Contextualizing Nuclear

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The Role of Nuclear Power in New England – Reliability, Carbon Reduction, and Market Prices.

ISO-New England: Consumer Liaison Group (CLG)
Westboro, MA
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Topics

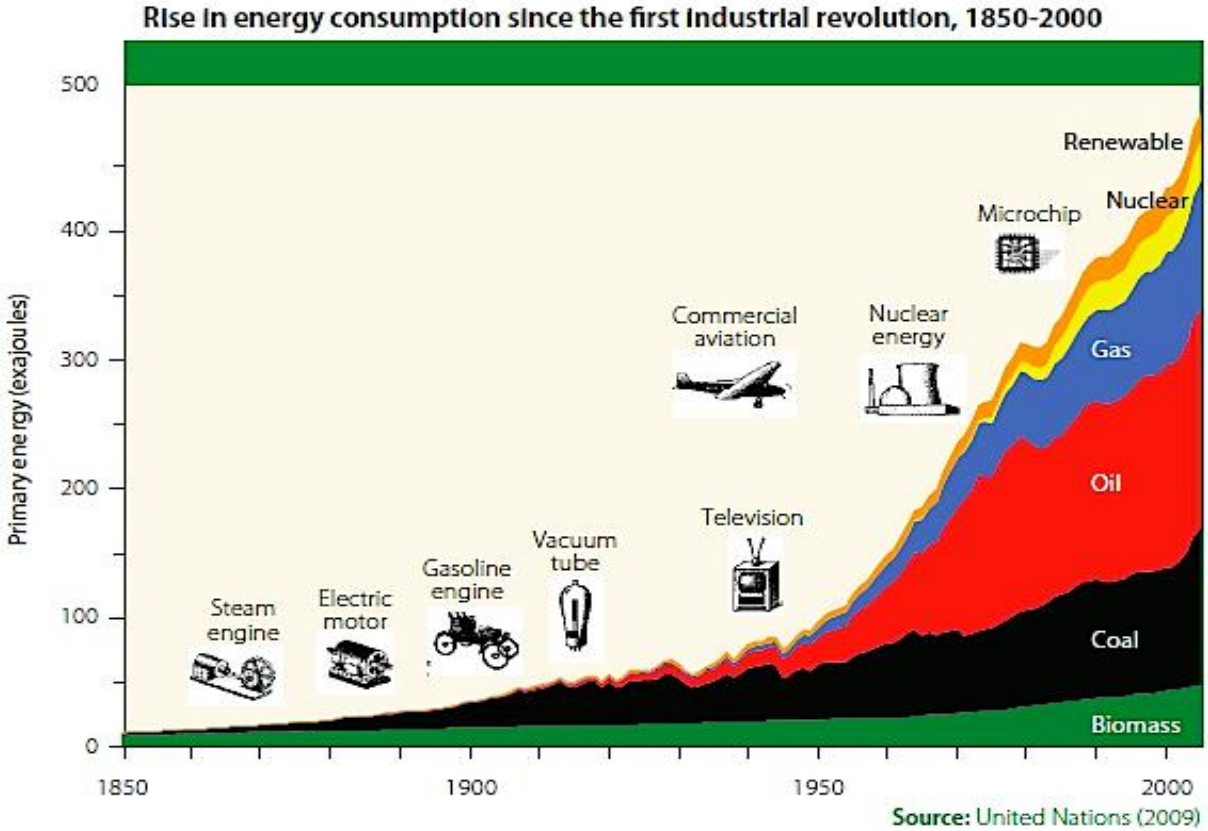
- Energy Perspectives
  - Energy utilization
  - Energy Sources
- Electricity Technology Options
  - What's available?
  - What attributes?
- Conclusion

Energy

Required for modern civilization

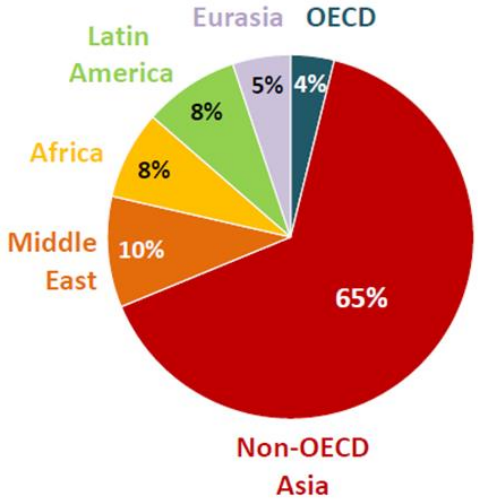
and **Quality of Life**

Historical Energy Demand



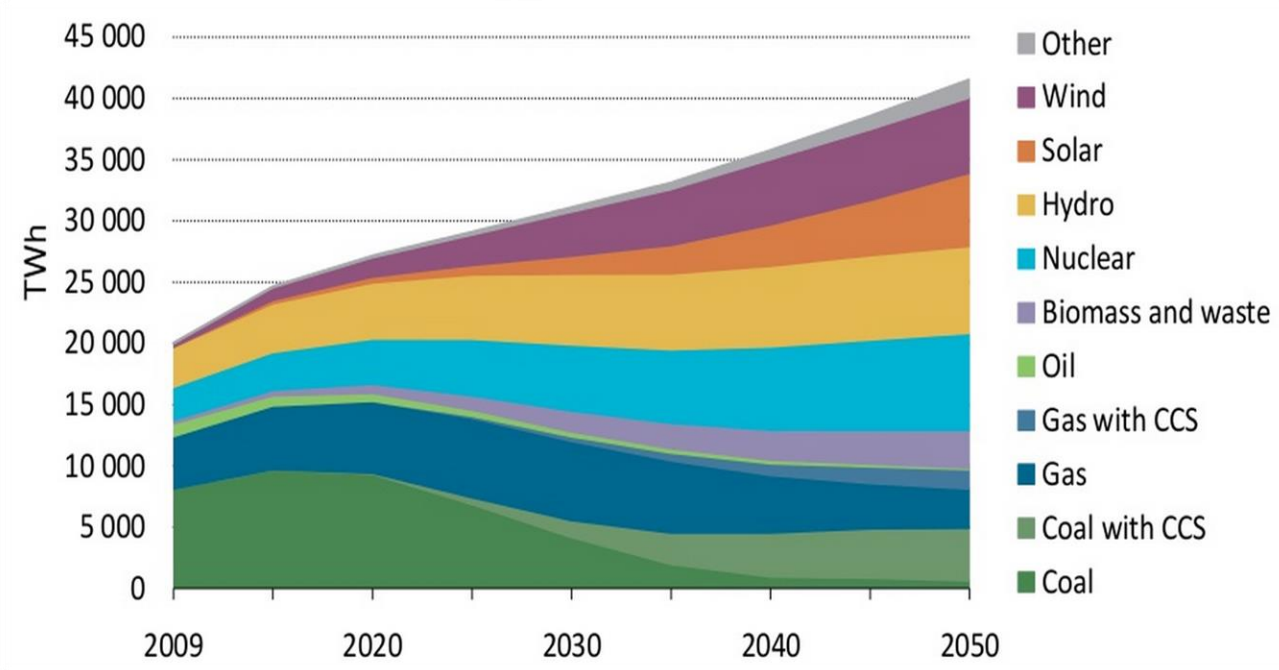
Primary energy demand, 2035 (Mtoe)

Share of global growth 2012-2035

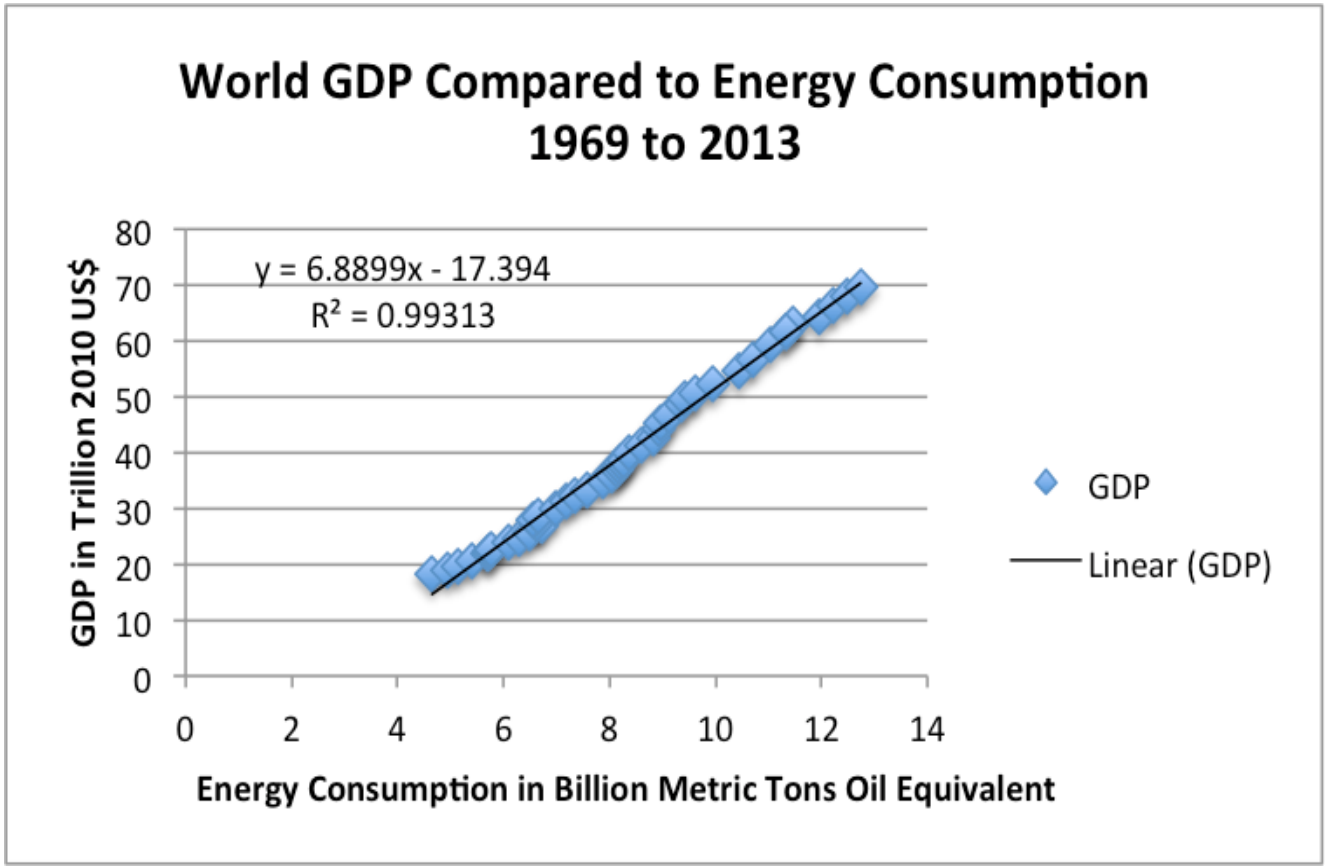


China is the main driver of increasing energy demand in the current decade, but India takes over in the 2020s as the principal source of growth

IEA 2°C Scenario

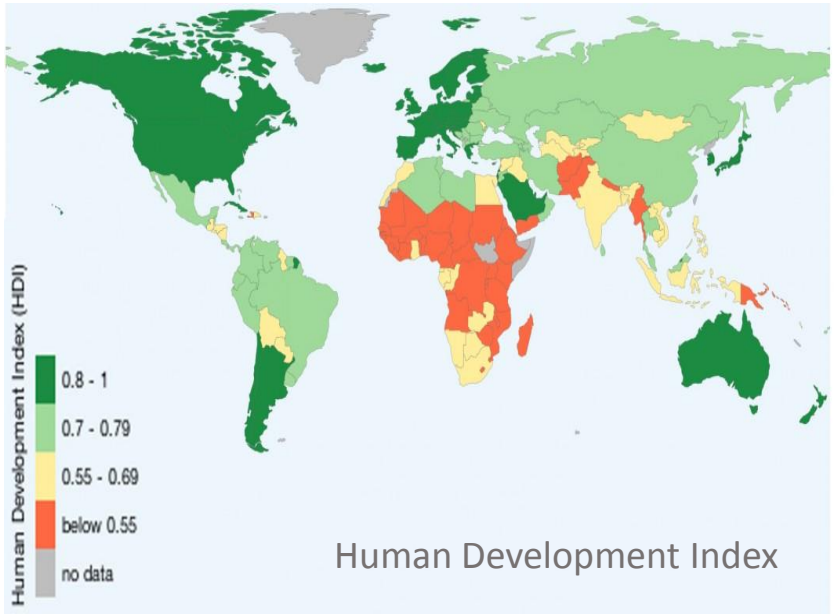


Source: IEA, Energy Technology Perspectives 2014

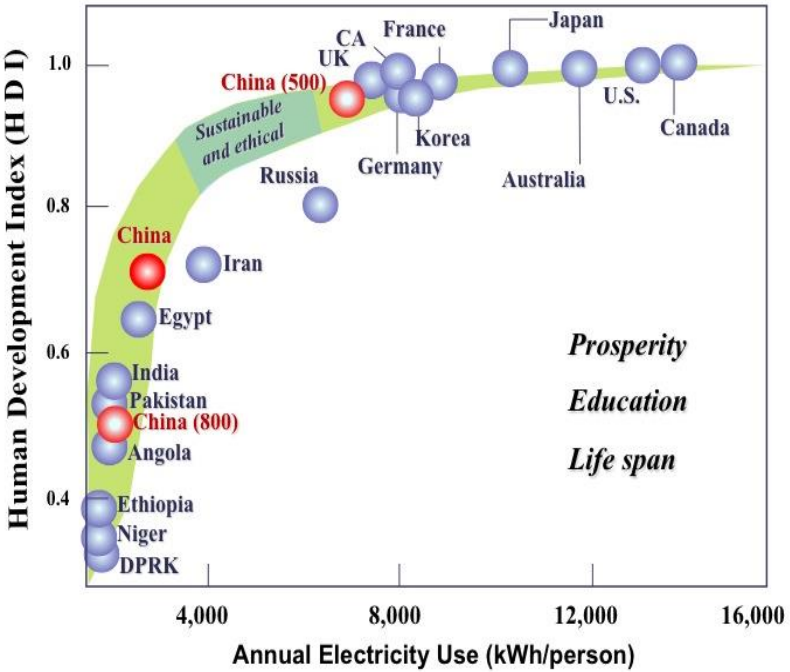

World GDP Compared to Energy Consumption
1969 to 2013
y = 6.8899x - 17.394
R² = 0.99313
GDP in Trillion 2010 US$
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
Energy Consumption in Billion Metric Tons Oil Equivalent
GDP
Linear (GDP)

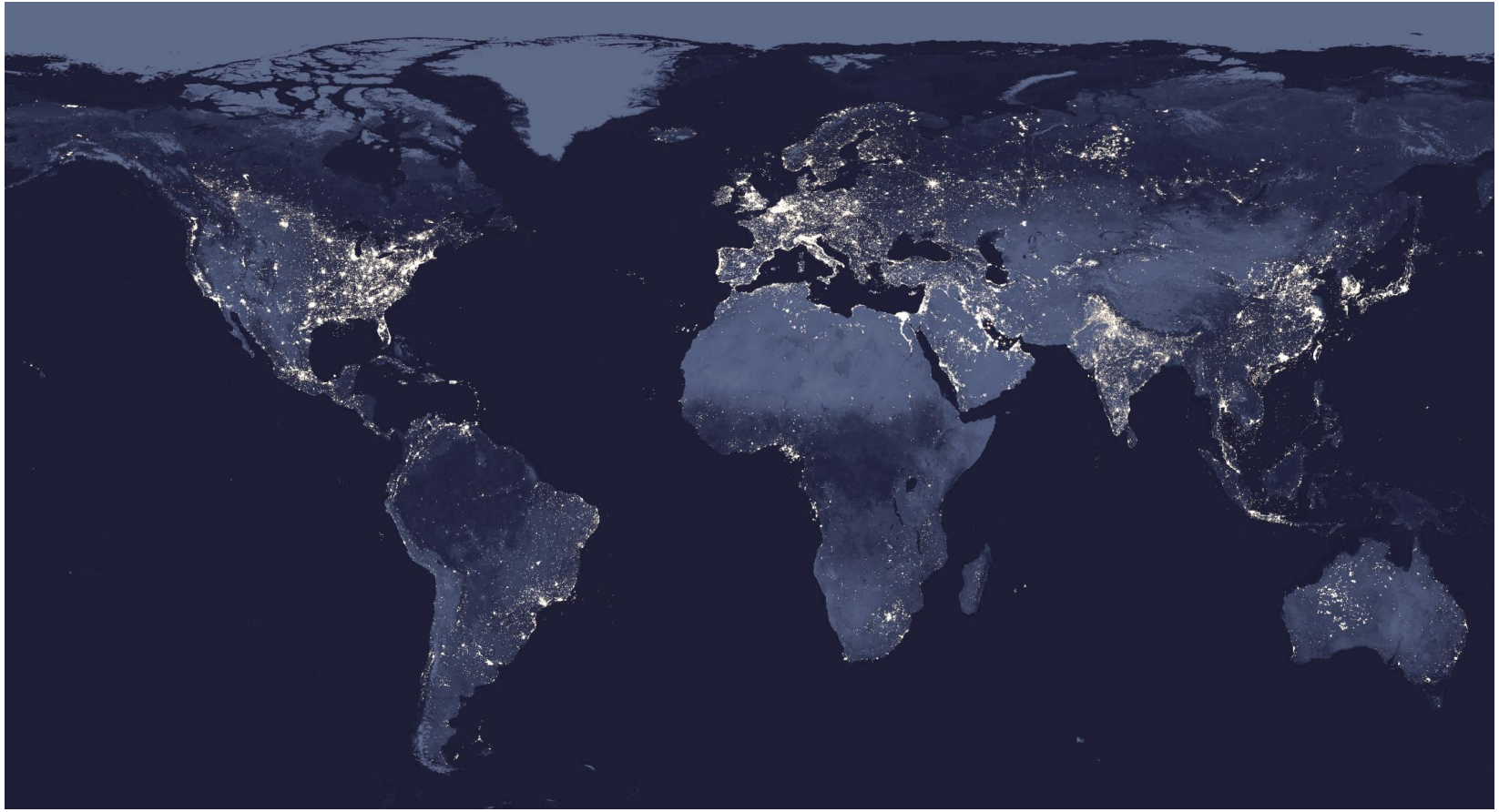
Quality of Life Index

80% of the world's population is below 0.8

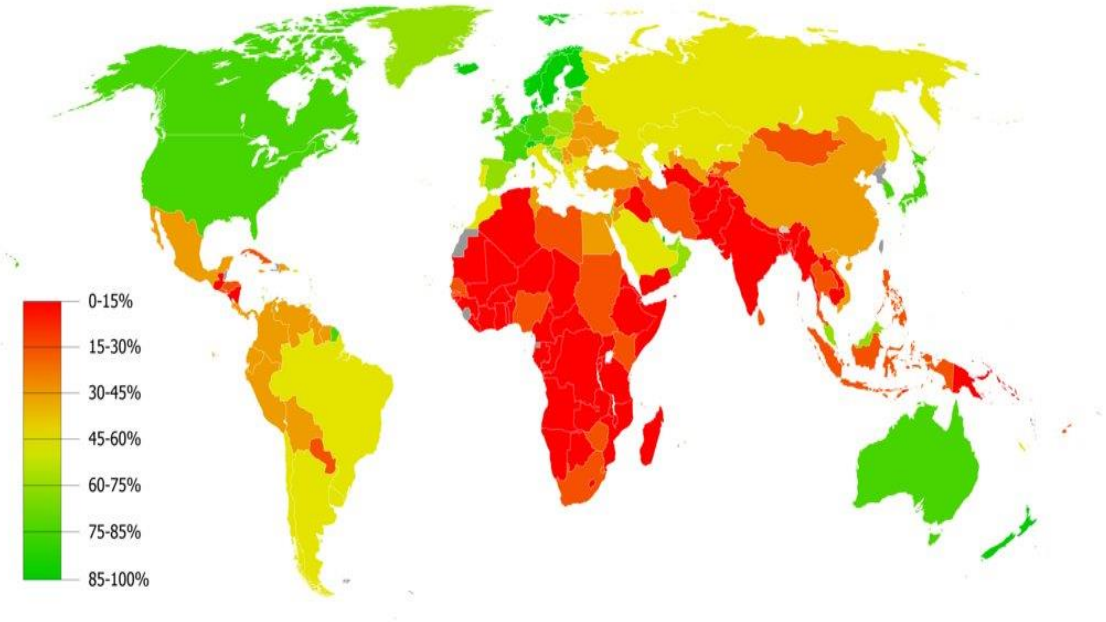


Human Development Index





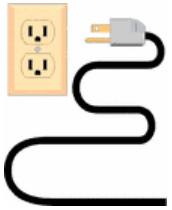
Internet Connectivity



Electricity:

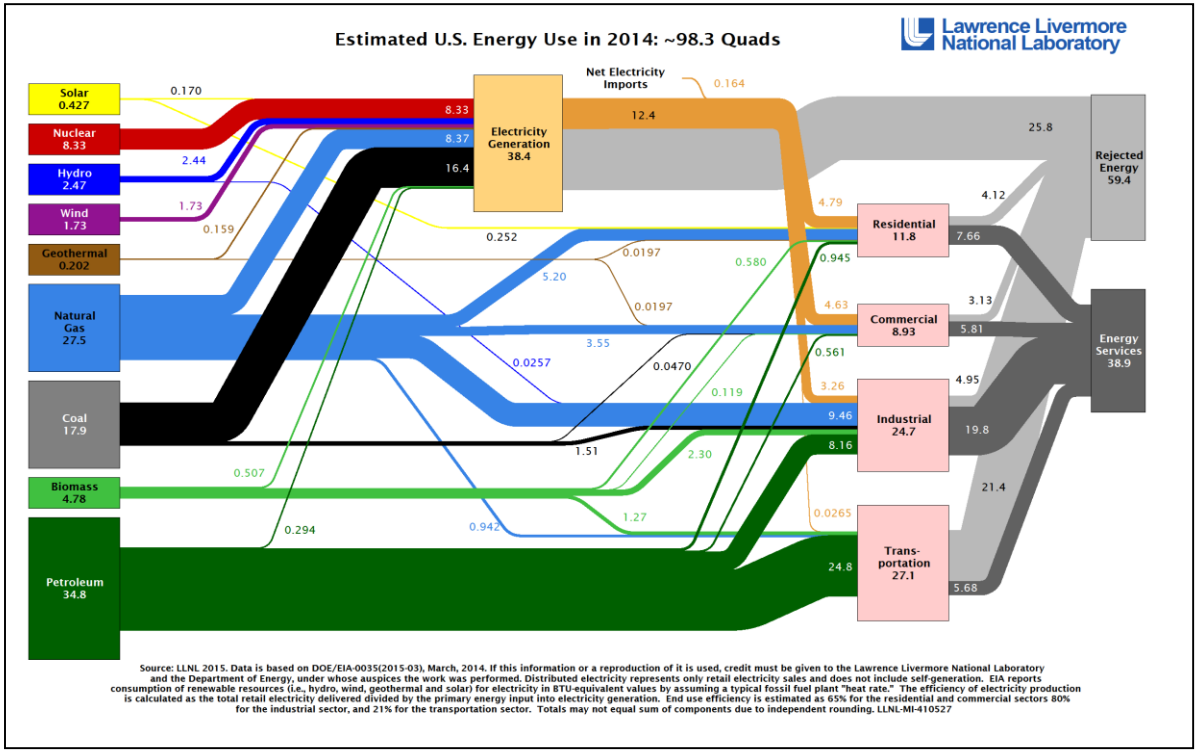
We all want it, but ….

… it doesn't just come out of the wall !!!

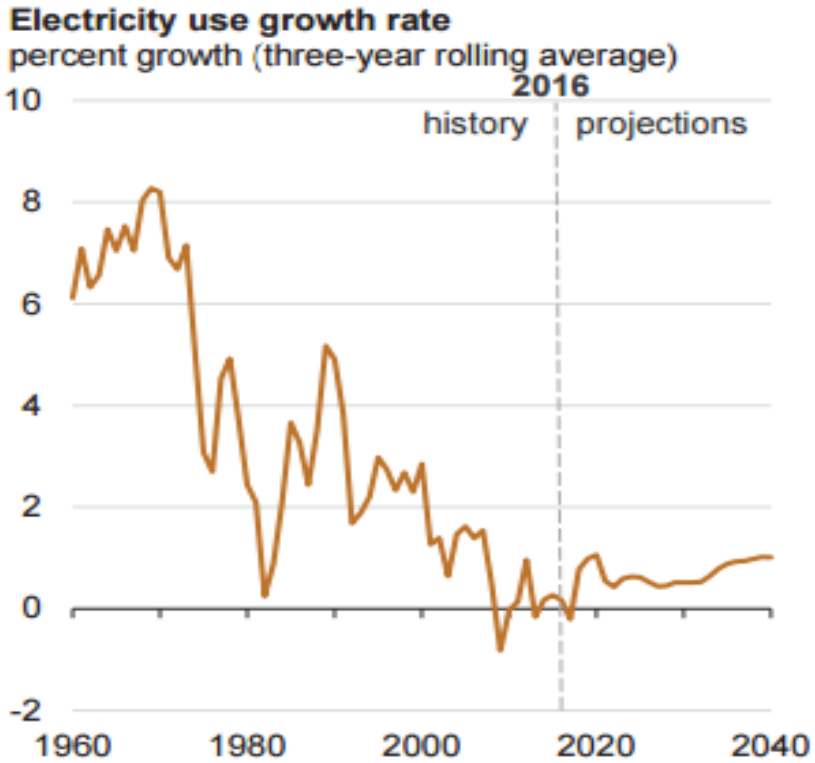


We need to make it !

Energy Utilization by Source



US Electricity Demand Growth



Source: EIA Annual Energy Outlook 2016

Energy Attributes (beyond technology)

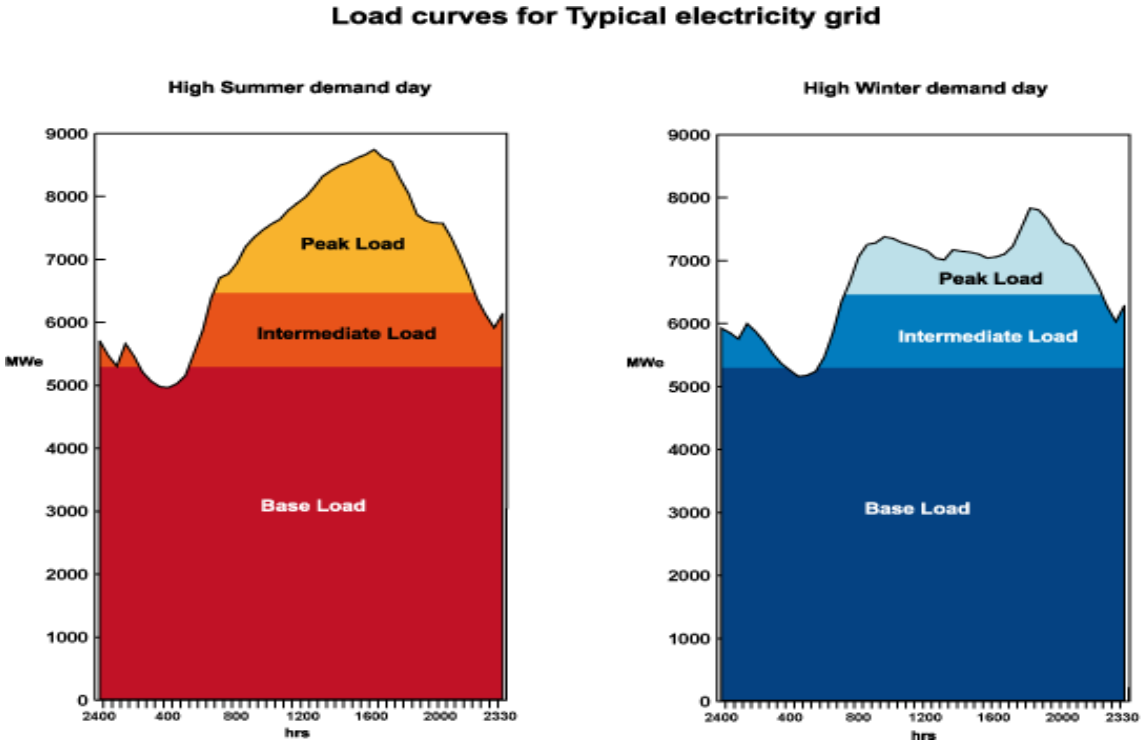
- Technologically capable
- Safe
- Reliable
- Economic
- Environmental friendly
- Politically Acceptable
- Jobs
- …..

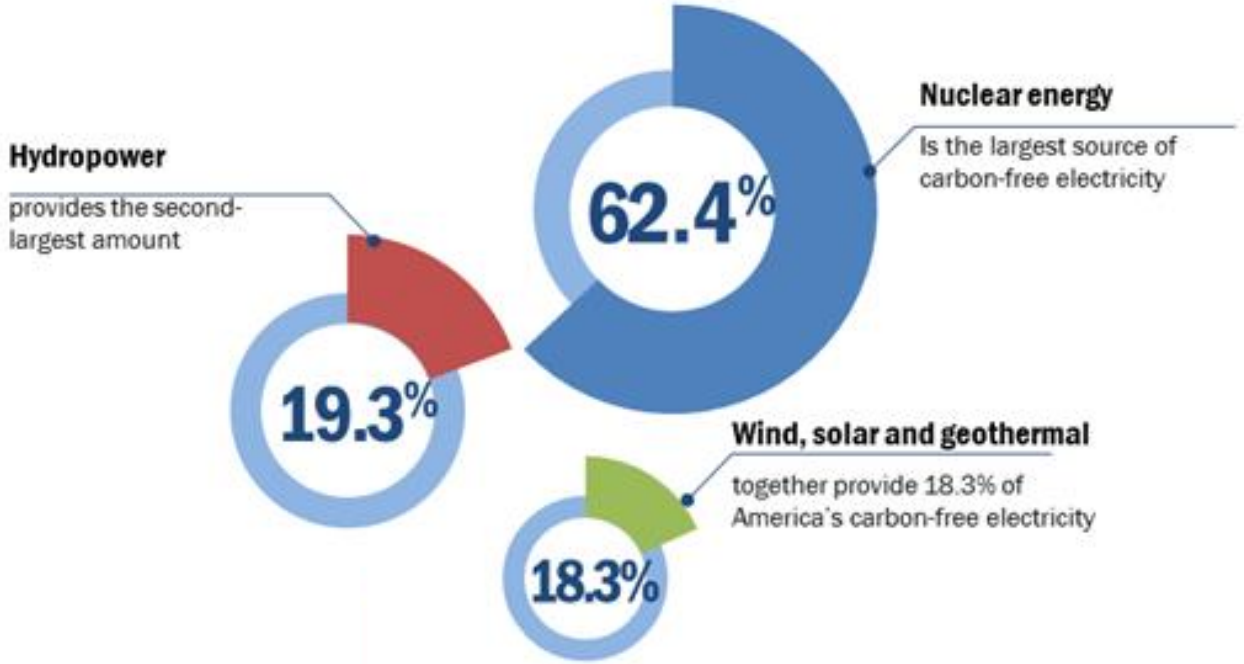
Technology Evaluation Methodology: Systemic Comparison of the Options*

Technology	Reliability	Safety	Environment	Economic	Public Policy
Coal					
Gas					
Hydro					
Nuclear					
Solar					
Wind					
*****					

* Ask the same (tough) questions about ALL the alternatives.

Reliable 24/7 Demand

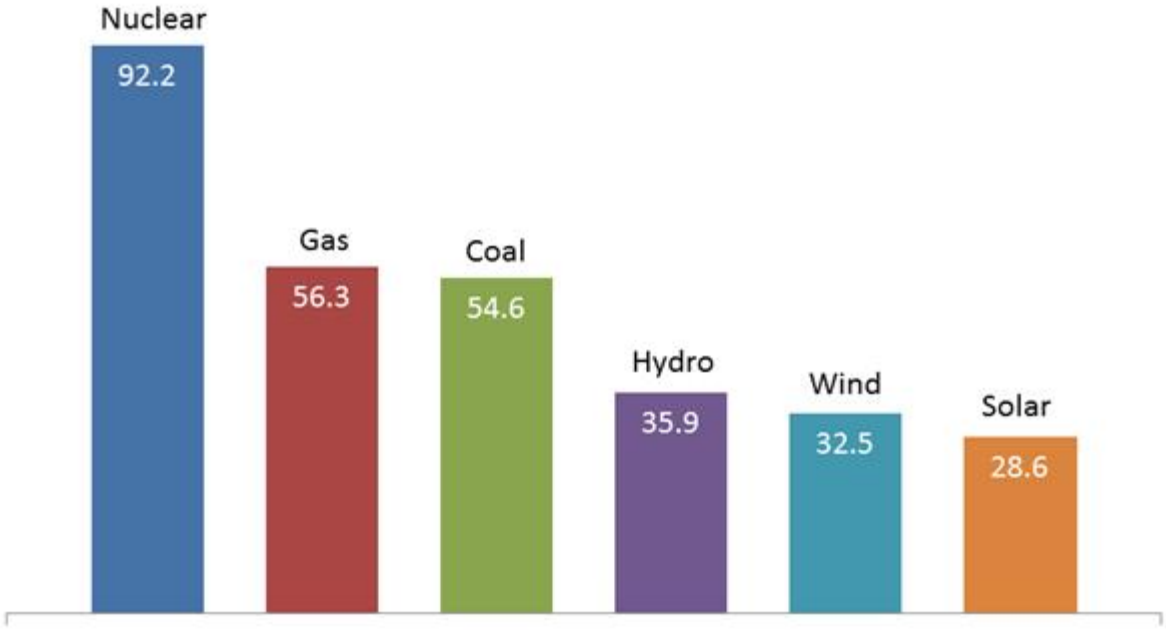


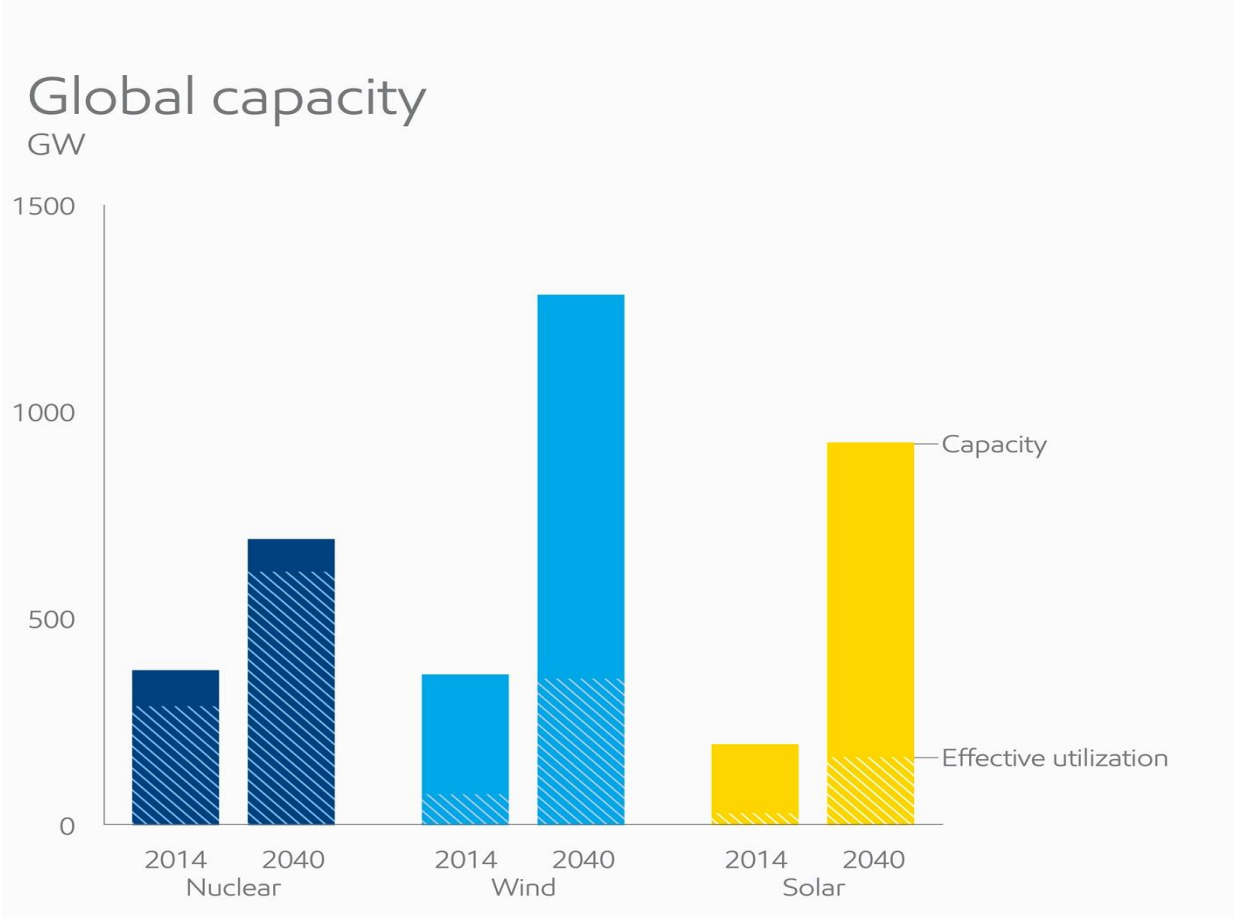


Carbon Free Sources of Electricity

Capacity Factor by Generating Source

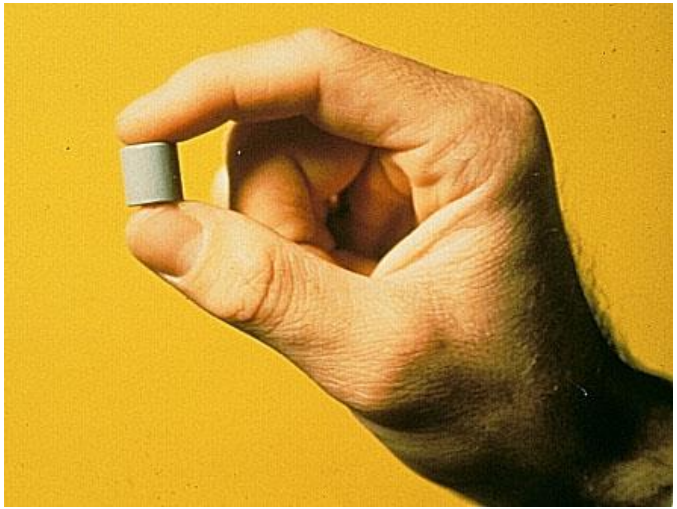
(percentage)





Source: Exxon Outlook for Energy 2016

Energy density



2.5 ounces of Uranium = 1 Ton of Coal
= 4 barrels of Oil
= 17,000 ft^3 Gas

Security

Safety

Energy Source	Deaths per TWh
Coal (world avg)	161
Coal (China)	278
Coal (USA)	15
Oil	36 (36% of world energy)
Natural Gas	4 (21% of world energy)
Biofuel/Biomass	12
Hydro	1.4
Solar (rooftop)	0.44 (0.2% of world energy for all solar)
Wind	0.14 (1.6% of world energy)
Nuclear	0.04 (5.9% of world energy)

Sources: World Averages from The World Health Organization and European national averages from EU ExternE

No technology is perfect!

Technology	Reliability	Safety	Environment	Economic	Public Policy
Coal	↑	↓	↓	↔	↓
Gas	↑	↓	↑	↑	↔
Nuclear	↑	↑	↑	↔	↓
Wind	↓	↑	↔	↓	↑
Solar	↓	↑	↔	↓	↑
Hydro	↑	↔	↓	↔	↓

* Ask the same tough questions about ALL the alternatives.

Conclusion

“By 2035, 80 percent of America’s electricity will come from clean energy sources.

Some folks want wind and solar. Others want nuclear, clean coal and natural gas.

To meet this goal we will need them all.”

2011 State of the Union Address