Tere tulemast

Välkommen

Welcome

Witamy

laipni lūdzam

Learning Platform:
Energy Generation *(1)*

Available language versions

This training material is also available in translated PDF versions.
Click the highlighted language text to open the corresponding file.

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Latviski

Materiāls ir pieejams arī

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Polski

Materiał jest również dostępny w

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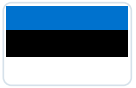

Eesti

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Svenska

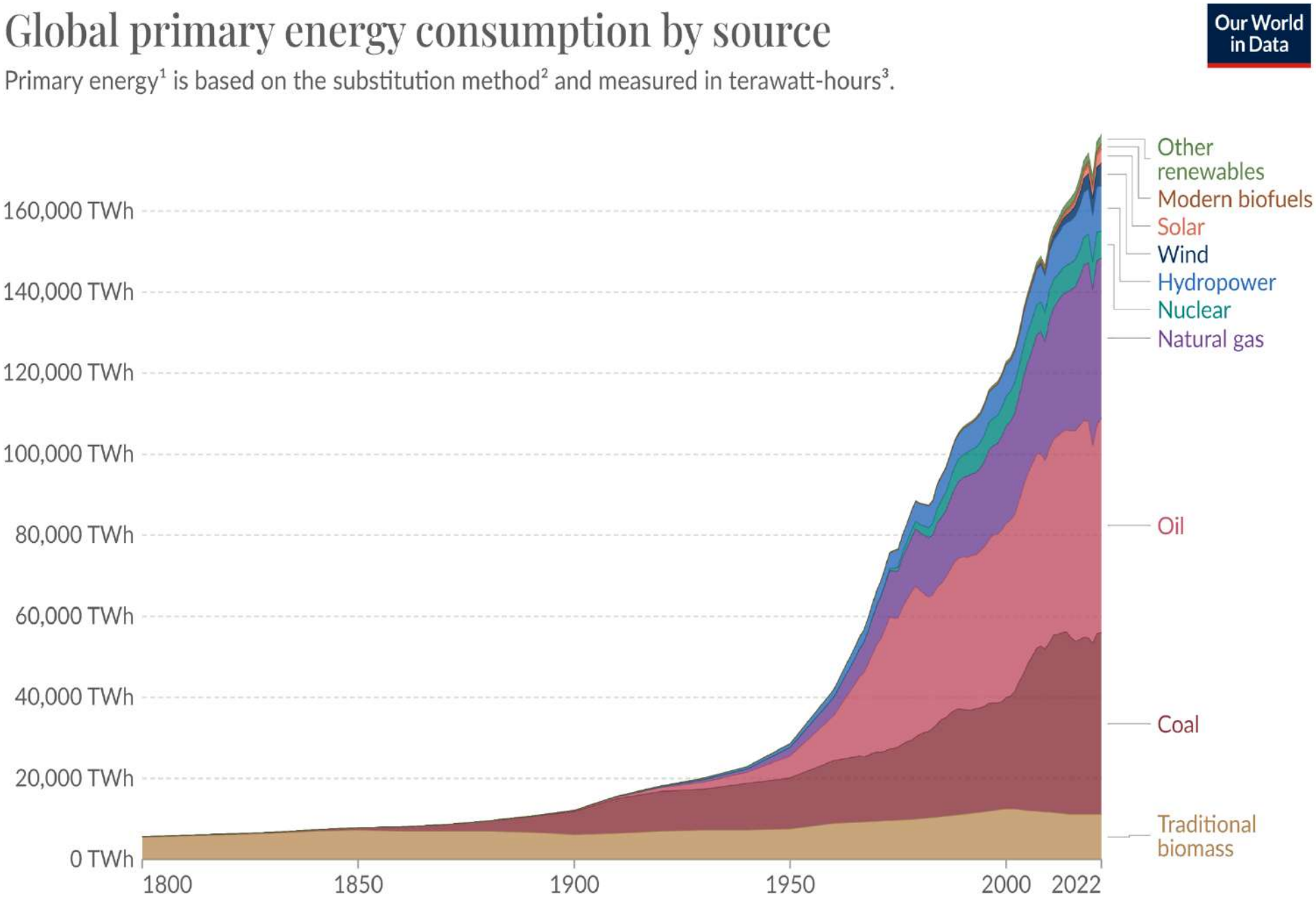
Materialet finns även tillgängligt på

svenska PDF

The English version is the reference version. Translations were prepared with the support of AI-based translation tools.

Outlines

- Figures and facts, global and EU level
- Energy and electricity generation – the basics
- History of electricity generation
- Climate impact of different electricity sources
- Coal
- Oil
- Gas
- Hydropower
- Wind
- Solar
- Biomass
- Geothermal
- Nuclear
- Electricity storage
- Activity: Create a draft electricity generation plan for your region



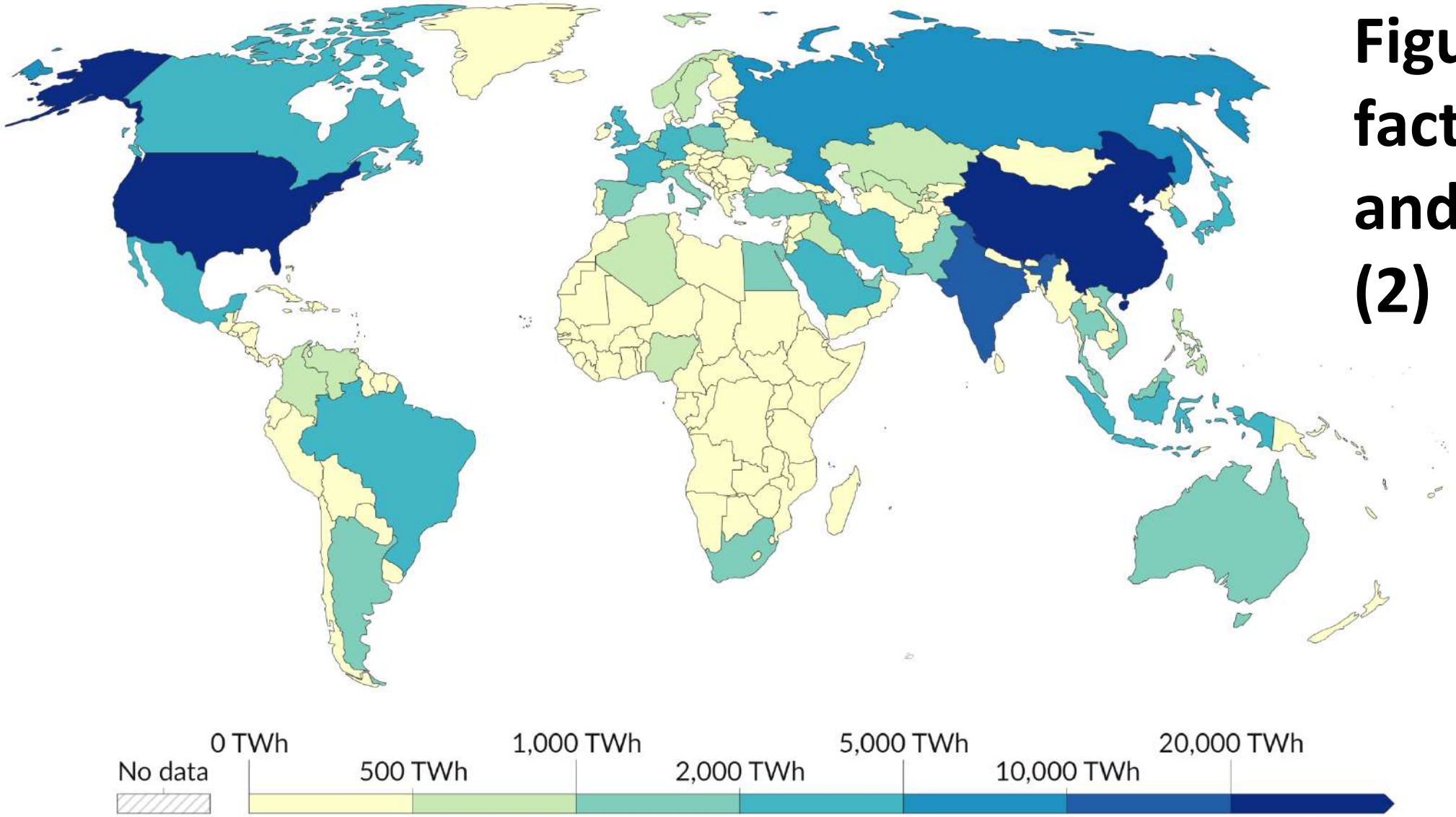
Figures & facts, global and EU level (1):

Primary energy (**PE**) is the energy found in nature that has not been subjected to any human engineered conversion process. For example, coal can be converted to synthetic gas, which can be converted to electricity; in this example, coal is primary energy, synthetic gas is secondary energy, and electricity is tertiary energy.

Primary energy consumption, 2022

Primary energy[1] consumption is measured in terawatt-hours[2], using the substitution method[3].

Our World in Data



Data source: U.S. Energy Information Administration (2023); Energy Institute - Statistical Review of World Energy (2023)

Figures and facts, global and EU level (2)

Primary energy (**PE**) is the energy found in nature that has not been subjected to any human engineered conversion process.

Energy and electricity generation – the basics (1)

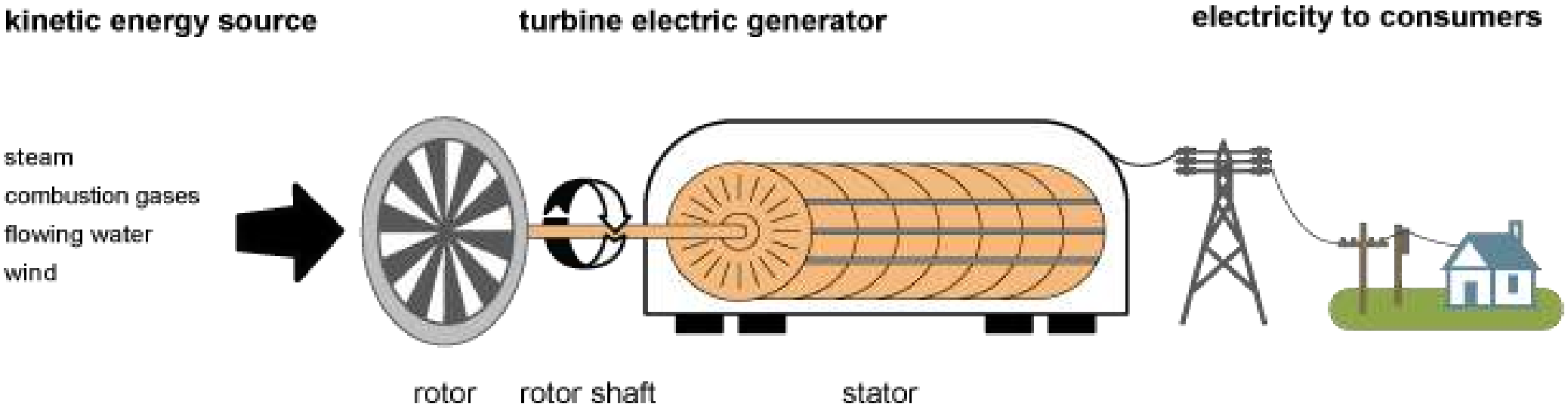
Electricity is a high-quality, extremely flexible, efficient energy currency that can be used for delivering all types of energy services. It is associated with modern economic activity and improved quality of life.

Two-thirds of electricity globally is generated from fossil fuels in thermal power plants, where **an average of 55% to 70% of resource energy is lost as waste heat**. Electricity generation from cleaner renewable energy sources, particularly wind and solar PV, is rapidly increasing.

Steam-cycle thermal plants like coal and nuclear must run continuously because they take a long time to turn on and off, while oil and natural gas turbine plants are peaking (they can come online quickly and fill peaks in demand but are more expensive to run). Hydro and natural gas combined cycle plants are considered intermediate plants.

Energy and electricity generation - the basics (2)

Electricity generation from an electric turbine



Source: U.S. Energy Information Administration

Energy and electricity generation - the basics (3)

Electricity is central to many parts of life in modern societies and will become even more so as its role in transport and heating expands through widening use of electric vehicles and heat pumps. Power generation is currently the largest source of CO2 emissions globally, but it is also the sector that is leading the transition to net zero emissions through the rapid deployment of renewables such as solar and wind.

Efforts to address climate change are leading to the **rapid electrification of numerous end-uses from transport to industry**, driving a massive increase in power demand as well as the need to generate as much of it as possible from renewable sources. The result is a dramatic transformation of power systems globally, even if unabated fossil fuels still account for over 60% of total global electricity generation.

Question: What potential solutions for increasing electricity demand do you see?

History of electricity generation (1)

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Electricity generation is the process of generating electric power from sources of primary energy.

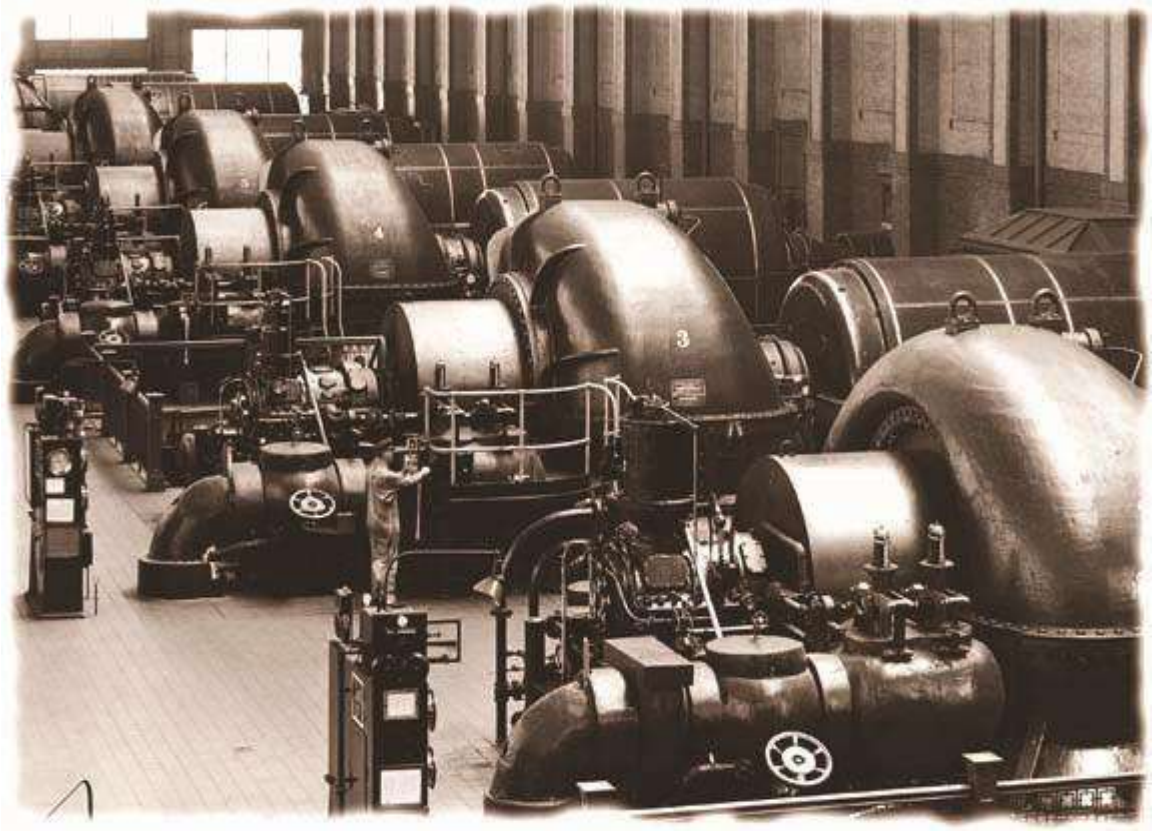
Usable electricity is not freely available in nature, so it must be "produced" - that is, transforming other forms of energy to electricity.

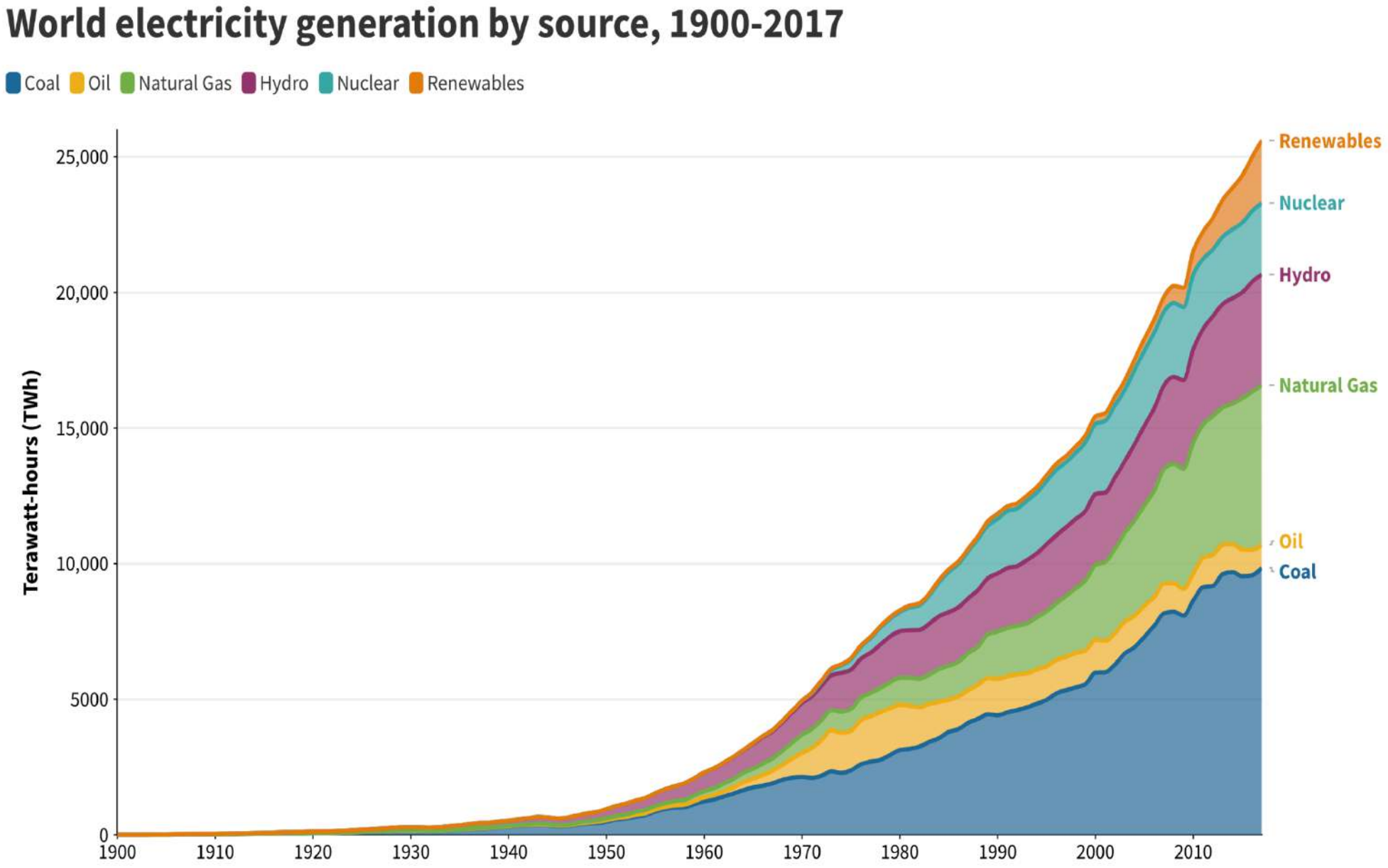
The fundamental principles of electricity generation were discovered in the 1820s and early 1830s by British scientist Michael Faraday.

His method, still used today, is for electricity to be generated by the movement of a loop of wire, or Faraday disc, between the poles of a magnet.

Commercial electricity production started with the coupling of the dynamo to the hydraulic turbine. The mechanical production of electric power began the Second Industrial Revolution.

Question: Try to imagine what our society would look like today without mass generation of electricity?





History of electricity generation (2)

Source: Pinto et al. (2022)
Boston University Institute for Global Sustainability | visualizingenergy.org | CC BY 4.0

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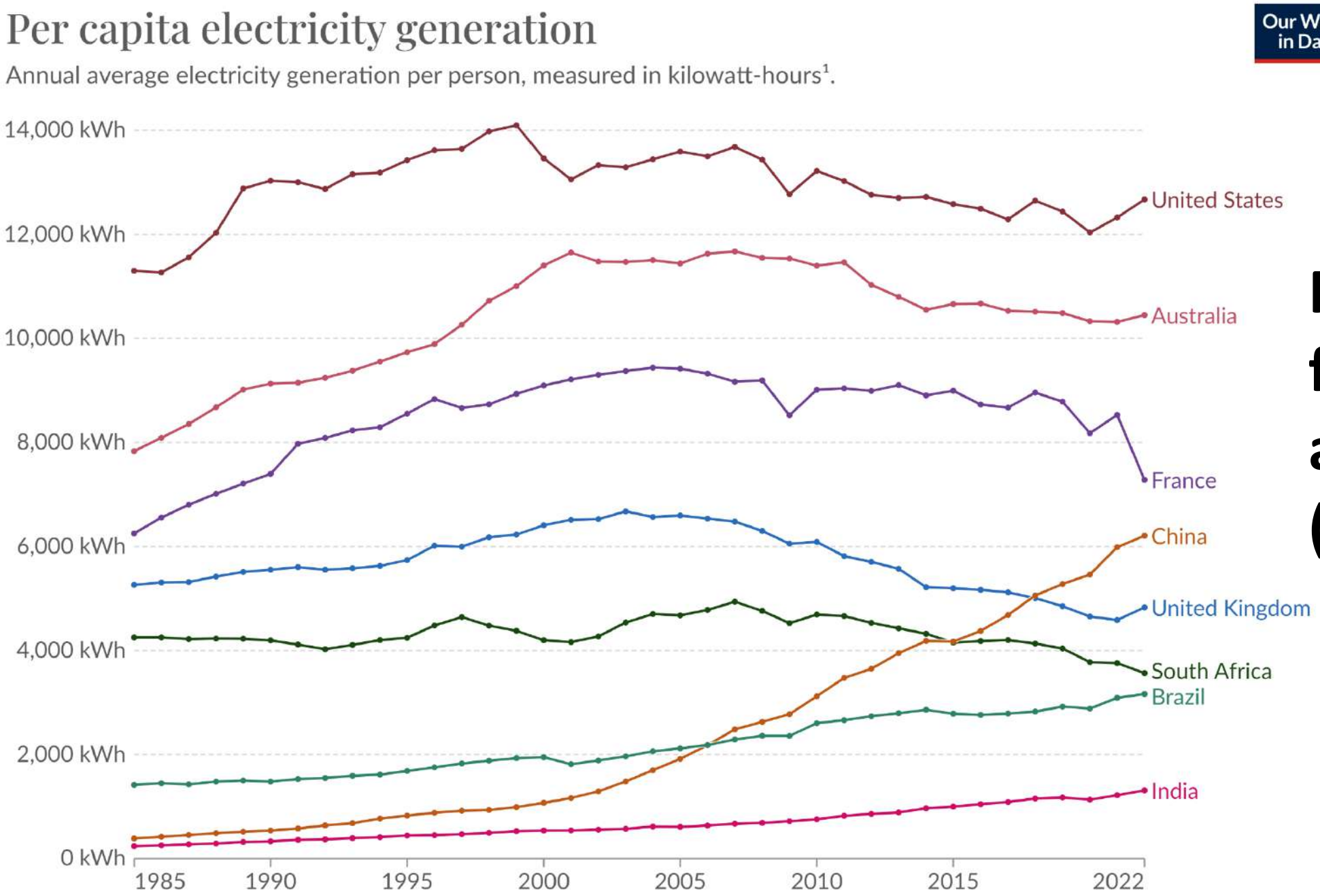
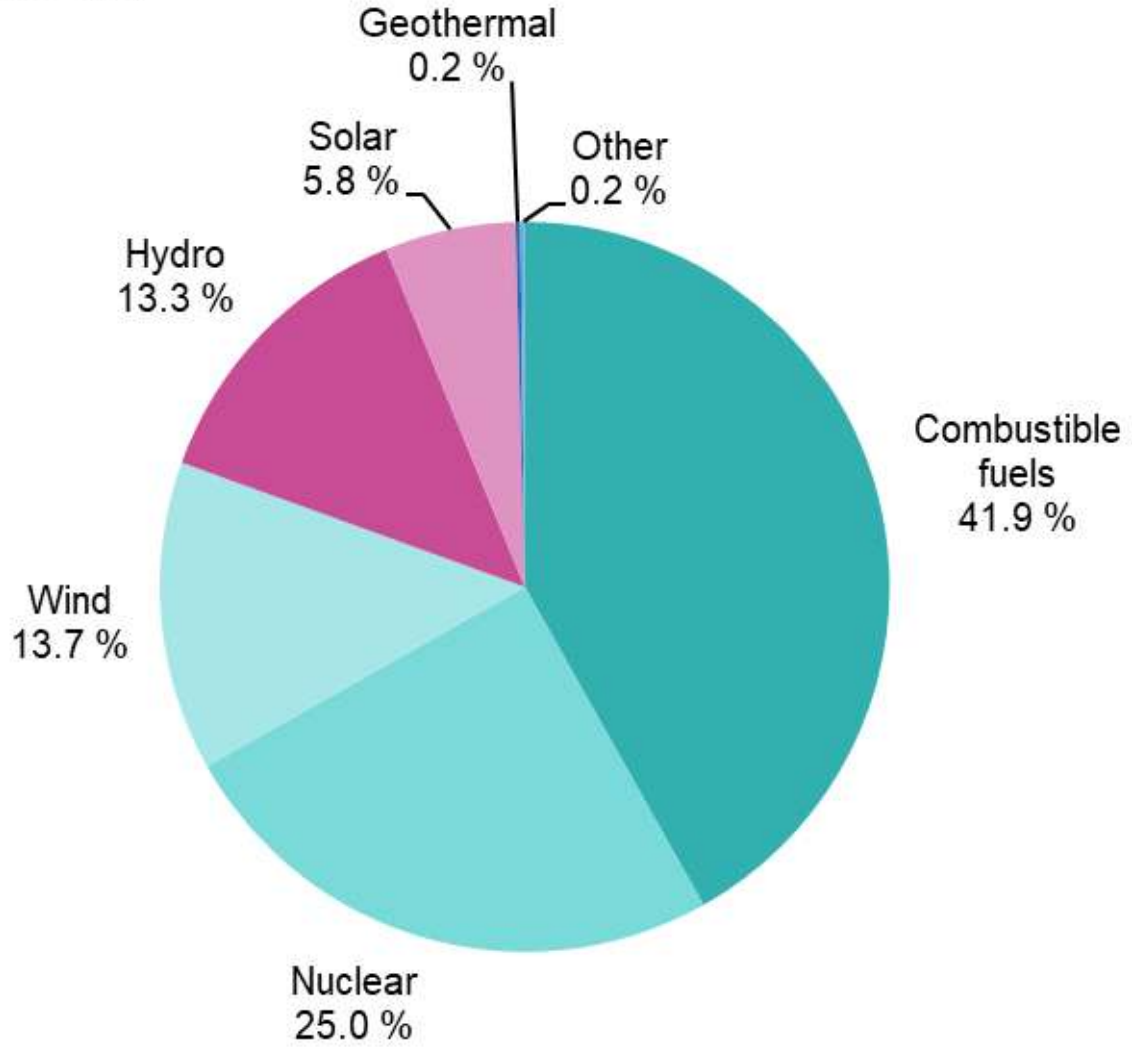


Figures and facts, global and EU level (3)

Net electricity generation, EU, 2021
(%, based on GWh)



Source: Eurostat (online data code: nrg_ind_peh)

eurostat

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Figures and facts, global and EU level (4)

Figures and facts, global and EU level (5)

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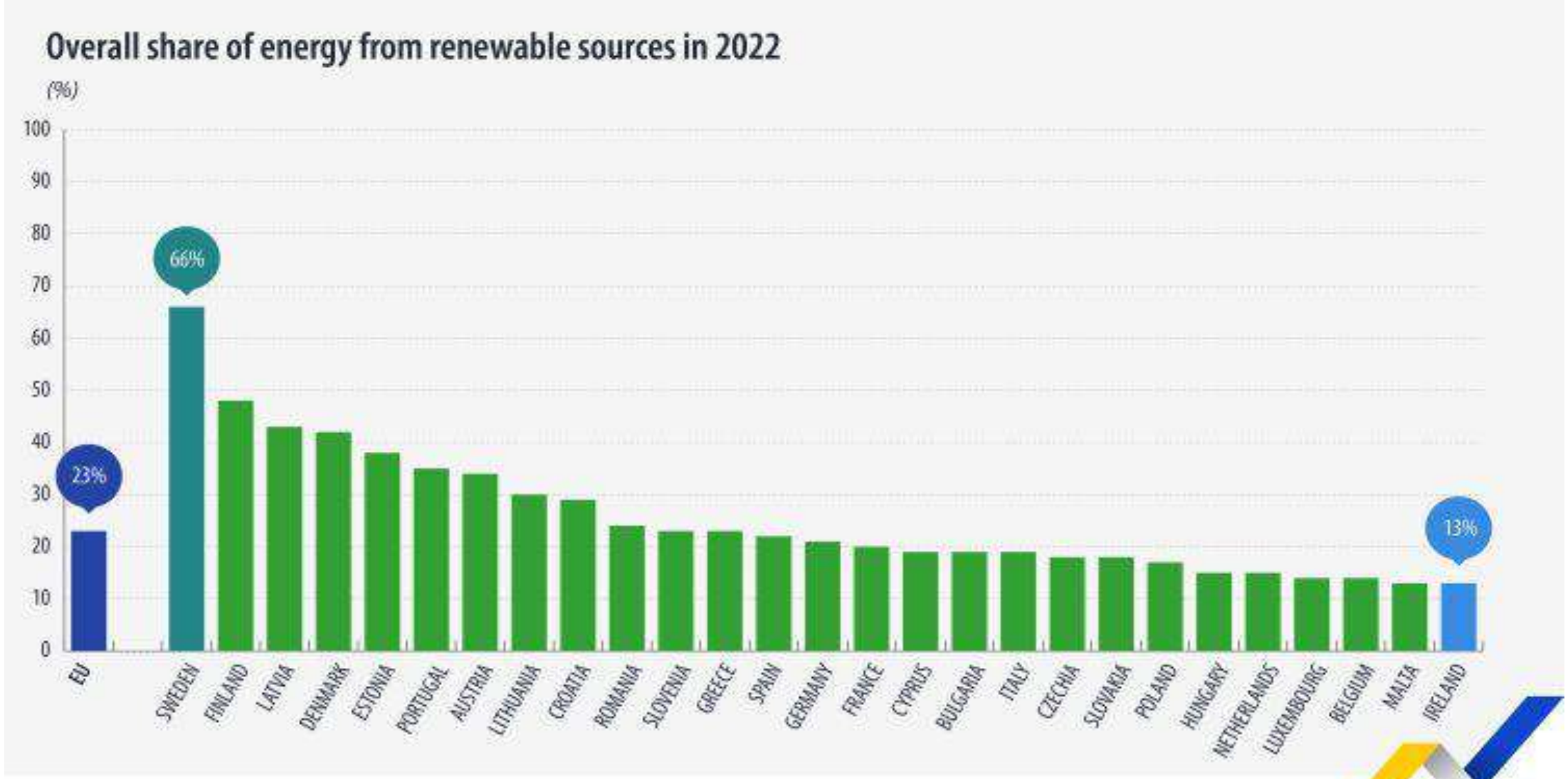

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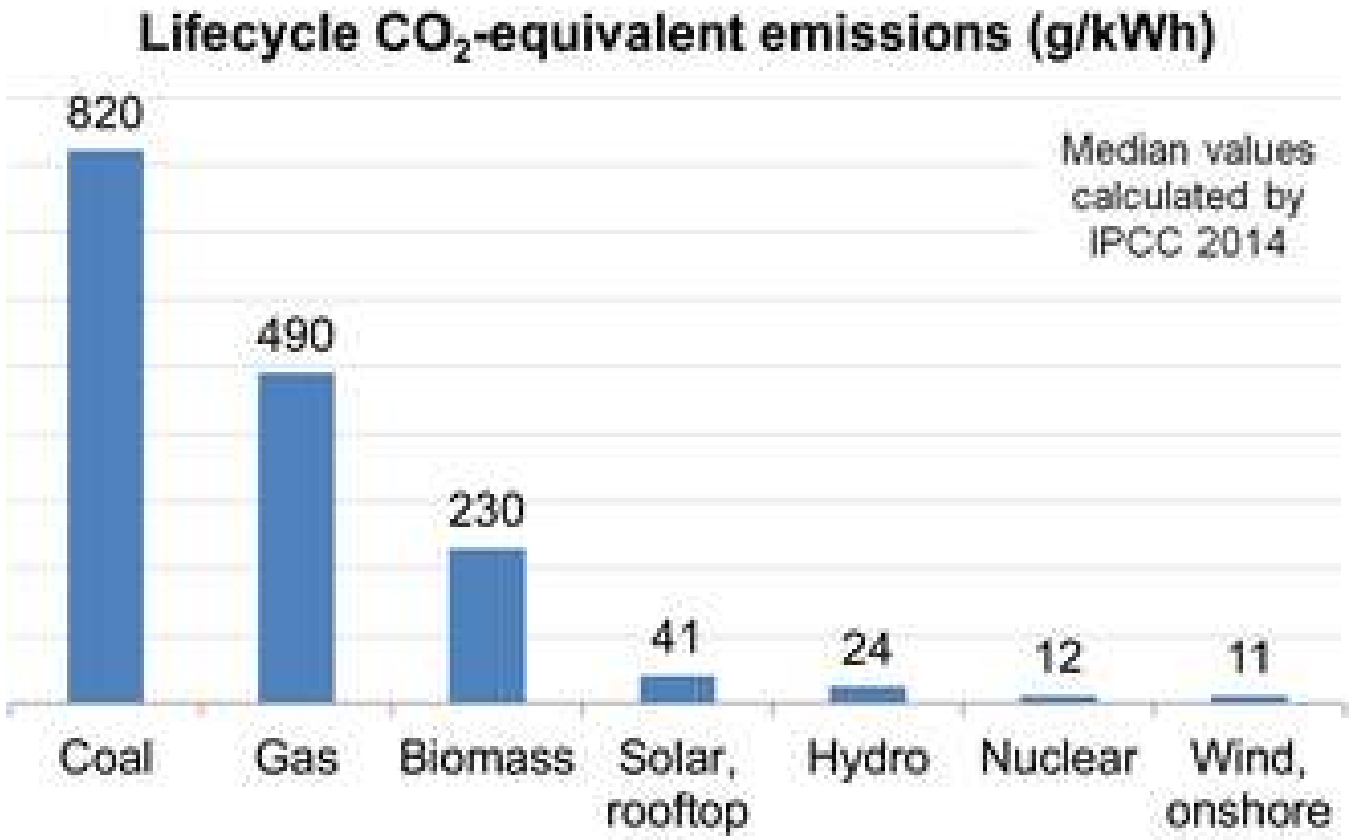
Climate impact of different electricity sources



To determine and compare the level of emissions and the climate impact of different energy sources, a method called life-cycle assessment can be used. GHG emissions are measured in grams of carbon dioxide equivalent per kilowatt hour (g CO2e/kWh). Carbon dioxide equivalent is a measure used to compare emissions of different greenhouse gases.

Coal

Coal still supplies just over a third of global electricity generation even though it is the most carbon-intensive fossil fuel.

For the second year in a row, global coal-fired generation reached an all-time high in 2022, pushing CO2 emissions from coal-fired power plants to record levels and accounting for more than one-third of total electricity generation.

At the end of 2021, Portugal closed its last remaining coal plant, becoming the fourth country in the European Union to do so after Belgium, Austria and Sweden.

To get on track with the Net Zero Scenario, a global annual average reduction of emissions from coal-fired power plants of around 10% is needed through to 2030.

Oil

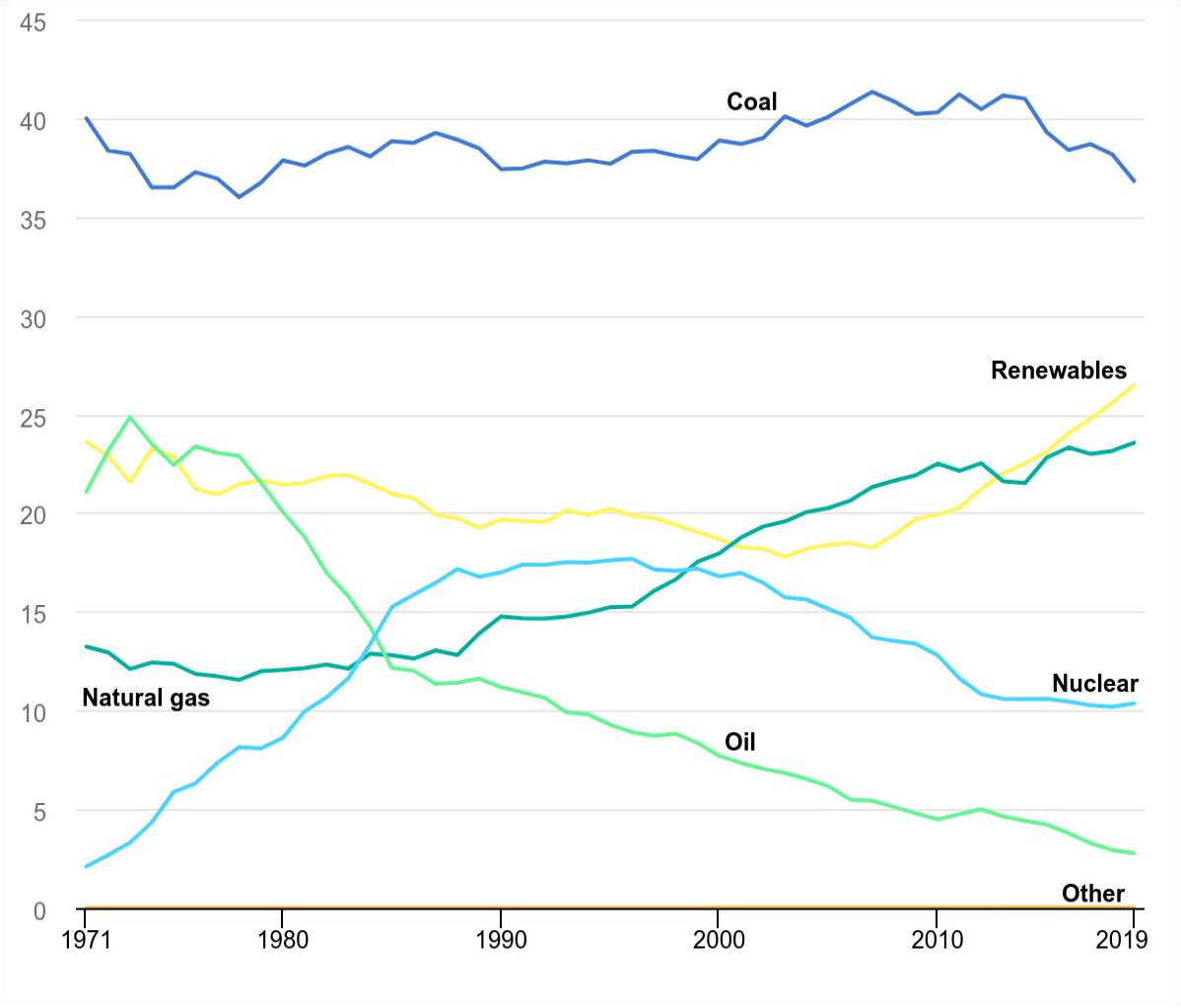
Fossil fuel power stations still provide most of the electrical energy used in the world and are major emitters of CO2.

Heavy fuel oil was once a significant source of energy for electric power generation.

After oil price increases of the 1970s, oil was displaced by coal and later natural gas.

Distillate oil is still important as the fuel source for diesel engine power plants used especially in isolated communities not interconnected to a grid.

The share of electricity generation from oil has decreased to around 3% compared to approx. 25% in the early 1970-ties.



Gas

(Natural) gas accounts for about a quarter of global electricity generation. It is easily stored and can be delivered through pipelines or liquefied and sent by ship. Gas-fired power plants can turn on and off quickly.

Natural gas, which emits less carbon than most other fossil fuels, has a limited role as a transition fuel from coal to renewable energy sources.

Natural gas has traditionally been delivered by pipeline, but disruptions to Europe's supply caused by Russia's invasion of Ukraine have spurred massive investments in liquified natural gas terminals.

Additionally, natural gas power generation may still be needed as back-up for variable wind and solar power.

Hydropower

Hydroelectric energy, also called hydroelectric power or hydroelectricity, is a form of energy that harnesses the power of water in motion—such as water flowing over a waterfall—to generate electricity. People have used this force for millennia.

Most hydroelectric power comes from the potential energy of dammed water driving a water turbine and generator. The power extracted from the water depends on the volume and on the difference in height between the source and the water's outflow.

Other techniques are Pumped Storage - produces electricity to supply high peak demands by moving water between reservoirs at different elevations – and Run-of-the-River.

Run-of-the-river hydroelectric stations are those with small or no reservoir capacity, so that only the water coming from upstream is available for generation at that moment, and any oversupply must pass unused.

A tidal power station makes use of the daily rise and fall of ocean water due to tides.

Question: What do you think about how hydro plants change the surrounding landscape?

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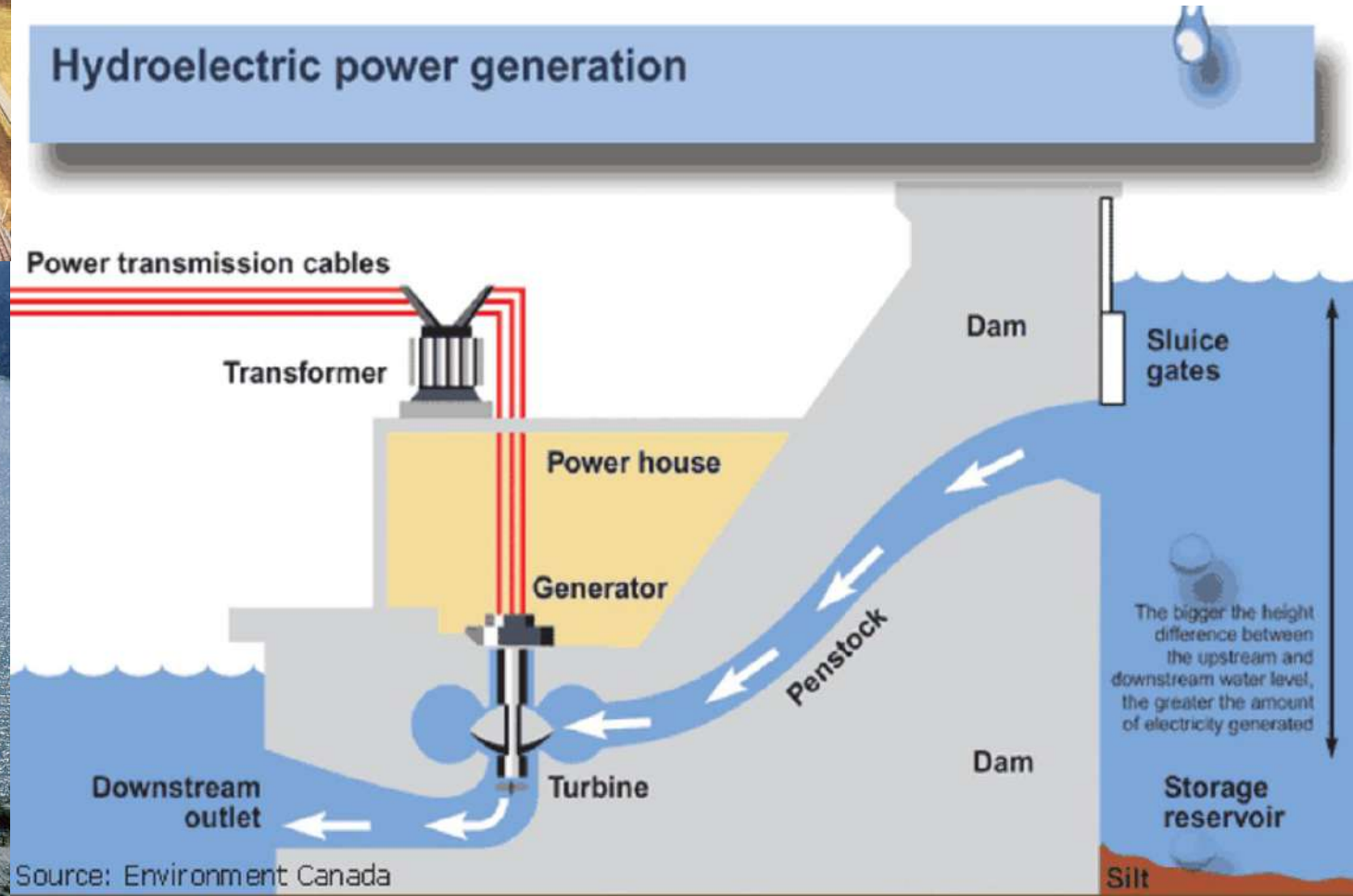
Hydropower (2)



Wind

Wind energy is one of the most important renewable energy sources to decarbonize the energy system. It is one of the lowest-cost electricity sources per unit of energy produced. In many locations, new onshore wind farms are cheaper than new coal or gas plants.

Wind turbines work on a simple principle: Wind turns the propeller-like blades of a turbine around a rotor, which spins a generator, which creates electricity.

Wind power is today providing 19% of Europe's electricity use.

A wind farm is a group of wind turbines in the same location. A large wind farm may consist of several hundred wind turbines. The land between the turbines may be used for agricultural or other purposes. A wind farm may also be located offshore.

Almost all wind turbines have the same design - a horizontal axis turbine having a rotor with 3 blades on top of a tall tubular tower.

Solar

Solar power works by converting energy from the sun into power. There are two forms of energy generated from the sun for our use – electricity and heat. Both are generated using solar panels, which range in size from residential rooftops to solar farms stretching over acres of land.

In 2023, solar generated 5% of the world's electricity,[4] compared to 1% in 2015.
Almost half the solar power installed in 2022 was rooftop.
Geography affects solar energy potential because different locations receive different amounts of solar radiation. With some variations, areas that are closer to the equator generally receive higher amounts of solar radiation. However, solar panels that can follow the position of the Sun can significantly increase the solar energy potential in areas that are farther from the equator.
A crucial question is the combination of solar plants and energy (electricity) storage.
The potential for solar energy is enormous, since about 200,000 times the world's total daily electric-generating capacity is received by Earth every day in the form of solar energy.

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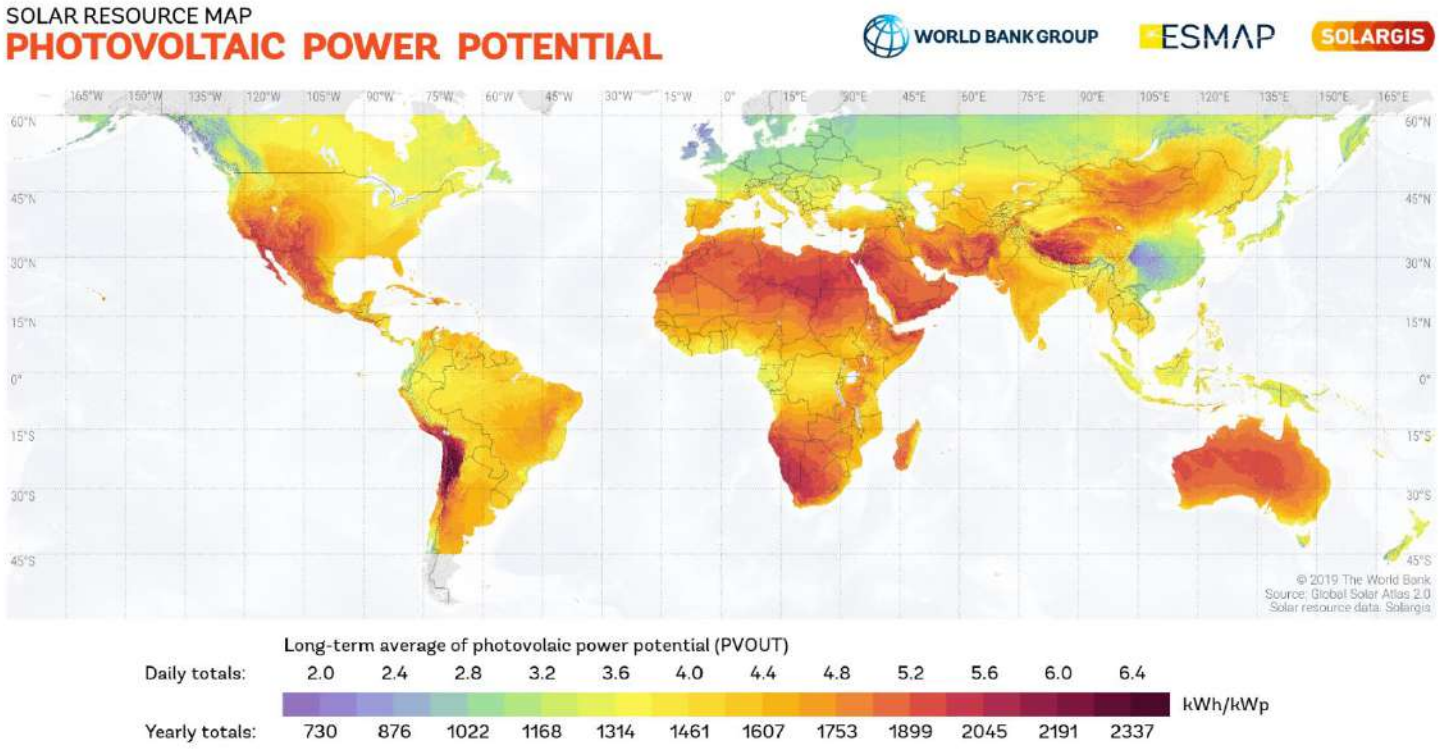
Solar (2)

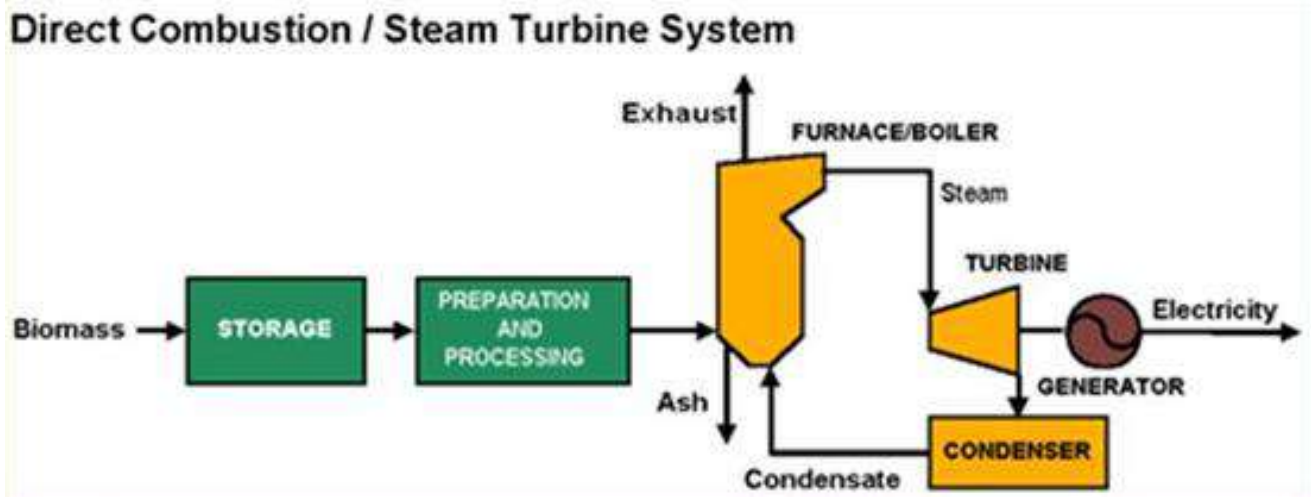


Biomass

Biomass can be converted into electric power through several methods. The most common is direct combustion of biomass material, such as agricultural waste or woody materials. Other options are gasification, pyrolysis, and anaerobic digestion.

Different methods work with different types of biomass. Typically, woody biomass such as wood chips, pellets, and sawdust are combusted or gasified to generate electricity. Corn stover and wheat straw residues are baled for combustion or converted into a gas using an anaerobic digester. Very wet wastes, like animal and human wastes, are converted into a medium-energy content gas in an anaerobic digester.

The biggest problems with biomass-fired plants are in handling and pre-processing the fuel. This is the case with both small grate-fired plants and large suspension-fired plants. Drying the biomass before combusting or gasifying it improves the overall process efficiency but may not be economically viable in many cases.



Geothermal

Geothermal power plants use steam to produce electricity.
The steam comes from reservoirs of hot water found a few miles or more below the earth's surface. The steam rotates a turbine that activates a generator, which produces electricity.

Most geothermal resources are near the boundaries of the earth's tectonic plates. The most active geothermal resources are usually found along major tectonic plate boundaries where most volcanoes are located.

As a source of renewable energy for both power and heating, geothermal has the potential to meet 3 to 5% of global demand by 2050.

Air and water pollution are two leading environmental issues associated with geothermal energy technologies. Additional concerns are the safe disposal of hazardous waste, siting and land subsidence.

The picture shows Krafla, a geothermal power station in Iceland.

Nuclear

Nuclear energy is a form of energy released from the nucleus, the core of atoms, made up of protons and neutrons. This source of energy can be produced in two ways: fission – when nuclei of atoms split into several parts – or fusion – when nuclei fuse together.

Nuclear energy today provides about 10% of the world's electricity from about 440 power reactors.

A major environmental concern related to nuclear power (fission) is the creation of radioactive wastes such as uranium mill tailings, spent reactor fuel, and other radioactive wastes. These materials remain radioactive and dangerous to human health for thousands of years.

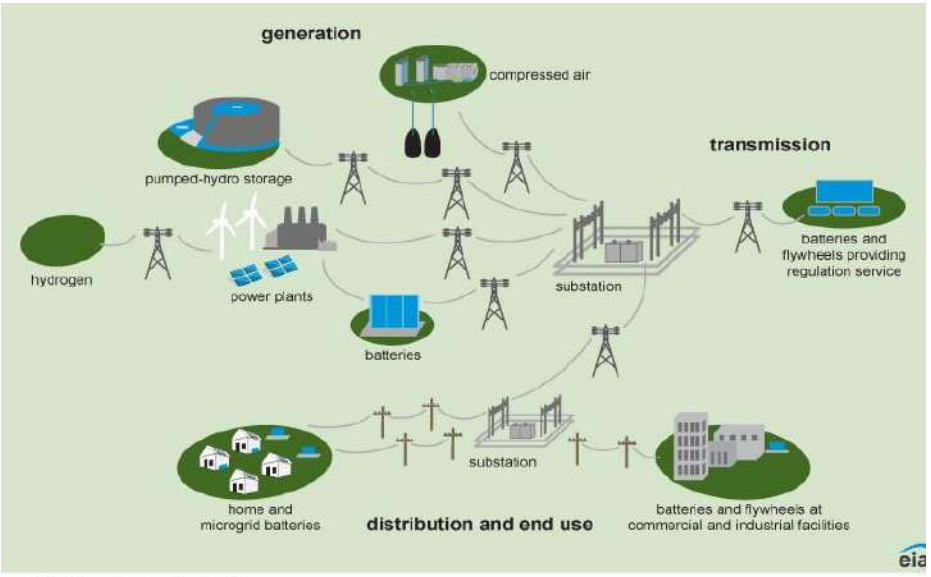
Main cons of Nuclear Energy:

- Expensive Initial Cost to Build. Construction of a new nuclear plant can take anywhere from 5-10 years to build, costing billions of Euros.
- Risk of Accident & radioactive waste.
- Limited Fuel Supply (uranium).

Electricity (energy) storage

An energy storage system for electricity generation uses electricity (or some other energy source, such as solar-thermal energy) to charge an energy storage system or device, which is discharged to supply (generate) electricity when needed at desired levels and quality. ESSs provide a variety of services to support electric power grids.

Electricity cannot itself be stored, but it can be converted to other forms of energy which can be stored and later reconverted to electricity on demand.



ource: U.S. Energy Information Administration

Most important types of energy storage systems:

- Hydroelectric
- Electro-chemical: Batteries, hydrogen etc.
- Solar electric with thermal energy storage

Energy storage can balance the supply and demand of renewable energy. Wind and solar power are both variable energy sources; simply put, energy storage can save the day when the sun doesn't shine or the wind doesn't blow, by feeding stored energy from sunnier or windier days to the grid.

Your turn: Create a draft electricity generation plan for your region

What sources would you prioritize and why?
What mix of electricity sources would you recommend and why?
What main problems do you expect regarding implementation?

enerhack

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Thank You for your attention!

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