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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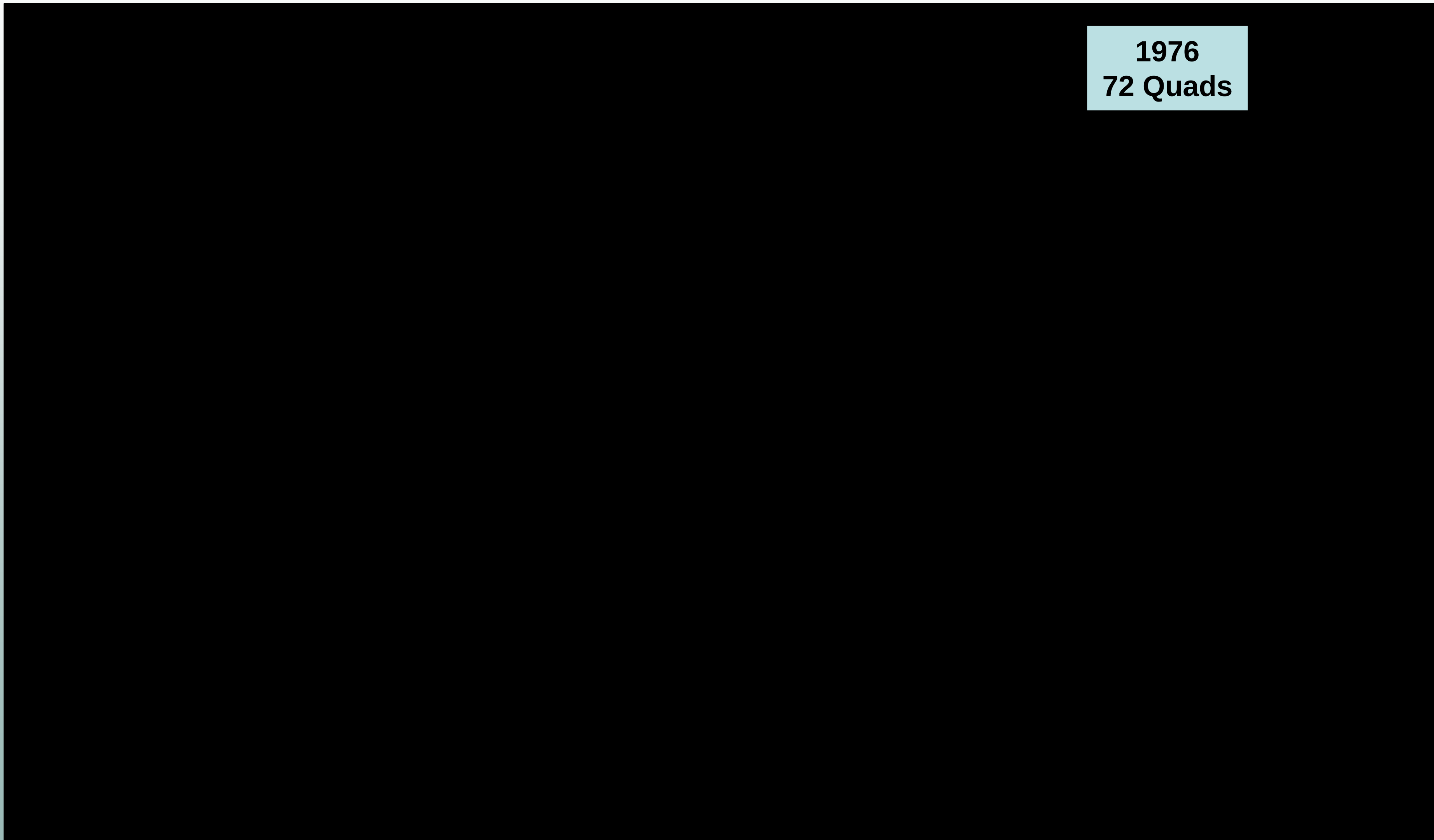
Energy versus exergy Quick Overview

- 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

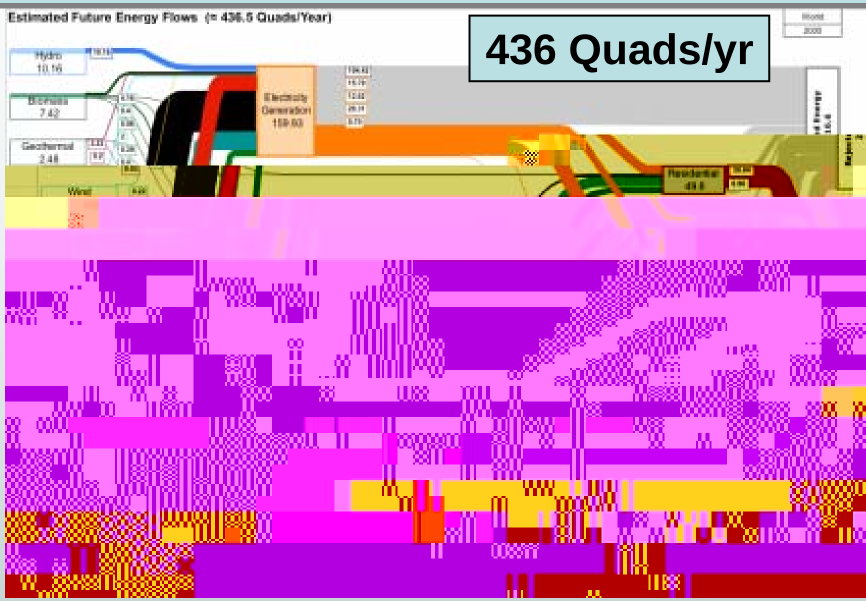
Exergy term first coined by Zoran Rant in 1956

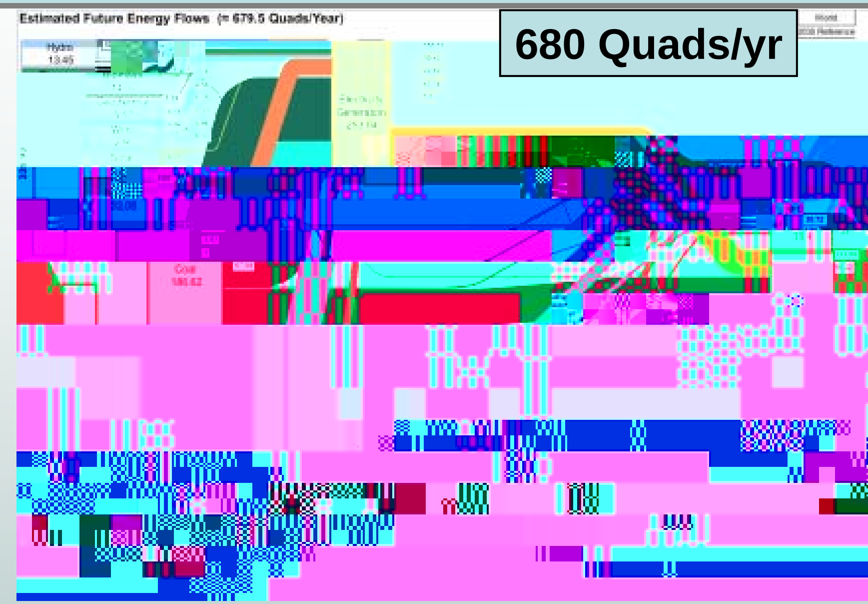
Flowcharts offer comprehensive snapshots linking source, conversion, and end-use

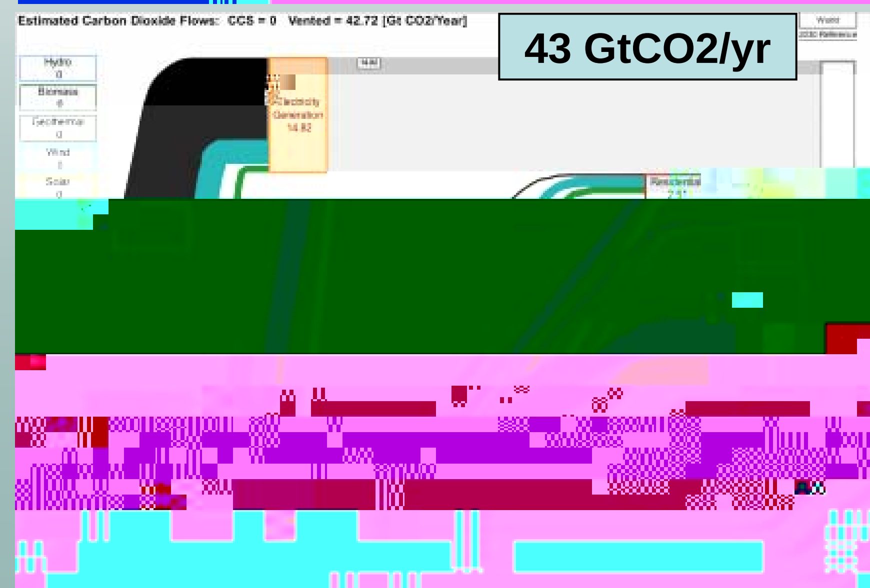


World Energy flows & CO_2 emissions

2005 ***(IEO 2006)*** ***2030 Reference Case*** ***(IEO 2006)***





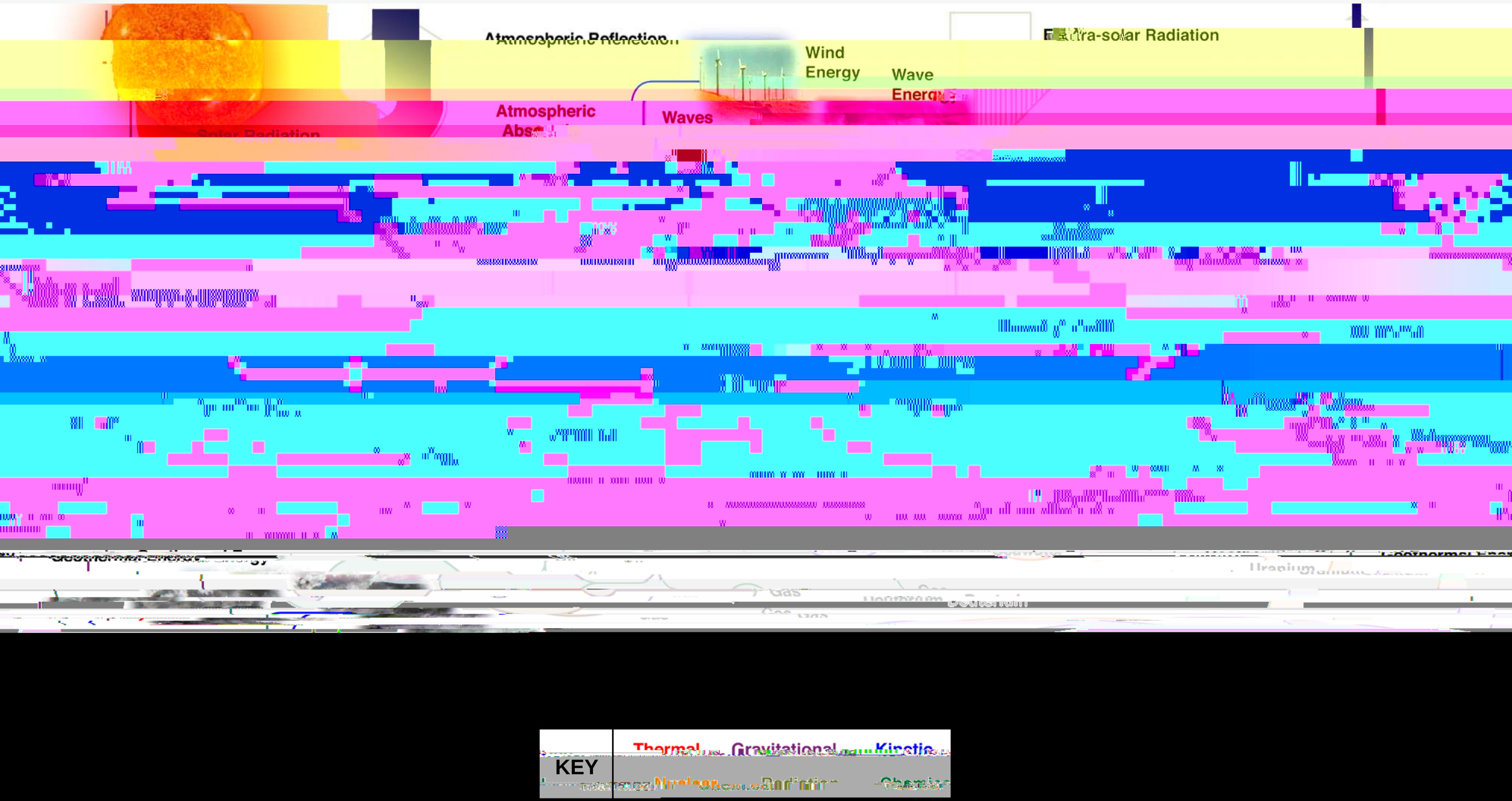


All of our exergy sources—power in TW and exergy in ZJ are drawn to scale

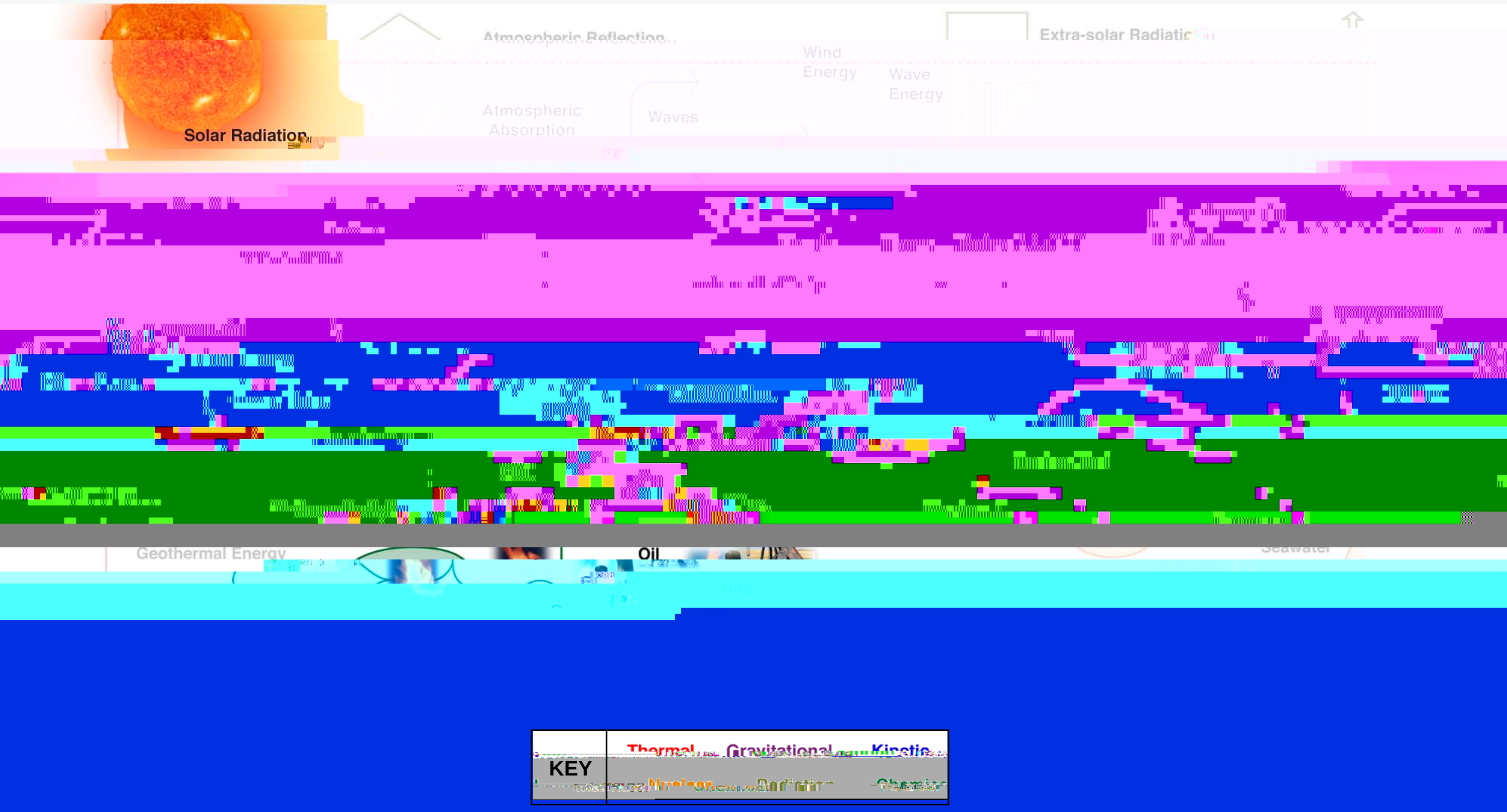
From Wes Hermann, GCEP, 2005

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



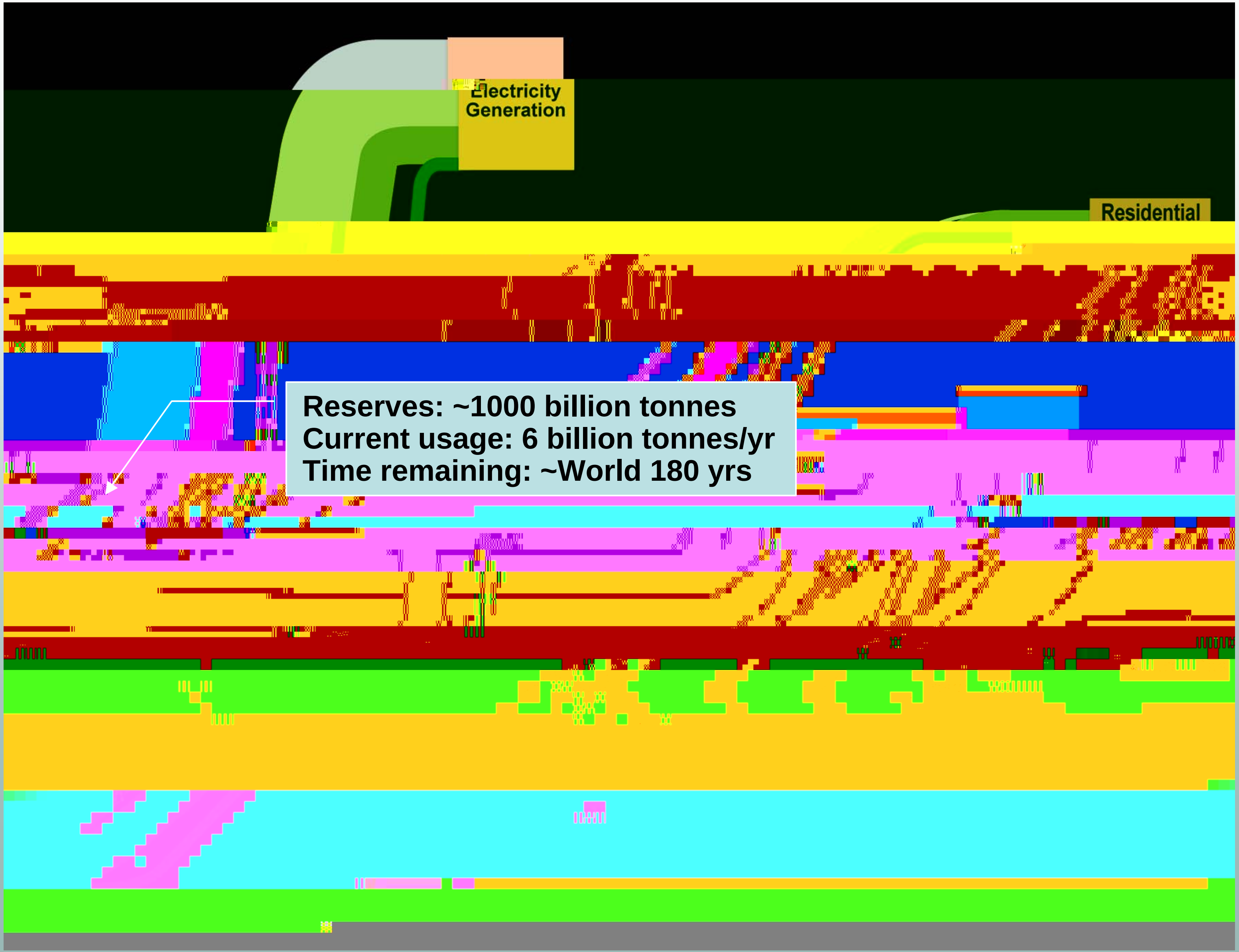
Nuclear fuels could last a thousands of years

Fission Energy

Fusion Energy

Fission and fusion are the future!

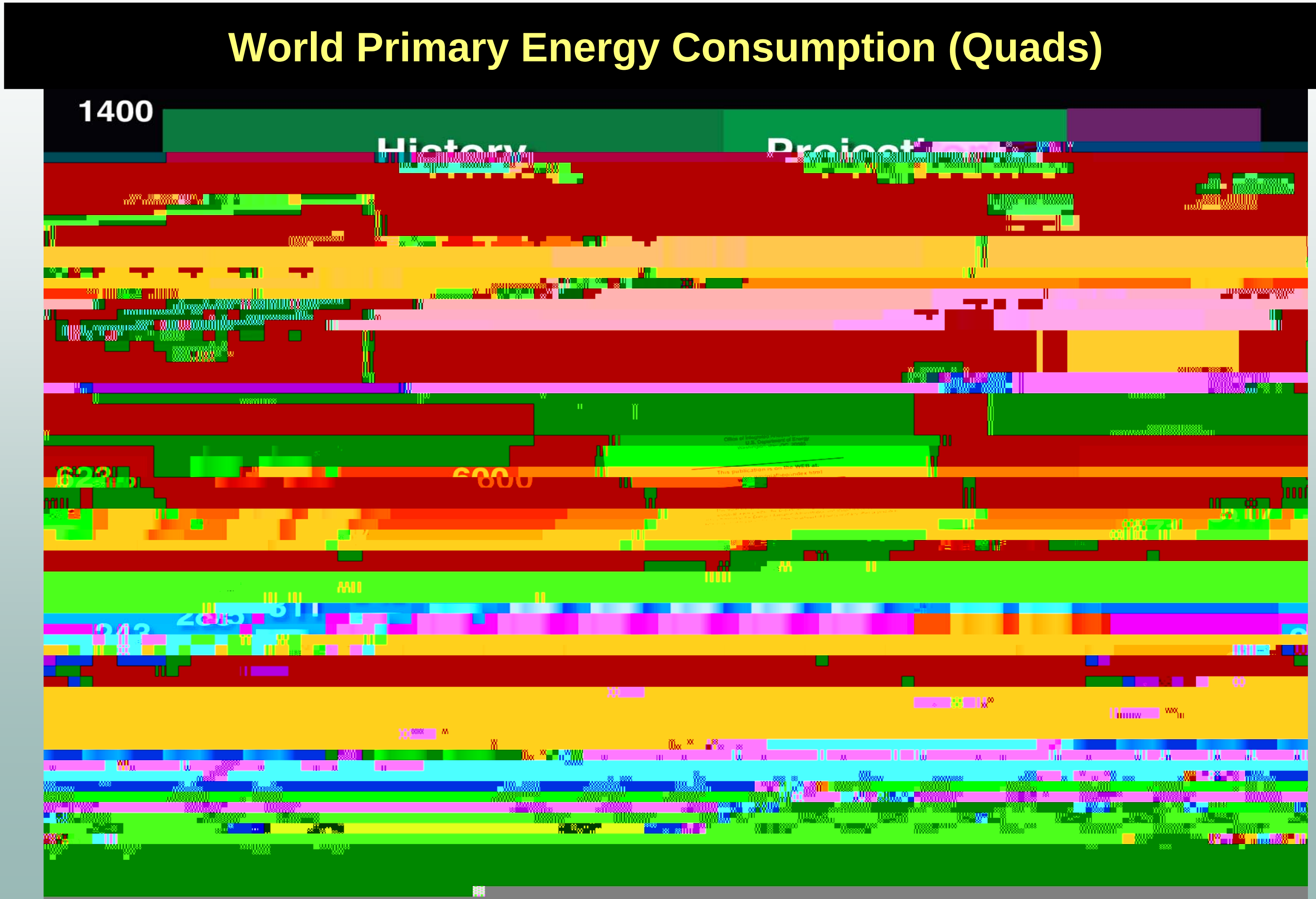
Oil is for transportation, coal for electricity, natural gas has multiple uses



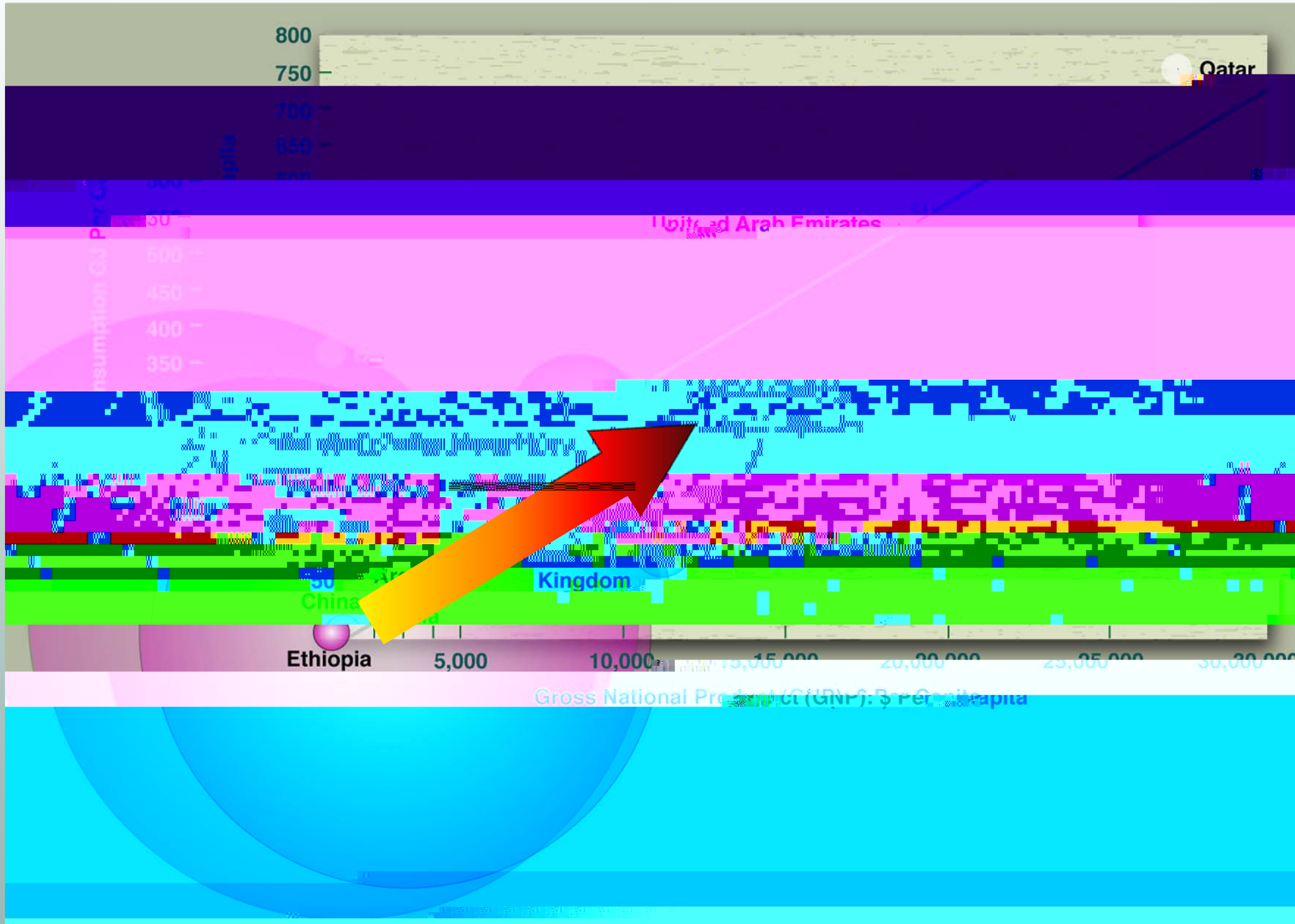
Nuclear fission is today's most utilized non-fossil exergy source

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



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



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.