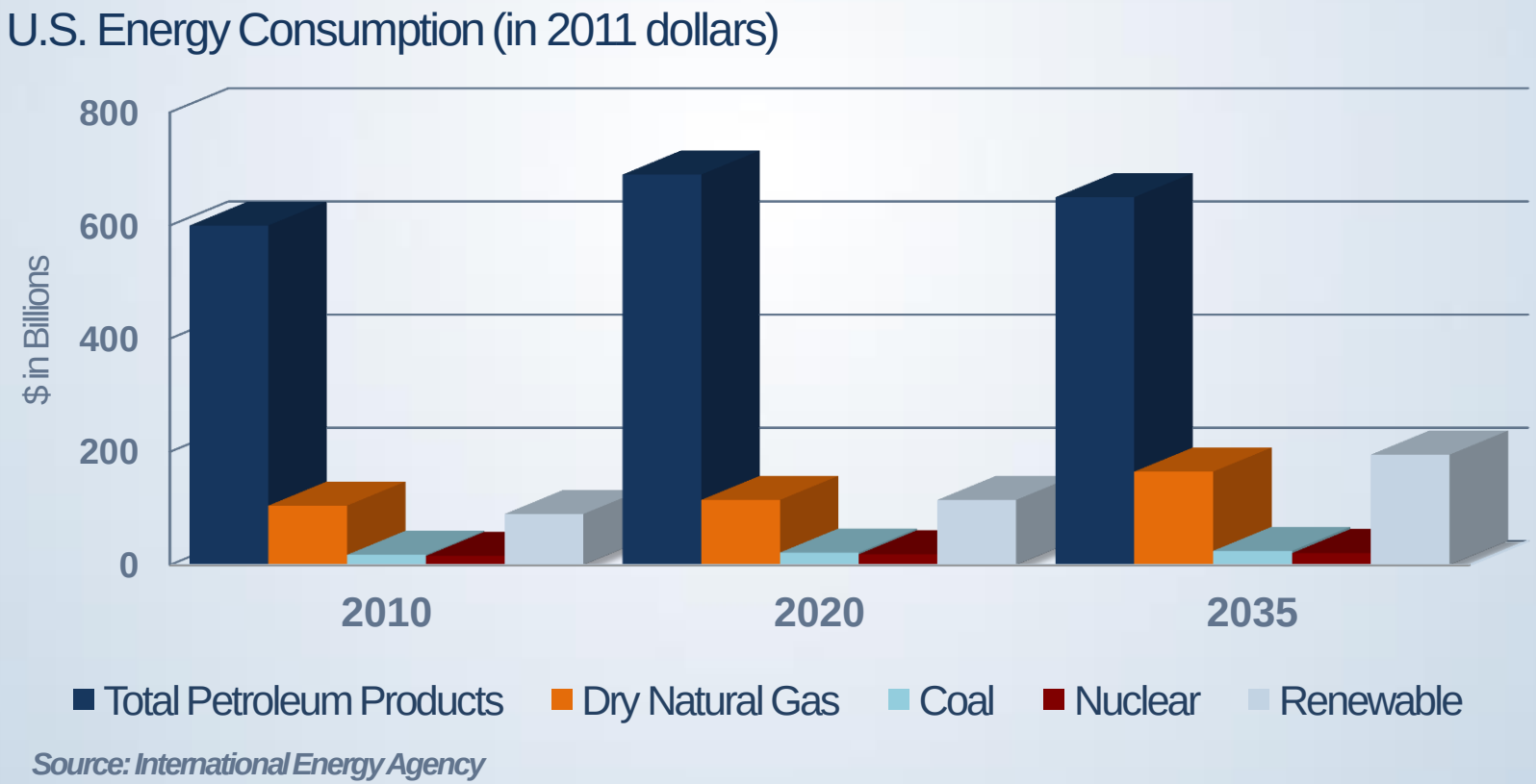
California CO_2 Emissions



Nearly two-thirds of California's CO_2 emissions come from petroleum

Source: International Energy Agency

Oil is also 6x more expensive



Source: International Energy Agency

So how do we solve this?

Popular solutions include:

- Increased efficiency
- Public transportation
- Taxation
- Electrification
- Alternative fuels

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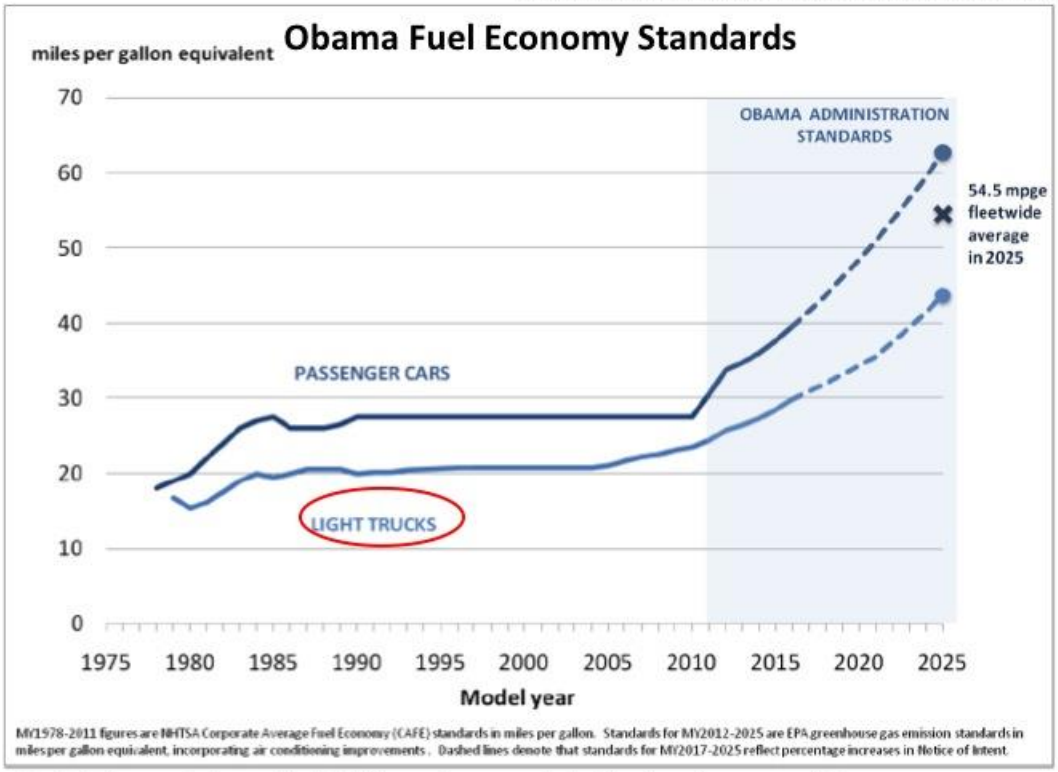
54.5 Fuel Economy Standard

http://www.whitehouse.gov/sites/default/files/fuel_economy_report.pdf



- Standards shown are industry-wide. Individual manufacturer standards will vary based on average vehicle "footprint" (wheelbase x average track width), weighted by model volumes.

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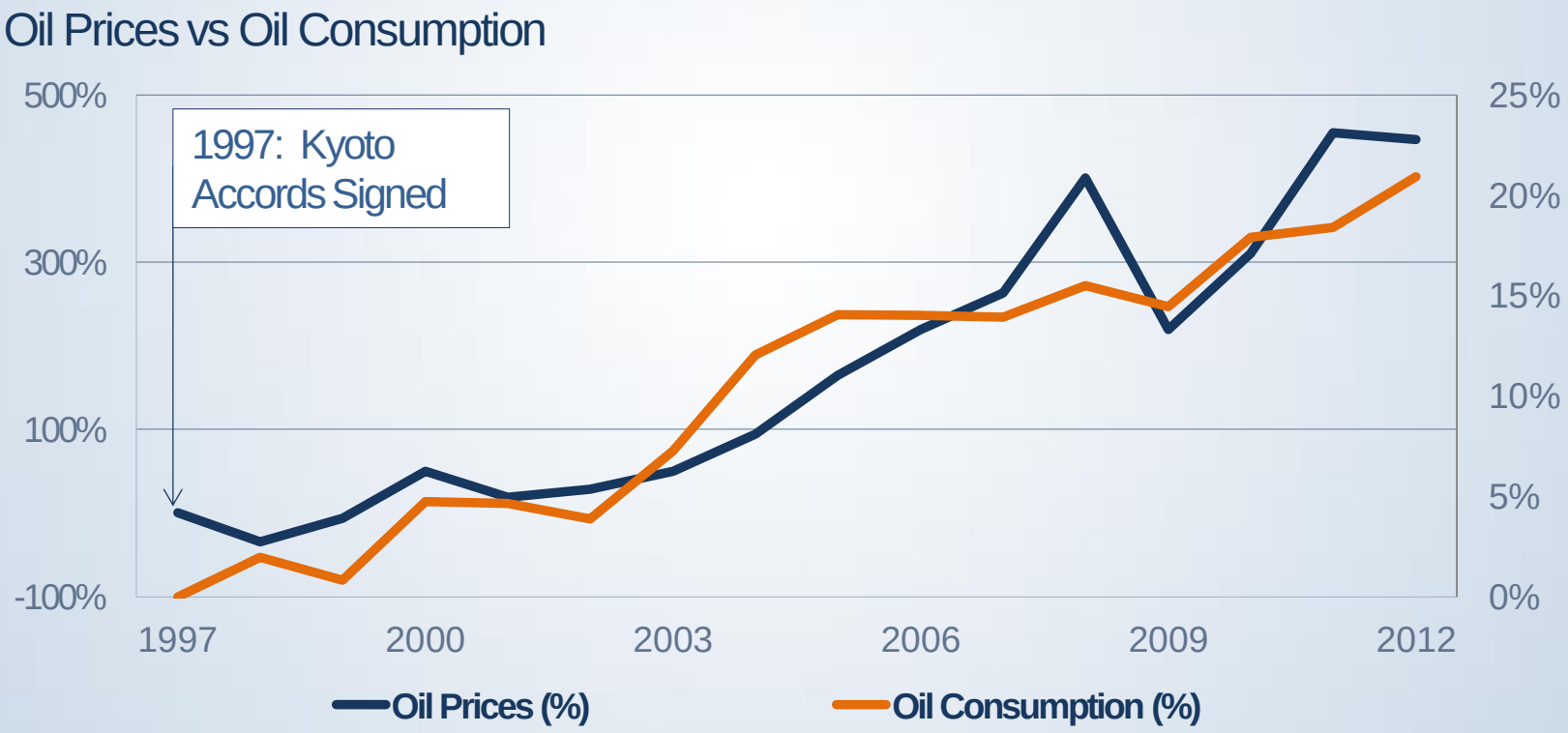
Will Taxation do it?

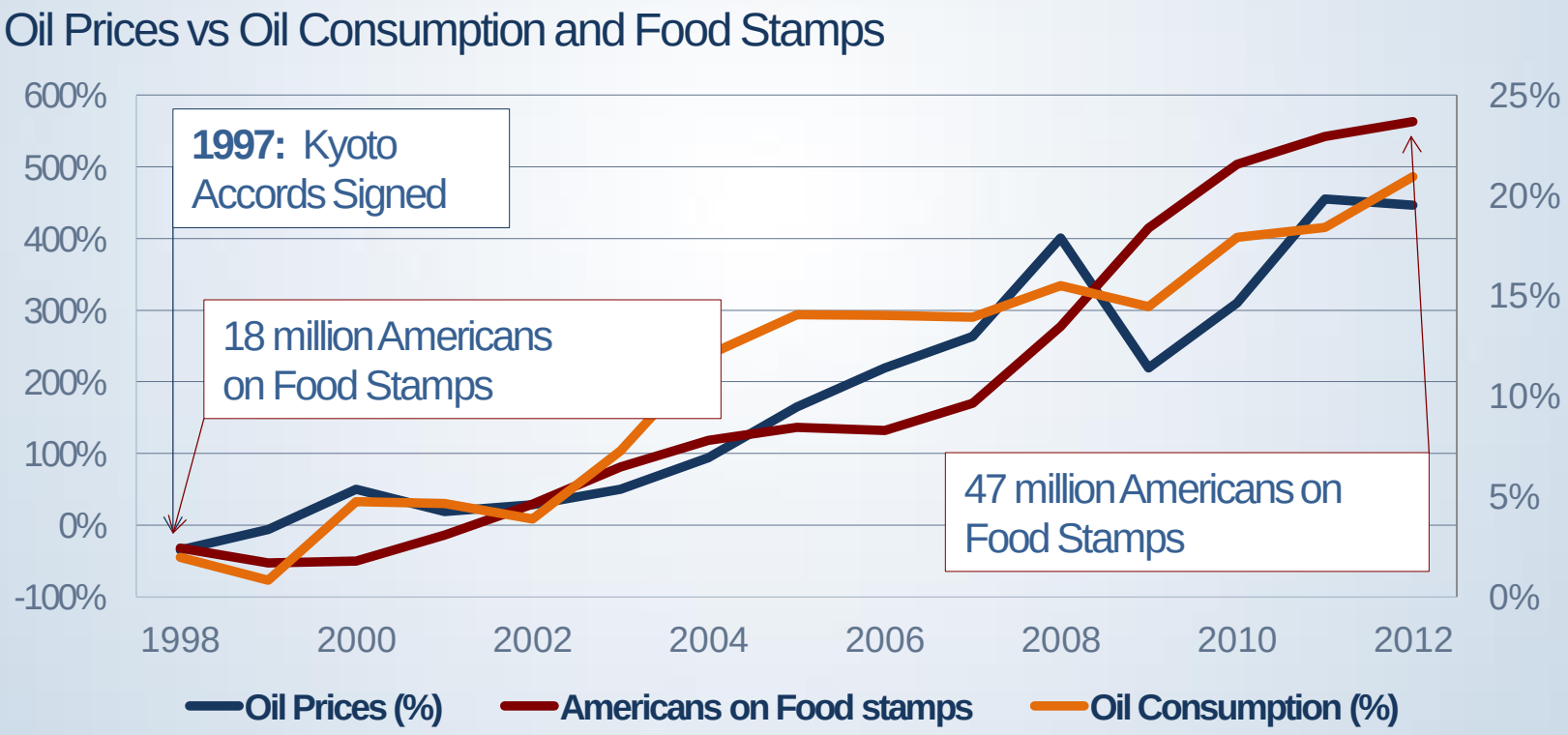
Source: EIA and USDA

Will Taxation do it?



Source: EIA and USDA

Will Taxation do it?



Source: EIA and USDA

Average Margin of Victory in a Presidential Election

6.3

MILLION VOTES

Source: Wikipedia

So how do we solve this?

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OFF GAS

What about Electrification?

Electric cars as a portion of the U.S. vehicle fleet

(Assuming optimistic 33% annual compounding growth rate)

Source: Source: EIA Annual Energy Outlook 2014

So how do we solve this?

Popular solutions include:

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Fuel Replacement

- Can we make replacement fuels that are better than oil for the environment?
- Can these fuels compete with oil in the marketplace?
- How long will it take them to make a real impact?

The key is fuels that work with your existing car

Alcohol fuels are high octane, liquid fuels used today for racing cars and…

Can work on YOUR car

Natural Gas? doesn't that mean Fracking?

- Fracking is no longer only a gas thing
- 90% of all new OIL wells use fracking

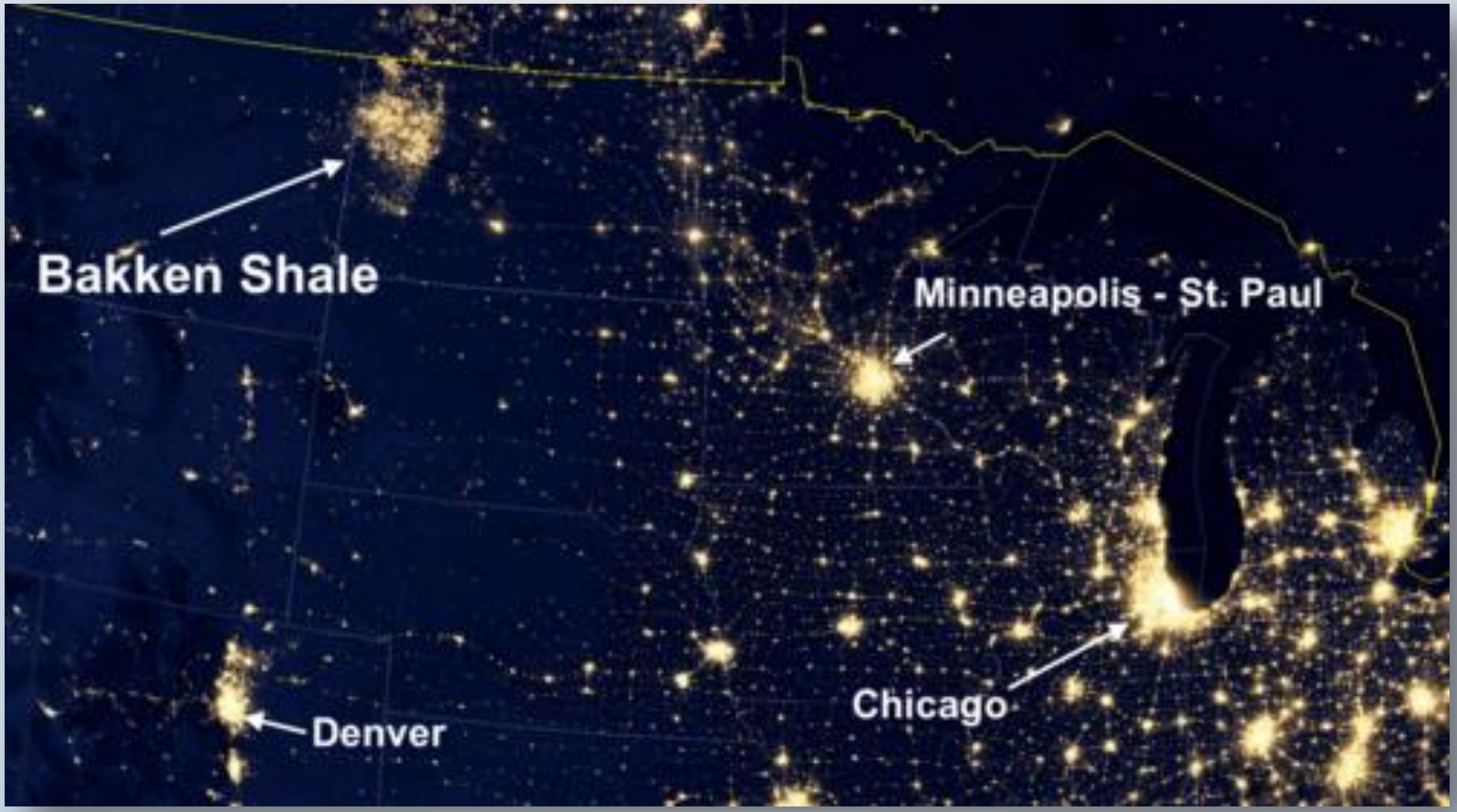
Choosing to do nothing is

choosing oil

and choosing oil is choosing

fracking

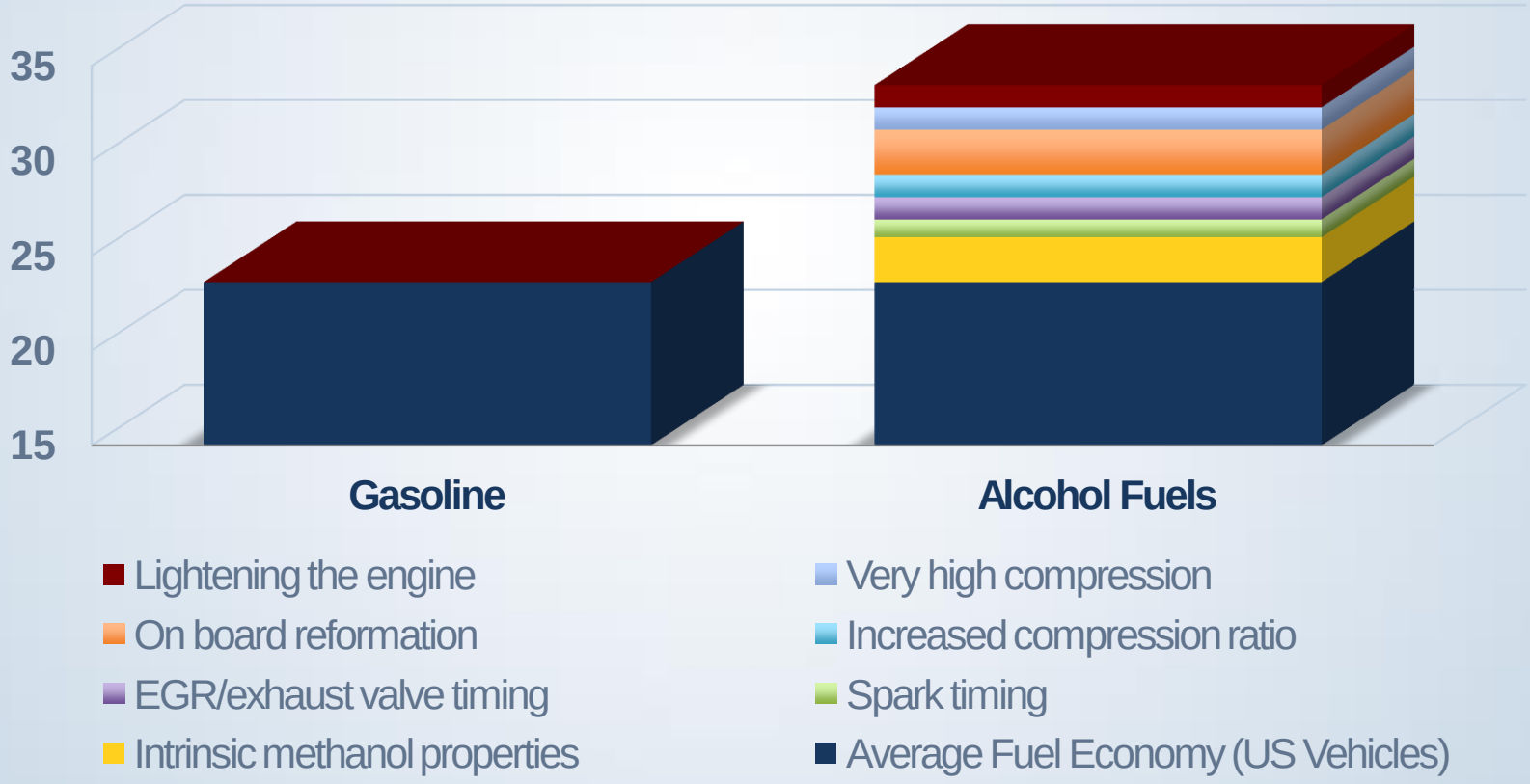
Natural gas is a byproduct of oil fracking



Alcohol Fuels: Environmental Advantages

- Dissolve in water, biodegradable
- Reduce smog
- Replace toxic aromatics in gasoline
- High octane means even higher efficiency engines
- Fewer GHG emissions
- Many possibilities for renewable sources

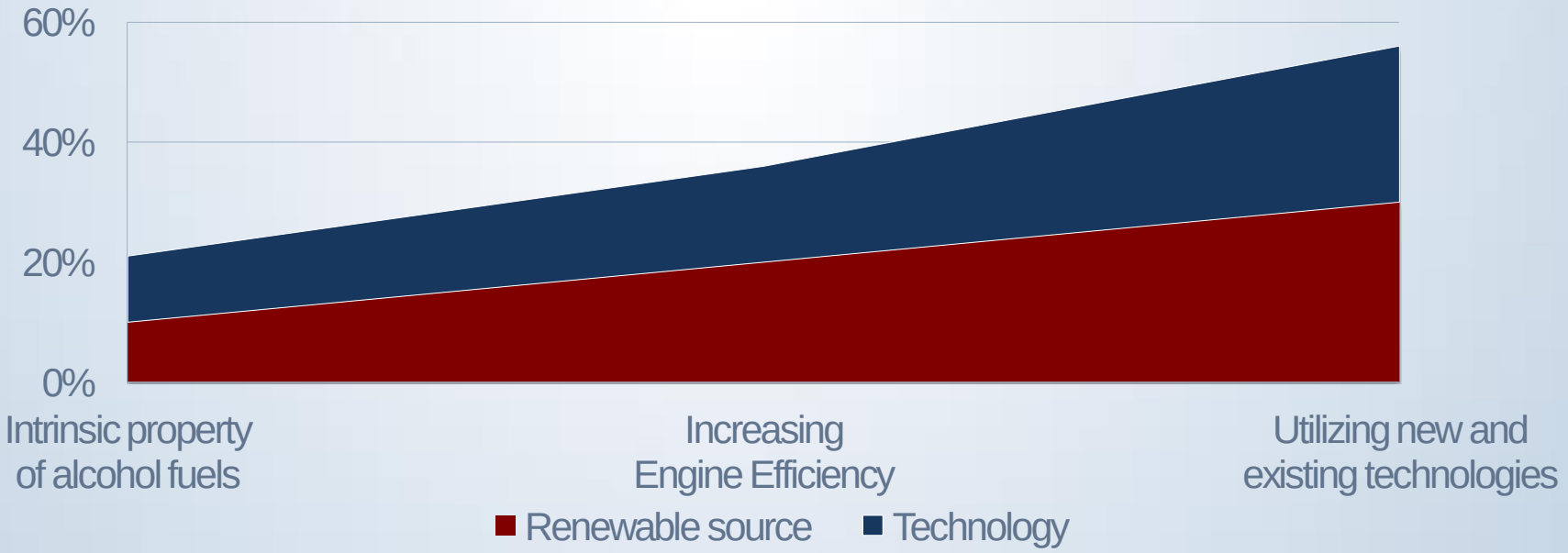
Alcohol Fuels: Engine Advantages



Source:: MIT and EPA

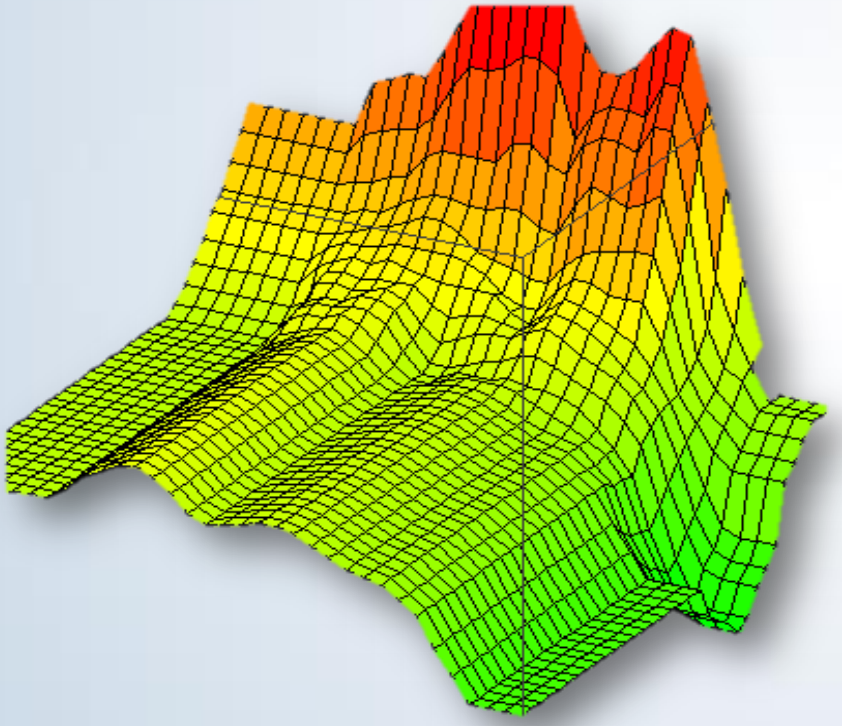
Alcohol Fuels: GHG Advantages

Assuming 30% of fuel is made from renewable, waste or methane by-product sources.

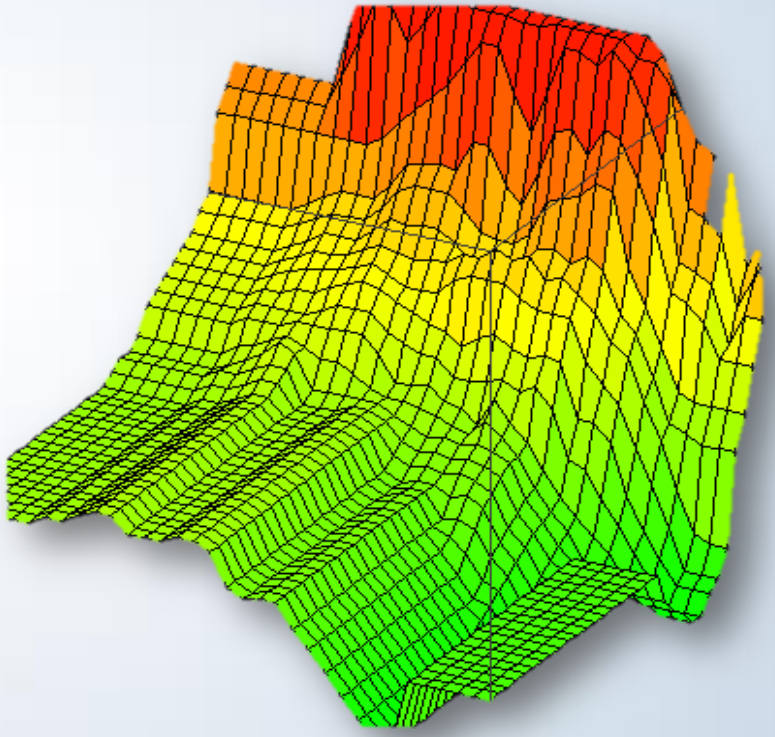


Source: Argonne MIT and Fuel Freedom Study

So how come driving on E85 is so lousy?

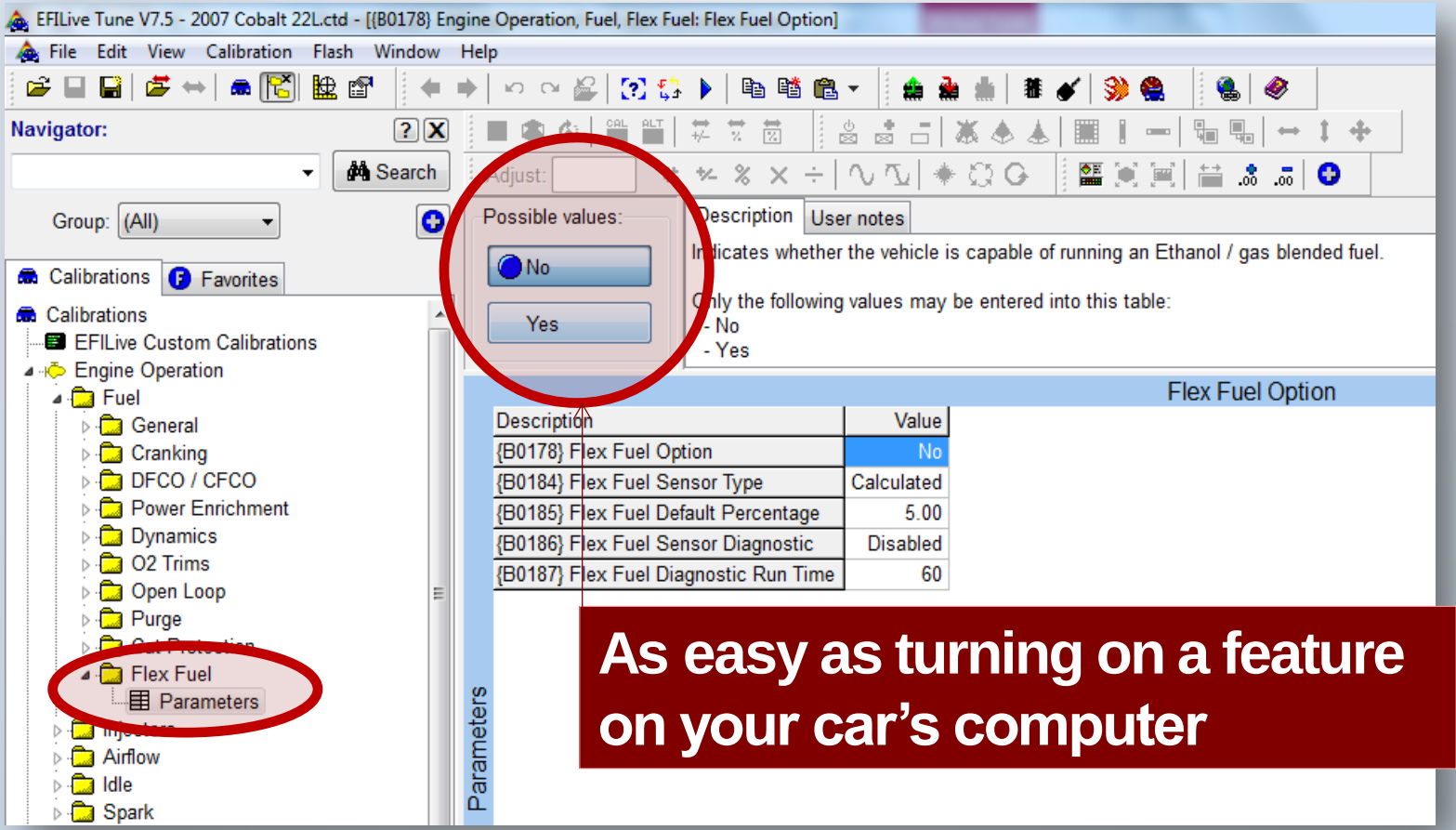


Stock engine optimization sucks, because it is only optimized for gasoline



We achieved a 20% increased fuel economy after optimizing for both alcohol and gasoline

Getting there is easier than you think



So what about the economy of this transition?

The Spread

- In the last 3 years we consumed about $400 billion in gasoline a year
- All of that could be replaced with $80 billion of natural gas
- Converted to alcohol (methanol) with 50% efficiency say, $160 billion
- That is a $240 billion arbitrage opportunity!

COMING SOON

In iTune/NetFlix
January, 2015:

PUMP The Movie.com

VISIT OUR WEBSITE:
www.fuelfreedom.org

FUEL FREEDOM FOUNDATION™

Session 2:
Forecasts of natural gas demand

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Critical Issues Forum

America's Increasing Reliance on Natural Gas: Benefits and Risks of a Methane Economy

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Password: (no password needed)

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