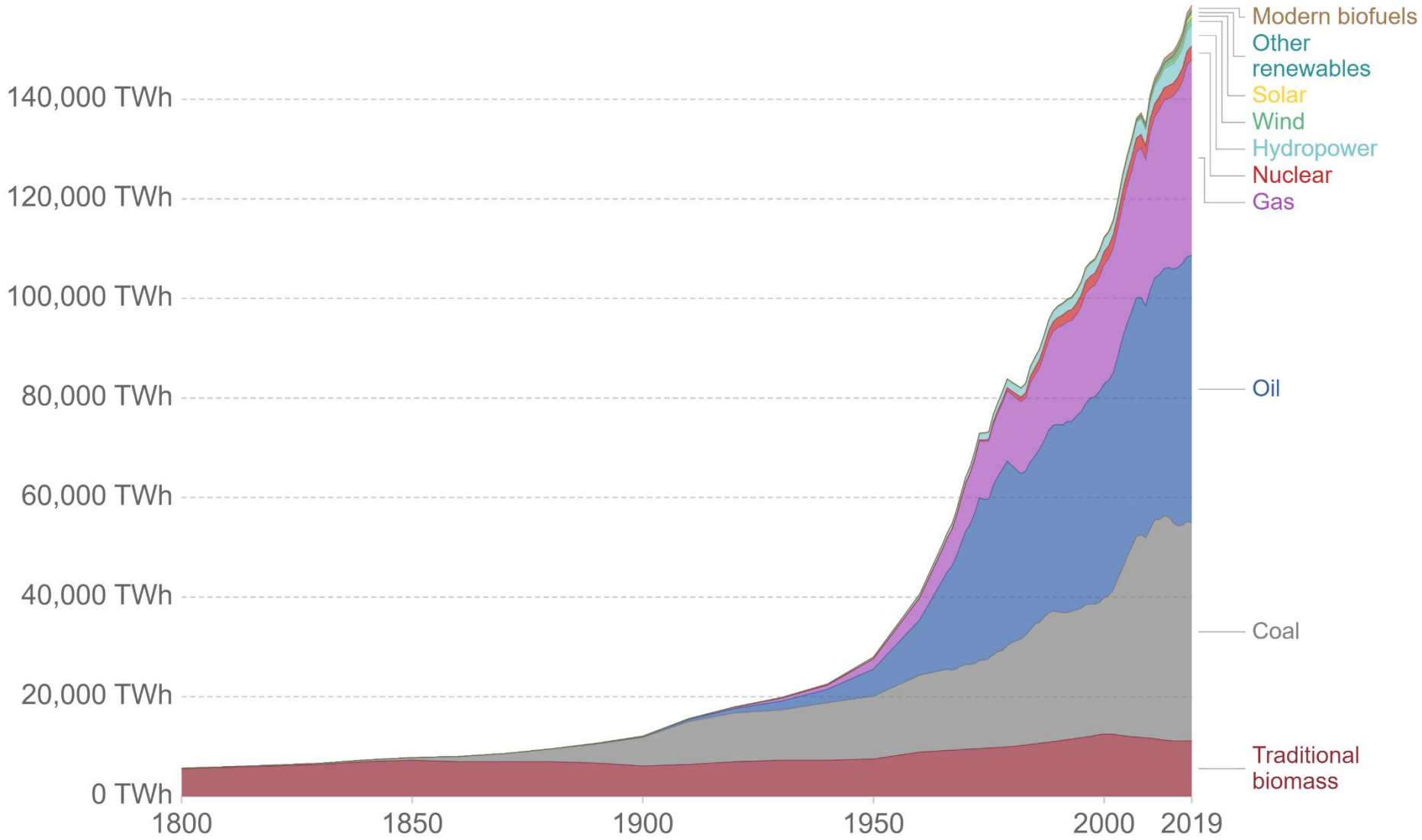
Coal, pollution, and externalities

Global direct primary energy consumption

Direct primary energy consumption does not take account of inefficiencies in fossil fuel production.

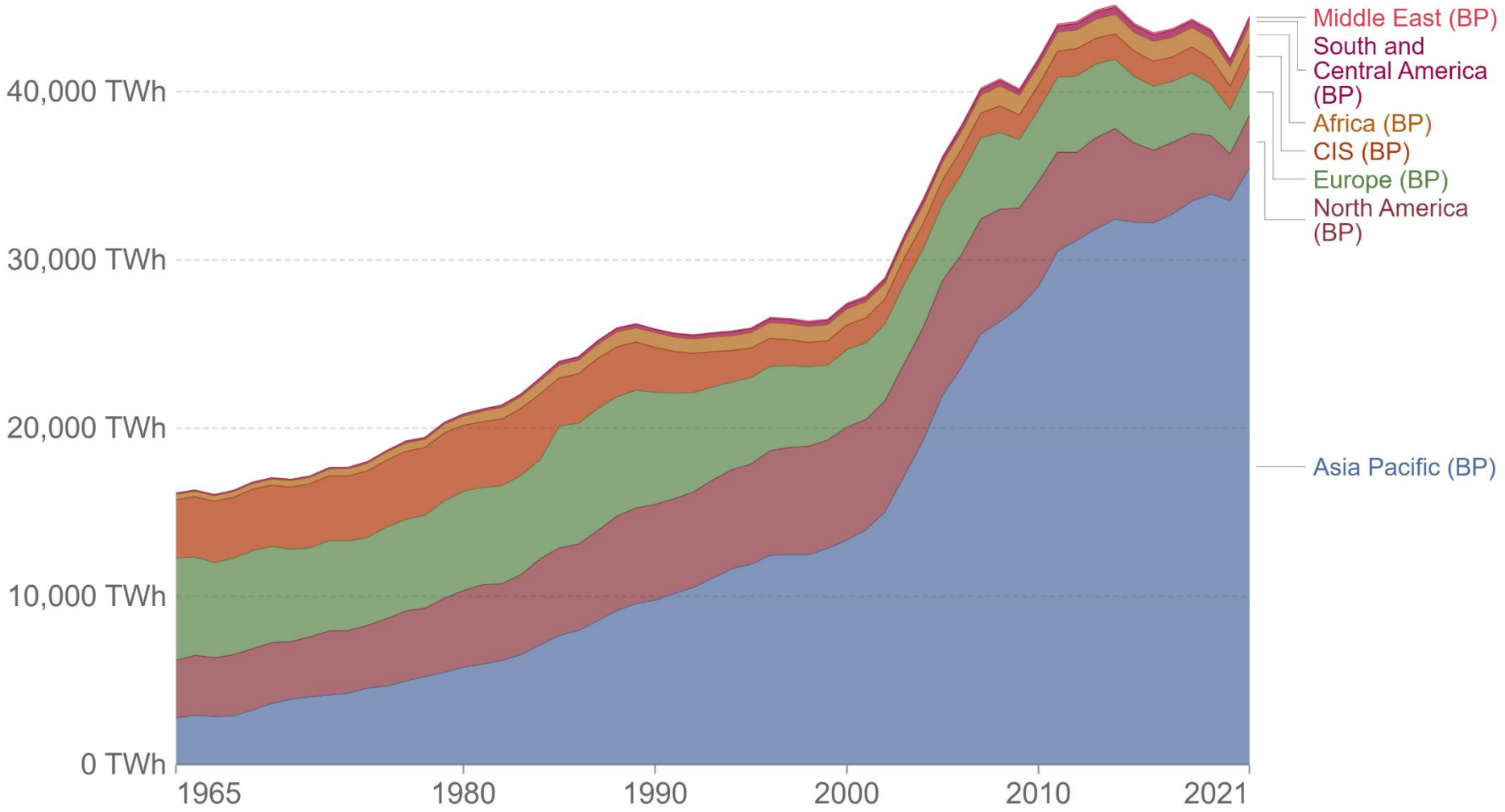
Our World in Data



Source: Vaclav Smil (2017) and BP Statistical Review of World Energy

Coal consumption by region

Annual coal consumption, measured in equivalents of terawatt-hours (TWh) per year.



Source: Statistical Review of World Energy - BP (2022)

OurWorldInData.org/fossil-fuels/ • CC BY

Note: CIS (Commonwealth of Independent States) is an organization of ten post-Soviet republics in Eurasia following break-up of the Soviet Union.

Environmental impacts

- Mining (opecast/surface mines and underground mines) – land use, water and air pollution, dust. Impact on biotops and landscape. Noise. Aestethical damages.
- Preparation for further processing – removal of impurities – acids, heavy metals, chemicals are released.
- Transport – dust from coal, transport-related pollution.
- Coal combustion – GHGs, primary pollutants, smog, acid rains.
- Solid waste – ash.

- Pollution - any substance that has harmful effects on natural ecosystems (and human health and well-being).

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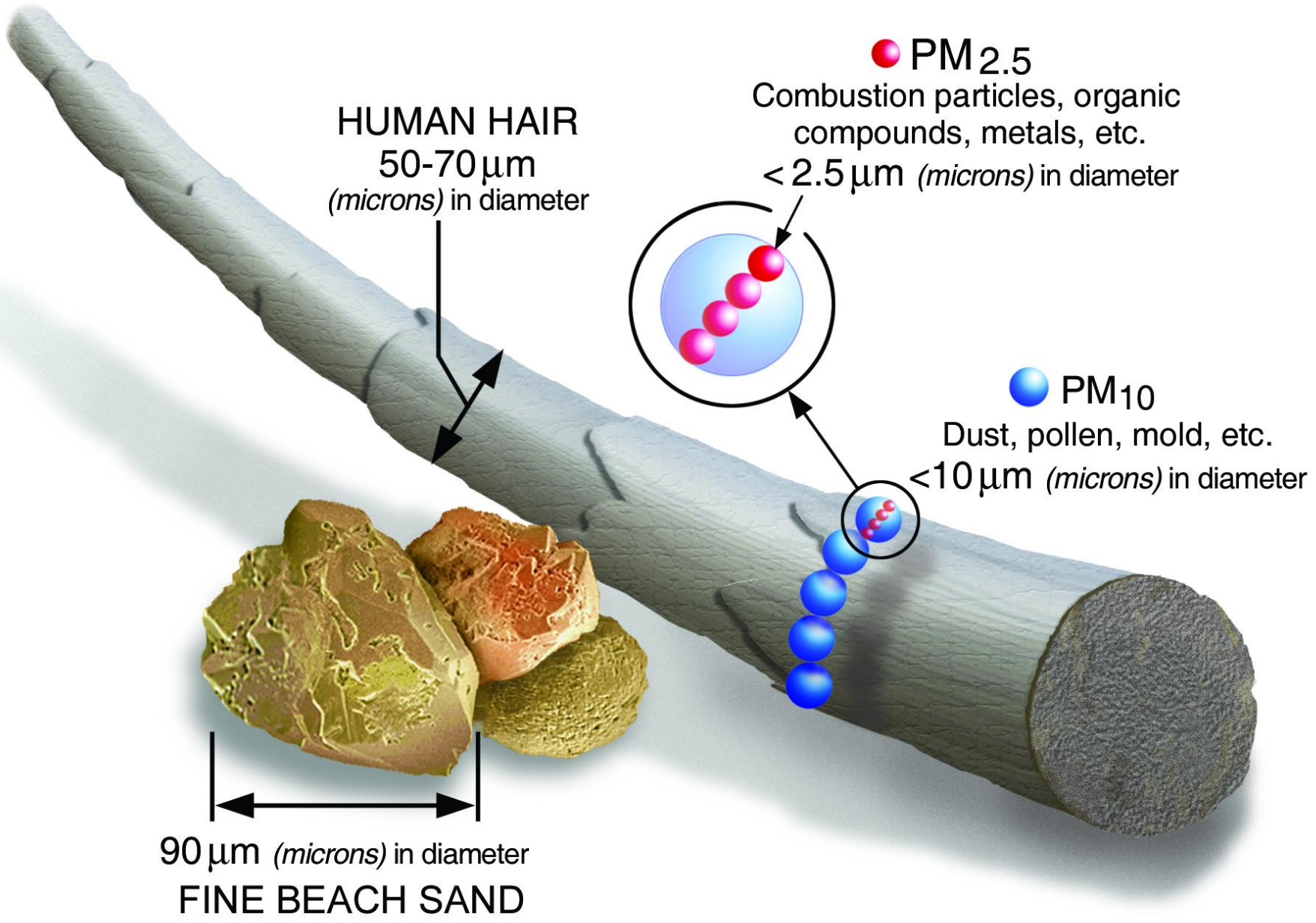
Particular matter

- Combustion of biomass, dung, coal, industrial processes, wind erosion, atmospheric reactions of gases, transportation, abrassion.
- Coal, heavier oils (incl. diesel oil)
- PM_{10} inhalable particles, $PM_{2,5}$ (fine inhalable particles)
- Respiratory (asthma development (suspected), asthma exacerbation, chronic obstructive pulmonary disease, stunted lung development, lung cancer), cardiovascular (cardiac arrhythmias, acute myocardial infarction, congestive heart failure) nervous system (ischemic stroke) impacts.


HUMAN HAIR
50-70 µm
(microns) in diameter
PM2.5
Combustion particles, organic
compounds, metals, etc.
< 2.5 µm (microns) in diameter
PM10
Dust, pollen, mold, etc.
<10 µm (microns) in diameter
90 µm (microns) in diameter
FINE BEACH SAND

Sulphur

- Combustion of sulfur-containing fuels (coal).
- Sulphur dioxide (SO_2).
- Can affect respiratory system and lung functions, aggravation of asthma and chronic bronchitis, make people more prone to infections of the respiratory tract; irritation of eyes; cardiac disease aggravated; ischemic stroke risk.
- Contributes to acid rains. Impact on aquatic life.

- $2SO_2 + O_2 \rightarrow 2SO_3$ $SO_3 + H_2O \rightarrow H_2SO_4$

- London smog
  - Smoke and fog, typically in winter (combination with inversion). SO_2 + PM (soot) + vater vapour = transport of gaseous matters of smog to the lungs.

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Carbon monoxide (CO)

- Incomplete (insufficient oxygen) combustion of fuels (and other carbon-containing materials, such as tobacco or wood).
- Mobile sources (cars, trucks, boats, aircraft etc.), fires, industriall processes, stationary combustion.
- Poisonous because of ability to bind to hemoglobin and block oxygen delivery to tissues. Visual impairment, reduced work capacity, reduced manual dexterity, poor learning ability, difficulty in performing complex tasks.

Nitrogen oxides

- Combustion of fuels. Mobile sources (transportation), stationary sources, industry, fires…
- Asthma development (suspected), asthma exacerbation, chronic obstructive pulmonary disease, stunted lung development; cardiac arrhythmias, ischemic stroke.
- Reacts with VOCs in sunlight to form ground- level ozone
- Increases an amount of nitrogen in soil and country – change of diversity. In aquasystems causes eutrophication. Increases acidity of soil and water.

Photochemical smog

- NO_2 + solar energy → NO+O; O+O_2 → O_3
- Ozone – bronchial constriction, coughing, wheezing, respiratory irritation, eye irritation, decreased crop yields, retars plant growth, damages plastics…

Heavy metals and other polutants

- Nickel, mercury, arsen, chromium, cadmium, lead, florine, chlorine…

CO_2 emissions by fuel (pouds of CO_2 /MBtu)

Coal (anthracite)	228.6
Coal (bituminous)	205.7
Coal (lignite)	215.4
Coal (subbituminous)	214.3
Diesel fuel and heating oil	161.3
Gasoline (without ethanol)	157.2
Propane	139.0
Natural gas	117.0

Emissions	**Amount of pollutants (in tons per 1TWh – 1000MW plant for 1000hrs)**
SO_2	2600
NO_x	2800

Representative 1000MW coal power plant = 6 million tons of CO_2 per year = equivalent of 2 million cars. Plus 2 670 000 tons of ash.

In CR production of around 40 TWh of electricity from coal, installed capacity around 11 700 MW. (2014).

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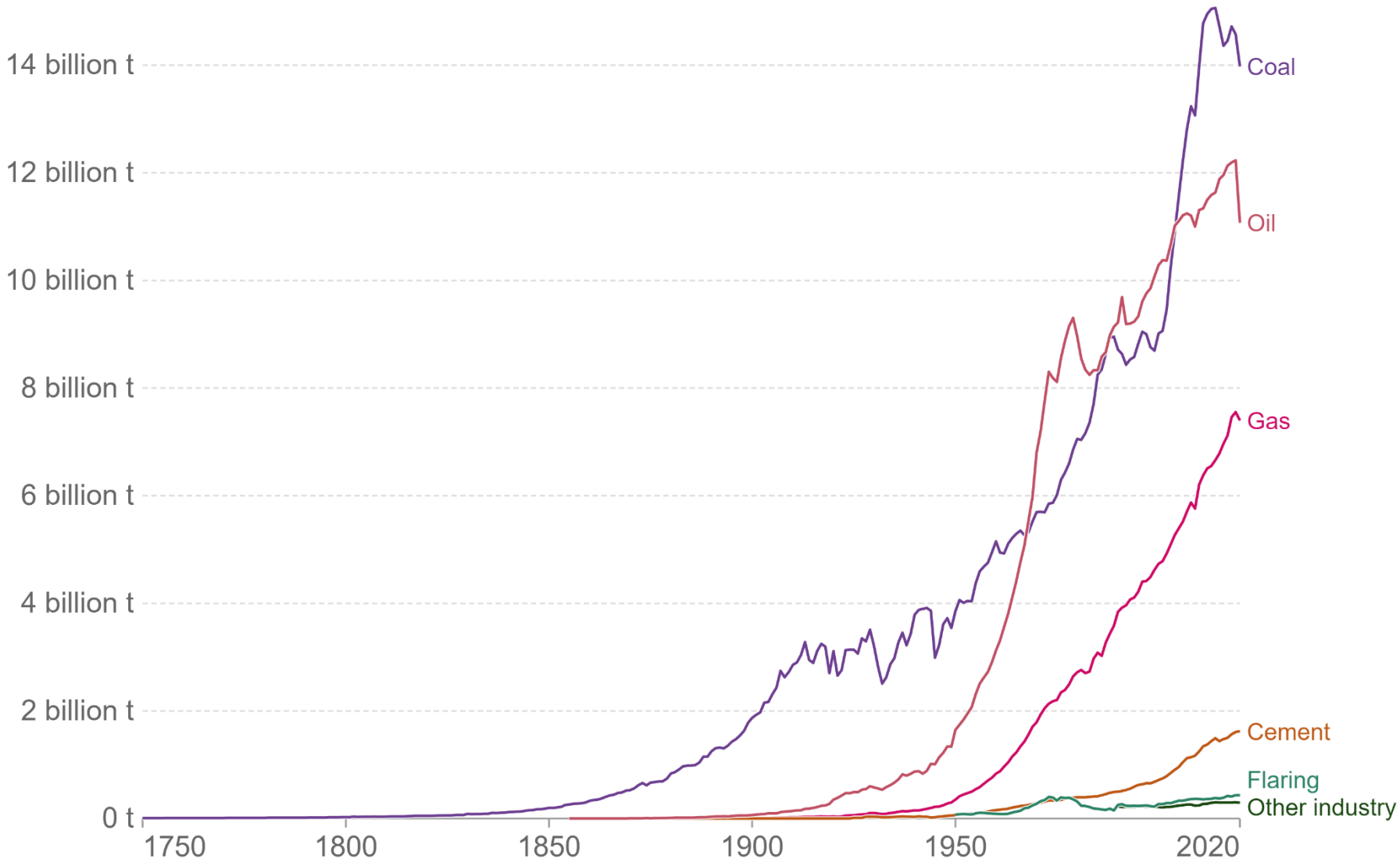
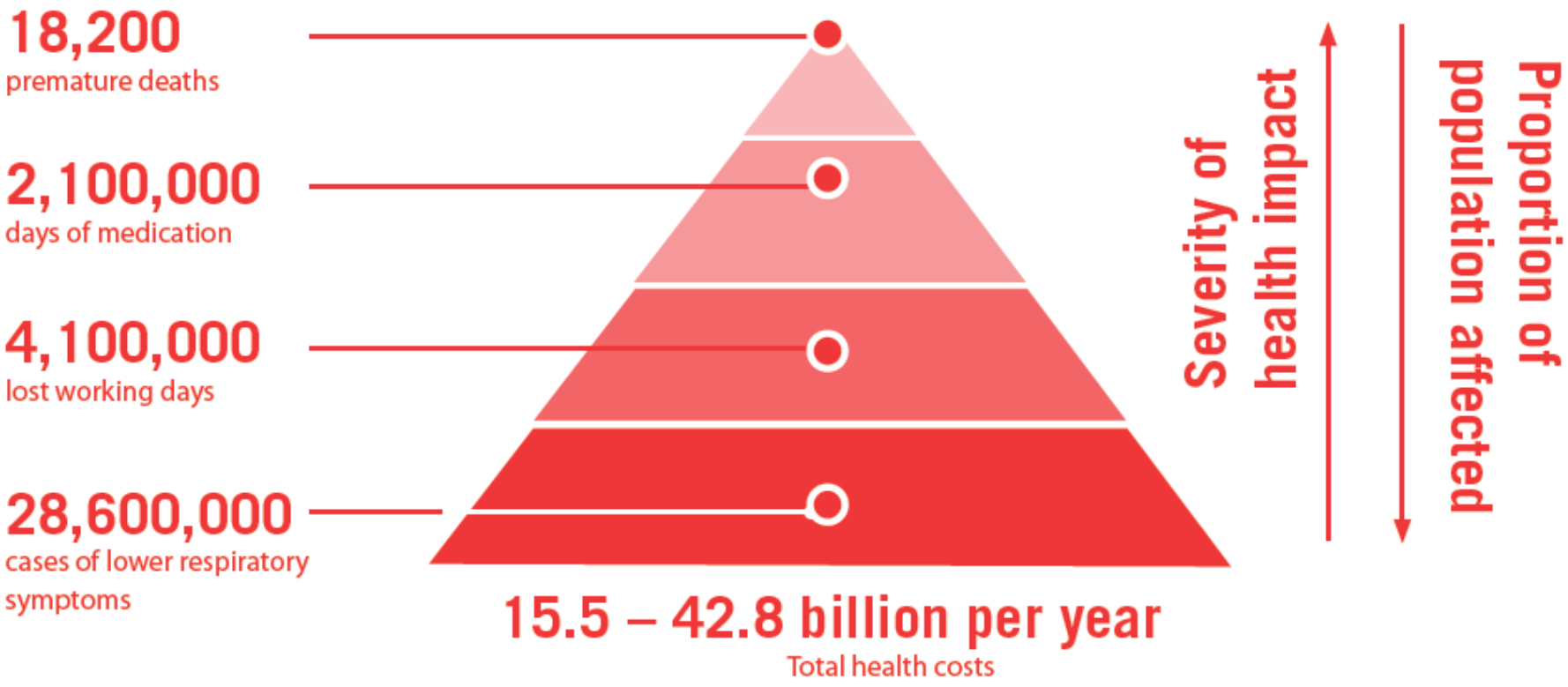
CO_2 emissions by fuel, World



Source: Global Carbon Project

OurWorldInData.org/co2-and-other-greenhouse-gas-emissions • CC BY

Health impacts of coal combustion

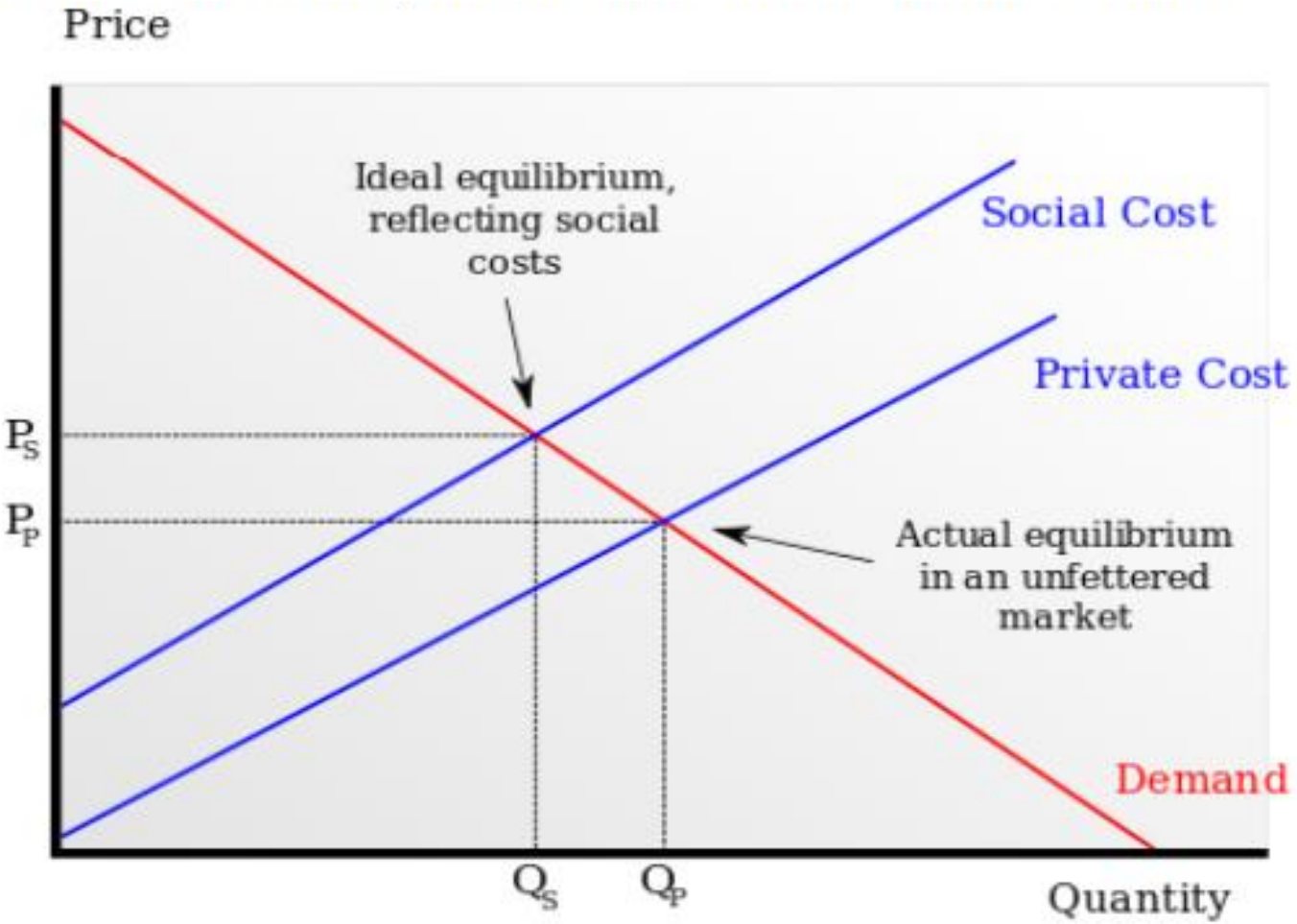


Annual health impacts caused by coal power plants in the EU (27 countries)

Externalities

- Who is paying for these damages to ecosystems and human health?
  - Reduction in life expectancy – respiratory and hearth ilnesses, cancers…
  - Degradation of buildings.
  - Reduction of crop yields.
  - Climate change.
  - Ecosystem loss and degradation.

Externalities



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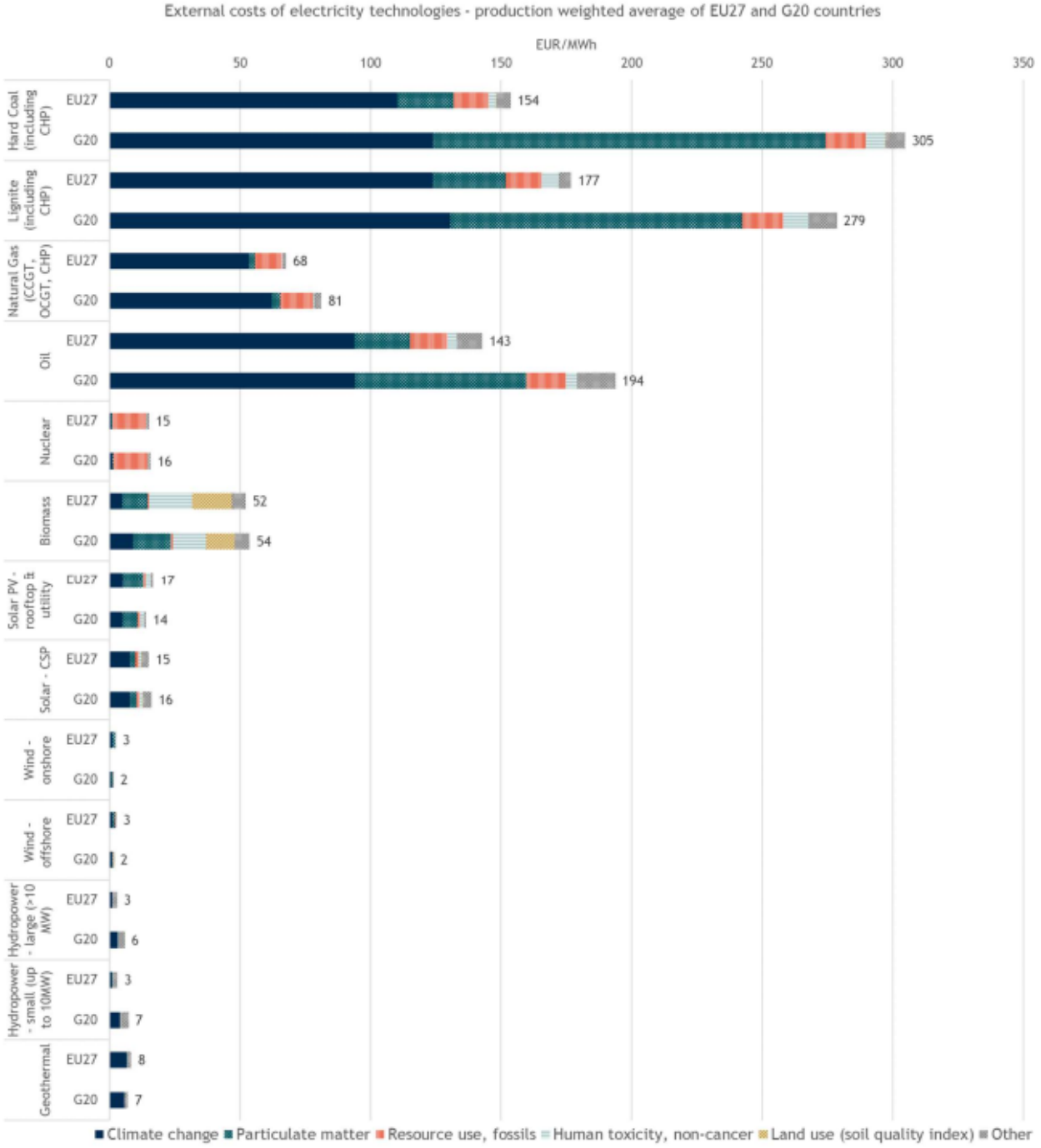
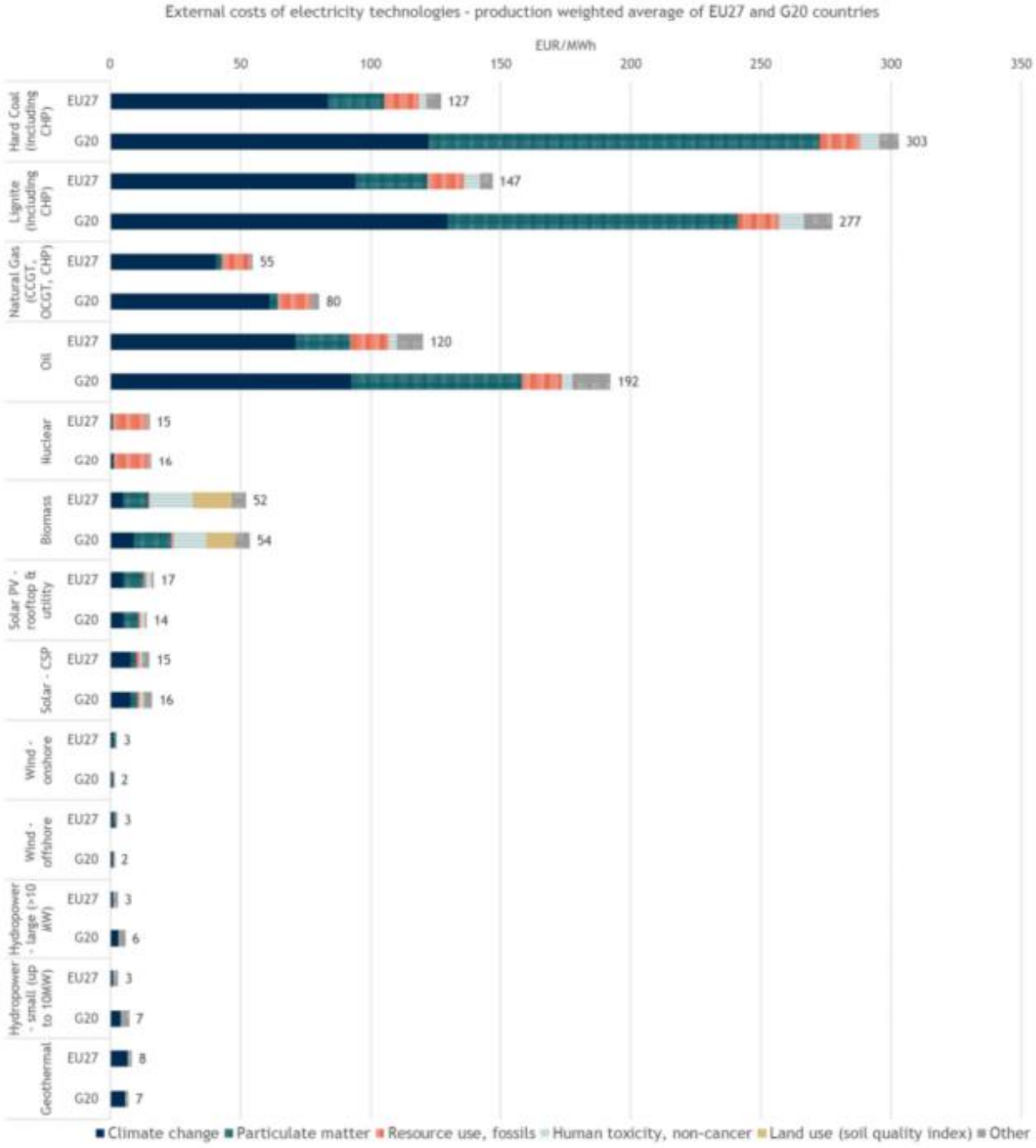

External costs of electricity technologies - production weighted average of EU27 and G20 countries
EUR/MWh
0
50
100
150
200
250
300
350
Hard Coal (including CHP)
EU27
154
G20
305
Lignite (including CHP)
EU27
177
G20
279
Natural Gas (CCGT, OCGT, CHP)
EU27
68
G20
81
Oil
EU27
143
G20
194
Nuclear
EU27
15
G20
16
Biomass
EU27
52
G20
54
Solar PV - rooftop & utility
EU27
17
G20
14
Solar - CSP
EU27
15
G20
16
Wind - onshore
EU27
3
G20
2
Wind - offshore
EU27
3
G20
2
Hydropower - large (>10 MW)
EU27
3
G20
6
Hydropower - small (up to 10MW)
EU27
3
G20
7
Geothermal
EU27
8
G20
7
Climate change
Particulate matter
Resource use, fossils
Human toxicity, non-cancer
Land use (soil quality index)
Other

Externality

- A consequence of an economic activity that is experienced by unrelated third parties. An externality can be either positive or negative.
  - (Pigouvian) taxes/subsidies.
  - Command and control solution.
  - Ownership rights.


External costs of electricity technologies - production weighted average of EU27 and G20 countries
EUR/MWh
0
50
100
150
200
250
300
350
Hard Coal (including CHP)
EU27
127
G20
303
Lignite (including CHP)
EU27
147
G20
277
Natural Gas (CCGT, OCGT, CHP)
EU27
55
G20
80
Oil
EU27
120
G20
192
Nuclear
EU27
15
G20
16
Biomass
EU27
52
G20
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G20
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Average monthly wholesale electricity prices

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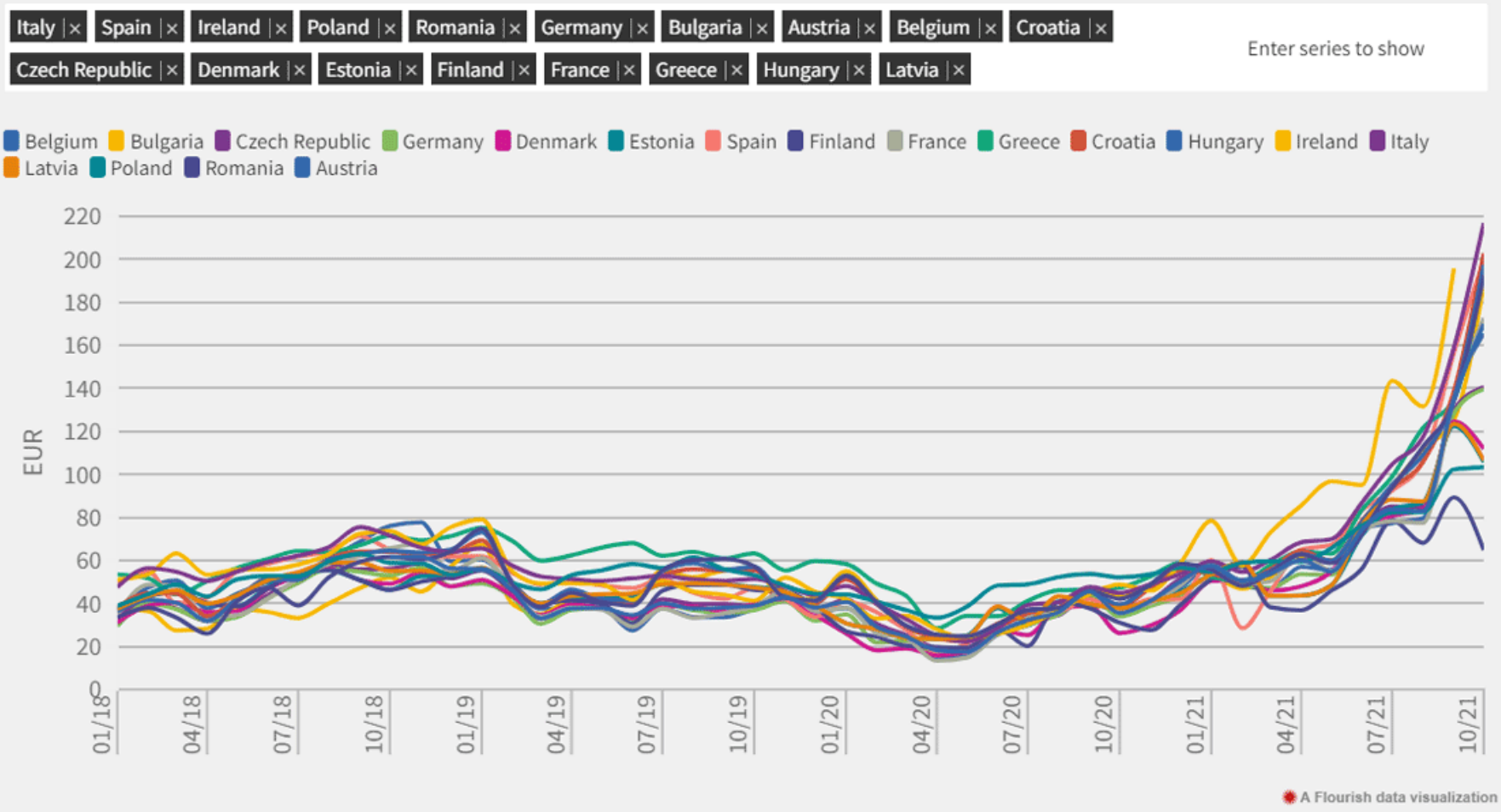

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Are fossil fuels cheap?

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Solution of the ´coal problem´?

- Source substitution.
- Higher efficiency of coal combustion.
- Reduction of coal pollutants during the process.
- CCS.

Sources

- IEA: Medium Term Coal Market Report 2015
- EIA: International Energy Statistics, 2015.
- HEAL: The Unpaid Helth Bill: How Coal Power Plants Make Us Sick, 2013
- Sourcewatch.org – External costs of coal
- Ecofys: Subsidies and costs of EU energy, 2014
- Ščastný, M.; Melichar, J.: External Cost of Fossil And Non-fossil Energy Systems: The Case of the Czech Republic, 2007
- Encyclopedia Britannica (n.d.): Asian Brown Cloud.
- EPA (n.d.): Particulate Matters (PM) Basics
- Guzder, D.(2009): Study Gets Inside the World´s „Brown Coal“.
- NASA (n.d.): Big Brown Cloud Storm over Asia
- Zdař Bůh: Důl ČSA na Mostecku musí těžař po konci dobývání zlikvidovat.

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