Roma Tre
Dipartimento di Scienze

ORDINE DEI GEOLOGI DEL LAZIO

SAPIENZA
UNIVERSITÀ DI ROMA
DIPARTIMENTO DI SCIENZE DELLA TERRA

LA GEOLOGIA NEL MONDO DEL LAVORO

A PIERLUIGI FRIELLO: UN GEOLOGO PROFESSIONISTA, UN AMICO

SEMINARI DI ORIENTAMENTO PER GLI STUDENTI ISCRITTI ALLA LAUREA TRIENNALE IN SCIENZE GEOLOGICHE E ALLE LAUREE MAGISTRALI NEL SETTORE UTILI PER LA PREPARAZIONE AGLI ESAMI DI STATO E PER L'AGGIORNAMENTO PROFESSIONALE CONTINUO DEI GEOLOGI PROFESSIONISTI

Geoscienze e Transizione Energetica

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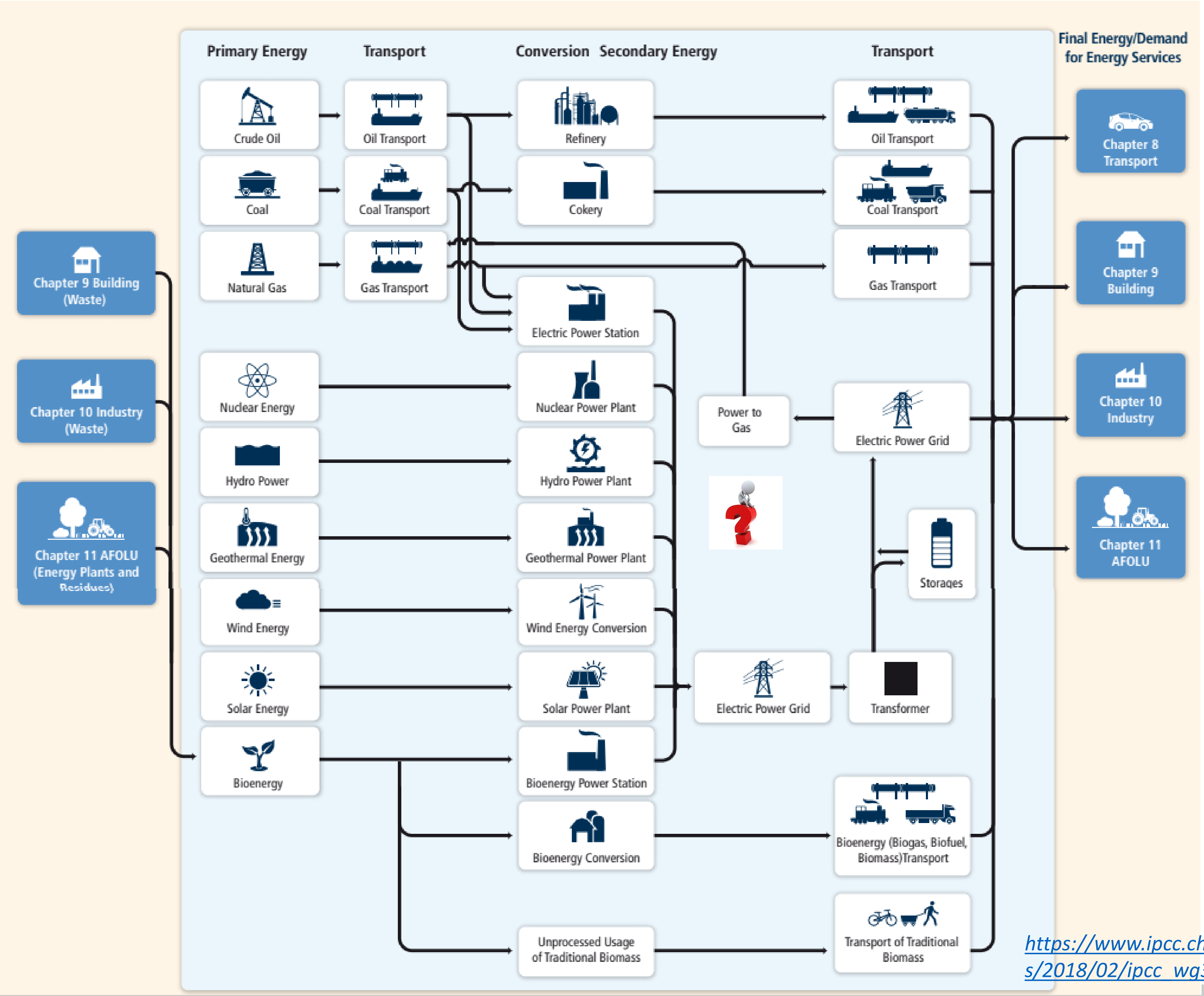
Head of Development – Reden Solar Italy
REDEN

14 marzo 2025

https://www.socgeol.it/N5518/il-ruolo-delle-geoscienze-nella-transizione-energetica.html

What is an Energy System?

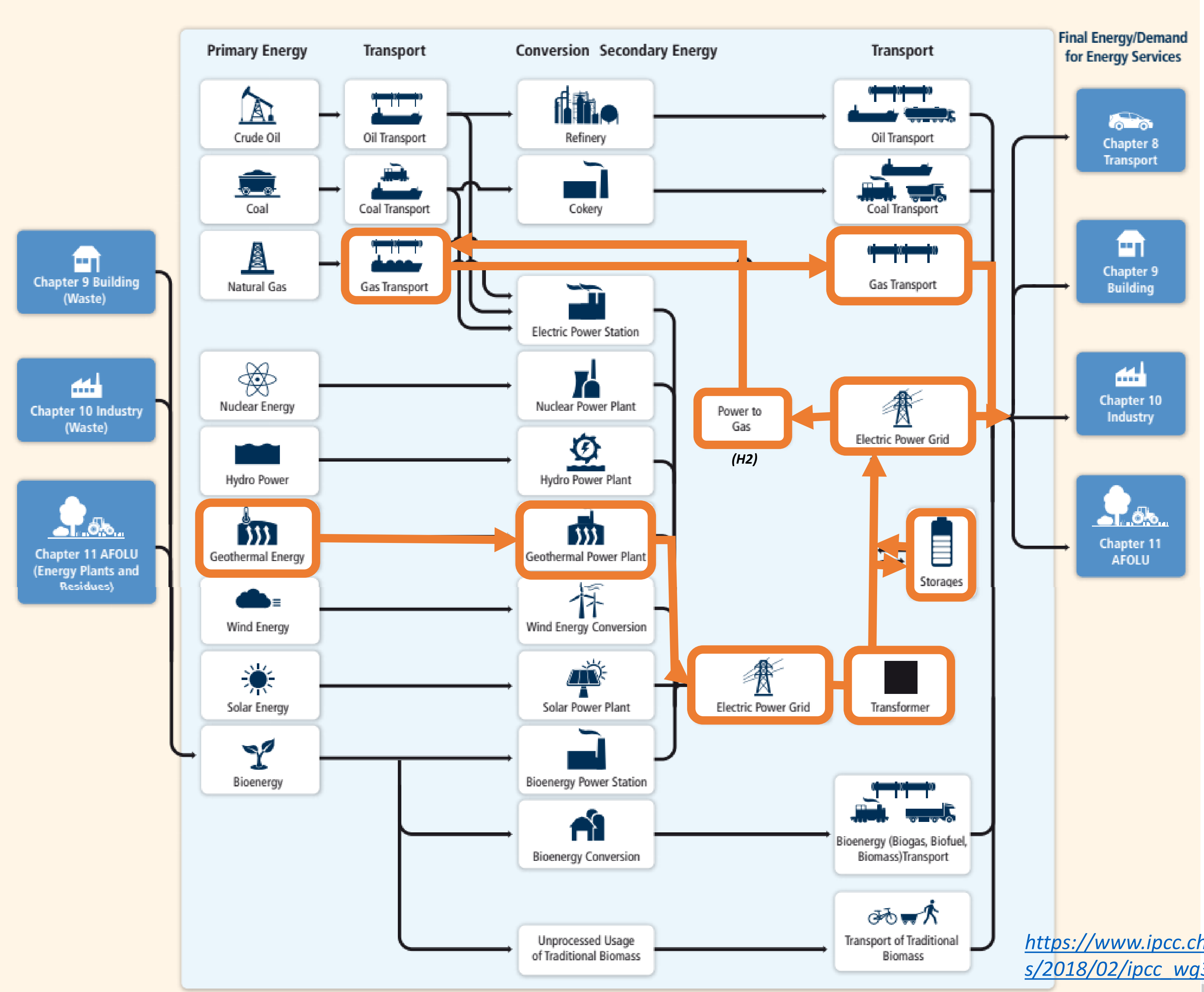
Glossary – Energy Syst



Power To Gas.
Utilizzo dell'energia elettrica derivata da fonti rinnovabili (centrali fotovoltaiche, idroelettriche ed eoliche) per produrre idrogeno attraverso l'elettrolisi.
L'**elettrolisi dell'acqua** è un metodo semplice per produrre idrogeno. Una corrente a basso voltaggio che attraversa l'acqua forma ossigeno gassoso all'anodo ed idrogeno gassoso al catodo. Generalmente quando si produce idrogeno si impiega un catodo di platino o di un altro metallo inerte.

https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter7.pdf

Glossary – Energy Syst



https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter7.pdf

Oxford Learner's Dictionaries

Sustainability */səˌsteɪnəˈbɪləti/ /səˌsteɪnəˈbɪləti/ noun*

- the use of natural products and energy in a way that does not harm the environment
- the ability to continue or be continued for a long time

Sustainable /səˈsteɪnəbl/ /səˈsteɪnəbl/ *adjective*

- involving the use of natural products and energy in a way that does not harm the environment
- *a company well-known for its commitment to environmental sustainability*
- *an environmentally sustainable society*

TRECCANI

Sostenibilità */so·ste·ni·bi·li·tà/ sostantivo femminile*

- possibilità di essere mantenuto o protratto con sollecitudine e impegno o di esser difeso e convalidato con argomenti probanti e persuasivi.
- possibilità di essere sopportato, spec. dal punto di vista ecologico e sociale.

Sostenìbile */ so·ste·ni·bi·le / aggettivo*

- che si può sostenere: *una tesi difficilmente sostenibile*.
- che può essere affrontato: *una spesa s.*; *questa situazione non è più s*.
- compatibile con le esigenze di salvaguardia delle risorse ambientali: *energia s.*; *sviluppo s.*

What Sustainability is?

No universally agreed definition of sustainability: many different viewpoints on this concept and on how it can be achieved.

Sustainable = an adjective for something that is able to be sustained, i.e, something that is “bearable” and “capable of being continued at a certain level”.

Sustainability = **sustain + able + ity**. To sustain = “to give support to”, “to hold up”, “to bear” or “to keep up”.

Sustainability can perhaps be seen as **the process(es) by which something is kept at a certain level**.

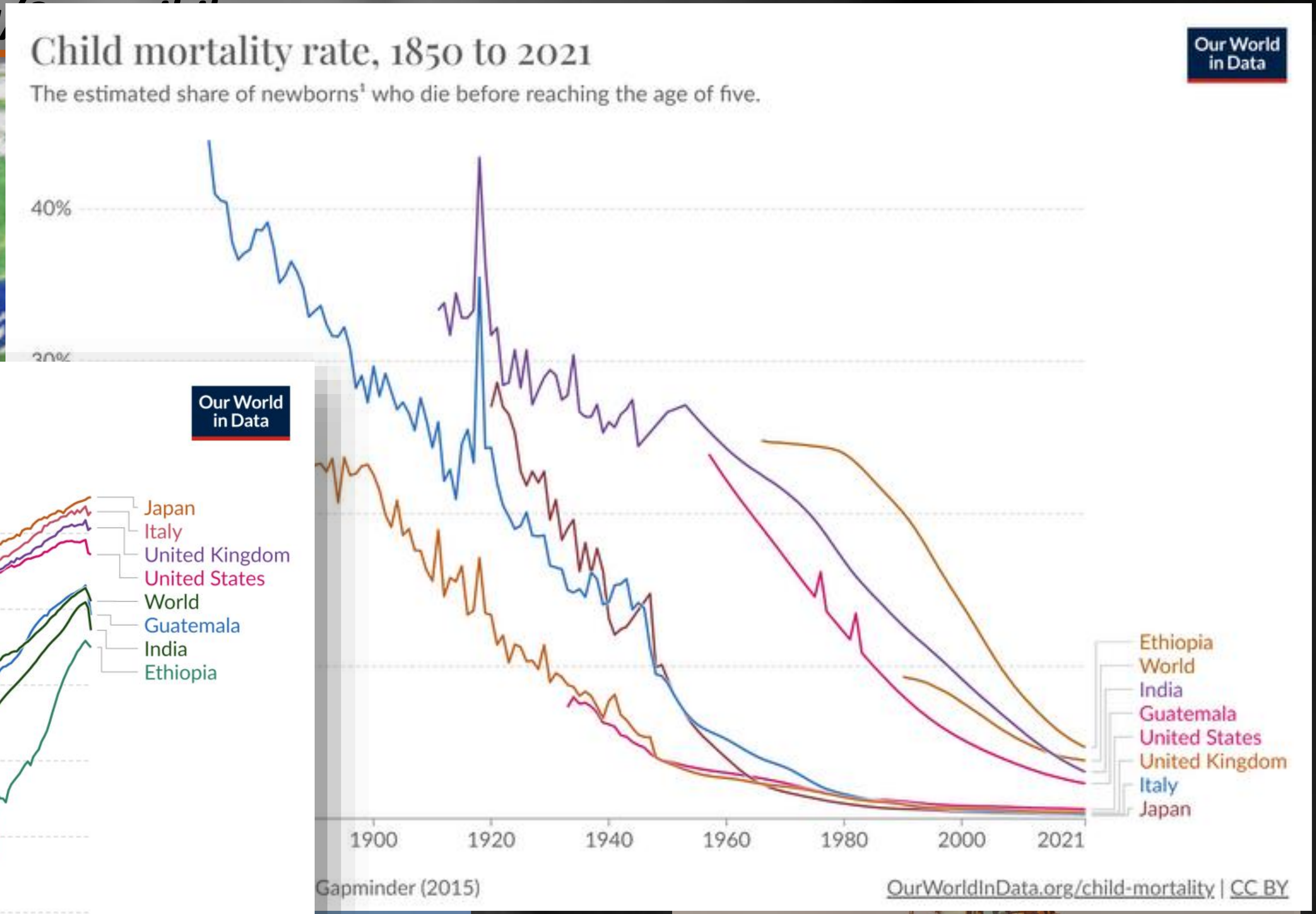
Due to the increasing awareness on environmental and social problems, sustainability has been increasingly used in a specific way:

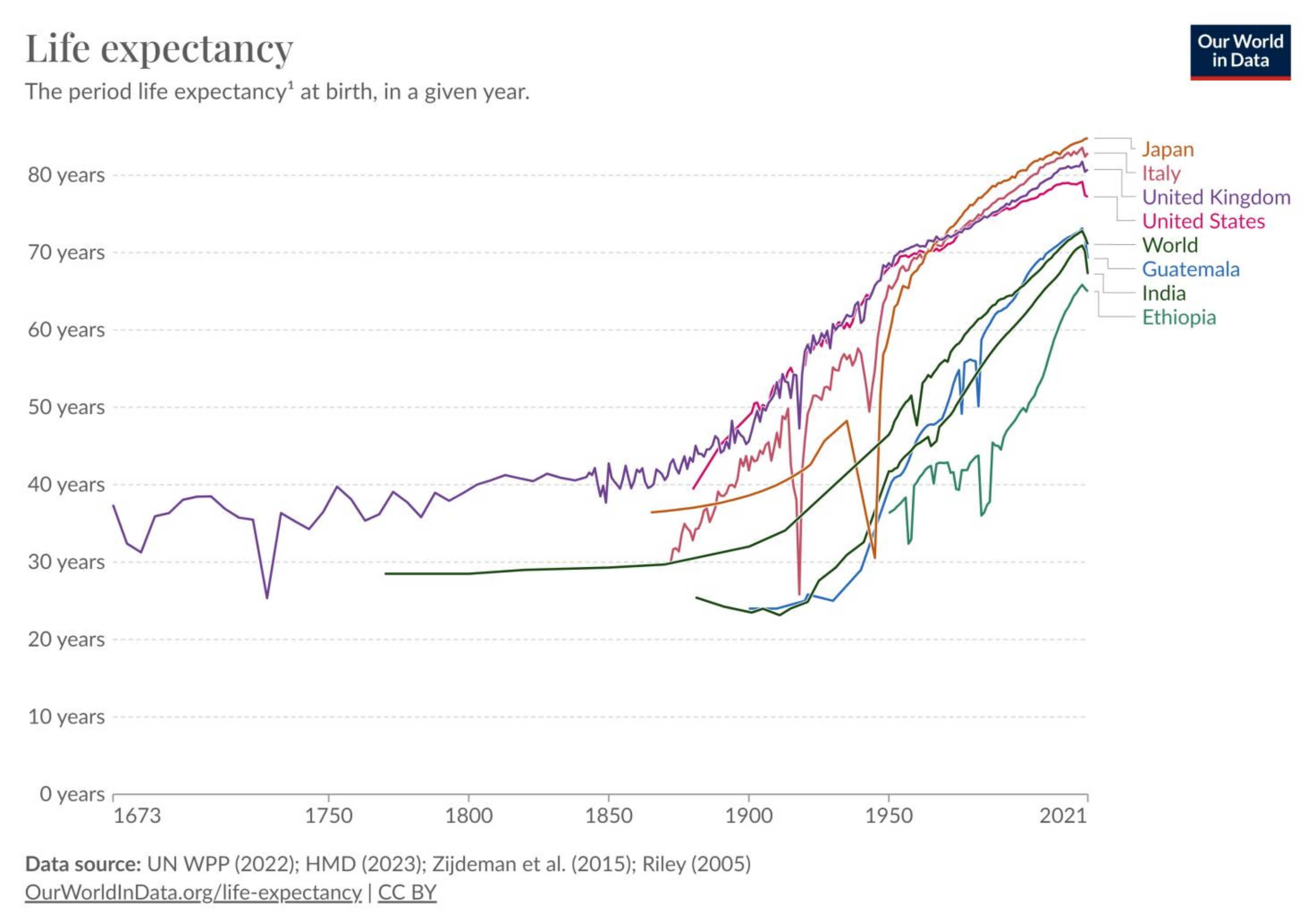
processes and actions through which humankind avoids the depletion of natural resources, in order to keep an ecological balance that doesn’t allow the quality of life of modern societies to decrease

Sustainability/ Sustainable *Sostenibilità/Sostenibile*

Sustainability/ Sustainable **Sostenibilità/Sostenibile**

Sustainability/ Sustainable Sostenibilità/

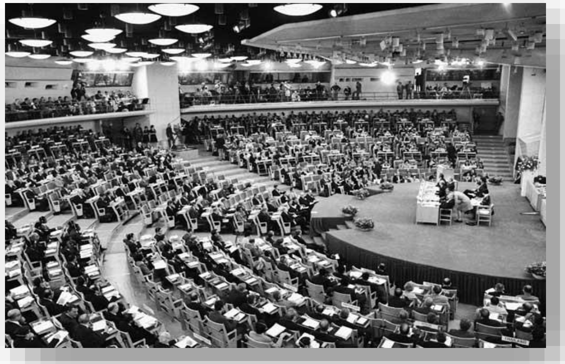




Sustainable development

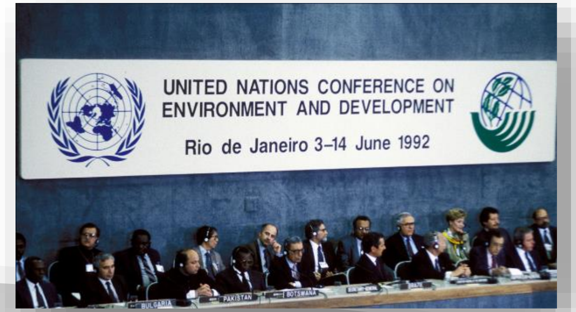
1972. UN Stockholm Conference on the Human Environment. First hints on international environmental law. Final report: **Declaration on the human environment**, containing key principles:

- configuration of the environment as a legal asset, the protection of which is not subordinated to respect for other state interests;
- extension of environmental protection to spaces located outside state sovereignty, such as the open sea, extra-atmospheric space, Antarctica;
- international cooperation for environmental protection purposes



1983. UN report **"Our Common Future"** of the World Commission on Environment and Development (WCED) on the world environment and development situation. The report laid the foundations for the modern concept of sustainable development and for the finalization of sectorial treaties based on damage prevention and cross-border pollution

1992. UN Rio de Janeiro Conference. Compatibility between economic development and environmental protection, with the extension of international cooperation on global environmental issues and the signing of universal agreements based on the precautionary principle



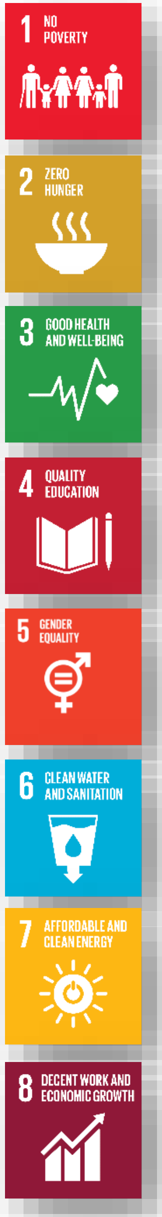
Agenda 2030 & the SDGs

- **1992, Earth Summit, Rio de Janeiro***:* >178 countries adopt **Agenda 21**, a global action plan to build a global partnership for sustainable development, to improve human life and protect the environment.
- **2000: New York.** *Adoption of the Millennium Declaration* with 8 **Millennium Development Goals** (MDGs) developed to reduce extreme poverty by 2015.
- **2002: UN World Summit, Johannesburg***:* the **Declaration on Sustainable Development** reaffirms the commitment of the global community to eradicate poverty and protect the environment**.**
- **2012: United Nations Conference on Sustainable Development (Rio + 20):** adoption of the document "**The Future We Want**" with the establishment of the United Nations high-level political forum on sustainable development.
- **2013***:* the General Assembly establishes an open working group of 30 members to develop GDS proposal
- **2015**: the General Assembly (Paris) adopts the *2030* ***Agenda for sustainable development***, with *17 SDGs*.

The ***2030 Agenda for Sustainable Development*** *provides a shared model for peace and prosperity for people and the planet, now and in the future*

17 Sustainable Development Goals: an urgent **call to action** recognizing that **ending poverty** must go hand in hand with strategies that **improve health and education, reduce inequality and stimulate economic growth, tackling climate change and preserving oceans and forests**.

Agenda 2030: 17 Goals + 169 Targets + 242 Indicators



NO POVERTY: End poverty in all its forms

ZERO HUNGER: End hunger, achieve food security, improve nutrition and promote sustainable agriculture

GOOD HEALTH AND WELL-BEING. Ensure healthy lives and promote well-being for all at all ages

QUALITY EDUCATION. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

GENDER EQUALITY. Achieve gender equality and empower all women and girls

CLEAR WATER AND SANITATION. Ensure availability and sustainable management of water and sanitation for all

AFFORDABLE AND CLEAN ENERGY. Ensure access to affordable, reliable, sustainable and modern energy for all

DECENT WORK AND ECONOMIC GROWTH. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work conditions for all

Agenda 2030: 17 Goals + 169 Targets + 242 Indicators

INDUSTRY INNOVATION AND INFRASTRUCTURE. Build resilient infrastrucures, promote inclusive and sustainable industrialization and foster innovation

REDUCE INEQUALITIES. Reduce inequalities within and among countries

SUSTAINABLE CITIES AND COMMUNITIES. Make cities and human settlements inclusive, safe, resilient and sustainable

RESPONSIBLE CONSUMPTION AND PRODUCTION. Ensure sustainable consumption and production patterns

CLIMATE ACTION. Take urgent action to combat climate change and its impacts

LIFE BELOW WATER. Conserve and sustainably use the oceans, seas and marine resources for sustainable development

LIFE ON LAND. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and biodiversity loss

PEACE, JUSTICE AND STRONG INSTITUTIONS. Promote peaceful and inclusive societies, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

PARTNERSHIP FOR THE GOAL. Strenghten the means of implementation and revitalize the Global Partnership for Sustainable Development

Traguardi e Indicatori

7 AFFORDABLE AND CLEAN ENERGY

Ensure universal access to affordable, reliable and modern energy services

Traguardi

7.1. Garantire accesso a servizi energetici convenienti, affidabili e moderni

7.2 Aumentare la quota di energie rinnovabili nel consumo totale di energia

7.3 Raddoppiare il tasso globale di miglioramento dell'efficienza energetica

7.a Accrescere la cooperazione internazionale per facilitare l'accesso alla ricerca e alle tecnologie legate all'energia pulita – comprese le risorse rinnovabili, l'efficienza energetica e le tecnologie di combustibili fossili più avanzate e pulite – e promuovere gli investimenti nelle infrastrutture energetiche e nelle tecnologie dell'energia pulita

7.b Implementare le infrastrutture e migliorare le tecnologie per fornire servizi energetici moderni e sostenibili, specialmente nei paesi meno sviluppati, nei piccoli stati insulari e negli stati in via di sviluppo senza sbocco sul mare, conformemente ai loro rispettivi programmi di sostegno

Indicatori

1. Tasso di accesso all'energia elettrica
2. Tasso di accesso a combustibile pulito
3. Tasso di crescita delle fonti rinnovabili nel mix energetico
4. Miglioramento della $\boxed{\text{intensità energetica}}$

https://sustainabledevelopment.un.org/topics/sustainabledevelopmentgoals
https://unstats.un.org/sdgs/indicators/Global%20Indicator%20Framework%20after%202019%20refinement_Eng.pdf

Traguardi e Indicatori

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7.b Im
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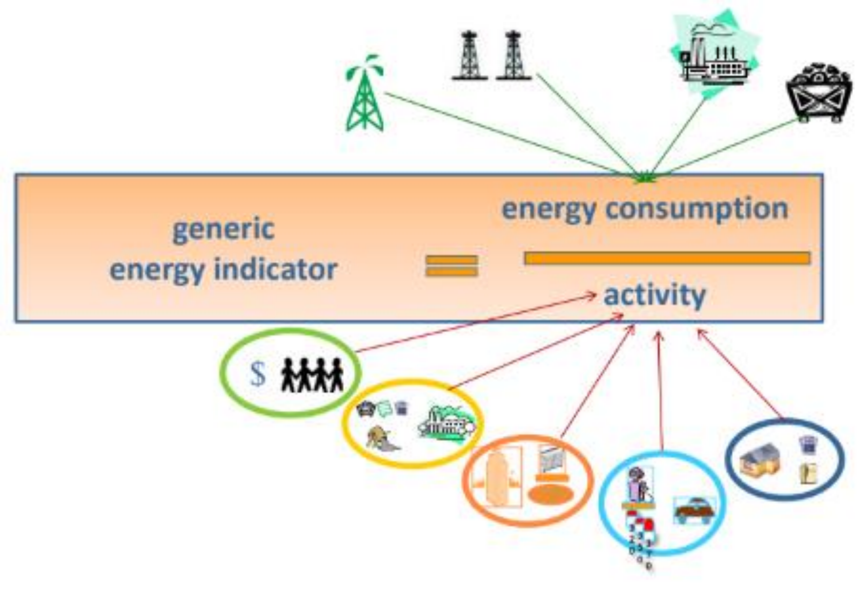
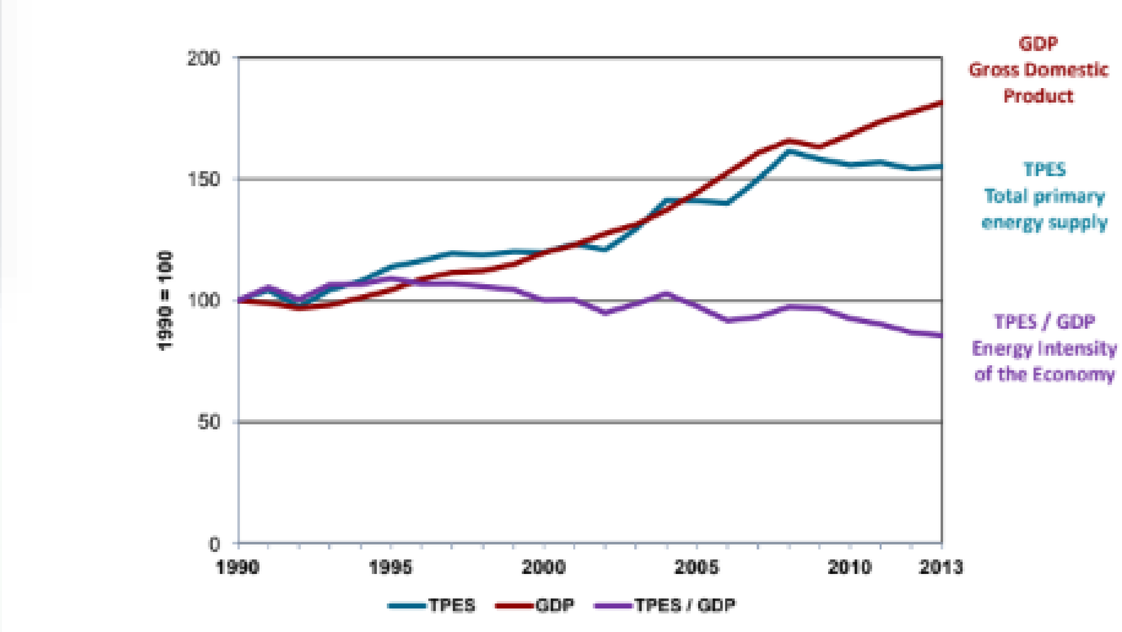


Energy Intensity: energy (TPES) per unit activity (GDP).

Variable due to several reasons: e.g. changes in economic structure, climate, ...



developmentgoals
https://unstats.un.org/sdgs/indicators/Global%20Indicator%20Framework%20after%202019%20refinement_Eng.pdf

What other goals/targets may be involved in Goal7?

7 AFFORDABLE AND CLEAN ENERGY

Ensure universal access to affordable, reliable and modern energy services

SDG & Ene

What otl

7 AFFORDABLE AND CLEAN ENERGY

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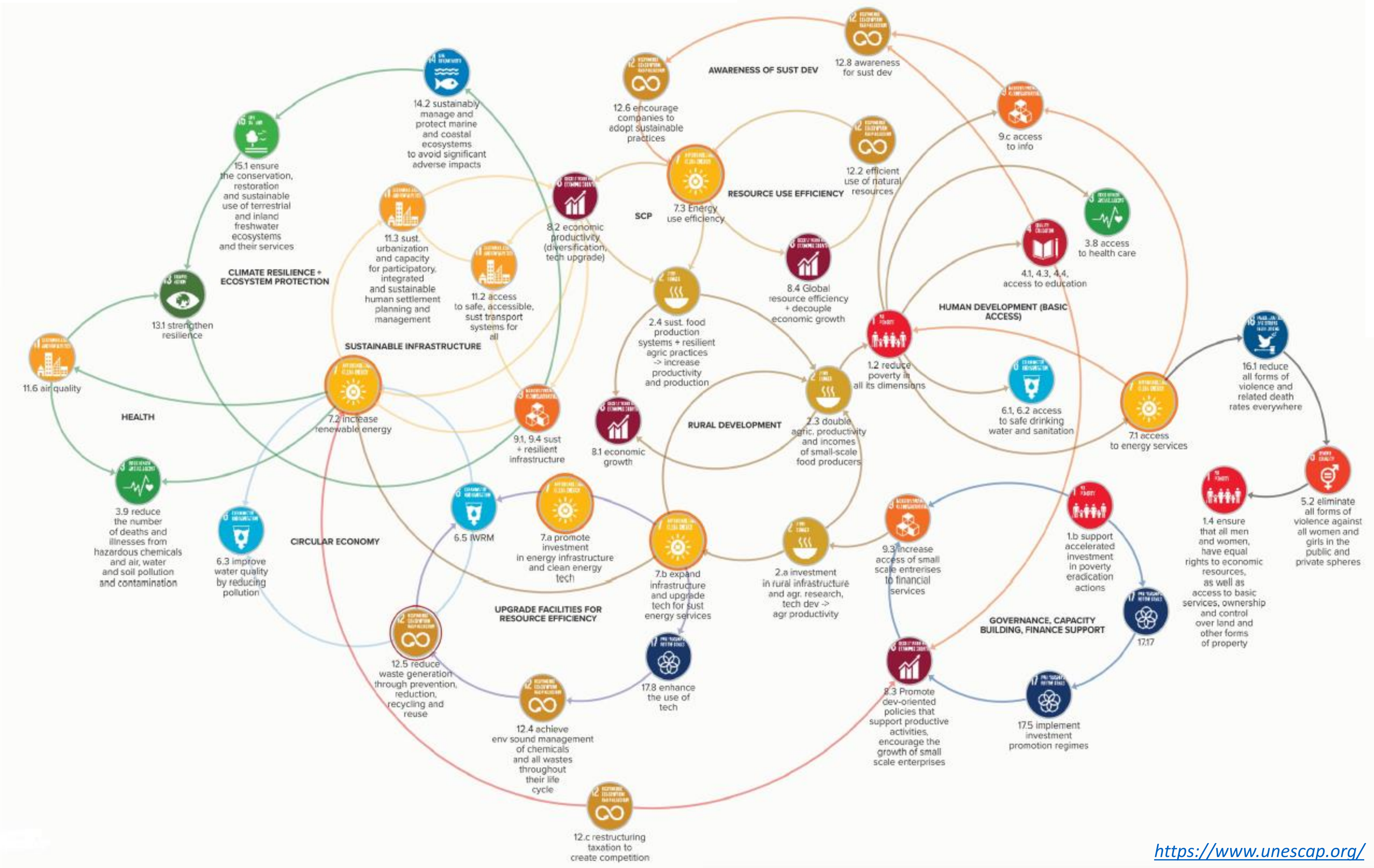

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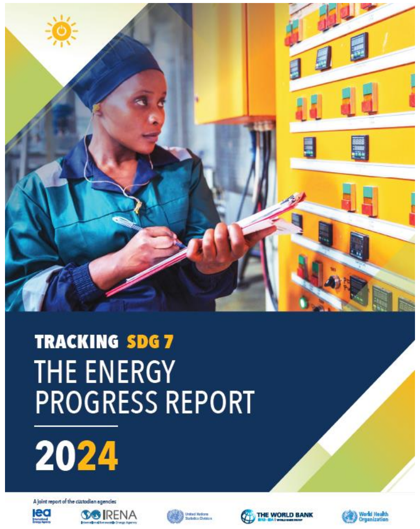
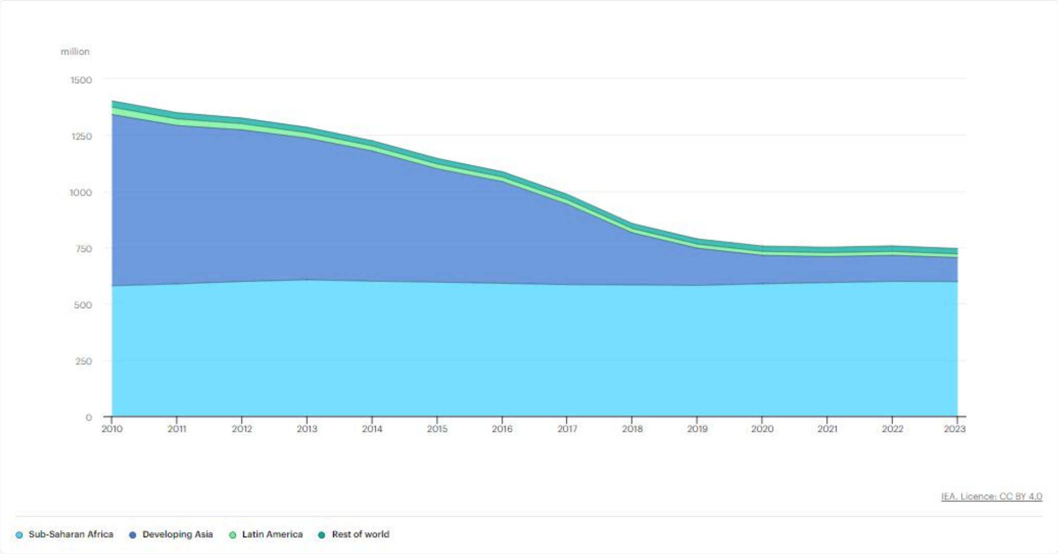
SDGs & Energy - IEA



Access to electricity-1

760 million people without access

2022: the number of people without electricity access dropped to 760 million, a record in recent years.



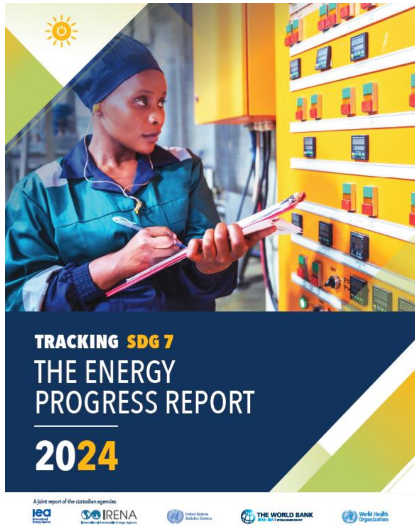
Progress is irregular, with 80% of the 760 million people who gained access since 2010 concentrated in Asia.

Efforts should step up in Africa if we are to reach universal access to electricity by 2030.

FIGURE 1.1 • PERCENTAGE OF POPULATION WITH ACCESS TO ELECTRICITY, 2000–30

Source: IEA and World Bank 2024b.

Access to electricity-2



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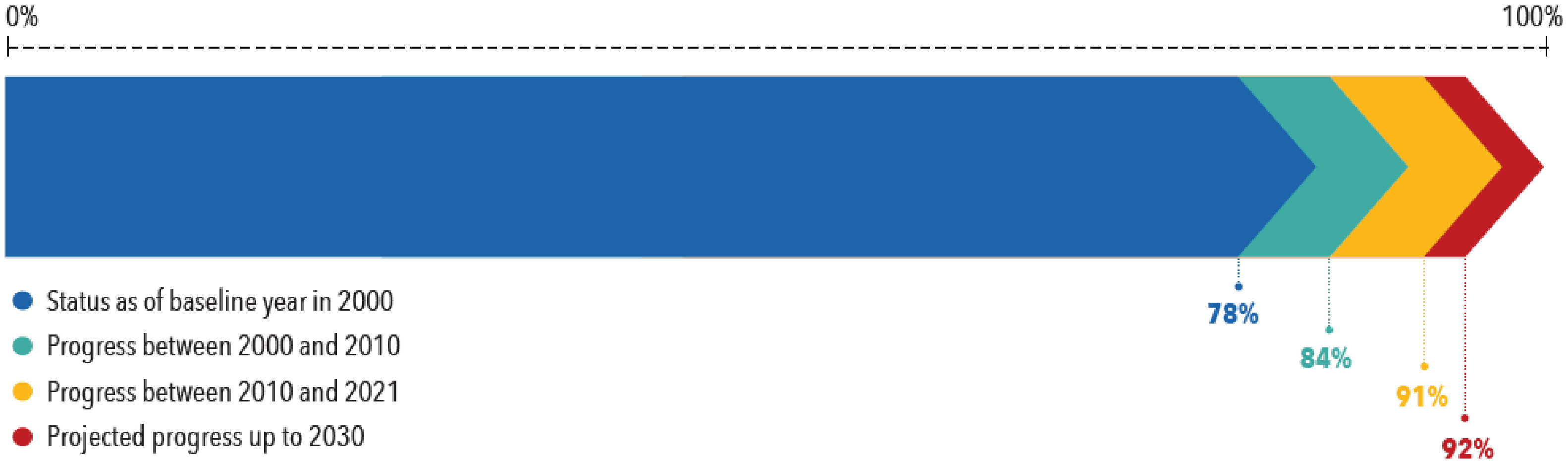


Source: IEA and World Bank 2024b.

Access to clean cooking-1

2 billion people without access

Over **2 billion people in 2022** do not have access to clean cooking facilities, relying on solid biomass, kerosene or coal as their primary cooking fuel.

Recent decades saw a decline in the number of people without access to clean cooking globally, from 2.9 billion in 2010, but the Covid-19 pandemic and global energy crisis threaten to reverse the situation

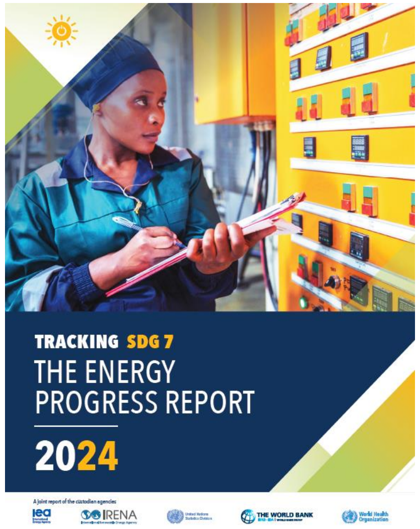
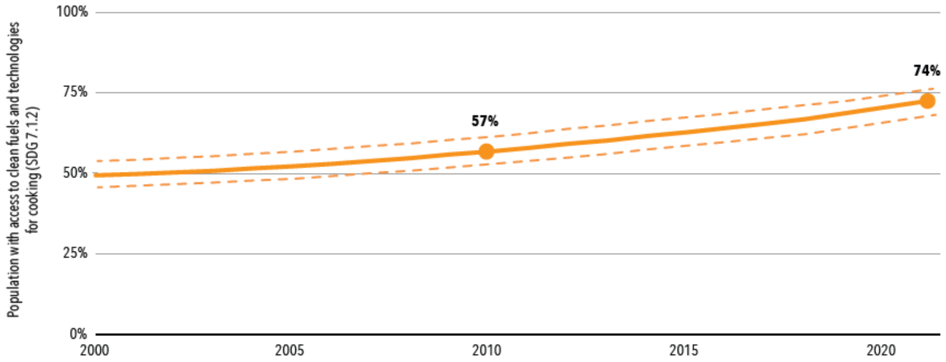
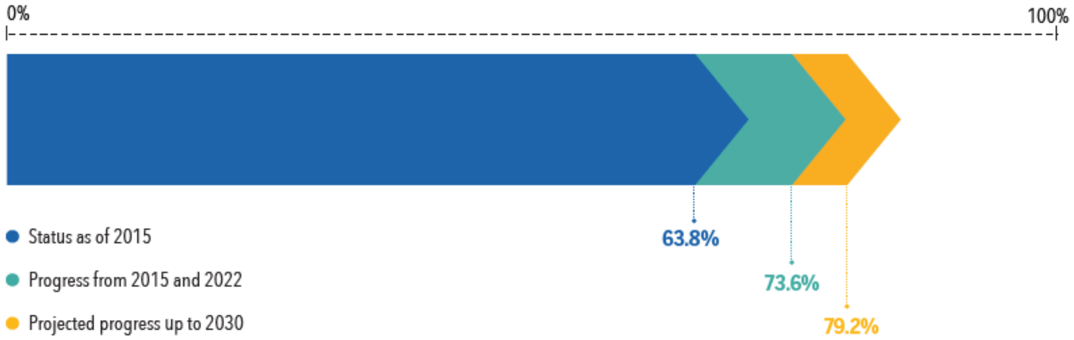


FIGURE 2.1 • PERCENTAGE OF THE GLOBAL POPULATION WITH ACCESS TO CLEAN COOKING FUELS AND TECHNOLOGIES, 2000–22



Source: WHO 2024a.
Note: Dashed lines are 95 percent uncertainty intervals.
SDG = Sustainable Development Goal.

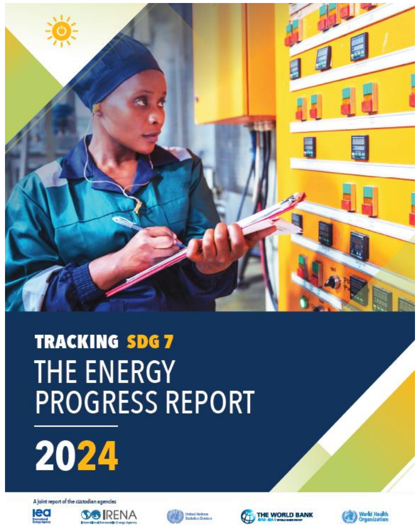
FIGURE 2.5 • PROGRESS TOWARD UNIVERSAL ACCESS TARGET, 2010–30 (IN PERCENTAGES)



Source: WHO 2024a.

Access to clean cooking-2

2.1 billion people without access



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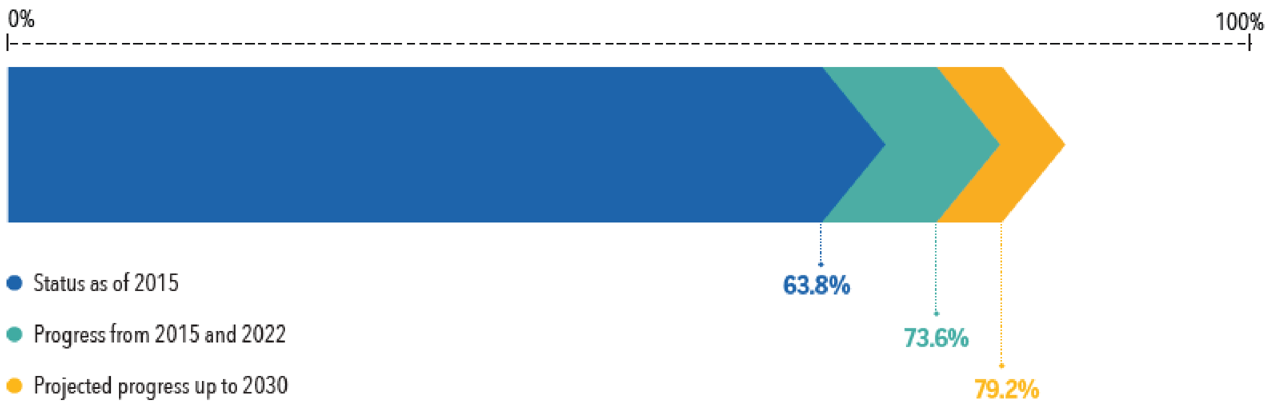


Source: WHO 2024a.

Renewables-1

2022: “Modern” renewables are @ 12.7% of total final energy consumption

The share of renewable energy has slowly increased from 2007, after a period of modest decline, due to strong growth in coal consumption in China. In 2016 it recovered to the same level as in 2000.

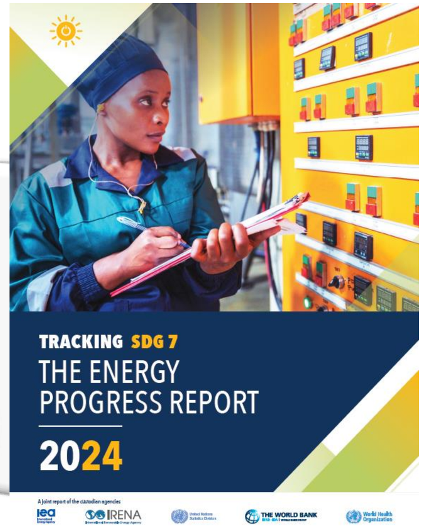
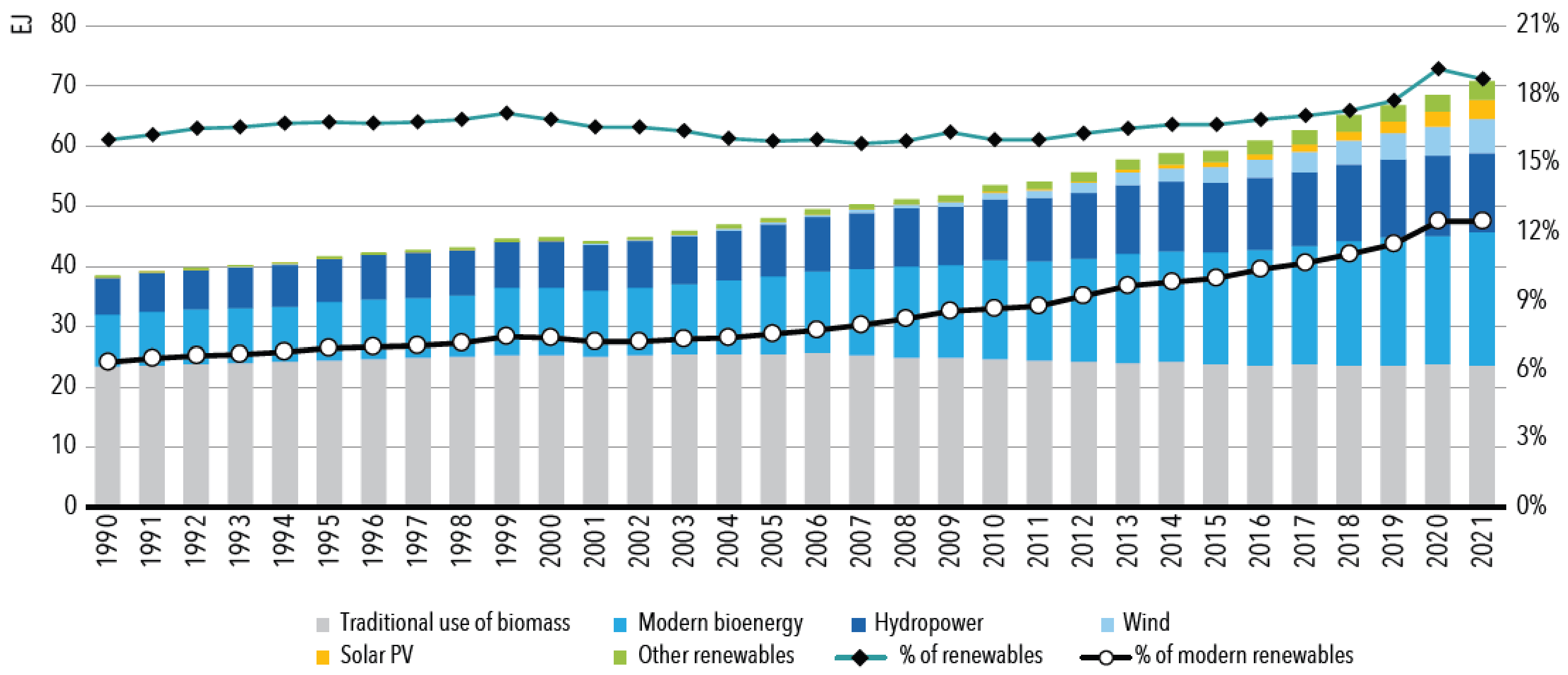
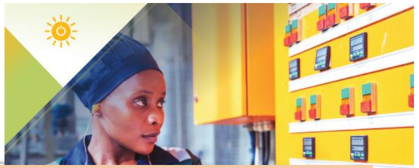


FIGURE 3.1 • RENEWABLE ENERGY CONSUMPTION AND SHARE IN TFEC BY TECHNOLOGY—MODERN AND TOTAL RENEWABLES—1990–2021



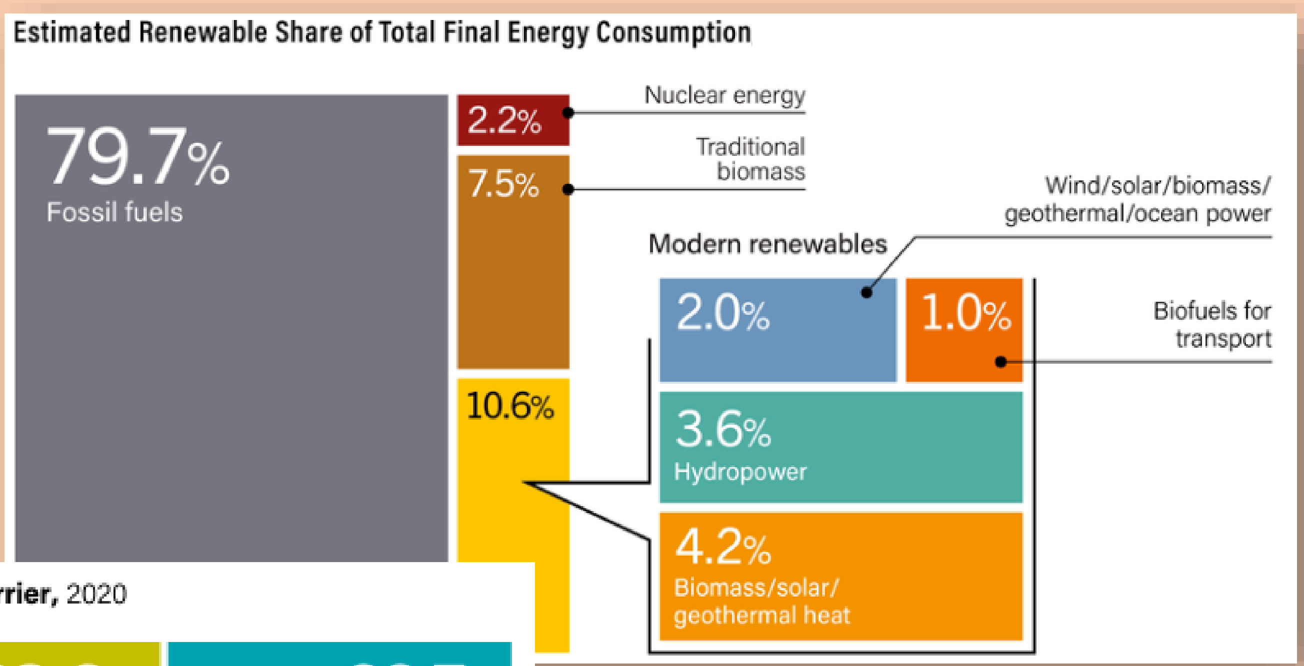
Source: International Energy Agency and United Nations Statistics Division.
EJ = exajoule; PV = photovoltaics.

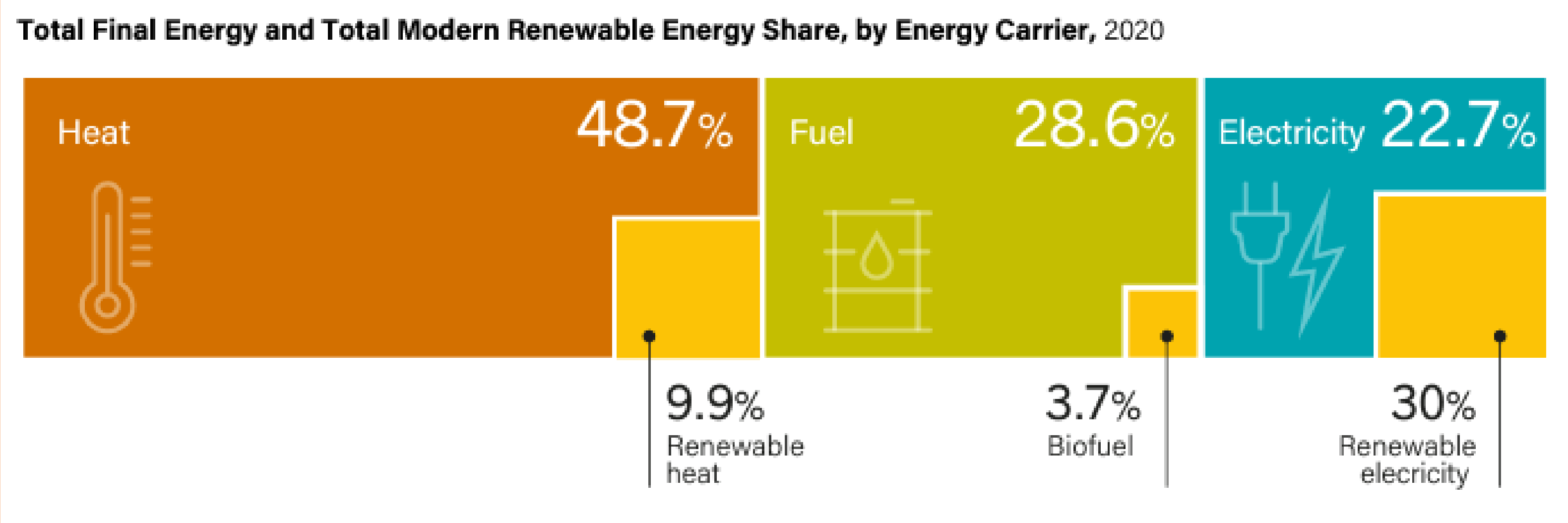
Overall, bioenergy accounts for 70% of global renewable energy consumption, followed by hydropower.



Renewables-1

Modern renewables: renewable technologies with exception to traditional biomass. These include **hydropower**, **solar**, **wind**, **geothermal** and **modern biofuel** production (including modern forms of waste-to-biomass conversion).





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Source: International Energy Agency and United Nations Statistics Division.
EJ = exajoule; PV = photovoltaics.

7 AFFORDABLE AND CLEAN ENERGY

Ensure universal access to affordable, reliable and modern energy services

Progressi 2015-2022

7.1 Accesso all'energia elettrica

- **91% della popolazione mondiale ha accesso all'elettricità**, rispetto al 78% dell'anno di riferimento 2000.
- **48 paesi hanno raggiunto l'accesso universale** all'elettricità tra il 2010 e il 2020.

Tuttavia, la crescita della popolazione ha superato la crescita dell'accesso tra il 2020 e il 2022, lasciando **10 milioni di persone in più senza accesso** nel 2022 rispetto al 2021.

Diversi fattori hanno contribuito a questa inversione di tendenza, tra cui le interruzioni dei mercati e dei prezzi dell'energia derivanti da shock globali come il COVID-19, la guerra in Ucraina e l'instabilità in Medio Oriente.

Inoltre, la popolazione rimanente non elettrificata è più difficile da servire perché gran parte di essa è remota e a basso reddito.

Negli scenari attuali, si prevede che il divario di accesso all'energia migliorerà modestamente, chiudendosi all'8 percento nel 2030, lasciando circa 660 milioni di persone senza accesso.

FIGURE ES.1 • PRIMARY INDICATORS OF GLOBAL PROGRESS TOWARD THE SDG7 TARGETS

INDICATOR	2015	LATEST YEAR
7.1.1 Proportion of population with access to electricity	**957.5 million** people without access to electricity	**685 million** people without access to electricity (2022)
7.1.2 Proportion of population with primary reliance on clean fuels and technology for cooking	**2.7 billion** people without access to clean cooking	**2.1 billion** people without access to clean cooking (2022)
7.2.1 Renewable energy share in total final energy consumption	**16.7%** share of total final energy consumption from renewables	**18.7%** share of total final energy consumption from renewables (2021)
7.3.1 Energy intensity measured as a ratio of primary energy and GDP	**4.9 MJ/USD** primary energy intensity	**4.6 MJ/USD** primary energy intensity (2021)
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	**12.3 USD billion** international financial flows to developing countries in support of clean energy	**15.4 USD billion** international financial flows to developing countries in support of clean energy (2022)
7.b.1 Installed renewable energy-generating capacity in developing and developed countries	**250 watts per capita** installed renewables capacity	**424 watts per capita** installed renewables capacity (2022)

L'obiettivo 7.2 mira ad aumentare la quota di energia rinnovabile nel mix energetico globale e ad aumentare la ca

7 AFFORDABLE AND CLEAN ENERGY

Ensure universal access to affordable, reliable and modern energy services

Progressi 2015-2022

7.2 Quota di fonti rinnovabili nella generazione di en.elettrica

Nel 2022, la quota di energia rinnovabile nel consumo energetico finale totale (TFEC) è del 18,7%.

La quota di energie rinnovabili moderne, ovvero escludendo gli usi tradizionali della biomassa, è del 12,5%, solo quattro punti percentuali in più rispetto al 2010.

L'attuale tendenza non è né in linea con l'obiettivo SDG7 né coerente con gli obiettivi climatici concordati a livello internazionale.

INDICATOR	2015	LATEST YEAR
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Issued October 2019

Table 2.6 | Global primary energy supply of 1.5°C pathways from the scenario database (Supplementary Material 2.SM.1.3).
Values given for the median (maximum, minimum) across the full range of 85 available 1.5°C pathways. Growth Factor = [(primary energy supply in 2050)/(primary energy supply in 2020) – 1]

	Median (max, min)	Count	Primary Energy Supply (EJ)			Share in Primary Energy (%)			Growth (factor) 2020-2050
			2020	2030	2050	2020	2030	2050	
Below-1.5°C and 1.5°C-low-OS pathways	total primary	50	565.33 (619.70, 483.22)	464.50 (619.87, 237.37)	553.23 (725.40, 289.02)	NA	NA	NA	–0.05 (0.48, –0.51)
	renewables	50	87.14 (101.60, 60.16)	146.96 (203.90, 87.75)	291.33 (584.78, 176.77)	14.90 (20.39, 10.60)	29.08 (62.15, 18.24)	60.24 (87.89, 38.03)	2.37 (6.71, 0.91)
	biomass	50	60.41 (70.03, 40.54)	77.07 (113.02, 44.42)	152.30 (311.72, 40.36)	10.17 (13.66, 7.14)	17.22 (35.61, 9.08)	27.29 (54.10, 10.29)	1.71 (5.56, –0.42)
	non-biomass	50	26.35 (36.57, 17.78)	62.58 (114.41, 25.79)	146.23 (409.94, 53.79)	4.37 (7.19, 3.01)	13.67 (26.54, 5.78)	27.98 (61.61, 12.04)	4.28 (13.46, 1.45)
	wind & solar	44	10.93 (20.16, 2.61)	40.14 (82.66, 7.05)	121.82 (342.77, 27.95)	1.81 (3.66, 0.45)	9.73 (19.56, 1.54)	21.13 (51.52, 4.48)	10.00 (53.70, 3.71)
	nuclear	50	10.91 (18.55, 8.52)	16.26 (36.80, 6.80)	24.51 (66.30, 3.09)	2.10 (3.37, 1.45)	3.52 (9.61, 1.32)	4.49 (12.84, 0.44)	1.24 (5.01, –0.64)
	fossil	50	462.95 (520.41, 376.30)	310.36 (479.13, 70.14)	183.79 (394.71, 54.86)	82.53 (86.65, 77.73)	66.58 (77.30, 29.55)	32.79 60.84, 8.58)	–0.59 (–0.21, –0.89)
	coal	50	136.89 (191.02, 83.23)	44.03 (127.98, 5.97)	24.15 (71.12, 0.92)	25.63 (30.82, 17.19)	9.62 (20.65, 1.31)	5.08 (11.43, 0.15)	–0.83 (–0.57, –0.99)
	gas	50	132.95 (152.80, 105.01)	112.51 (173.56, 17.30)	76.03 (199.18, 14.92)	23.10 (28.39, 18.09)	22.52 (35.05, 7.08)	13.23 (34.83, 3.68)	–0.40 (0.85, –0.88)
	oil	50	197.26 (245.15, 151.02)	156.16 (202.57, 38.94)	69.94 (167.52, 15.07)	34.81 (42.24, 29.00)	31.24 (39.84, 16.41)	12.89 (27.04, 2.89)	–0.66 (–0.09, –0.93)

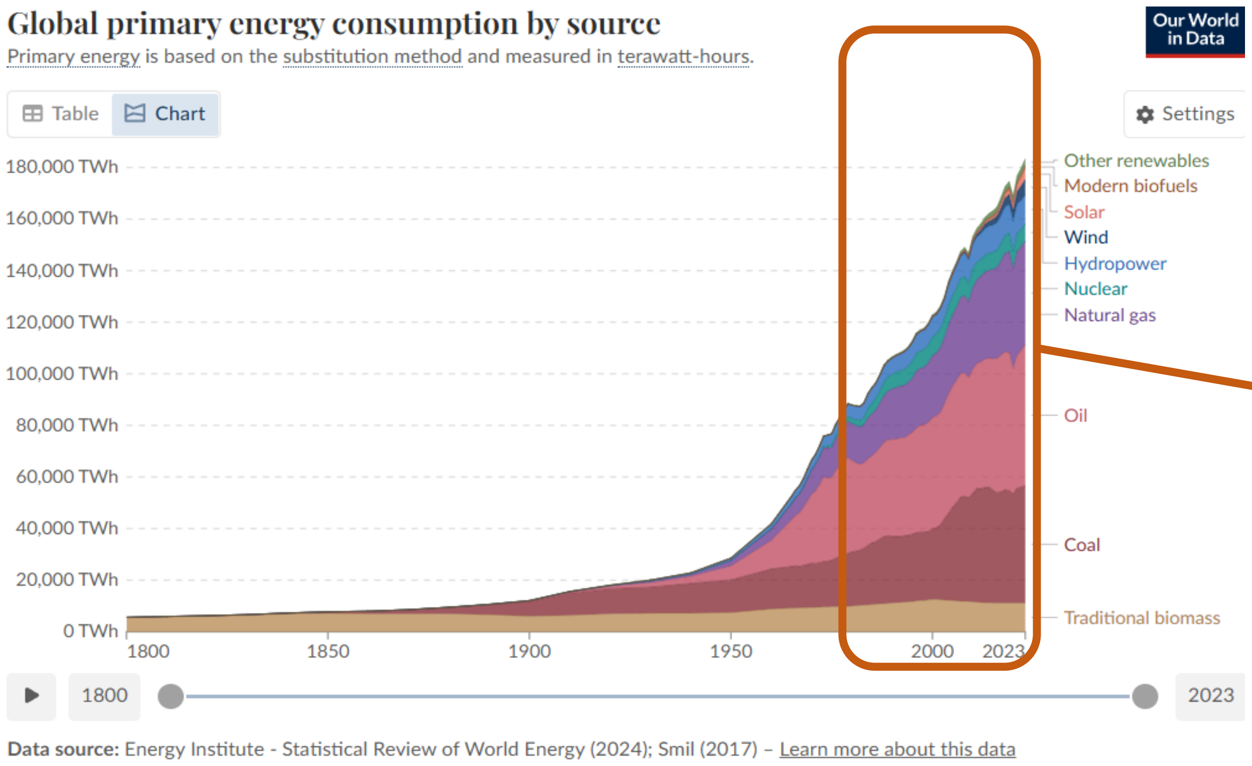
2.4.2 Energy Supply

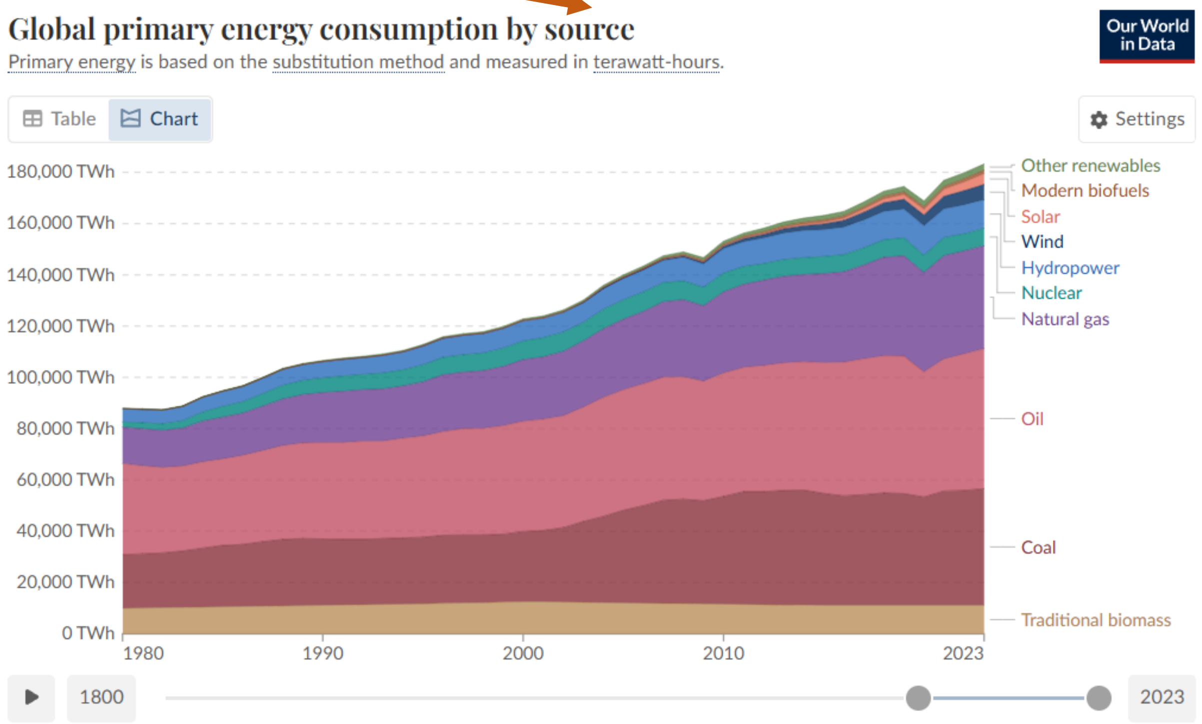
Several energy supply characteristics are evident in 1.5°C pathways assessed in this section:

1. *growth in the share of energy derived from low-carbon-emitting sources (incl. **REN, nuclear and fossil fuel with CCS**) (Section 2.4.2.1),*
2. *rapid decline in the carbon intensity of electricity generation simultaneous with further electrification of energy end-use (Section 2.4.2.2),*
3. *growth in the use of **CCS applied to fossil and biomass** carbon in most 1.5°C pathways (Section 2.4.2.3)*

https://www.ipcc.ch/sr15/

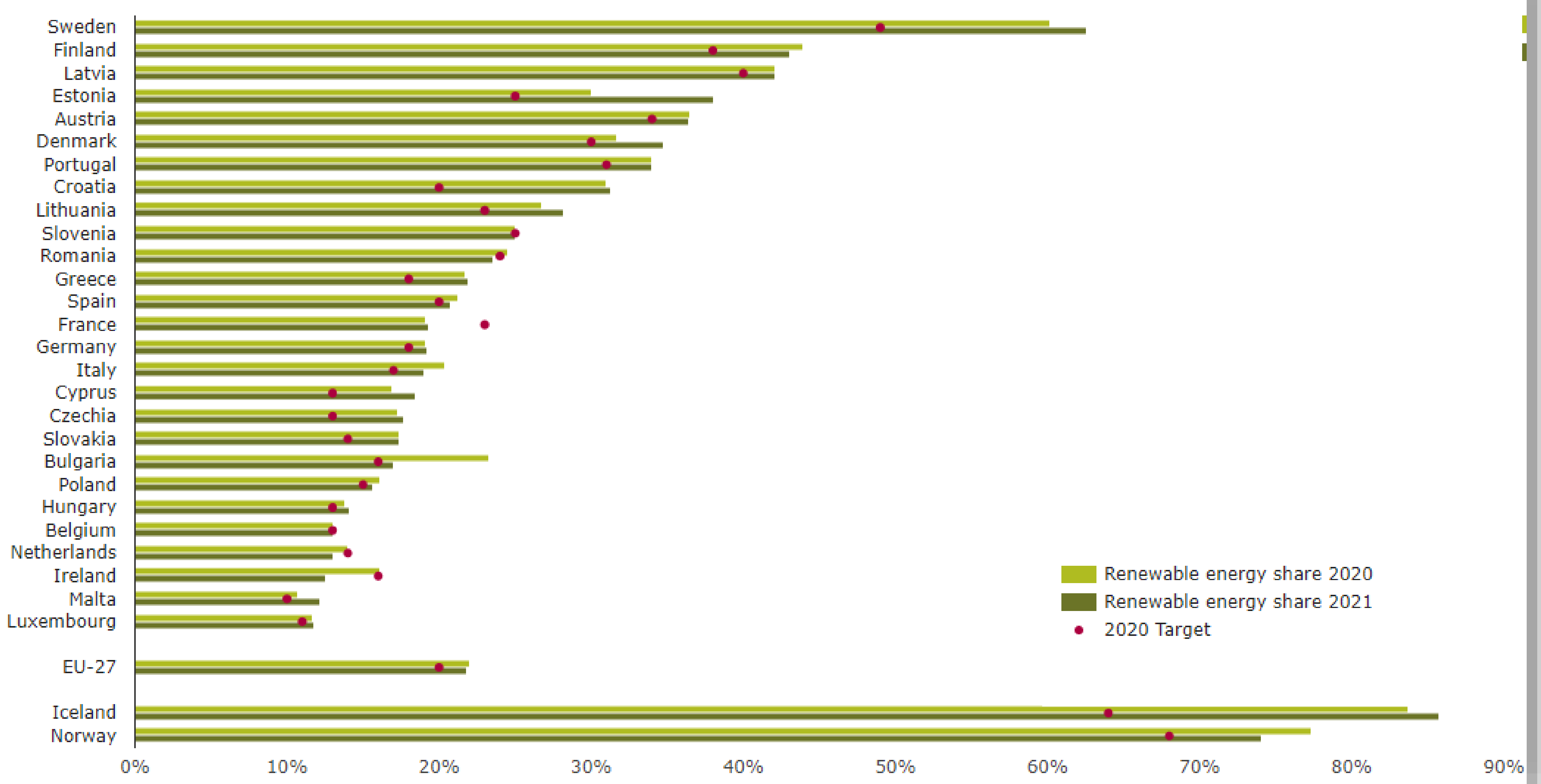
Energy statistics - mondo





Energy statistics - EU

Chart — Share of energy from renewable sources, by country

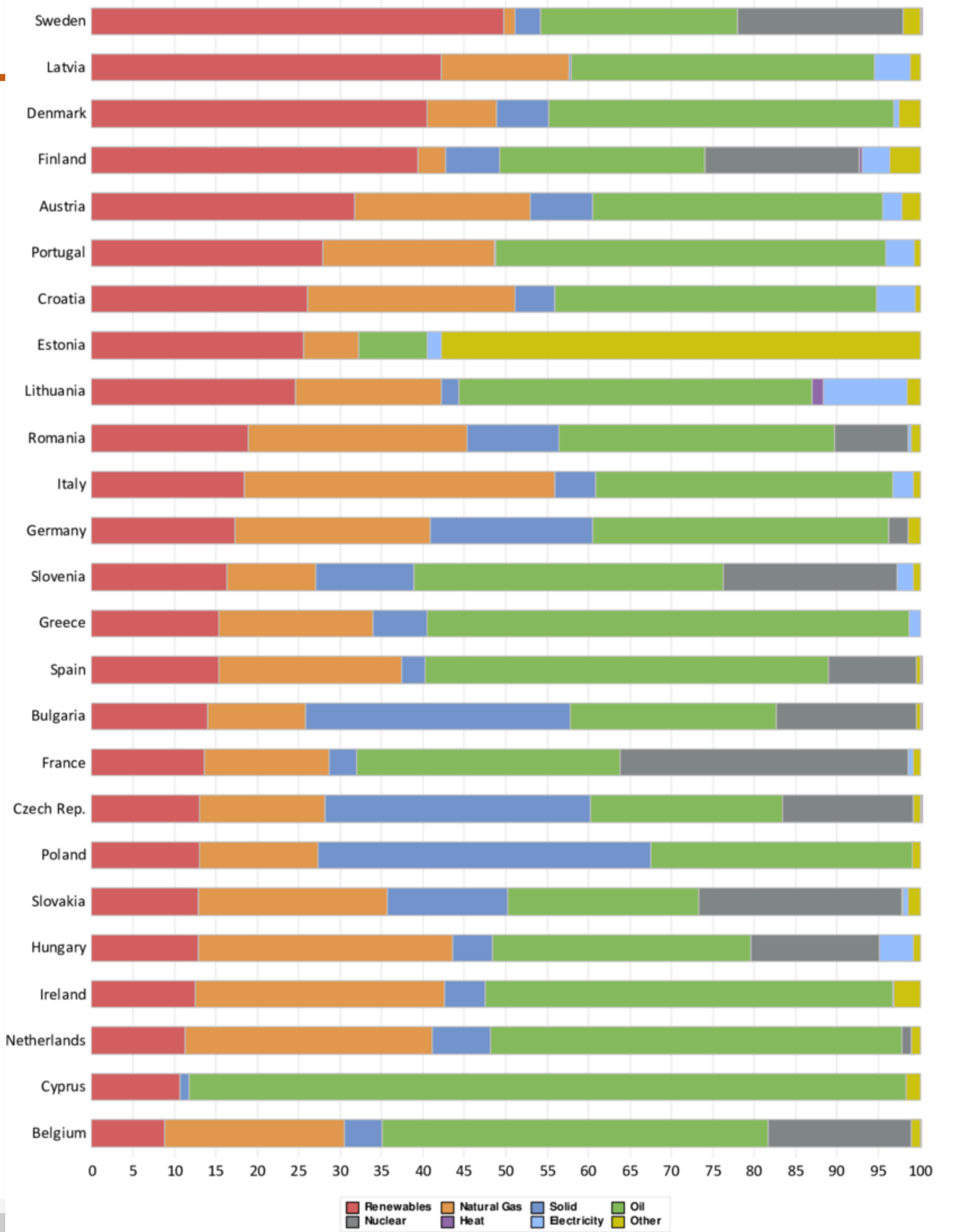


eurostat Statistics Explained

Energy statistics - EU

eurostat Statistics Explained

2022



MINISTERO DELL'AMBIENTE
E DELLA SICUREZZA ENERGETICA

DIPARTIMENTO ENERGIA

DIREZIONE GENERALE FONTI ENERGETICHE E TITOLI ABILITATIVI

LA SITUAZIONE ENERGETICA NAZIONALE NEL 2023

Tabella 1: Il bilancio dell'energia in Italia – La disponibilità energetica lorda (ktep)

	2022	2023								
	Totale	Combustibili solidi	Petrolio e prodotti petroliferi	Gas naturale	Rinnovabili e bioliquidi	Rifiuti non rinnovabili	Calore derivato	Energia elettrica	**Totale**	**Var % 23/22**
+ Produzione	36.171	-	5.776	2.234	27.014		-	-	35.980	**4,2%**
+Saldo importazioni	138.565	4.864	76.327	50.630	2.052		-	4.692	138.644	**-9,0%**
- Saldo Esportazioni	31.220	184	28.074	2.145	531		-	285	31.220	**-5,6%**
+ Variazioni scorte	444	179	589	- 374	50		-	-	444	**-113,3%**
= Disp. En. lorda	**150.531**	**4.859**	**54.618**	**50.345**	**28.586**	**1.146**	**-**	**4.407**	**143.849**	**-4,4%**

Fonte: Ministero dell'ambiente e della sicurezza energetica - Bilancio Energetico Nazionale - Metodologia Eurostat

Nel 2023 è diminuita la **disponibilità energetica** lorda del Paese, a 143.961 migliaia di tonnellate equivalenti (ktep) di petrolio, con un – 4,4% rispetto al 2022.

L'**intensità energetica** ha registrato un forte calo rispetto al 2022 (-5,2%), come conseguenza diretta del decremento della disponibilità energetica.

Tabella 7: Produzione lorda di energia elettrica da fonti rinnovabili in Italia - TWh

Fonte	2018	2019	2020	2021	2022	2023*
Idraulica	48,8	46,3	47,6	45,4	28,4	40,4
Eolica	17,7	20,2	18,8	20,9	20,5	23,3
Solare	22,7	23,7	24,9	25,0	28,1	30,7
Geotermica	6,1	6,1	6,0	5,9	5,8	5,7
Bioenergie (**)	19,2	19,6	19,6	19,1	17,6	16,0
Totale FER	**114,4**	**115,8**	**116,9**	**116,3**	**100,5**	**116,2**
CIL - Consumo Interno Lordo (***)	331,9	330,1	310,8	329,7	325,1	313,9
FER/CIL	**34,5%**	**35,1%**	**37,6%**	**35,3%**	**30,9%**	**37,0%**

(*) Dati provvisori

(**) Biomasse solide, bioliquidi, biogas e frazione rinnovabile dei rifiuti

(***) Il CIL è pari alla produzione lorda di energia elettrica più il saldo scambi con l'estero ed è qui considerato al netto degli apporti da pompaggio. Per l'energia elettrica, tale grandezza corrisponde alla disponibilità lorda.

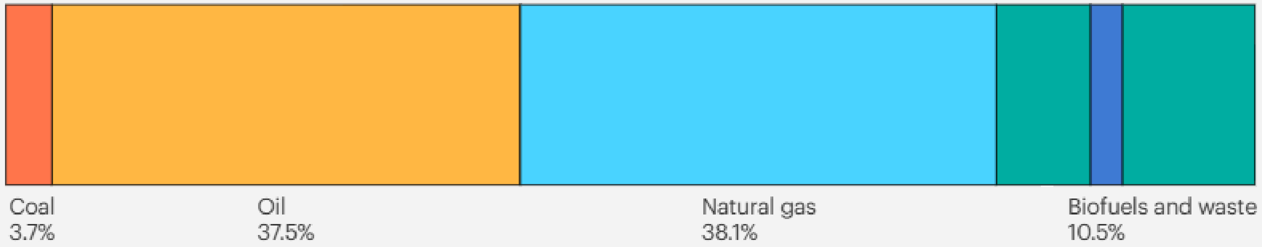
Fonte: TERNA, GSE

Energy statistics - Italy

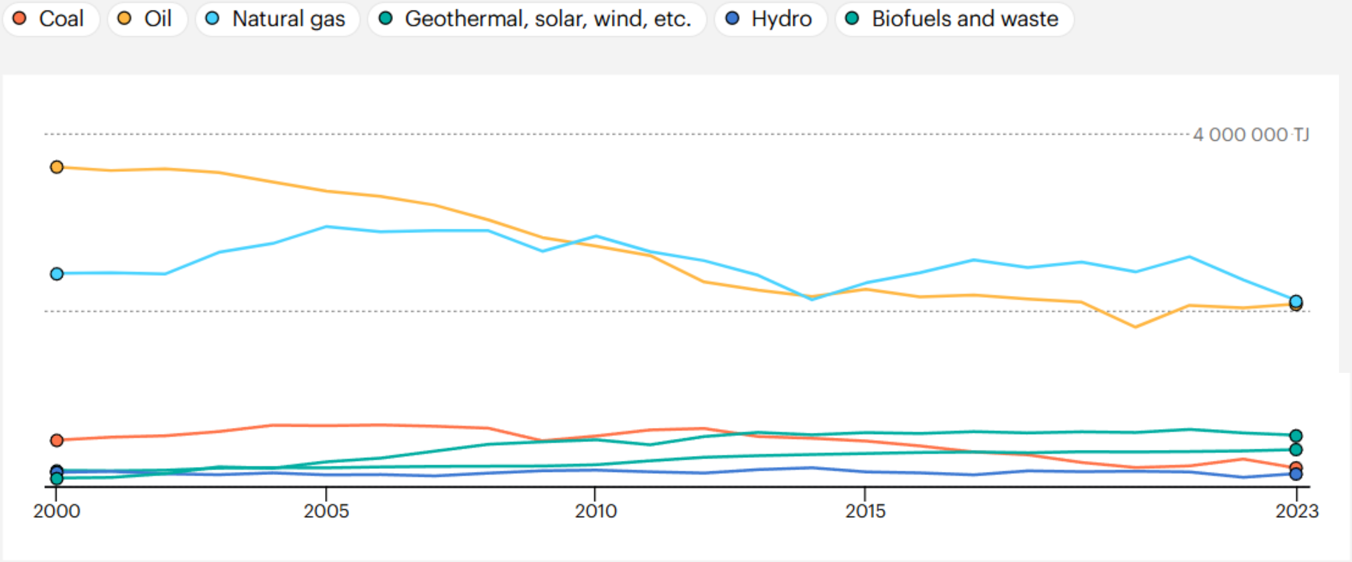
Energy mix

Total energy supply, Italy, 2023

Total energy supply | Production | Electricity | Consumption



Evolution of total energy supply in Italy since 2000



Emissions

Energy-related CO2 emissions, Italy, 2022

310 Mt CO2

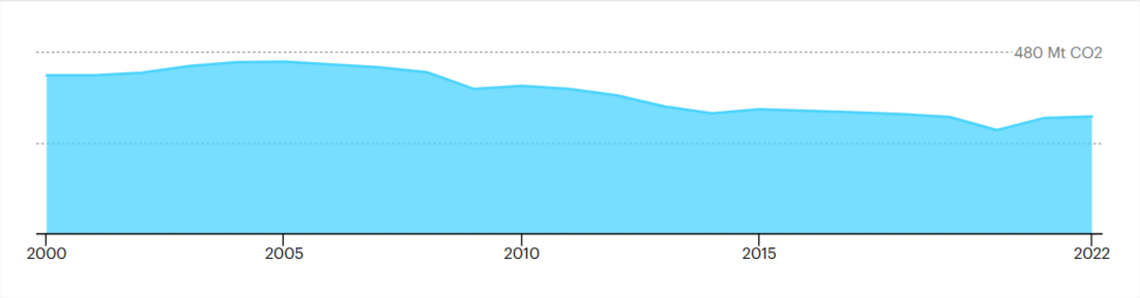
0.91%

of global emissions

↓26%

change since 2000

CO2 emissions from fuel combustion, Italy

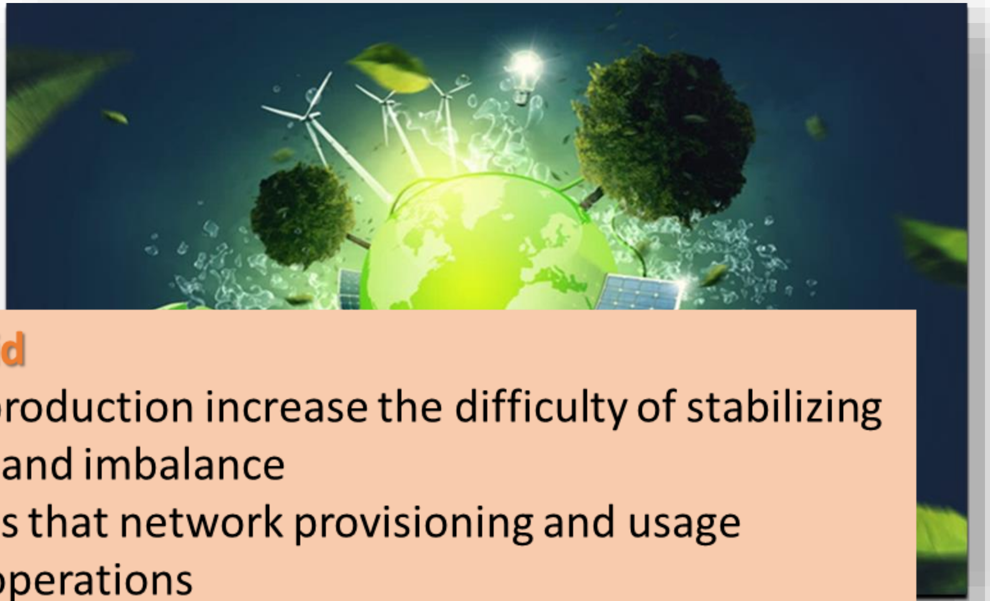


https://www.iea.org/countries/italy

what future for a geologist in this changing world?

Traditional energy sources: the resource availability is homogeneous; the delivery of power/energy from their production plants can be modulated according to the demand

Renewable energy sources: the delivery of power/energy from their production plants is higly dependant on the resource availability/storage. **Intermittent energy sources**



Traditional energy sources: the resource availability is homogeneous; the delivery of power/energy from their production plants can be modulated according to t

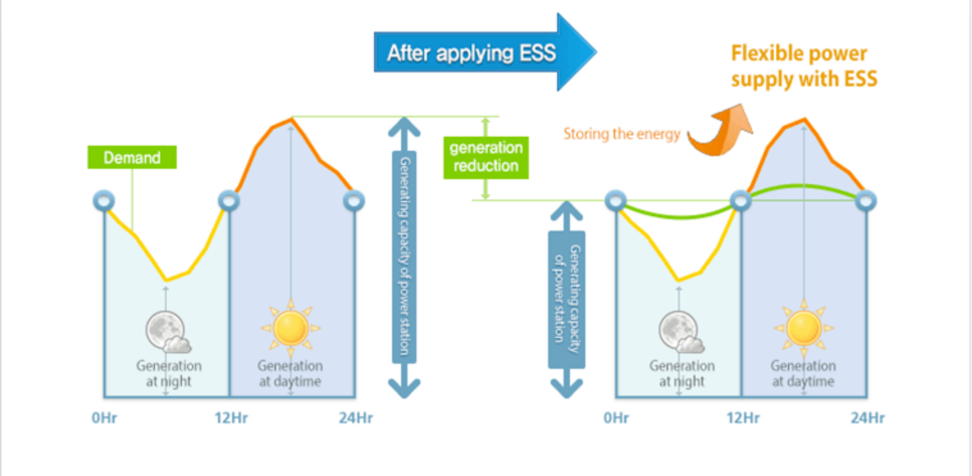
Renewable energy sourc
production plants is higly
availability/storage. **Inter**

Difficulties with renewables integration in the grid

- Fluctuating sources and decentralized energy production increase the difficulty of stabilizing the power network, mainly due to supply/demand imbalance
- Unpredictable character of renewables requires that network provisioning and usage regulations be established for optimal system operations
- Peak supply of renewables (solar, wind) and demand of energy do not match and hence create a gap

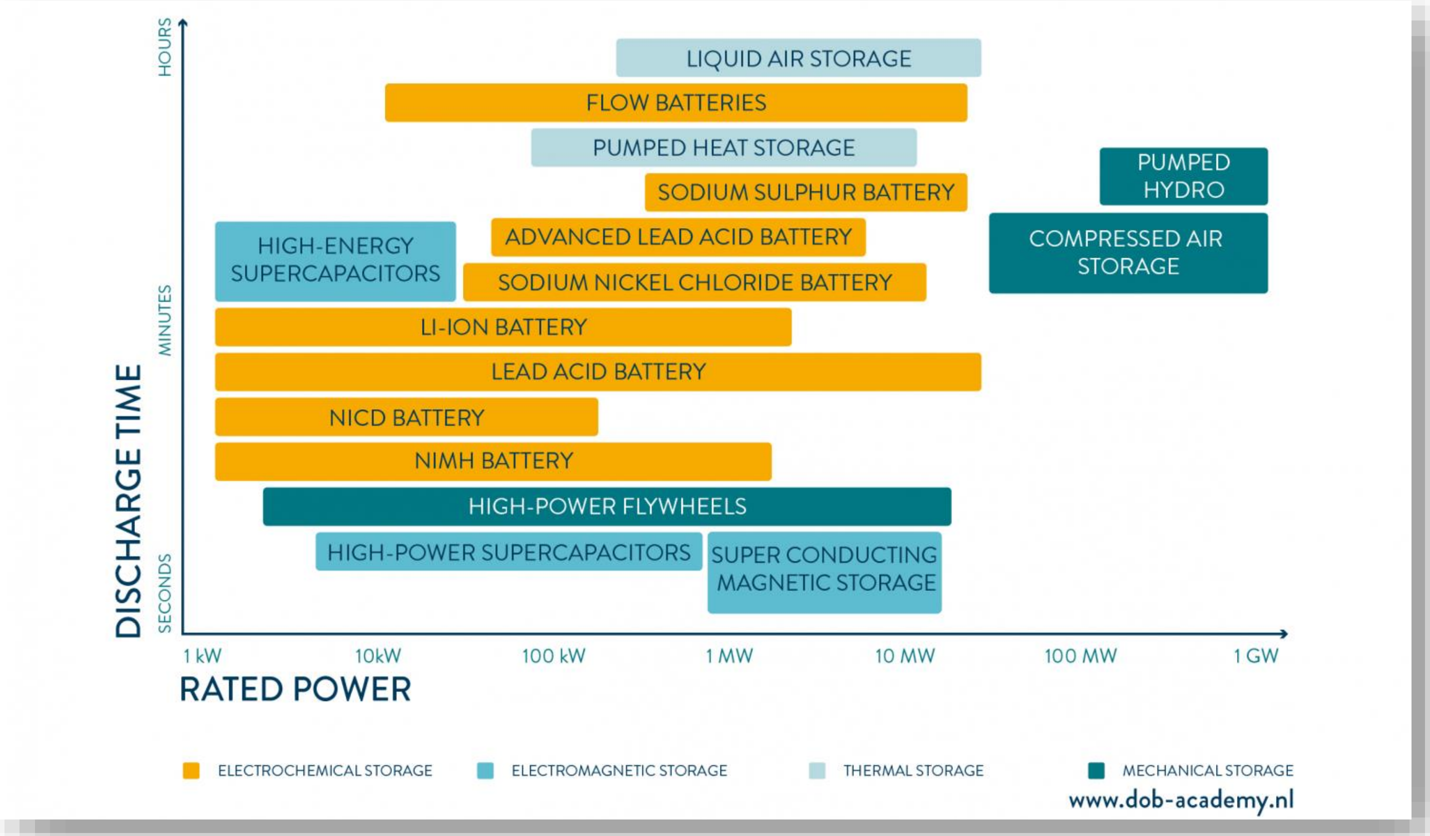
Energy Storage Systems - ESS

- Conversion of excess energy into a different form of energy, to be converted in electricity with minimum losses
- Increases the dispatch ability, makes power available on demand; by reducing the supply/demand gap reduces the nedd for newer power plants



Concept Map of Energy Storage System (ESS)

Energy storage



Intermittency of energy supply: increase of energy storage capabilities. This could include:

- advancement in **battery technologies**
- **subsurface air & thermal energy** and **pumped hydro**

Decarbonisation/transition of power generation, industry, transport and heating needs expansion in renewables and nuclear, many of which require **critical raw materials and metals** to manufacture (which rely on sources of minerals and metals e.g. lithium, cobalt, cadmium).

A **sustainable and secure supply of mined materials** is required

The Role of Geoscience in Decarbonisation

The Geological Society
serving science, profession & society

21 - 23 January 2019
The Geological Society, Burlington House
https://www.geolsoc.org.uk/Lovell19

Decarbonisation/transition of power generation, industry, transport and heating to meet climate change targets: a major challenge that intrinsically involves the subsurface and geoscience.

Renewables	increase in grid-scale energy storage to cover intermittency: greater efforts on more efficient batteries, pumped storage and compressed air energy storage
Civil nuclear	understanding of risks associated with natural hazards (seismicity); challenge of geological disposal of radioactive waste
Geothermal power, heating and cooling	assessment of resources and impacts
Hydrogen *(it is a vector, not a source!!!)*	development of technology; environmental and geological assessment for underground storage and transport
Carbon Capture and Storage (CCS)	definition of the reservoirs and volumes of potential storage; risks assessment associated with natural and induced hazards (seismicity, …)
Natural gas	the **energy resource for the transition** needs environmental and resources assessment

All require **geological studies**: investigating the geological origin and prospectivity of transition metals and rare earth elements for batteries; for siting of power station, dams and tunnels in pumped water storage; geological studies for CCS; detailed characterisation of the subsurface for radio- waste disposal.

The Role of Geoscience in Decarbonisation

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Scientific and technological challenges for Geosciences in the Energy Transition

- ✓ **Characterise** the physical properties, chemistry and structure of the subsurface to determine feasibility of various subsurface storage and infrastructure projects.
- ✓ **Improve** understanding of how the properties of the subsurface respond to changing physical and chemical conditions, e.g. during cyclical pressurisation and depressurisation of hydrogen or thermal fluids.
- ✓ **Assess** the origin, distribution and extractability of subsurface critical raw materials needed for decarbonisation.
- ✓ **Develop** and design effective and cost-efficient monitoring techniques for various uses of the subsurface.
- ✓ **Improve** scientific understanding on how fluids flow in the subsurface (HC, thermal energy storage, geothermal resources).

Critical to the success of the decarbonisation initiative is **knowledge and data sharing** across geographical borders, between industries, and by all "subsurface stakeholders".

There are key geoscientific lessons to be learned across planning, exploration, exploitation, decommissioning and remediation

The Role of Geoscience in Decarbonisation

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The opportunity for Geosciences in the Energy Transition

Europe is well placed to develop subsurface decarbonisation technologies. It has an excellent base of worldclass universities, research institutes, and **the experience of Oil&Gas companies**.
A combination of state-of-the-art technology, improvements to efficiency and low-carbon fuel switching will be needed to achieve the ambitious decarbonisation targets.

However, for some industrial processes, such as steel manufacturing, cement production, and refining, subsurface carbon-capture technologies are the only viable decarbonising solution.

According to IPCC, **negative emissions** can only realistically be achieved adding **nuclear and carbon capture and storage (CCS)**

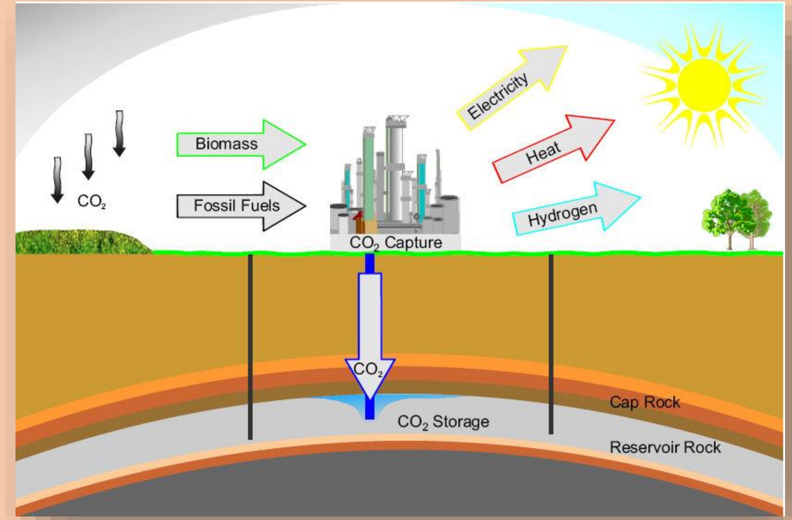
The opportu

Europe is w
universities
A combinat
to achieve
However, fo
carbon-cap
According t
nuclear and

CCS - Carbon Capture & Storage

The quantity of $CO2$ to be stored via CCS over this century in 1.5°C pathways ranges, depending by different scenarios, from zero to >1,200 $GtCO2$.

The **IPCC Special Report on Carbon Dioxide Capture and Storage** found that, worldwide, it is likely that there was a technical potential of at least about 2,000 $GtCO2$ of storage capacity in geological formations, with possible additional potential for geological storage in saline formations.



The **cumulative demand for CO2 storage was small compared to a practical storage capacity estimate worldwide**.

The global potential storage capacity is estimated today from 8,000 to 55,000 $GtCO2$,which is sufficient at a global level for this century.

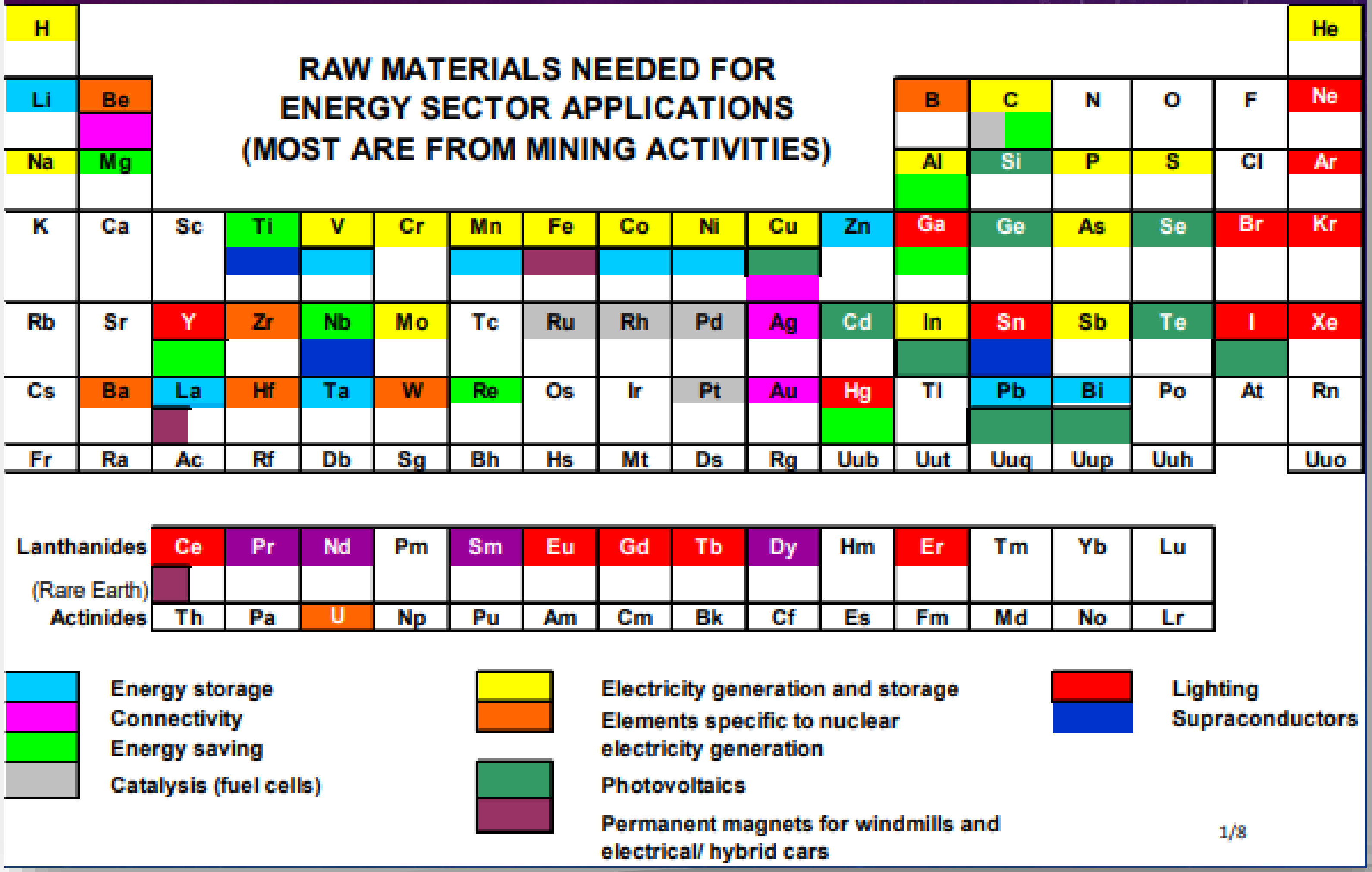
The storage capacity of all of these global estimates is likely to be larger than the cumulative CO2 stored via CCS in 1.5°C pathways over this century

Mining

ANCRE
Alliance Nationale de Coordination de la Recherche pour l'Énergie

COP21 · CMP11
PARIS 2015
UN CLIMATE CHANGE CONFERENCE

Most elements in the periodic table are essential to the innovative technologies required to address mankind's energy problems



The **energy sector** contributes to the rapid demand growth for a **wide range of** minerals and metals.

The production of minerals and metals

- **requires energy** (currently about 10.5% of the global production),
- **generates emissions** (CO2, sulfur and nitrogen oxydes, particulate matter, mercury from coal production, radionucleides from coal combustion and rare earth production…).

http://www.mineralinfo.fr/sites/default/files/upload/ancre_rapport_2015-ressources_minerales_et_energie_0.pdf

Mining

nature reviews materials

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Comment | Published: 24 May 2021

Mining our green future

Richard Herrington

Nature Reviews Materials **6**, 456–458 (2021) | Cite this article

The green energy revolution is heavily reliant on raw materials, such as cobalt and lithium, which are currently mainly sourced by mining. We must carefully evaluate acceptable supplies for these metals to ensure that green technologies are beneficial for both people and planet.

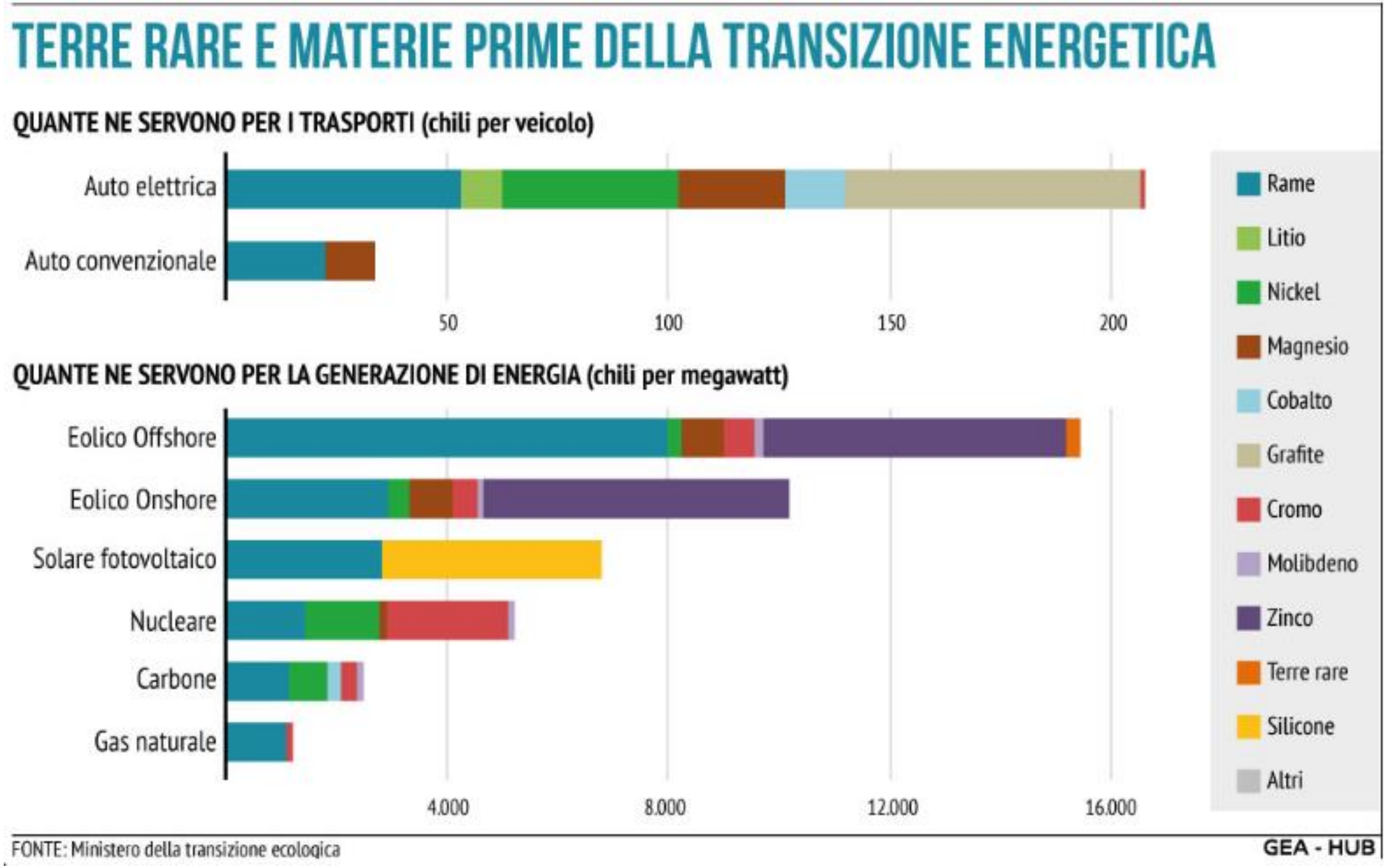
Table 1 | **Anticipated increase in demand for the 12 most needed commodities for delivering a green energy future**

Commodity	% increase in demand in 2050 compared with 2018
Graphite	494
Cobalt	460
Lithium	488
Indium	231
Vanadium	189
Nickel	99
Silver	56
Neodymium	37
Lead	18
Molybdenum	11
Aluminium	9
Copper	7

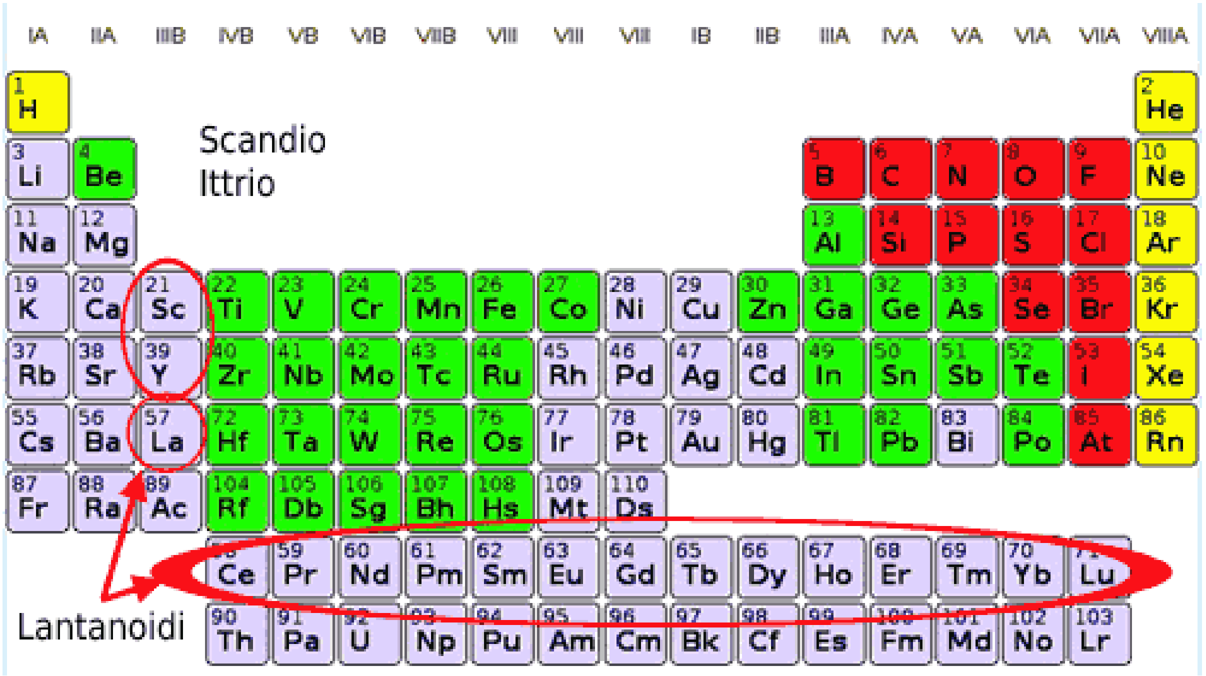
Data source: World Bank Report in 2020

Mining

Mining


TERRE RARE E MATERIE PRIME DELLA TRANSIZIONE ENERGETICA
QUANTE NE SERVONO PER I TRASPORTI (chili per veicolo)
Auto elettrica
Auto convenzionale
50
100
150
200
QUANTE NE SERVONO PER LA GENERAZIONE DI ENERGIA (chili per megawatt)
Eolico Offshore
Eolico Onshore
Solare fotovoltaico
Nucleare
Carbone
Gas naturale
4.000
8.000
12.000
16.000
Rame
Litio
Nickel
Magnesio
Cobalto
Grafite
Cromo
Molibdeno
Zinco
Terre rare
Silicone
Altri
FONTE: Ministero della transizione ecologica
GEA - HUB

Rare Earth Elements



Produzione e **funzionamento** di oggetti della quotidianità: all'interno di smartphone, touchscreen, lampade, hard disk. Alla base di fibre ottiche e laser, di molte apparecchiature mediche, nelle batterie per le auto elettriche. Costituiscono magneti permanenti, sensori elettrici, convertitori catalitici indispensabili per la produzione di tecnologie green (turbine eoliche e pannelli fotovoltaici).

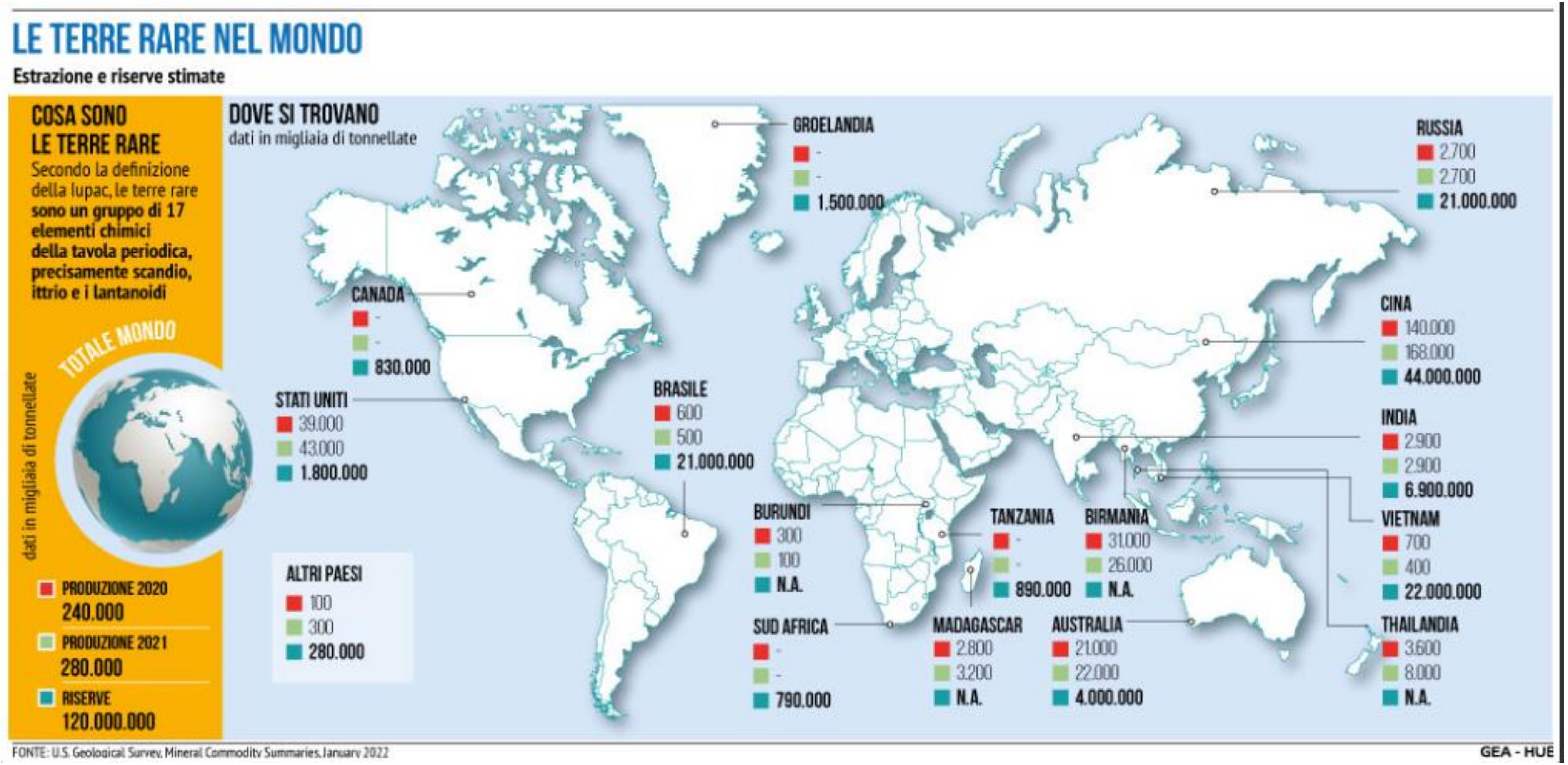
Preziose e fondamentali per lo sviluppo della tecnologia verde e non solo: le **Terre rare**, anche definite con l'acronimo **REE** (**Rare Earth Elements**), sono 17 metalli presenti nella tavola periodica degli elementi chimici, con colori che variano dal grigio all'argento.

Includono lo **scandio** (Sc) e l'**ittrio** (Y), più l'intera serie dei lantanidi, gli elementi chimici dal numero atomico dal 57 al 71.

Nell'ordine: **lantanio** (La), **cerio** (Ce), **praseodimio** (Pr), **neodimio** (Nd), **promezio** (Pm), **samario** (Sm), **europio** (Eu), **gadolinio** (Gd), **terbio** (Tb), **disprosio** (Dy), **olmio** (Ho), **erbio** (Er), **tulio** (Tm), **itterbio** (Yb), **lutezio** (Lu).

Le loro straordinarie proprietà magnetiche e conduttive ne implementano l'utilizzo in svariati ambiti, dall'industria elettronica e tecnologica a quella aereonautica e militare.

Mining


LE TERRE RARE NEL MONDO
Estrazione e riserve stimate
COSA SONO LE TERRE RARE
Secondo la definizione della Iupac, le terre rare sono un gruppo di 17 elementi chimici della tavola periodica, precisamente scandio, ittrio e i lantanoidi
TOTALE MONDO
dati in migliaia di tonnellate
PRODUZIONE 2020 240.000
PRODUZIONE 2021 280.000
RISERVE 120.000.000
DOVE SI TROVANO
dati in migliaia di tonnellate
GROELANDIA - - 1.500.000
RUSSIA 2.700 2.700 21.000.000
CANADA - - 830.000
CINA 140.000 168.000 44.000.000
STATI UNITI 39.000 43.000 1.800.000
BRASILE 600 500 21.000.000
INDIA 2.900 2.900 6.900.000
BURUNDI 300 100 N.A.
TANZANIA - - 890.000
BIRMANIA 31.000 26.000 N.A.
VIETNAM 700 400 22.000.000
ALTRI PAESI 100 300 280.000
SUD AFRICA - - 790.000
MADAGASCAR 2.800 3.200 N.A.
AUSTRALIA 21.000 22.000 4.000.000
THAILANDIA 3.600 8.000 N.A.
FONTE: U.S. Geological Survey, Mineral Commodity Summaries, January 2022
GEA - HUE

Mining

U.S. Global Investors

THE PERIODIC TABLE OF COMMODITIES RETURNS 2023

Natural resources are vital for global progress and prosperity, but their prices can fluctuate significantly over time, as demonstrated in a table highlighting price movements over the past decade. This volatility aligns with the principle of mean reversion, where returns tend to revert to their average levels. The prices of commodities exhibit both seasonal and cyclical patterns historically. Therefore, investing in natural resources necessitates a diversified portfolio managed by professionals knowledgeable about these assets and their global trends. However, diversification doesn't eliminate market risks or ensure profits, and past performance doesn't predict future outcomes.

Materie prime

Performance

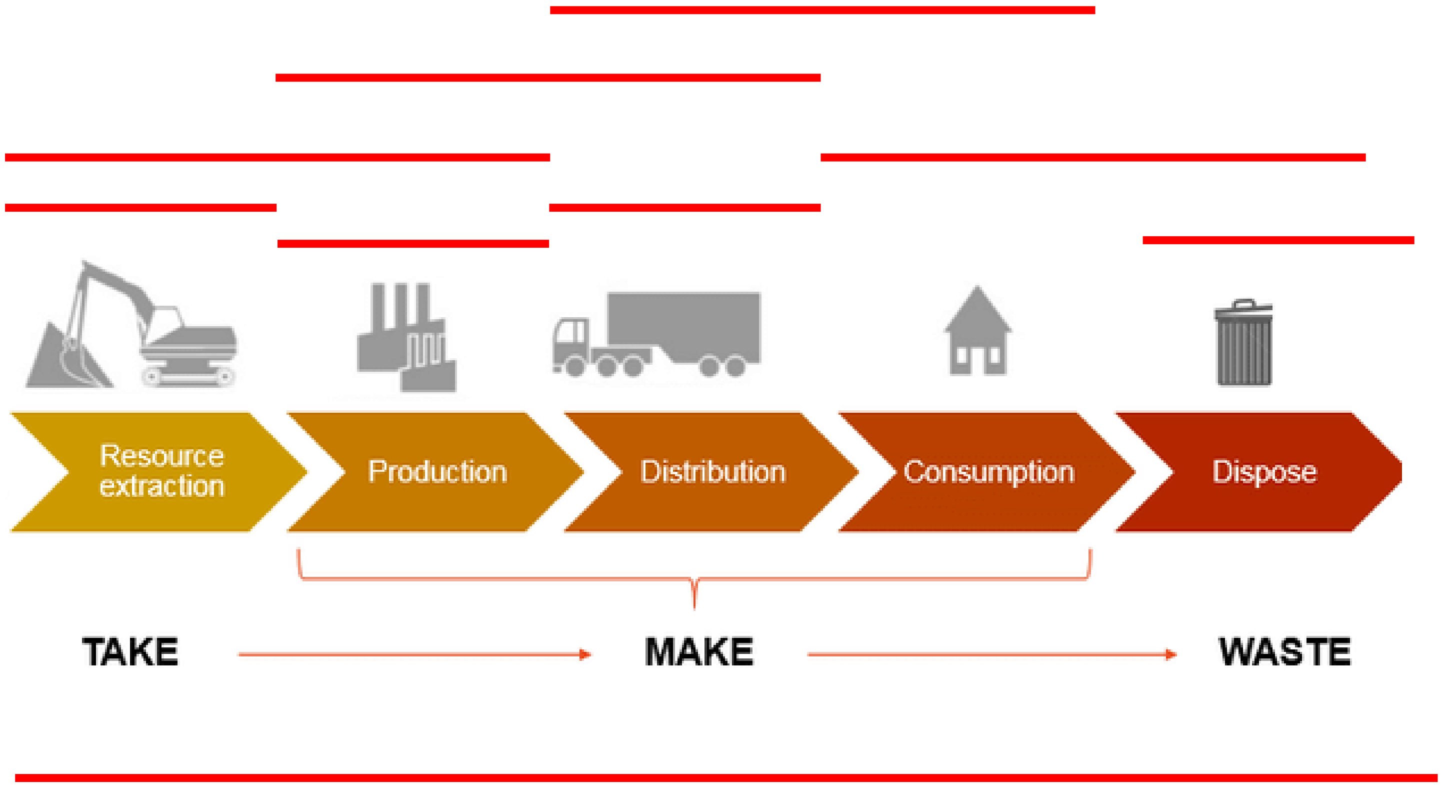
2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
11.35% Pd	187.05% Li	103.67%	56.25% Pd	18.59% Pd	54.20% Pd	47.89% Ag	442.80% Li	72.49% Li	13.10% Au
6.91% Ni	-2.50% Pb	60.59% Zn	40.51% Li	17.86%	34.46%	26.02% Cu	160.61%	43.13% Ni	1.19% Cu
4.82% Li	-9.63%	59.35%	32.39% Al	6.91%	31.55% Ni	25.86% Pd	55.01%	19.97%	-0.17% Al
3.91% Zn	-10.42% Au	45.03%	31.19%	-0.44%	21.48% Pt	25.12% Au	46.91%	14.37%	-0.66% Ag
3.80% Al	-10.72%	20.96% Pd	30.49% Cu	-1.58% Au	18.31% Au	24.82%	42.18% Al	10.90% Pt	-7.67% Pt
-1.72% Au	-11.75% Ag	17.37% Cu	30.49% Zn	-8.53% Ag	15.21% Ag	19.73% Zn	31.53% Zn	6.71%	-9.97%
-2.24%	-17.79% Al	14.86% Ag	27.51% Ni	-14.49% Pt	11.03%	18.66% Ni	26.14% Ni	2.77% Ag	-10.73%
-5.52%	-19.11%	13.58% Al	24.27% Pb	-16.54% Ni	3.40%	15.99%	25.70% Cu	2.76%	-12.10% Zn
-11.79% Pt	-20.31%	13.49% Ni	13.09% Au	-17.43% Al	3.36% Cu	14.63%	22.57%	-0.05% Pb	-12.93% Pd
-14.00% Cu	-26.07% Pt	11.27% Pb	12.47%	-17.46% Cu	-4.38% Al	13.15% Li	20.34%	-0.28% Au	-20.71%
-15.51%	-26.10% Cu	8.56% Au	6.42% Ag	-19.23% Pb	-4.66% Pb	10.92% Pt	18.32% Pb	-5.89% Pd	-30.55%
-16.00% Pb	-26.50% Zn	1.16% Pt	4.66%	-22.16%	-9.49% Zn	10.80% Al	-3.64% Au	-14.13% Cu	-38.63% Pb
-19.34% Ag	-29.43% Pd	-1.88%	2.99% Pt	-24.54% Zn	-18.02%	3.25% Pb	-9.64% Pt	-16.27% Al	-43.82%
-31.21%	-30.47%	-8.63% Li	-0.63%	-24.84%	-25.54%	-1.29%	-11.72% Ag	-16.34% Zn	-45.21% Ni
-45.58%	-41.75% Ni	-13.19%	-20.70%	-54.70% Li	-38.50% Li	-20.54%	-22.21% Pd	-48.34%	-81.43% Li

Legend: Coal, Copper, Crude Oil, Natural Gas, Wheat, Aluminum, Corn, Gold, Lithium, Zinc, Lead, Palladium, Silver, Nickel, Platinum

Source: Bloomberg and U.S. Global Investors

Impact Assessment

Environmental Assessment
Standard approach



LIFE CYCLE

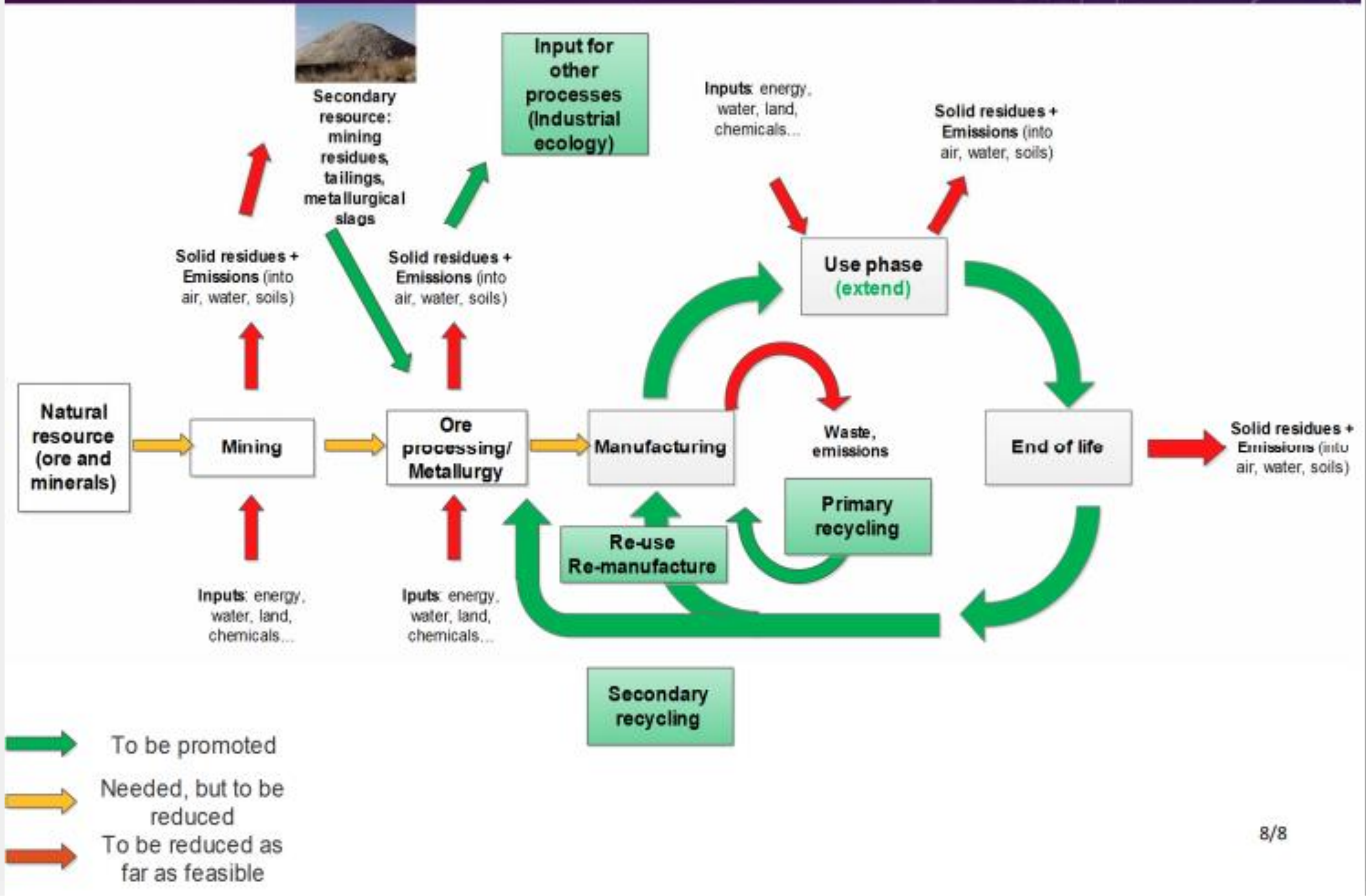
Life Cycle Assessment
Olistic approach

Life-cycle assessment - **LCA** also known as **life-cycle assessment**, **cradle-to-grave analysis, Ecobalance**:

the evaluation of some aspects - often the environmental aspects - of a product system through all stages of its life cycle. It represents a family of tools and techniques designed to help in environmental management and, longer term, in sustainable development.

European Environmental Agency (1997)"Life Cycle Assessment, A guide to approaches, experiences and information sources"

Circular economy: absolute decoupling beween desired growth and its negative impacts. A long-term objective and many obstacles in its way

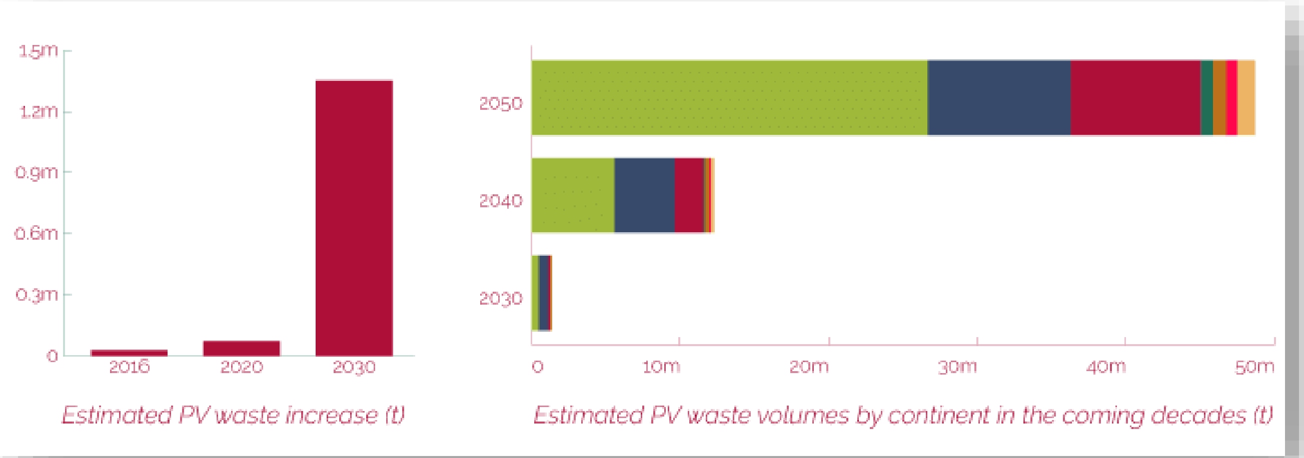


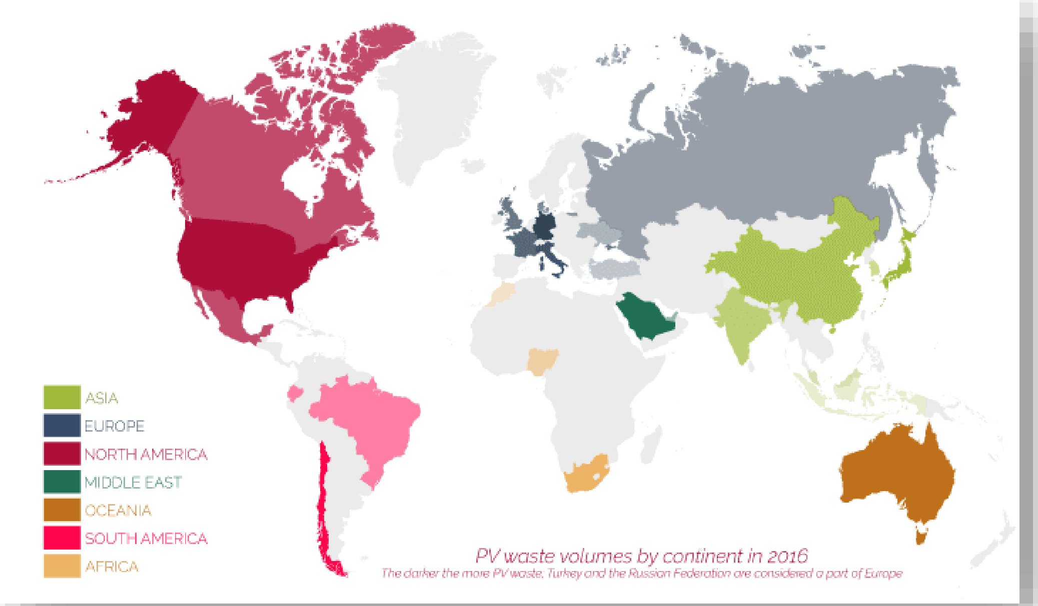
http://www.mineralinfo.fr/sites/default/files/upload/ancre_rapport_2015-ressources_minerales_et_energie_0.pdf

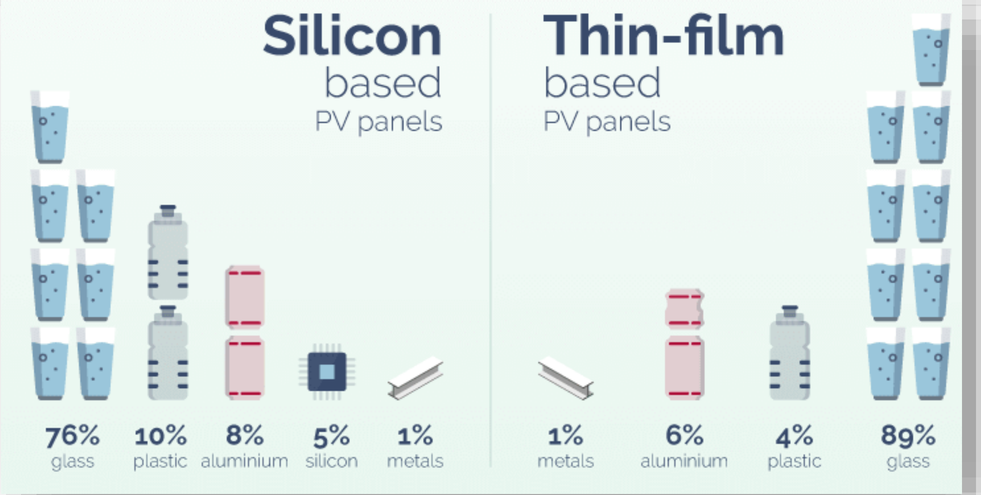
Example

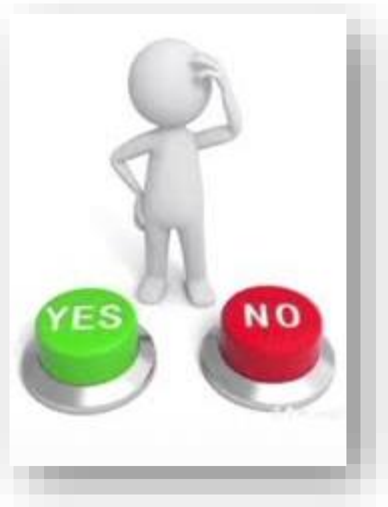
An LCA view of solar panels

PV panel from raw material extraction to end-of-life reuse, recycle and disposal

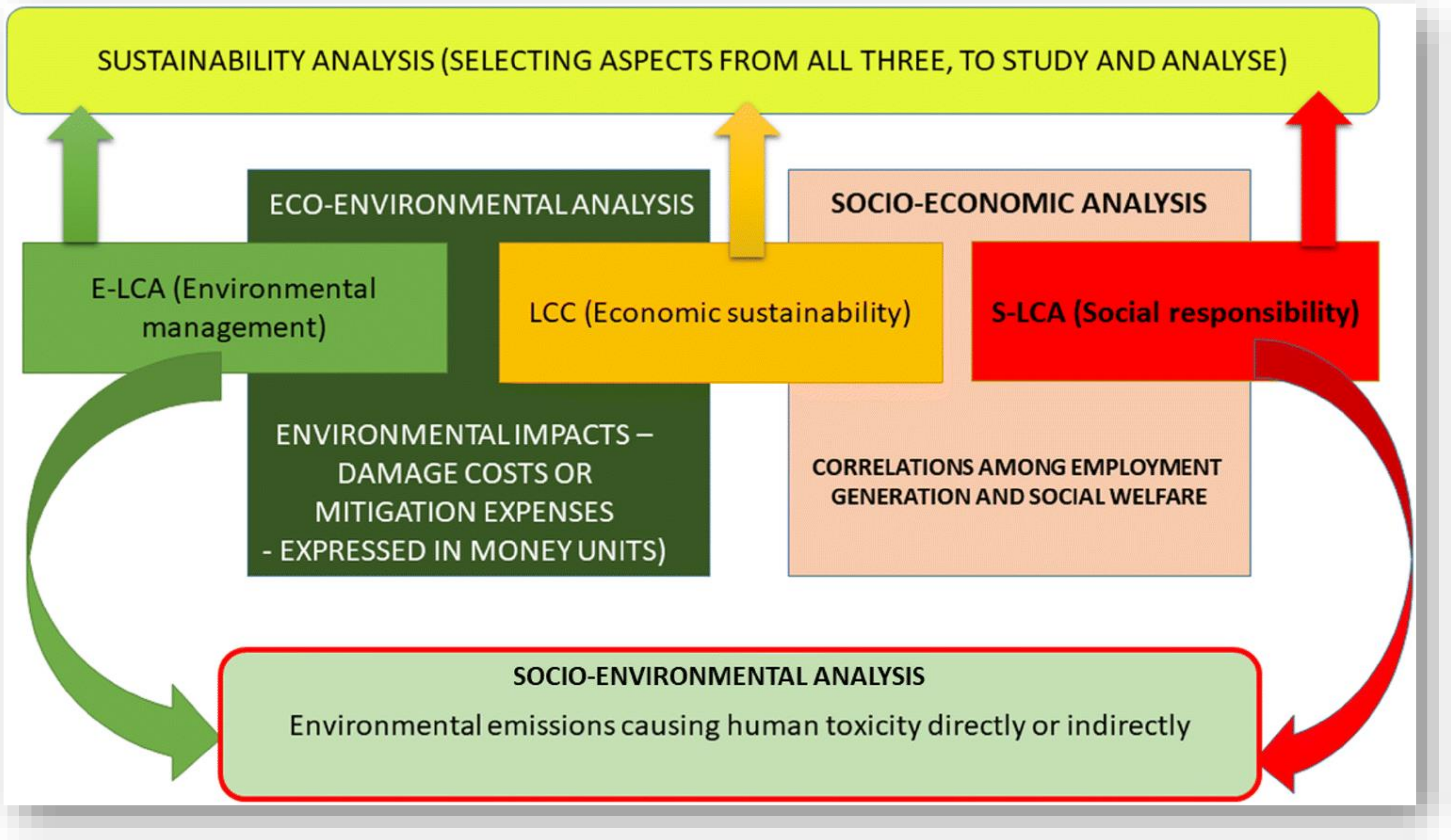




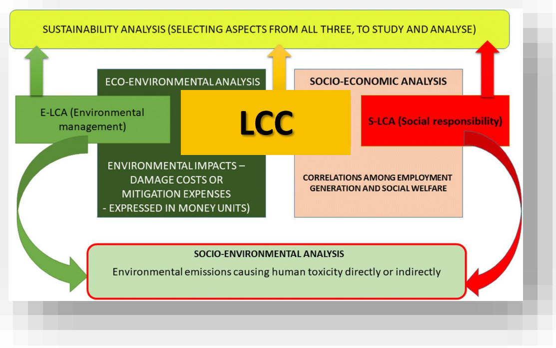




Is LCA a sufficient tool to analyze the full spectrum of the impacts of a policy/product on the environmental, economic, social sphere?


SUSTAINABILITY ANALYSIS (SELECTING ASPECTS FROM ALL THREE, TO STUDY AND ANALYSE)
ECO-ENVIRONMENTAL ANALYSIS
SOCIO-ECONOMIC ANALYSIS
E-LCA (Environmental management)
LCC (Economic sustainability)
S-LCA (Social responsibility)
ENVIRONMENTAL IMPACTS – DAMAGE COSTS OR MITIGATION EXPENSES - EXPRESSED IN MONEY UNITS)
CORRELATIONS AMONG EMPLOYMENT GENERATION AND SOCIAL WELFARE
SOCIO-ENVIRONMENTAL ANALYSIS
Environmental emissions causing human toxicity directly or indirectly

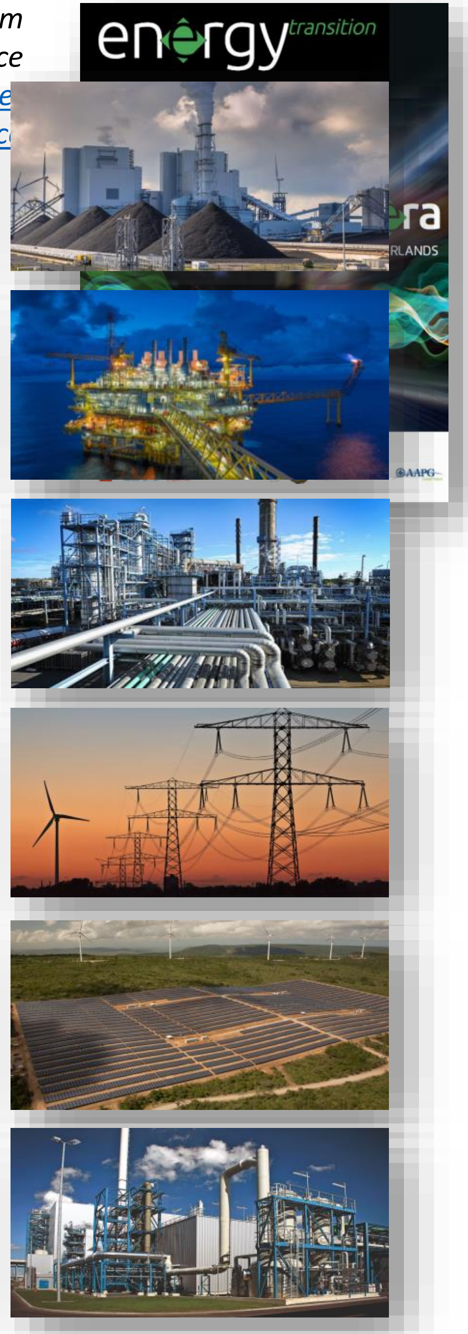
LCC elements



PREPARATION COSTS			SUSTAINMENT COSTS		
RDI Costs	Replication Cost	Cost of Investments	Costs of Schedule and Non-Schedules Maintenance	Cost of Use of Facilities	Disposal Costs
Non-Recurring	Recurring	Non-Recurring	Recurring	Recurring	Recurring
Occurs only once for all units produced	Occur for each unit produced	Occur for every installation of each unit	Occur for each unit installed and for each maintenance cycle	Occur for each unit installed and for each operation cycle	Occur only once for each unit installed
TSR Technology and Systems Research	PSP Production of Systems and Products	Installation Project	ILS Integrated Logistic Support	Operation	Legal Permission
SCR Systems Concepts Research	Factory Acceptance Tests	Design and Construction of Infrastructure	Replacement and Renovation	Training for Continued Operation	Demolition and Disposal
DSP Development of Systems and Products	Qualification and Certification	Improvement of Equipment and Infrastructure	Modification of Systems and Equipment	Consumption of Energy , Water, Communications and Other	Repairs and Restorations
SPA Systems and Products Assurance		Improvement of Utilities	Materials, Labor-Work, Charges	Supply of Materials and Consumables	Depreciation
Trading and Contracting		Systems Integration and Commissioning	Transportation and Insurance	Rents	Improving the Environmental Sustainability
		Initial Preparations for Operation		Outsourced Services	
Management and Documentation	Management and Documentation	Management and Documentation	Management and Documentation	Management and Documentation	Management and Documentation
TCA TOTAL COST OF ACQUISITION				COO COST OF OPERATION	
TCO TOTAL COST OF OWNERSHIP					

Energy transition and Geology

AAPG Energy Transition Forum
A New Era in Geoscience
[https://energytransition.aapg.org/2018/About-the Conferenc](https://energytransition.aapg.org/2018/About-the)



Geosciences drivers underpinning the transition:

The **hydrocarbon era** is not over soon: fossil fuel use might flatten from 2035, with oil and coal in decline but gas use continuing to expand.

- **Coal demand**: peak expected in next 10y, with a rapid shift toward gas. Gas is a viable and profitable alternative to coal.
- **Oil demand**: expected to peak in the next 15-20y. Decline won’t be for lack of supply: technological and economic competition for oil is coming, with a shift from oil-based transport to electricity-based transport. The question is “when” rather than “if”.
- **Gas demand**: will continue to grow to 2040, due to its affordability relative to other fuels, technologies and policies.
- **Electrification**, particularly in buildings and road transport, underlies an acceleration of electricity demand. Energy intensity is improving across regions and end-use sectors with the switches to more efficient fuels and technologies. Strong improvements in economics of electric vehicles trigger rapid uptake. In a disrupted case, electricity demand growth could be boosted to 2.9%/y.
- **Renewables**’ cost decline accelerates, out-competing new-built fossil capacity today and existing capacity in 5-10 years causing electricity demand to grow four times faster than all other fuels.
- **CCS & Nuclear** can play a prominent role in the Energy Transition, but face much resistance from communities. Technological, political and social constraints are the challenge.

AAPG Energy Transition Forum
A New Era in Geoscience
https://energytransition.aapg.org/2018/About/

Geosciences in the Energy transition.

- **Natural energy resources**: a primary role for **oil** and mainly **gas** E&P– certainly until 2050 - 2060. Crucial in **CCS**, **geothermal** and new energy solutions (technologies and concepts to be developed;
- The **2050 2°c economy** will generate a huge demand for **new metals and minerals**: + 200% for aluminum, iron, lead and nickel; +1000% for cobalt, lithium, manganese. Challenge? Very little understanding of geology means huge demand for skill sets;
- The **mix of skills** of a geoscientists is unique, particularly in **managing data** and **solving complex problems**. There will be a need for **multiskilled people**, able to integrate geological knowledge with IT, economy and social sciences. Geoscientists have much to contribute because of way they think, used to dealing with complex environments, good at systems thinking and without full data sets;
- **Universities** need to proactively reinforce the message that petroleum/underground geologists are still needed in the future; they need to **adapt the curriculum** and how the profession is promoted;
- The **next generation** is already hugely **environmentally aware:** important that senior professionals/politicians inject optimism and empowerment into the next generation of decision makers;
- We have to develop the **ability to speak** easy and, more important, the **ability to listen** to the requests and doubts of the local communities. This is the only way for a correct **dissemination of knowledge**.

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- The **2050** 200% for Challenge
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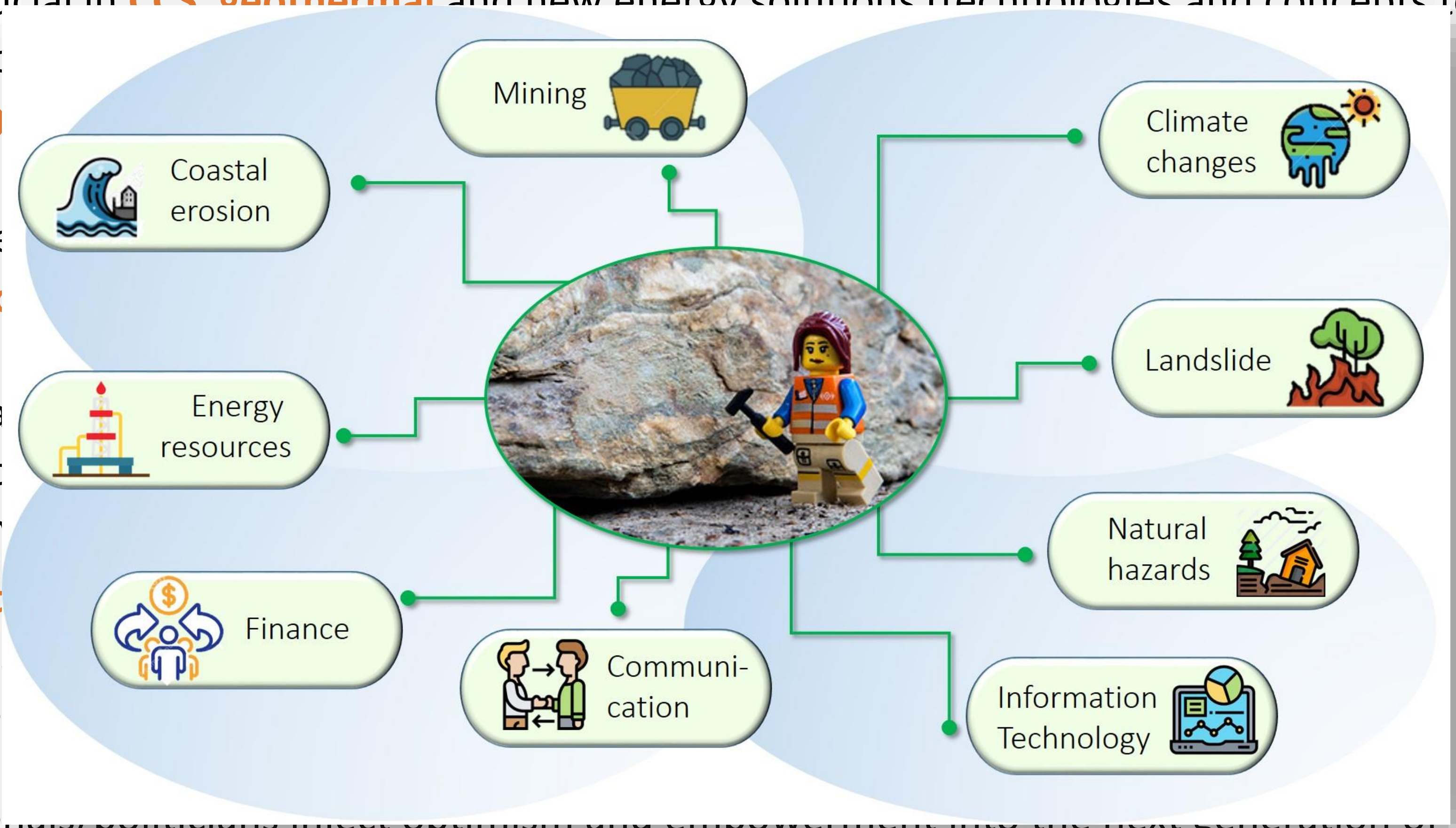
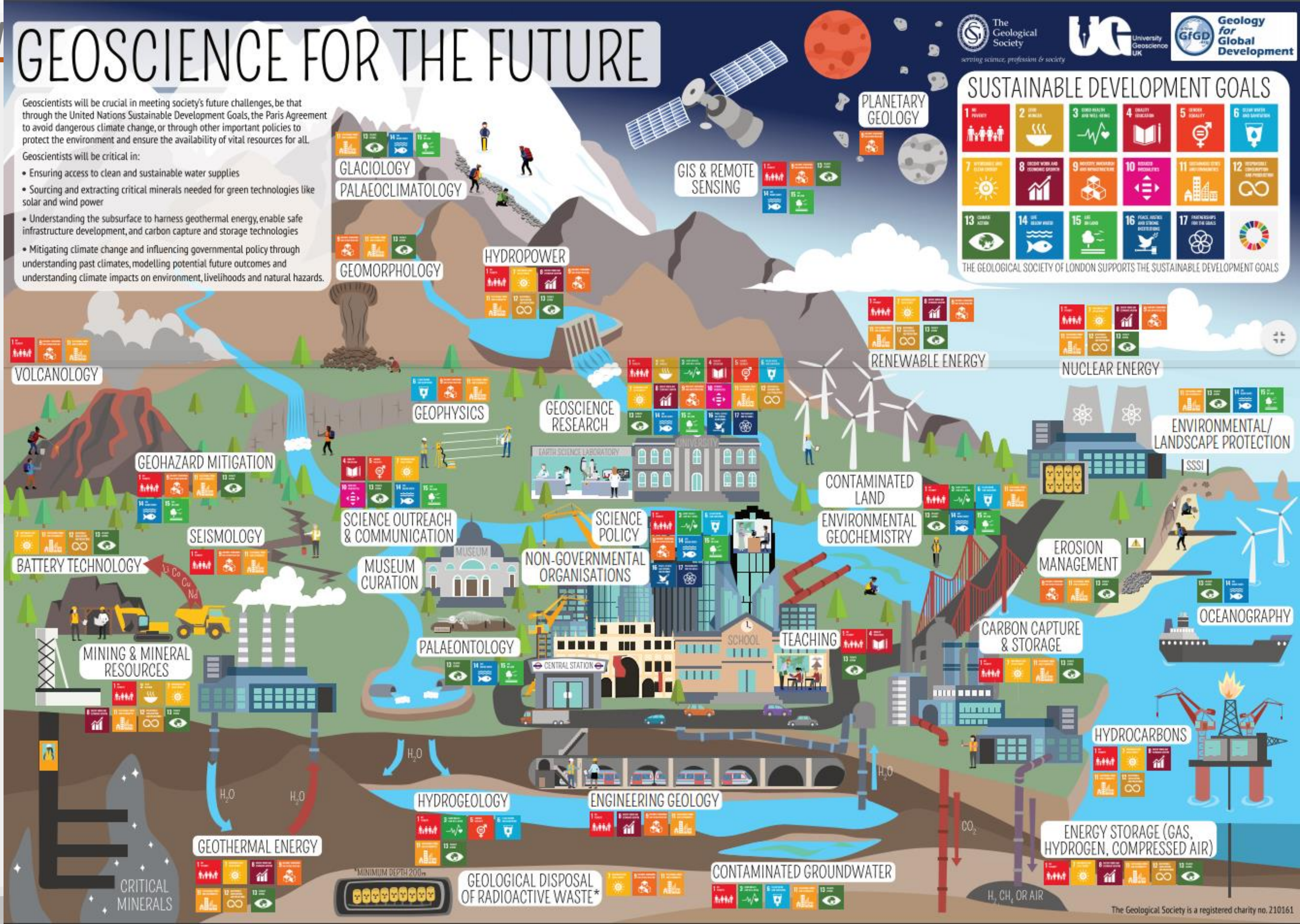


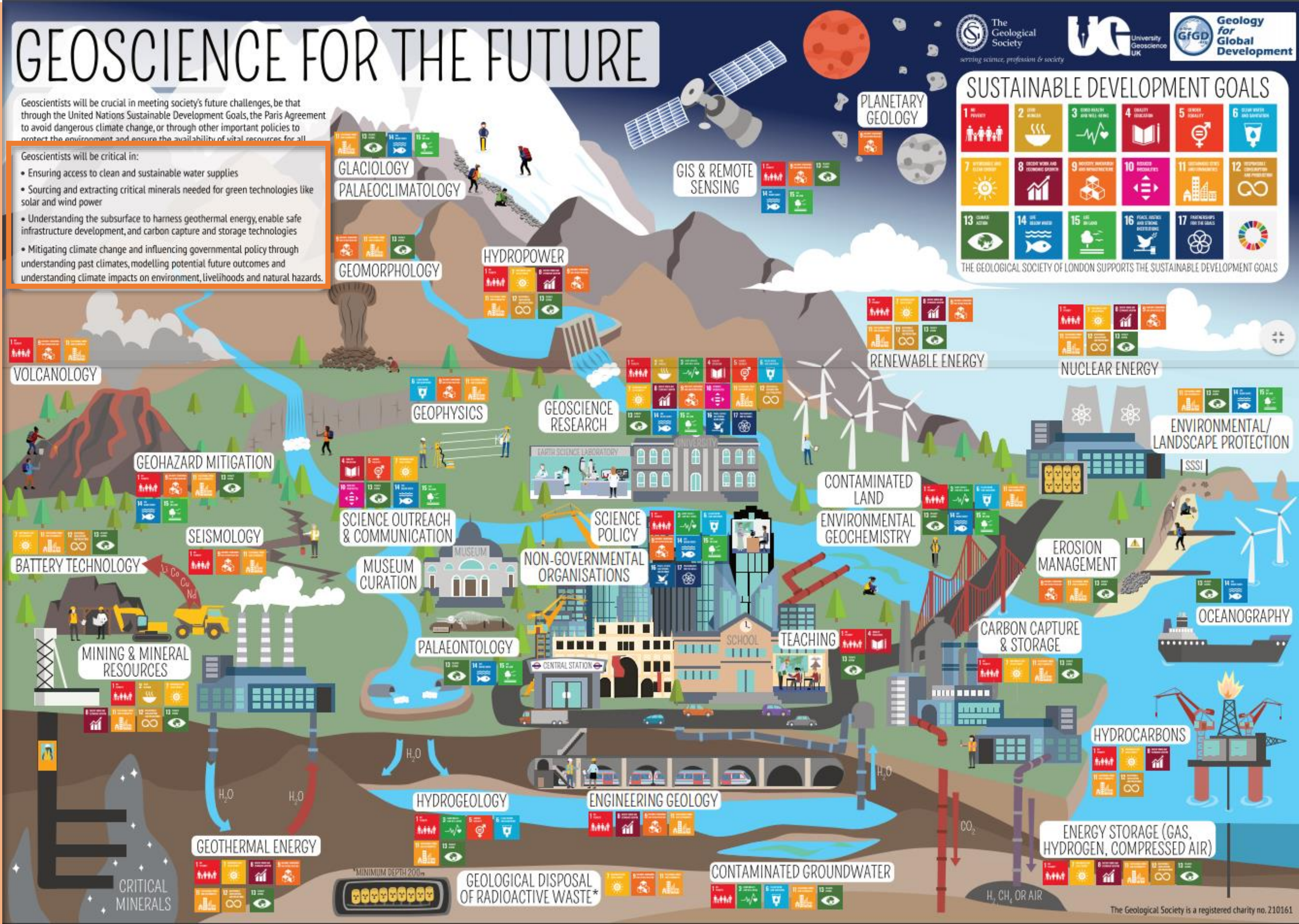
Geosciences in the changing world

To sum up:



Le geoscienze saranno fondamentali per:

- **Garantire** l'accesso a forniture idriche pulite e sostenibili
- **Esplorare e produrre** i minerali critici necessari per tecnologie pulite come l'energia solare ed eolica
- **Comprendere** il sottosuolo per sfruttare O&G e l'energia geotermica; **consentire** lo sviluppo di infrastrutture sicure e di tecnologie CCS
- **Mitigare** i cambiamenti climatici influenzando le politiche governative attraverso la comprensione del passato, la modellazione di scenari futuri e degli impatti climatici sull'ambiente, sulla vita e sugli eventi naturali



CO_2 emissions

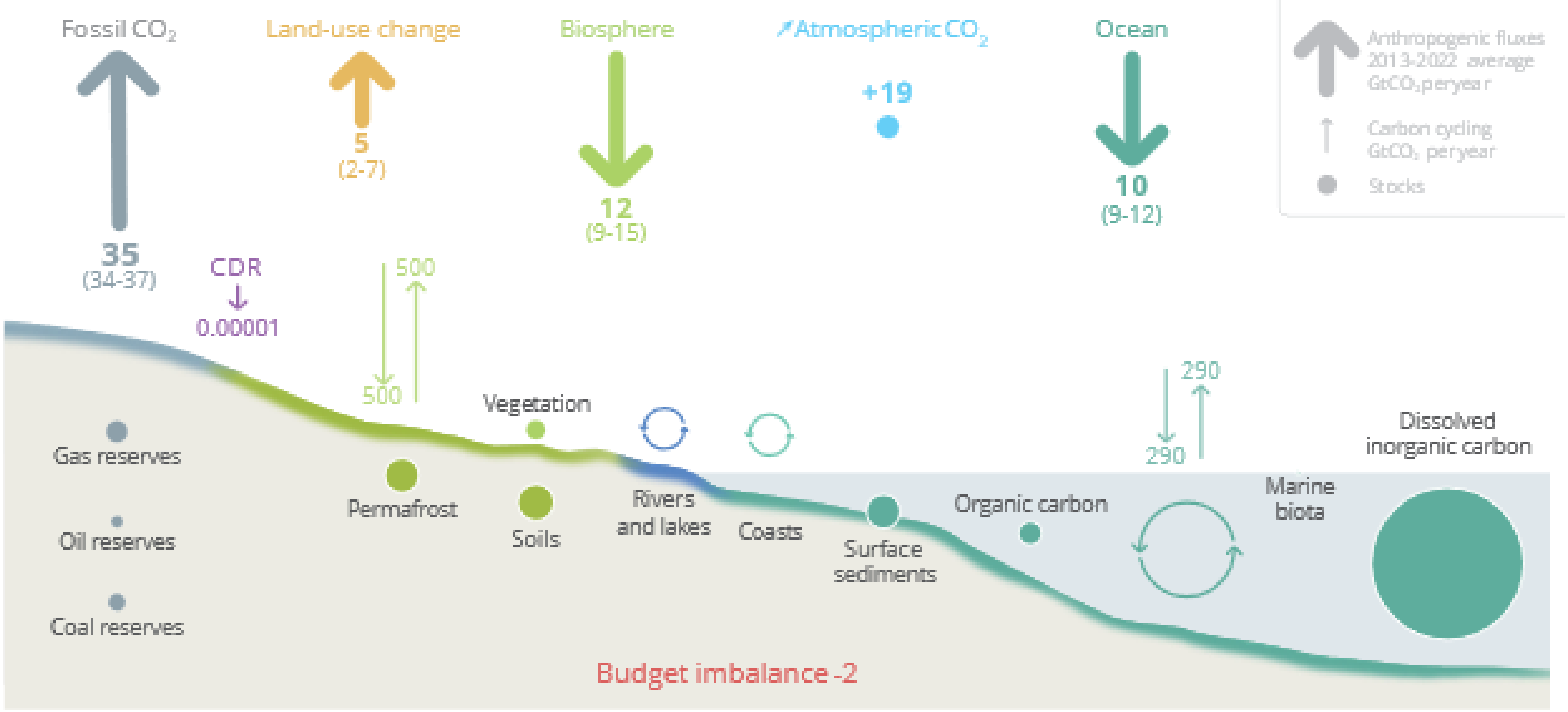
Il **Global Carbon Budget GCB** conta oltre 100 contributori provenienti da molte organizzazioni e paesi.
È stato fondato dal team scientifico internazionale del Global Carbon Project per monitorare le tendenze delle emissioni e dei contenimenti naturali di carbonio globali ed è una misura chiave dei progressi verso gli obiettivi dell’Accordo di Parigi.
È ampiamente riconosciuto come il rapporto più completo nel suo genere.
Il GCB viene aggiornato annualmente e pubblicato ogni anno in occasione delle riunioni della COP.

Emissioni di CO_2 per il 2023

- Le emissioni globali di CO_2 fossile raggiungeranno un livello record, con +1,1% rispetto al 2022 e +1,4% rispetto ai livelli pre-COVID-19 del 2019.
- Le emissioni diminuiranno nell’UE, negli USA e nel resto del mondo, ma aumenteranno in India e Cina.
- Le emissioni derivanti dalla deforestazione permanente rimangono troppo elevate per essere compensate dalle rimozioni di CO_2 derivanti dalla riforestazione e dall’imboschimento.
- I serbatoi di CO_2 terrestri e oceanici hanno continuato ad assorbire il 53% negli ultimi dieci anni della CO_2 di origine antropica emessa in atmosfera.

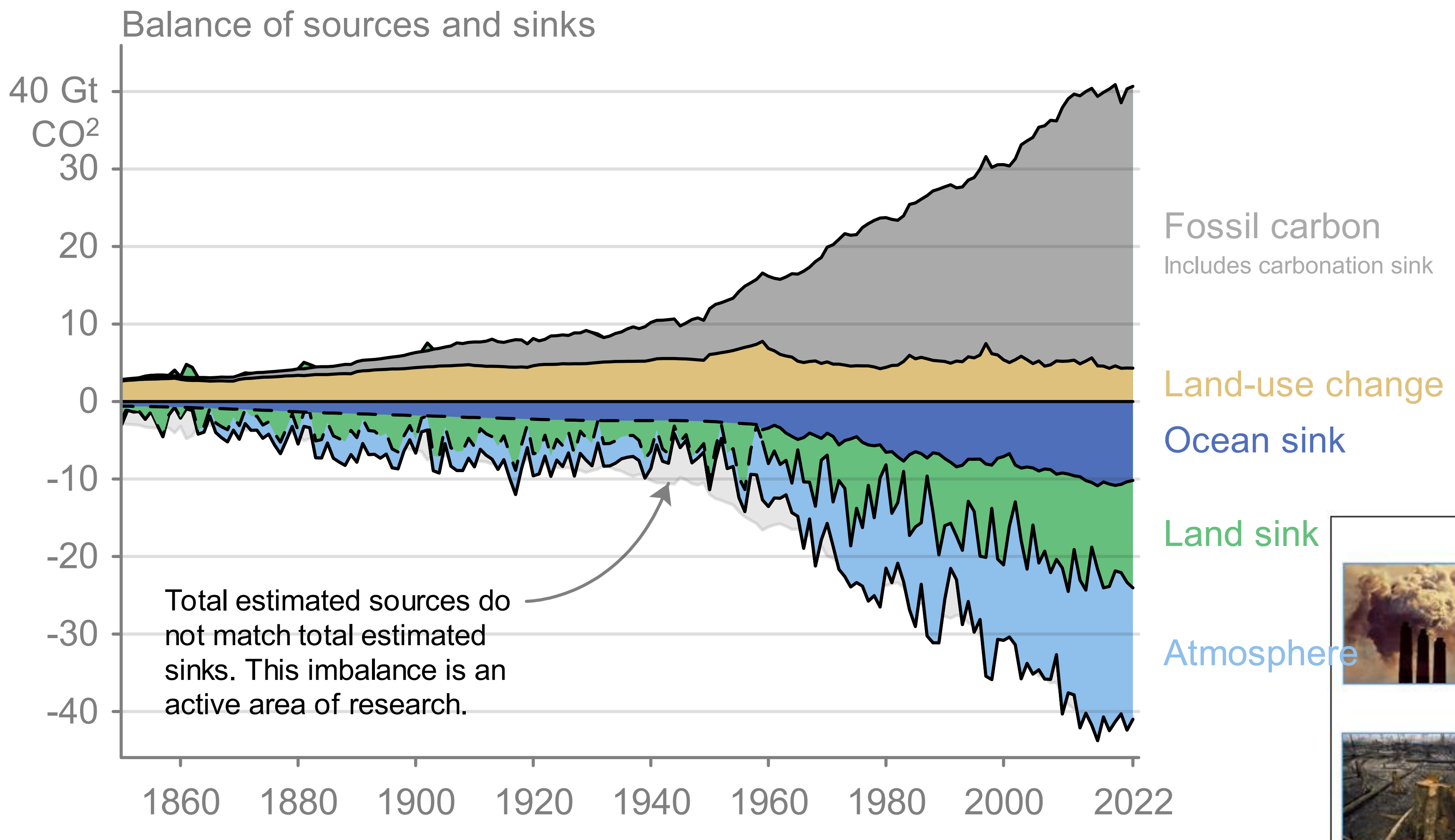
Anthropogenic perturbation of the global carbon cycle

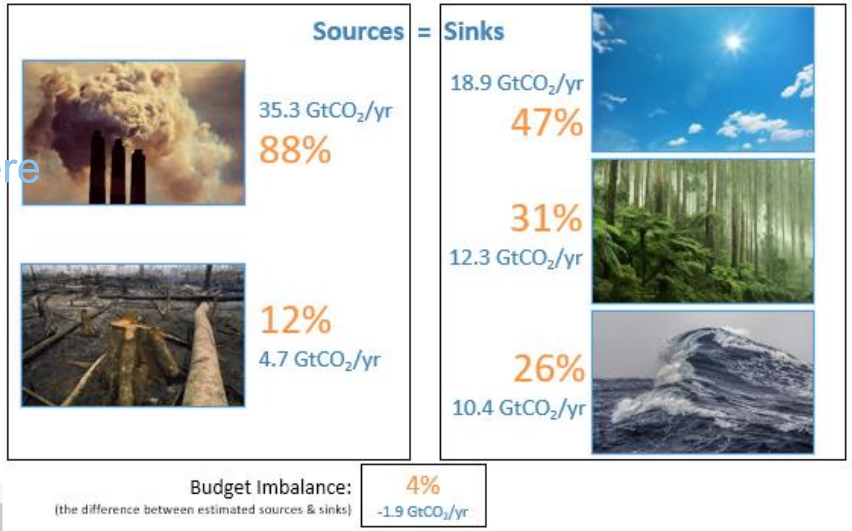
Perturbation of the global carbon cycle caused by anthropogenic activities, global annual average for the decade 2013–2022 ($GtCO_2$/yr)



CO2 emissions

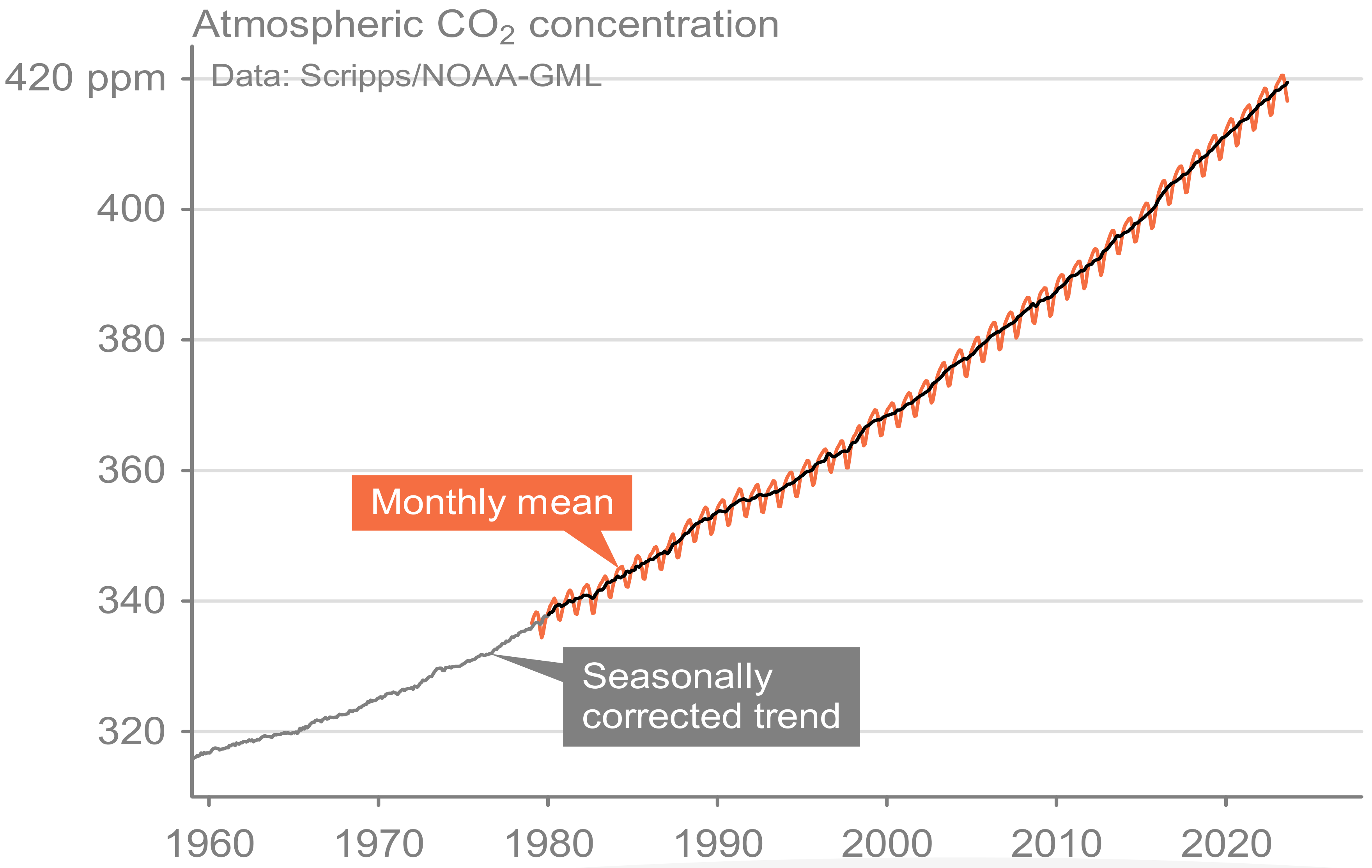
Carbon emissions are partitioned among the atmosphere and carbon sinks on land & in the ocean
The "imbalance" between total emissions and total sinks is an active area of research





Atmospheric CO_2 concentration

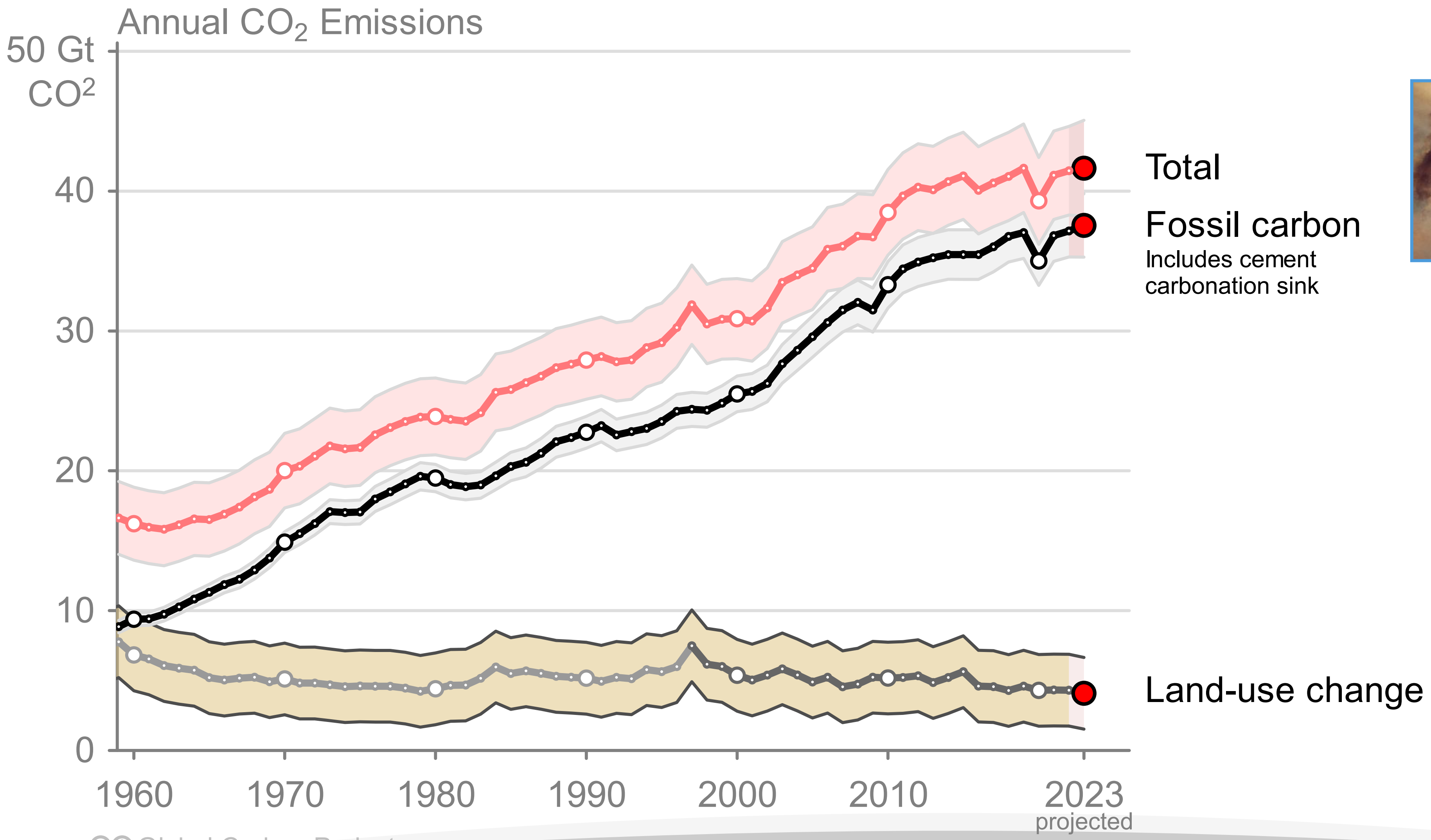
The global CO_2 concentration increased from ~277 ppm in 1750 to 419.3 ppm in 2023 (up 51%)



Total global emissions

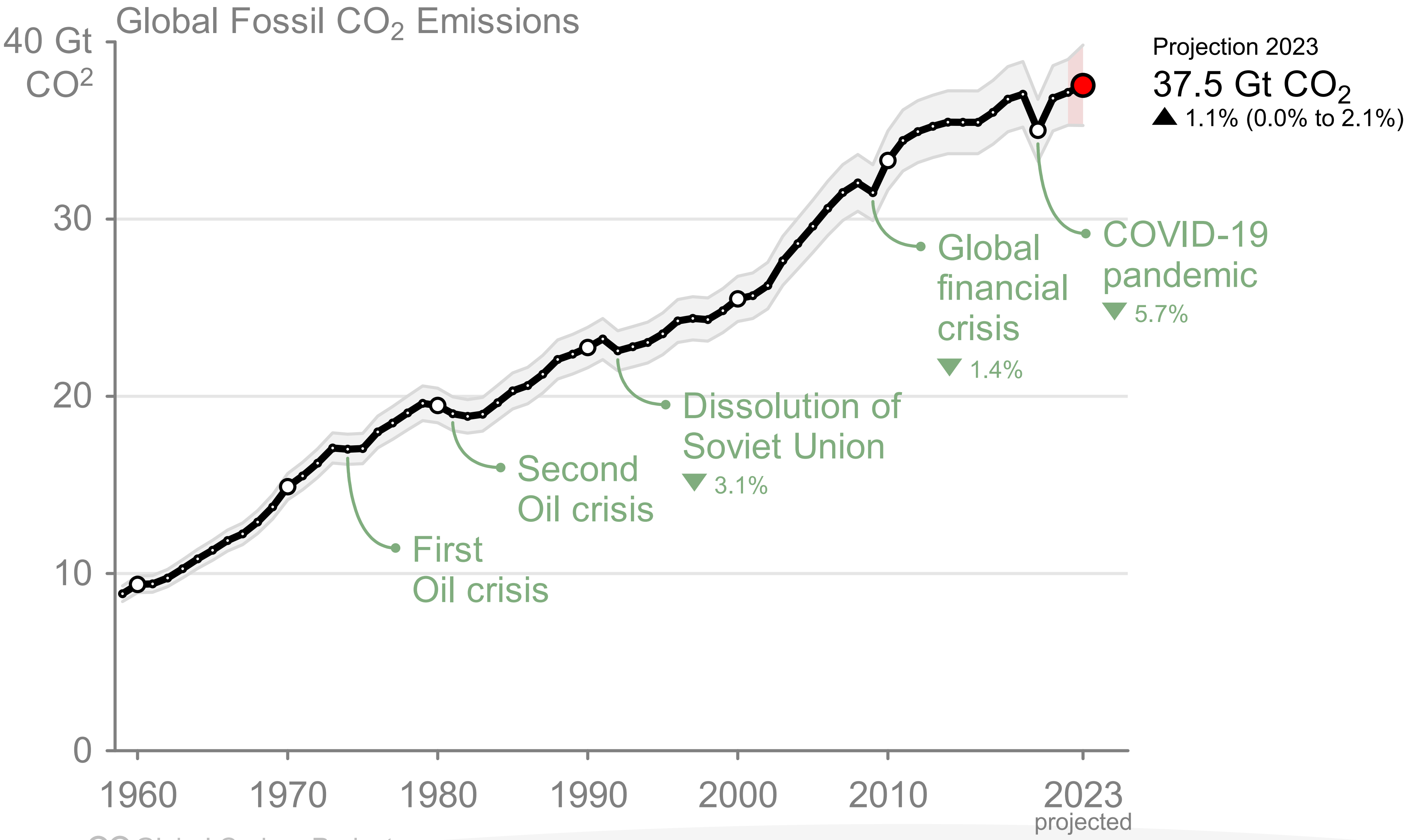
Total global emissions, projected to reach 40.9 ± 3.2 $GtCO_2$ in 2023, 47% over 1990

Percentage land-use change: 42% in 1960, 12% averaged 2013–2022



CO2 emissions

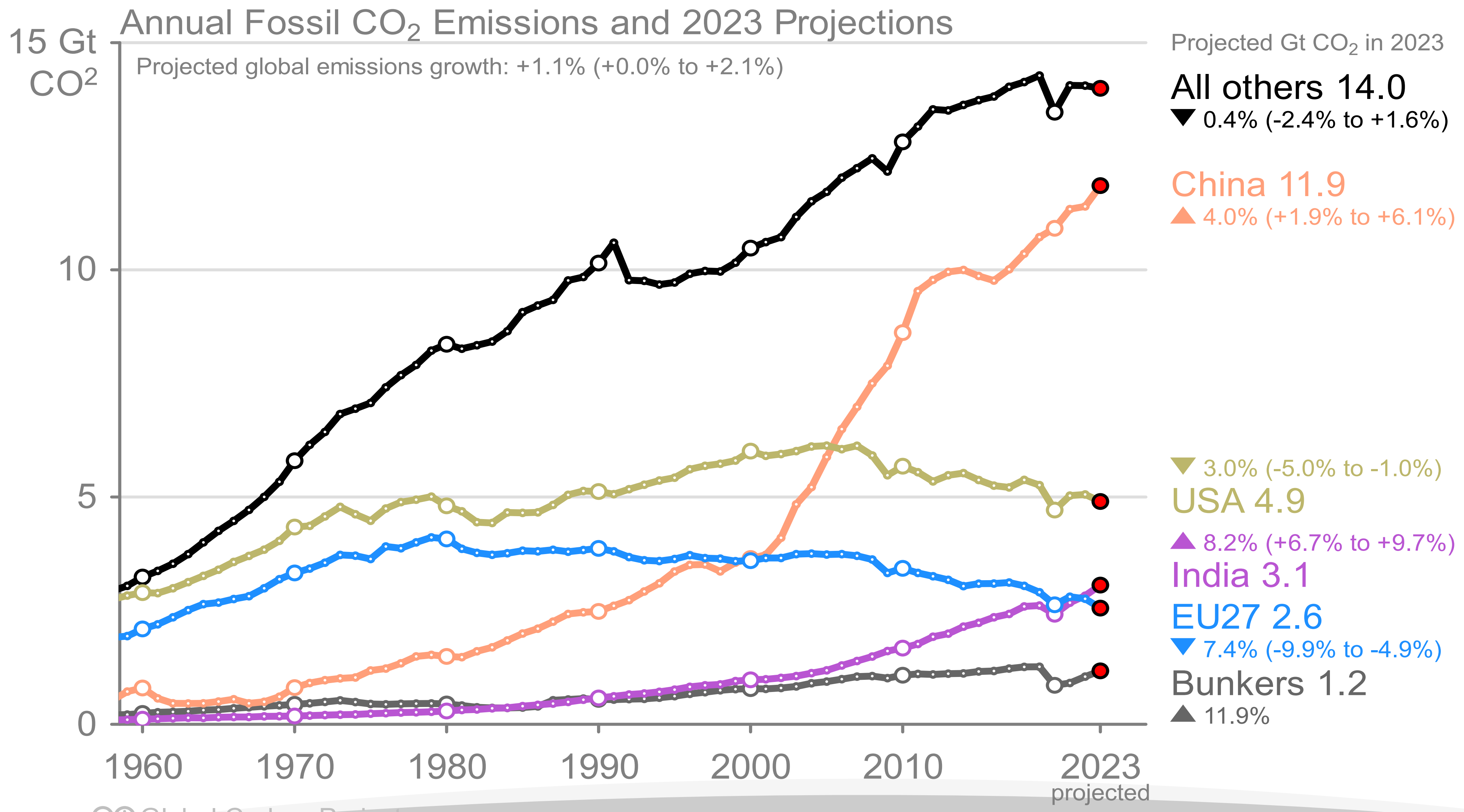
Global fossil CO_2 emissions have risen steadily over the last decades.
Emissions are set to grow again in 2023.



CO2 emissions

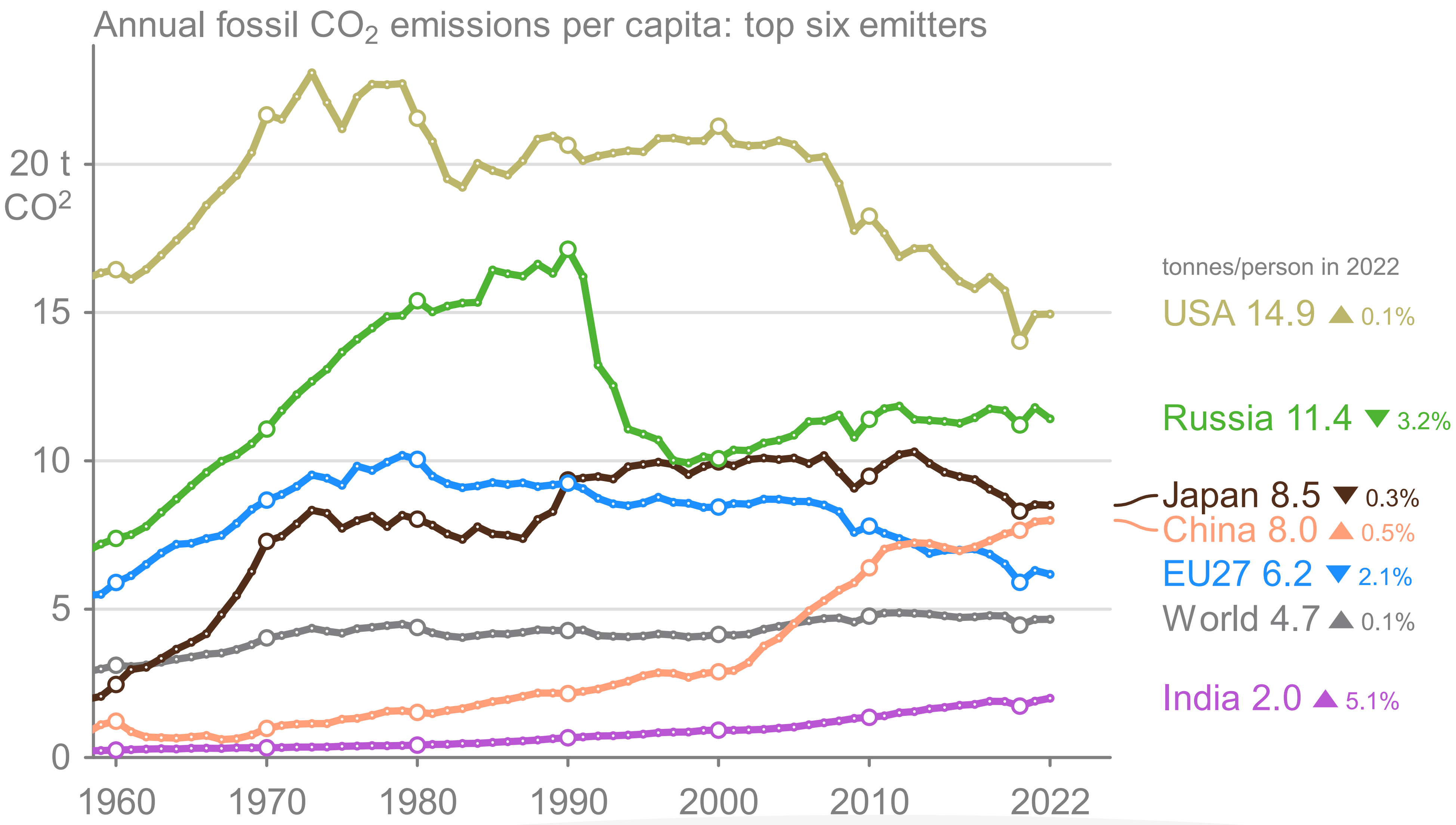
Emissions Projections for 2023

There are sharp contrasts between the projected emissions changes for the top emitters



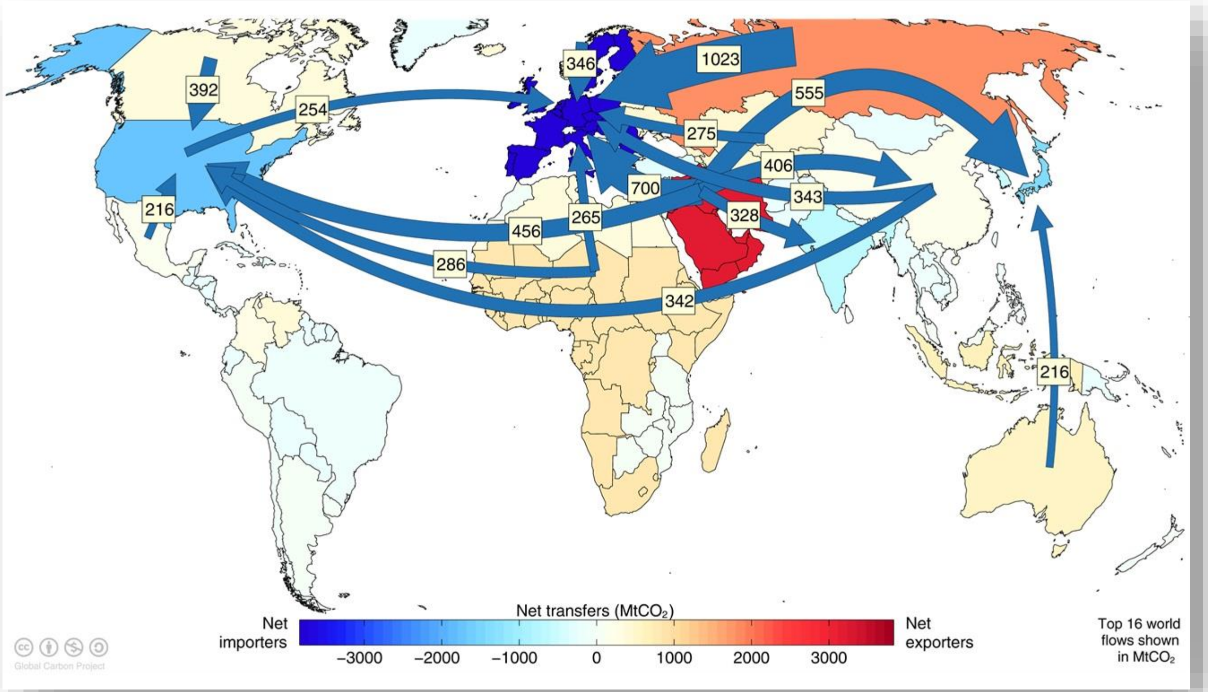
Top emitters: Fossil CO_2 emissions per capita to 2022

Countries have a broad range of per capita emissions reflecting their national circumstances

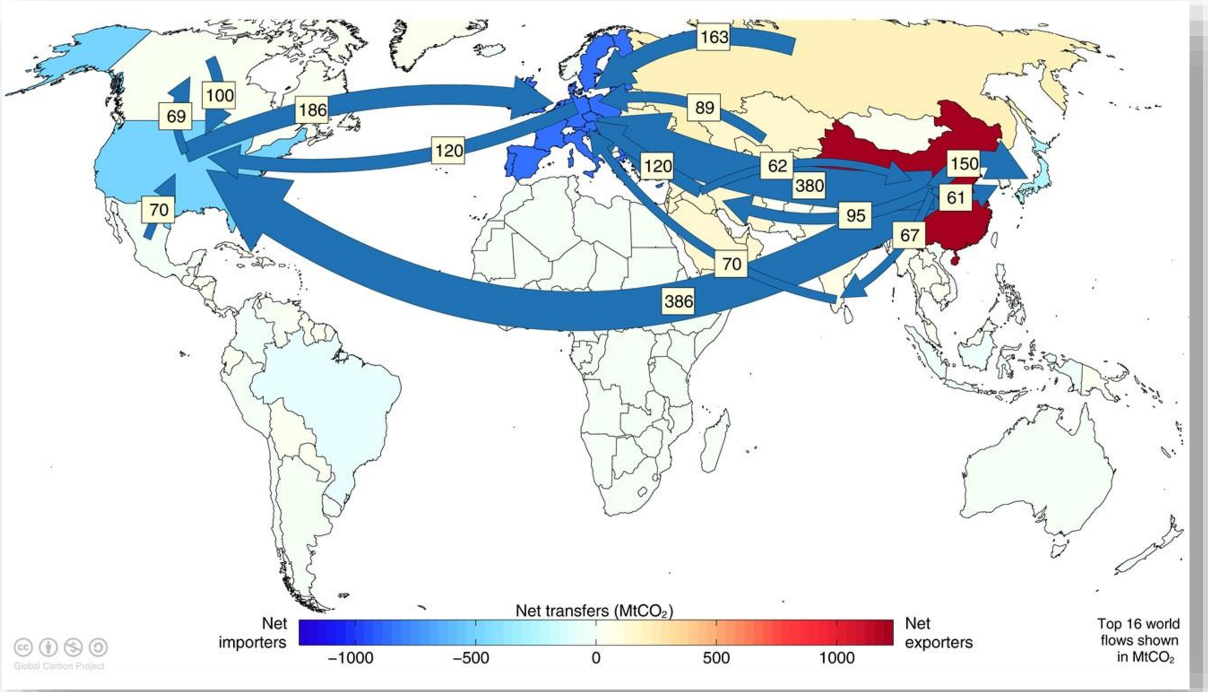


GLOBAL CARBON BUDGET 2023

Flows from location of fossil fuel extraction to location of consumption of goods and services

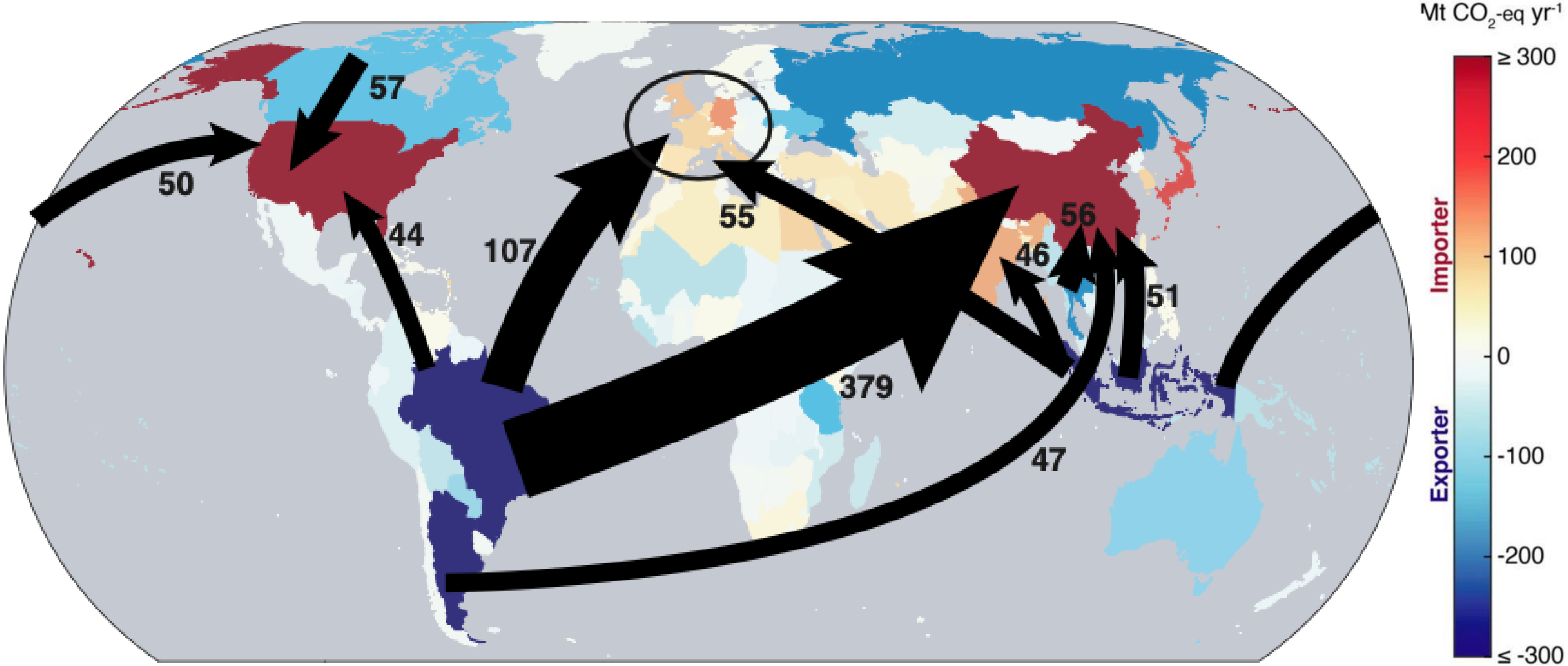


Flows from location of generation of emissions to location of consumption of goods and services



Major flows from production to consumption (2017) — Land Use Change CO_2

Global distribution of land-use change emissions embodied in trade: Arrows show largest flows from location of generation of emissions to location of consumption of agricultural and forestry goods.



Perché le previsioni a volte sbagliano clamorosamente?

*Due tipi di incertezze possono portare a grandi errori di previsione di sistemi complessi: le incognite sconosciute (**unknown unknowns**) e le incognite conosciute (**known unknowns**).*
*Le prime, dette **epistemiche**, riguardano il fatto che nei sistemi complessi ci sono più variabili di quante se ne possano considerare.*
*Le seconde, dette **stocastiche**, si riferiscono alla natura intrinsecamente non lineare di molti sistemi complessi, tra cui i sistemi energetici.*
*Gli eventi che portano ai primi tipi di errori sono definiti "cigni neri" (**black swan**), quelli che portano ai secondi sono invece definiti "cigni morenti" (**dying swan**).*

(Alberto Clò)