Renewable & Non-Renewable Energy

Introduction & energy data presentation & Fossil Fuel Formation

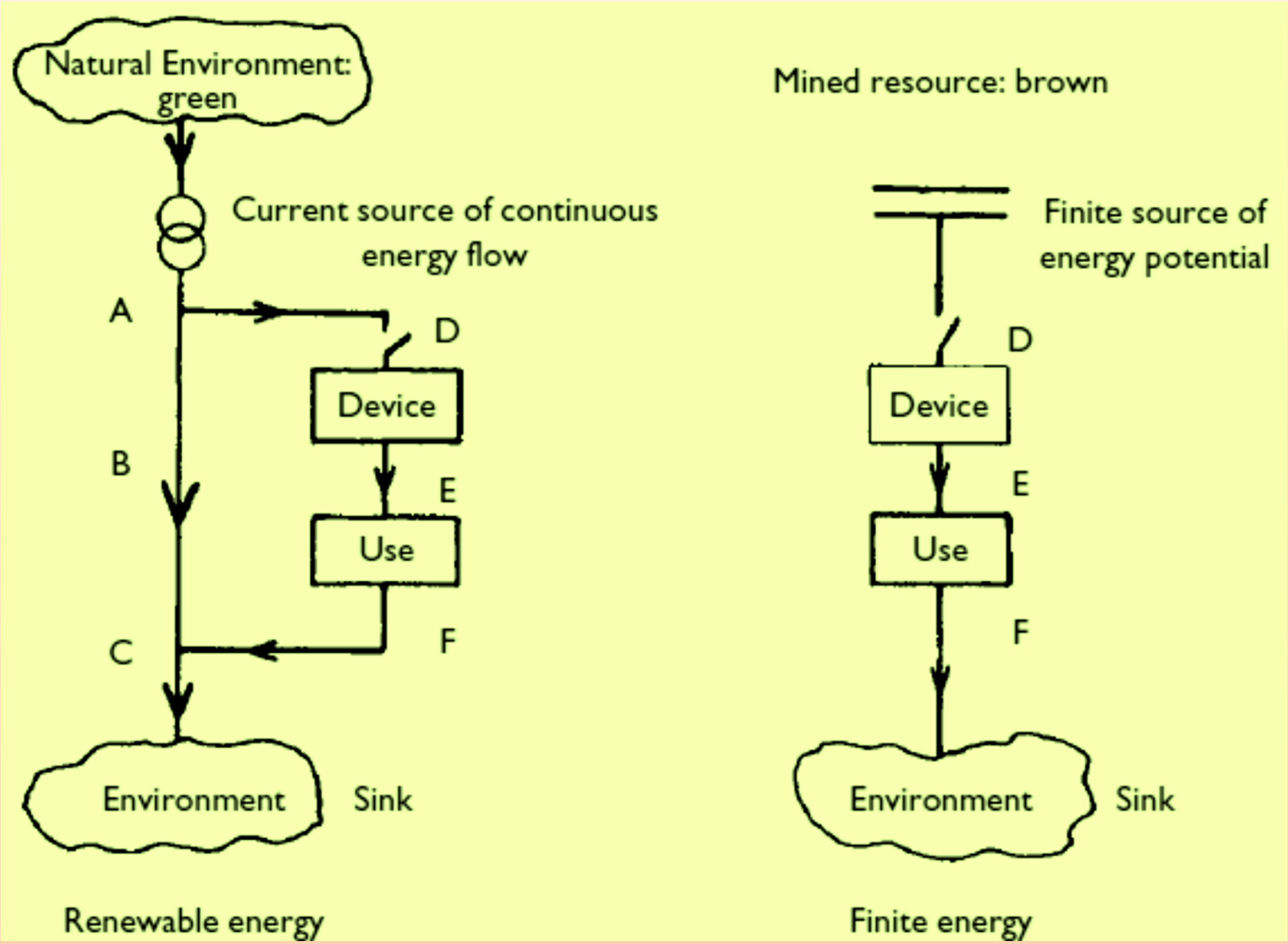
Introduction

Energy supplies can be divided into two classes:

1. **Renewable energy**: 'Energy obtained from natural and constant flows of energy occurring in the immediate environment'. An obvious example is solar (sunshine) energy, where 'repetitive' refers to the 24-hour major period. Note that the energy is already passing through the environment as a *current* or *flow*, irrespective of there being a device to intercept and harness this power. Such energy may also be called ***Green Energy*** or ***Sustainable Energy.***

2. **Non-renewable energy**: 'Energy obtained from static stores of energy that remain underground unless released by human interaction'. Examples are nuclear fuels and fossil fuels of coal, oil and natural gas. Note that the energy is initially an isolated energy *potential*, and external action is required to initiate the supply of energy for practical purposes. To avoid using the ungainly word 'non-renewable', such energy supplies are ***called finite supplies*** or ***Brown Energy***.

Comparison between renewable (green) and finite (brown) energy supplies.



Environmental energy flow ABC, harnessed energy flow DEF.

Energy sources

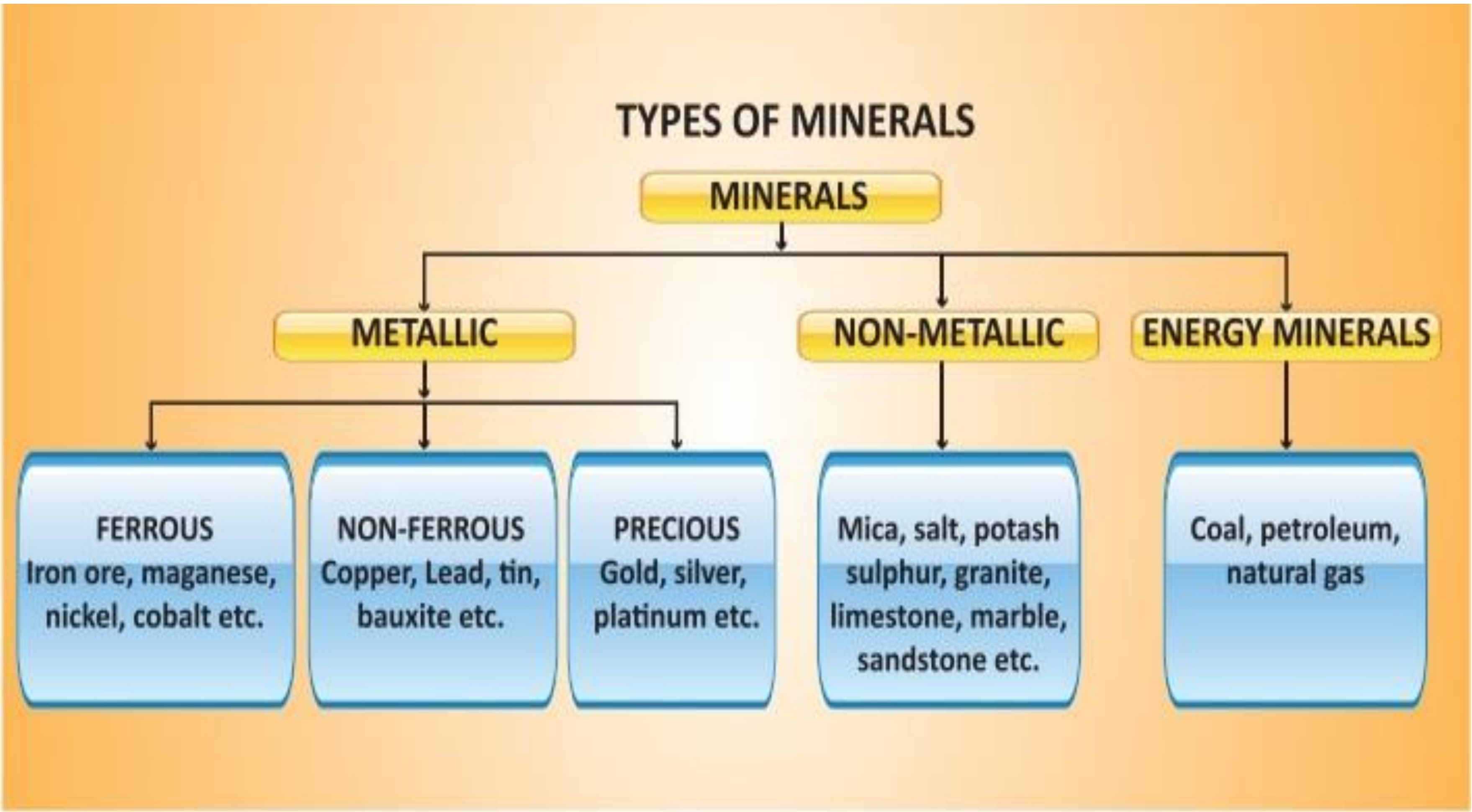
There are five ultimate primary sources of useful energy:

1. The Sun.
2. The motion and gravitational potential of the Sun, Moon and Earth.
3. Geothermal energy from cooling, chemical reactions and radioactive decay in the Earth.
4. Human-induced nuclear reactions.
5. Chemical reactions from mineral sources.

Notes:

- ✓ Renewable energy derives continuously from sources 1, 2 and 3 (aquifers).
- ✓ Finite energy derives from sources 1 (fossil fuels), 3 (hot rocks), 4 and 5.
- ✓ The sources of most significance for global energy supplies are 1 and 4.
- ✓ The fifth category is relatively minor, but useful for primary batteries, e.g. dry cells.

Types of mineral resources



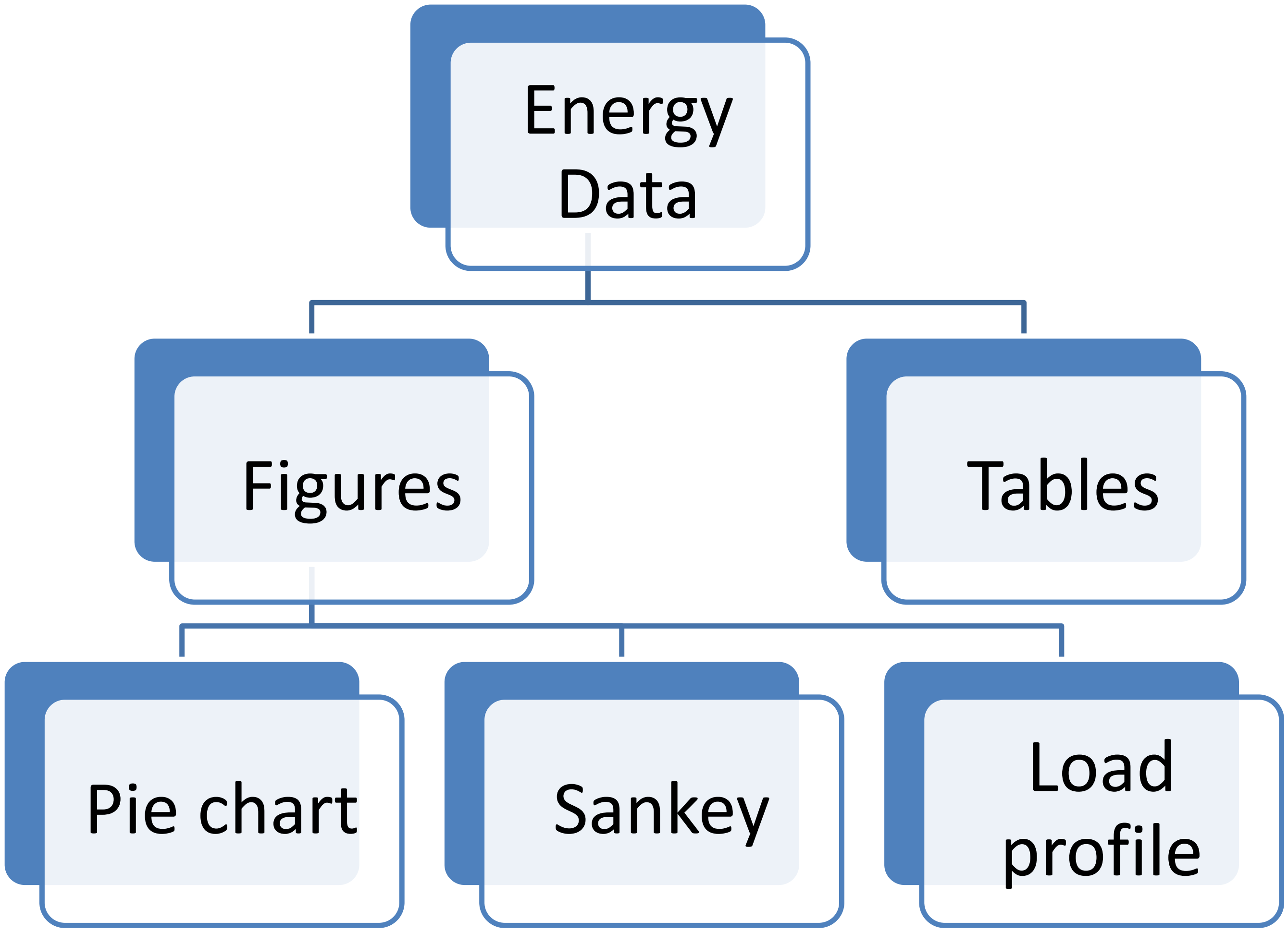
Note

- For renewable energy (wind, water, biomass, sunshine and other such continuing sources, including wastes), four questions are asked for practical applications:
  1. How much energy is available in the immediate environment – what is the resource?
  2. For what purposes can this energy be used – what is the end-use?
  3. What is the environmental impact of the technology – is it sustainable?
  4. What is the cost of the energy – is it cost-effective?

Comparison of renewable and conventional energy systems

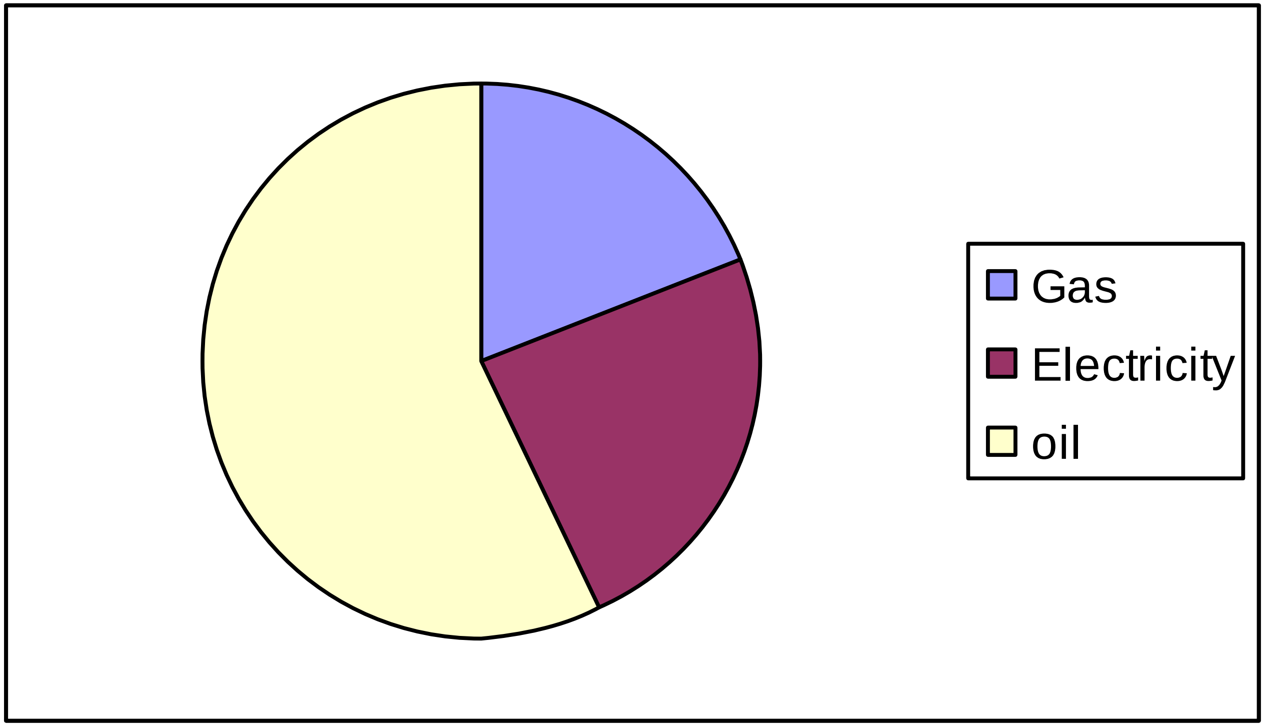
	Renewable energy supplies (green)	*Conventional energy supplies (brown)*
Examples	Wind, solar, biomass, tidal	Coal, oil, gas, radioactive ore
Source	Natural local environment	Concentrated stock
Normal state	A current or flow of energy. An income	Static store of energy. Capital
Initial average intensity	Low intensity, dispersed: $\leq$300 W m^{-2}	Released at $\geq$100 kW m^{-2}
Lifetime of supply	Infinite	Finite
Cost at source	Free	Increasingly expensive.
Equipment capital cost per kW capacity	Expensive, commonly $\approx$US\$1000 kW^{-1}	Moderate, perhaps \$500 kW^{-1} without emissions control; yet expensive >US\$1000 kW^{-1} with emissions reduction
Variation and control	Fluctuating; best controlled by change of load using positive feedforward control	Steady, best controlled by adjusting source with negative feedback control
Location for use	Site- and society-specific	General and invariant use
Scale	Small and moderate scale often economic, large scale may present difficulties	Increased scale often improves supply costs, large scale frequently favoured
Skills	Interdisciplinary and varied. Wide range of skills. Importance of bioscience and agriculture	Strong links with electrical and mechanical engineering. Narrow range of personal skills
Context	Bias to rural, decentralised industry	Bias to urban, centralised industry
Dependence	Self-sufficient and 'islanded' systems supported	Systems dependent on outside inputs
Safety	Local hazards possible in operation: usually safe when out of action	May be shielded and enclosed to lessen great potential dangers; most dangerous when faulty
Pollution and environmental damage	Usually little environmental harm, especially at moderate scale Hazards from excess biomass burning Soil erosion from excessive biofuel use Large hydro reservoirs disruptive Compatible with natural ecology	Environmental pollution intrinsic and common, especially of air and water Permanent damage common from mining and radioactive elements entering water table. Deforestation and ecological sterilisation from excessive air pollution Climate change emissions
Aesthetics, visual impact	Local perturbations may be unpopular, but usually acceptable if local need perceived	Usually utilitarian, with centralisation and economy of large scale

How do you present the energy data?

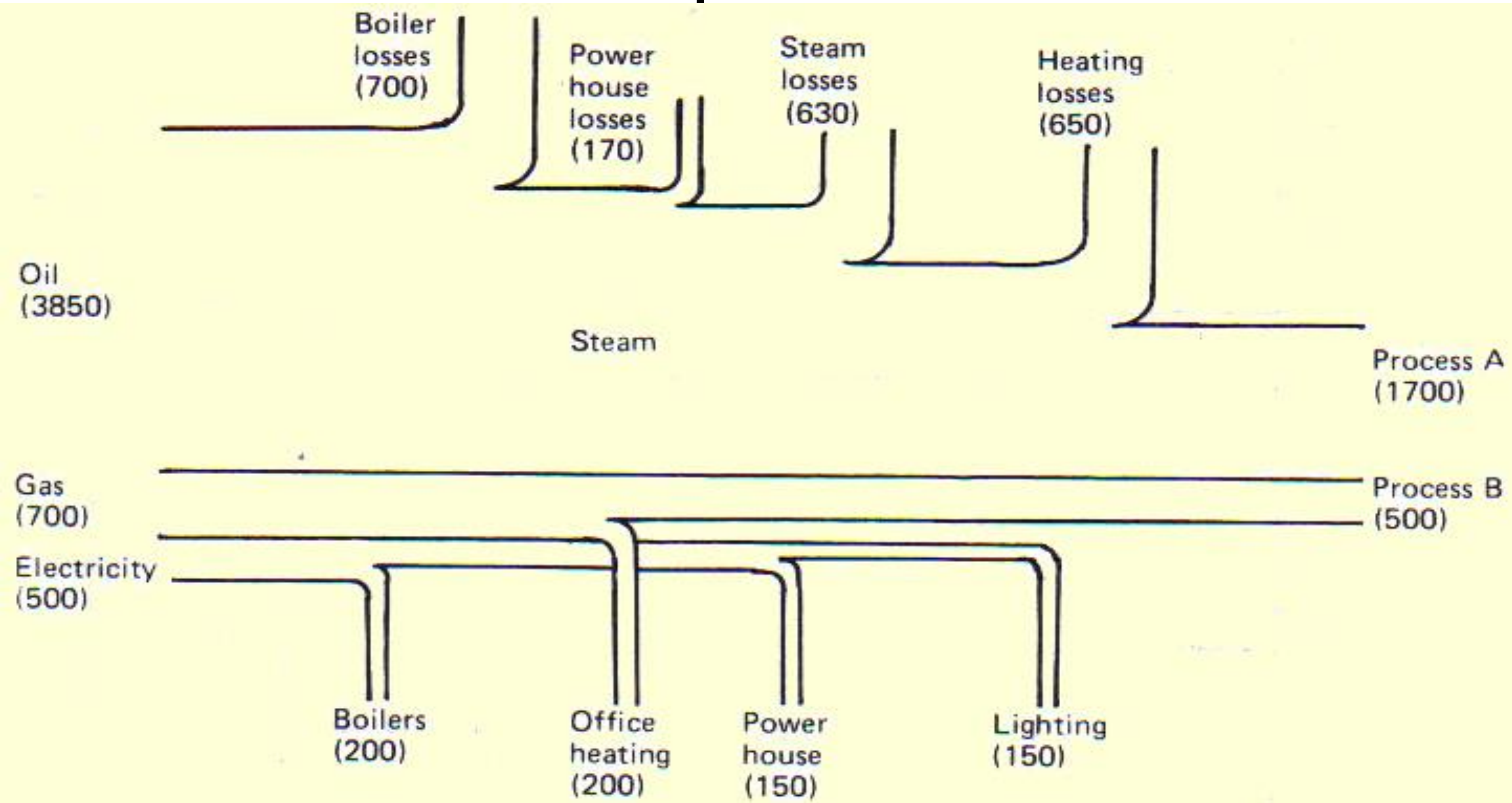


Pie-Chart

Example: Accompany uses on an hourly basis $11.72x10^3$ therms gas, $500x10^3$ W electricity and $4.32x10^9$ J oil.

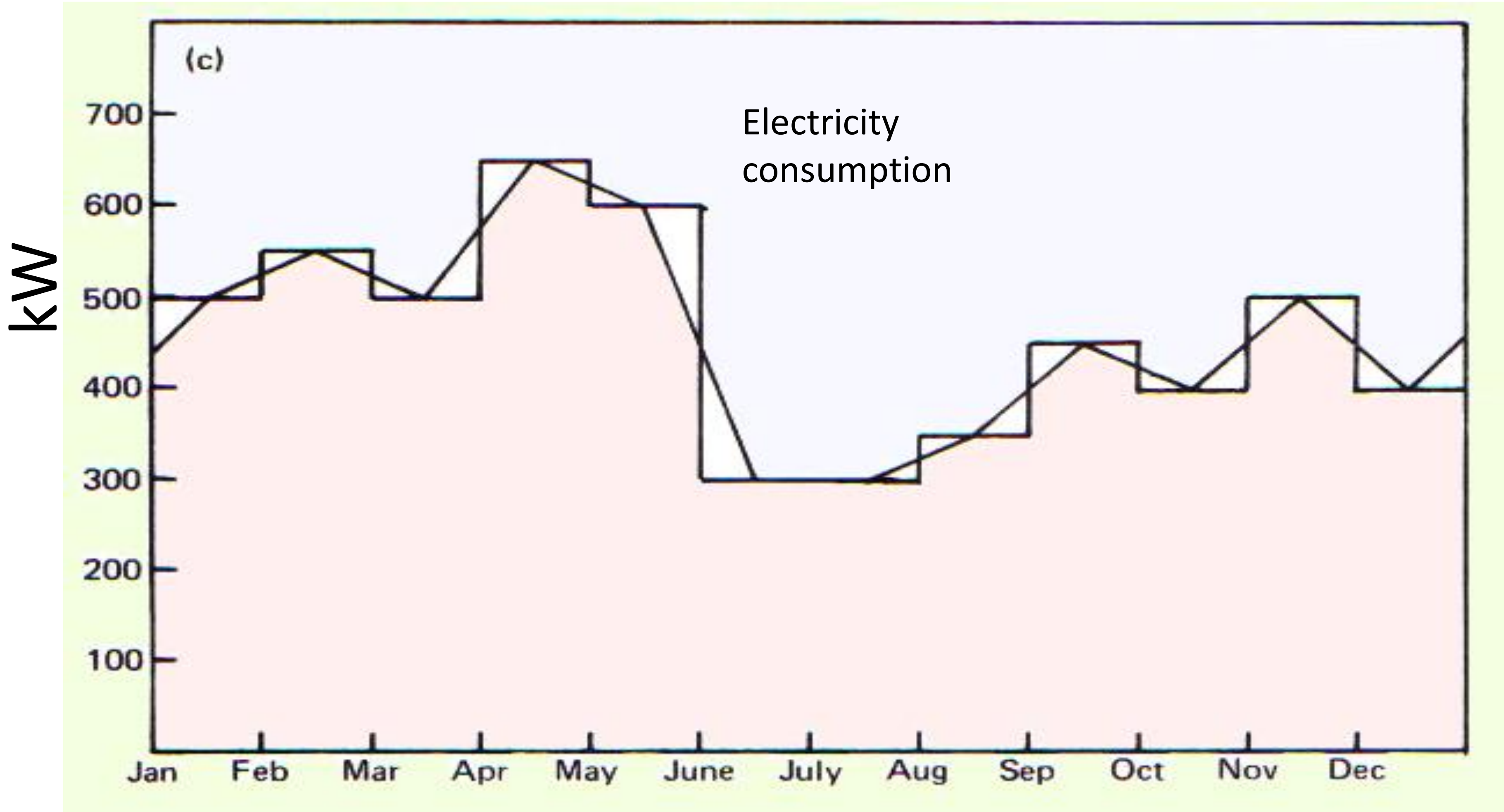


Sankey diagram “Tree & Spacgattie &Pipes”



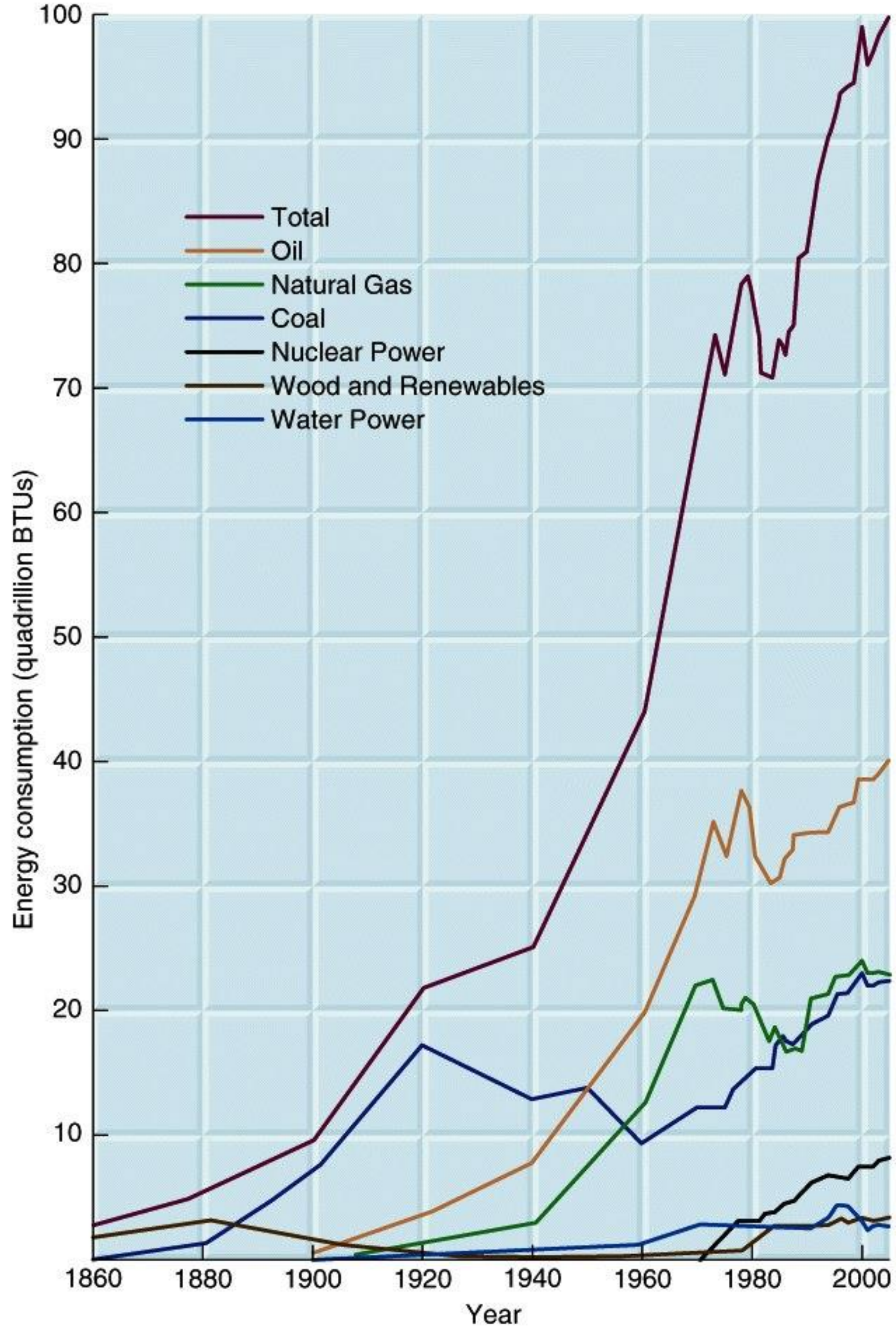
Sankey diagram representation energy usage (10^6 J / h) by a company

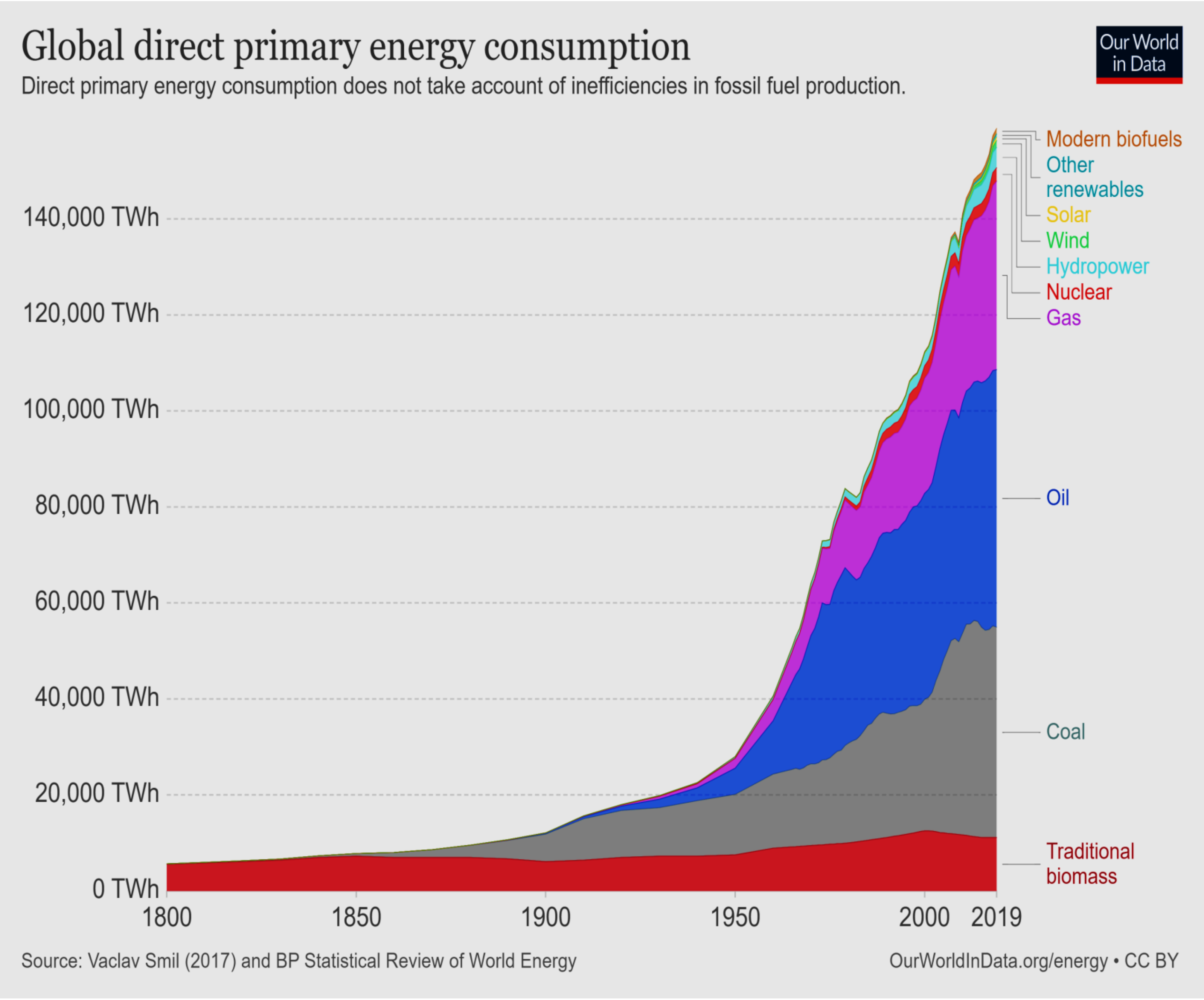
Load profile



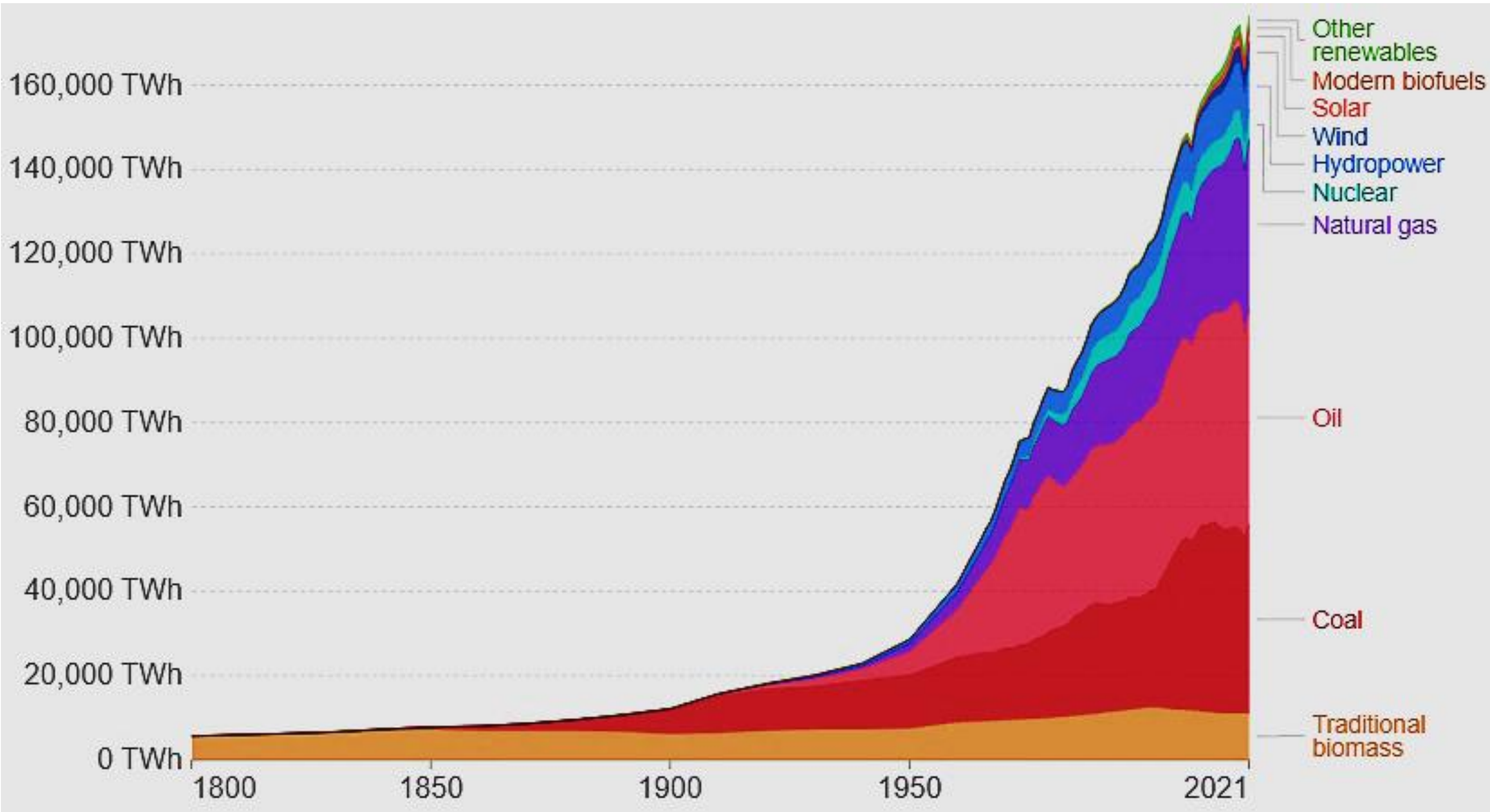
Note: Could be cumulative load profile.

History of Fossil Fuels in the US



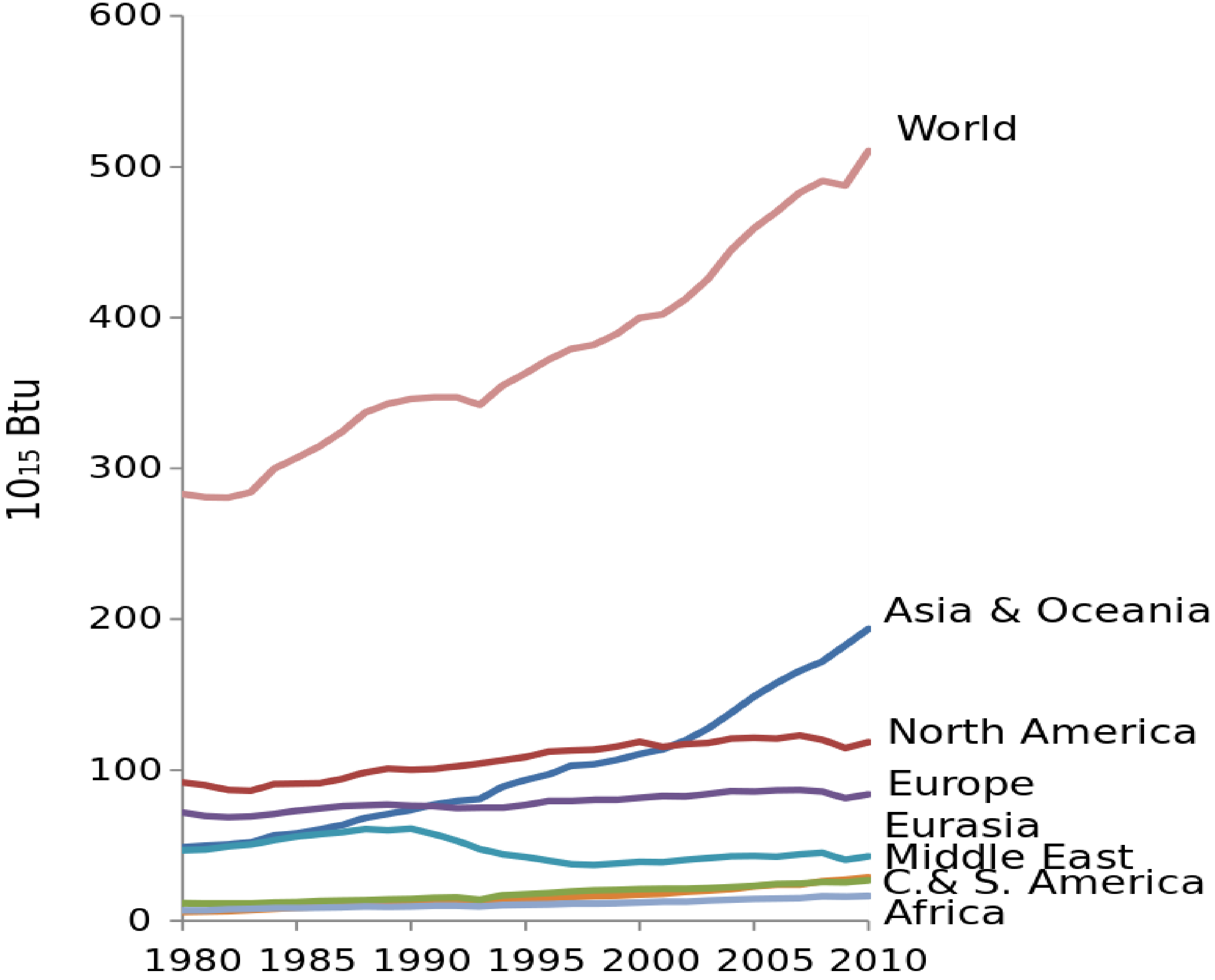

Global direct primary energy consumption
Direct primary energy consumption does not take account of inefficiencies in fossil fuel production.
Our World in Data
140,000 TWh
120,000 TWh
100,000 TWh
80,000 TWh
60,000 TWh
40,000 TWh
20,000 TWh
0 TWh
1800
1850
1900
1950
2000
2019
Modern biofuels
Other renewables
Solar
Wind
Hydropower
Nuclear
Gas
Oil
Coal
Traditional biomass
Source: Vaclav Smil (2017) and BP Statistical Review of World Energy
OurWorldInData.org/energy • CC BY

Global primary energy consumption by sources

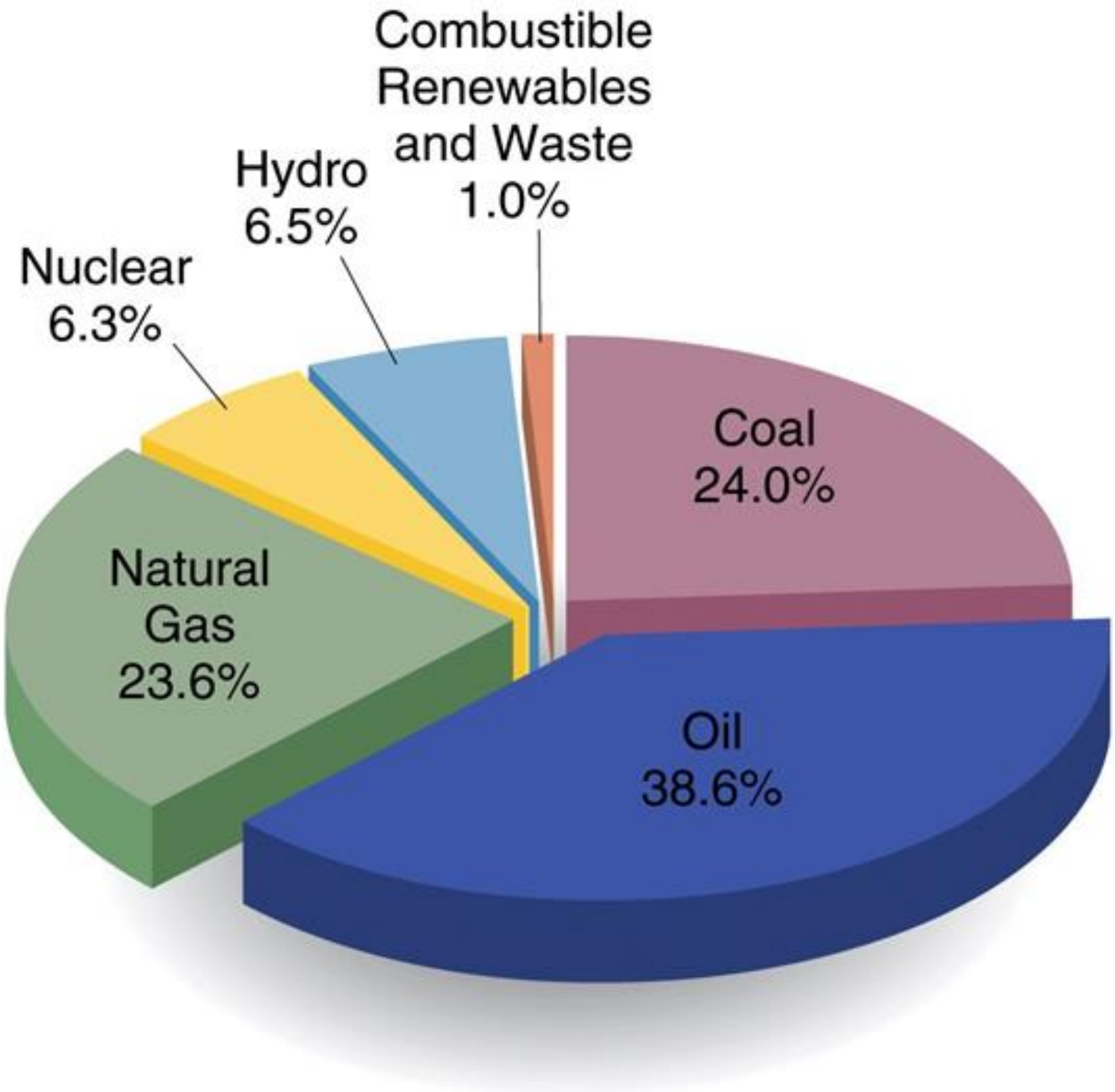


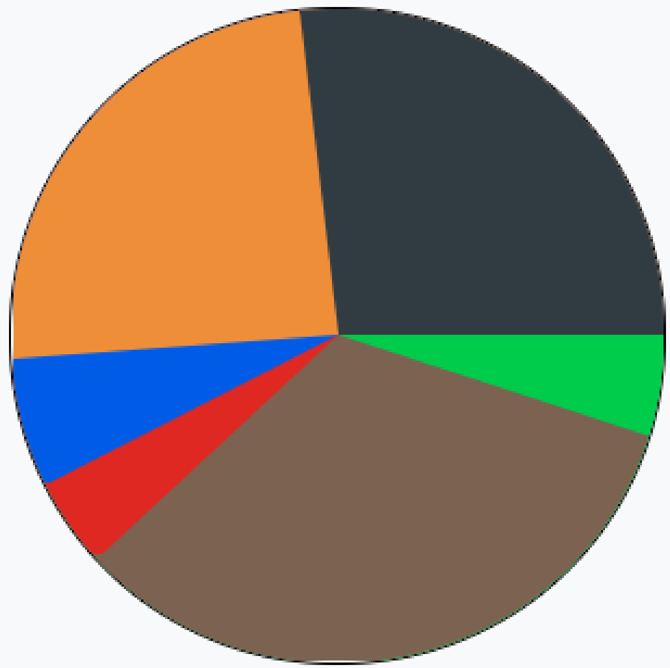
Source: Our World in Data based on Vaclav Smil (2017) and BP Statistical Review of World Energy

Annual Energy Demand by Region



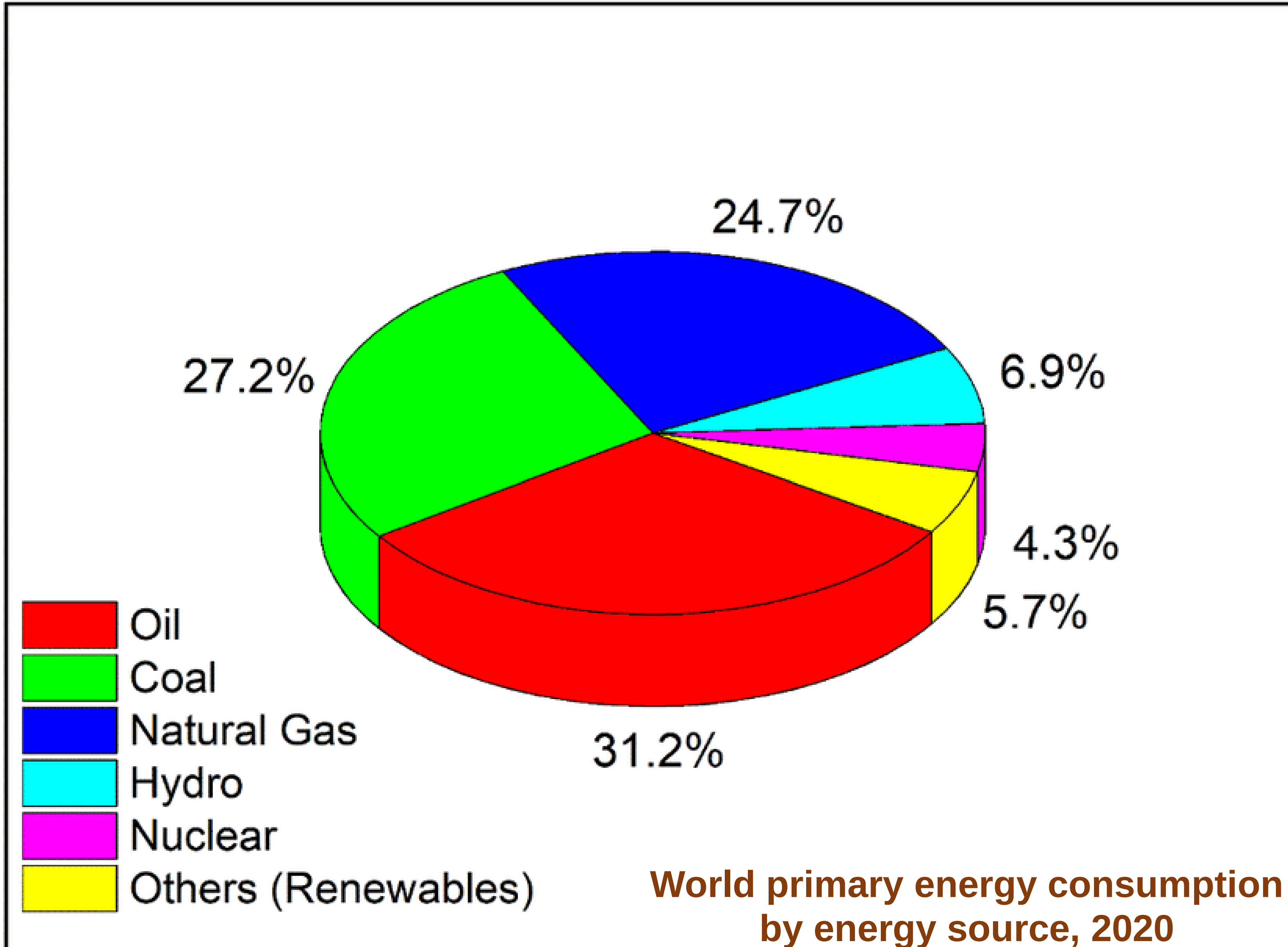
World Energy Type Usage Today





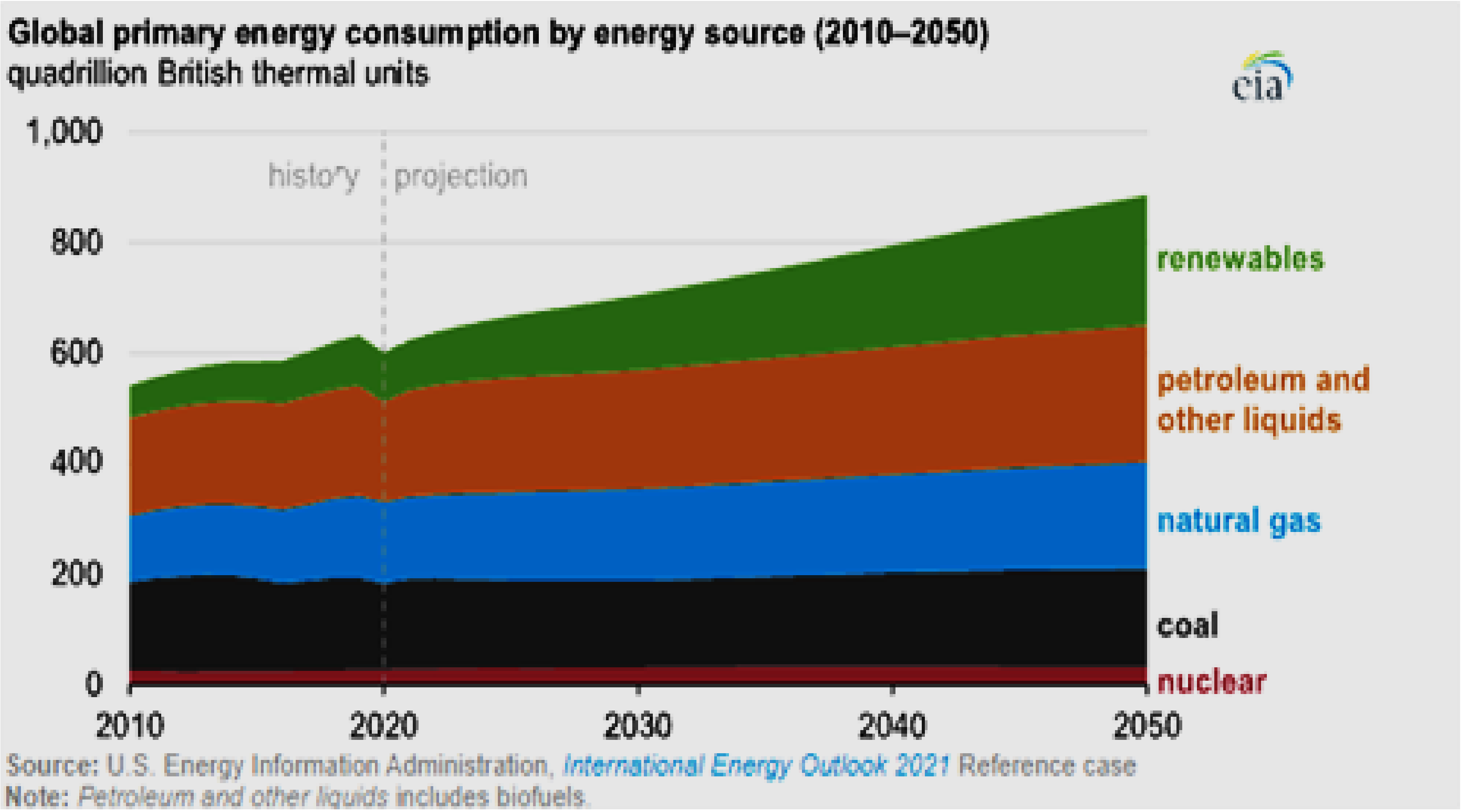
World total primary energy consumption by fuel in 2019[2]

- Coal (27%)
- Natural Gas (24.2%)
- Hydro (renewables) (6.4%)
- Nuclear (4.3%)
- Oil (33.1%)
- Others (renewables) (5%)

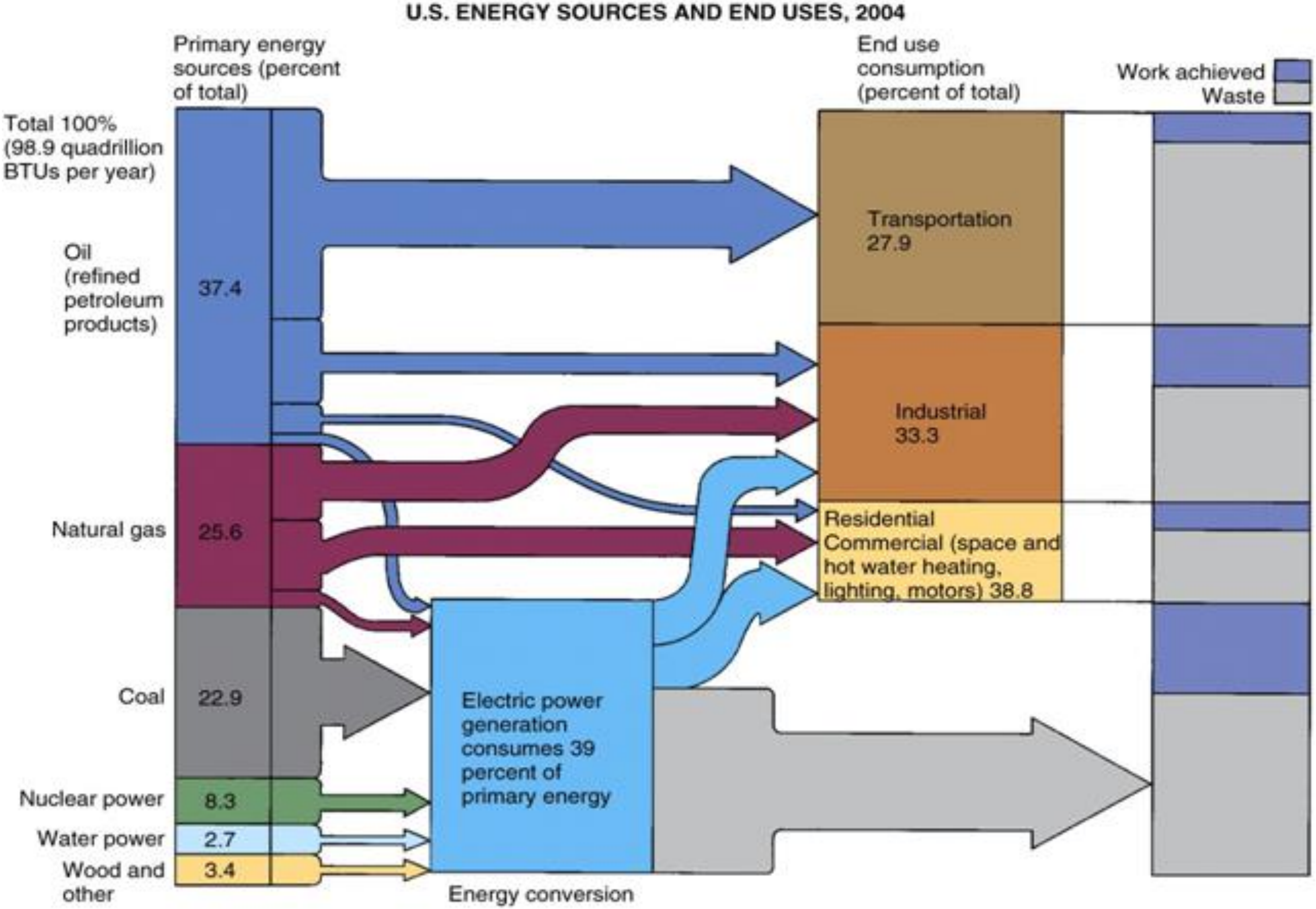


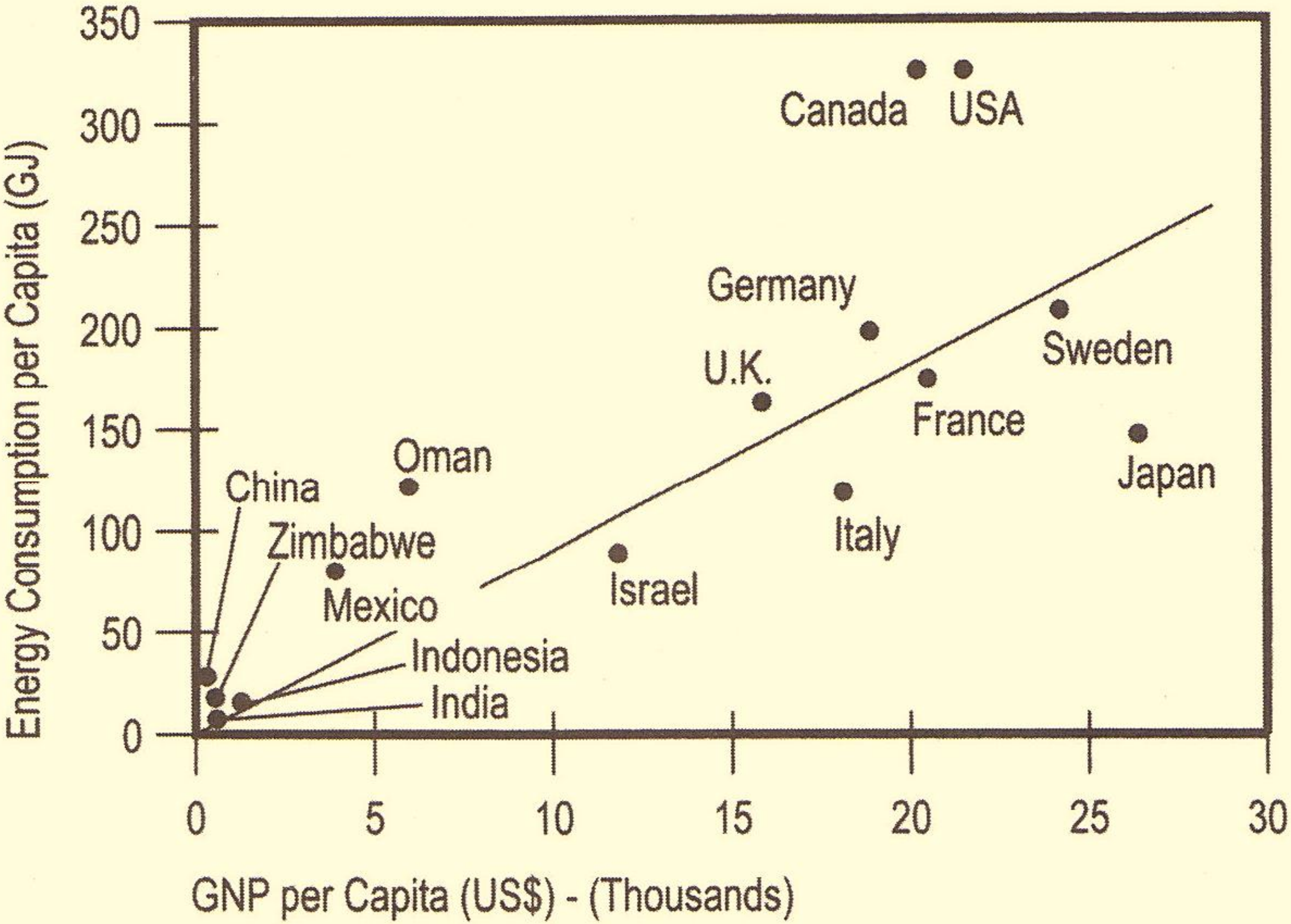
World primary energy consumption by energy source, 2020

EIA projects nearly 50% increase in world energy use by 2050



Pathway from Primary energy to end uses in the US





Energy Consumption per Capita (GJ)
350
300
250
200
150
100
50
0
Canada
USA
Germany
Sweden
U.K.
France
Japan
Oman
China
Italy
Zimbabwe
Israel
Mexico
Indonesia
India
0
5
10
15
20
25
30
GNP per Capita (US$) - (Thousands)