



Structure of this lecture

1. Energy as the most vital natural resource
2. Intro to energy system analysis
3. Energy and economy
4. Energy and environment
5. Concluding remarks



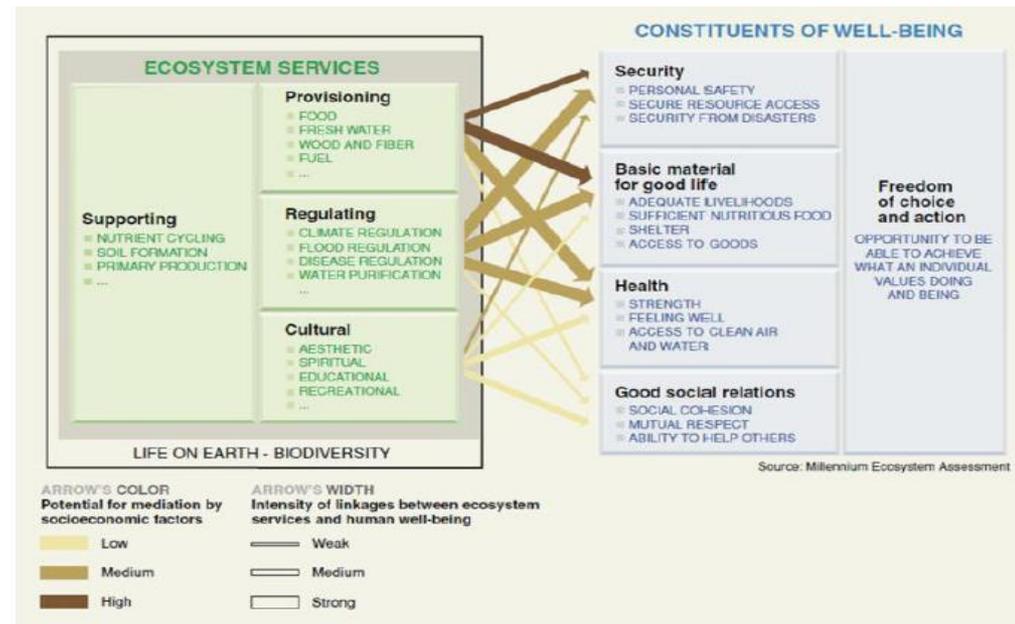
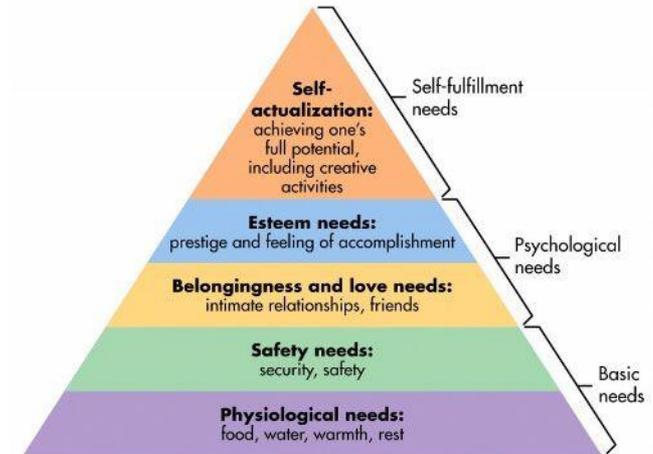
Energy?

- Many are familiar with the concept of energy
- Frequently connected with ability, power or potential to do something
- From a natural science perspective, energy is defined as the ability to do physical work
- All changes to our physical reality requires energy



What is needed by society?

- Focus on basic needs
 - Maslow's pyramid is helpful
- Food and water supply
 - To ensure human survival
 - Agriculture & food preparation
- Raw materials & goods
 - Needed for manufacturing, construction, etc.
- Energy
 - Required for all the above and other essential services



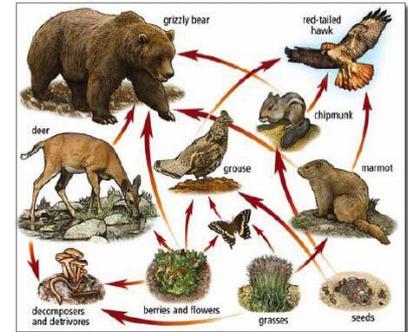


Energy is vital

- Darwin proposed natural selection and "survival of the fittest" as evolutionary mechanisms
 - Resources are limited by nature, so abilities that enhances survival and reproduction is "better" and will increase in frequency over generations
 - Influential ideas for sociology, economy, and politics (e.g. social darwinism) from 1870s and onwards
 - From 1960s, computer modelling paved the way for future families of large Integrated Assessment Models (IAM) used to understand, plan, and explore societal trends today
- Early attempts tried to create models based on interactions between society and natural resources using Darwinian or pseudo-Darwinian concepts
 - Societal metabolism (e.g. Spencer, Durkheim, etc.)
 - Resource limitations/boundaries (ex. Malthus, Meadows)
 - Ecological carrying capacity (e.g. Verhulst, Odum)

Importance of energy:

- All forms of life and society require **energy**
- **Example:** plants use sun for energy
 - Animals consume food for energy
- If the flow of energy is **disrupted**, the organisms stop functioning and start to **die off**.
- **Example:** if predators run out of food, they will starve to death

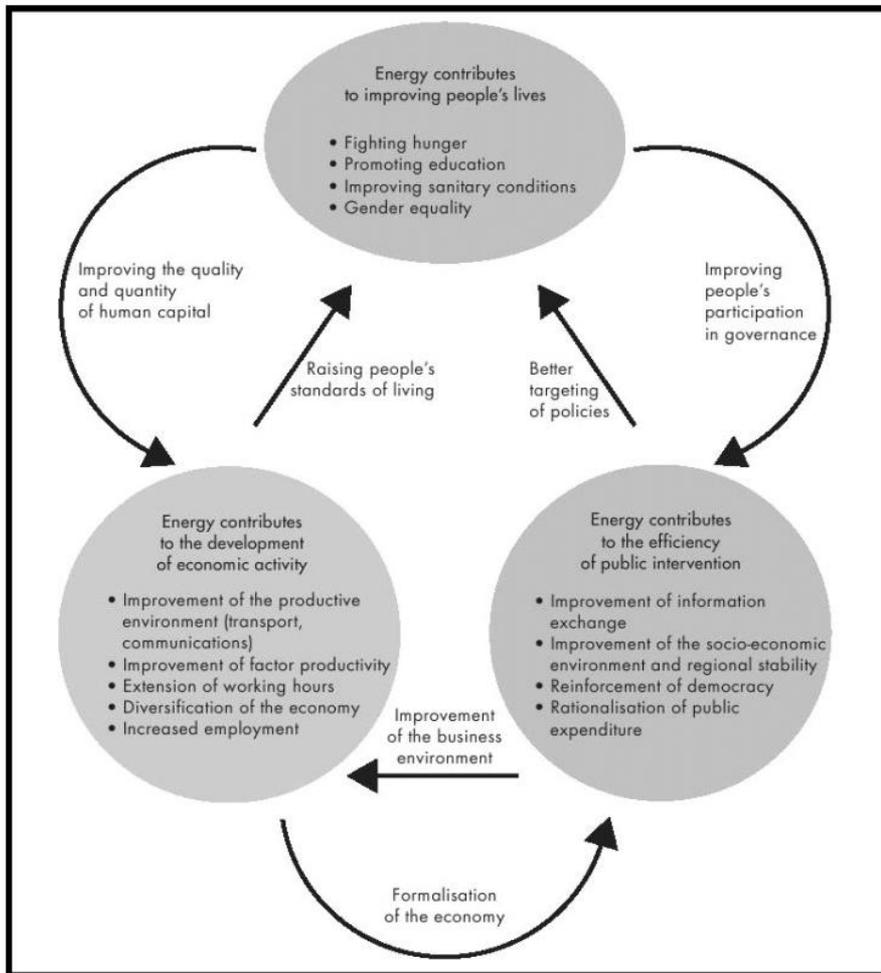


"Available energy is the main object at stake in the struggle for existence and the evolution of the world." –Ludwig Boltzmann



Energy and sustainable development

Figure 2. Links between energy and human, economic and social development



Source: *African Economic Outlook* (OECD/ADB, 2004).

- Energy is clearly intertwined with many of the SDGs
 - Directly to SGD7
 - Indirectly to 1, 3,6, 8, 11, 12, and 13

SUSTAINABLE DEVELOPMENT GOAL 7

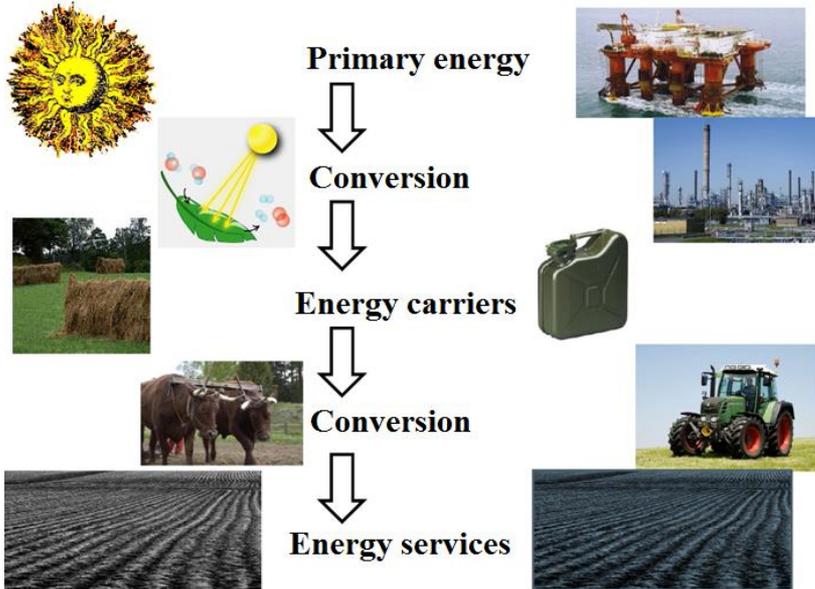
Ensure access to affordable, reliable, sustainable and modern energy for all



- It is also strongly connected to economic growth and increased welfare for citizens



Energy systems



Energy systems converts primary energy into desired energy services

- **Primary Energy** refers to energy as it occurs in nature
- **Energy carriers** are secondary forms of energy for easier transmission or use, such as refined fuels or electricity
- **Energy services** is a name for all "useful" work that is demanded by consumers to meet specific needs
 - E.g. transportation, cooking, illumination, communication, etc.



Different types of primary energy

Flows (quickly refilled)

- Solar
- Wind, water, waves
- Geothermal

Funds (slowly renewed)

- Biomass
- Peat (depends!)

Stocks (finite resources)

- Coal
- Oil
- Natural gas
- Nuclear fuels

Desirable properties:

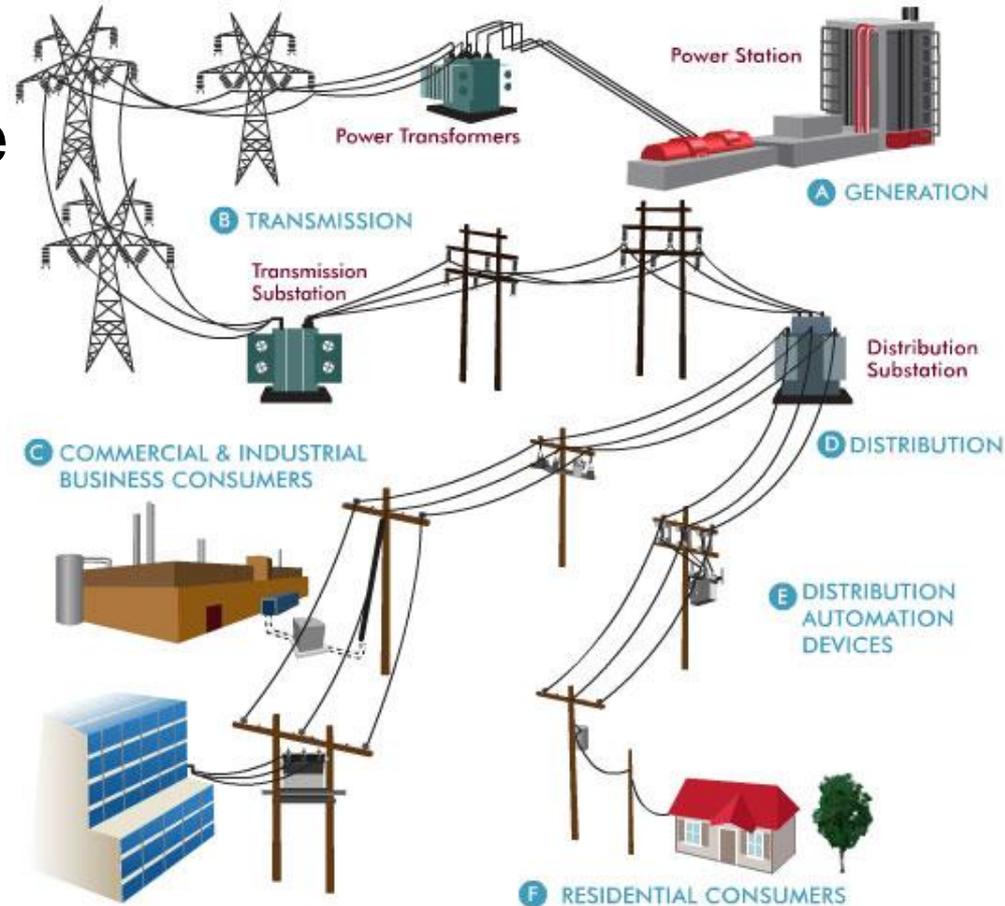
- Flexible power
- Low costs
- Easy handling
- Low environmental impact





Secondary energy = energy carriers

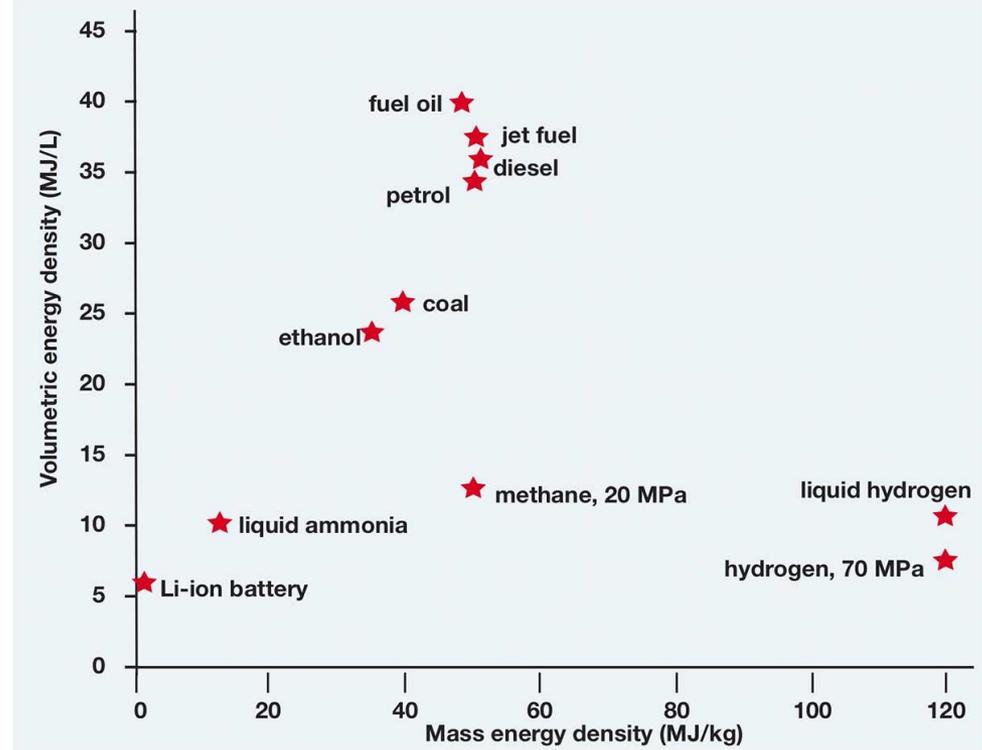
- Act as a middle man between the primary energy and the final use
- Rather stores or transports energy without being any real energy sources
- Also called "*energy carriers*"





Desirable energy carriers

- High energy density (per volume & mass)
- High efficiency
- Transportability
- Storability
- Safety
- Purity
- Cost
- Etc.



Relative performance parameters for various transport fuels

	Fuel	LHV fuel (MJ/L)	LHV fuel with tank	Power (kW)	Engine efficiency (%)	Recharge time (min)	Relative performance	Time at max power (h)
Horse	600 kg Oats	6.00	6.00	0.75	15	120.00	3.84	0.10
Internal combustion engine	Small Petrol	32.72	25.17	147.00	30	5.00	32.22	2.14
	Large Diesel	35.92	30.61	284.11	35	5.00	45.72	4.13
	Truck Diesel	35.92	30.61	380.31	35	10.00	45.72	20.32
Fuel cell	Fuel cell Hydrogen	4.76	0.17	128.00	60	5.00	0.43	0.05
Li-ion battery	Battery Electricity	2.49	0.26	615.00	90	60.00	1.00	0.14



Energy carriers for society

The society is primarily built around two types of energy carriers close to final energy consumption

Electricity



Heat



- Heat is easy to produce and can be useful for heating or for transformation to mechanical work using various heat engines
- Electricity is harder to produce, but very flexible and can be transmitted over long distances and easily transformed to many other energy forms

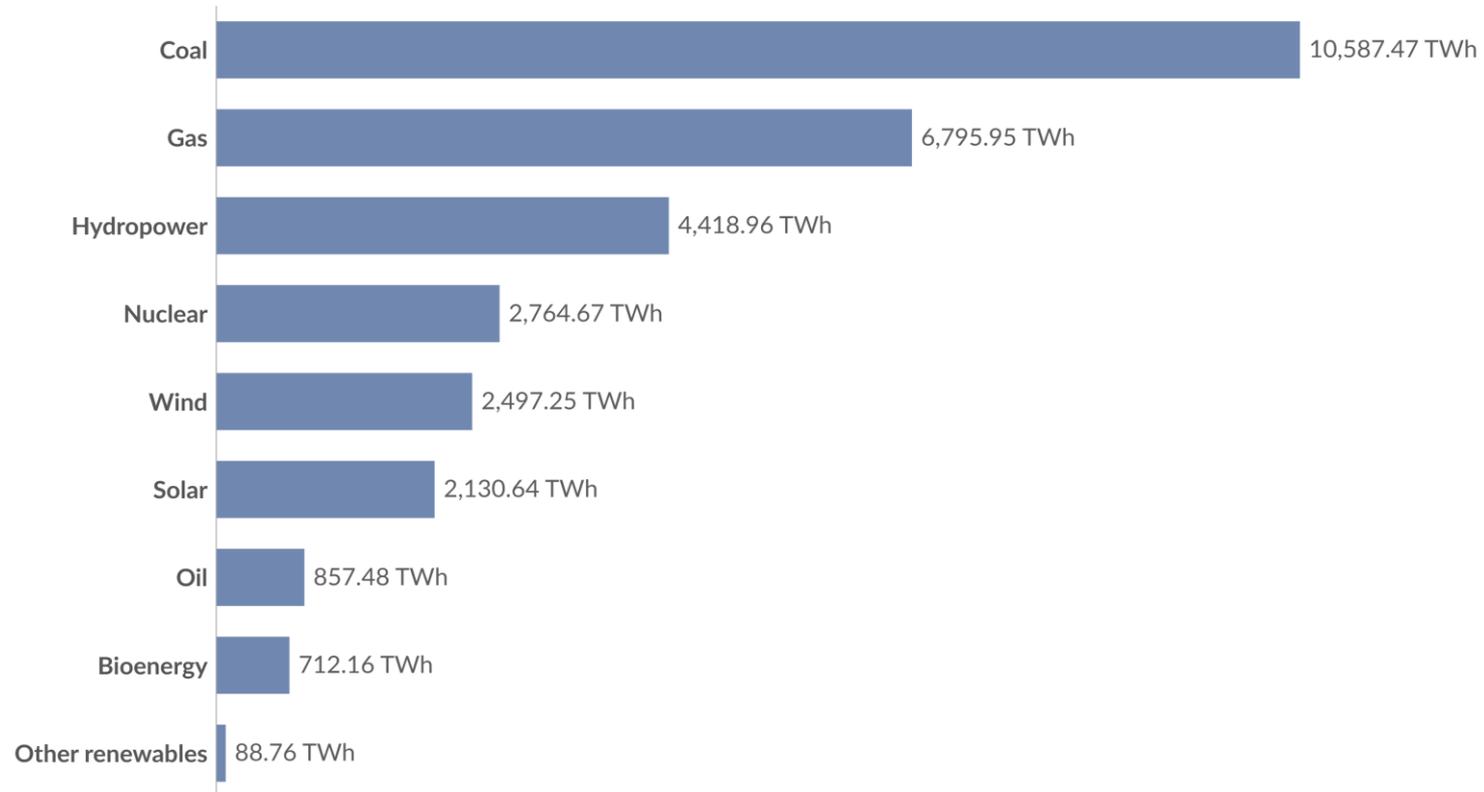


Global electricity

Electricity production by source, World, 2024



Measured in terawatt-hours¹.



Data source: Ember (2025); Energy Institute - Statistical Review of World Energy (2025)

OurWorldinData.org/energy | CC BY

Note: "Other renewables" include geothermal, wave, and tidal energy.

Note that electricity is only **18%** of global primary energy!!!



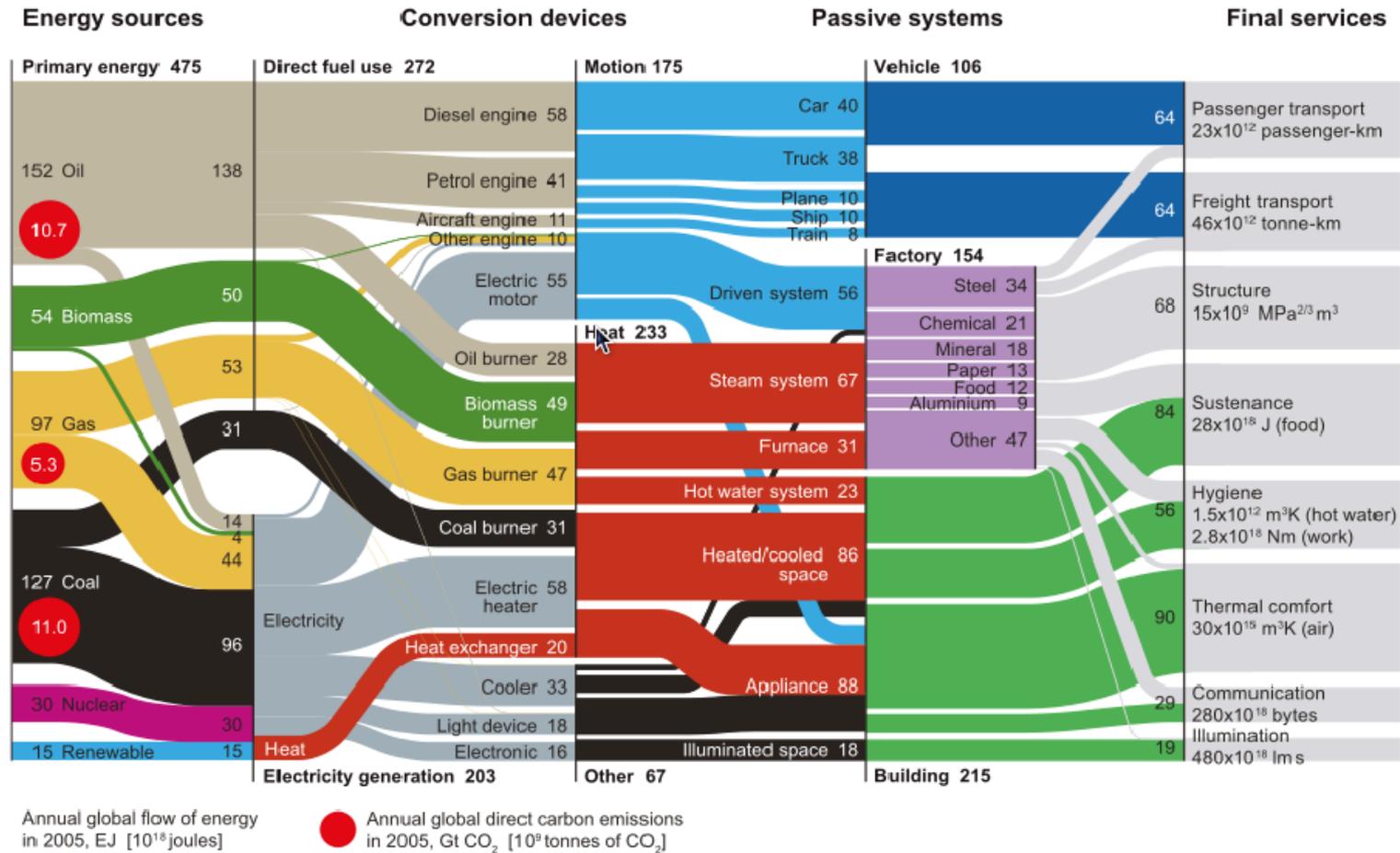
Energy services

- Collective name for all "useful" work that is demanded by consumers
- Different services may require different energy forms
 - Sometimes this cause practical limits
 - Affects the required energy technologies
- Some examples:
Mechanical work, manufacturing, communication, transportation, heating/cooling, illumination, etc.





Global transformations



Source: Cullen JM, Allwood JM (2010). The efficient use of energy: Tracing the global flow of energy from fuel to service. *Energy Policy*, 38(1), 75-81.



Energy system analysis

- Energy system analysis is by definition a multidisciplinary and encompasses both natural and social sciences

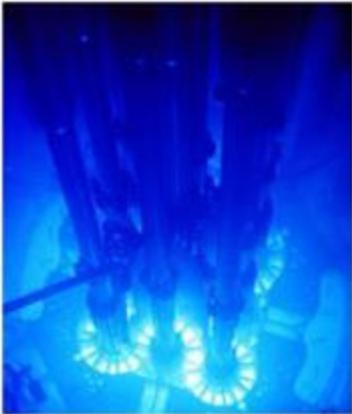
The goal of Energy Systems Analysis is often:

- tracking the fate of resources as they are processed through the energy economy;
- determining the practical or economic feasibility of various energy use scenarios or projections;
- predicting the economic outcomes of energy policies
- finding the causes of, and solutions to, technological, market, or policy failure.



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Current state of energy systems





Chosen energy system

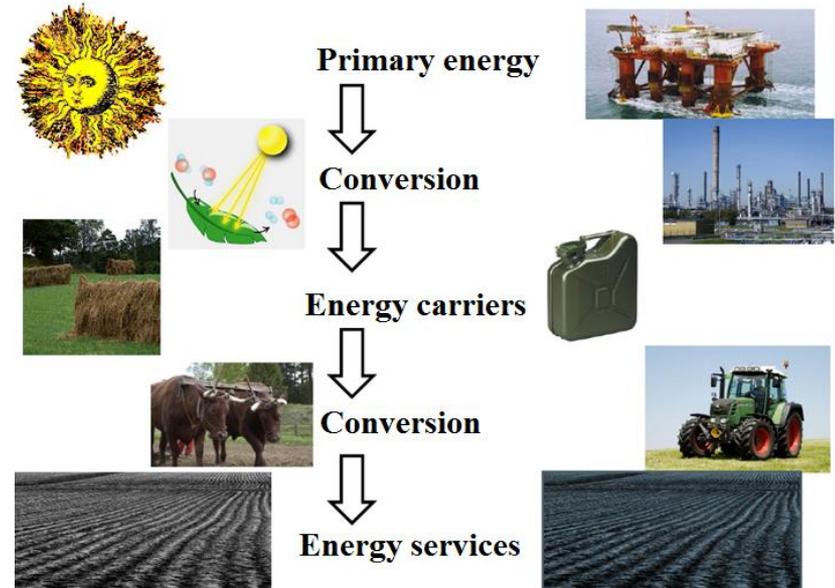
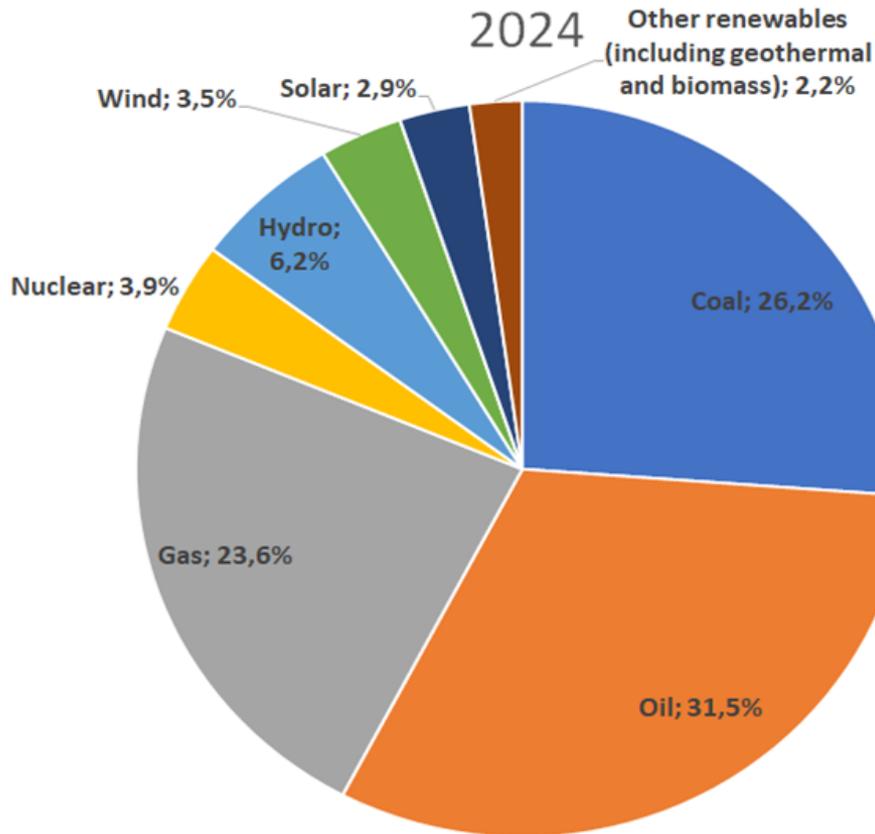
- Real energy systems are affected by several factors
- **Physical availability**
 - Some energy resources are only found in certain places
- **Technical and geopolitical accessibility**
 - Must be technically and geopolitically possible
- **Economic attractiveness**
 - Energy resources compete with others on energy markets and must be attractive for consumers
- **Social acceptance**
 - Energy development must be socio-politically acceptable



A global energy perspective (2024 data)

World primary energy consumption by source in

2024



Total primary energy consumption equals 175 271 TWh,
The fossil fuels account for 81.3% or 142 420 TWh

Källa: Our World in Data (2025) Primary energy consumption by source, World, 2024

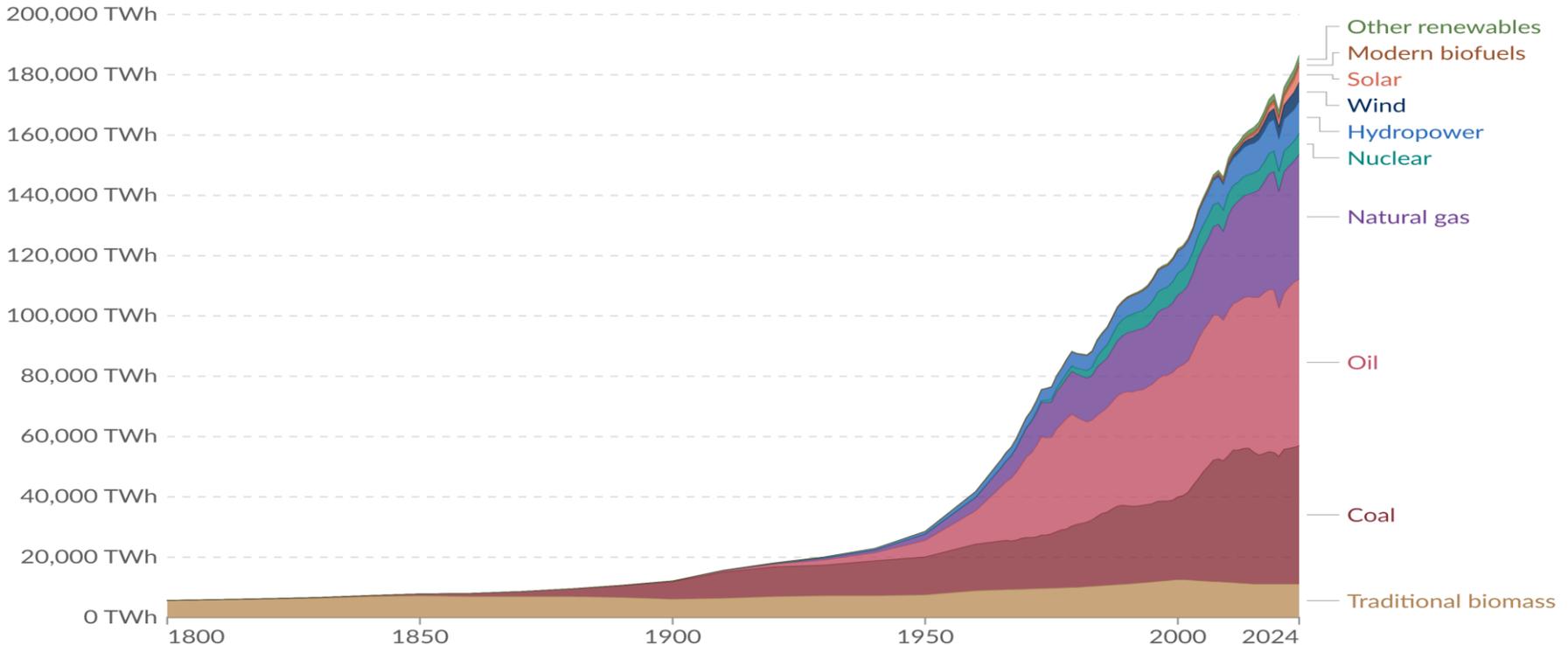


Global energy over time

Global primary energy consumption by source

Our World
in Data

Primary energy¹ is based on the substitution method² and measured in terawatt-hours³.



Data source: Energy Institute - Statistical Review of World Energy (2025); Smil (2017)

OurWorldinData.org/energy | CC BY

Note: In the absence of more recent data, traditional biomass is assumed constant since 2015.

Over 80% of all energy originates from fossil fuels
We are not replacing fossil fuels – only adding more energy

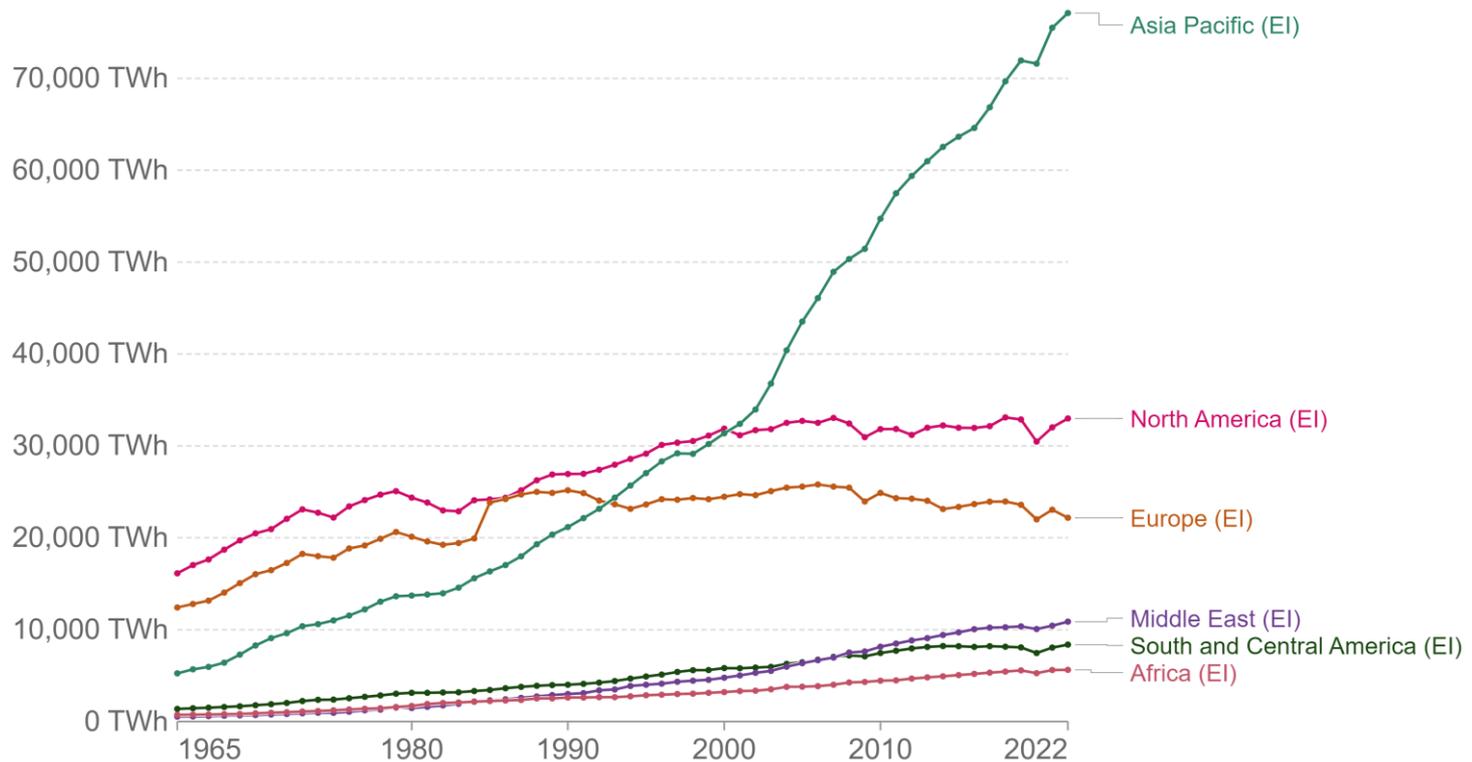


World primary energy consumption

Primary energy consumption by world region

Our World
in Data

Primary energy consumption is measured in terawatt-hours (TWh). Note that this data includes only commercially-traded fuels (coal, oil, gas), nuclear and modern renewables used in electricity production. As such, it does not include traditional biomass sources.



Data source: Energy Institute Statistical Review of World Energy (2023)

OurWorldInData.org/energy/ | CC BY

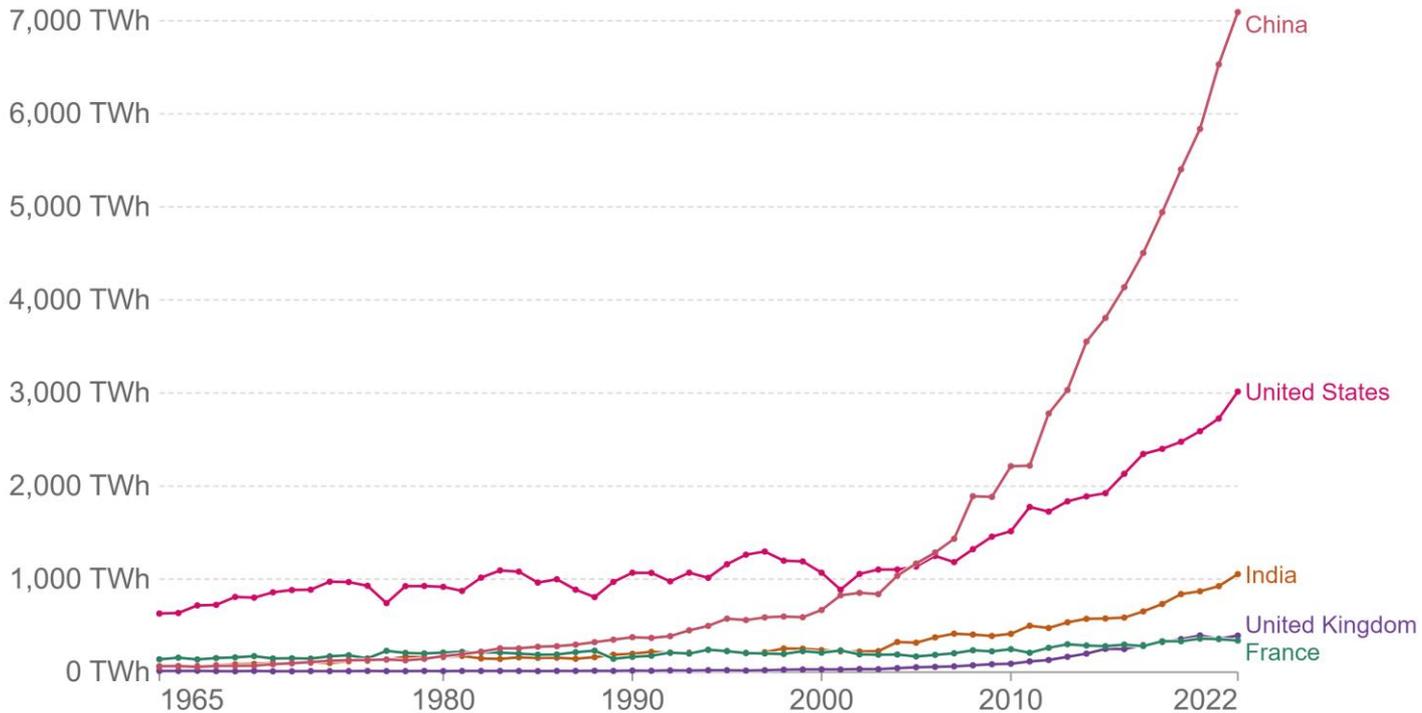


World primary renewable energy

Primary energy consumption from renewables

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Renewable energy includes hydropower, solar, wind, geothermal, wave and tidal and bioenergy. Traditional biofuels are not included. Energy consumption is based on primary energy equivalents, rather than final electricity use.



Data source: Energy Institute Statistical Review of World Energy (2023)

OurWorldInData.org/energy/ | CC BY

Note: 'Primary energy' refers to energy in its raw form, before conversion into electricity, heat or transport fuels. It is here measured in terms of 'input equivalents' via the substitution method: the amount of primary energy that would be required from fossil fuels to generate the same amount of electricity from renewables.

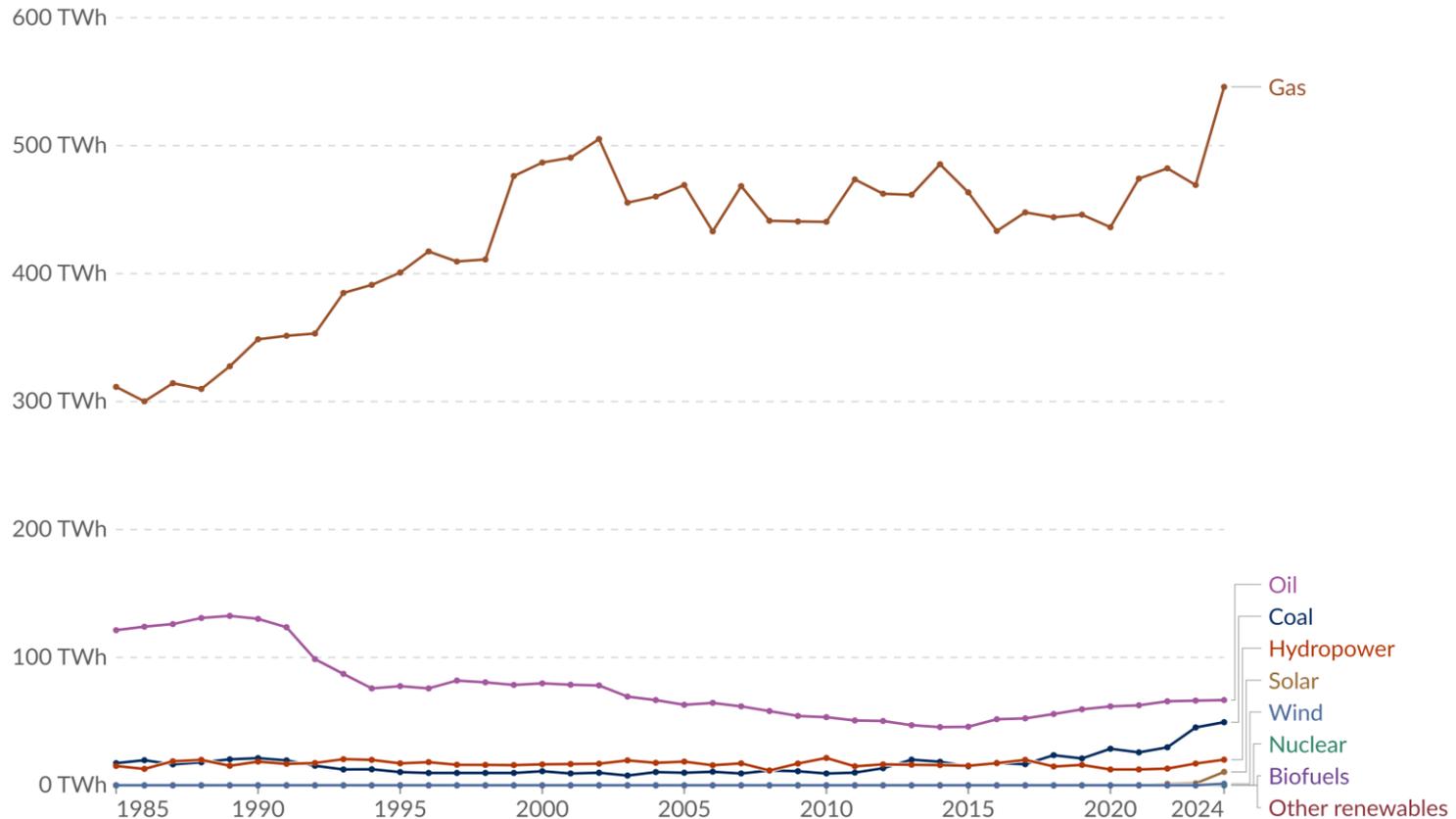


View for Uzbekistan

Primary energy consumption by source, Uzbekistan

Our World
in Data

Primary energy¹ is measured in terawatt-hours², using the substitution method³.



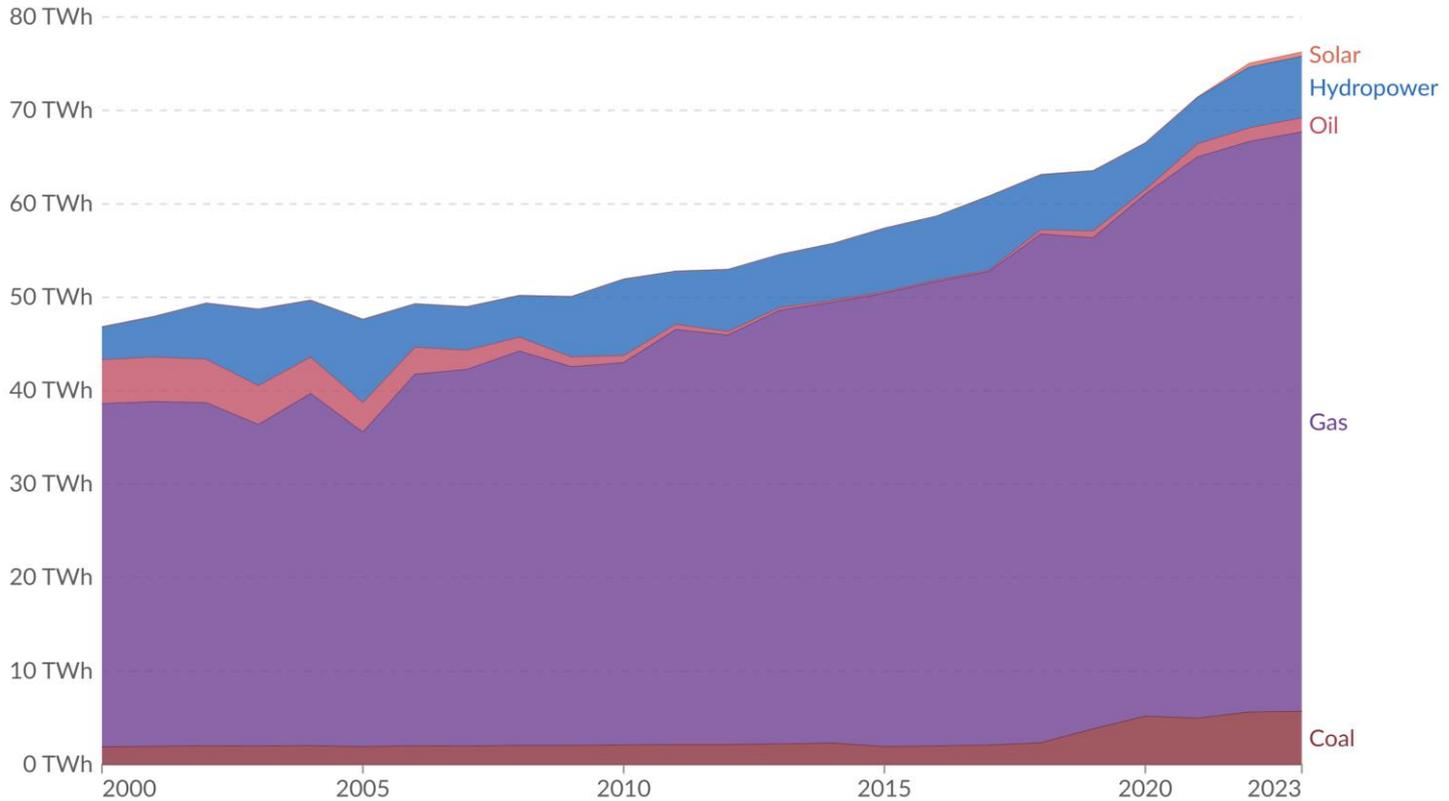


Electricity by source

Electricity production by source, Uzbekistan

Our World
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Measured in terawatt-hours¹.



Data source: Ember (2026); Energy Institute - Statistical Review of World Energy (2025)

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Note: "Other renewables" include geothermal, wave, and tidal.

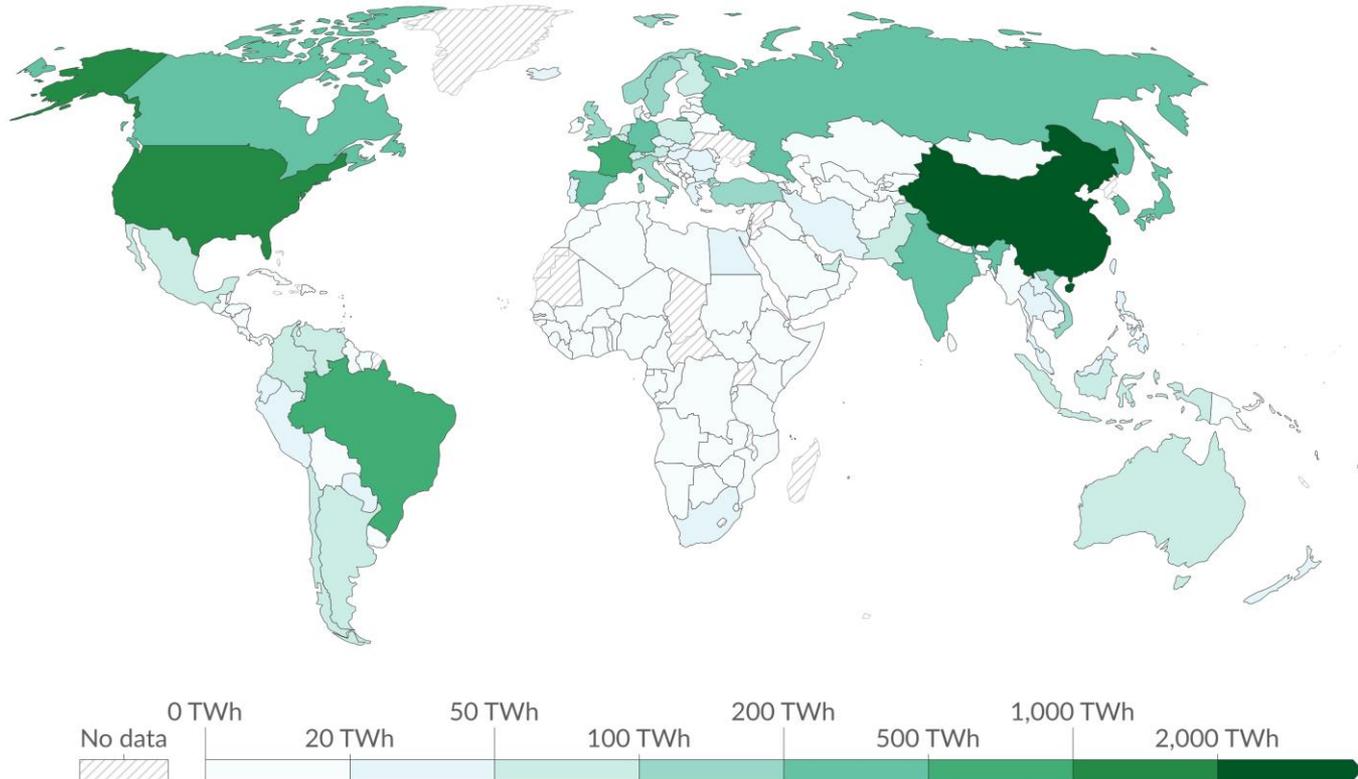


Global low-carbon electricity

Electricity generation from low-carbon sources, 2025

Our World
in Data

Measured in terawatt-hours¹. Low-carbon sources correspond to renewables and nuclear power, that produce significantly less greenhouse-gas emissions² than fossil fuels. Renewables include solar, wind, hydropower, bioenergy, geothermal, wave, and tidal.





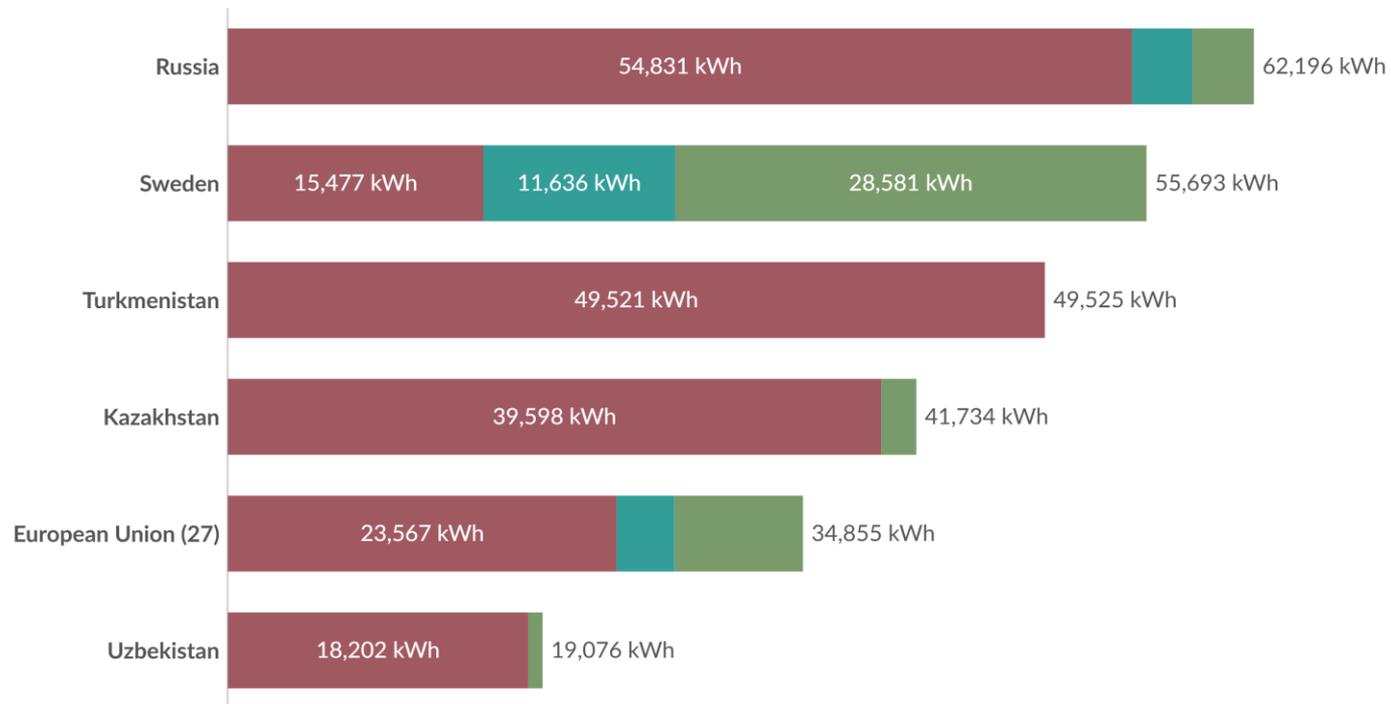
Some differences

Per capita energy from fossil fuels, nuclear and renewables, 2024

Our World
in Data

Measured in kilowatt-hours¹ of primary energy² consumption per person, using the substitution method³.

Fossil fuels Nuclear Renewables

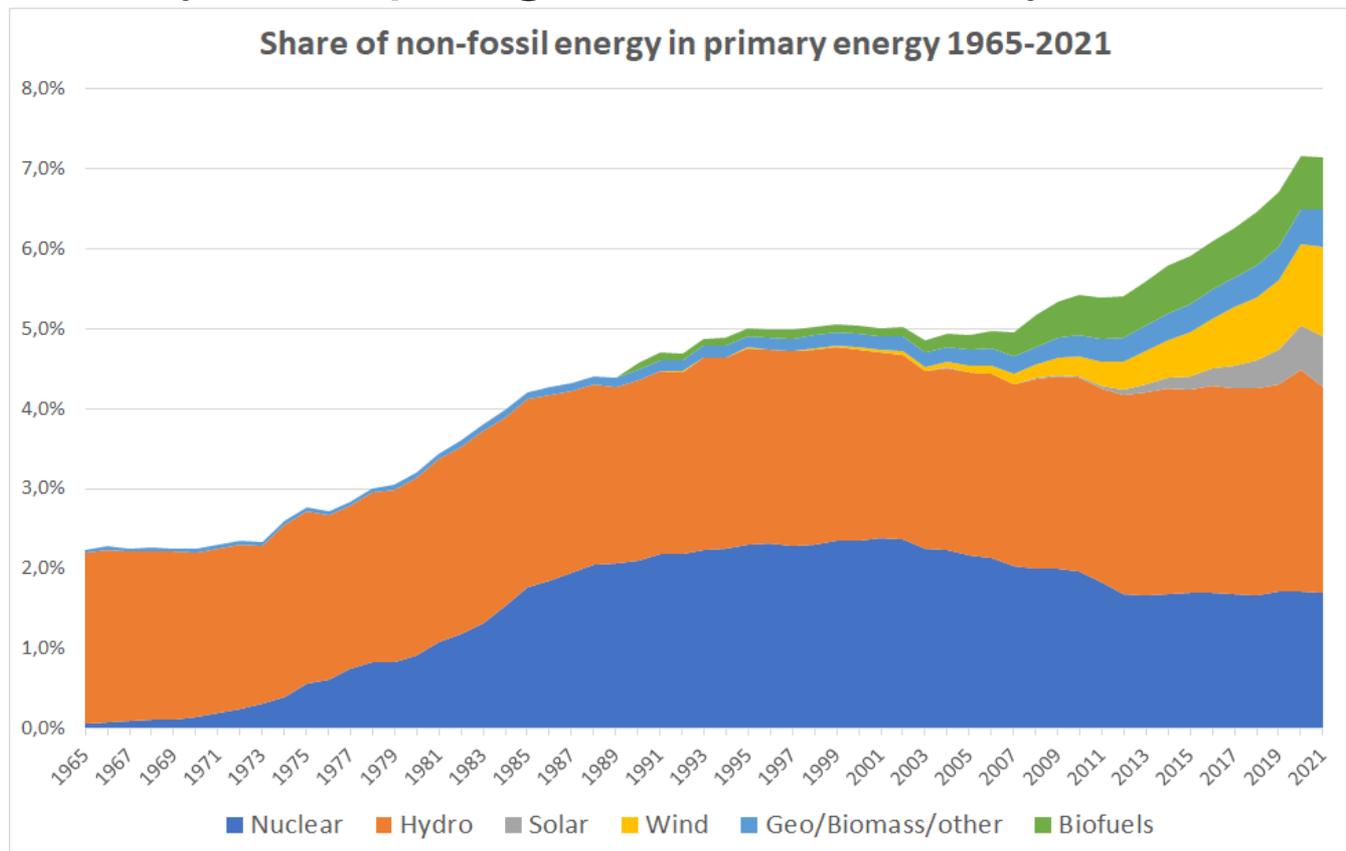


Data source: Energy Institute - Statistical Review of World Energy (2025); Population based on various sources (2024)
OurWorldinData.org/energy-mix | CC BY



Growth of non-fossil energy

- Non-fossil energy has experienced two phases
- Currently, a rapid growth driven by solar/wind





Accessibility

- Renewable energy needs to be converted to energy forms that can be made accessible and useful by consumers in society
 - Access to conversion technologies are often much more important in practice than abundant availability in nature
- Many different barriers exist
 - Land use restrictions and competing activities
 - Transportation distances and limits
 - Structural barriers with patents, etc.
 - Technology access
 - Geopolitical factors



A question about scale



- Can Sahara meet the global electricity demand of $\sim 30\,000$ TWh?
 - Covering just 9% of Saharan desert areas would suffice
 - Area is $\sim 800\,000$ km²
 - Assuming 20% PV efficiency
 - Would correspond to 18 750 GW installed PV



How about industrial capacity?



- **Manufacturing numbers:**
- Typical power: 350-400 W/panel
- Typical panel area is: 1,6-2 m²

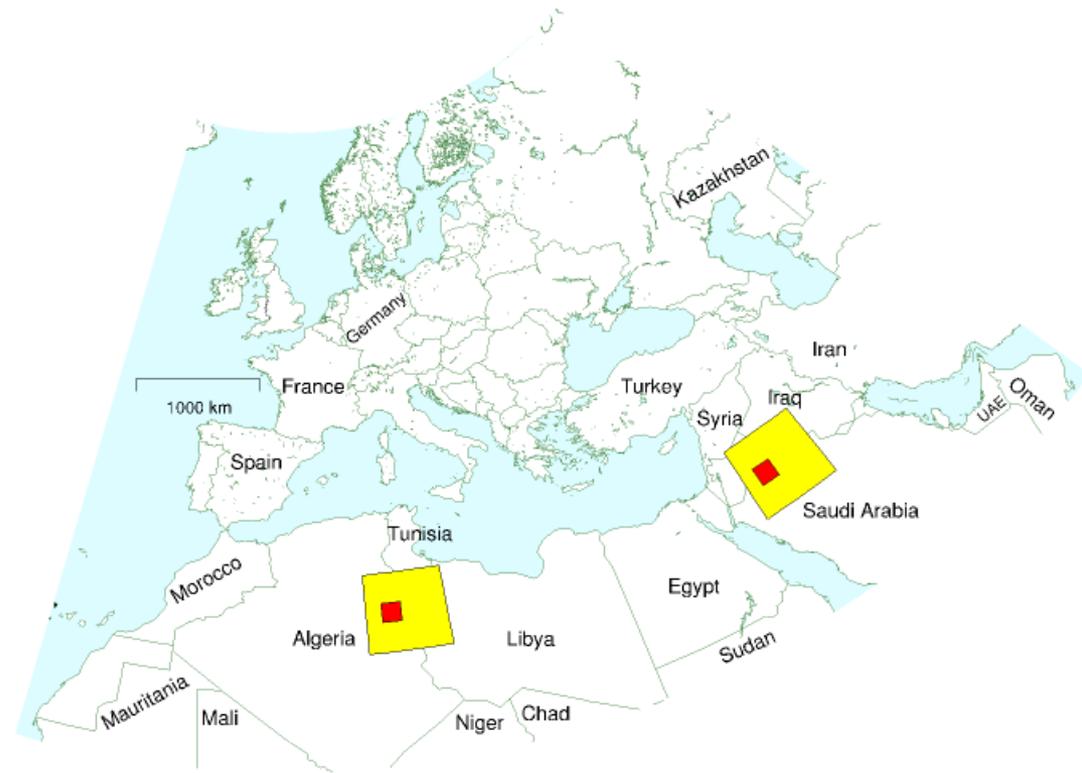
- In 2022, the world PV industry produced 380 000 MW PV panels or roughly 1900 km²

- So covering 9% of Sahara would require >400 years with current industrial capacity



Twilight in the desert?

- A small area of Sahara could cover the European energy needs using solar
- But how secure is it to produce all the energy for Europe?
 1. In unstable regions
 2. Far away on another continent

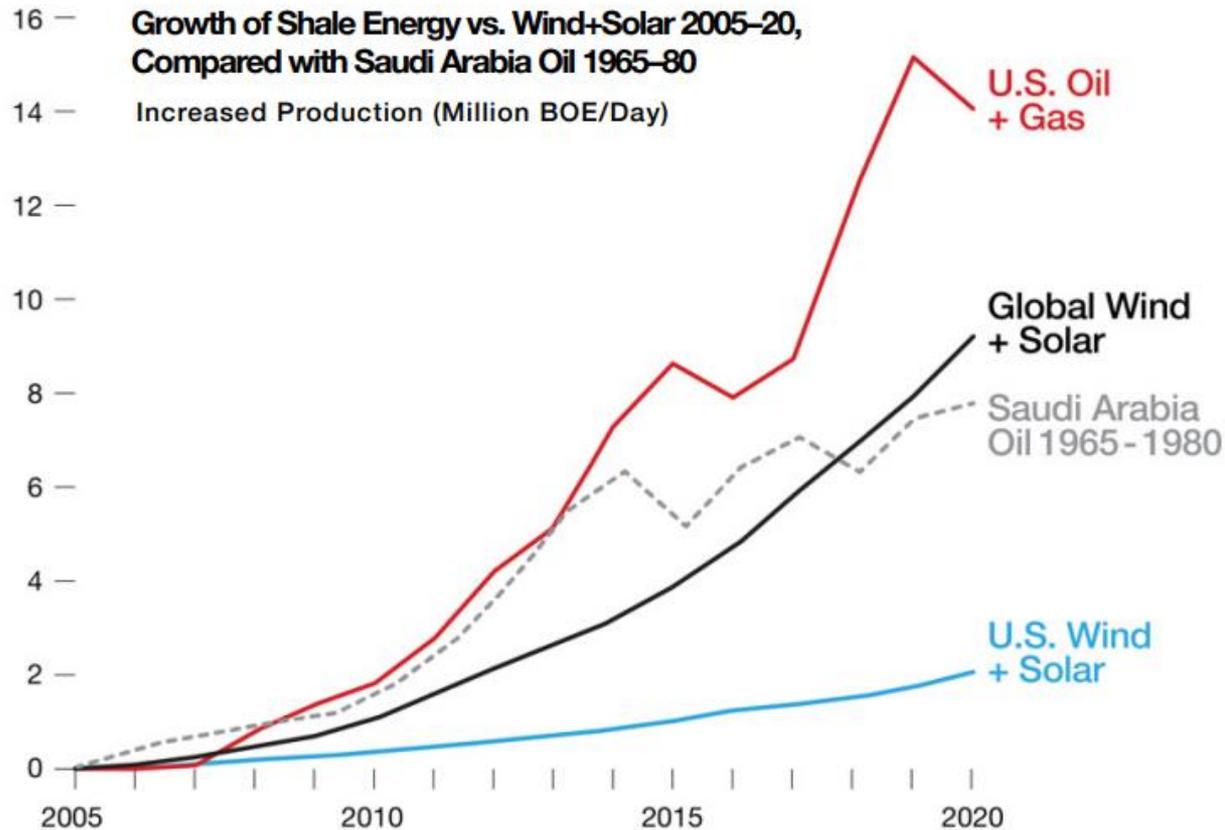


MacKay (2009). *Sustainable Energy — without the hot air*



Investments vs energy output

SHALE TECHNOLOGY IS HISTORY'S BIGGEST ENERGY REVOLUTION



Despite impressive investments, growing renewables are vastly outperformed by North American shale oil/gas in terms of produced energy for society



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Pause

- 10 minute



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Economy and energy



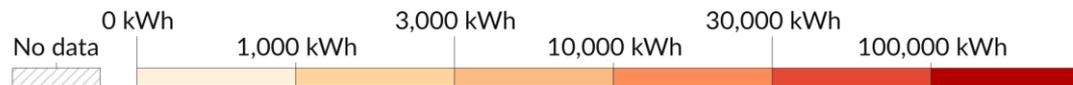
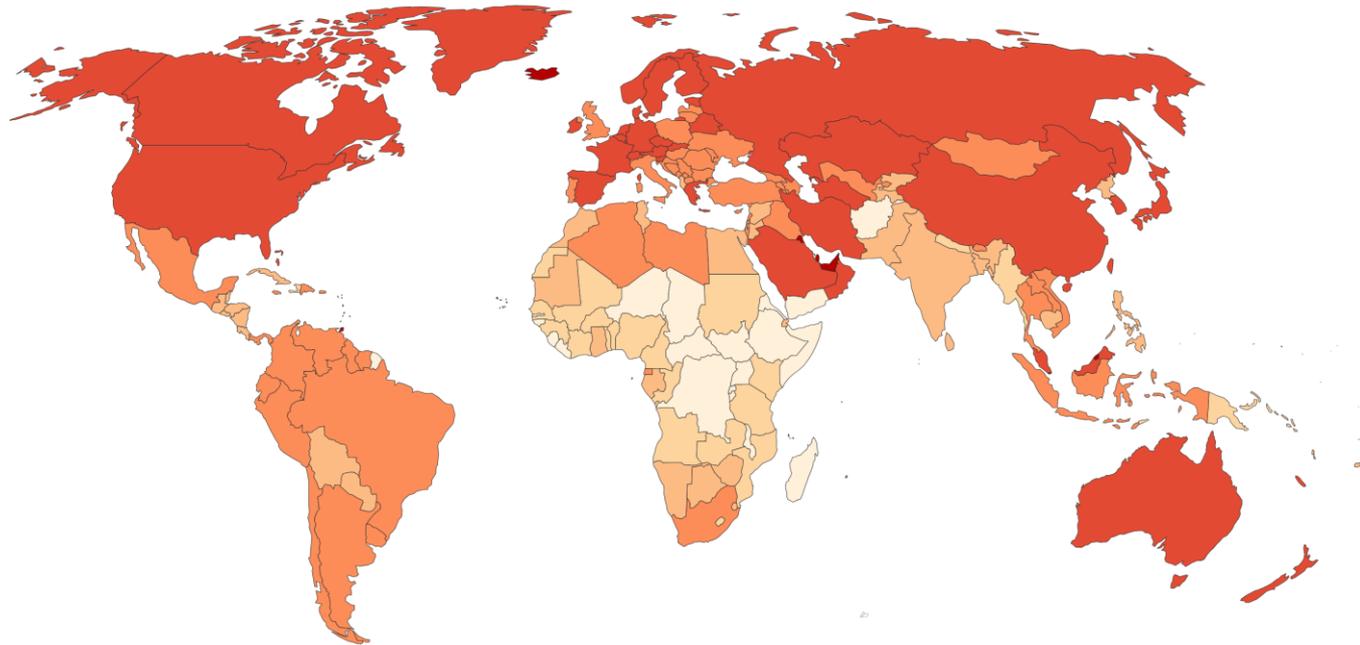


Energy use in the world

Energy use per person, 2024

Our World
in Data

Measured in kilowatt-hours per person. Here, energy refers to primary energy using the substitution method.



Data source: U.S. Energy Information Administration (2025); Energy Institute - Statistical Review of World Energy (2025); Population based on various sources (2024)

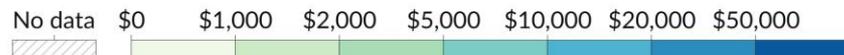
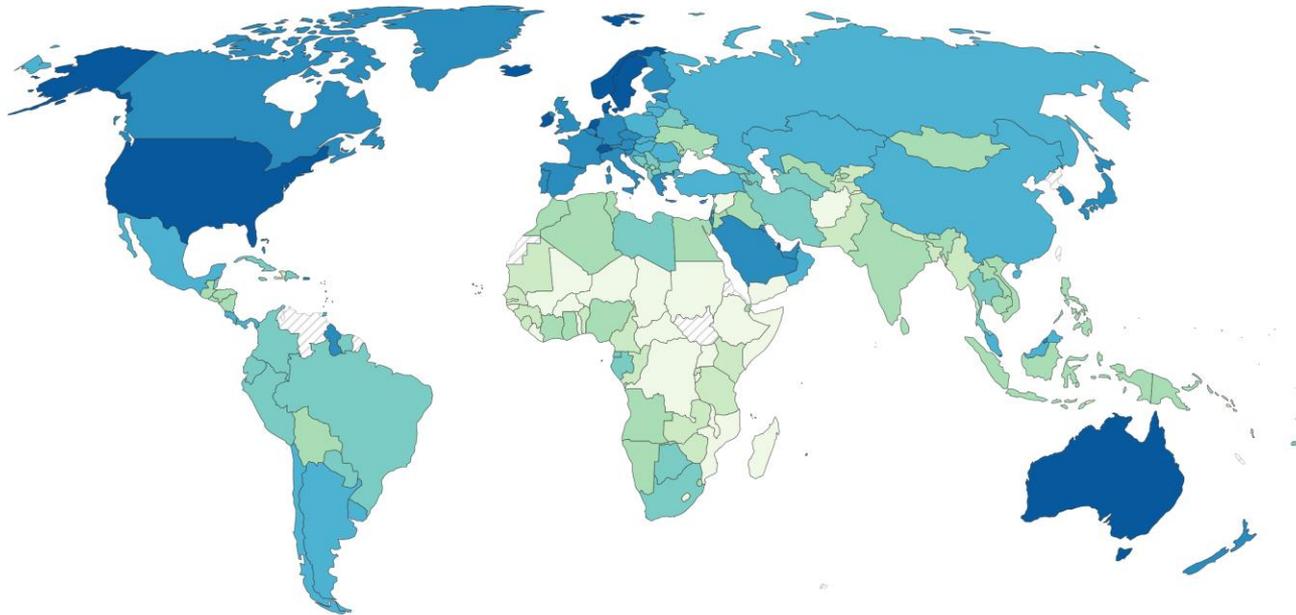


GDP per capita in the world

GDP per capita, 2023

Our World
in Data

This data is expressed in US dollars. It is adjusted for inflation but does not account for differences in living costs between countries.



Data source: World Bank and OECD national accounts (2025)

Note: This data is expressed in constant 2015 US\$.

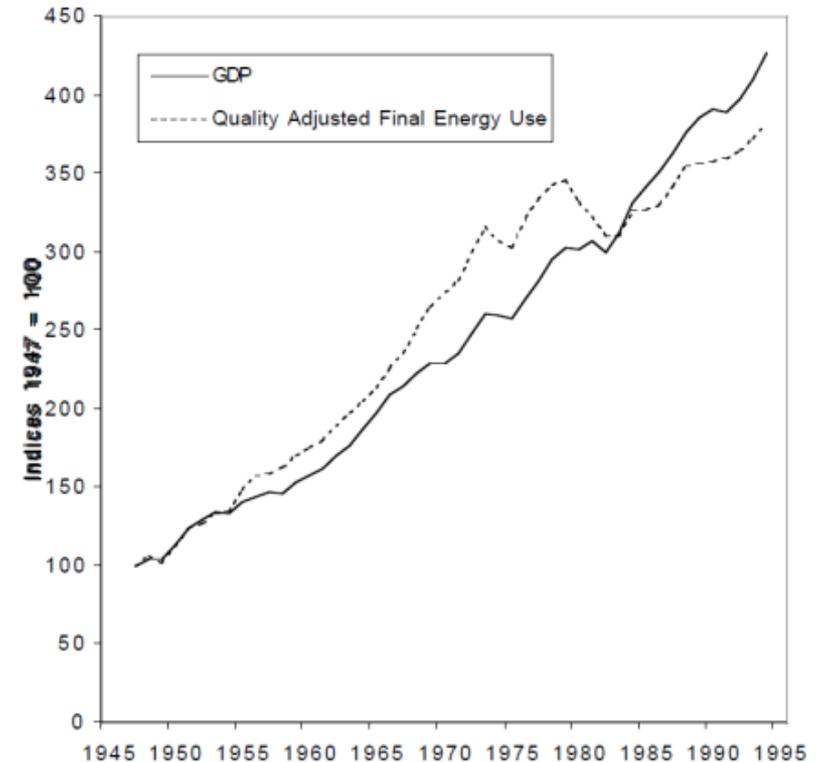
OurWorldinData.org/economic-growth | CC BY



Energy gives wealth

- The richest nations are major energy user
- Strong correlation between increased GDP or economic development and energy use
 - The real economy is a complex process that converts energy and raw materials into useful materials and services

Figure 7. U.S. GDP and Quality Adjusted Final Energy Use



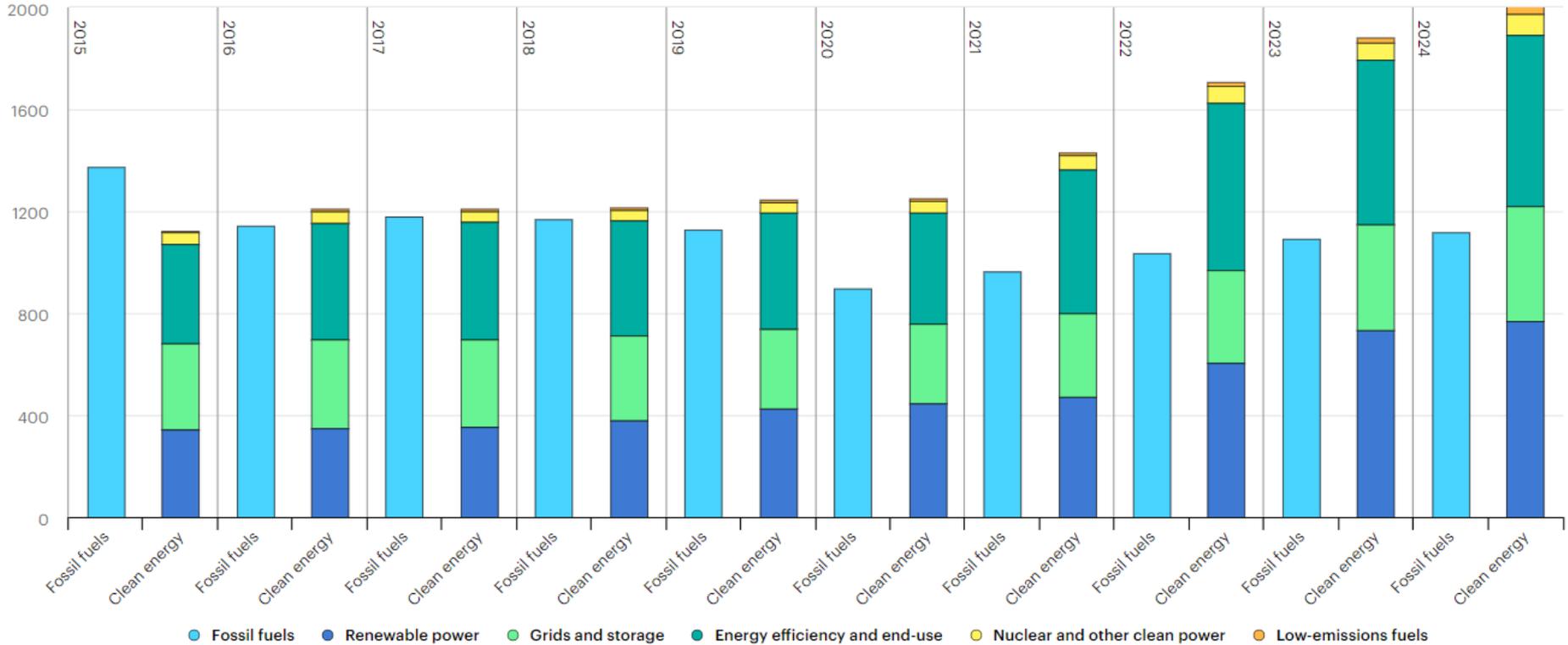
Notes: GDP is in constant dollars i.e. adjusted for inflation. Energy use is a Divisia index of the principal final energy use categories – oil, natural gas, coal, electricity, biofuels etc. The different fuels are weighted according to their average prices.

Source: Stern & Cleveland (2003) Energy and economic growth. *Rensselaer Working Papers in Economics*.



Global energy investments

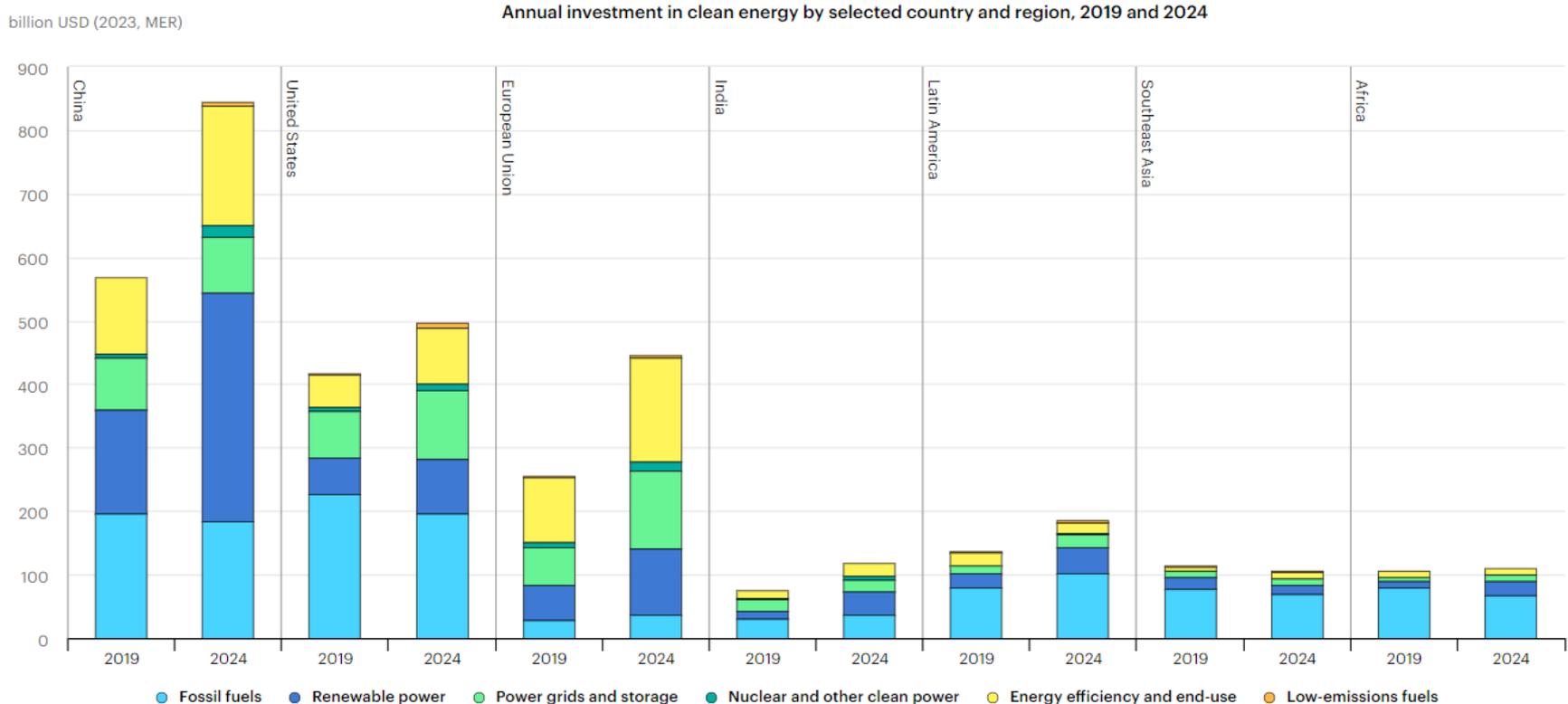
billion USD (2023, MER)



Be aware of details, such as that grid investments can be useful for any form of energy – even fossil power



Large regional differences

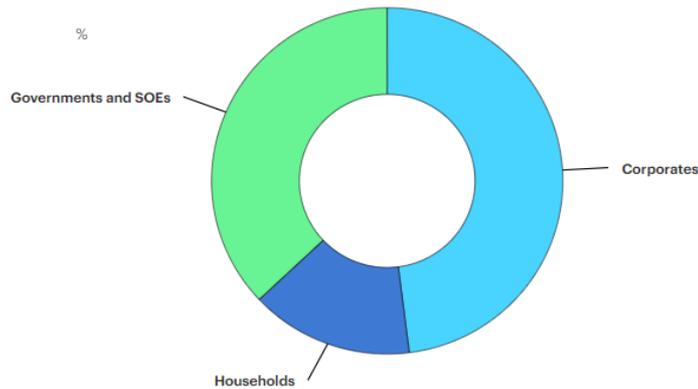


There are major imbalances in investment, and *Emerging Market and Developing Economies (EMDE)* outside China account for only around 15% of global clean energy spending

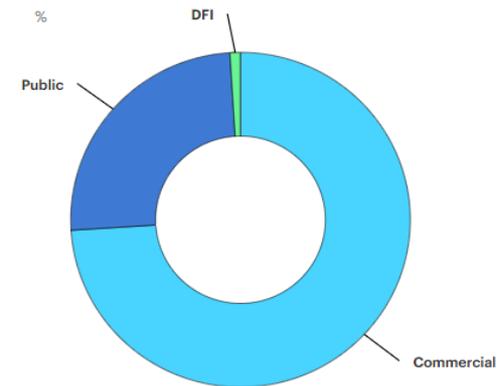


Investment sources

Sources of investment in the energy sector, average 2018-2023



Sources of finance in the energy sector, average 2018-2023



Energy investment decisions are primarily driven and financed by the private sector, but governments have essential direct and indirect roles in shaping capital flows

Three quarters of global energy investments today are funded from private and commercial sources, and around 25% from public finance, and just 1% from national and international development finance institutions (DFIs).



Energy and environment

- Common environmental issues associated to energy:
 - Greenhouse gas emissions
 - Acid rain
 - Particulates and smog
 - Landscape alteration
 - Release of toxic compounds
 - Biodiversity losses
 - Etc.





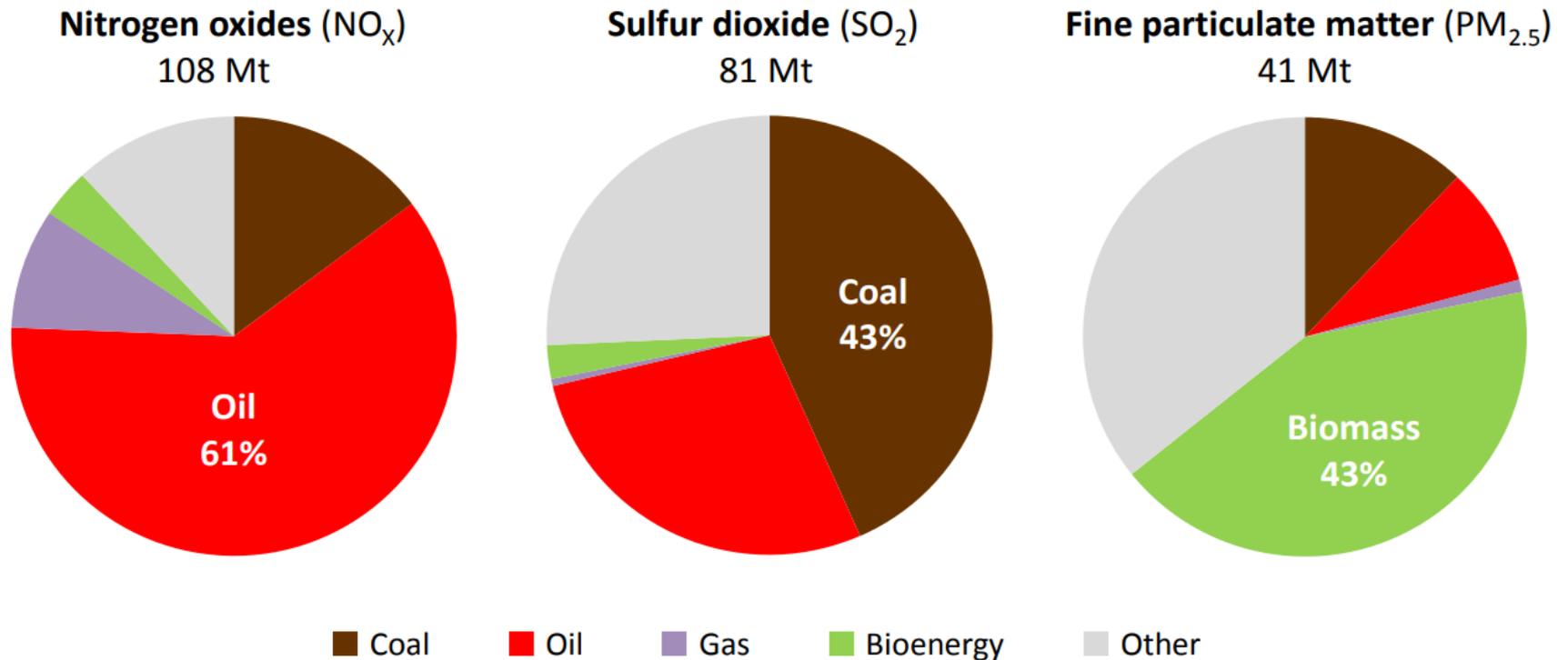
Conversion equals impact

- Each energy conversion process implies impacts on the surrounding environment
 - As energy and mass are conserved, waste or undesired flows must arise
- Some originate from the intrinsic losses of the actual conversion process itself (waste heat, radioactivity, combustion pollutants, toxic by-products, etc.)
- Additional impacts arise from raw materials required to construct conversion technologies (turbines, power plants, infrastructure, etc.)



Energy is the chief villain

Pollutant emissions, 2015

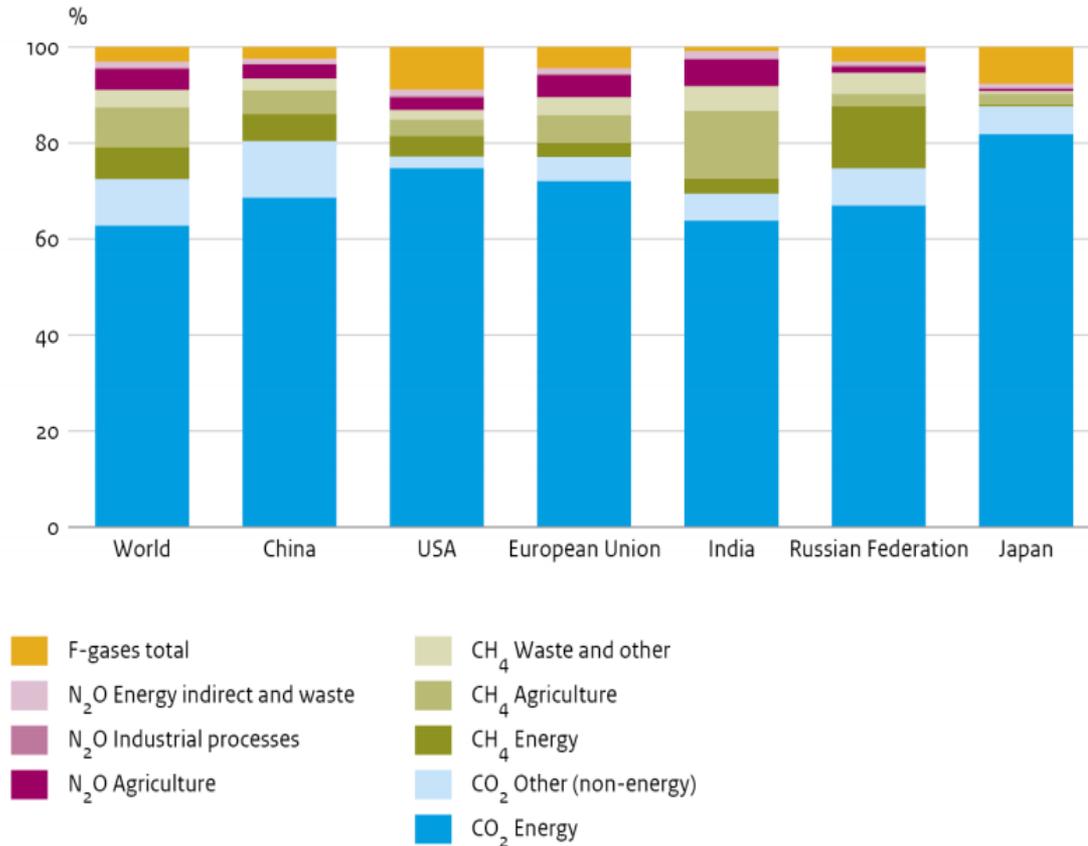


Energy is the single most important cause of emissions of all main pollutants



Energy and emissions

Contribution to 2016 greenhouse gas emissions per emission category



Source: EDGAR v4.3.2. (EC-JRC/PBL 2017); IEA (2017); BP (2017)



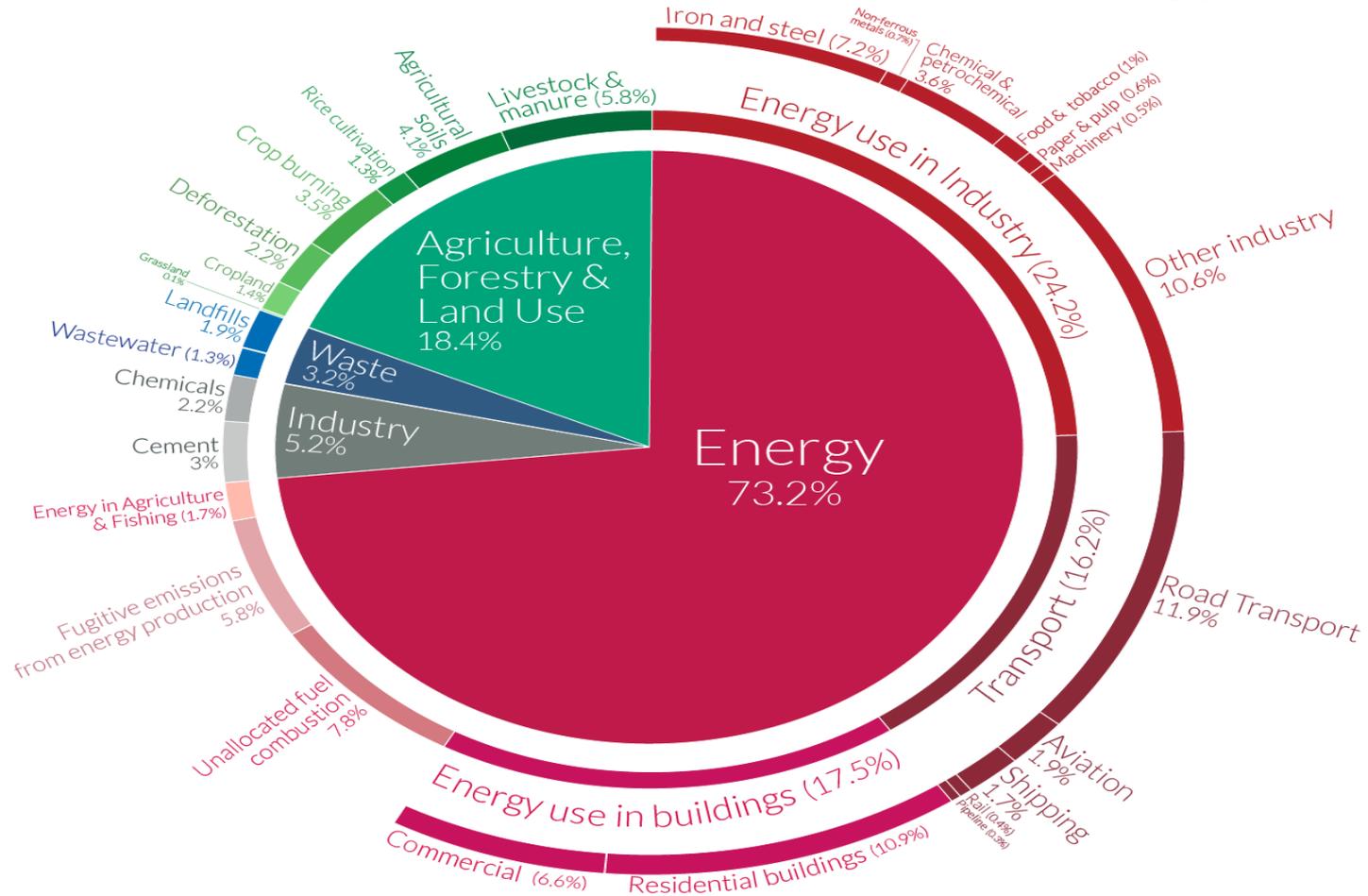
Nearly all is about energy in various forms...



Global GHG emissions by sector

Global greenhouse gas emissions by sector

This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO₂eq.





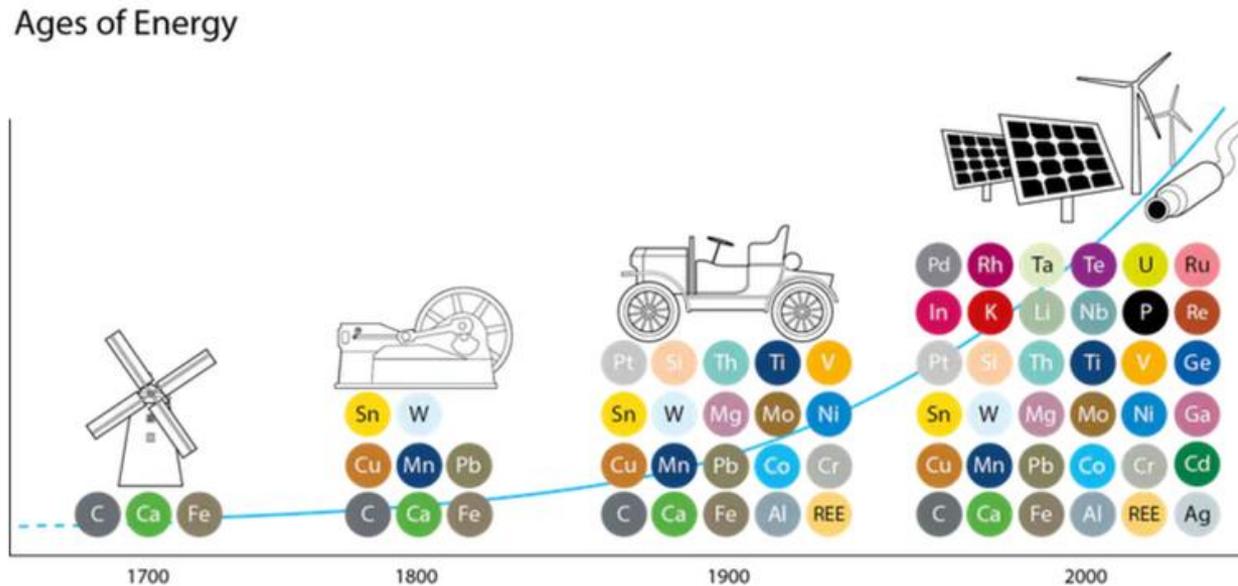
Energy & environment

- In both local and global contexts, energy and environmental impacts are intimately linked
- Energy and environmental decisions strongly affect each other as energy conversion activities is a dominant source of environmental impact
- Sustainability requires adequate and holistic understanding of energy systems, given their dominance of environmental impacts



Energy shifts and material demand

- New energy developments increase demand for many elements and minerals
- Understanding material supply is essential!



Elements widely used in Energy Pathways



Sustainable energy and materials

- For sustainability and environmental reasons, reducing fossil fuel reliance is essential
 - Renewable energy is often presented as more or less automatically sustainable by many, but this is often due to oversimplifications or just focusing on one societal factor such as GHG emissions
 - Renewable energy technologies are more metal intensive than current energy sources and would increase demand for raw materials (Kleijn et al, 2011; Fizaine & Court, 2015)
 - Material flows from mining, manufacturing, and recycling industry gets increasingly tied together with the energy sector as the share of renewable energy increases (Elshkaki & Graedel, 2013; Davidsson et al, 2014; Kim et al, 2015; Davidsson & Höök, 2017)

Source: Kleijn et al, 2011. Metal requirements of low-carbon power generation. *Energy* 36:5640–5648

Fizaine & Court, 2015. Renewable electricity producing technologies and metal depletion: A sensitivity analysis using the EROI. *Ecological Economics* 110:106–118

Elshkaki & Graedel, 2013. Dynamic analysis of the global metals flows and stocks in electricity generation technologies. *Journal of Cleaner Production* 59:260–273

Davidsson et al, 2014. Growth curves and sustained commissioning modelling of renewable energy: Investigating resource constraints for wind energy. *Energy Policy*, 73:767–776

Kim et al, 2015. Critical and precious materials consumption and requirement in wind energy system in the EU 27. *Applied Energy* 139:327–334

Davidsson & Höök, 2017. Material requirements and availability for multi-terawatt deployment of photovoltaics. *Energy Policy*, 108(9), 574–582



Criticality of materials

- Studies on ‘*critical materials*’ represent a rapidly increasing domain of material flow analysis
 - Criticality captures both supply risks and the vulnerability of a system to a potential supply disruption
- The term ‘*criticality*’ could also be seen as an assessment of risks connected to a wide array of factors such as geological occurrences, geographical concentration of deposits or production facilities, market and regulatory structures, social issues, geopolitics, environmental aspects, recycling potential, and sustainability over the full life cycle of a certain material

Selected Metals	Area of use
Antimon	Batteries
Beryllium	Nuclear tech
Gallium	LEDs, electronics, solar cells
Germanium	Solar cells
Indium	Nuclear tech, solar cells
Cobolt	Batteries, magnets, catalysts
Lithium	Batteries, refrigeration tech
Platina Group Metals (PGMs)	Fuel cells technologies
Rare Earth Elements (REE)	Generators, electric motors, batteries, etc.
Rhenium	Catalysts
Selenium	Solar cells
Tantal / Niobium	Special alloys, filaments
Tellurium	Solar cells

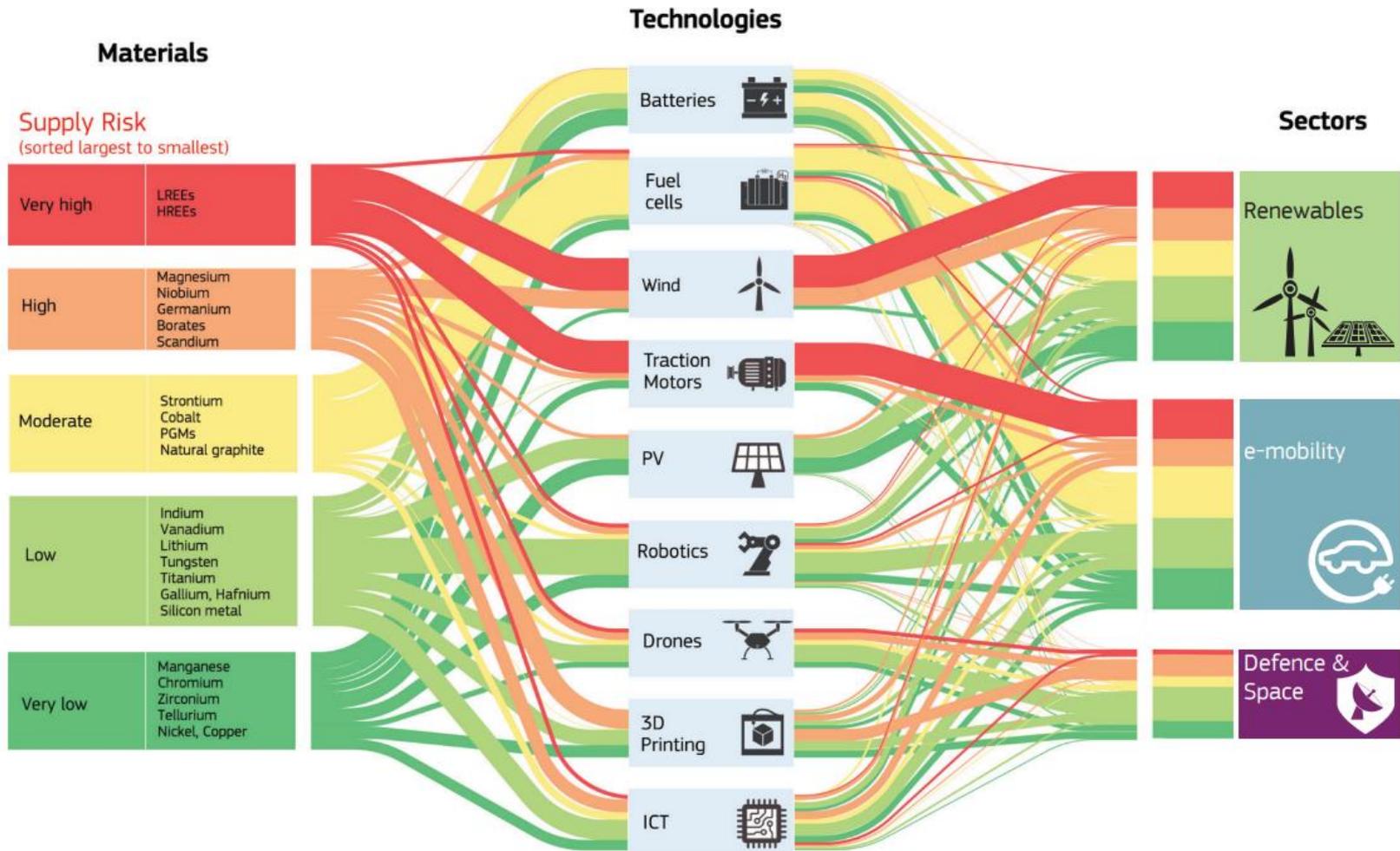
Sources: Erdmann & Graedel, 2011. Criticality of non-fuel minerals: a review of major approaches and analyses. *Environmental Science and Technology*, 45:7620–7630

Achzet & Helbig, 2013. How to evaluate raw material supply risks—an overview. *Resources Policy*, 38(4):435–447

Graedel & Nuss, 2014. Employing considerations of criticality in product design. *JOM*, 66(11):2360–2366



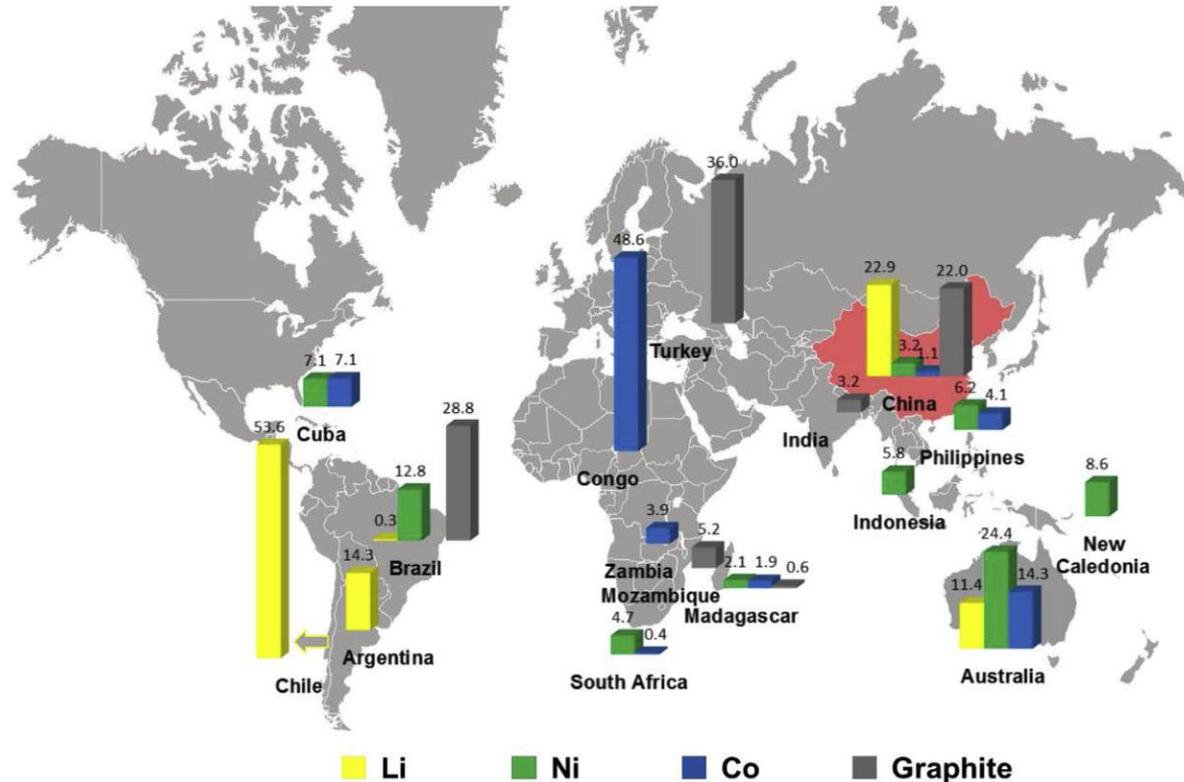
Supply risks for various sectors





Electric car materials

Global distribution of critical materials for electromobility. Height refers to the percentage of worlds known recoverable resources





Critical materials

- EU:s work on Critical Raw Materials (CRMs)
 - **First list of CRMs** – in 2011, a list of 14 CRMs was published in the communication on raw materials.
 - **Second list of CRMs** – in 2014, a first revised list of 20 CRMs was published
 - **Third list of CRMs** – in 2017, a third list of 27 CRMs was published in the communication on the list of critical raw materials 2017, based on a refined methodology
 - **Fourth list of CRMs** – in 2020, and now contains 30 elements and minerals to keep up with the rapid evolution of the industry

EUROPE FACES DEPENDENCIES ON KEY CRITICAL RAW MATERIALS

The EU is heavily dependent on critical raw materials from a number of third countries. Our dependency, combined with the growing global demand due to the shift towards a digital and green economy makes supply chains vulnerable.



WHAT ARE WE DOING?

The European Critical Raw Materials Act aims to strengthen EU's critical raw materials capacities **along all stages of the value chain**. It aims to increase our resilience by reducing dependencies, increasing preparedness and promoting supply chain sustainability and circularity.



Market dominance

- Many critical materials are heavily dominated by one single producer affecting world market dynamics
- In a globalized economy direct and indirect transfer of energy and material resources occurs via international trade patterns
- This leads to import and export dependencies in material flows that usually span multiple economies, potentially creating issues

Råmaterial	Producent-land	Andel av världsproduktionen i %	Användningsområden
Sällsynta jordartsmetaller	Kina	95	I elektroniska, optiska, magnetiska och metallurgiska produkter som är oundgängliga i det moderna samhället och alltmer viktiga inom högteknologisk industri och miljövänlig teknik.
Antimon	Kina	87	I flamskyddsmedel och batterier.
Volfram	Kina	84	Används i bland annat superlegeringar och specialstål eftersom det har den högsta smältpunkten av alla grundämnen.
Gallium	Kina	73	Halvledare i elektronikindustrin (integrerade kretsar), LED-belysning och solceller (CIGS).
Grafit	Kina	69	Infodring i smältugnar, smörjmedel, batterier, flamskyddsmedel, neutronmoderator i kärnreaktorer, elektromotorer (borstar), friktionsprodukter (till exempel bromsband), blyertspennor samt i nya högteknologiska material som grafen.
Indium	Kina	56	I solpaneler (bland annat i så kallade tunnfilms solceller CIGC) och plattskärmar.
Niob	Brasilien	90	I HSLA stål (high-strength, low-alloy) och i så kallade superlegeringar i produkter med motståndskraft mot korrosion och som tål höga temperaturer, bland annat för användning inom kärnkraft och rymdindustrin.
Beryllium	USA	90	Inom elektronik-, telekom-, försvars-, medicin- och rymdindustrin.
Platina	Sydafrika	70	Katalysatorer för avgasrening, petroleumraffinering och kemisk industri samt i smycken och elektronik.
Kobolt	DR Kongo	64	I superlegeringar, uppladdningsbara batterier (litiumjonbatterier) och katalysatorer.
Palladium	Ryssland	46	Katalysatorer för avgasrening, petroleumraffinering och kemisk industri samt i smycken och elektronik.



The PV Market

- About 95% of all solar cells manufactured and sold are based on silicon
 - The remaining 5% are thin-film solar cells, but even here amorphous silicon dominates over the other technologies
 - Only a few percent are non-silicon-based technology such as CIGS, Grätzel or CdTe cells
 - The most efficient types, i.e. multijunction cells, often rely on scarce materials and are too expensive for widespread use

China dominates solar manufacturing

Solar PV manufacturing capacity and solar deployment by country and region, 2021

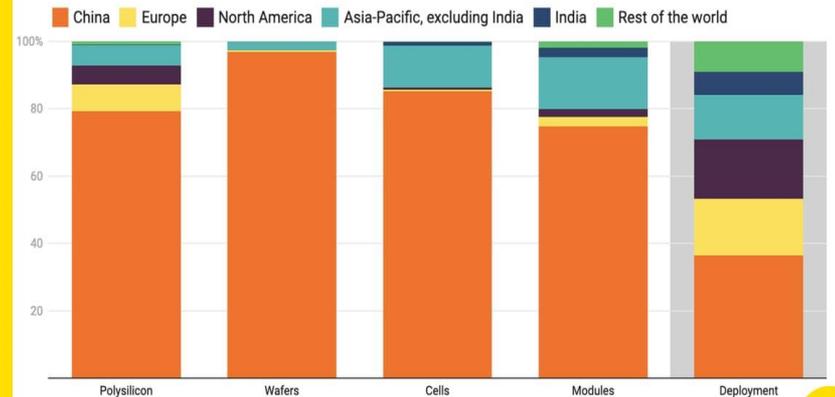
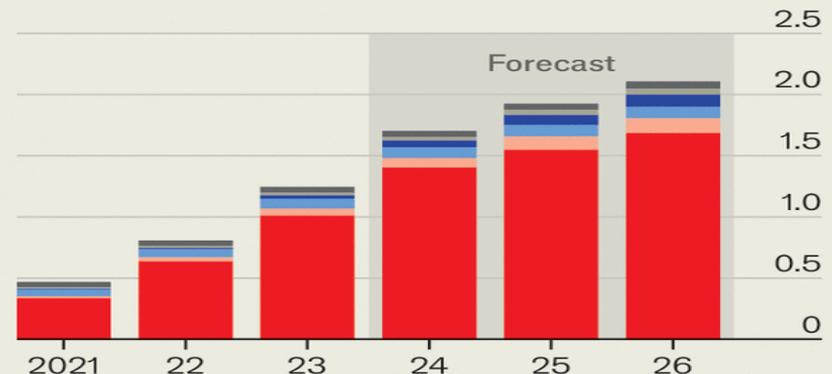


Chart: Canary Media. Source: IEA, "Special Report on Solar PV Global Supply Chains," 2022

Solar-module production capacity by region, terawatts

China India South-East Asia
US Europe Rest of world



Source: Wood Mackenzie



Supply risks, bottlenecks and key players for PV supply chains



Raw materials

Processed materials

Components

Assemblies

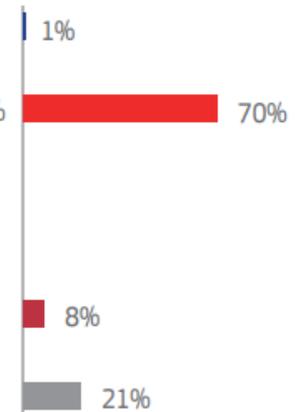
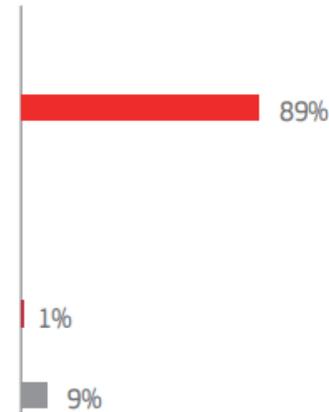
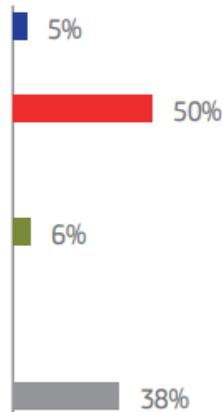
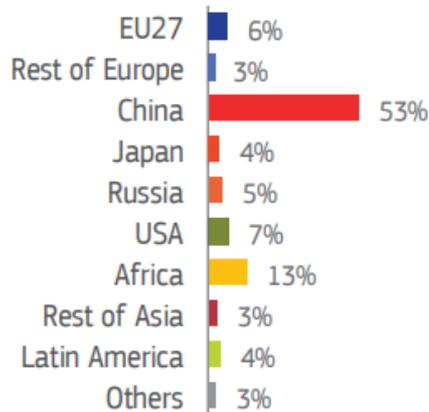
Al, B, Cd, Cu, Ga,
Ge, In, Fe, Pb, Mo,
Ni, Se, Si, Ag, Te,
Sn, Zn

Si-metal, polysilicon,
Cu refined, Al, CdTe

Crystalline /
amorphous Si cells,
Wafer

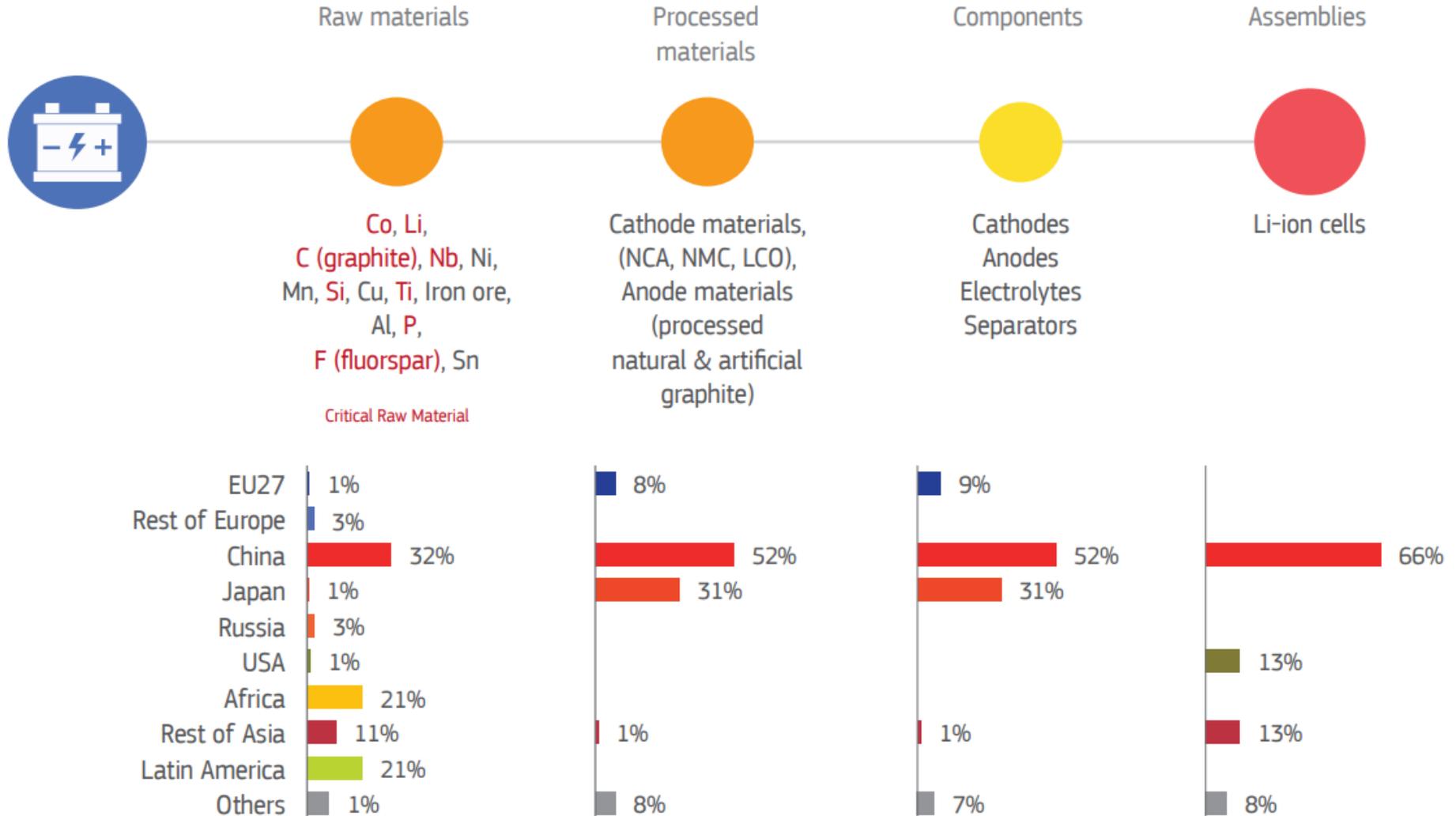
Si modules,
Thin film Si/non Si
modules

Critical Raw Material



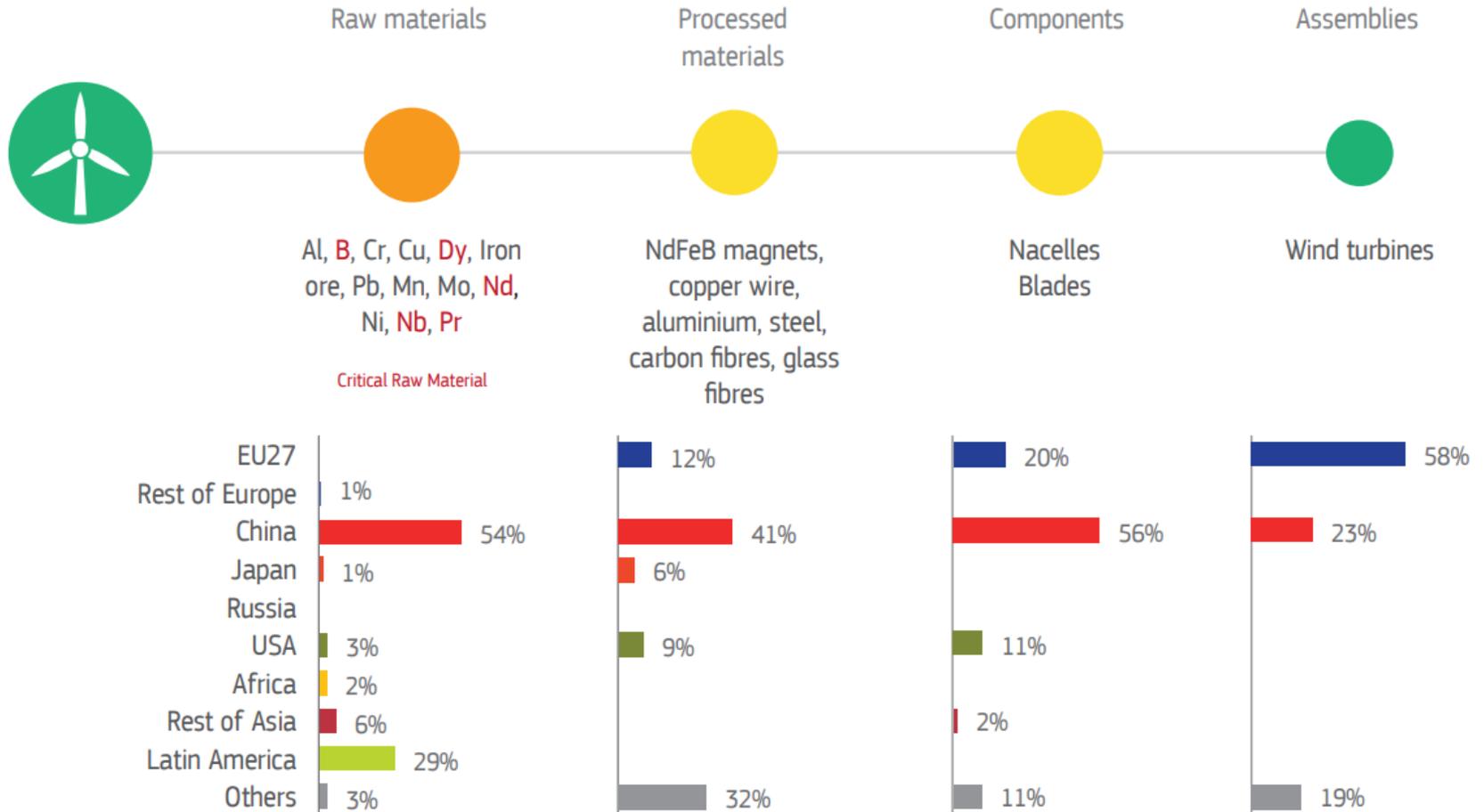


Supply risks, bottlenecks and key players for battery supply chains



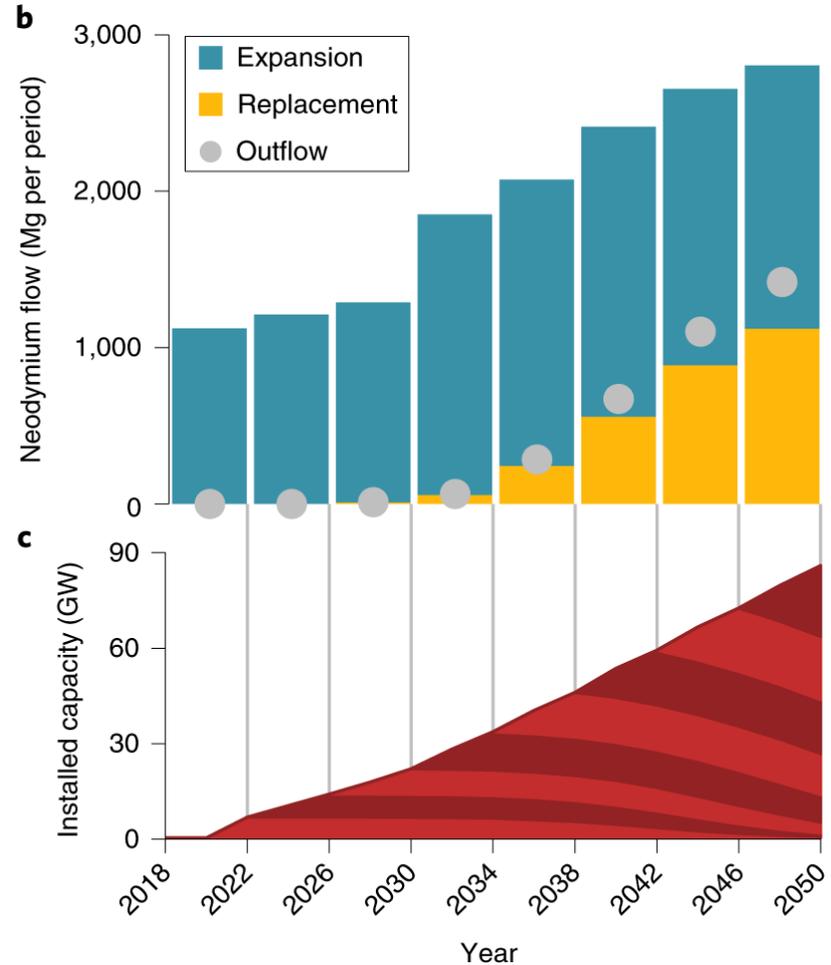
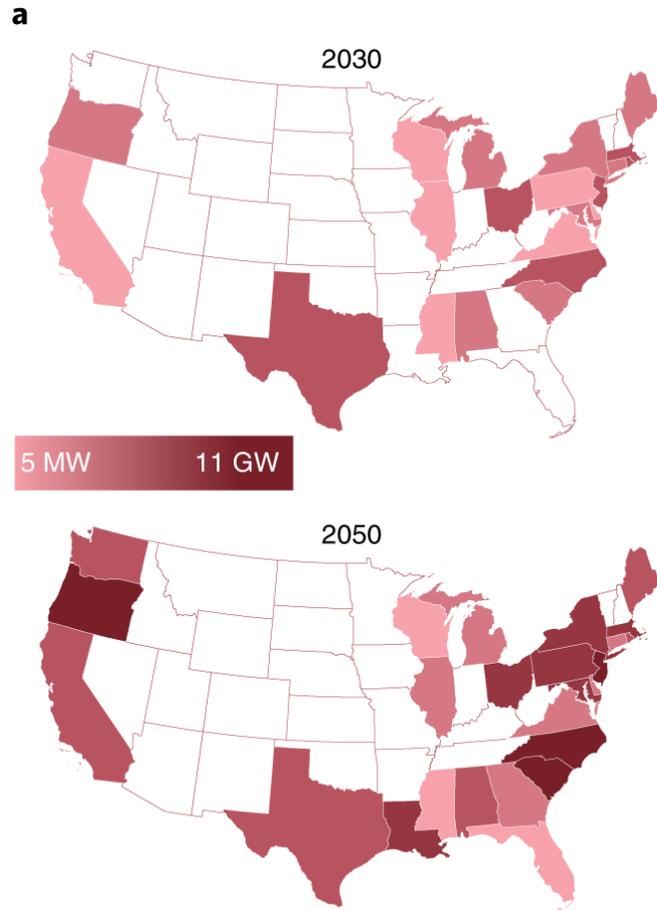


Supply risks, bottlenecks and key players for wind supply chains





US wind power och neodymium





Neodym as a challenge

- Can USs goal for wind power be reached by 2050?
 - Estimated material demand is 15 000 ton Nd to reach the DoE projection for future wind power
 - US is not mining Nd domestically, but imports about 2000 t Nd in electronics/etc that can be recycled
 - World production of Nd is about 25 000 tons per year
- Equivalent to Nd-demand for ~20 million electric cars (~0.75 kg/vehicle)
 - Rapid expansion of EVs and wind may increase competition among countries significantly



Energy-Mineral Nexus

- Rapid energy transitions capable of meeting the 2° C-target typically rely on ample upscaling of green/clean energy technologies with associated supply chains
- Constructing new energy systems require increased and sometimes new material flows that entail increased interrelation with metal and material sectors
- Renewable energy technologies are more metal intensive than current ones and a green energy transition would increase demand for many materials

Sources: Tokimatsu et al 2017. Energy modeling approach to the global energy-mineral nexus: A first look at metal requirements and the 2C target. *Applied Energy* 207: 494–509

Kleijn et al 2011. Metal requirements of low-carbon power generation. *Energy* 36:5640–5648

Elshkaki & Graedel 2013. Dynamic analysis of the global metals flows & stocks in electricity generation technologies. *Journal of Cleaner Production* 59:260–73

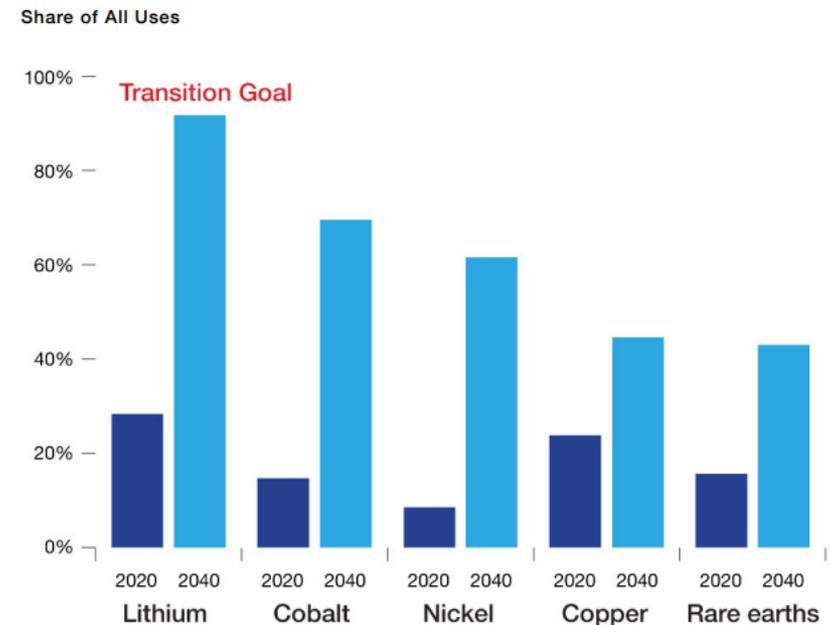
Grandell et al 2016. Role of critical metals in the future markets of clean energy technologies. *Renewable Energy* 95:53-62



Material issues

- Access to required critical material could potentially be a significant constraint for different solar and wind technologies in the future
 - Certain solar energy concepts are unrealistic in terms of achieving TW scales
- Renewable energy is driving EU into China's monopolistic supply chain control unless new mines could be found elsewhere
 - China's reliability is compromised, necessitating non-Chinese mining and processing (Stegen, 2015)

Energy Sector Share of Mineral Demands for All Purposes



Source: IEA (2021) The role of critical minerals in clean energy transitions.



Global summary

- Global energy systems are currently dominated by fossil energy
 - So are emissions and many other related issues too
 - Consequently, energy issues are often dominated by challenges related to fossil fuels
- Nuclear, solar, wind and hydropower are just marginal contributors to the energy supply, despite large publicity in media or public debate
 - However, they can be important in single countries or selected regions
 - Perspectives on scales and geographics are important



Final remarks

- Renewable energy sources are not always more secure or "sustainable" since they still rely on natural resources and external supply
- Reduced systems, oversimplifications, cherry-picking or attributing extreme weight to a few selected parameters may easily mislead or even deceive if energy analysis is undertaken
- It is critically important to be clear with what issues that are being targeted, how risks are assessed, what system border that are relevant, etc.



Thanks for your attention!

“Saving our planet, lifting people out of poverty, advancing economic growth... these are one and the same fight. We must connect the dots between climate change, water scarcity, energy shortages, global health, food security and women's empowerment. Solutions to one problem must be solutions for all.”

-Ban Ki-moon

Read more about our research here:
<http://www.geo.uu.se/forskning/nrhu/>