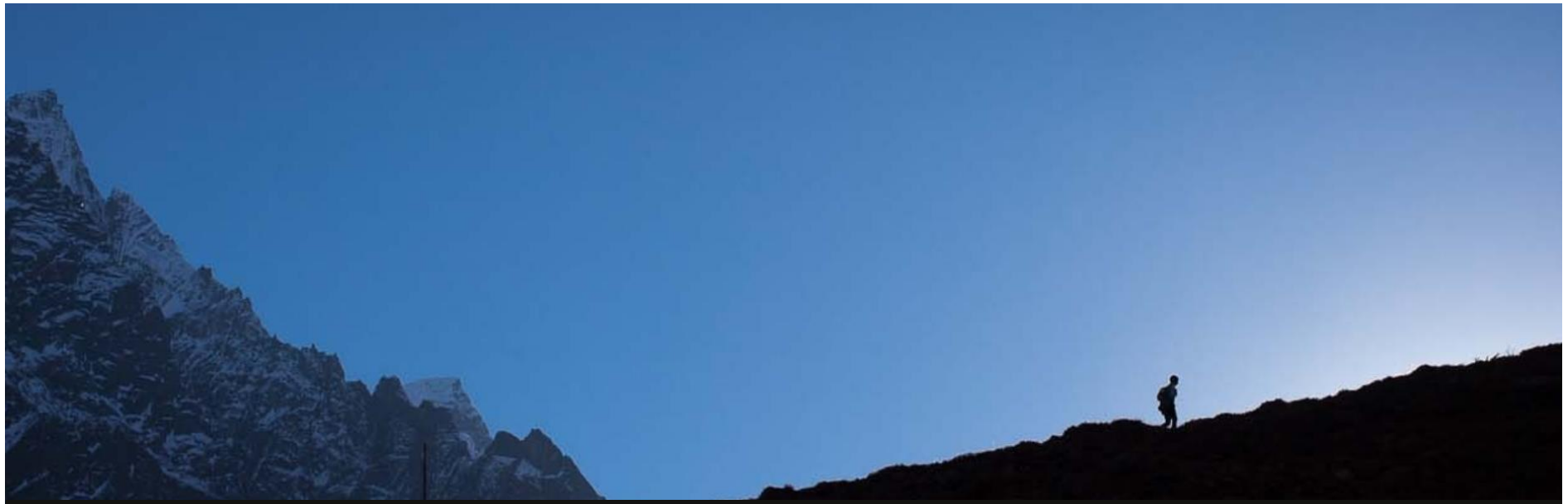
Doutoramento em Alterações Climáticas e Políticas de Desenvolvimento Sustentável



Class 2: 2nd March 2024 | Energy Concepts & Global energy system:

Sofia G. Simoes

SEMINAR ENERGY & CLIMATE CHANGE

Climate Change and Sustainable Development Policies

LNEG

NOVA SCHOOL OF SCIENCE & TECHNOLOGY

CENSE center for environmental and sustainability research

#	DATE		TOPIC	PROF.
1	02/mar Sat	9h-11h	**ENERGY & CLIMATE CHANGE:** A COMPLEX RELATION, PERENE AND INTERDISCIPLINARY. Framework and purpose of the course in the PDACPDS. Practicalities and seminar program. Basic concepts of the energy systems.	J. Seixas, FCT NOVA
2	02/mar Sat	11h-13h	**Energy Concepts & Global energy system:** primary/final energy; energy efficiency; sankey diagrams; energy services; energy carriers; final energy supply cost curves; energy production and consumption regions; energy access; energy and carbon intensity. How GHG (greenhouse gases emissions) are estimated.	S. Simões
3	16/mar Sat	9h-11h	**Global balance of CO_2 emissions** associated with energy and industrial processes. The greenhouse effect. GHG emissions from fossil energy per sources and countries. Estimates of the Global Carbon Budget (http://www.globalcarbonproject.org/) and its relationship to the global energy system and changes in land use. Future scenarios for GHG emissions: SSPs and RCPs. Global emissions based on consumption vs. production.	S. Simões
4	22/mar Friday	18h-20h	**GHG Emission Mitigation options:** Mitigation vs adaptation. Fuel switch, renewable energy, energy efficiency, green hydrogen, nuclear power, carbon capture & storage/utilisation, carbon removal. Behavioural mitigation options. Introduction to assignment.	S. Simões
5	05/apr Friday	14h-16h	**Drawdown** - Multisector Climate Solutions	J.P. Gouveia
6	12/apr Friday	14h-16h	**Renewables technologies:** Renewable energy technologies. Energy security of endogenous vs. imported resources. Learning curves of renewable energy technologies. Definition and usefulness of LCOE. System value of Renewables. Global renewables' market. Sustainability issues related with renewables. Land & water use, critical raw materials. Discussion: Where to place 7GW of solar PV in Portugal till 2030?	S. Simões
7	19/apr Friday	14h-16h	**Policy and economy of Climate Change:** Global framework to deal with climate change: UNFCCC, Paris Agreement. EU climate policy framework (FF55, REPowerEU, CBAM, etc.). Fundamentals of carbon and climate economics: risks and opportunities for organisations and businesses. State of the art on carbon pricing: emissions trading schemes, carbon taxes. Introduction to EN-Roads Simulation Game	S. Simões

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8	03/may Friday	16h-18h	**30min Mini-quizz in class** (20% of final grade). **EN-Roads** simulation game: the transformation towards sustainability — interconnected challenges and solutions	students / S. Simões
9	10/may Friday	16h-18h	**Resources and datasets on energy and GHG emissions**: access to energy databases, Portuguese and European (PORDATA, DGEG, EUROSTAT). i) How to find and explore energy statistics and emissions of greenhouse gas (GHG) emissions for Europe and Portugal; ii) How to make energy conversions; iii) How to build indicators and charts with added value; iii) How to analyze economic sectors, and interpret their performance in terms of energy consumption and greenhouse gas emissions.	S. Simões
10	17/may Friday	16h-18h	**Energy systems modelling:** most well known models and exemplary applications at different scales & **Mentoring** with each students' group : discussion on the approach and methods adopted by the students, expected results to be obtained with the final work; assessing preliminary results, if any.	S. Simões
11	23/may Thursday	18h-20h	**Business strategy for climate change:** Climate change risks for companies. Mitigation, adaptation and risk management in companies. GHG emissions inventories. Carbon footprint of products. Rationale and examples of carbon voluntary markets.	S. Simões
12	24/may Friday	18h-20h	**Sustainable Cities and Buildings:** concept, components and implications for the energy systems. Energy poverty and the energy transitions.	J.P. Gouveia
13	07/jun Friday	18h-20h	**Evaluation**: assignment presentation by the students. Discussion in class (80% of final grade)	S. Simões / J. Seixas

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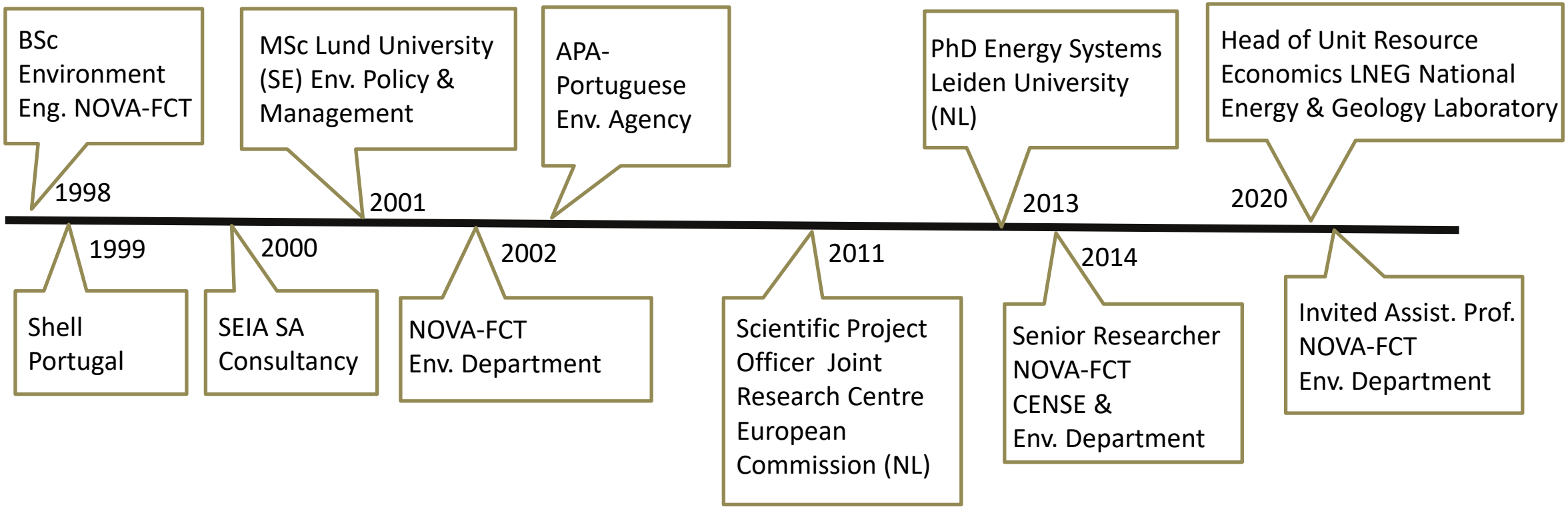
Sofia G. Simões



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LNEG Resource Economics Unit

The unit is **crosscutting the Energy and Geology areas** of LNEG
Develops I&D&D activities and decision-support for both public policy-makers and the private sector on **energy and geology resource economics, towards carbon neutrality and sustainable resource exploitation and use**

The unit applies techno-economic & social analytical approaches in the following I&D fields:

1

Sustainable energy systems

2

Resource use for energy production and consumption

3

Classification of geological deposits in a global economy

4

Economic and social impact of the energy transition

5

Circular economy, including design of products, services, systems and business models

6

Sustainable public circular procurement

https://www.lneg.pt/en/unit/resource-economics-unit/

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If you need to discuss topics related to the course, including the assignment, I am available on Thursdays 10h-11h – send me an e-mail to book this slot at least 4 days before

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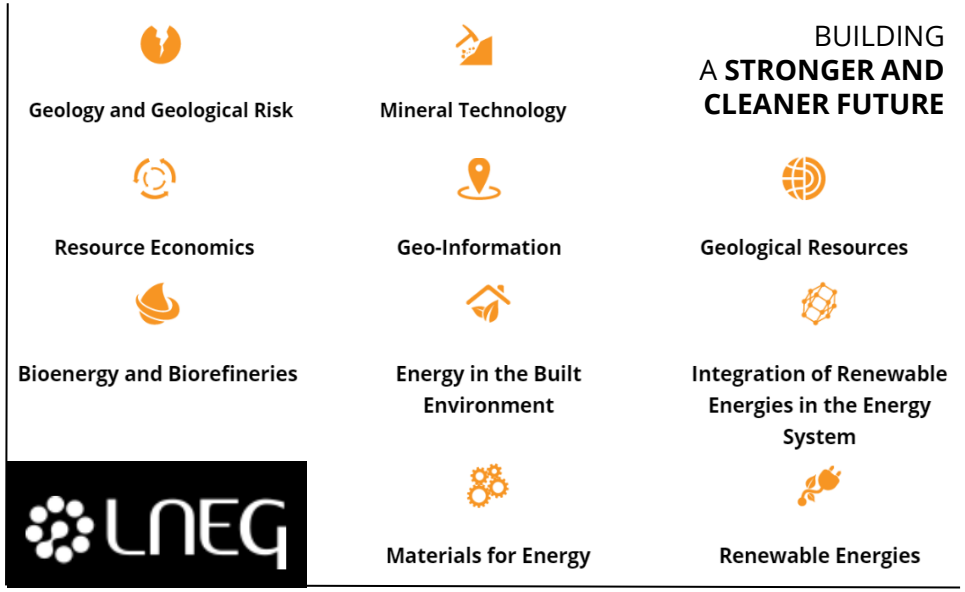

http://www.lneg.pt

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sgcs@fct.unl.pt

REPÚBLICA PORTUGUESA
AMBIENTE E AÇÃO CLIMÁTICA

BP Statistical Review of World Energy 2015
© BP p.l.c. 2015

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86% OF CAR JOURNEYS TO WORK ARE DRIVER ONLY

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Topics

- Some energy concepts
  - Primary/final energy
  - Energy efficiency
  - Energy carriers and energy services
  - Sankey diagrams
  - Final energy supply cost curves
- energy production and consumption regions
- energy access
- energy and carbon intensity
- How GHG (greenhouse gases emissions) are estimated.

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Seminar on Energy and climate change course will give you some skills from the following domains

- Engineering
- Geophysics
- Management and economics
- Systems thinking
- Marketing and psychology
- Law and international affairs
- …

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Some energy concepts

Darling Harbour, Sydney, Australia

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Let's talk energy (units)

toe/tep tonne of oil equivalent (Mtoe, ktoe)

Wh watt hour (TWh, GWh, MWh, kWh)

J joule (**EJ, PJ**, TJ, GJ)

Btu British thermal units

cal calorie

tce tonne of coal equivalent

[Installed capacity in GW, TW, MW]

https://www.iea.org/reports/unit-converter-and-glossary

Capacity (MW) x operation hours (no. hours) x capacity factor (non-dimensional) = energy production (MWh)

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Some of the best sources of information

https://www.iea.org/

https://www.irena.org/

https://www.ipcc.ch/

https://www.globalcarbonproject.org/

https://ourworldindata.org/

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Basic energy concepts (part 1)

Primary/final energy

Primary energy consumption refers to energy the is converted into **final energy** (e.g. coal, crude oil, natural gas, wind resources, solar power, biomass), which in turns refers to what end users actually consume (e.g. electricity, heat, gasoline, and here it can also be natural gas if used directly in a boiler and not for electricity generation). The difference between the two relates mainly to what the energy sector needs itself and to transformation and distribution losses.

Energy efficiency

In general terms, **energy efficiency** refers to the amount of output that can be produced with a given input of energy. It is frequently measured as the amount of energy output for a given energy input (e.g. the amount of mechanical energy that an electric motor produces for a given input of electrical energy). More info here

Energy services

Energy services are the tasks performed using energy, such as: space heating and cooling, domestic water heating, machine drive, process heat for industry, mobility of passengers and goods, lighting, entertainment, cooking, clothes washing & drying, refrigeration, etc. More info here.

Energy carriers

An **energy carrier** is a substance or a phenomenon that can be used to produce mechanical work or heat or to operate chemical or physical processes. **Energy carriers** occupy intermediate steps in the energy-supply chain between primary sources and end-use applications. "An energy carrier is thus a transmitter of energy, or, in other words, any system or substance that contains energy for conversion as usable energy later or somewhere else". Examples of energy carriers are: electricity, heat and solid (coal, wood), liquid(petroleum, ethanol, gasoline) or gaseous(hydrogen, natural gas) fuels, but the concept can also be applied to springs, electrical batteries, capacitors, pressurized air or dammed water. More info here

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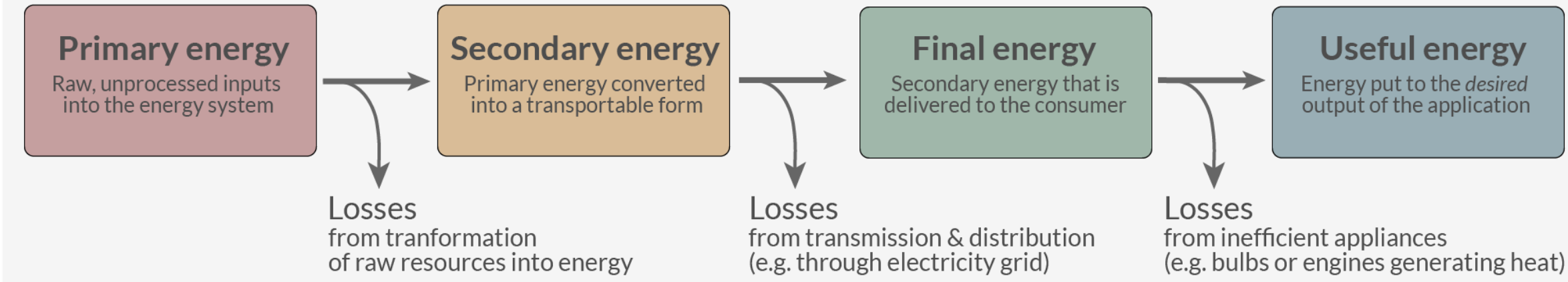
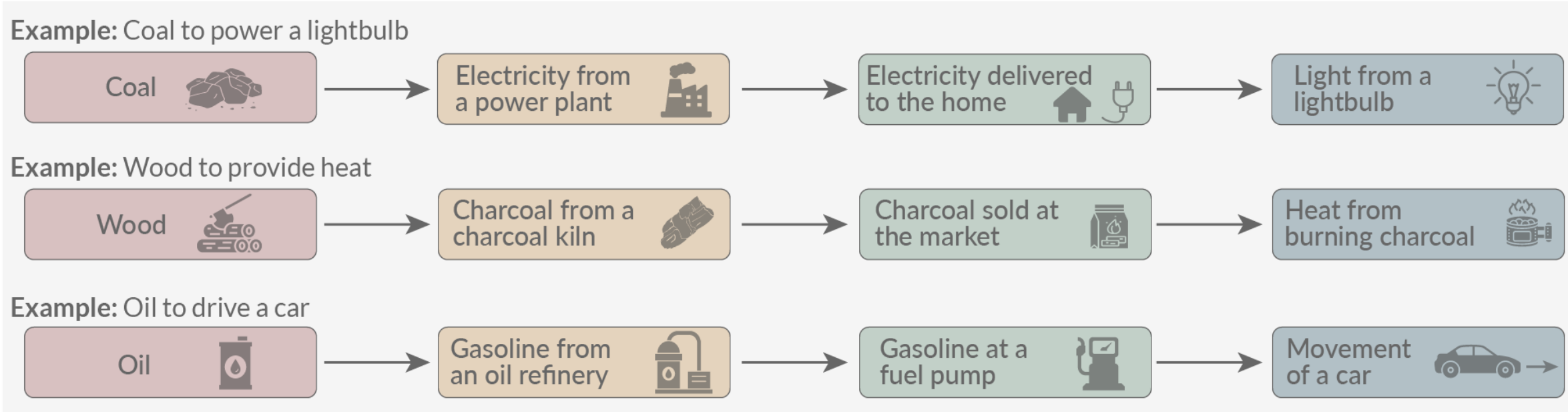
The four ways of measuring energy

https://ourworldindata.org/energy-substitution-method

Our World in Data





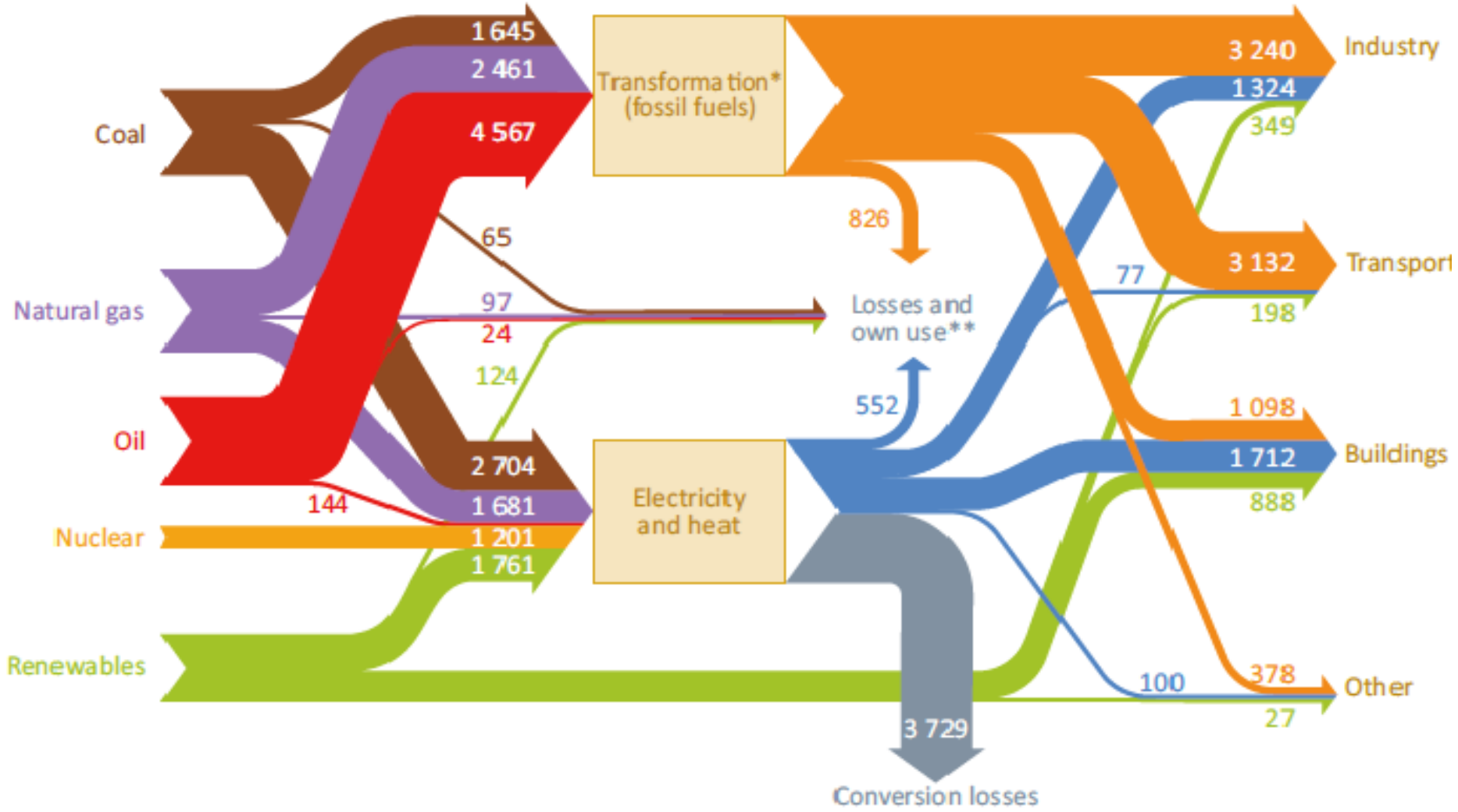
Icon source: Noun Project.

OurWorldinData.org – Research and data to make progress against the world's largest problems.

Licensed under CC-BY by the author Hannah Ritchie.

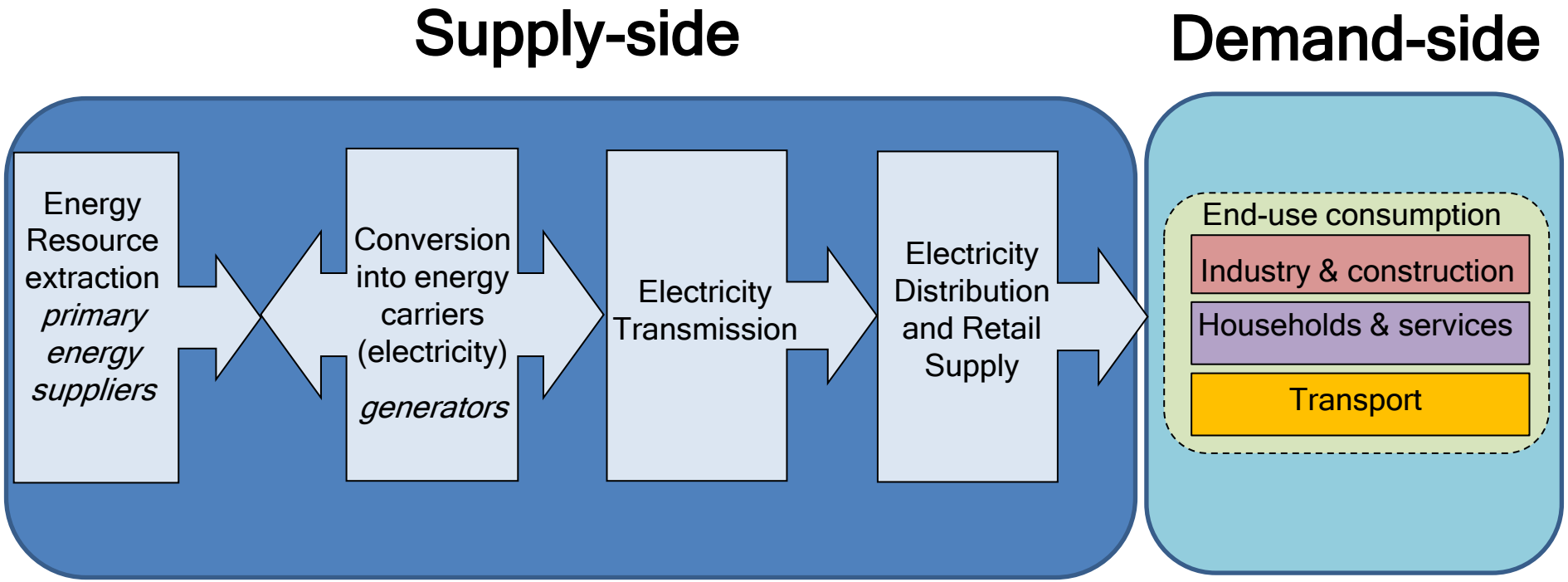
Sankey diagram

Figure 2.11 ▷ World energy demand by fuel and sector in the New Policies Scenario, 2040 (Mtoe)



© OECD/IEA 2015 – World Energy Outlook 2015

Energy & Climate Change – systemic approach needed



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Energy services – not the same as energy demand

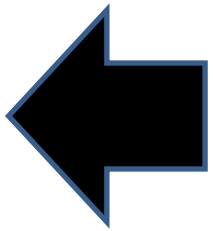
Energy services

- Lighting
- Refrigeration
- Freezing
- Cooking
- Clothes washing, drying
- Dishwashing
- Space heating
- Space cooling
- Water heating
- Recreation
- Drilling
- Ventilation
- Communication
- Water pumping

- Mobility

- Process heat
- Machine drive in industry

- (…)



ENERGY

What technology to buy?
How to use the energy technology properly?
Do we really need that technology?

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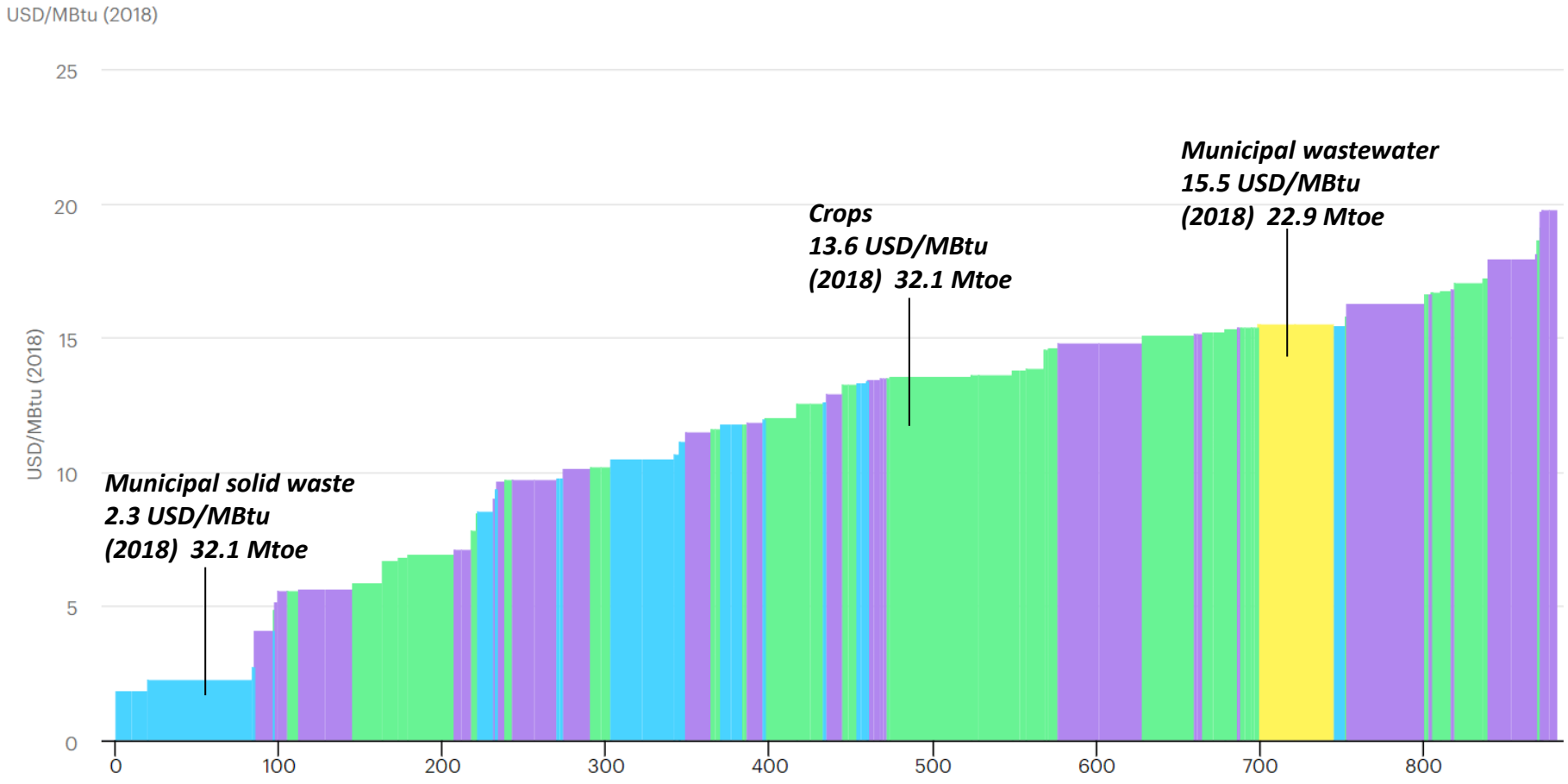
Energy services drivers

Energy demand drivers for human consumption:

- Energy services: food, comfort, hygiene, health, culture
- Population and households
- Wealth
- Consumption profiles: preferences in expenditures with goods and services

Final energy supply cost curves

Cost curve of potential global biogas supply by feedstock, 2040



https://www.iea.org/data-and-statistics/charts/cost-curve-of-potential-global-biogas-supply-by-feedstock-2040

Climate Change and Sustainable Development Policies

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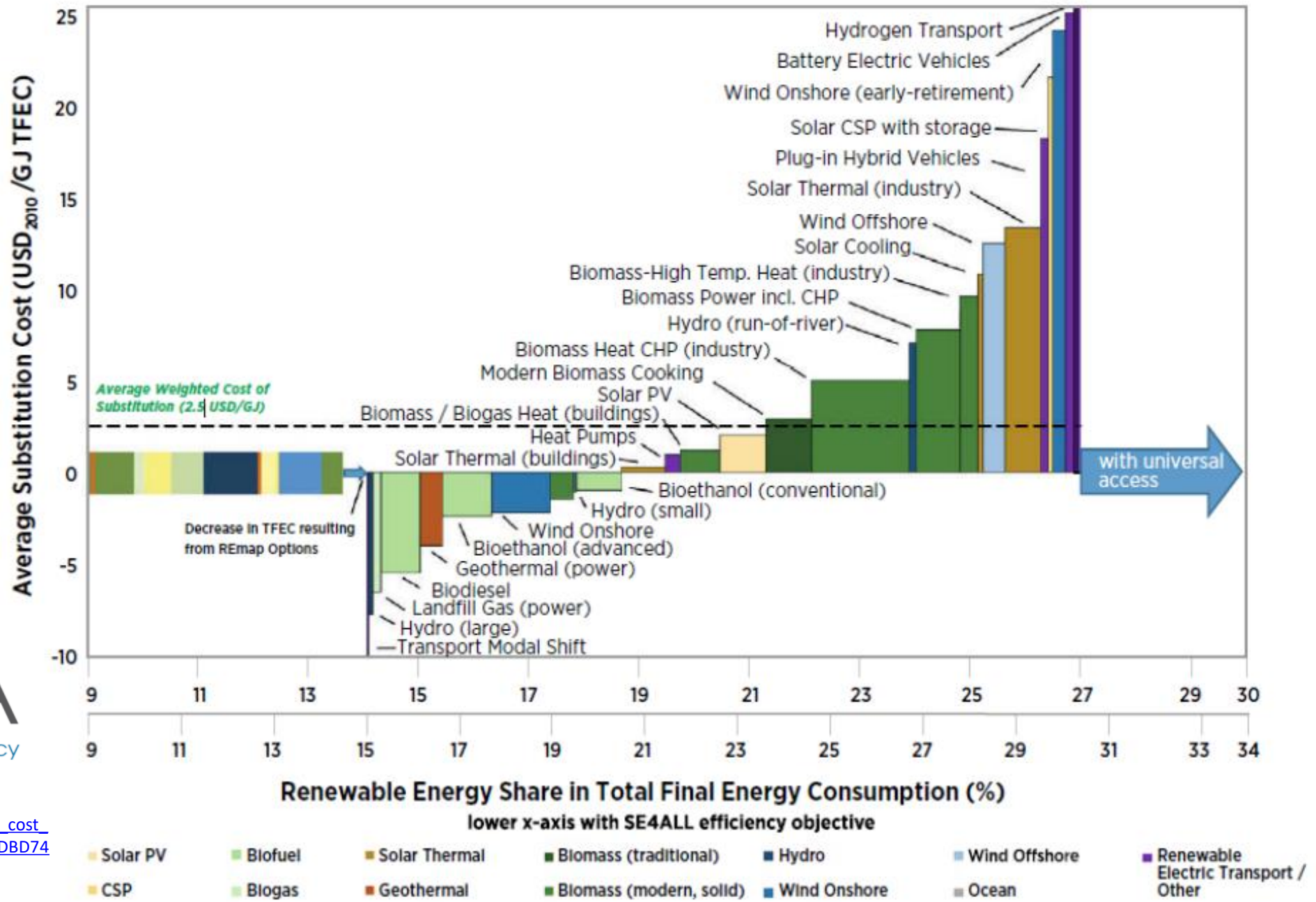
Final energy supply cost curves for 26 REmap countries

TFEC = total final energy consumption



IRENA
International Renewable Energy Agency

https://www.irena.org/-/media/Files/IRENA/REmap/Methodology/IRENA_REmap_cost_methodology_2014.pdf?la=en&hash=A60771A19A50742DBD747B69B775BAC8849A4539

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Energy production and consumption regions

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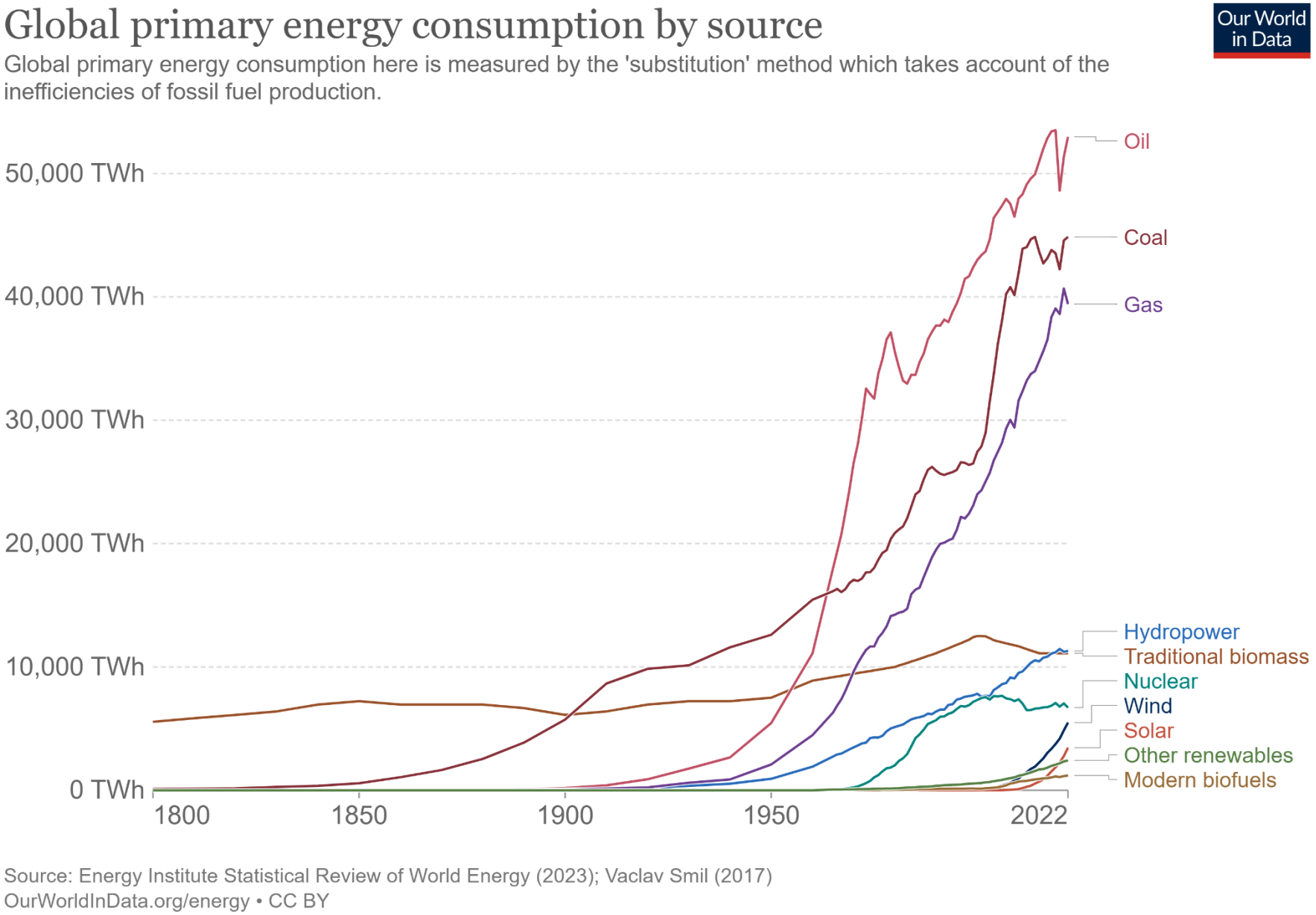
Energy consumption



https://ourworldindata.org/grapher/global-energy-consumption-source

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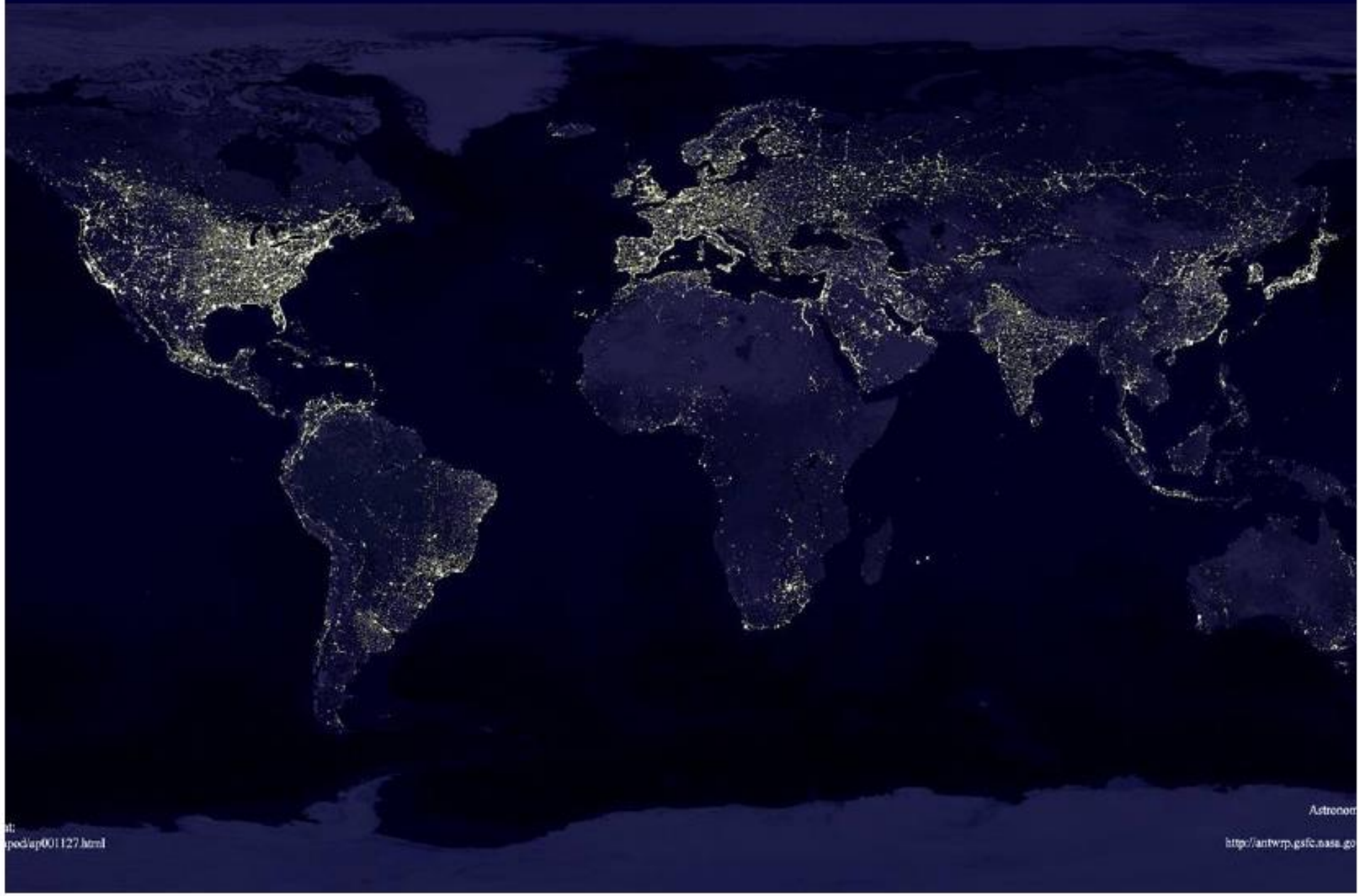
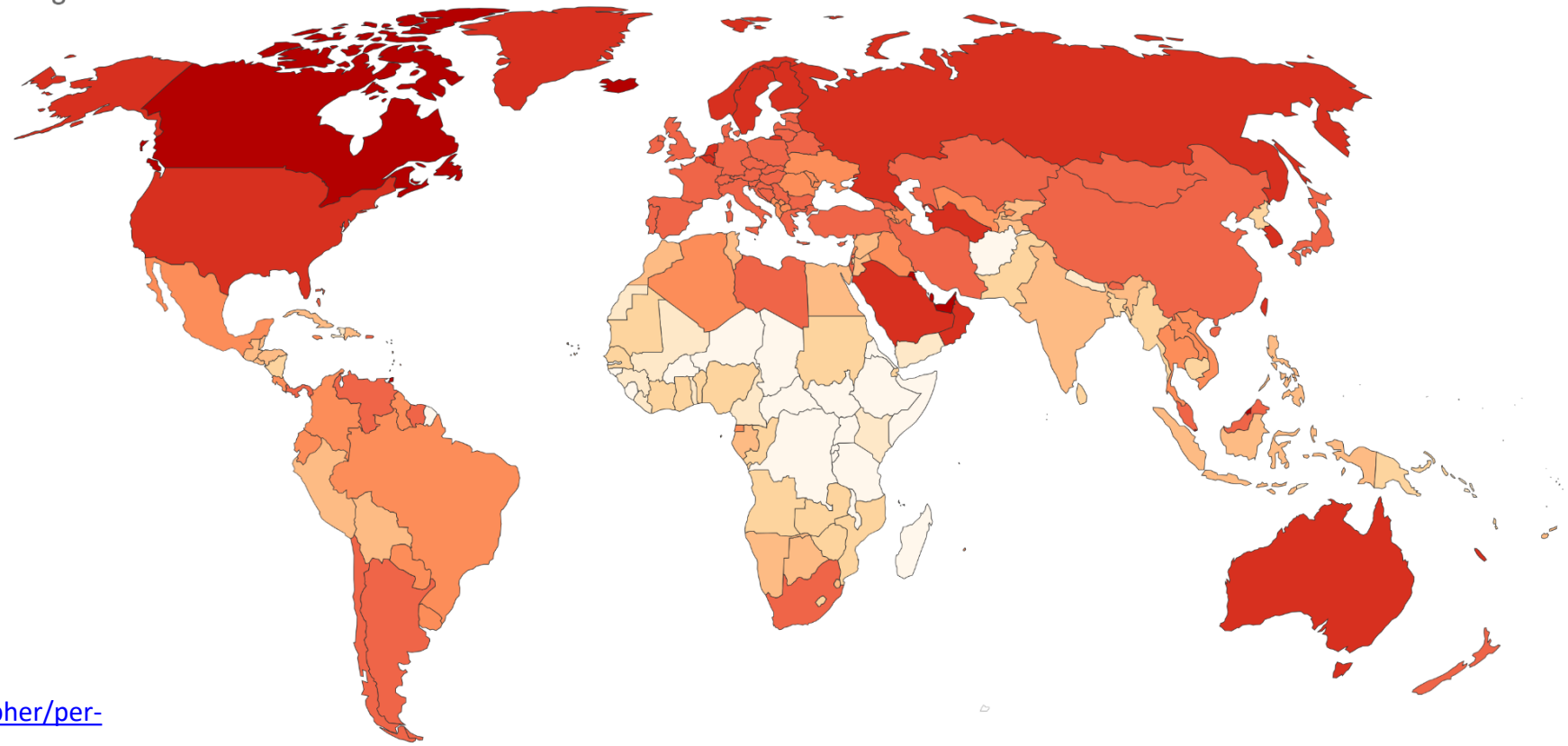
Energy Demand & Prosperity



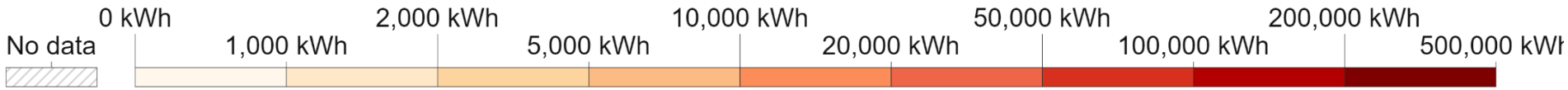
Energy use per person, 2022

Energy use not only includes electricity, but also other areas of consumption including transport, heating and cooking.

Our World in Data



https://ourworldindata.org/grapher/per-capita-energy-use



Source: U.S. Energy Information Administration (EIA); Energy Institute Statistical Review of World Energy (2023)
Note: Energy refers to primary energy – the energy input before the transformation to forms of energy for end-use (such as electricity or petrol for transport).
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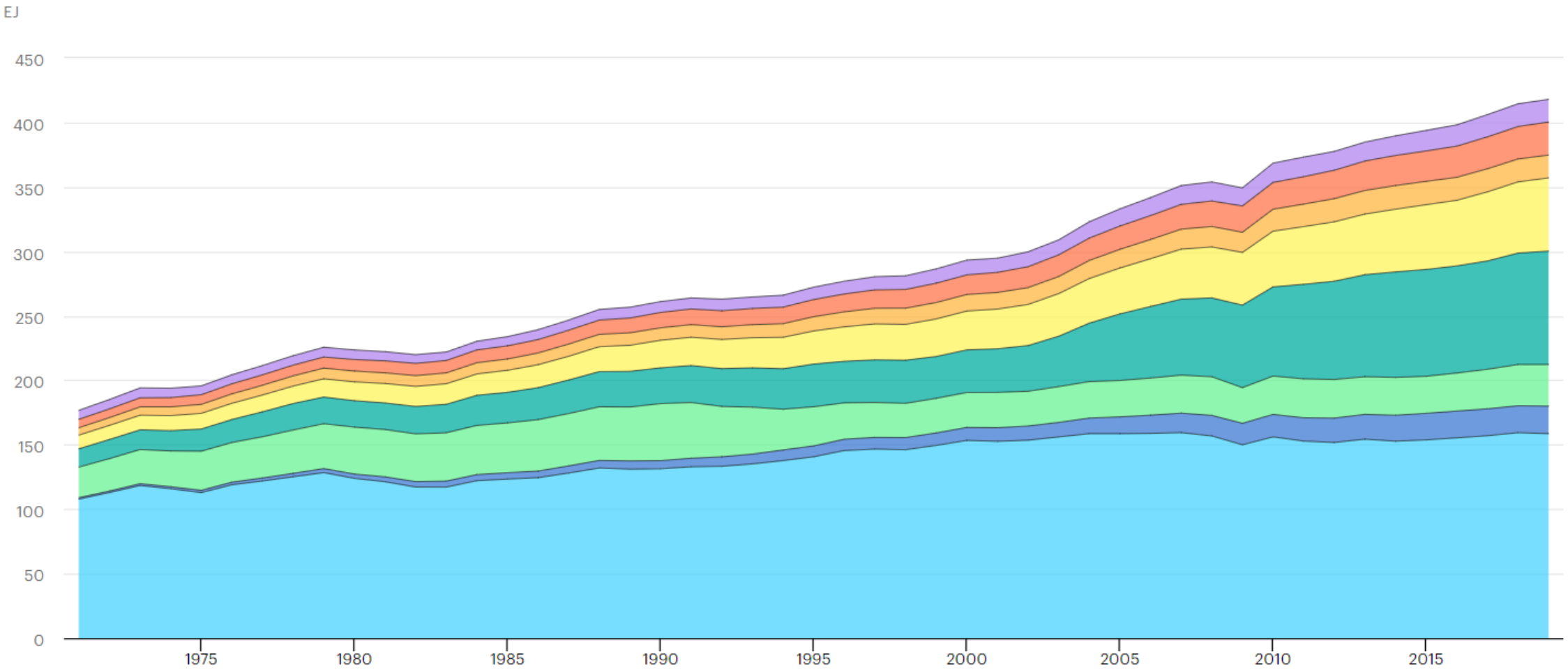
World total final consumption by region – which is which????



https://www.iea.org/reports/key-world-energy-statistics-2021/final-consumption

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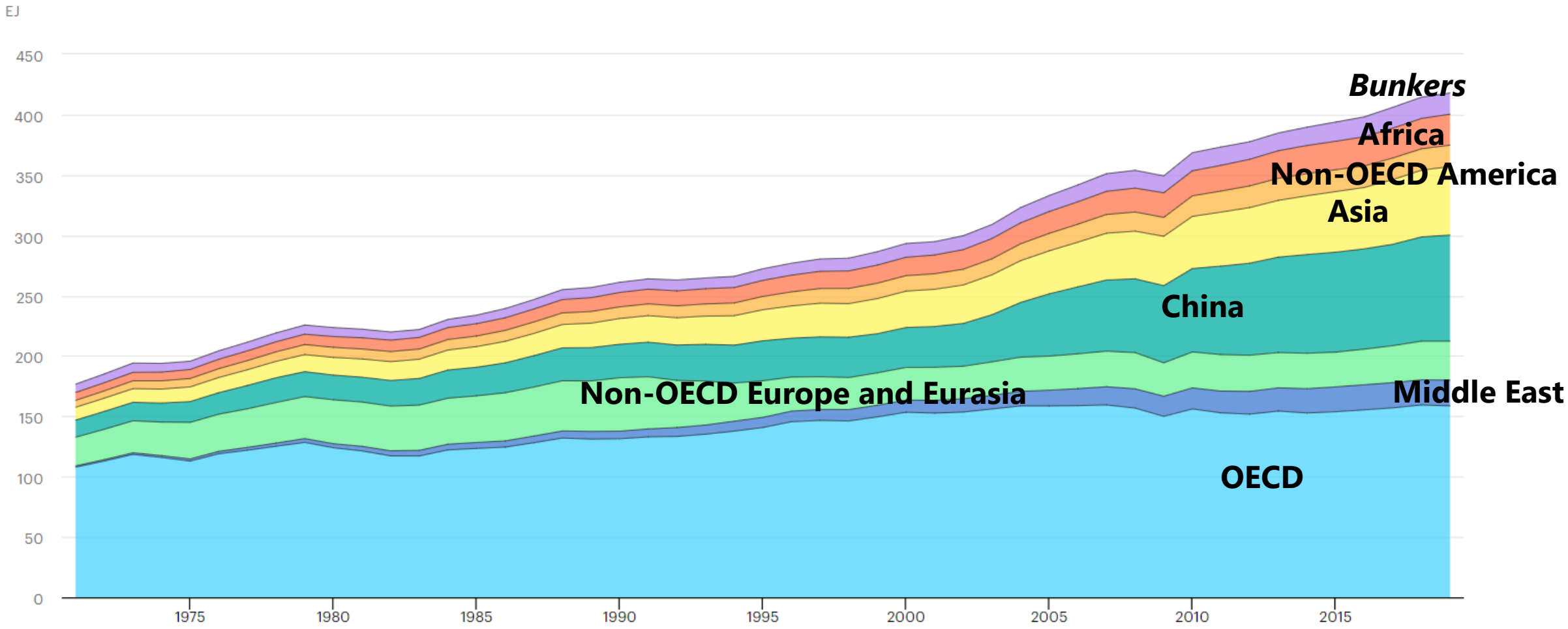
World total final consumption by region



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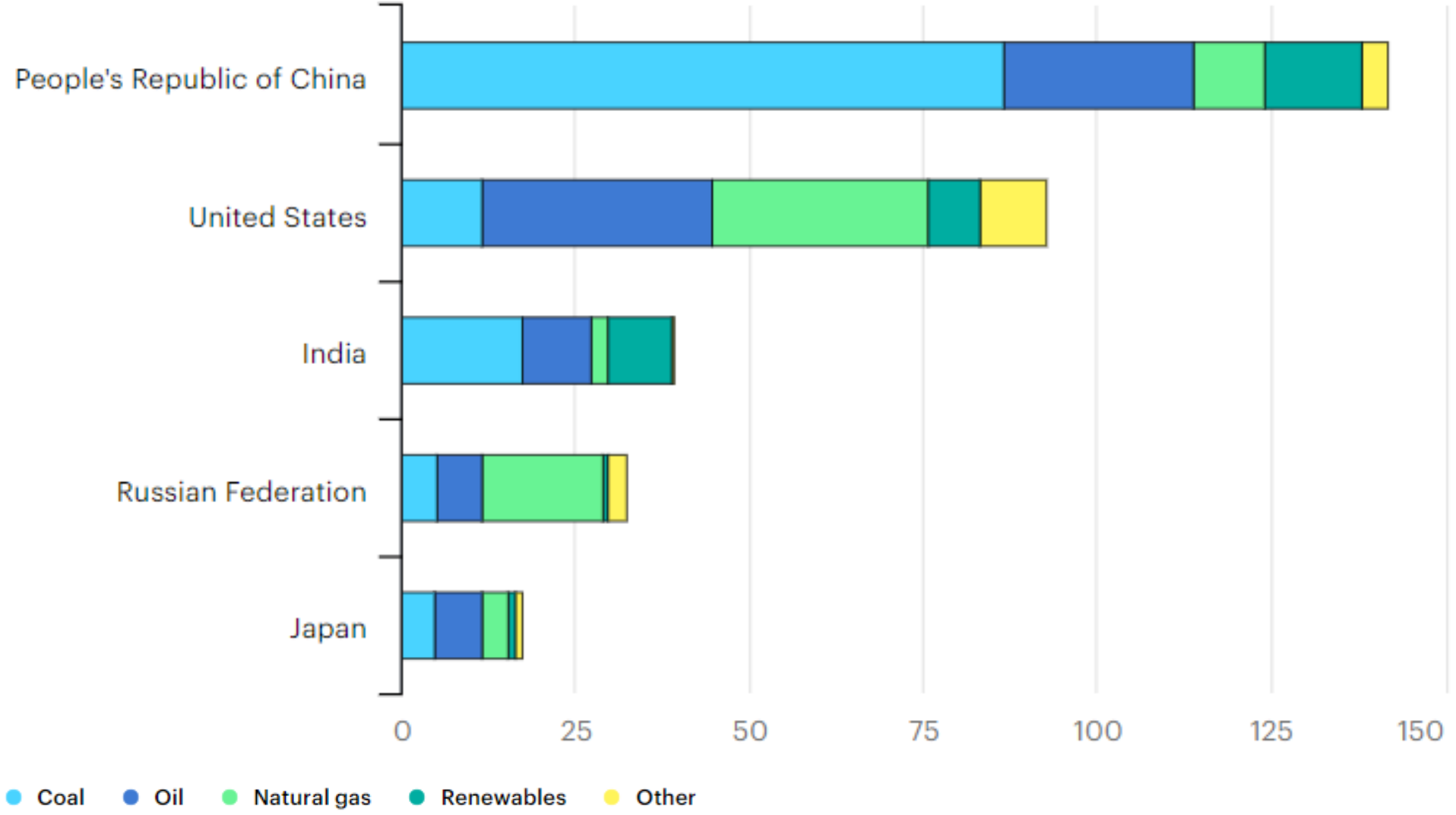
https://www.iea.org/reports/key-world-energy-statistics-2021/final-consumption

Top five countries by total energy SUPPLY by energy source, 2019 (EJ)



https://www.iea.org/reports/key-world-energy-statistics-2021/final-consumption

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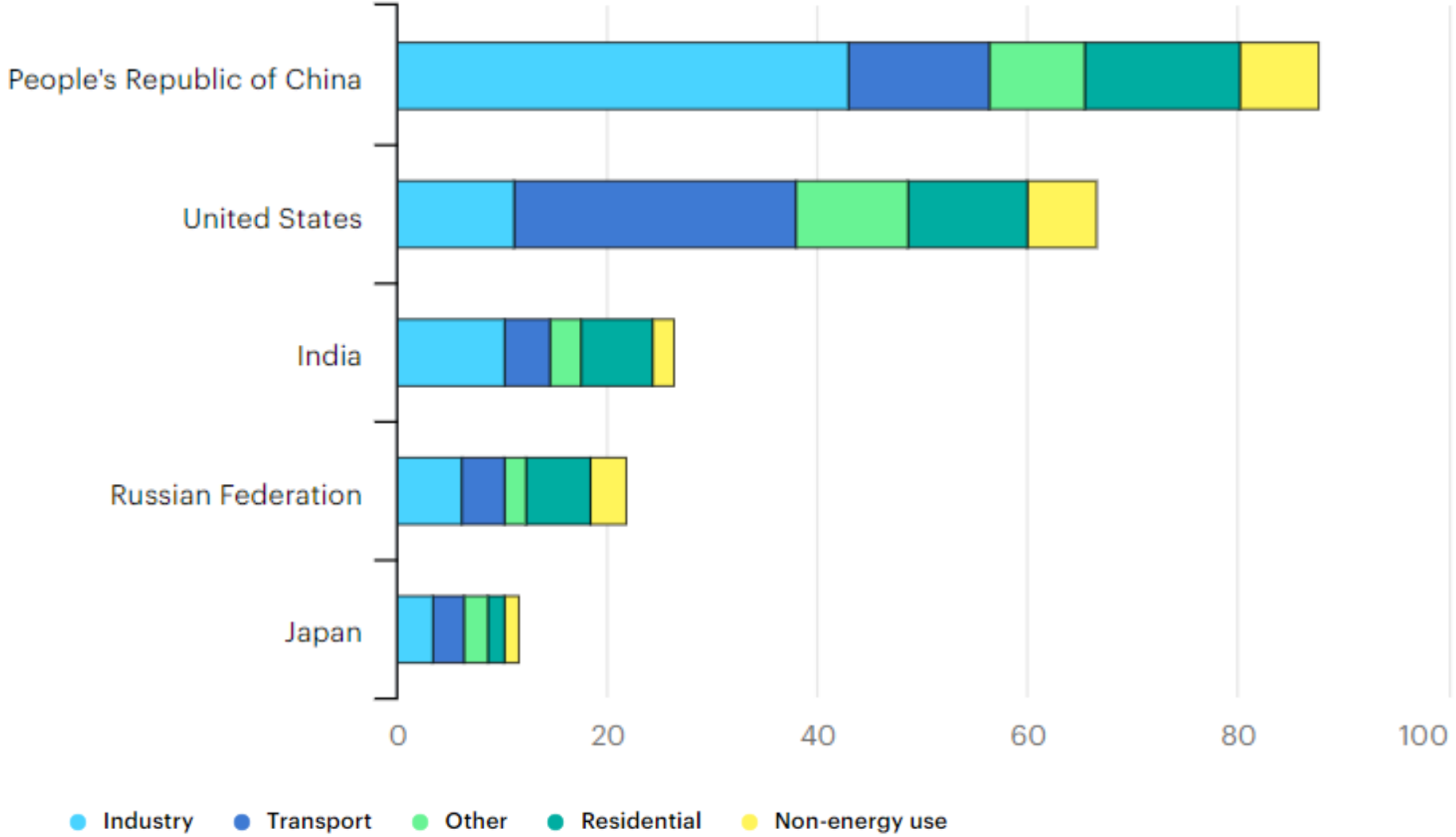
Top five countries by total final CONSUMPTION by sector, 2019 (EJ)



https://www.iea.org/reports/key-world-energy-statistics-2021/final-consumption

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Energy access

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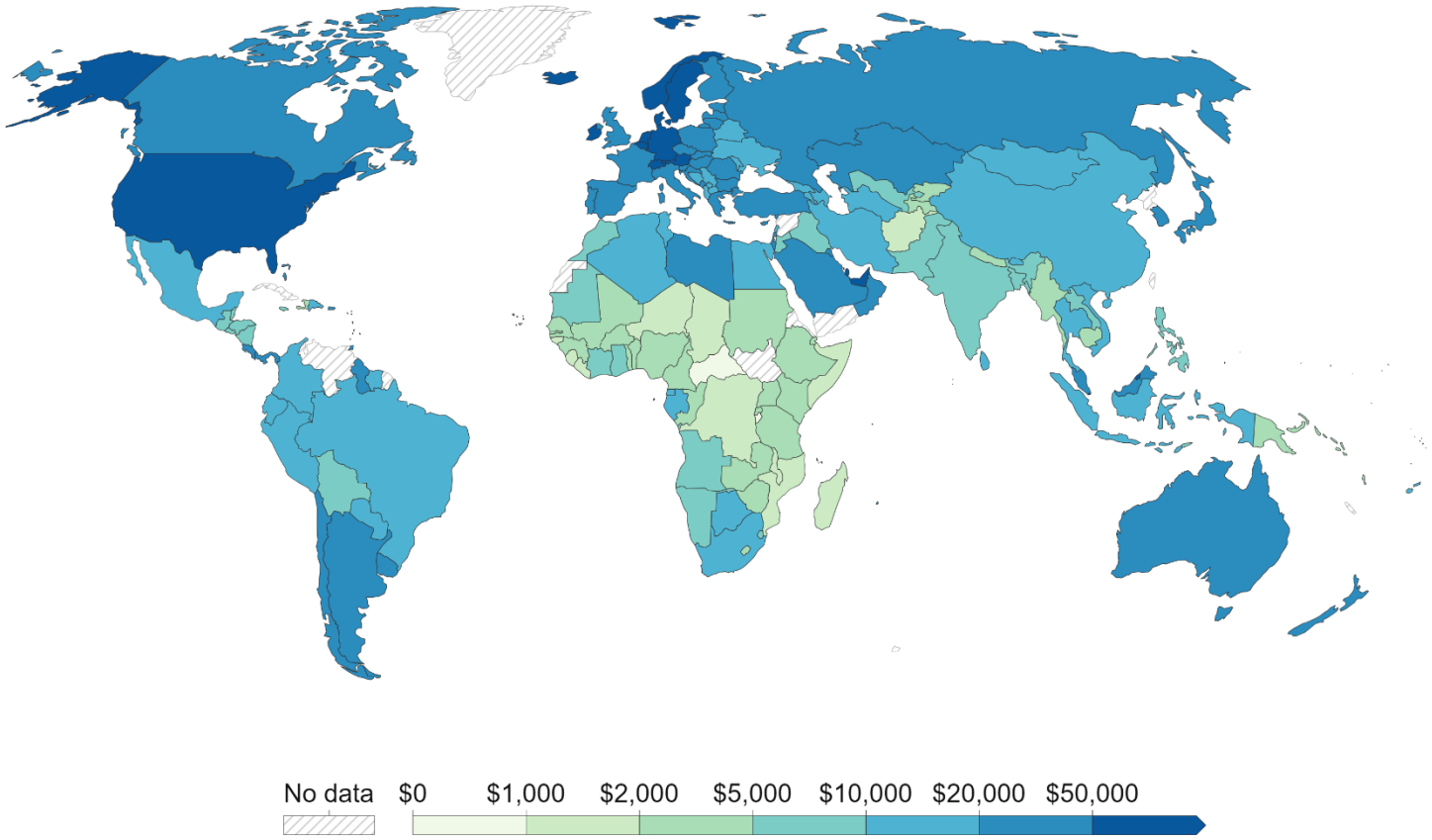
GDP per capita, 2021

This data is adjusted for inflation and for differences in the cost of living between countries.

Our World in Data



Source: Data compiled from multiple sources by World Bank
Note: This data is expressed in international-$[1] at 2017 prices.

OurWorldInData.org/economic-growth • CC BY

1. International dollars: International dollars are a hypothetical currency that is used to make meaningful comparisons of monetary indicators of living standards. Figures expressed in international dollars are adjusted for inflation within countries over time, and for differences in the cost of living between countries. The goal of such adjustments is to provide a unit whose purchasing power is held fixed over time and across countries, such that one international dollar can buy the same quantity and quality of goods and services no matter where or when it is spent. Read more in our article: What are Purchasing Power Parity adjustments and why do we need them?

Energy access

"**a household having reliable and affordable access to both clean cooking facilities and to electricity**, which is enough to supply a basic bundle of energy services initially, and then an increasing level of electricity over time to reach the regional average"

https://www.iea.org/articles/defining-energy-access-2020-methodology

iea

733 million people without access to electricity in 2020

https://www.irena.org/publications/2022/Jun/Tracking-SDG-7-2022

IRENA
International Renewable Energy Agency

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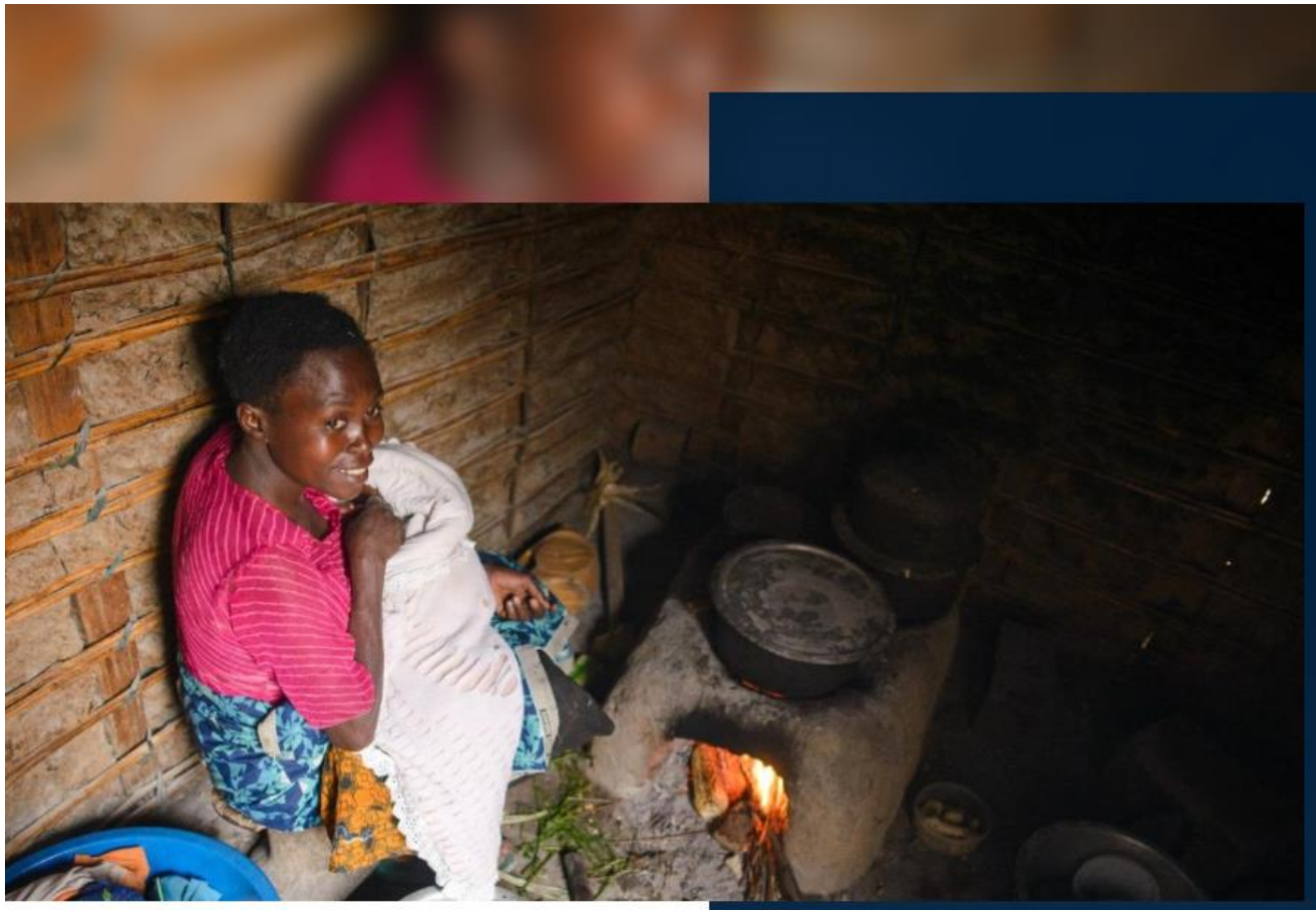
International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), the United Nations Statistics Division (UNSD), the World Bank, and the World Health Organization (WHO)



Basic Energy Access Lags Amid Renewable Opportunities New Report Shows

6 June 2023 | **Press Releases**

https://www.irena.org/News/pressreleases/2023/Jun/Basic-Energy-Access-Lags-Amid-Renewable-Opportunities-New-Report-Shows

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"Global energy access gap persists: 675 million people without electricity, 2.3 billion people reliant on harmful cooking fuels"

- In 2010, **84% of the world's population had access to electricity - 91% in 2021** BUT the growth pace of access slowed in 2019-2021. Rural electrification efforts contributed but large gap within urban areas.
- In 2021, **567 million people in sub-Saharan Africa did not have access to electricity**, accounting for more than 80% of the global population without access. The access deficit in the region stayed almost the same as in 2010.
- The world remains **off track to achieve universal access to clean cooking by 2030**. Up to 2.3 billion people still use polluting fuels and technologies for cooking, largely in sub-Saharan Africa and Asia. The use of traditional biomass also means households spend up to 40 hours a week gathering firewood and cooking, which prohibits **women from pursuing employment or participating in local decision-making bodies and children from going to school** - **3.2 million premature deaths each year were attributable to household air pollution** created by using polluting fuels and technologies for cooking.
- Renewable electricity use in global consumption has grown from 26.3% in 2019 to 28.2% in 2020 BUT efforts to increase renewables' share in **heating and transport** (> 3/4 of global energy consumption) remain **off target** to achieve 1.5˚C climate objectives.

https://www.irena.org/News/pressreleases/2023/Jun/Basic-Energy-Access-Lags-Amid-Renewable-Opportunities-New-Report-Shows

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	INDICATOR	2010	LATEST YEAR
	7.1.1 Proportion of population with access to electricity	**1.1 billion** people without access to electricity	**675 million** people without access to electricity (2021)
	7.1.2 Proportion of population with primary reliance on clean fuels and technology for cooking	**2.9 billion** people without access to clean cooking	**2.3 billion** people without access to clean cooking (2021)
	7.2.1 Renewable energy share in total final energy consumption	**16%** share of total final energy consumption from renewables	**19.1%** share of total final energy consumption from renewables (2020)
	7.3.1 Energy intensity measured as a ratio of primary energy and GDP	**5.53 MJ/USD** primary energy intensity	**4.63 MJ/USD** primary energy intensity (2020)
	7.a.1 International financial flows to developing countries in support of clean energy research and development and renewable energy production, including in hybrid systems	**11.9 USD billion** international financial flows to developing countries in support of clean energy	**10.8 USD billion** International flows to developing countries in support of clean and renewable energy (2021)

ps://www.irena.org/News/pressreleases/2023/Jun/Basic-Energy-Access-Lags-id-Renewable-Opportunities-New-Report-Shows

Energy security and energy and carbon intensity

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Energy security & endogenous vs. imported resources

"The IEA defines energy security as the uninterrupted availability of energy sources at an affordable price. Energy security has many aspects: long-term energy security mainly deals with timely investments to supply energy in line with economic developments and environmental needs. On the other hand, short-term energy security focuses on the ability of the energy system to react promptly to sudden changes in the supply-demand balance." More here.

Energy dependency (rate)

"shows the proportion of energy that an economy must import. It is defined as net energy imports divided by gross inland energy consumption plus fuel supplied to international maritime bunkers, expressed as a percentage. A negative dependency rate indicates a net exporter of energy, while a dependency rate in excess of 100 % indicates that energy products have been stocked." See more here
Endogenous energy resources are the ones that can be sourced within the borders of a certain region, whereas exogenous resources are consumed in the region but where extracted/produced outside its borders.

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Energy and carbon intensity

Energy intensity

Energy Intensity is measured by the quantity of energy required per unit output or activity, so that using less energy to produce a product reduces the intensity. It can be measured as energy consumed per kt or produced cement, per travelled km or per economic value of a sector or economy
More here.

Carbon intensity

Ratio of CO_2 emitted per unit output or activity

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Carbon intensity

Total carbon emissions / total units of production (e.g. tones cement or kWh electricity)

Total carbon emission / total economic activity (GDP)

To deal with climate change and global warming we need to become less carbon intensive as a whole

Climate Change and Sustainable Development Policies

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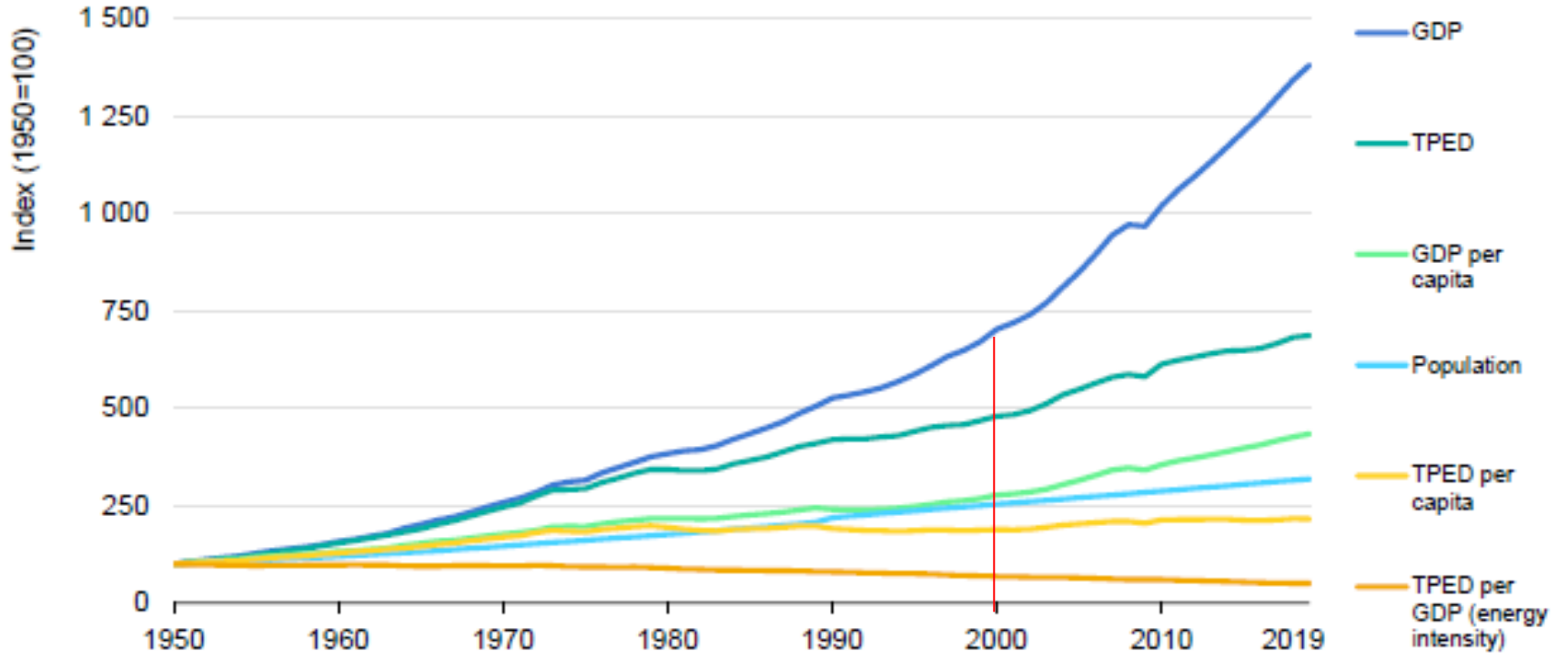
Evolution of primary energy and GDP

Since 2000, energy intensity (energy consumption per unit of GDP) has been declining.

"Today, the world needs 20% less energy to produce one dollar of economic output than it did only 19 years ago"

Figure 1.1 Global total primary energy demand, population and GDP, 1950-2019



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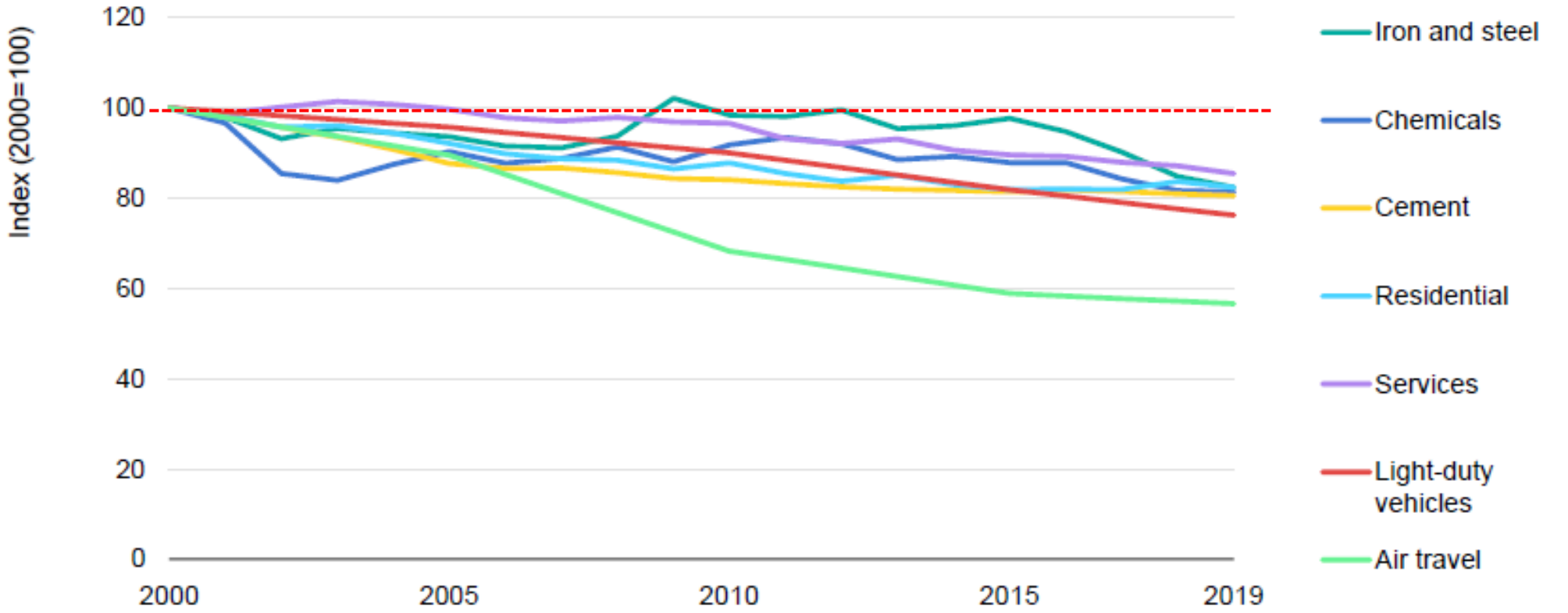
Note: TPED = total primary energy demand.

Energy demand has historically been driven by GDP and population, reaching a sevenfold increase from 1950.

Energy intensity everywhere (from 2000)

Figure 1.6 Global average energy intensity in selected end-use sectors, 2000-19



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Key information you should have apprehended after the class

- Main energy units for installed capacity of power plants
- Main energy units for energy flows
- Differences between primary energy, final energy and useful energy
- What are energy services and energy carriers
- Why it is important to think about energy services and not just energy consumption
- What is energy access, why is it important?
- Main energy producing and consuming regions
- Energy and carbon intensity