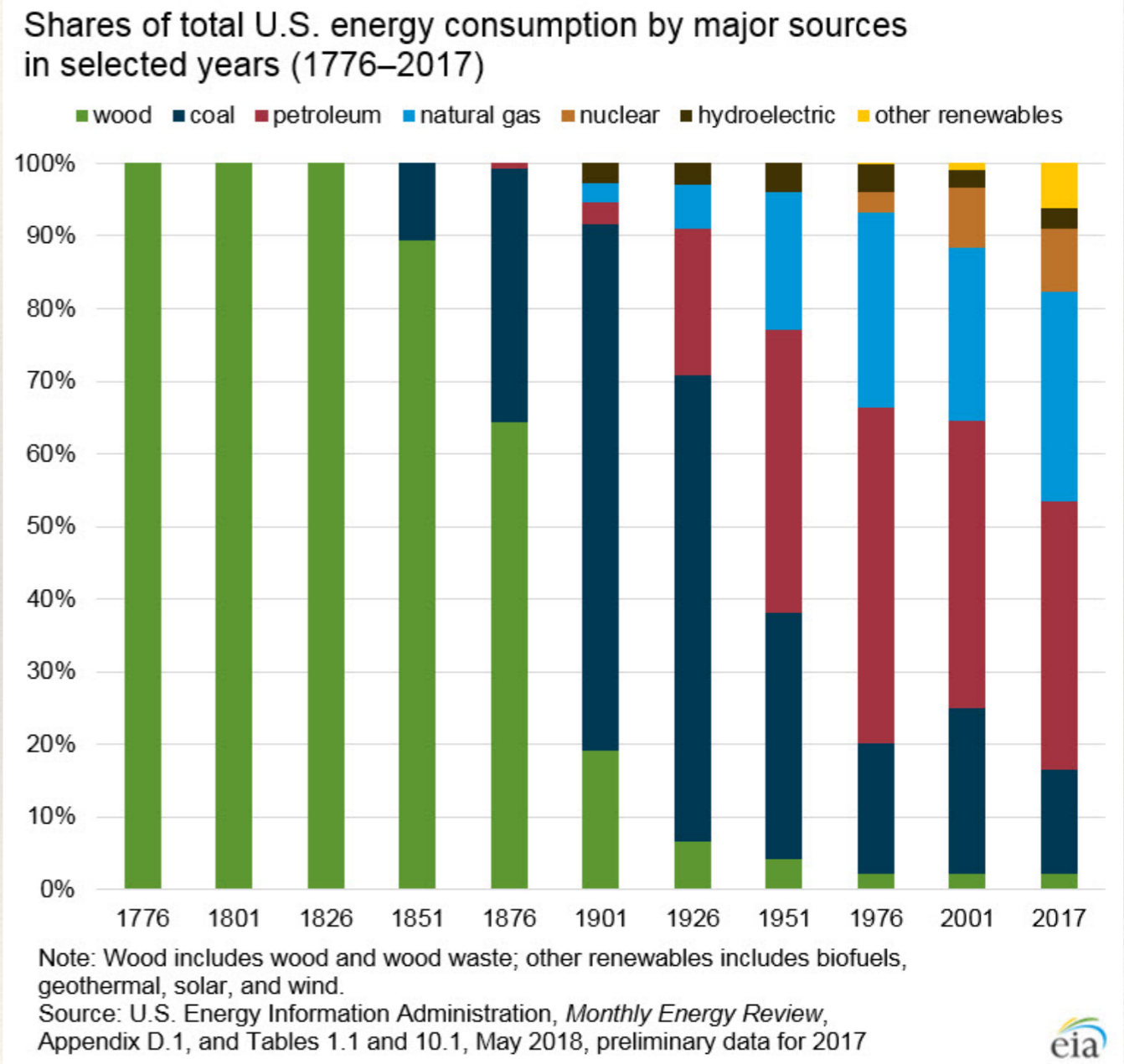

Wicked Problems

Energy & Sustainability

Energy Sustainability - a wicked problem

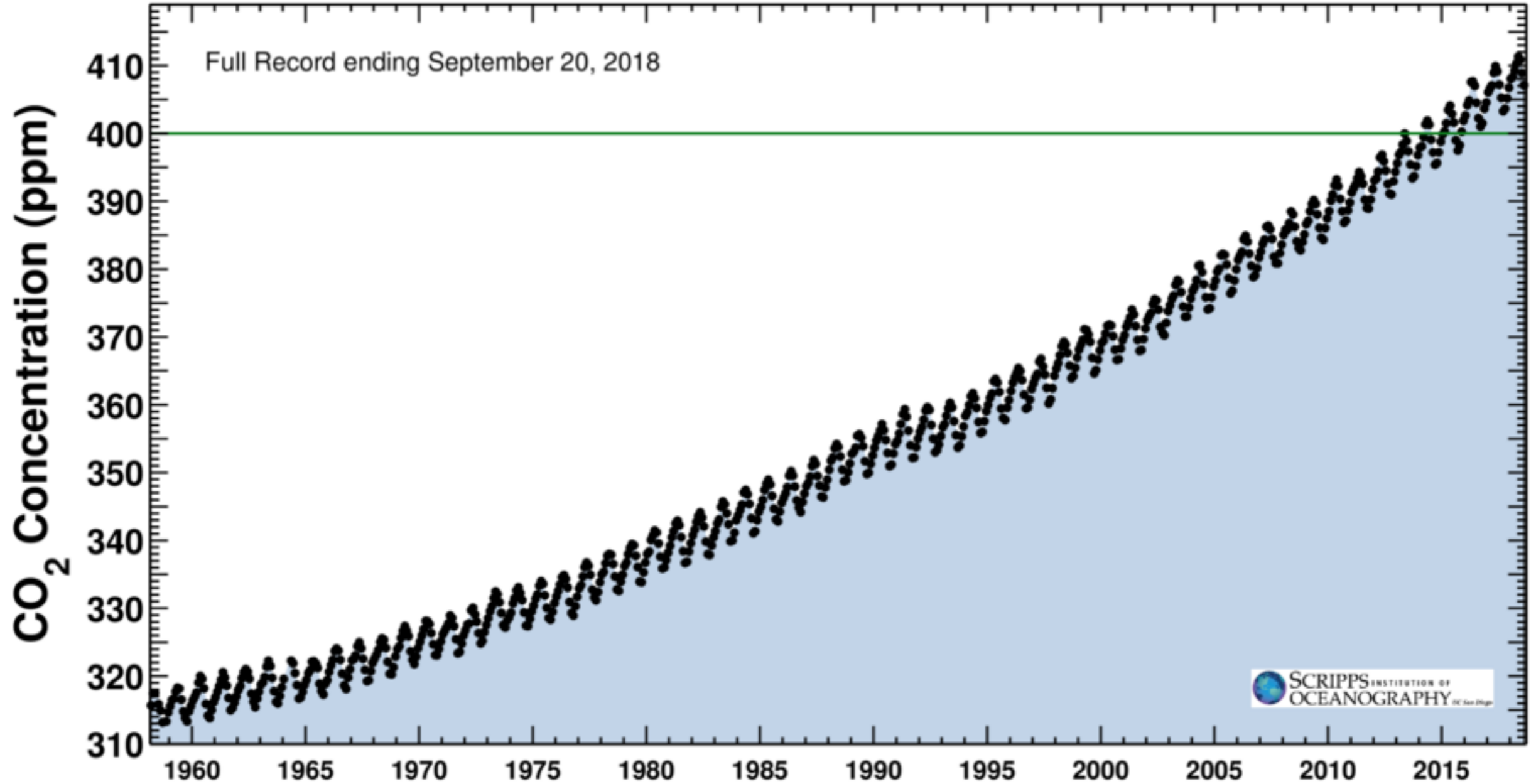
- ❖ What, if anything, surprised you about Smil's history of energy use in industrial economies?
- ❖ What are the most important relationships in his story?
- ❖ What systems are important for talking about human energy use that were not part of Smil's story



Latest CO₂ reading
September 20, 2018

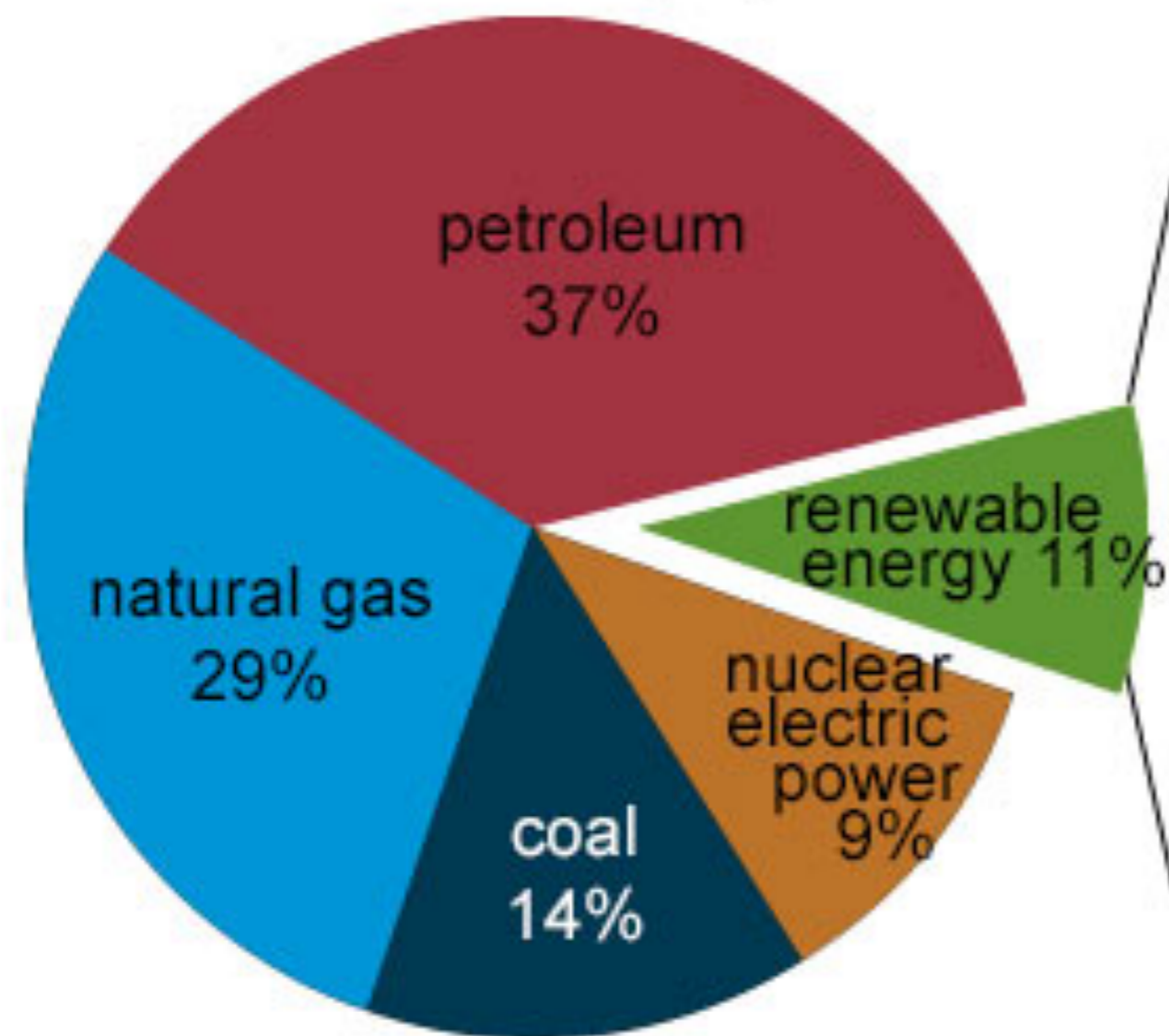
405.57 ppm

Carbon dioxide concentration at Mauna Loa Observatory

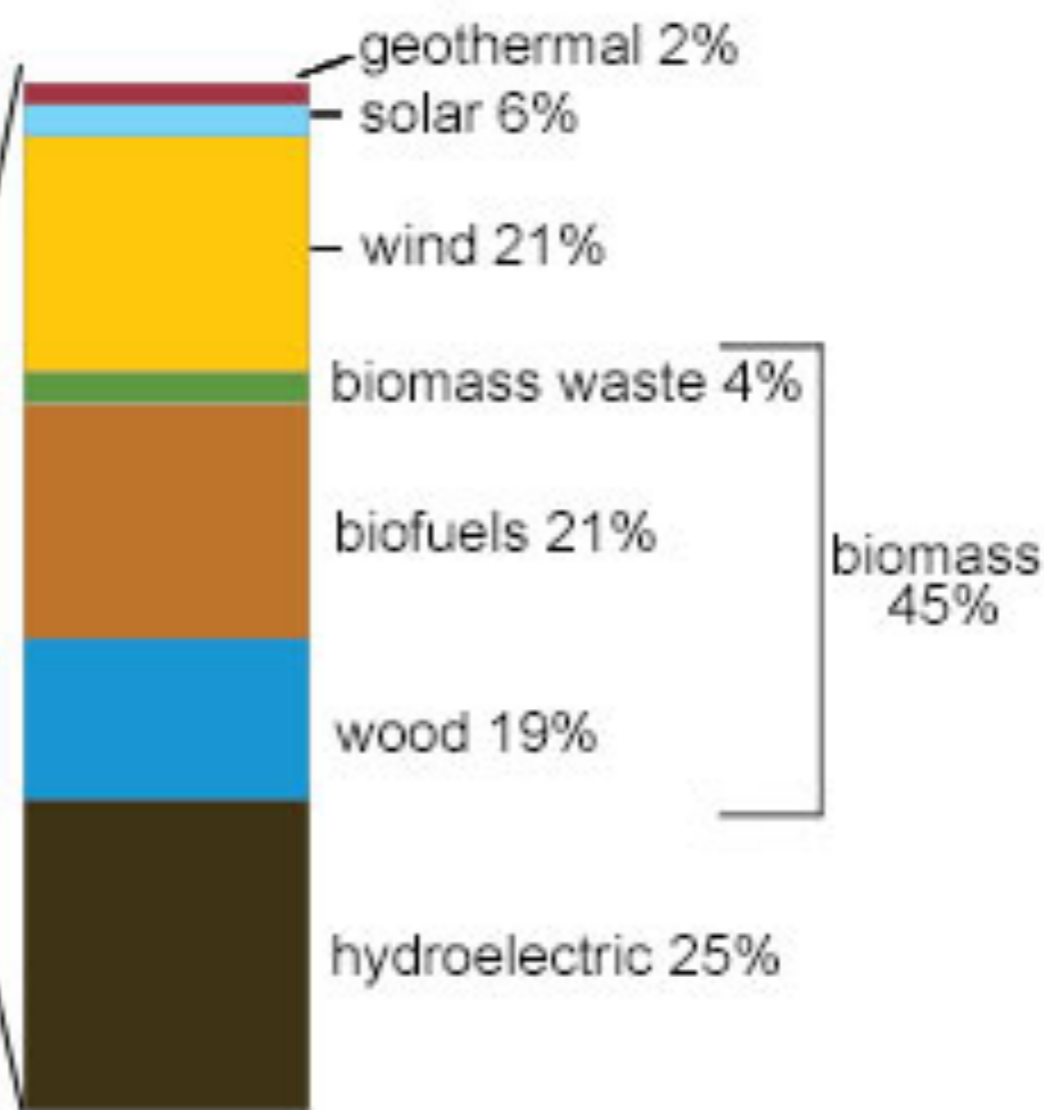


U.S. energy consumption by energy source, 2017

Total = 97.7 quadrillion
British thermal units (Btu)



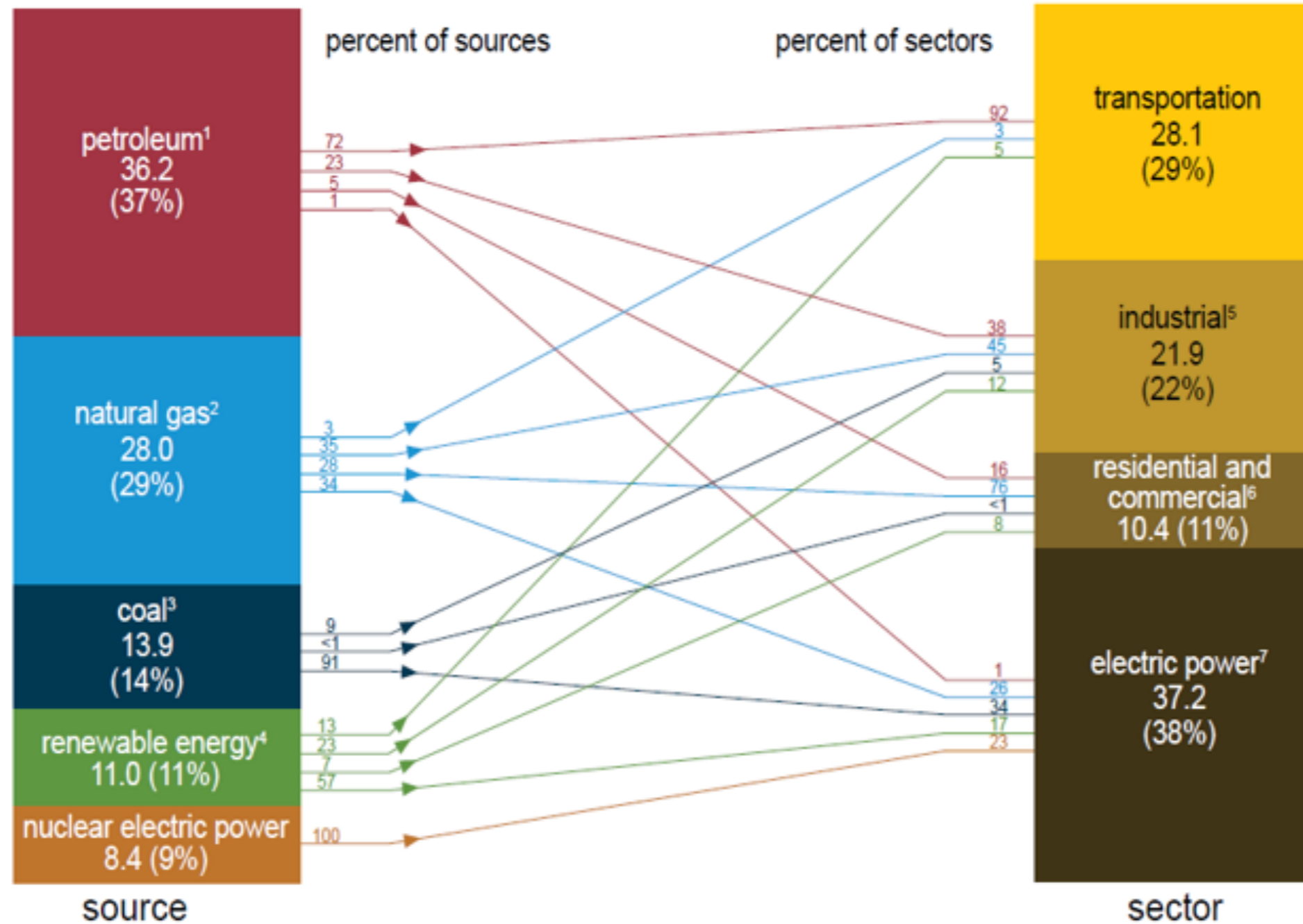
Total = 11.0 quadrillion Btu



Note: Sum of components may not equal 100% because of independent rounding.
Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3 and 10.1, April 2018, preliminary data

U.S. primary energy consumption by source and sector, 2017

Total = 97.7 quadrillion British thermal units (Btu)



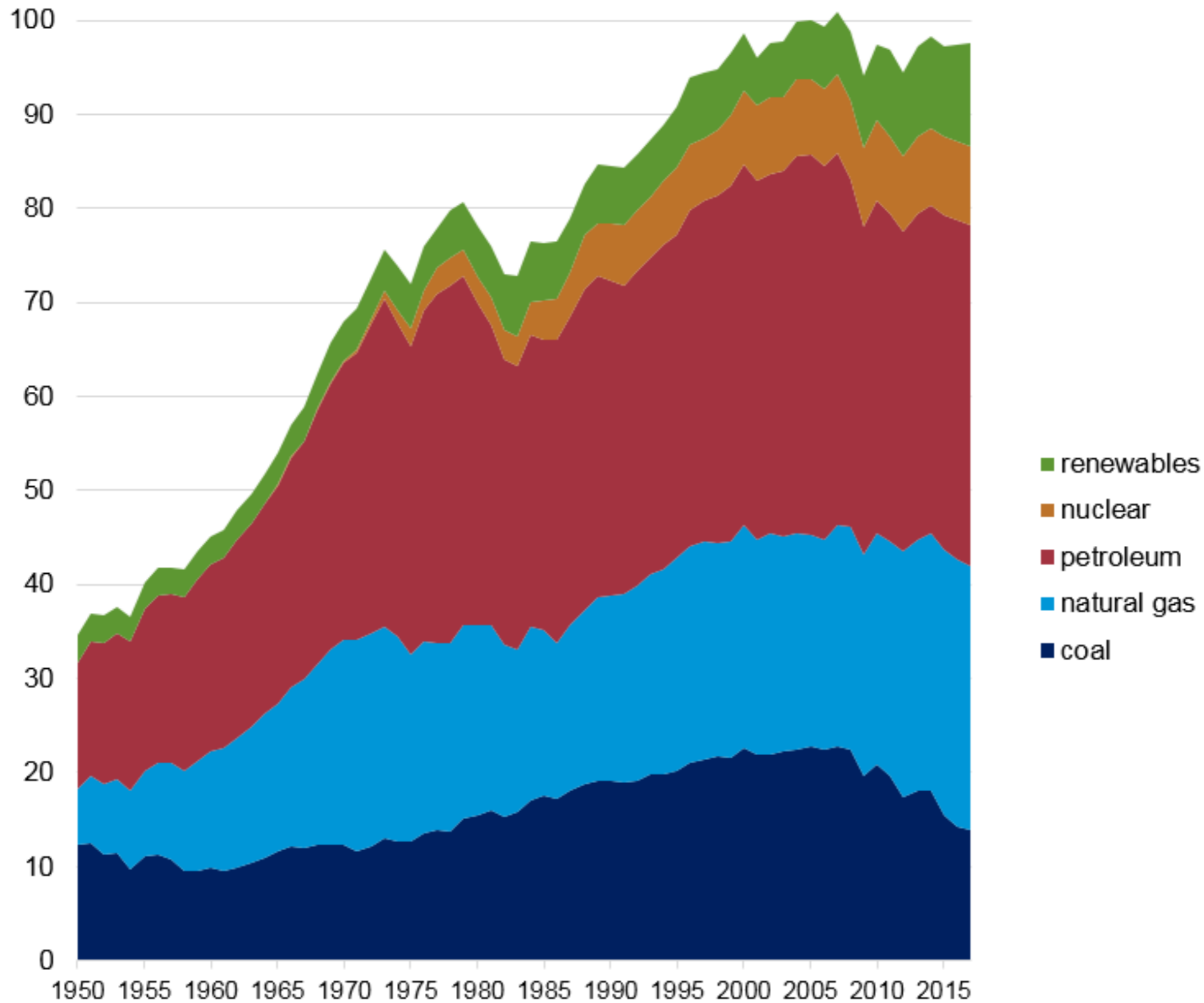
¹ Does not include biofuels that have been blended with petroleum—biofuels are included in "Renewable Energy."
² Excludes supplemental gaseous fuels.
³ Includes -0.03 quadrillion Btu of coal coke net imports.
⁴ Conventional hydroelectric power, geothermal, solar, wind, and biomass.
⁵ Includes industrial combined-heat-and-power (CHP) and industrial electricity-only plants.
⁶ Includes commercial combined-heat-and-power (CHP) and commercial electricity-only plants.
⁷ Electricity-only and combined-heat-and-power (CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public. Includes 0.17 quadrillion Btu of electricity net imports not shown under "source."

Notes: • Primary energy is energy in the form that it is accounted for in a statistical energy balance, before any transformation to secondary or tertiary forms of energy occurs (for example, coal is used to generate electricity). • The source total may not equal the sector total because of differences in the heat contents of total, end-use, and electric power sector consumption of natural gas. • Data are preliminary. • Values are derived from source data prior to rounding. • Sum of components may not equal total due to independent rounding.
 Sources: U.S. Energy Information Administration, *Monthly Energy Review* (April 2018), Tables 1.3, 1.4a, 1.4b, and 2.1-2.6.



U.S. primary energy consumption by major sources, 1950–2017

quadrillion British thermal units¹



Note: Petroleum is petroleum products excluding biofuels, biofuels are included in renewables.

Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3, April 2018