History of human using energy

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Periodization Construct

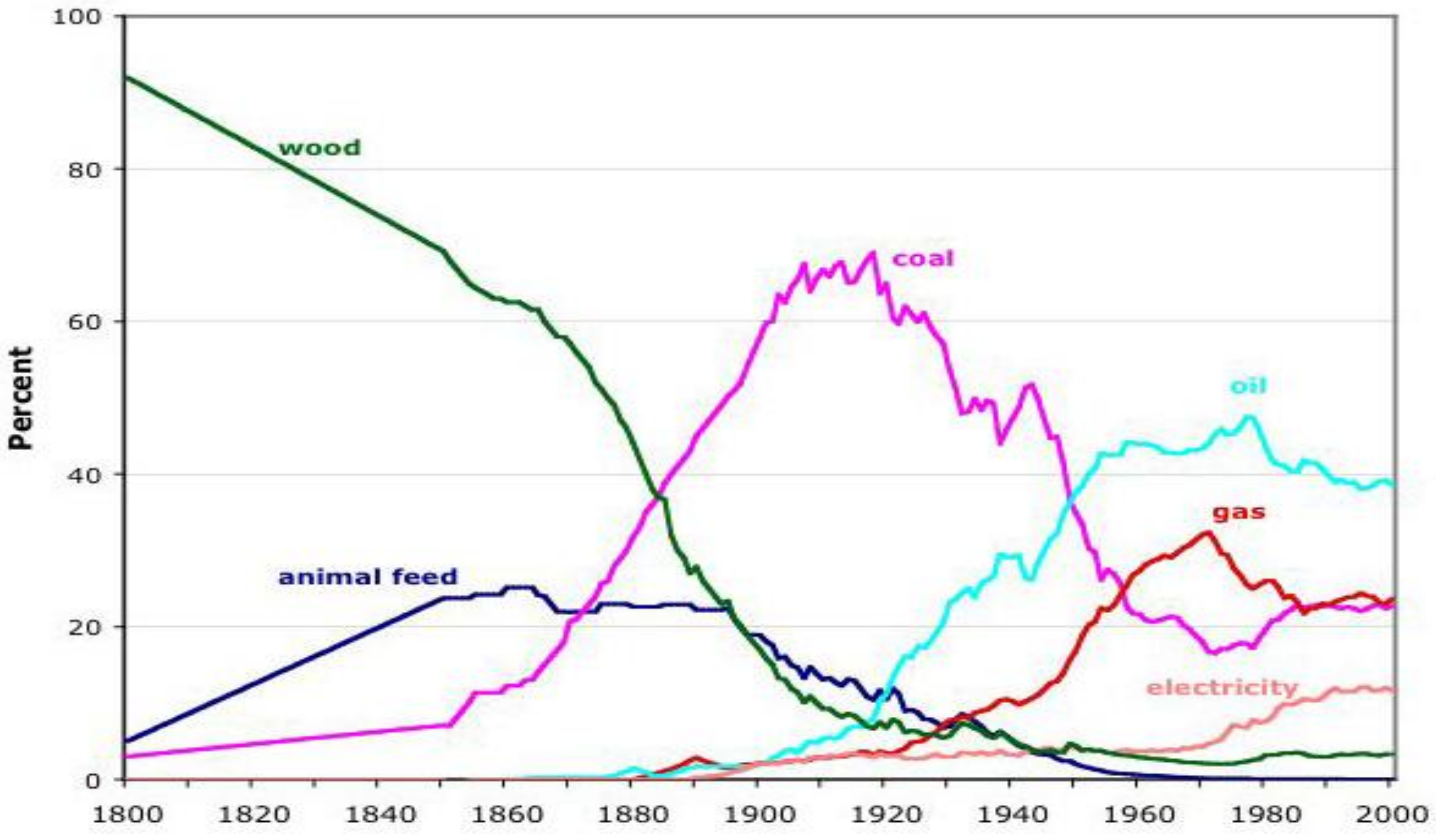
Period I (pre-1820): dominated by human/animal power, wind-, wood-, and waterpower.

Period II (1820-1914): Industrial era dependent on wood, waterpower, and ultimately coal.

Period III (1914-9145): Oil emerges as a leading fuel; electrical power production dramatically increases.

Period IV (1945-1970s): A 'postindustrial' economy dependent on oil, punctuated by the 1970s 'energy crisis.'

Period V: (1970s-?): Post-energy crisis



From Emmett Duffy, "The Next Energy Transition" (2007)

(via Cutler Cleveland)

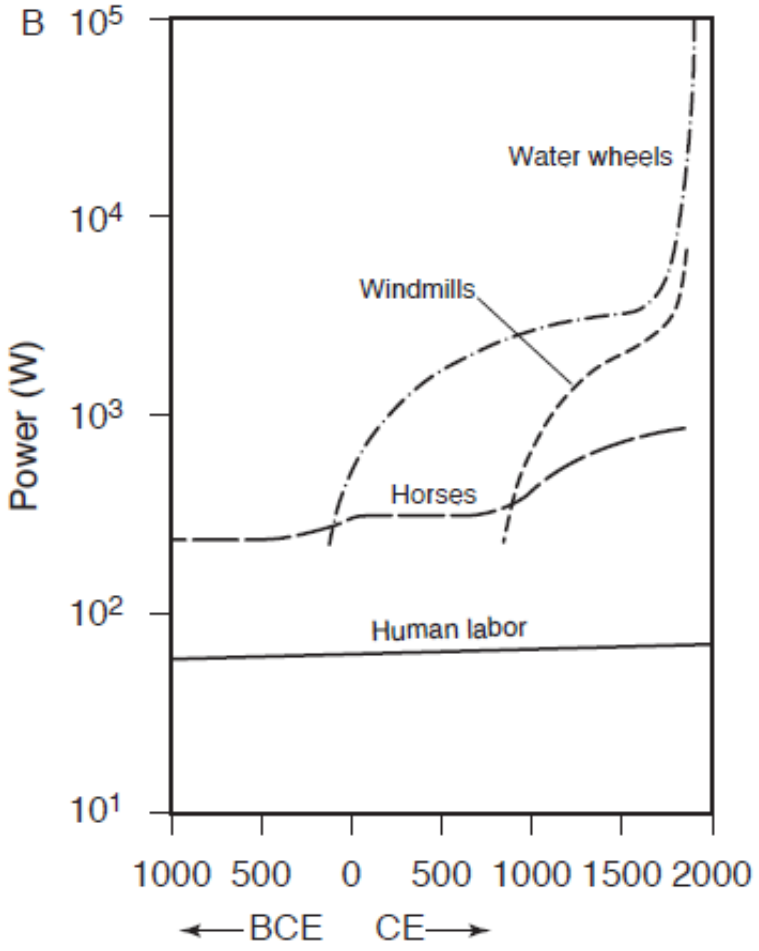
Fire, the first milestone of mankind's utilization of energy

- Dates back at least 4–500,000 years.
- Cooking and heating, using biomass (mainly wood) as fuel.
- In addition, fire created light and thus improved safety in human settlements.
- Discovery of ovens
  - ✓ permitted the early forms of crafting
  - ✓ made it possible to produce pottery and to refine metals from ore

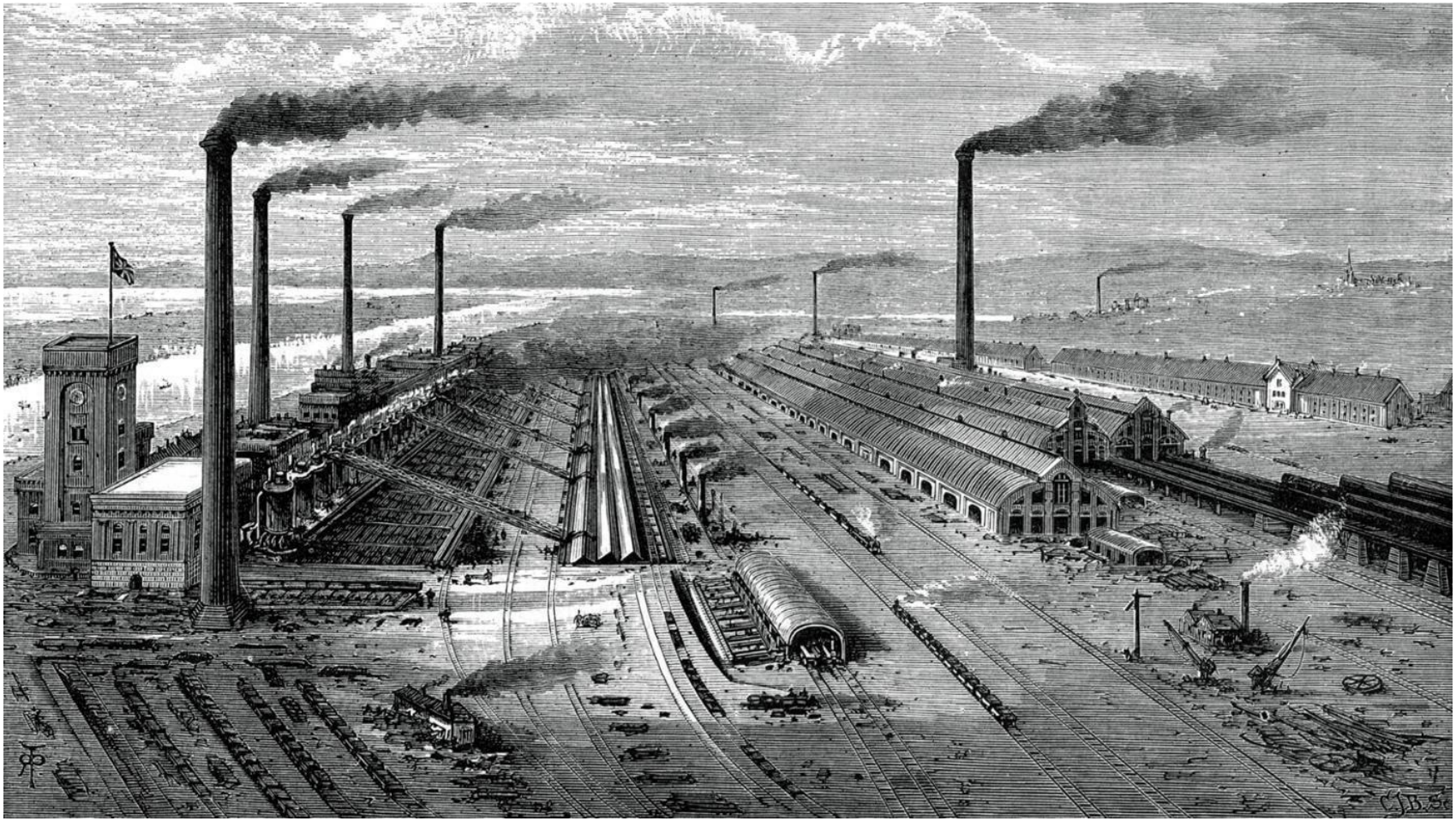
Agricultural Revolution

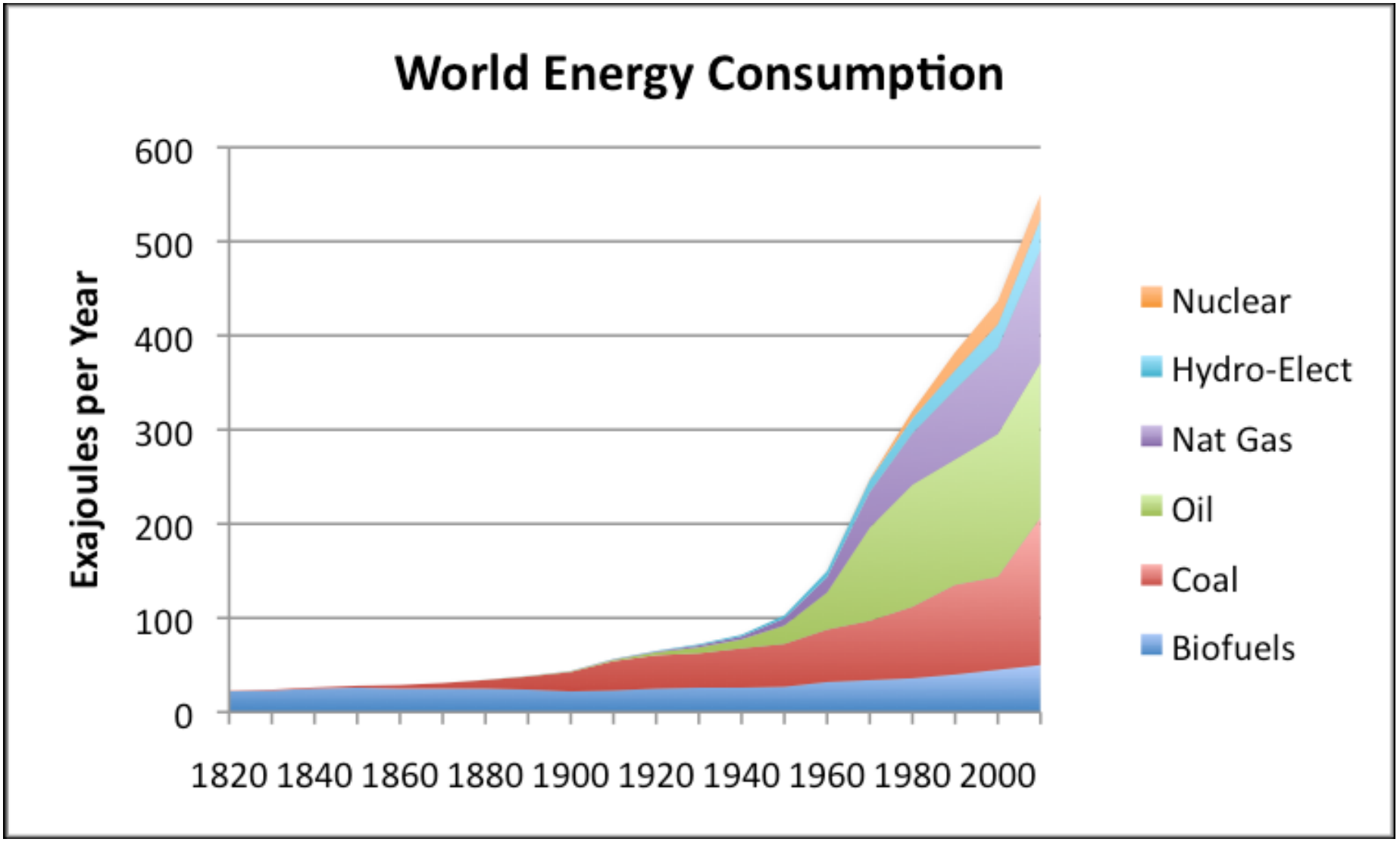
- The introduction of agriculture
  - ✓ amount of available food,
  - ✓ permitting the first permanent human settlements
- Shifting to this era
  - ✓ removal of vegetation
  - ✓ adoption of fire to produce bricks and containers and to smelt metals, beginning with copper (before 4000 BCE)
- Charcoaling was used to convert wood to a fuel of higher energy density superior quality.

Watermills

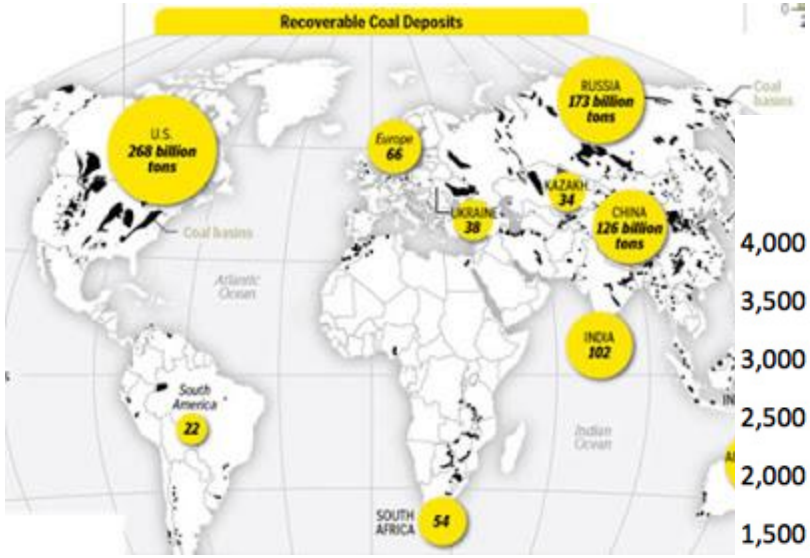

B
10^5
10^4
10^3
10^2
10^1
Power (W)
Water wheels
Windmills
Horses
Human labor
1000 500 0 500 1000 1500 2000
←BCE CE→

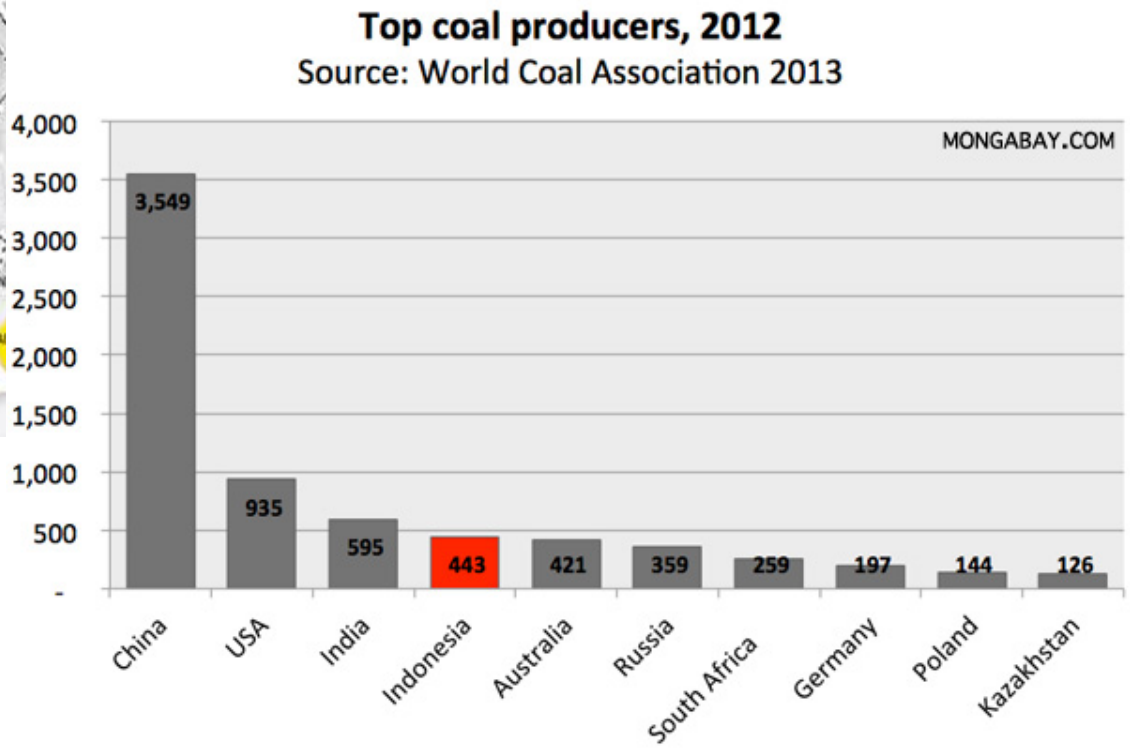
Industrial revolution and Coal



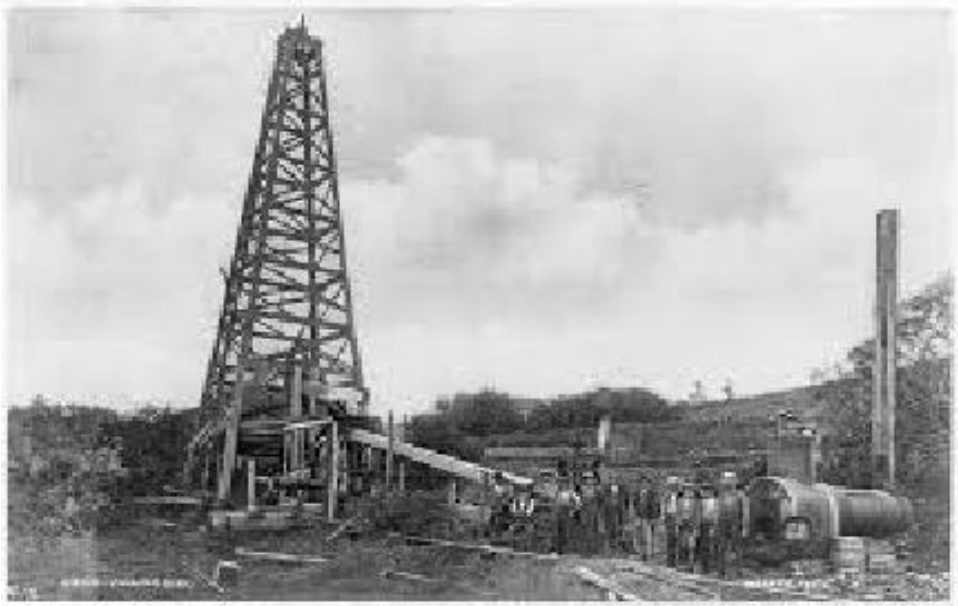

World Energy Consumption
Exajoules per Year
600
500
400
300
200
100
0
1820 1840 1860 1880 1900 1920 1940 1960 1980 2000
Nuclear
Hydro-Elect
Nat Gas
Oil
Coal
Biofuels

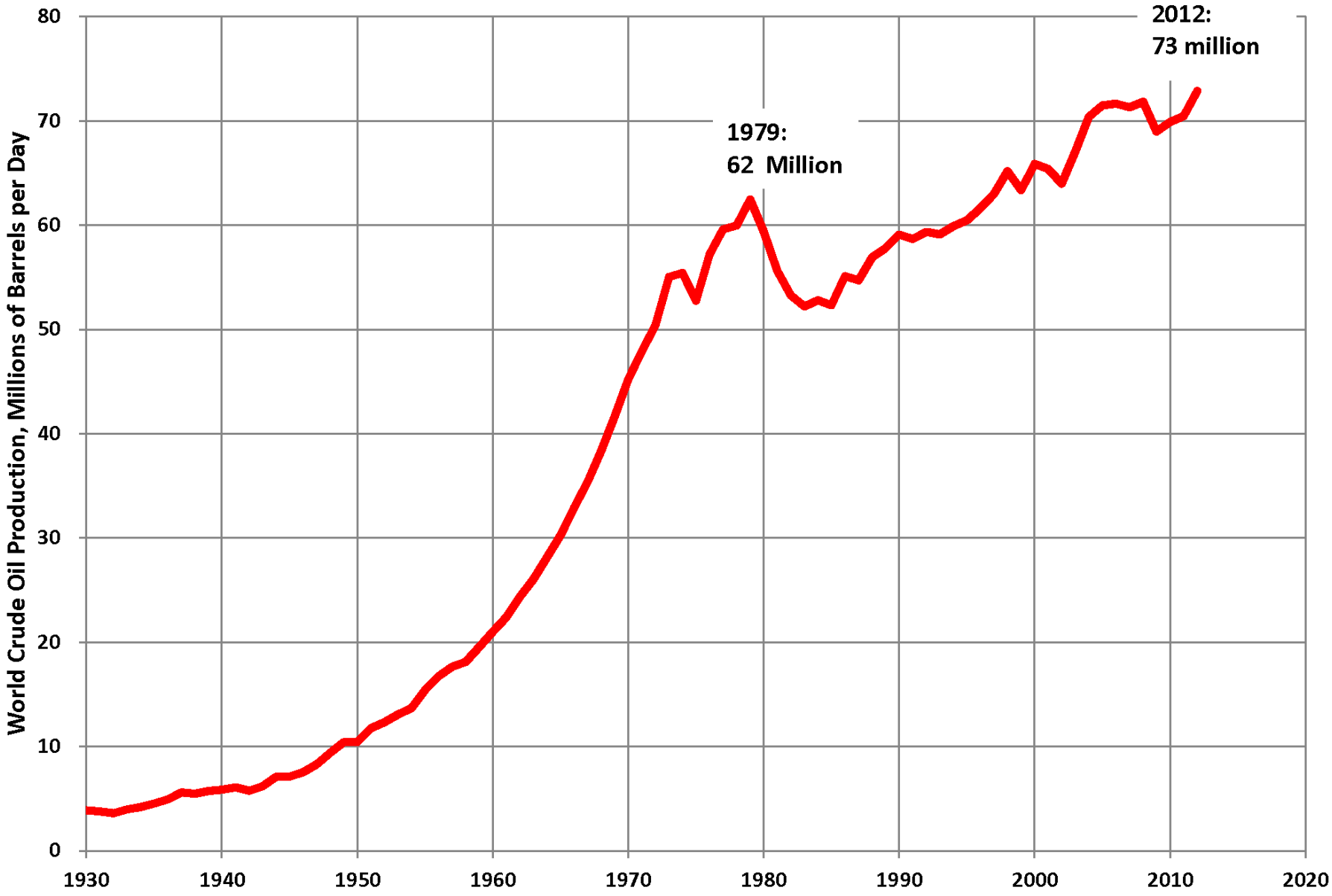
Coal reserves and production





Extraction of oil in Pennsylvania 1859




World Crude Oil Production, Millions of Barrels per Day
80
70
60
50
40
30
20
10
0
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
1979:
62 Million
2012:
73 million

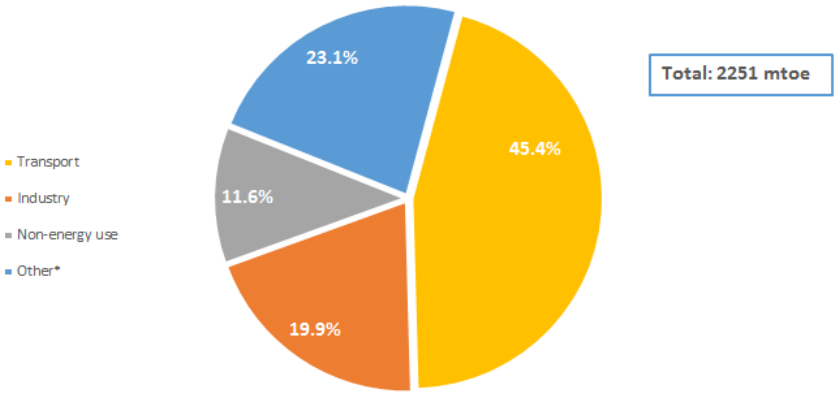
The petroleum industry grew through the 1800s ~ becoming a leading international industry as the 20th century progressed.

Today's top 3 oil producing countries:

Saudi Arabia
Russia
United States

Proven Reserves (millions of barrels)		U.S. EIA (start of 2015)[1]
Country	Rank	Reserves
Venezuela (see: Oil reserves in Venezuela)	1	298,350
Saudi Arabia (see: Oil reserves in Saudi Arabia)	2	268,289
Canada (see: Oil reserves in Canada)	3	172,481
Iran (see: Oil reserves in Iran)	4	157,800
Iraq (see: Oil reserves in Iraq)	5	144,211
Kuwait (see: Oil reserves in Kuwait)	6	104,000
UAE (see: Oil reserves in the United Arab Emirates)	7	97,800
Russia (see: Oil reserves in Russia)	8	80,000
Libya (see: Oil reserves in Libya)	9	48,363
United States (see: Oil reserves in the United States)	10	39,933

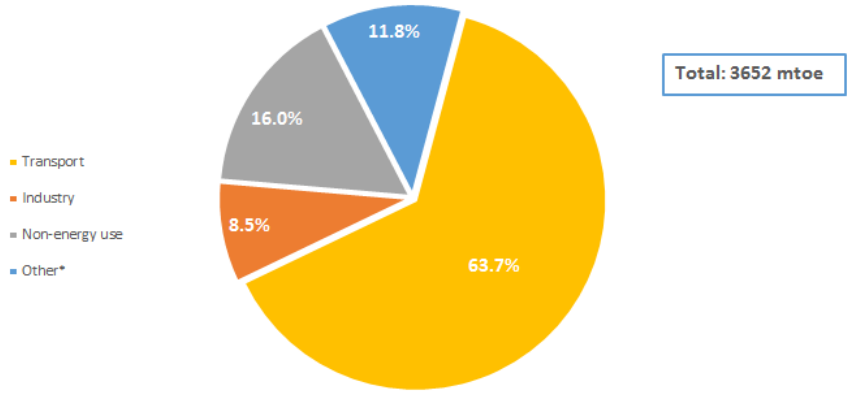
Global crude oil consumption in 1973, breakdown by sector



*Agriculture, buildings, commercial & public services, and others.

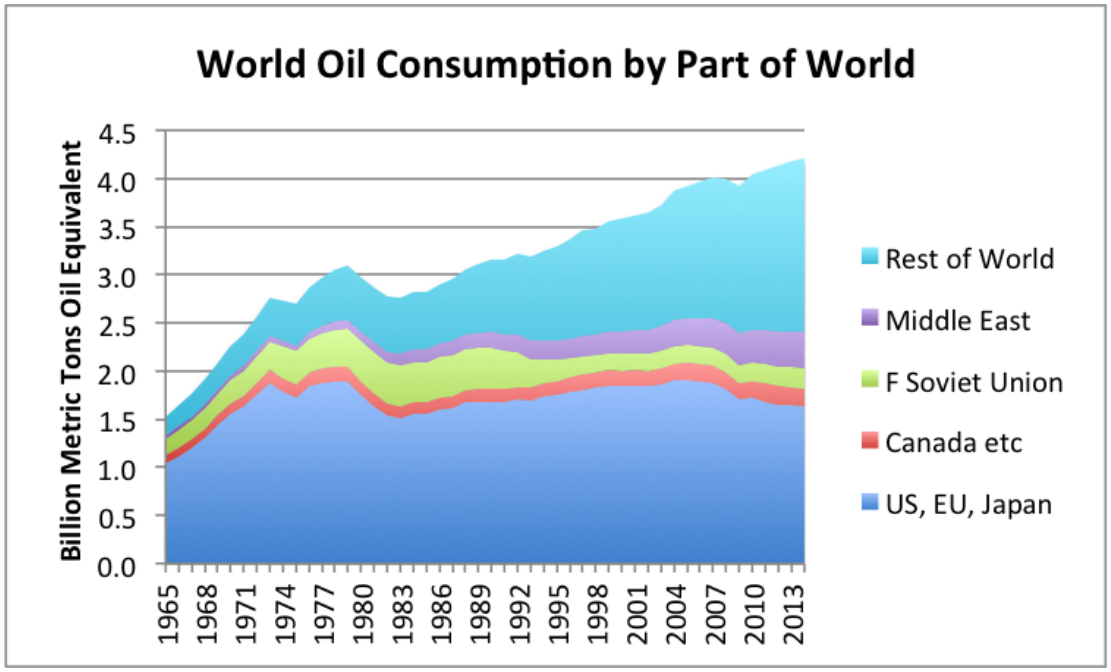
Source: IEA Key World Energy Statistics 2014

Global crude oil consumption in 2012, breakdown by sector



*Agriculture, buildings, commercial & public services, and others.

Source: IEA Key World Energy Statistics 2014



Natural Gas

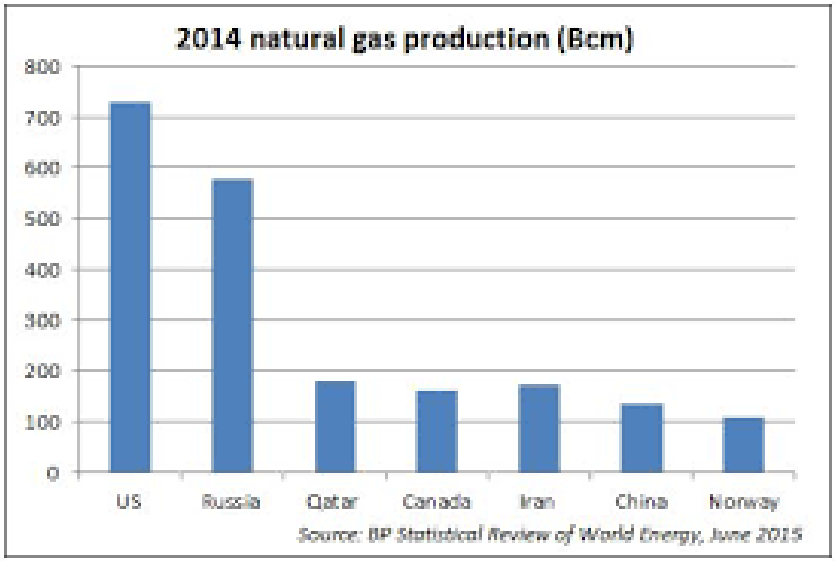
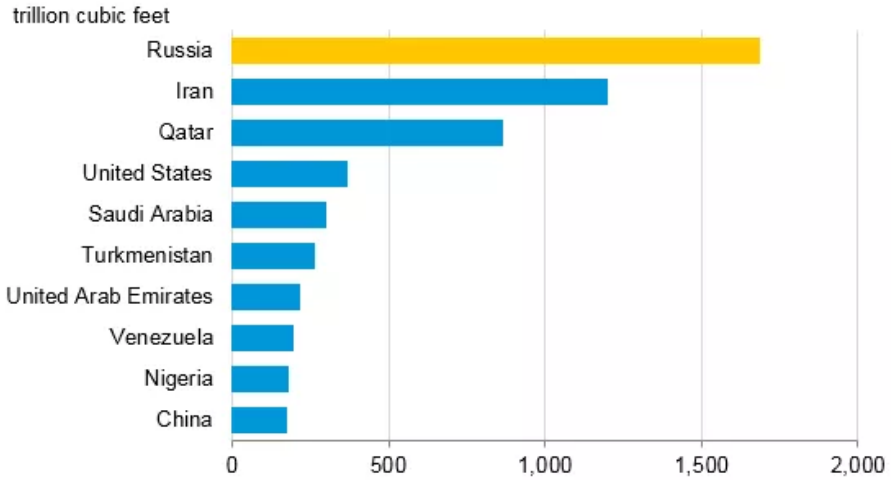
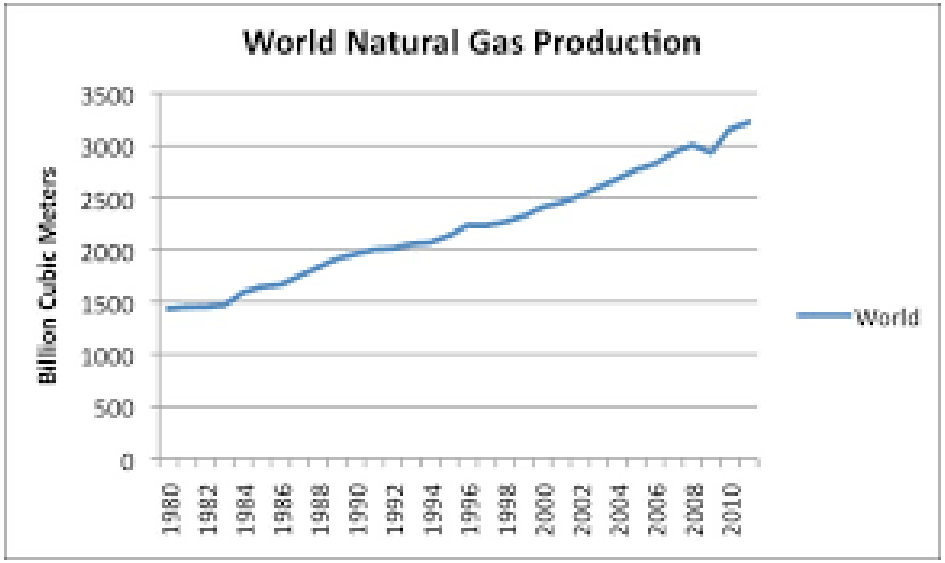


Figure 5. Estimated proved natural gas reserves, as of January 1, 2016

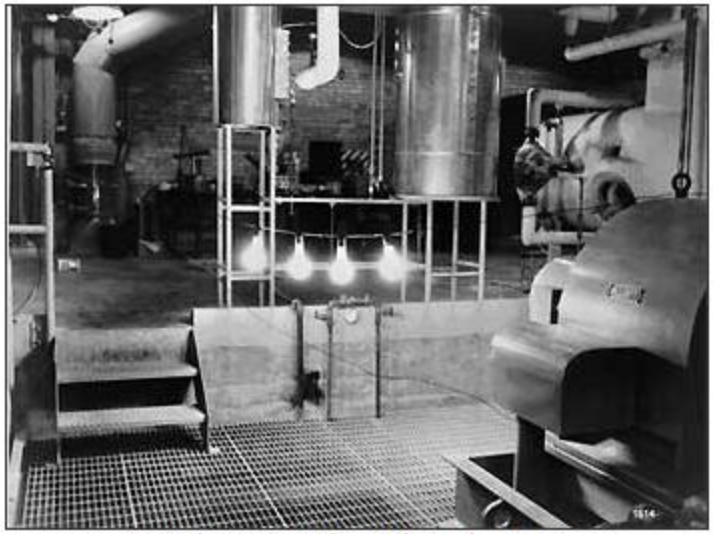


eia Source: *Oil & Gas Journal*, "Worldwide Look at Reserves and Production," December 7, 2015.

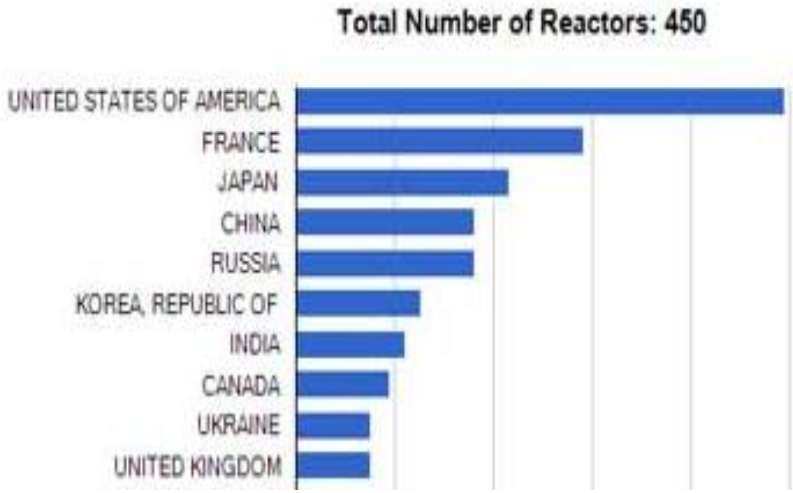


Nuclear Power Plants

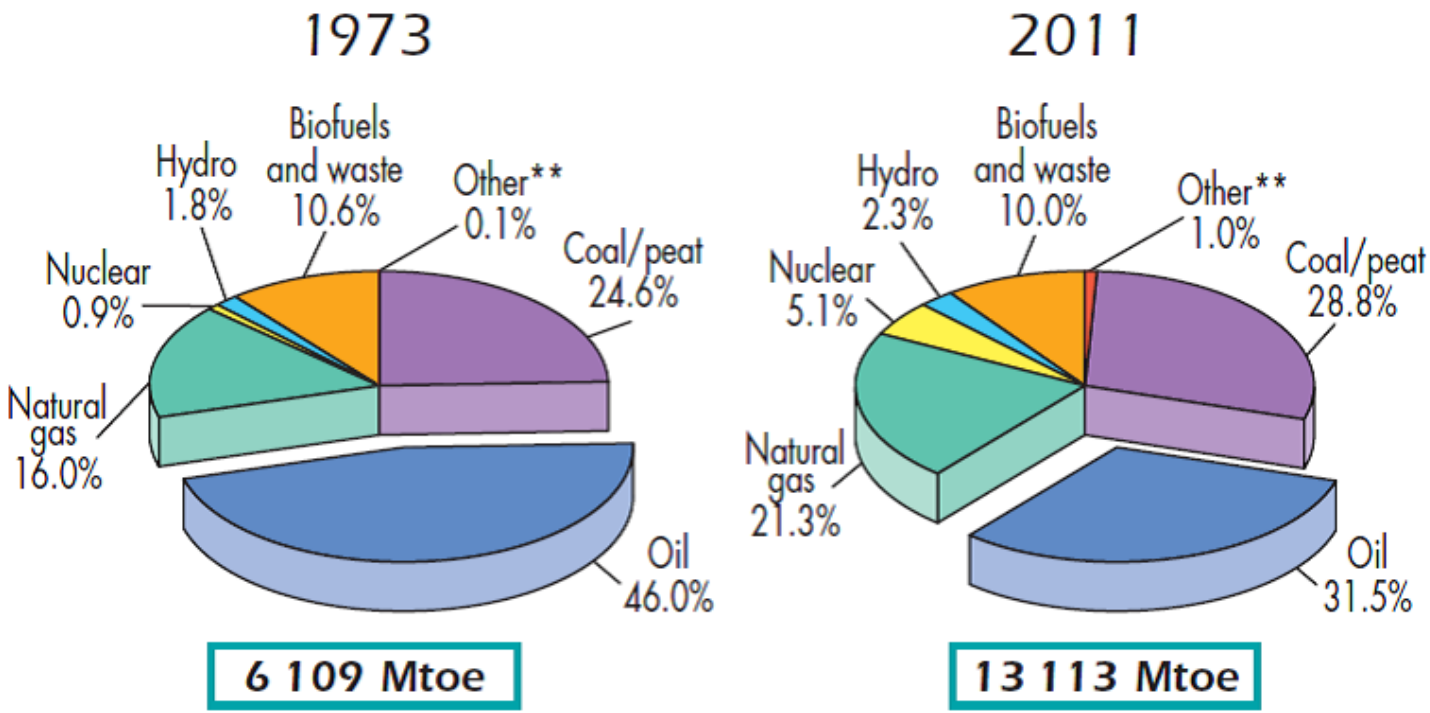
- Firstly discovered by physicist Enrico Fermi in 1934.



First electricity production by nuclear energy
Experimental Breeder Reactor EBR-I, 20 Dec.1951, Arco, Idaho, USA

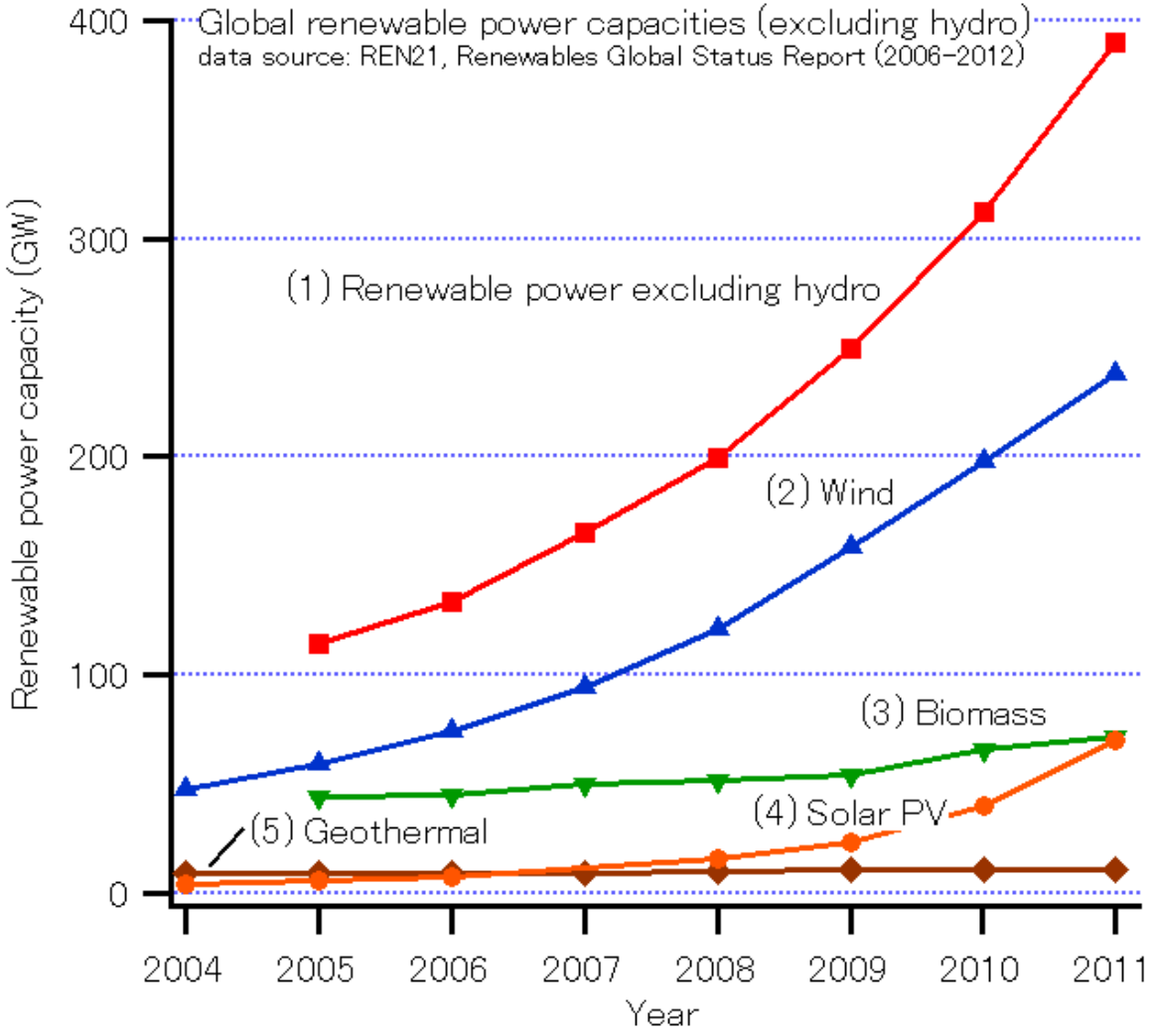


1973 and 2011 fuel shares of TPES

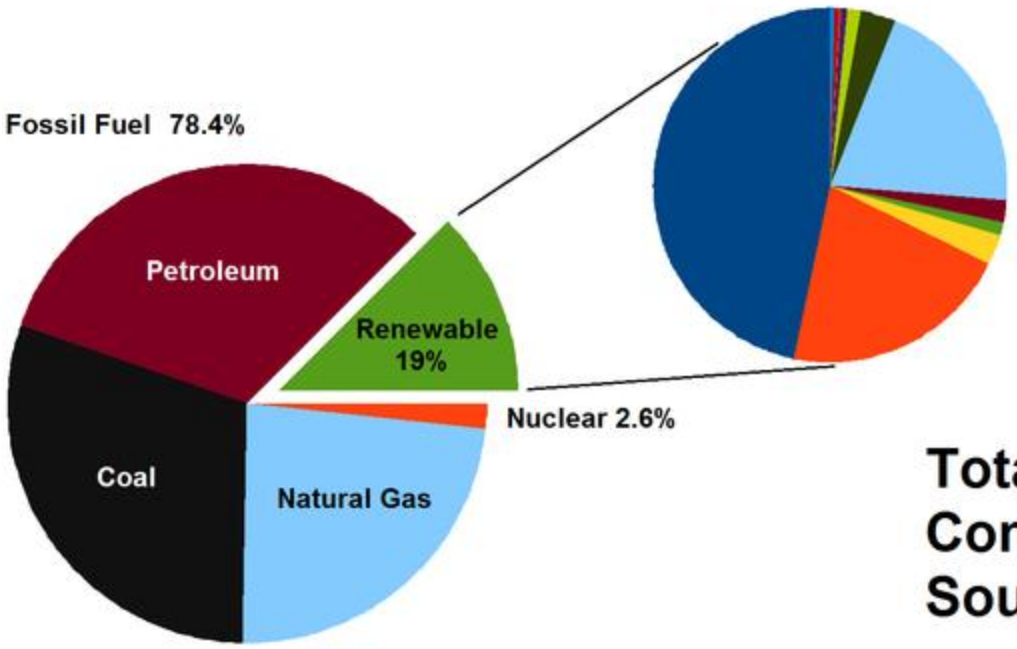


*World includes international aviation and international marine bunkers.
**Other includes geothermal, solar, wind, heat, etc.

Renewable energies



Selected renewable energy global indicators	2008	2009	2010	2011	2012	2013	2014	2015
Investment in new renewable capacity (annual) (10^9 USD)[83]	182	178	237	279	256	232	270	285
Renewables power capacity (existing) (GWe)	1,140	1,230	1,320	1,360	1,470	1,578	1,712	1,849
Hydropower capacity (existing) (GWe)	885	915	945	970	990	1,018	1,055	1,064
Wind power capacity (existing) (GWe)	121	159	198	238	283	319	370	433
Solar PV capacity (grid-connected) (GWe)	16	23	40	70	100	138	177	227
Solar hot water capacity (existing) (GWth)	130	160	185	232	255	373	406	435
Ethanol production (annual) (10^9 litres)	67	76	86	86	83	87	94	98
Biodiesel production (annual) (10^9 litres)	12	17.8	18.5	21.4	22.5	26	29.7	30
Countries with policy targets for renewable energy use	79	89	98	118	138	144	164	173
Source: The Renewable Energy Policy Network for the 21st Century (REN21)–Global Status Report[84][85][86][87][88]								



Renewable

Traditional biomass	9%
Bio-heat	2.6%
Ethanol	0.34%
Biodiesel	0.15%
Biopower generation	0.25%
Hydropower	3.8%
Wind	0.39%
Solar heating/cooling	0.16%
Solar PV	0.077%
Solar CSP	0.0039%
Geothermal heat	0.061%
Geothermal electricity	0.049%
Ocean power	0.00078%

Total World Energy Consumption by Source (2013)