Visualizing Future Exergy Flows for the U.S. & World

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Geothermal Energy Utilization Associated with Oil and Gas Development

SMU

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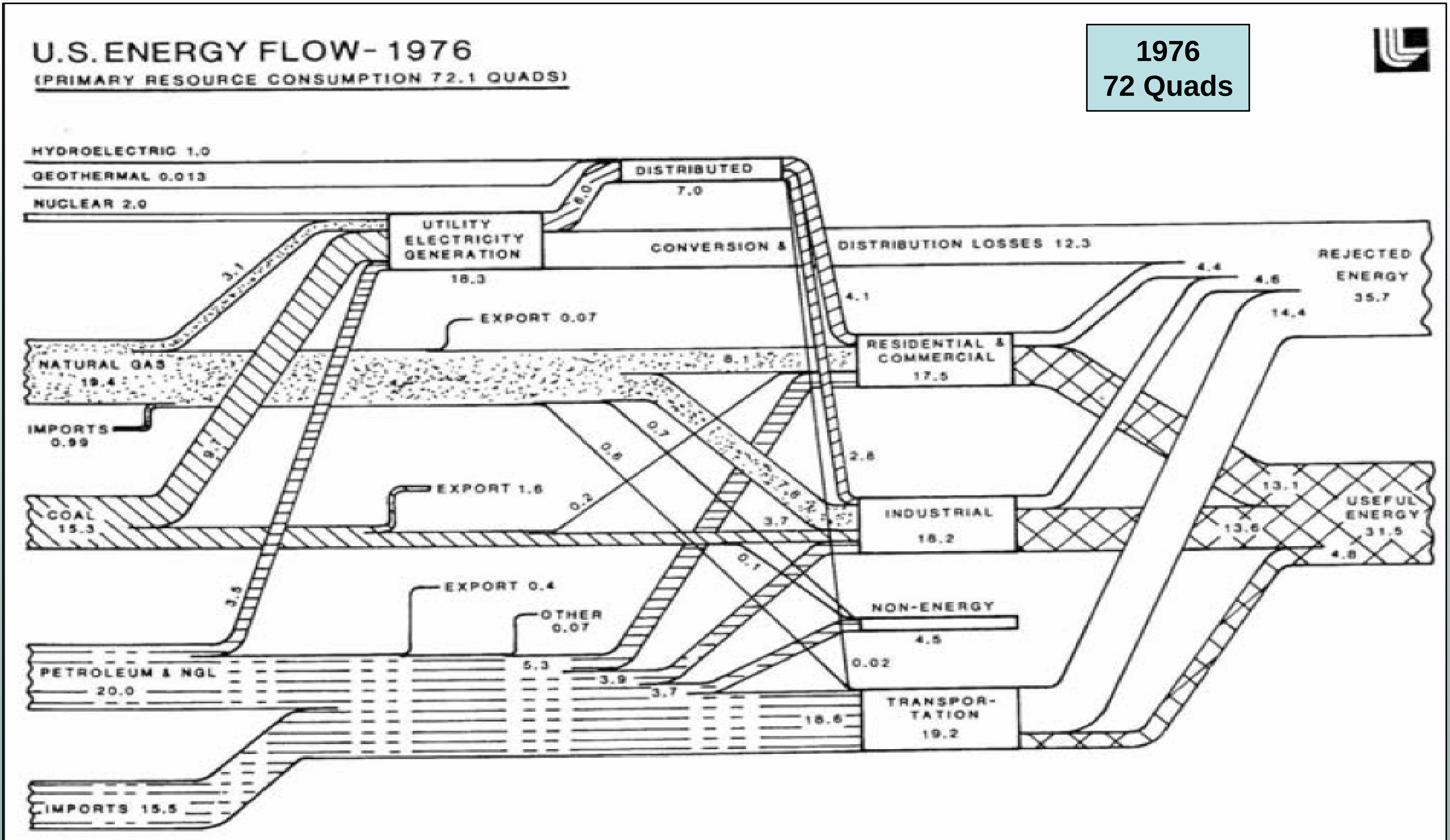
Energy versus exergy
Quick Overview

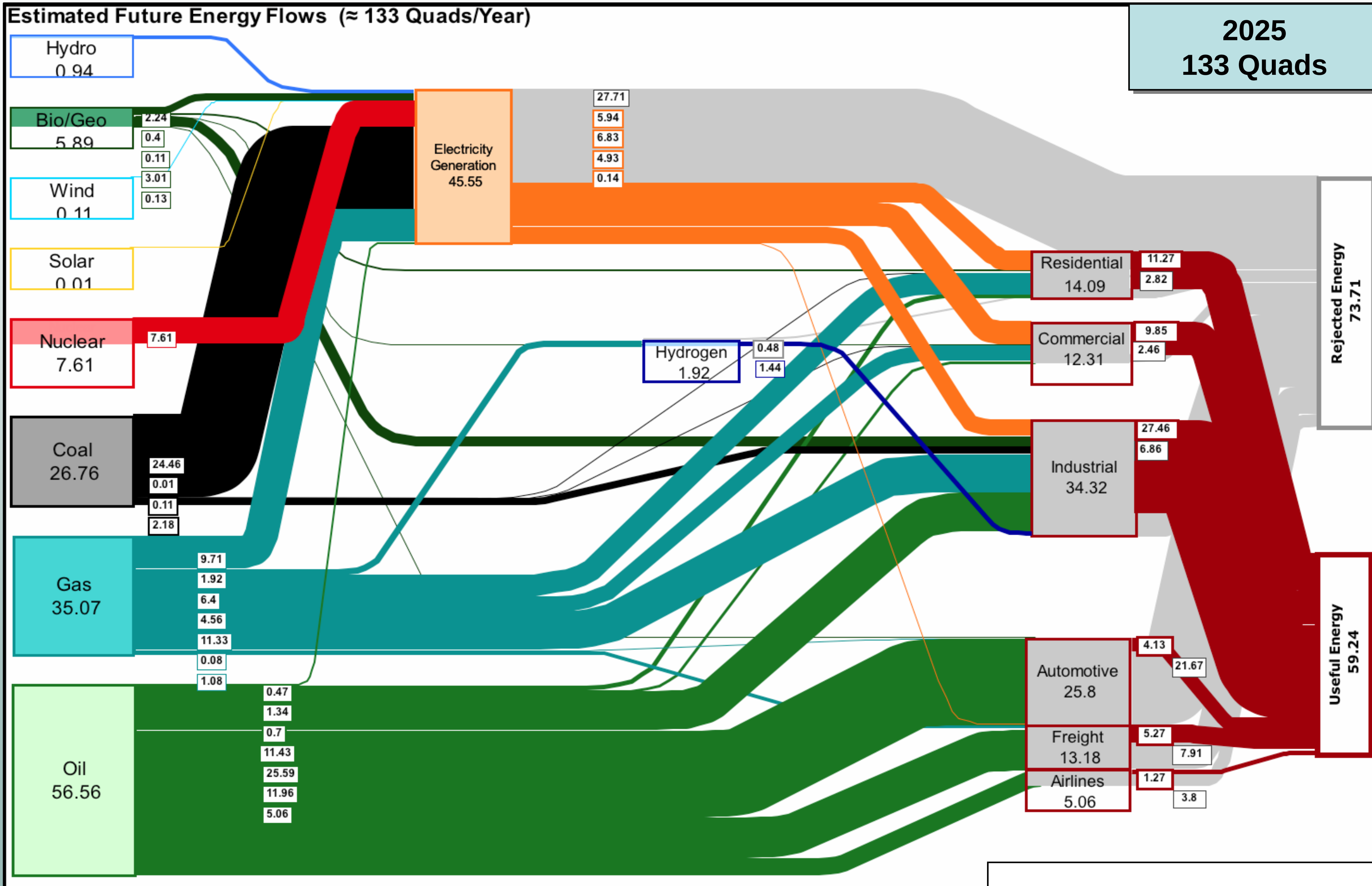
- While energy is conserved its exergy content can be destroyed when the energy is converted
- What is exergy?
  - The useful portion of energy that allows us to do work and perform energy services
  - Includes the quality of energy a substance contains in addition to the quantity
  - providing deeper insight into work potential than analyses which only utilize the first law
- We gather exergy in energy-carrying substances called resources
- These resources are converted into forms of energy called carriers
- www.exergy.org

Exergy term first coined by Zoran Rant in 1956

Flowcharts offer comprehensive snapshots linking source, conversion, and end-use



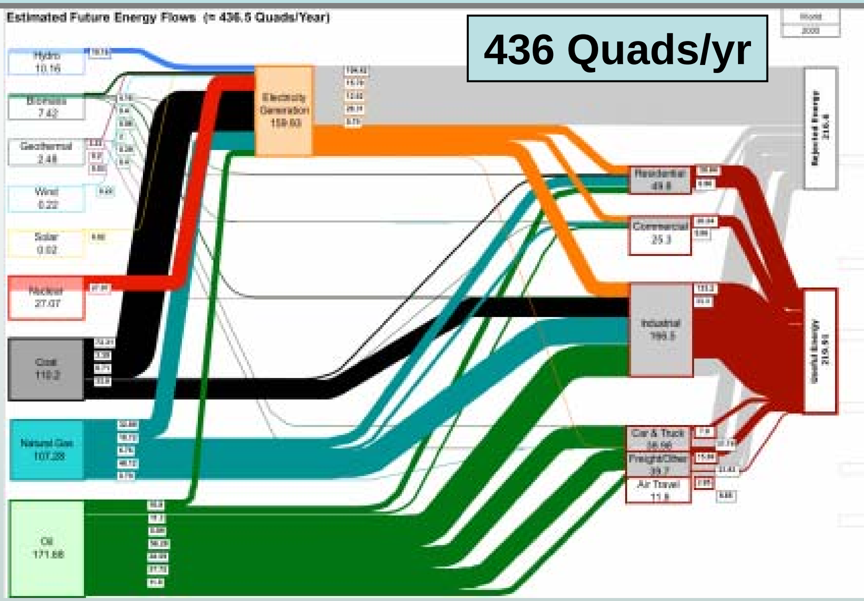
Flowcharts offer comprehensive snapshots linking source, conversion, and end-use

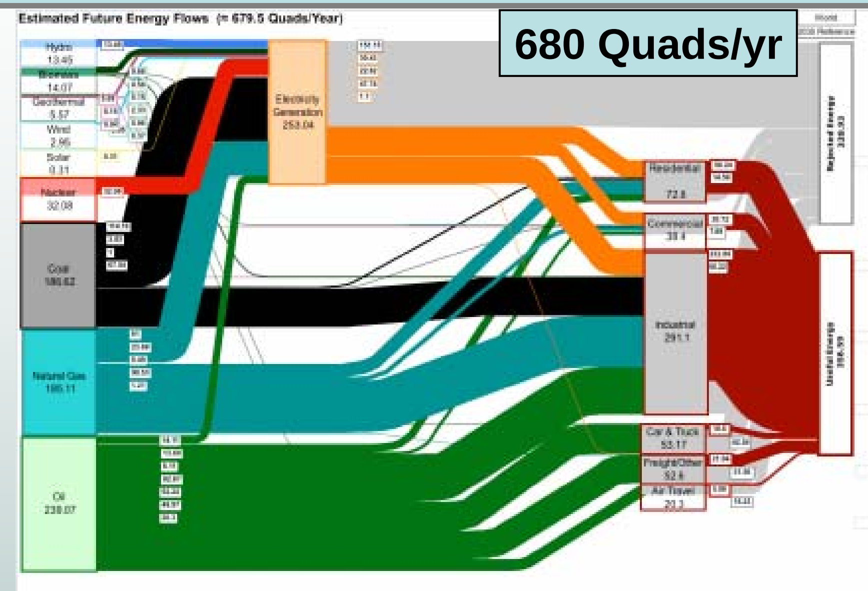


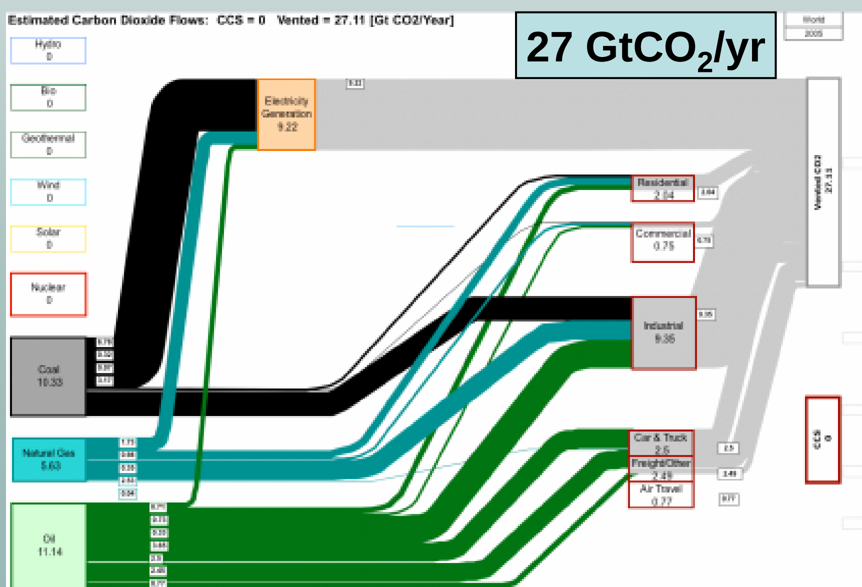
World Energy flows & CO_2 emissions

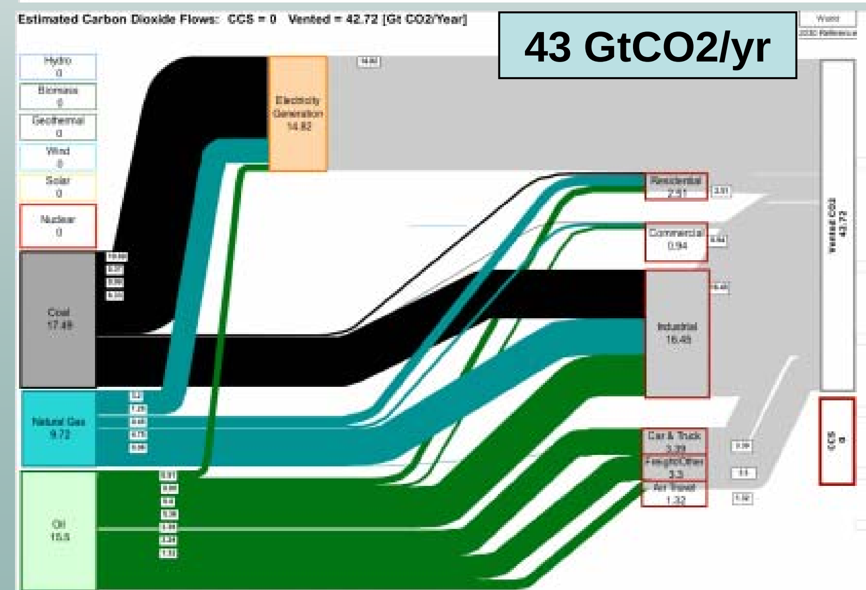
2005 ***(IEO 2006)***

2030 Reference Case ***(IEO 2006)***



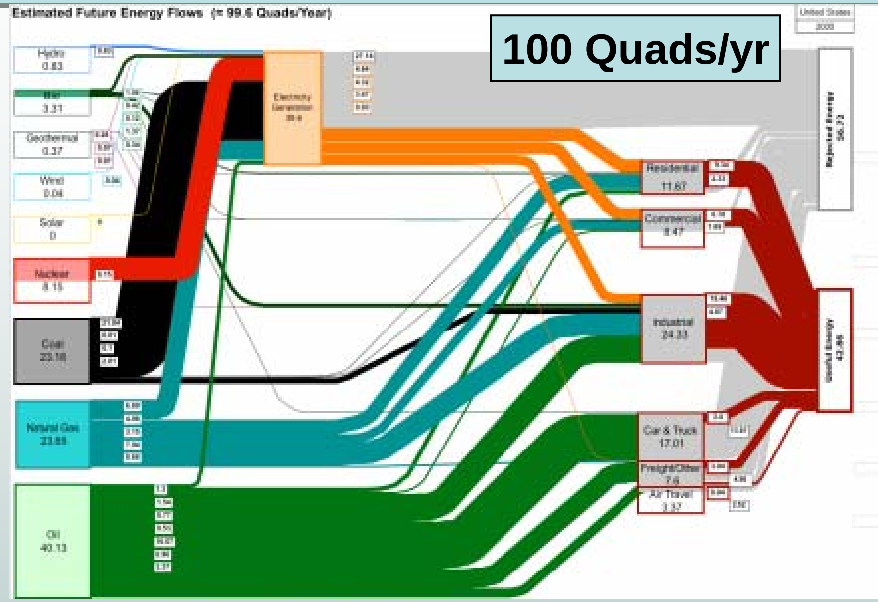


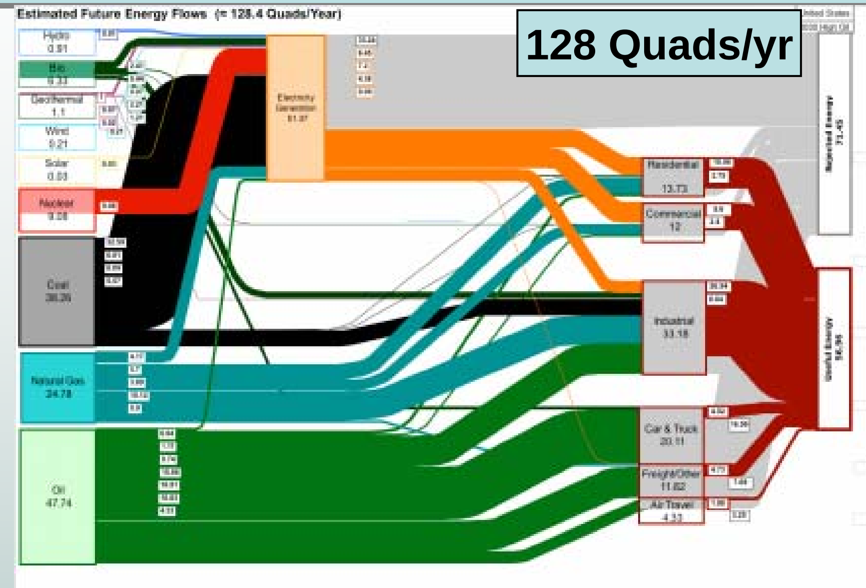


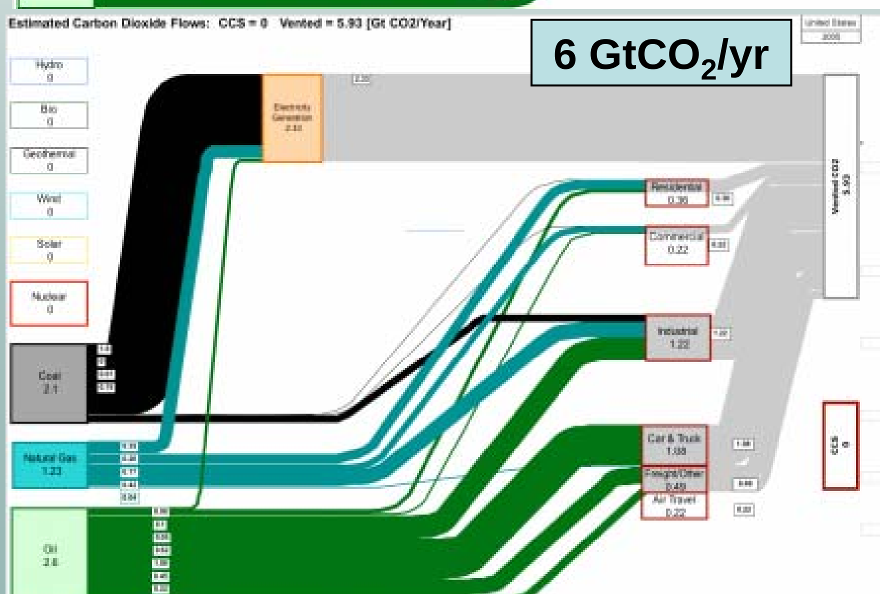


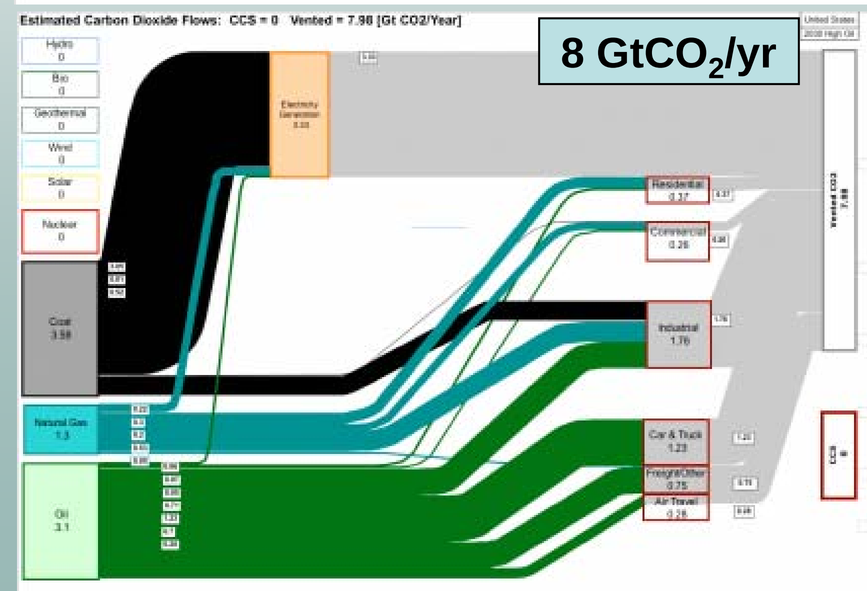
United States CO_2 & Energy Flows

***2005** (AER 2006)* — ***2030 High Oil Case** (AEO 2006)*

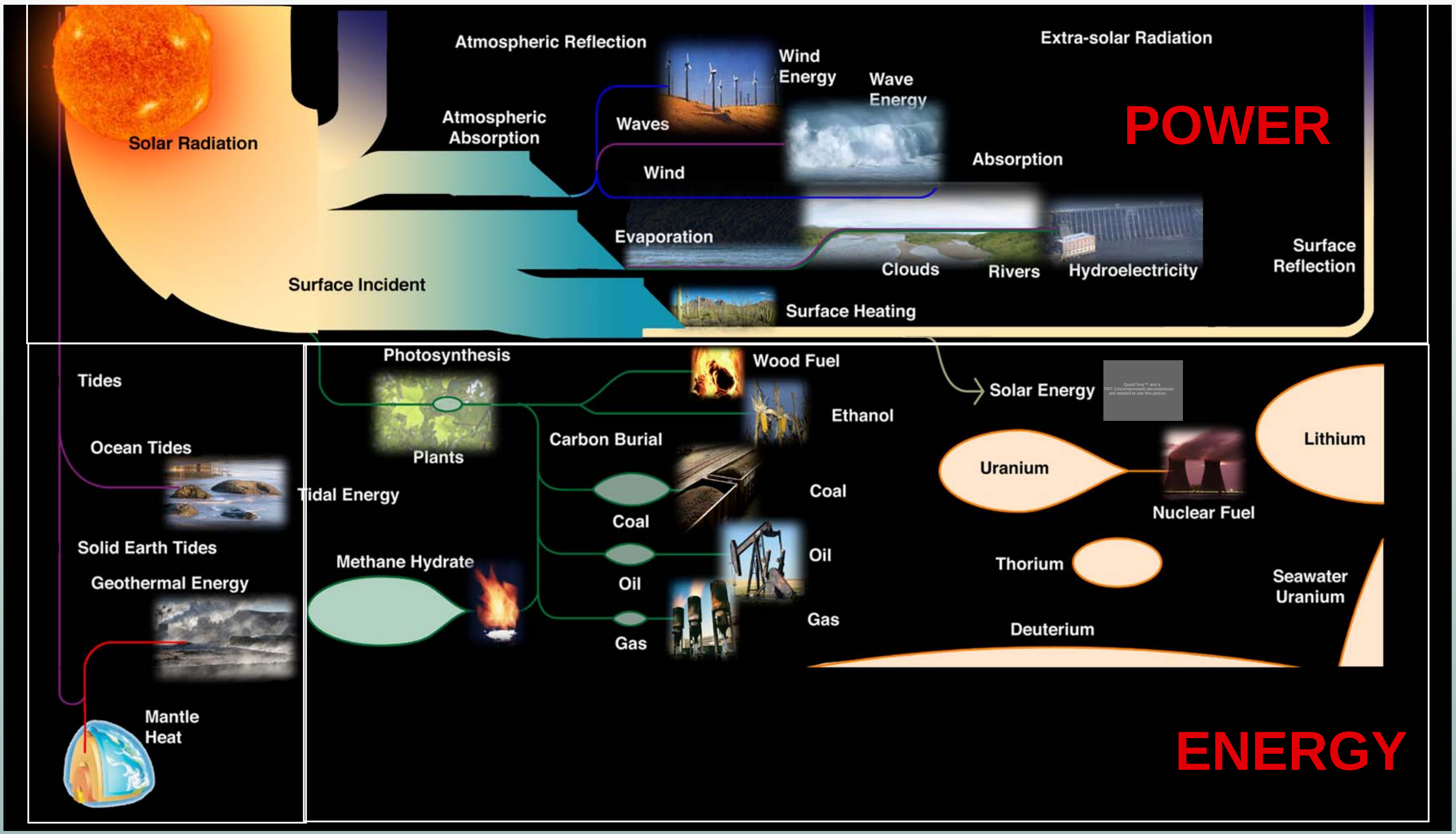








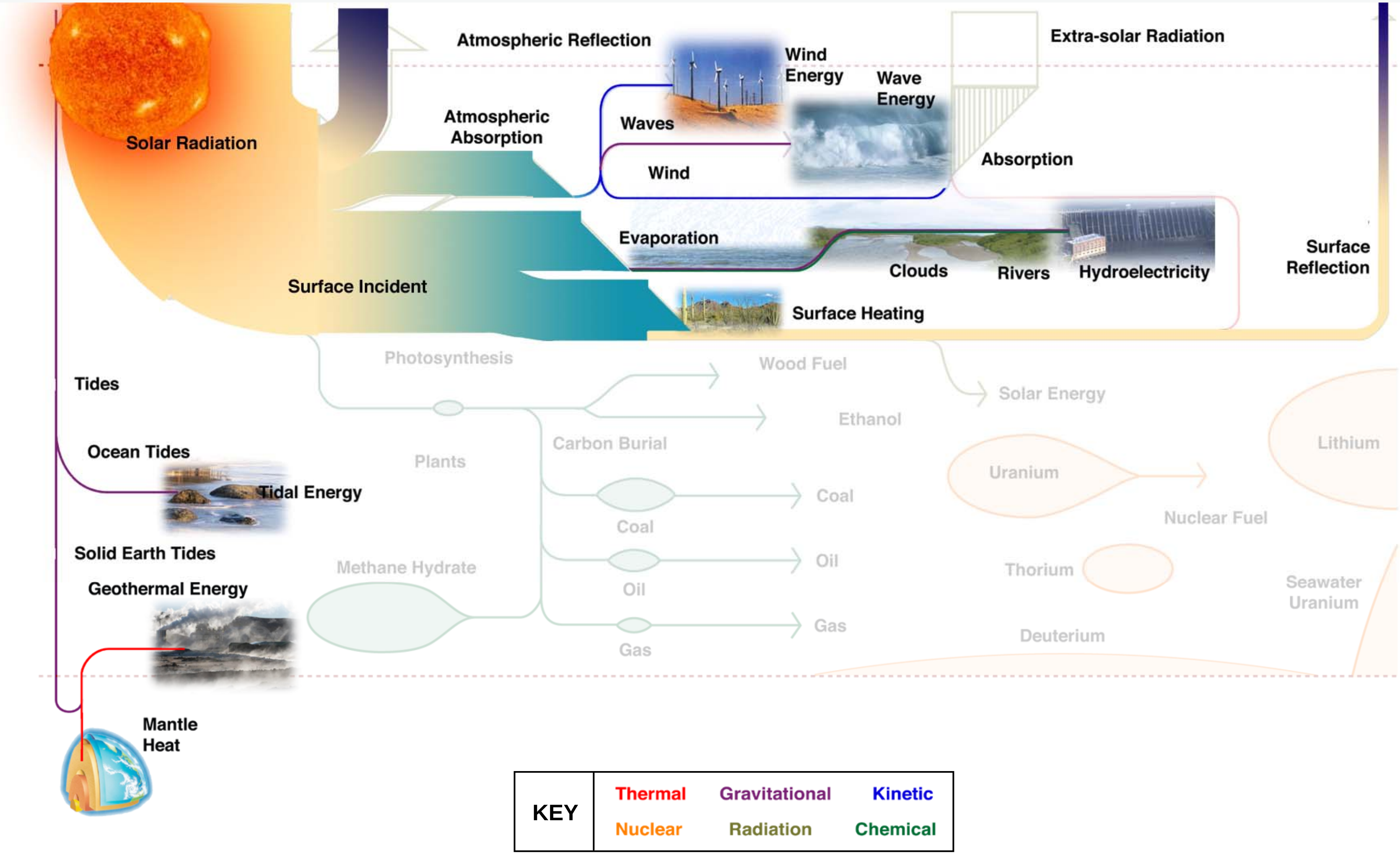
All of our exergy sources—power in TW and exergy in ZJ are drawn to scale



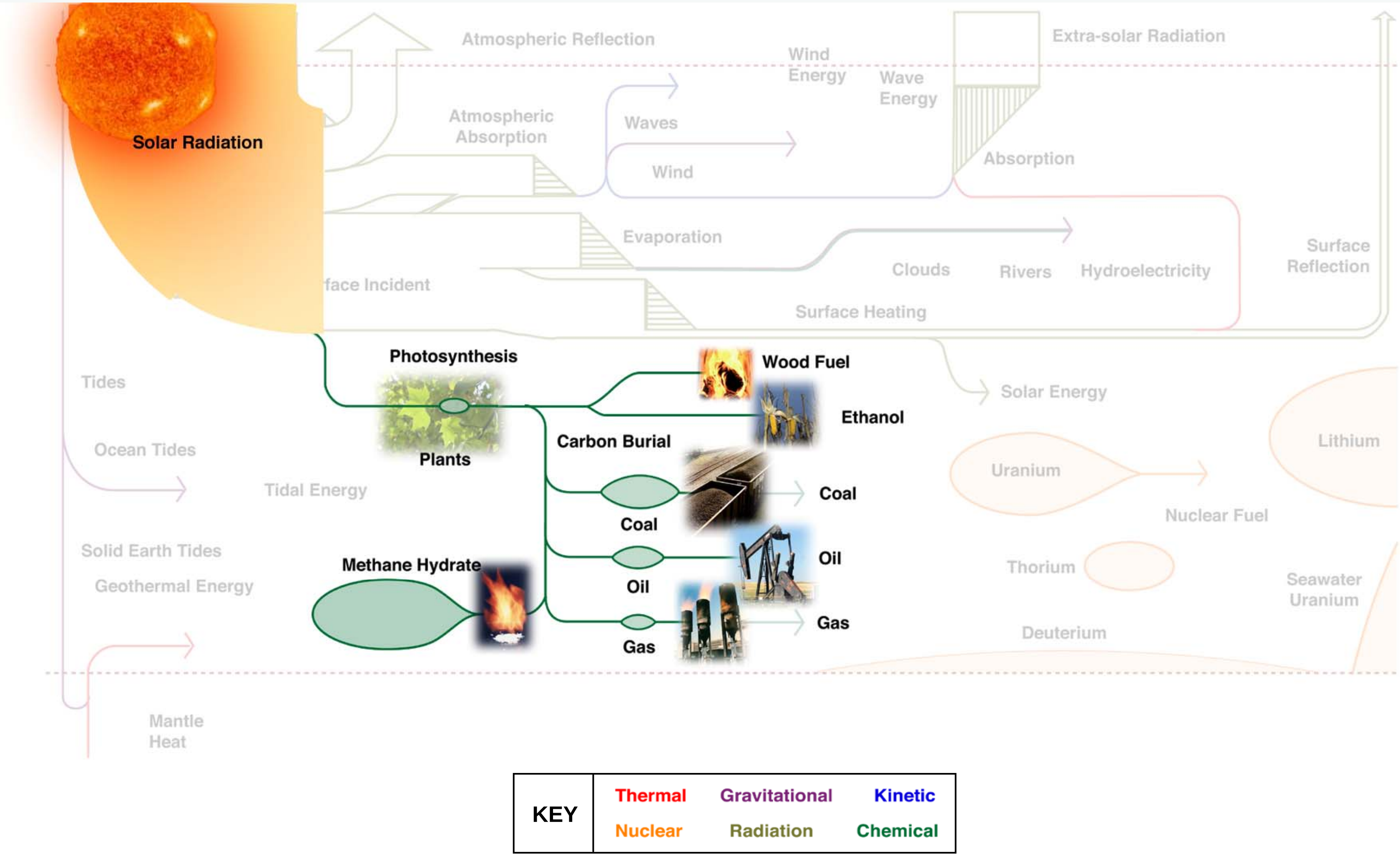
From Wes Hermann, GCEP, 2005

World uses about 15 TW today; solar radiation is 162,000

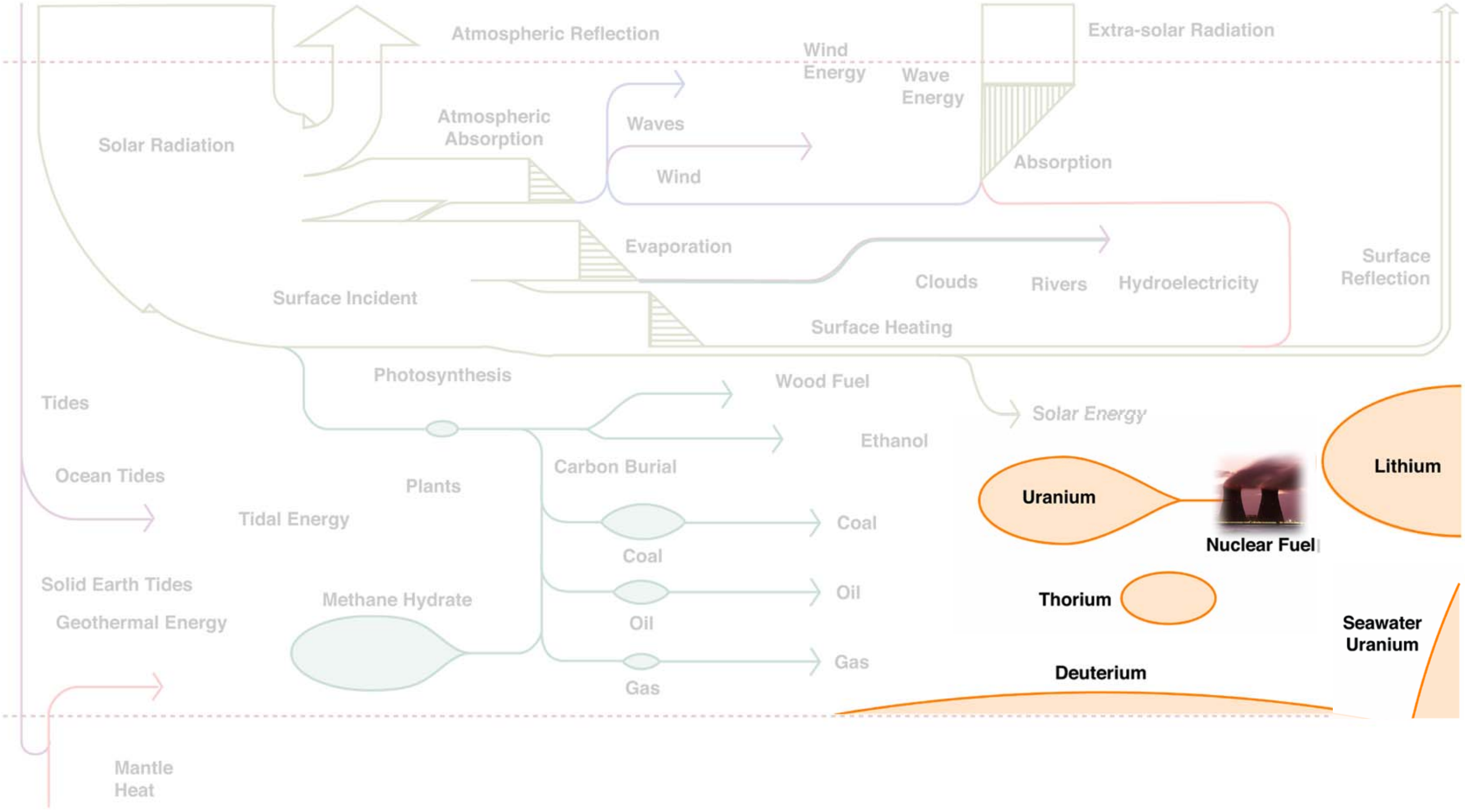
The sun powers all our renewable exergy

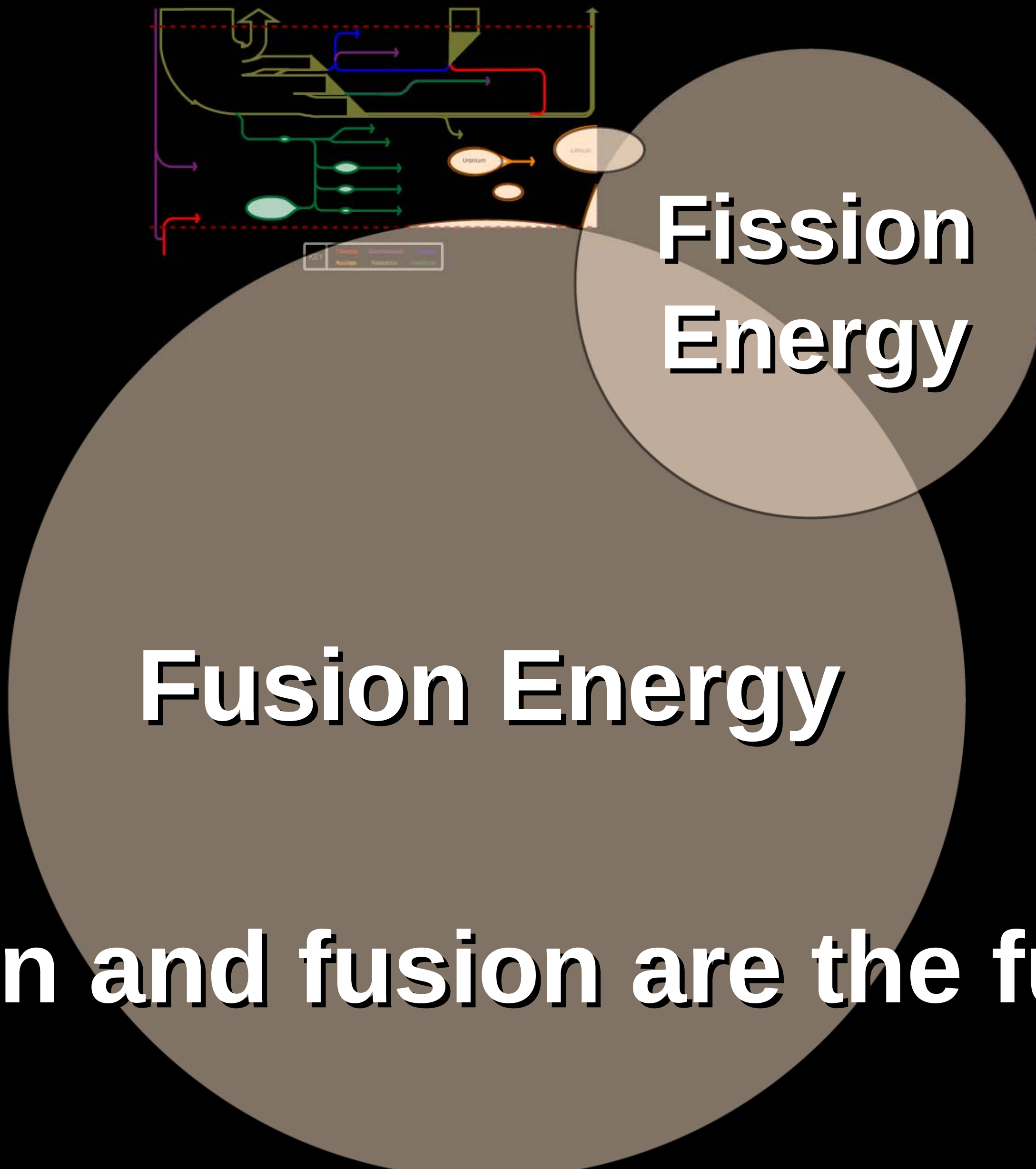


Fossil fuels are derived from the sun and are finite



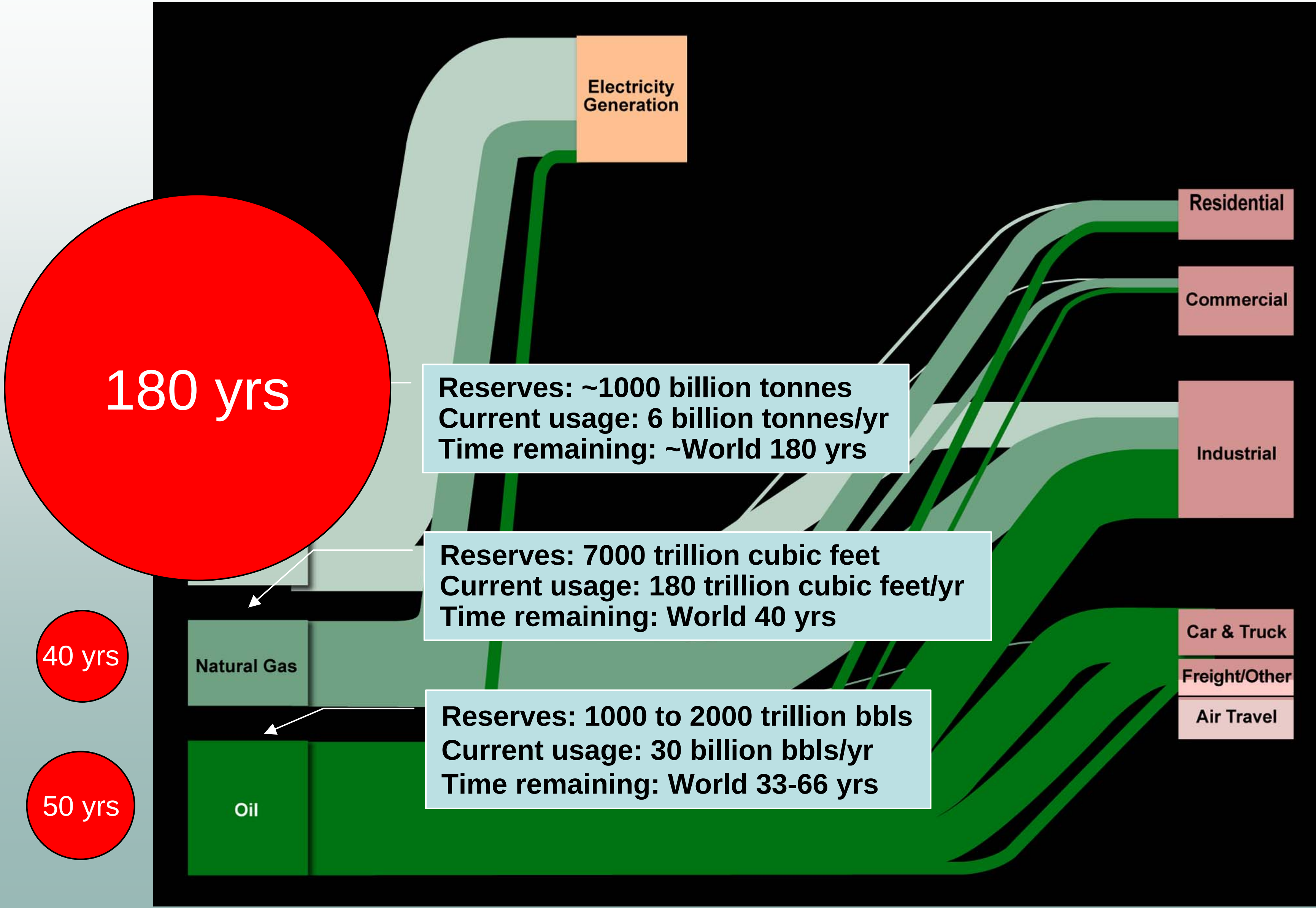
Nuclear fuels could last a thousands of years



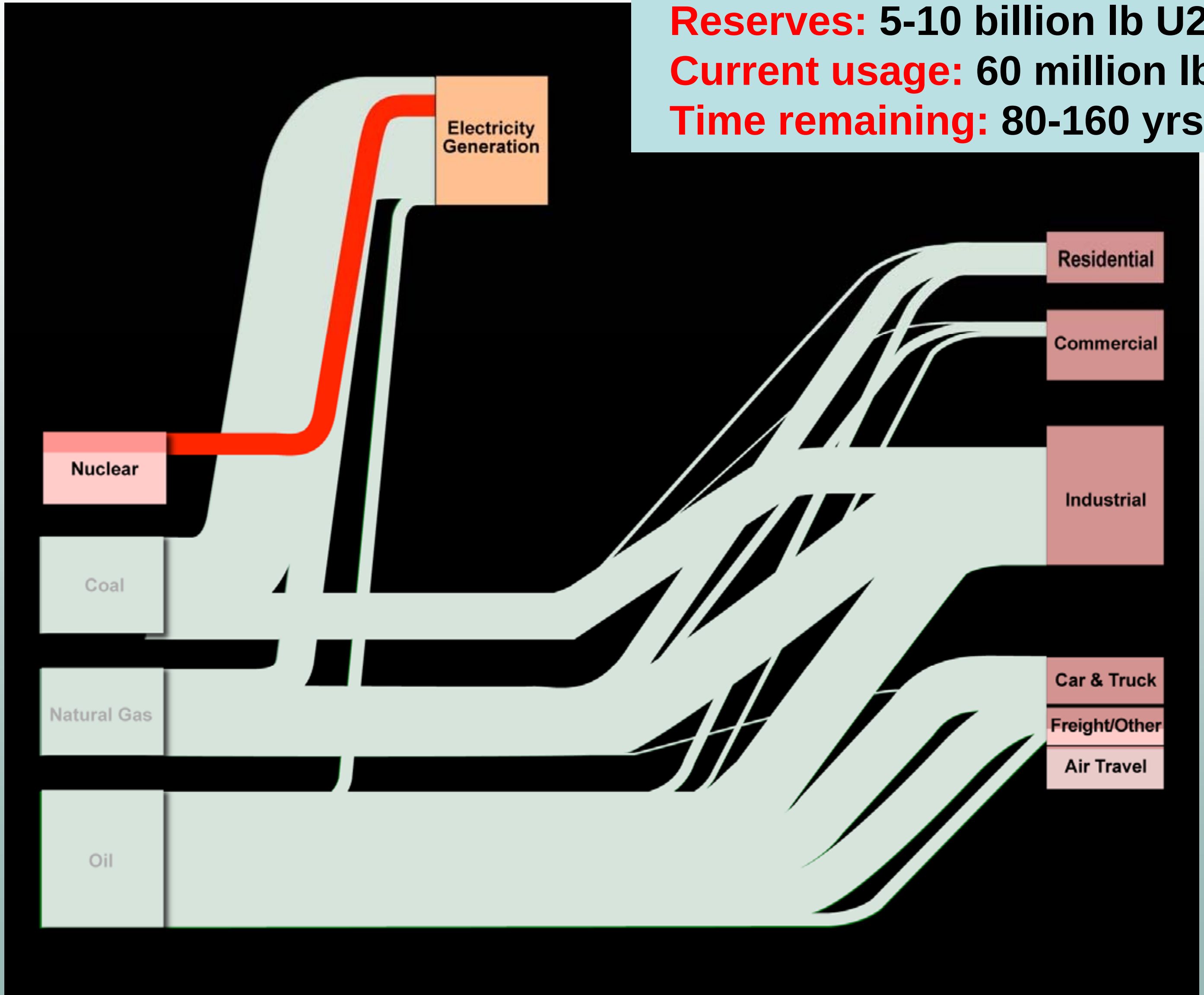


Fission and fusion are the future!

Oil is for transportation, coal for electricity, natural gas has multiple uses

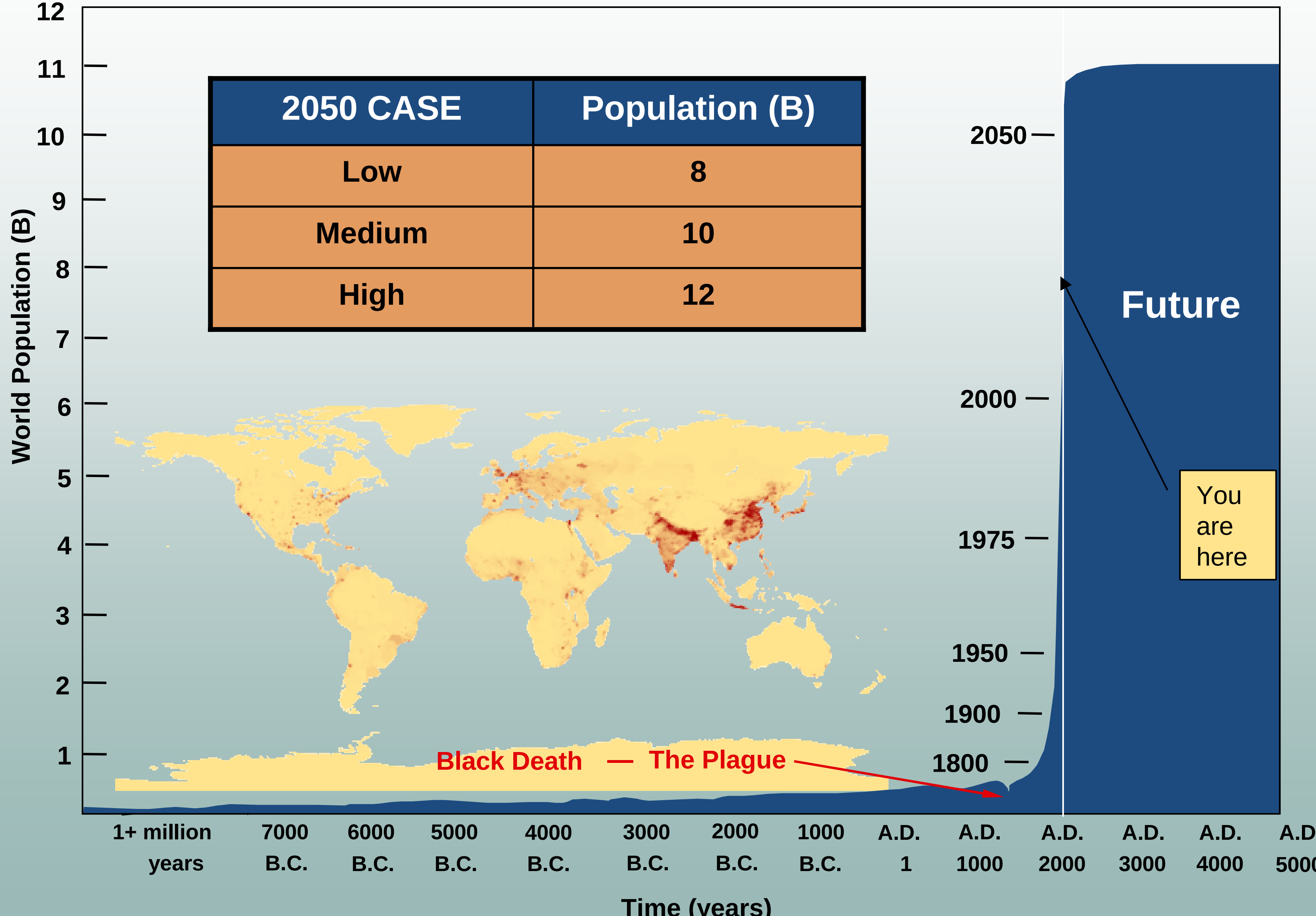


Nuclear fission is today's most utilized non-fossil exergy source



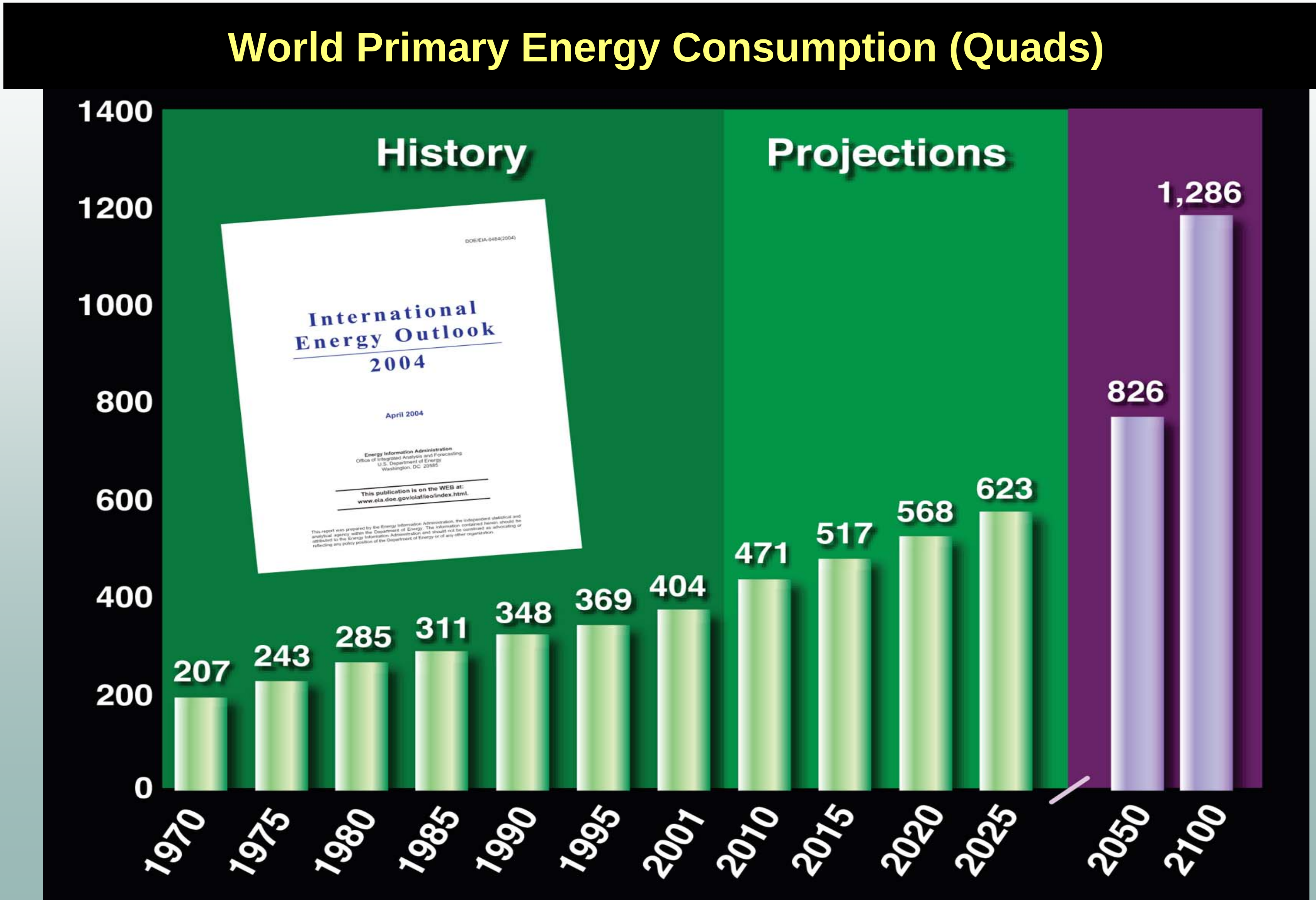
Reserves: 5-10 billion lb U238 (U.S.)
Current usage: 60 million lb/yr (U.S.)
Time remaining: 80-160 yrs (U.S.)

Future world energy needs are dependent on population growth

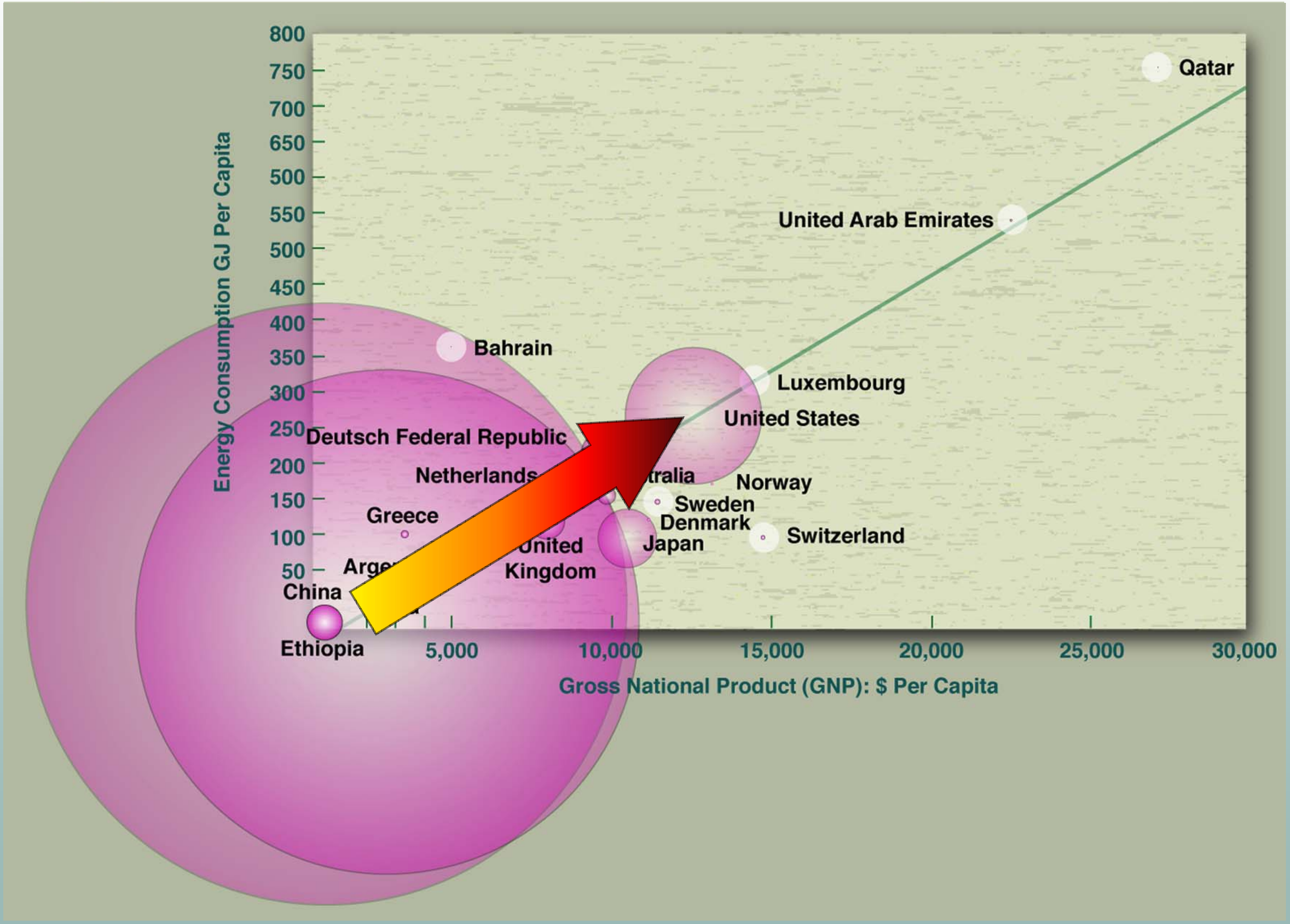


2050 CASE	Population (B)
Low	8
Medium	10
High	12

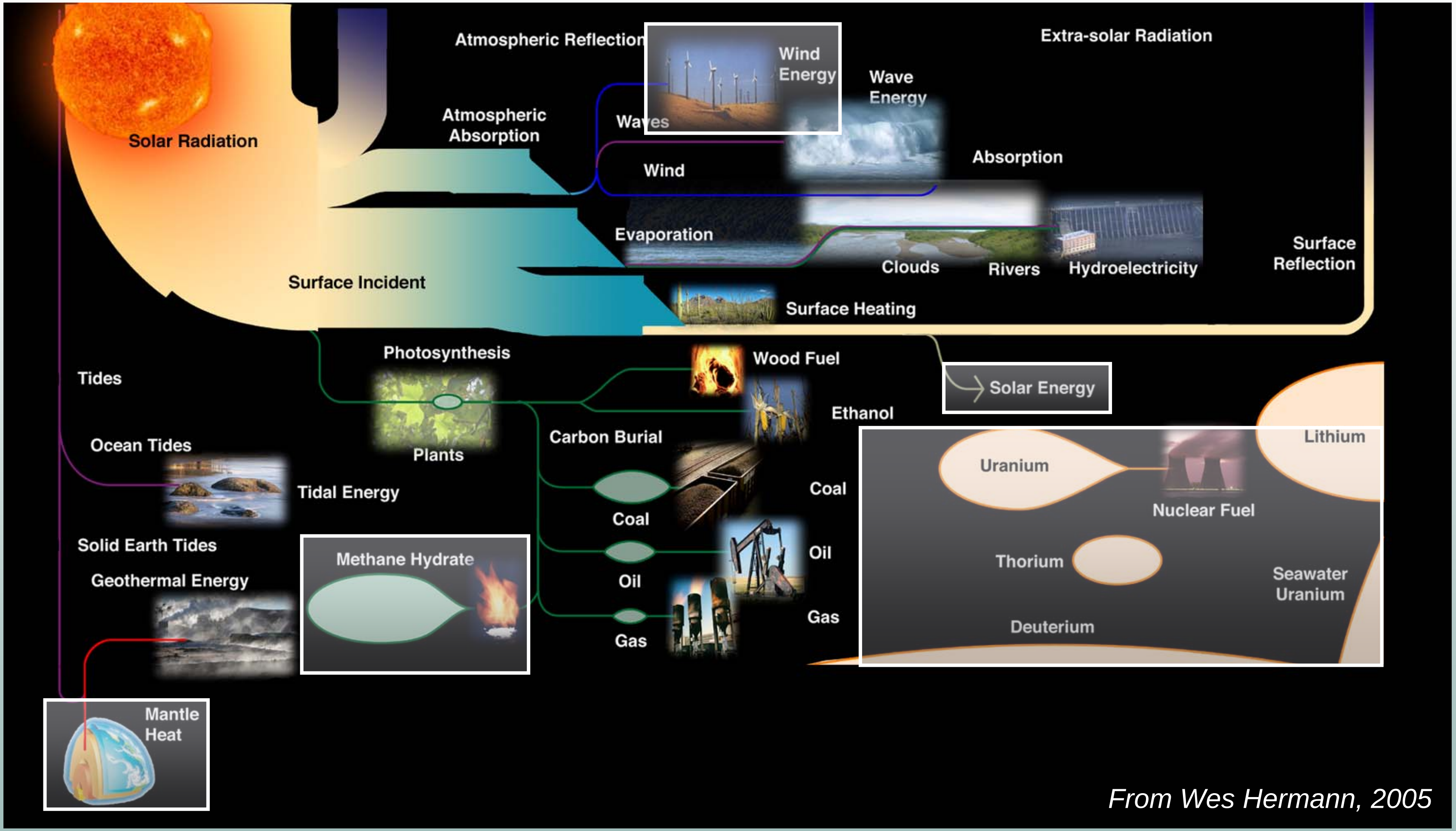
Future world energy needs are dependent on population growth



Real crisis: future world exergy needs are strongly dependent on standard of living



What can we do?



Three ways to go: 1) more fossil fuels, 2) massive renewables, and 3) more nuclear exergy technologies

Conclusions

- Rapid electrification will continue moving CO_2 emissions from buildings to power plants
- Coal will overtake oil as the largest source of CO_2 emissions
- Industry is projected to exceed all other CO_2 sources combined by 2030 (world as a whole not in the US)
- Deep CO_2 reductions will require **Herculean** contributions from <u>every</u> technology, even with moderate growth
- If we expect to achieve these reductions, CO_2 needs to peak by 2010 and get to 1990 levels by 2020

Conclusions

- **Energy and carbon flow charts were employed to investigate possible end-member 2050 U.S. carbonless energy system configurations naturally integrating particular future demand-driven, source, efficiency and technology scenarios. (*http://eed.llnl.gov/flow/*)**
- **Major energy efficiency improvements, carbon capture and storage, hydrogen-fueled vehicles/trains/trucks/planes, and implementing V2G with an aggressive renewables/hydrogen program are all needed to affect steep reductions in emissions by 2050—but it is not enough.**
- **Geothermal energy's role may make significant contributions in electrical generation displacing, say, nuclear energy or other renewables but can only directly reduce carbon emissions when employed to heat/cool residential, industrial and commercial buildings.**

Bottom line: besides competing with other renewables to de-carbonize the electrical system—massive application of passive geothermal by 2050 could provide a significant contribution to a carbonless energy system.