



How the US Makes Electricity... and wastes energy

Presentation to ENGG 174: Energy Conversion Technology

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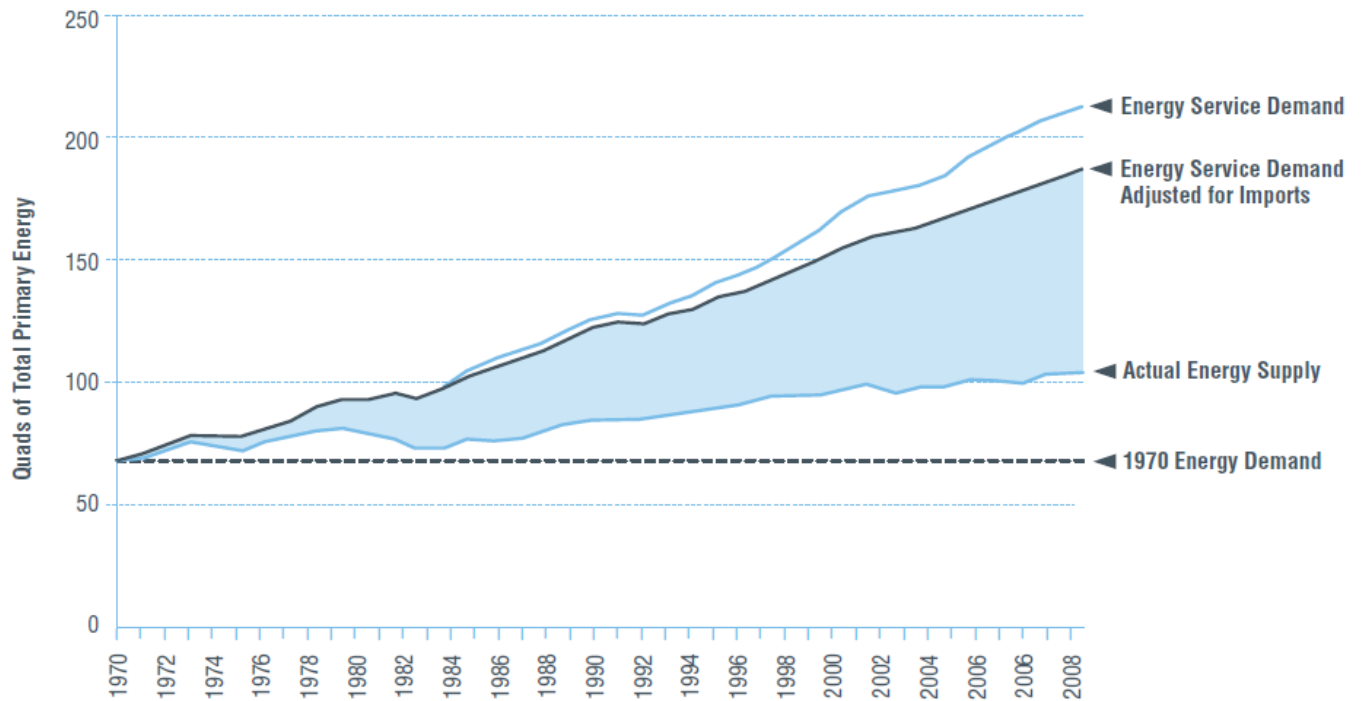
Hanover, NH

Is energy a supply or demand problem?

- October 10, 2010 Rasmussen poll:
 - “58% of U.S. Voters think finding new sources of energy is more important than reducing the amount of energy Americans now consume.”
 - “60% of voters think investing in renewable energy sources like wind and solar is a better long-term investment for America than investing in fossil fuels like oil, gas and coal. 27% feel fossil fuels are the better long-term investment.”
 - “42% of voters believe there is a conflict between economic growth and environmental protection”
- Note consistent assumption that energy conversion efficiency is fixed!

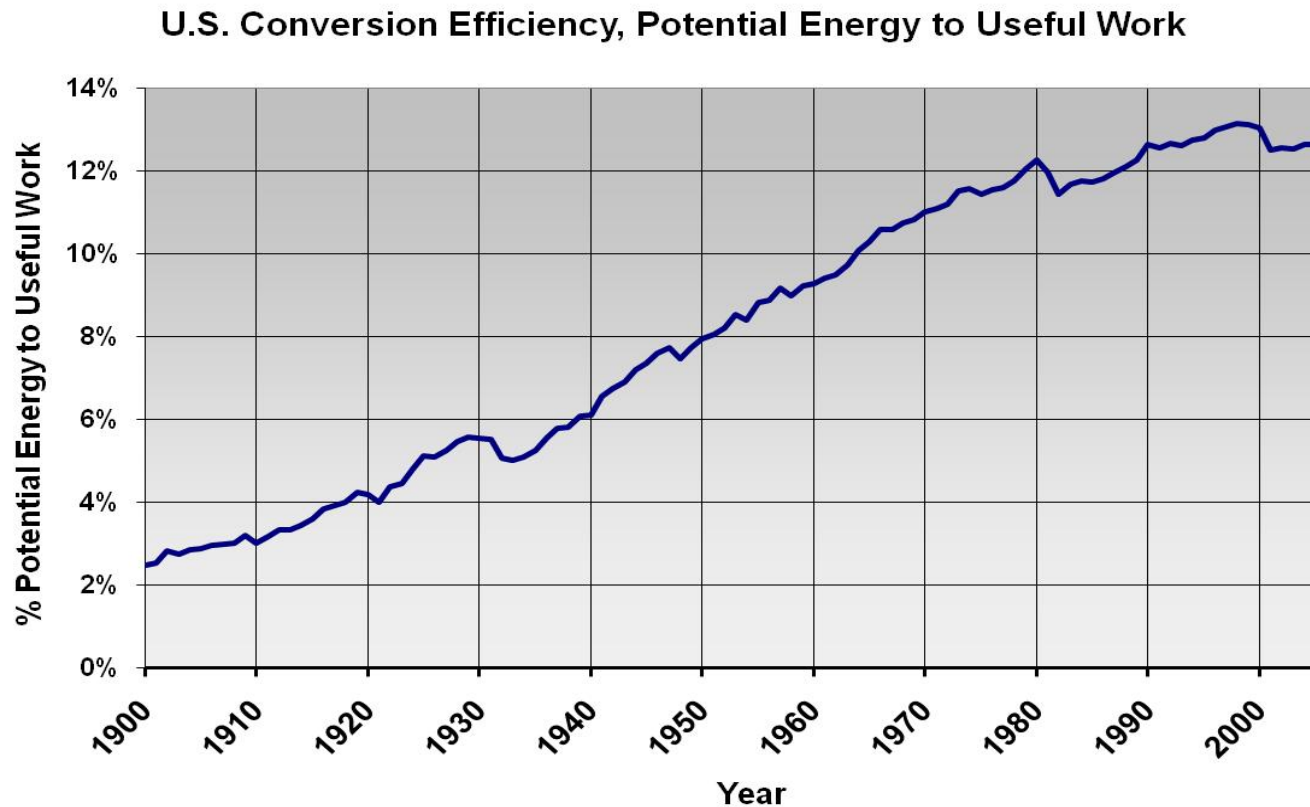
Reality: conversion efficiency isn't fixed... but it's benefits are invisible.

U.S. Energy Use in Relation to GDP
Energy Consumption in the United States 1970 - 2008



Source: Skip Laitner, ACEEE

However, exergetic efficiency trends are saturating – why?



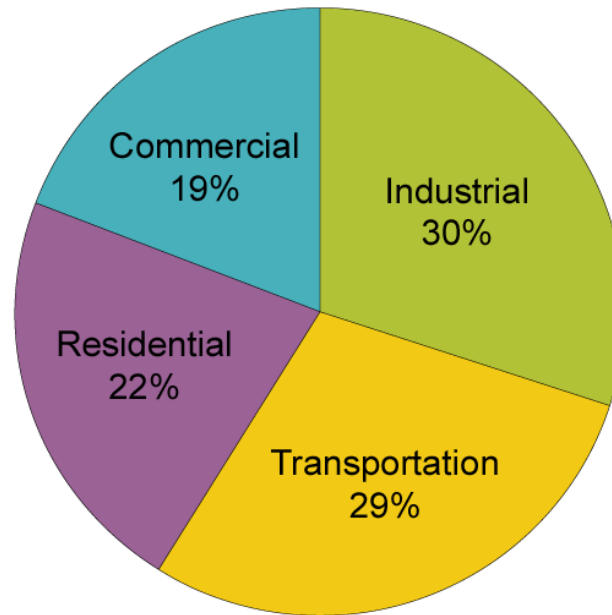
Source: Robert Ayres, INSEAD

Ex-US data suggests we are far from fundamental limits (and intuition).

- Japan, Austria and UK achieve about 20% exergetic efficiencies of fuel to useful work, versus 12% to 13% in the U.S.
 - Many nations with efficiency- (rather than supply-) focused policies have not yet been studied; expect >25% in Denmark, Netherlands, Finland, others.
- At 25% efficiency, these countries produce useful energy services with half of the fossil carbon dioxide associated with U.S. energy services
 - Even the best countries underdeploy lots of no-brainer efficiency measures (window caulk, white roofs, etc.) – reasonable to conclude that every country could increase further.
- The U.S. has an efficiency deficit versus its trading partners that it can fix

So where do we use energy?

Share of Energy Consumed by Major Sectors of the Economy, 2009



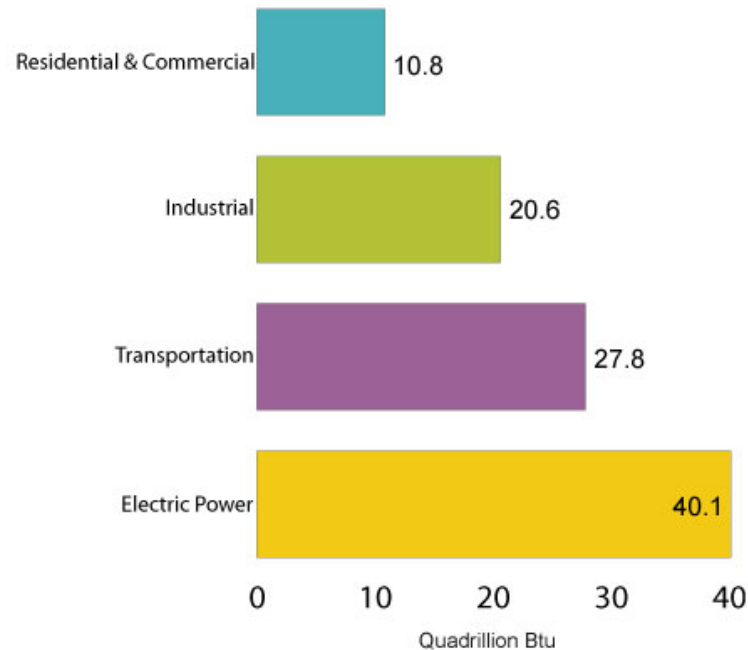
Source: U.S. Energy Information Administration, *Annual Energy Review 2009*.

Data commonly presented this way – but useless, because it mixes & matches end use (residential) with energy conversion (transport)

Charts like this cause sloppy thinking, lousy policy. (Example: “buildings are biggest energy users” – while true, it’s like setting ag policy based on grocery store purchases.)

Better data: reducing primary energy use must start with electric industry.

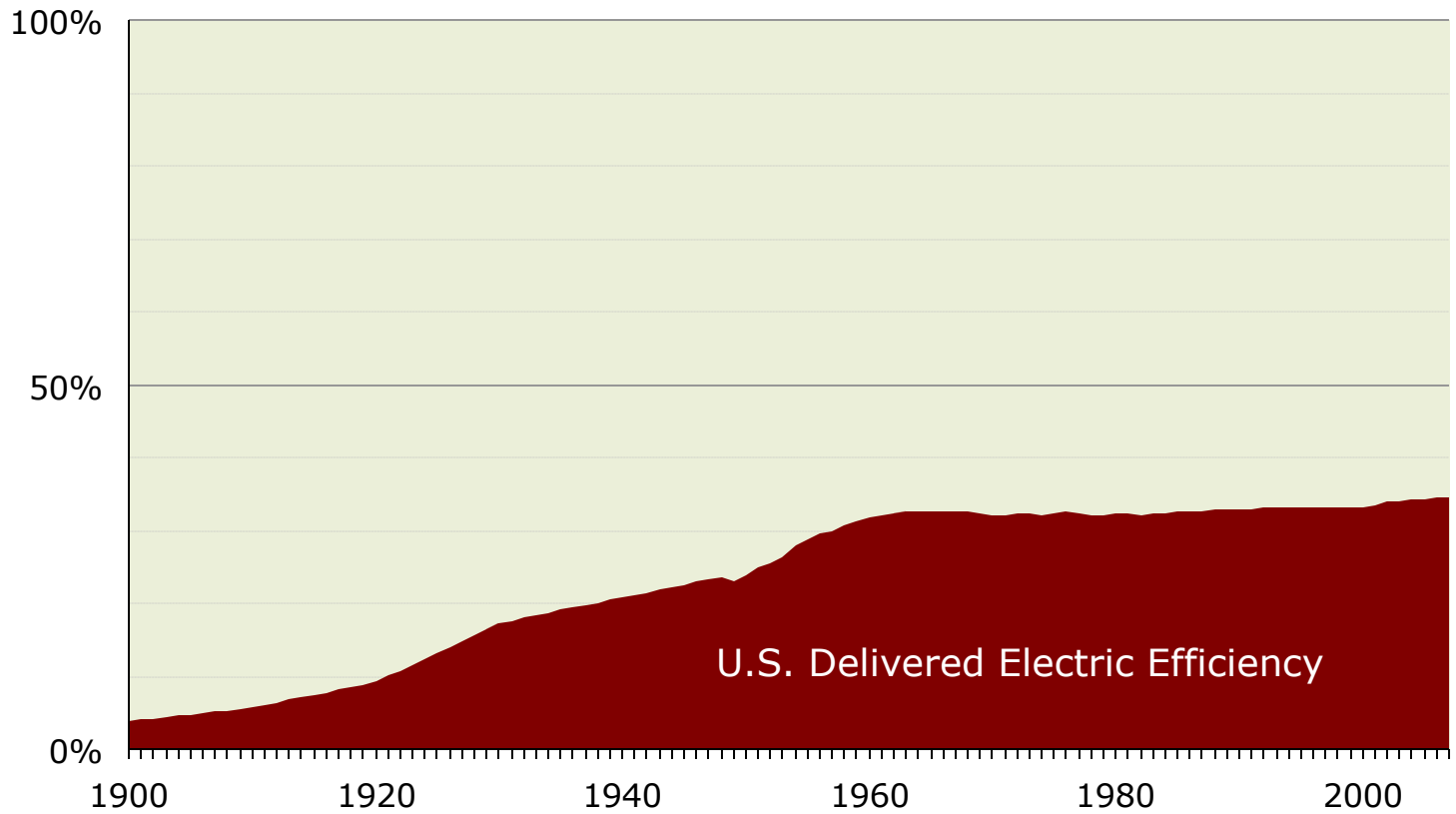
**Primary Energy Use by Sector,
2008, Quadrillion Btu**



Source: U.S. Energy Information Administration, *Annual Energy Review 2008*.

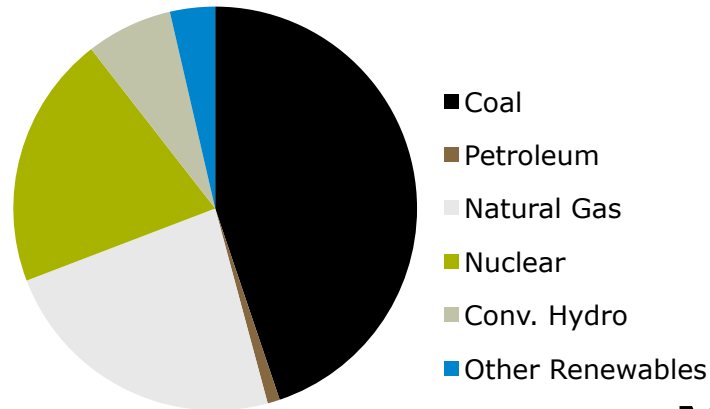


And it's efficiency has been stagnant for 50 years!

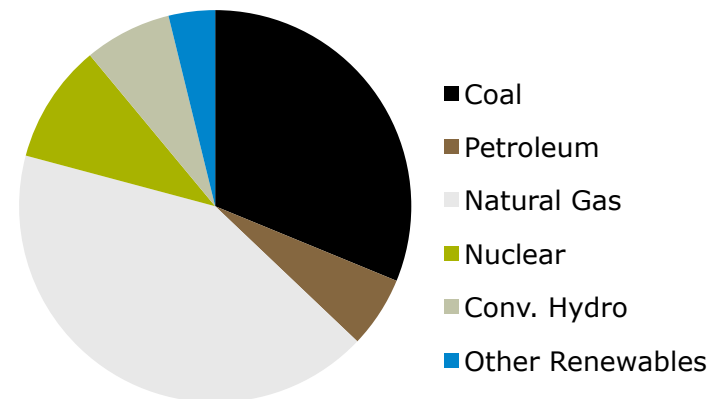


Understanding why starts with existing asset base.

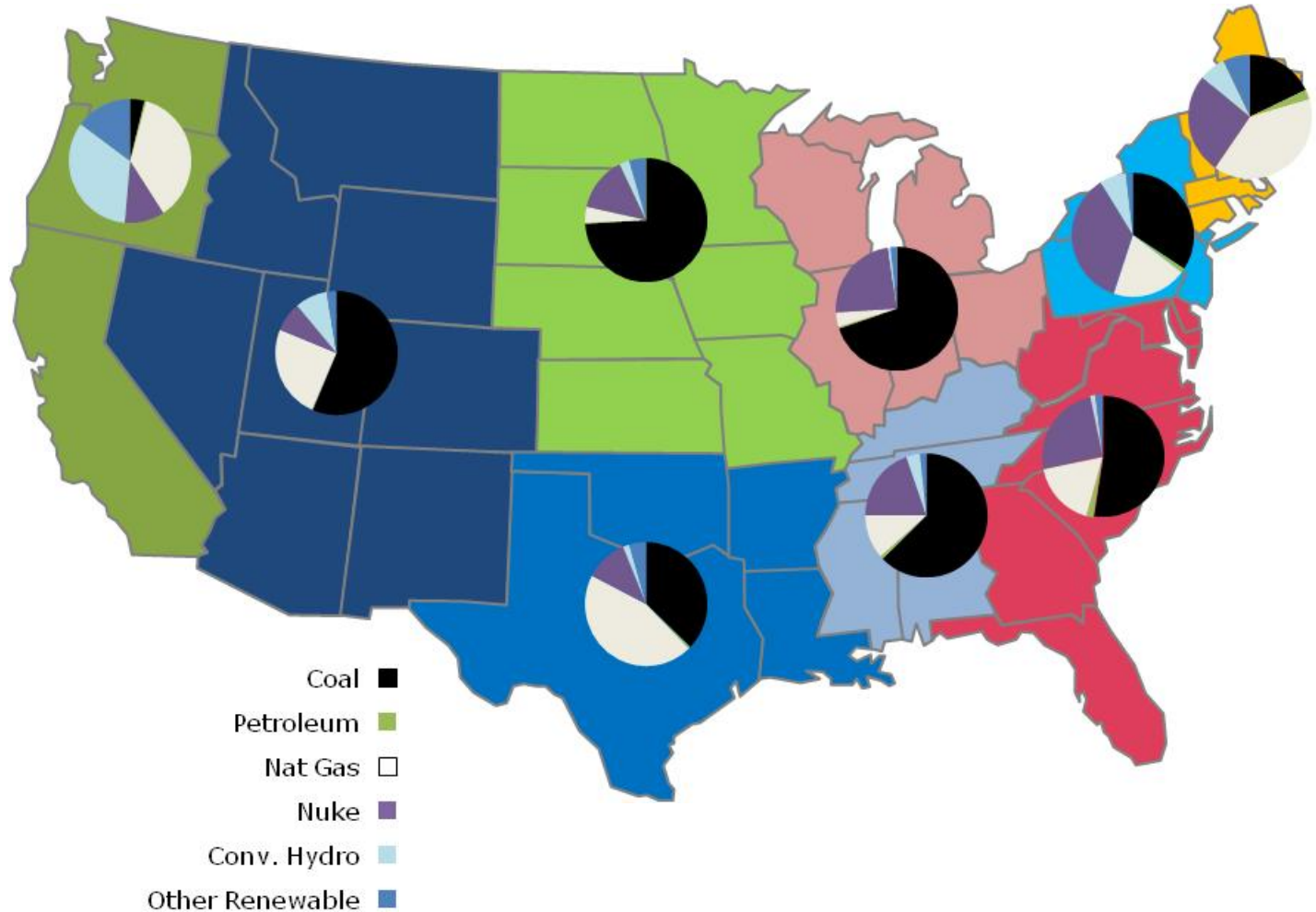
MWh Basis



MW Basis

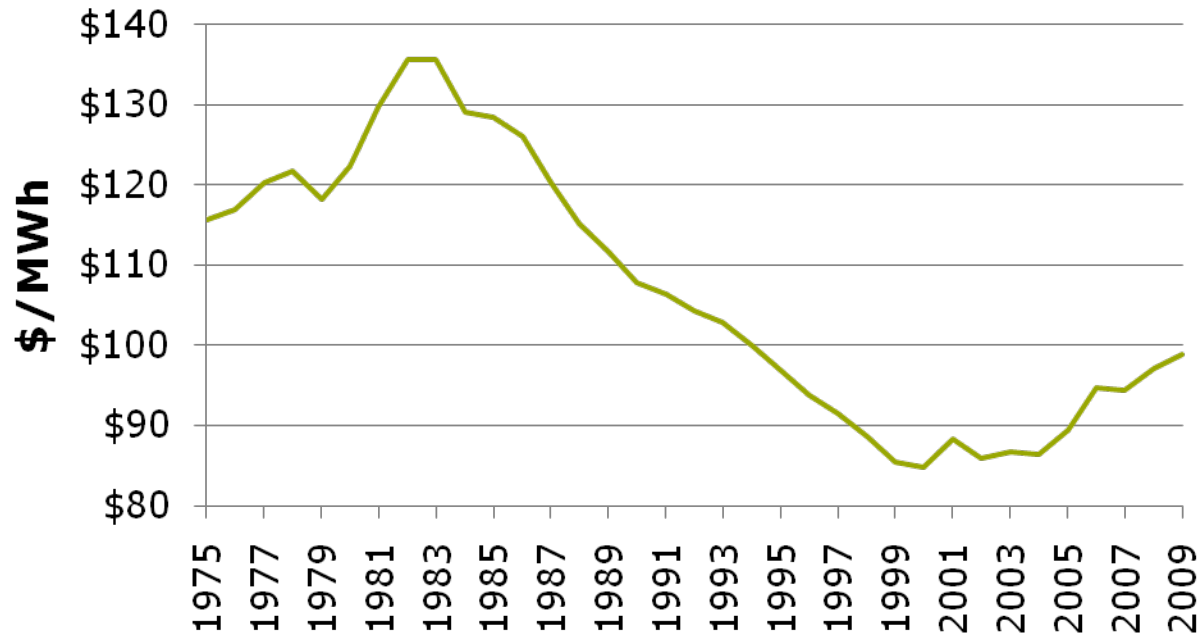


Regional variation: New England is not typical! (MWh basis)

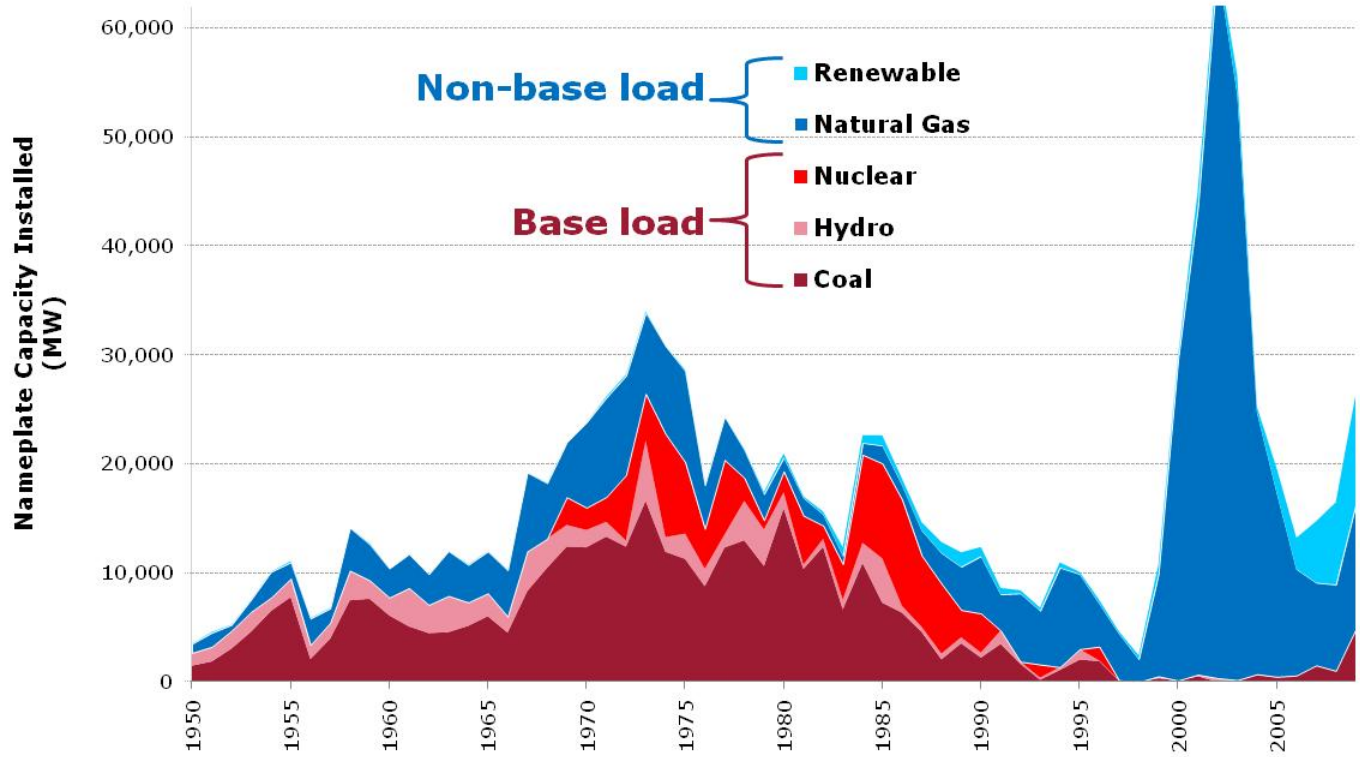


But wait – if efficiency is flat and coal is cheap, what’s up with power prices?

US Average Retail Electric Rates (2009 \$)

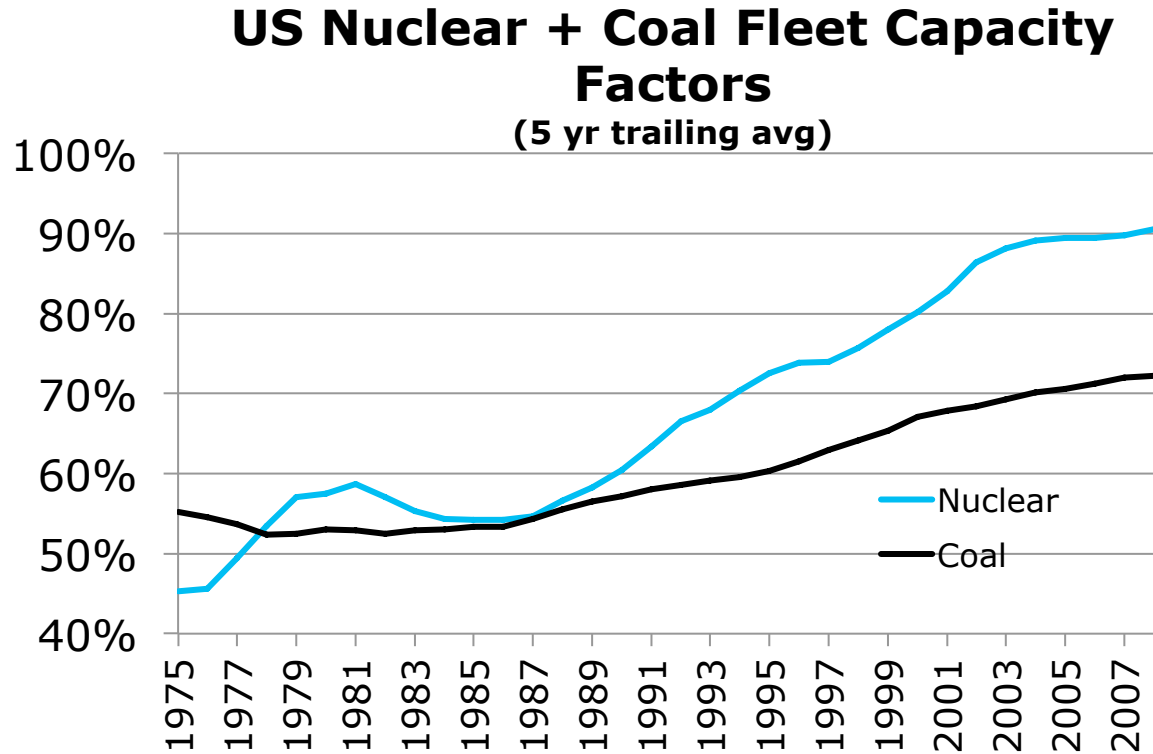


US generation deployment history tells part of the story...

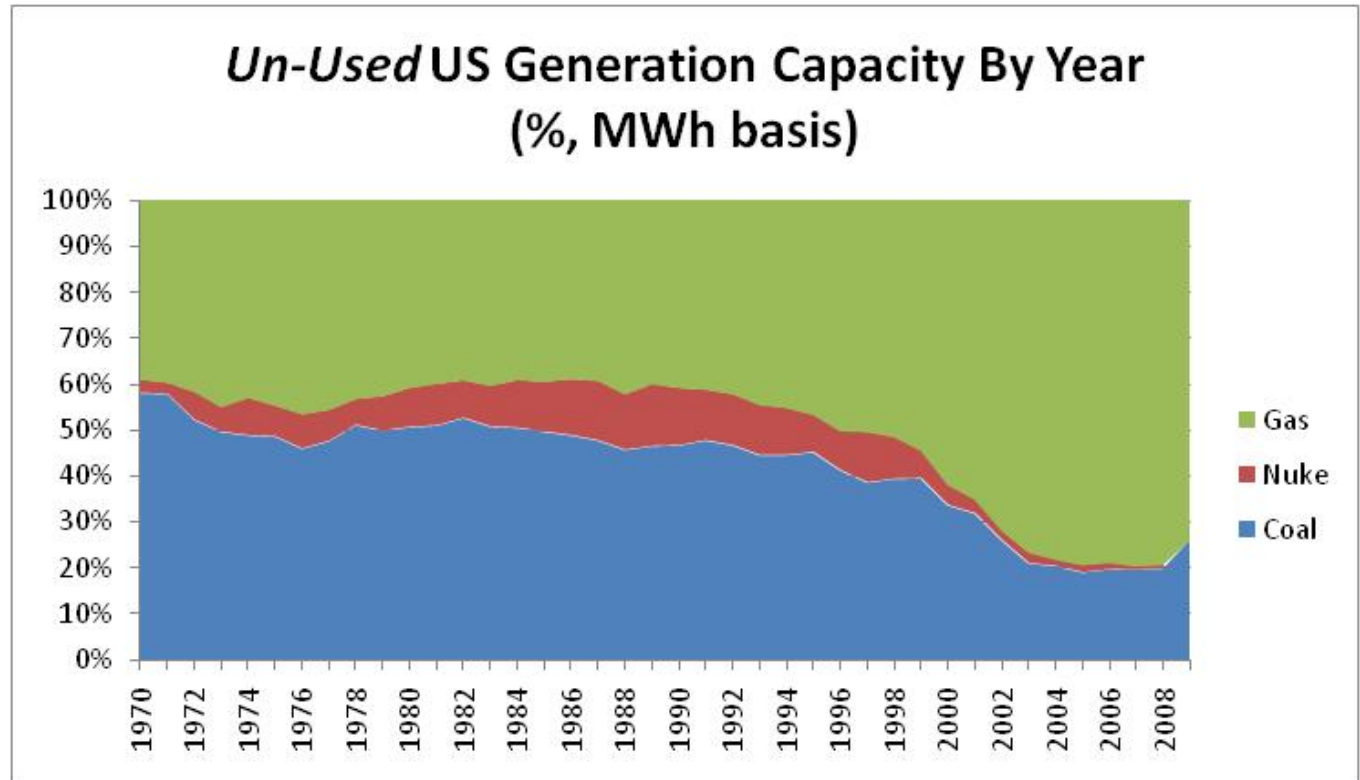


Source: EIA's Existing Electric Generating Units in the United States, 2008 and Planned Capacity Additions for 2009

... and capacity factors tell the rest.



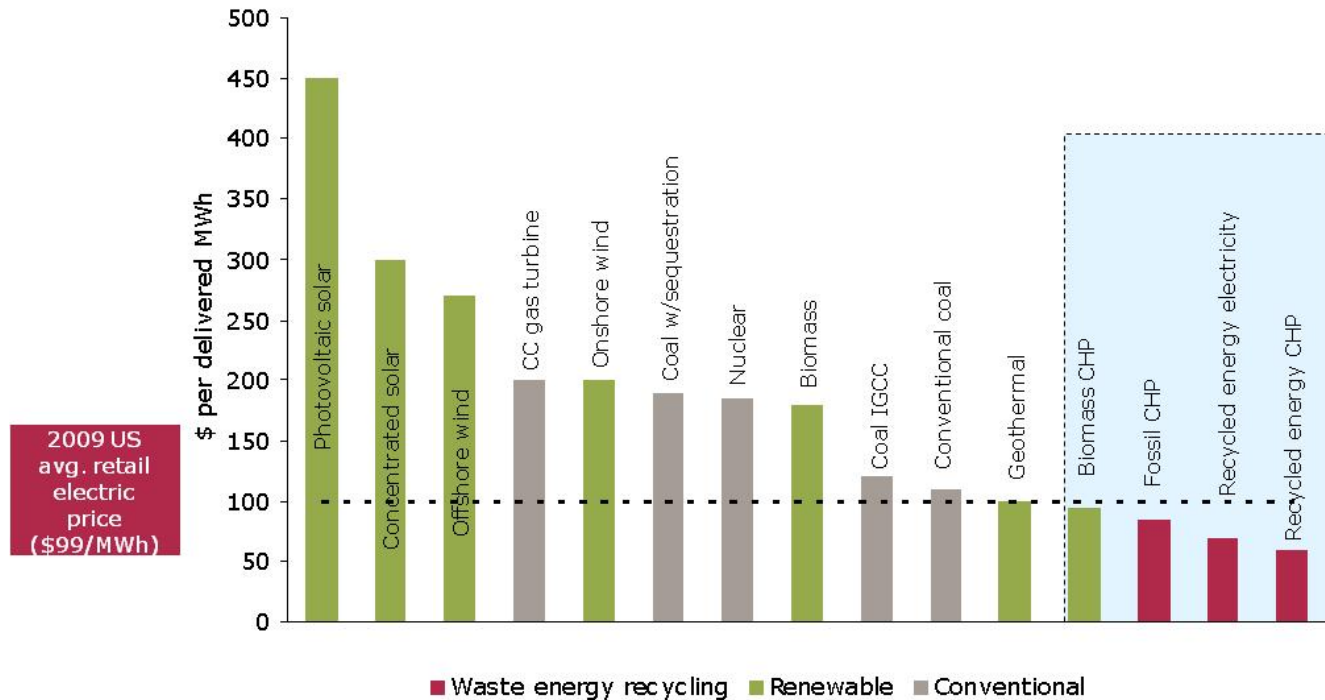
Viewed another way: our reserve margin is 60 – 70% gas.



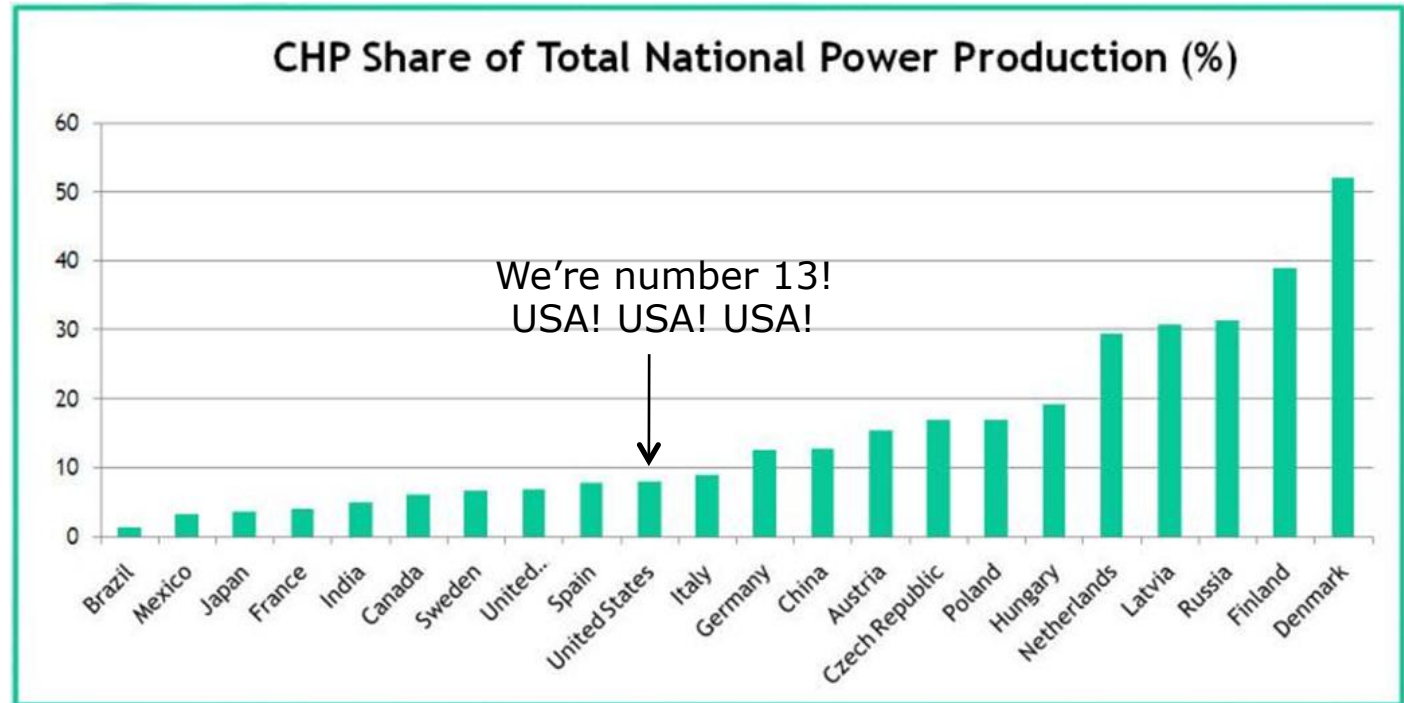
In other words... the past is a lousy predictor of the future.

Good news: on an all-in basis, the cleanest, most cost-effective techs are the most under-deployed.

Delivered cost of new US generation



Bad news: our trading partners have a big head start.



Source: IEA, CHP: Evaluating the Benefits of Greater Global Investment (2008).

How did we get here?

- Electric regulatory model
- Clean Air Act
- 3 mile island
- Inconsistent energy policy, except for big, regulated assets.

Consequences

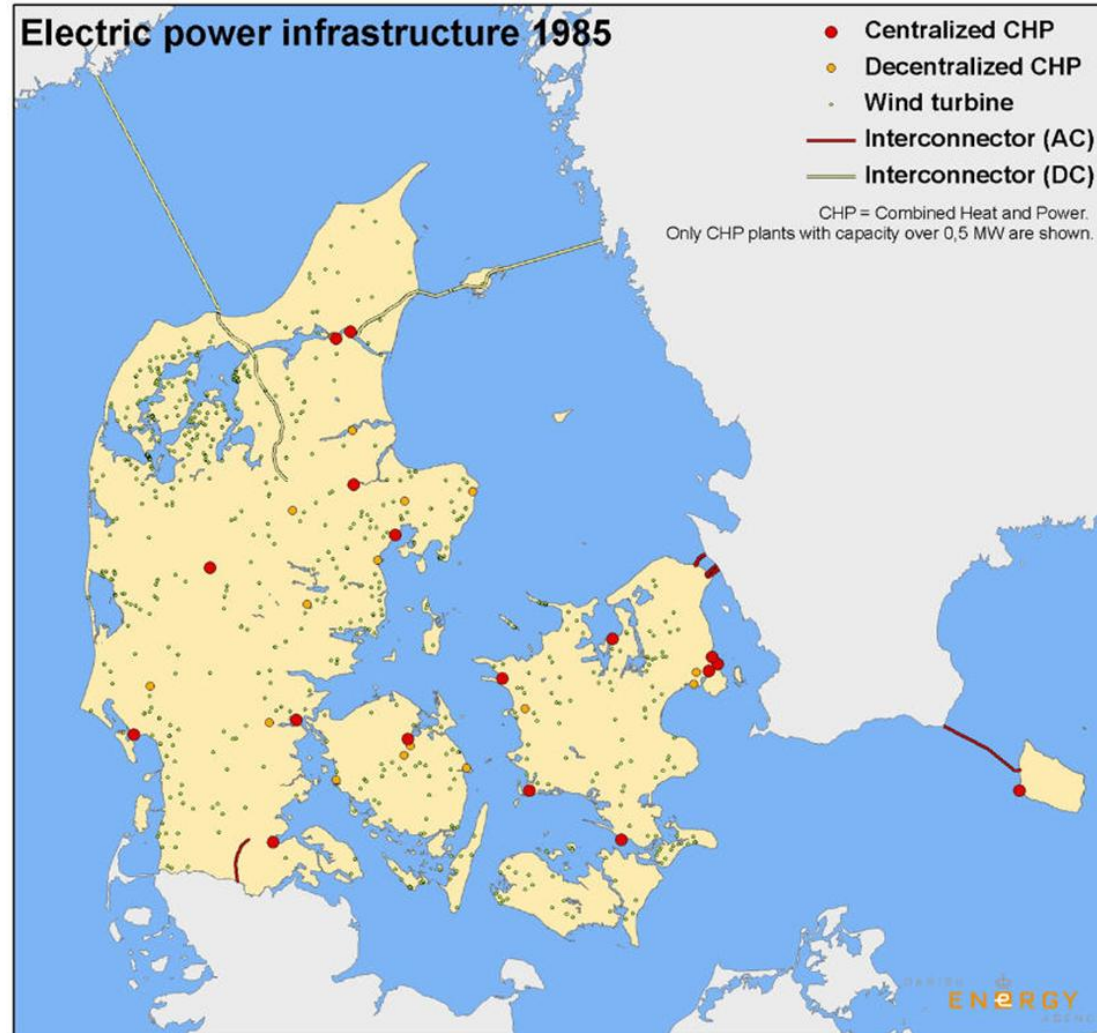
- US economy grew by access to cheap energy; no longer. Can't attract energy-intensive mfrs to US anymore.
- Push away from energy intensive activities corresponds to hollowing out of economy; those are the good jobs for folks with moderate education levels that we're losing.
- This affects every part of the US economy and politics – income inequality, immigration trends, economic growth, health costs all skew unfavorably so long as we under-deploy the cleanest, cheapest energy.

China faces the same challenges, but is taking a top-down approach to solve. What are we doing?

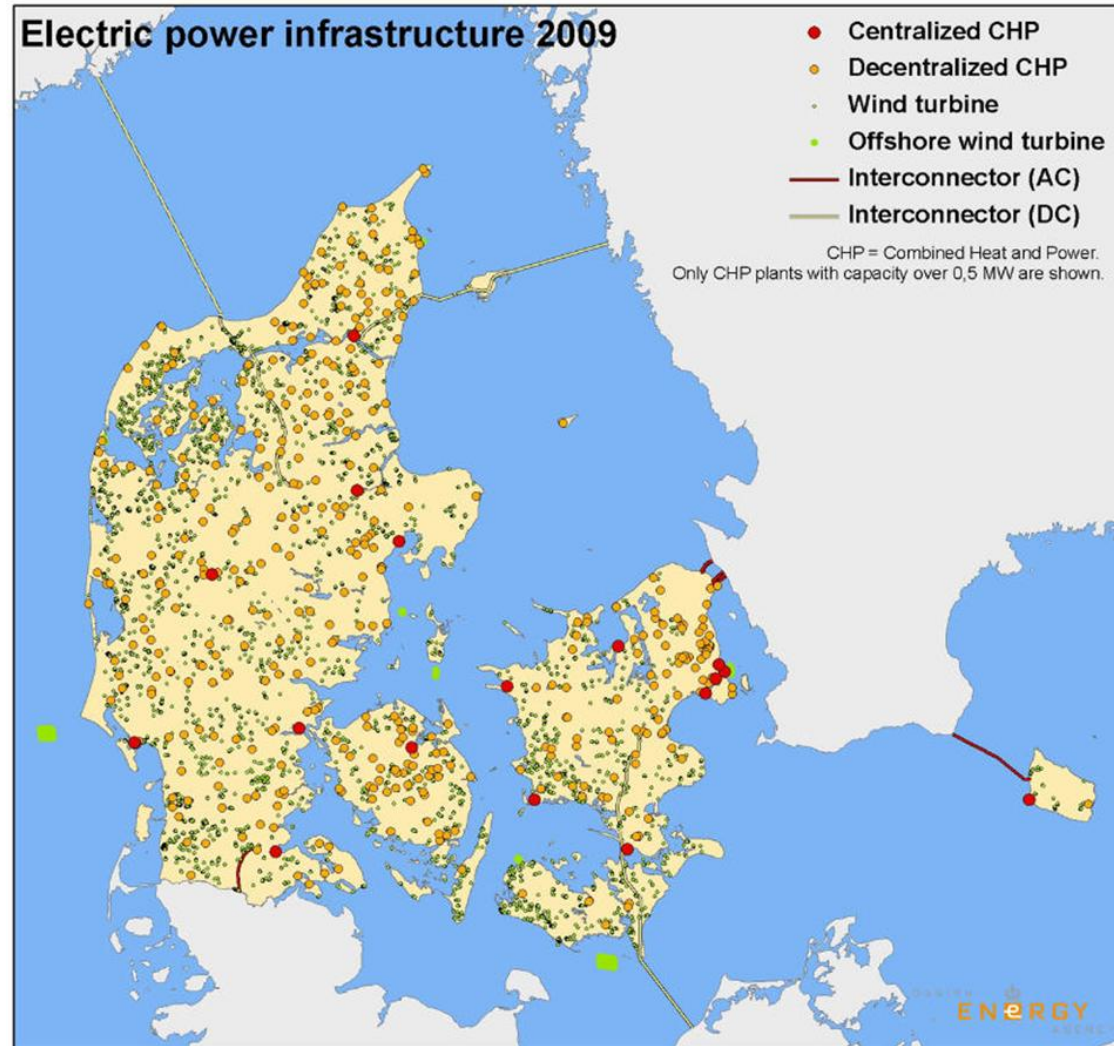
“Behind the [power plant construction boom in China] are myriad forms of government intervention. Most [Chinese utilities] lost money in 2008, made fairly low returns in 2009 and, thanks to a government policy of holding down tariffs are unlikely to be particularly profitable in the future. The huge expansion of generating capacity serves many purposes... **Cheap, reliable electricity is one reason why China remains the preferred destination for manufacturing even as its wages rise.**”

- “China is parlaying it’s hunger for power into yet more economic clout”, *The Economist*, April 29, 2010

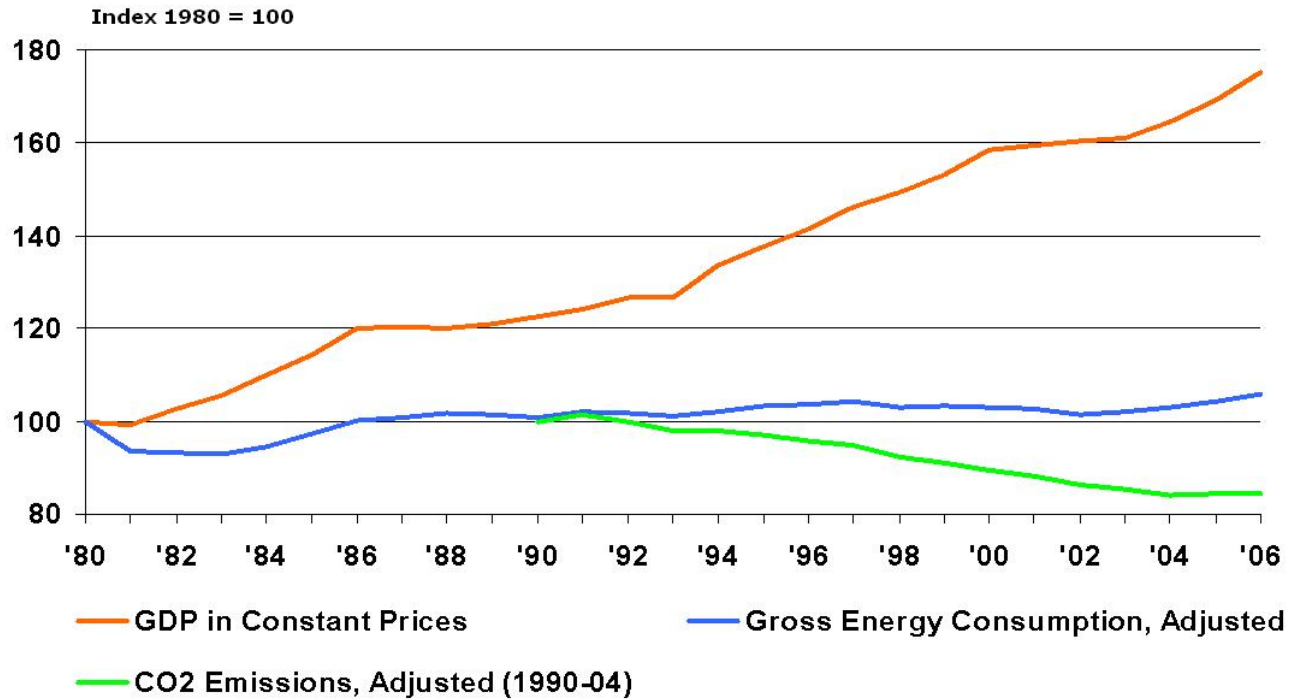
What's possible: the Denmark story



What's possible: the Denmark story



Something isn't rotten in Denmark!



Source: Danish Energy Authority

What if the US followed Denmark's example?



Would use 28% less primary energy AND economic growth. Waxman-Markey sought 17%, with economic pain.

Conclusions

- Our energy policy and policy conversation tends to focus exclusively on upstream supply and downstream demand
 - Palin: “Drill, baby drill” vs. Carter: “Put on a sweater”
- Supply is subject to natural limits, demand for *useful energy* grows with GDP.
- Limiting conversation to those two variables invokes Malthusian doom. Fortunately, they are not the only two variables.
- It’s all about energy conversion!