Energia Nuclear e Ambientalismo
Uma perspectiva Europeia

REPLANET

liberate nature | elevate humanity


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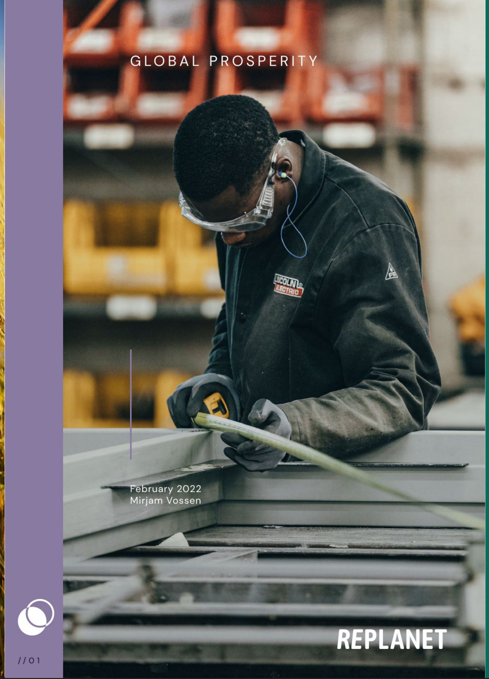
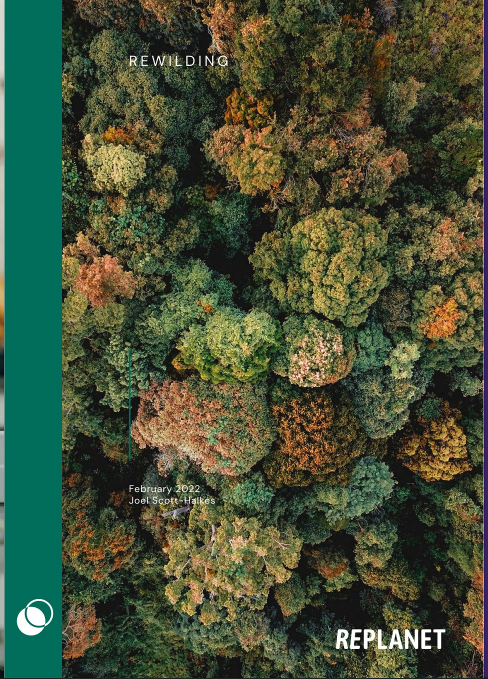
liberate nature | elevate humanity





[Agricultura]

[Prosperidade global]

[Rewilding]

Restauração de ecossistemas

[Energia]

- Em 1988, o Climatologista James Hansen defende perante o congresso dos EUA que a atividade humana é responsável por alterações climáticas.
- Numa publicação de 2013 estima que a não utilização de energia nuclear entre 1971-2009 causou 1.8 milhões de mortes prematuras.
- Defende que o “problema dos resíduos nucleares” pode ser resolvido com a próxima geração de reatores nucleares.


5 REASONS WHY NUCLEAR BELONGS IN THE EU TAXONOMY
REPLANET
1. SMALL LAND USE FOOTPRINT
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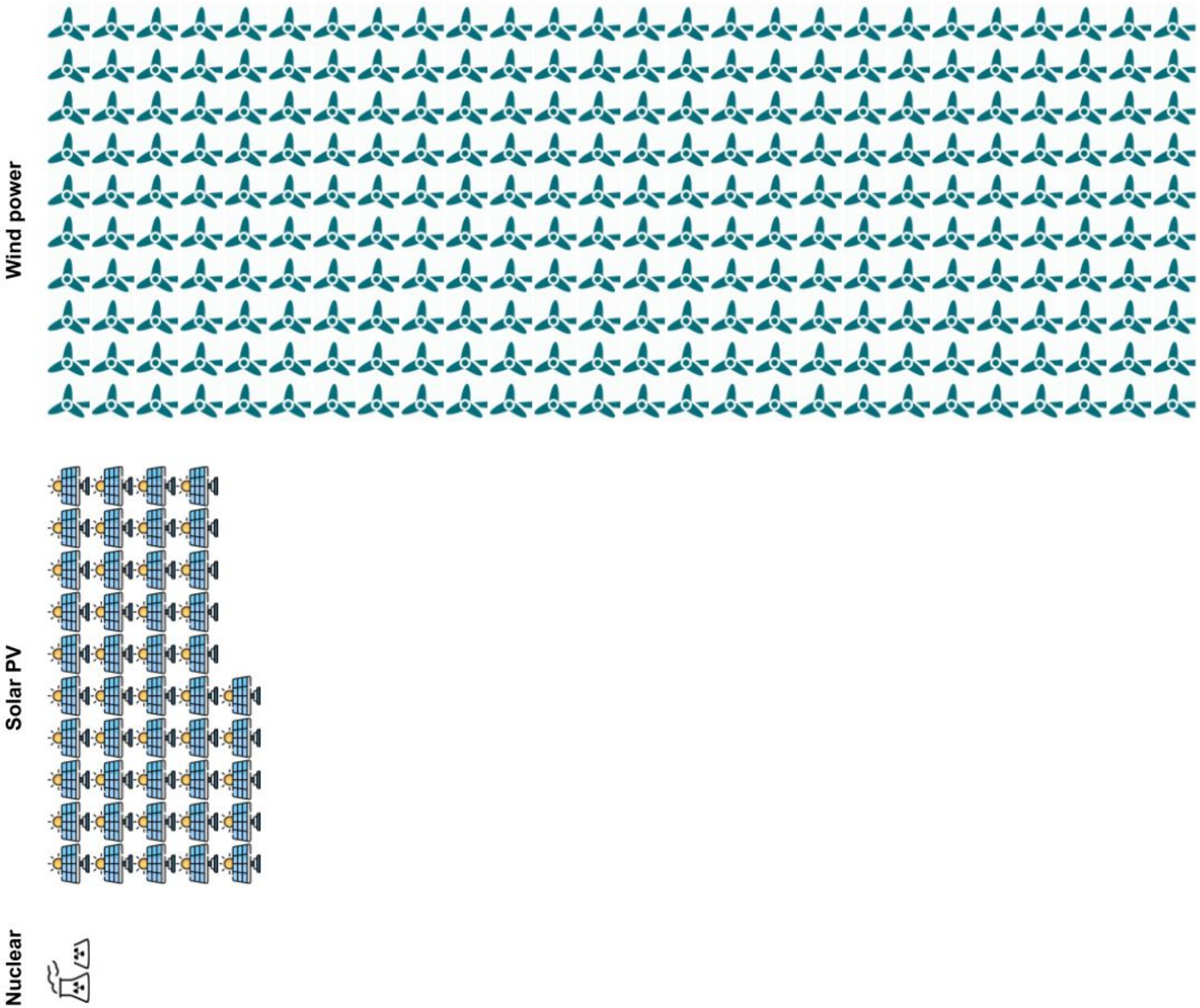
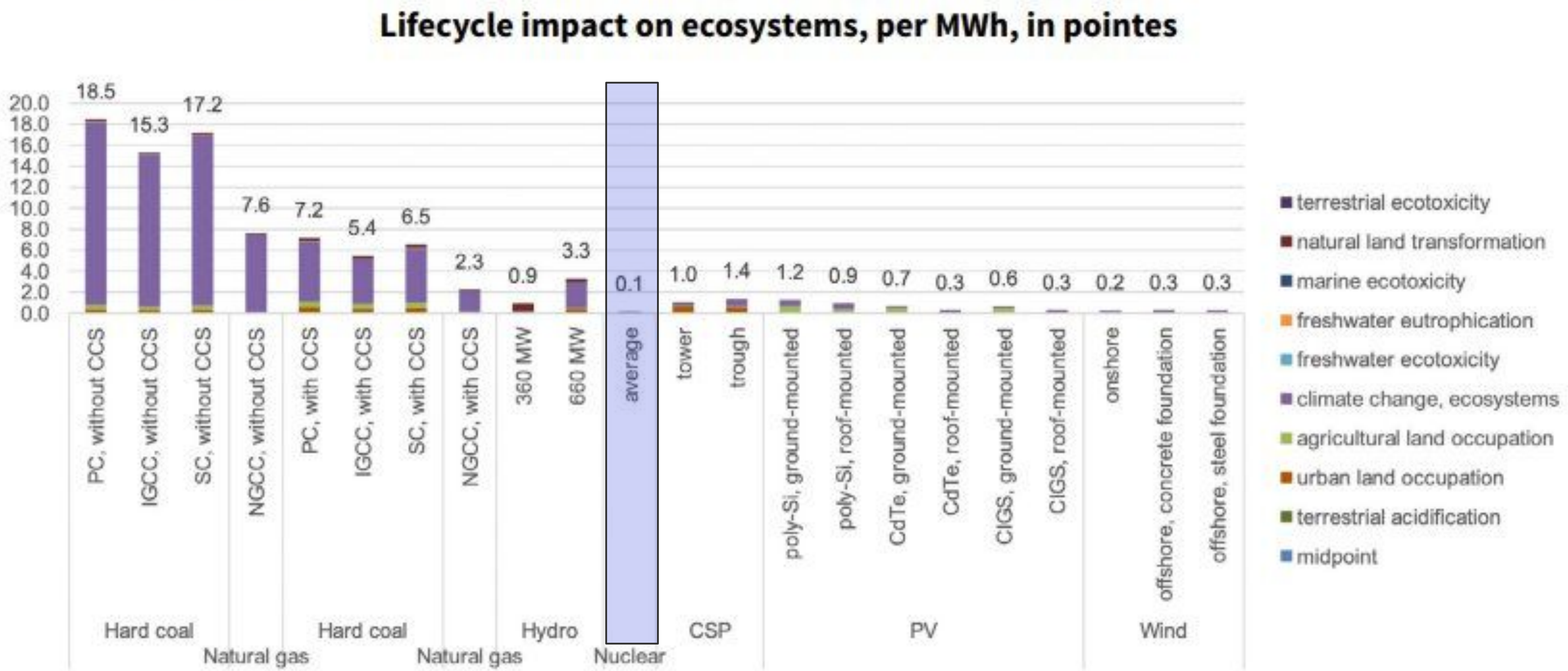


Requisitos de área por fonte de eletricidade

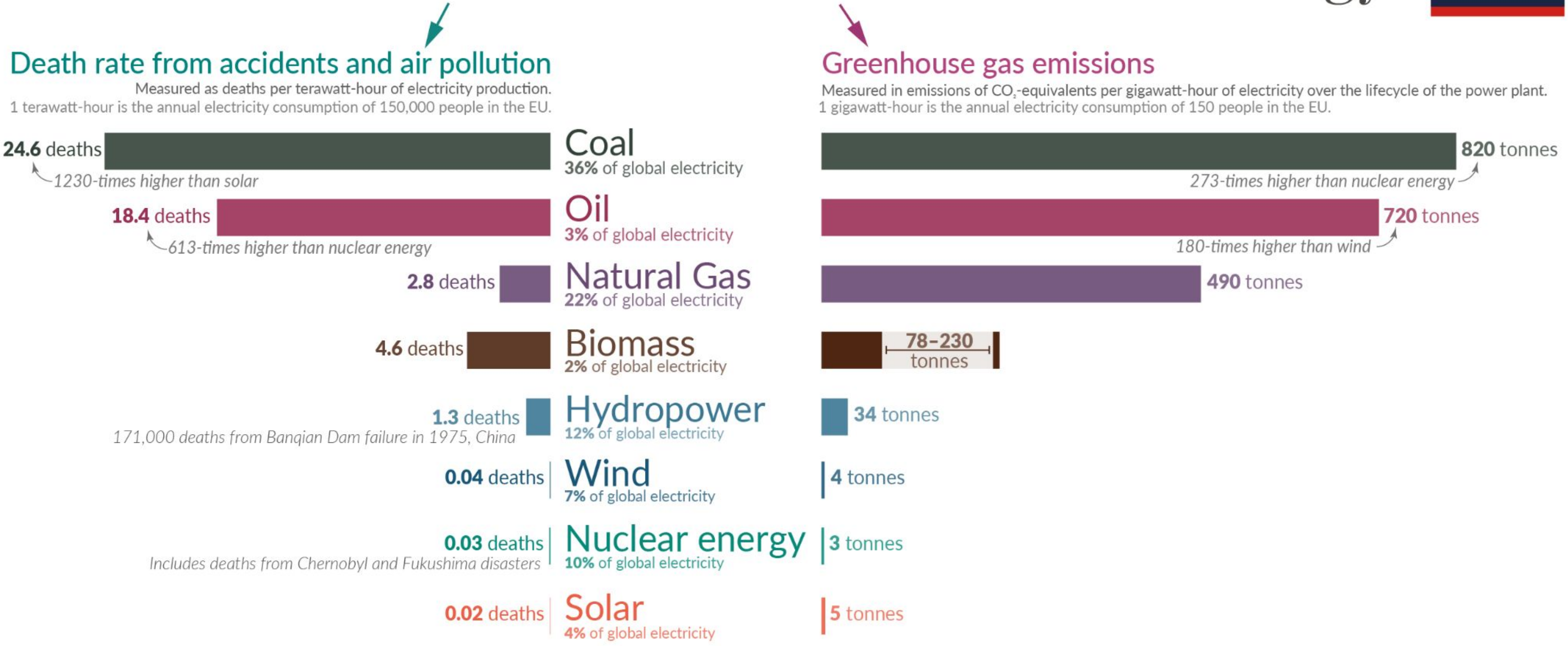

Diablo Canyon, California
Fornece eletricidade para >2M habitações

Figure 48 **Lifecycle impacts on ecosystems, in points, including climate change.**
Note on unit: 1 point is equivalent to the impacts (in species-year) of 1 person (globally) over one year.



What are the safest and cleanest sources of energy?

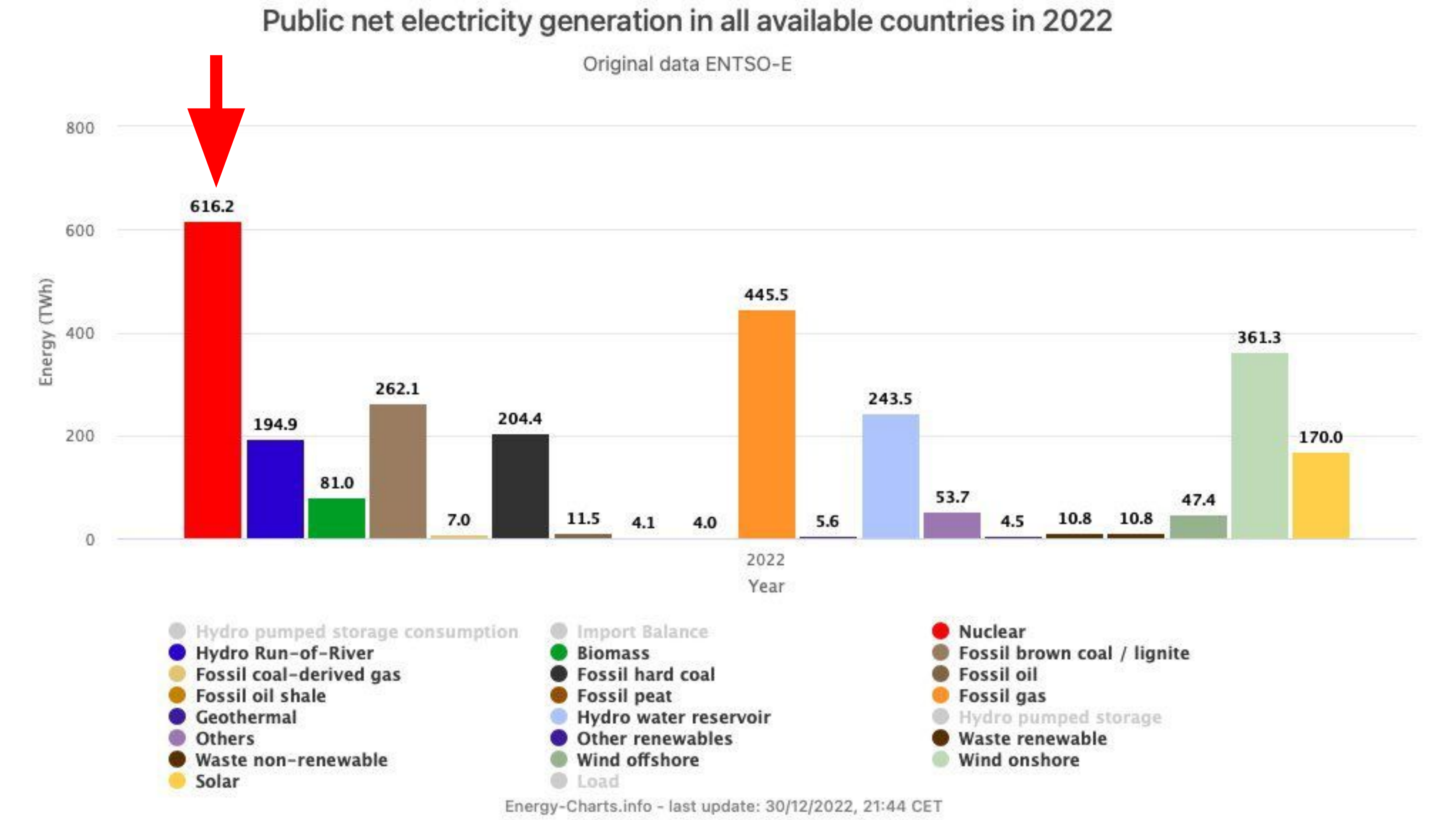
Our World in Data



Death rates from fossil fuels and biomass are based on state-of-the art plants with pollution controls in Europe, and are based on older models of the impacts of air pollution on health. This means these death rates are likely to be very conservative. For further discussion, see our article: OurWorldinData.org/safest-sources-of-energy. Electricity shares are given for 2021.

Data sources: Markandya & Wilkinson (2007); UNSCEAR (2008; 2018); Sovacool et al. (2016); IPCC AR5 (2014); Pehl et al. (2017); Ember Energy (2021).

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



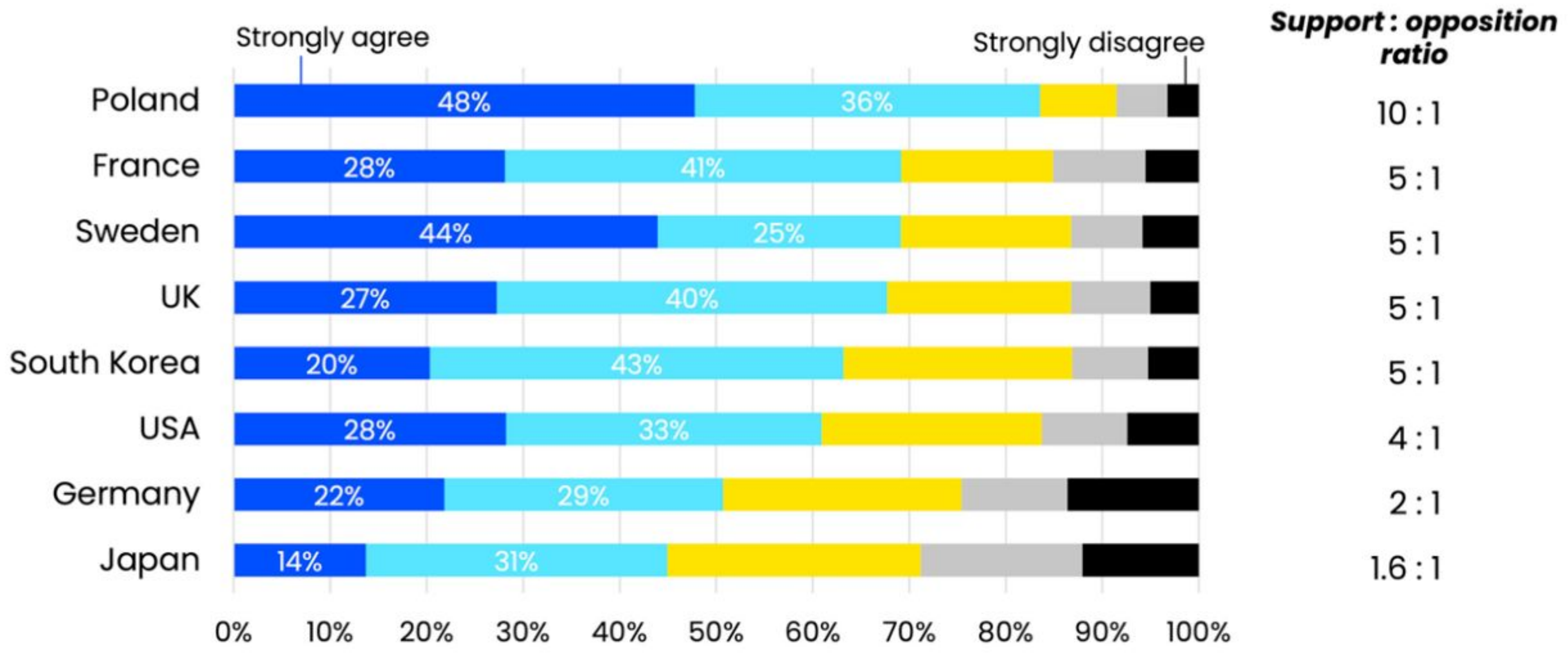
Public net electricity generation in all available countries in 2022
Original data ENTSO-E
800
600
400
200
0
Energy (TWh)
616.2
194.9
81.0
262.1
7.0
204.4
11.5
4.1
4.0
445.5
5.6
243.5
53.7
4.5
10.8
10.8
47.4
361.3
170.0
2022
Year
Hydro pumped storage consumption
Import Balance
Nuclear
Hydro Run-of-River
Biomass
Fossil brown coal / lignite
Fossil coal-derived gas
Fossil hard coal
Fossil oil
Fossil oil shale
Fossil peat
Fossil gas
Geothermal
Hydro water reservoir
Hydro pumped storage
Others
Other renewables
Waste renewable
Waste non-renewable
Wind offshore
Wind onshore
Solar
Load
Energy-Charts.info - last update: 30/12/2022, 21:44 CET

THE WORLD WANTS NEW NUCLEAR

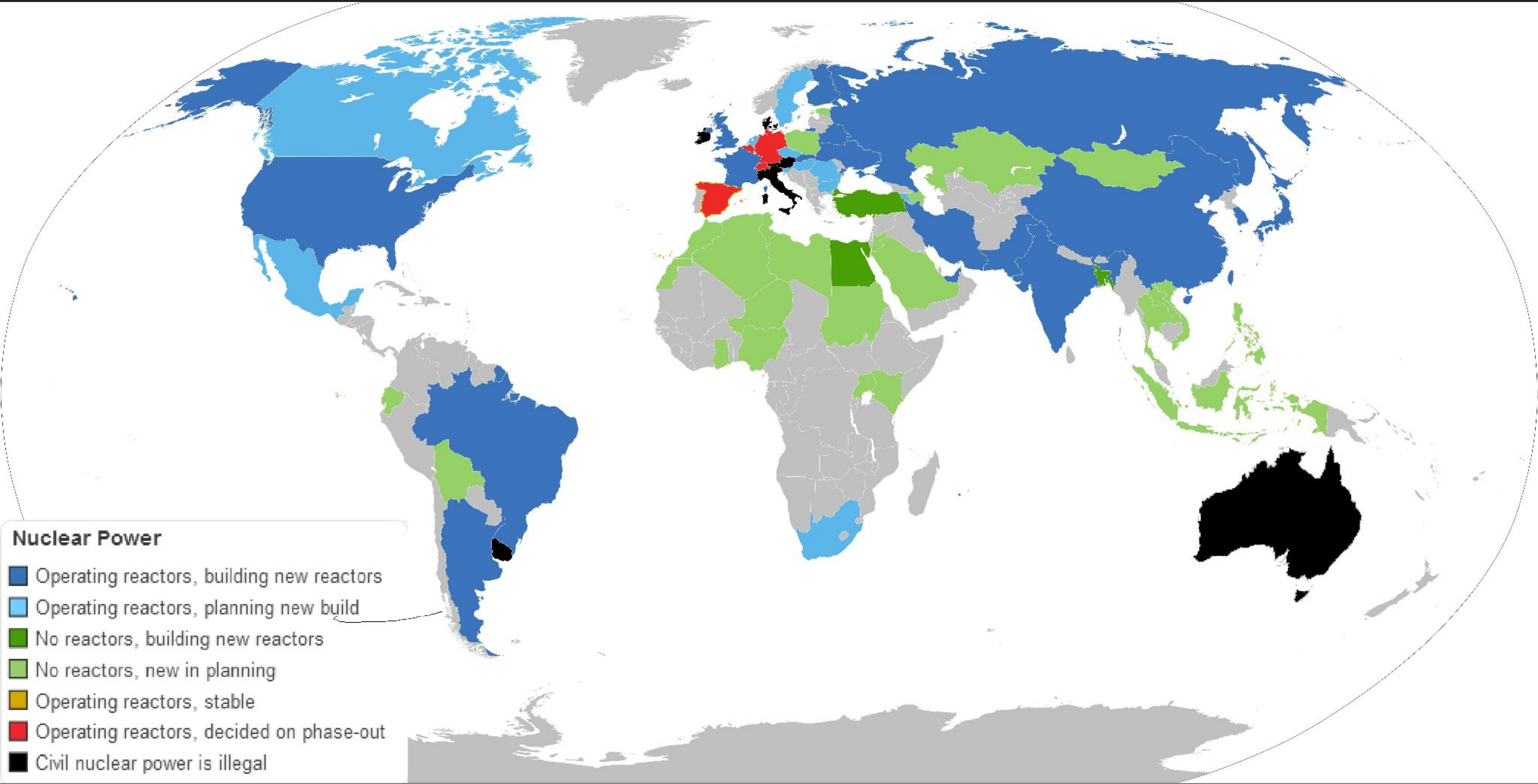
Findings from a comprehensive evaluation of the world's understanding and support for advanced nuclear

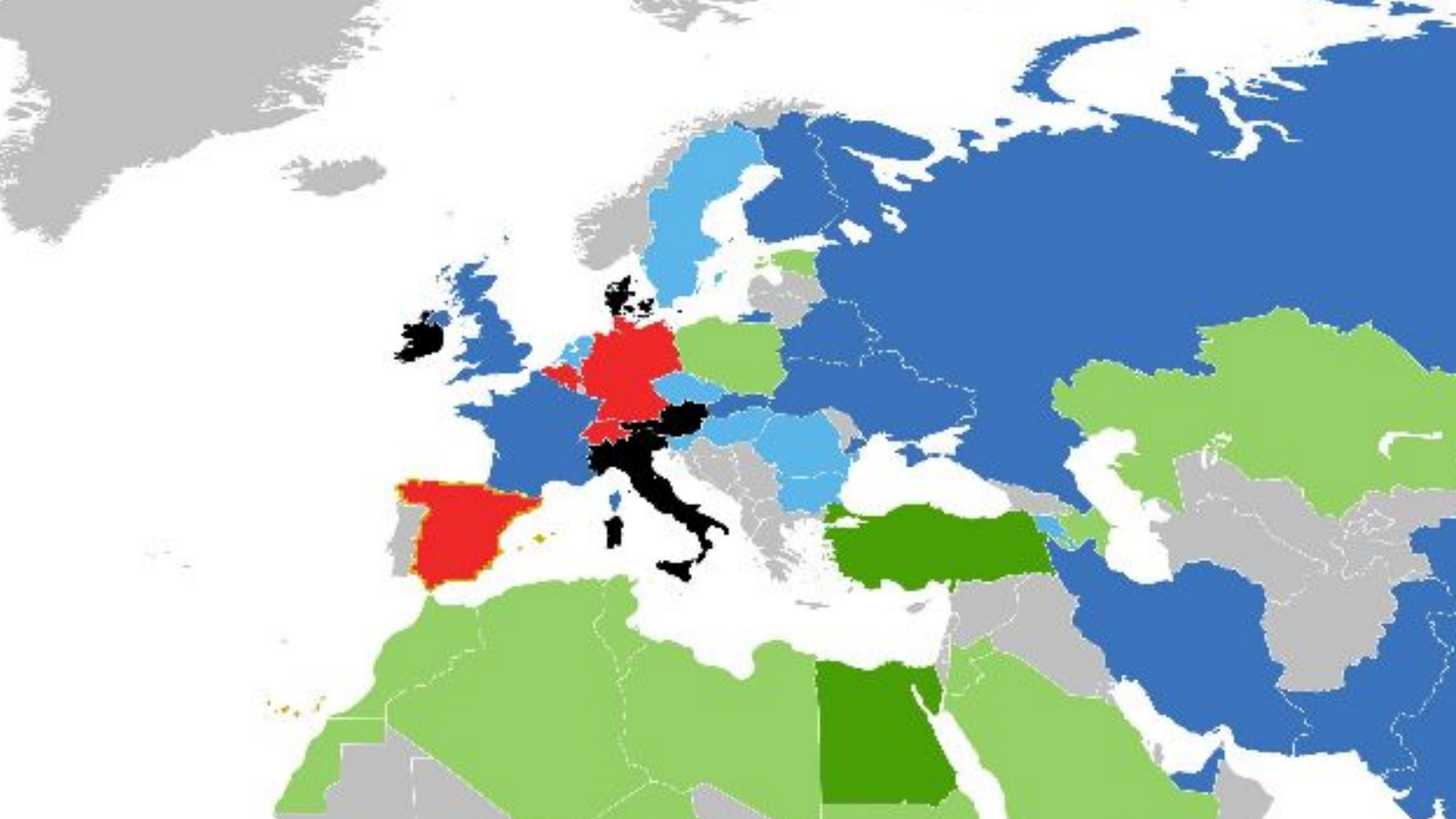
Figure 1: Support significantly outnumbers opposition across the globe

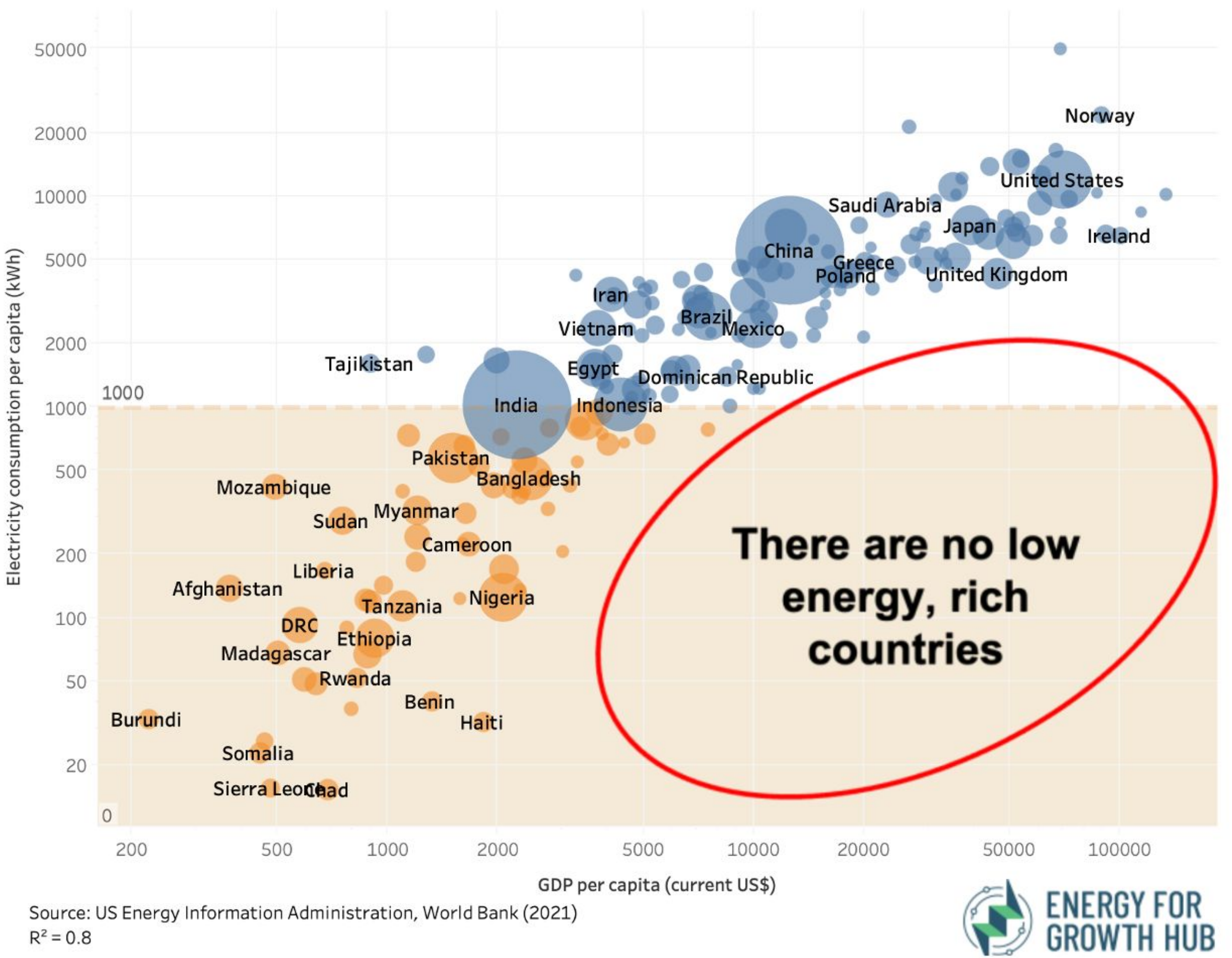
"I support the use of the latest nuclear energy technologies to generate electricity, alongside other energy sources." (5-point scale from strongly disagree to strongly agree)



Source: *The World Wants New Nuclear*, May 2023


Nuclear Power
Operating reactors, building new reactors
Operating reactors, planning new build
No reactors, building new reactors
No reactors, new in planning
Operating reactors, stable
Operating reactors, decided on phase-out
Civil nuclear power is illegal



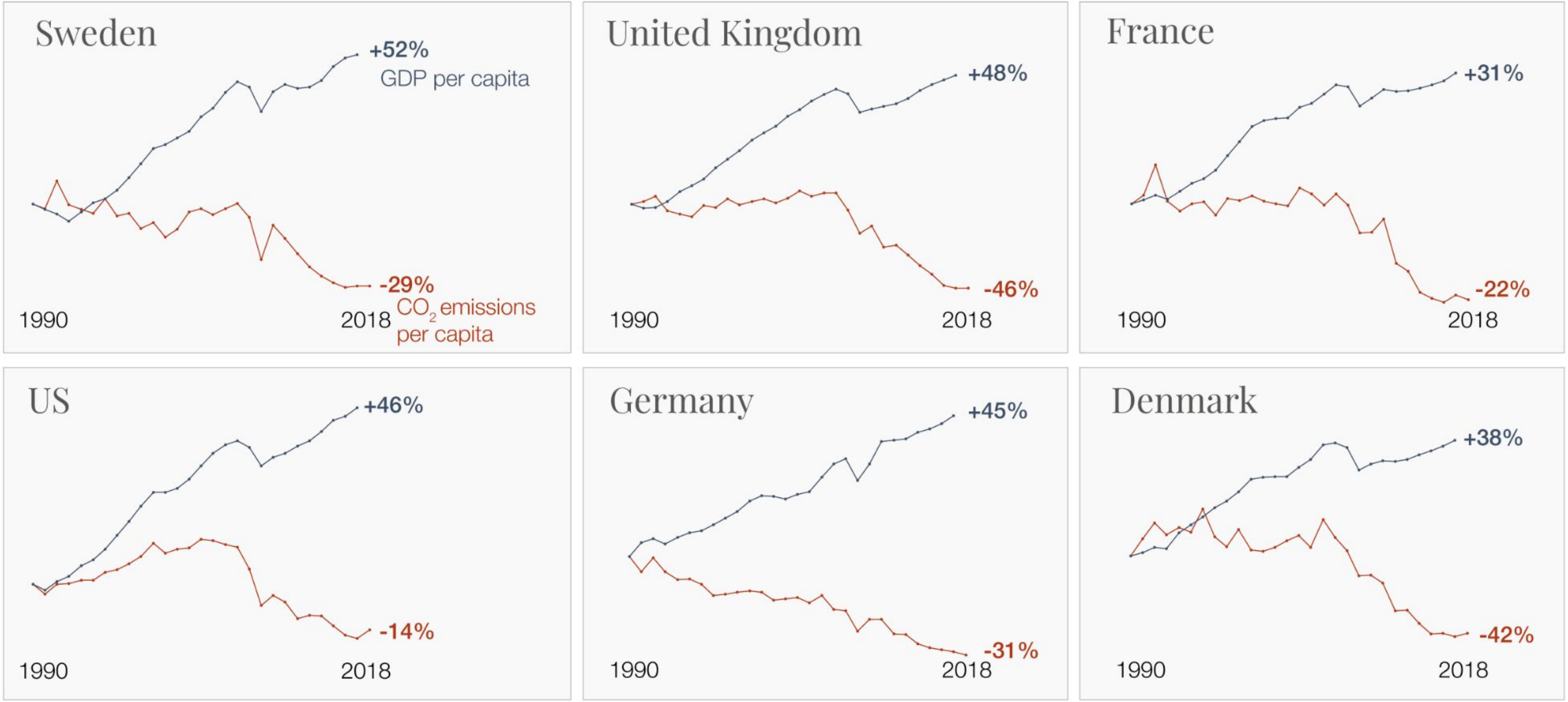


Não há países ricos pobres em energia

Six countries that achieved strong economic growth while reducing CO_2 emissions

Emissions are adjusted for trade. This means that CO_2 emissions caused in the production of imported goods are added to its domestic emissions; for goods that are exported the emissions are subtracted.

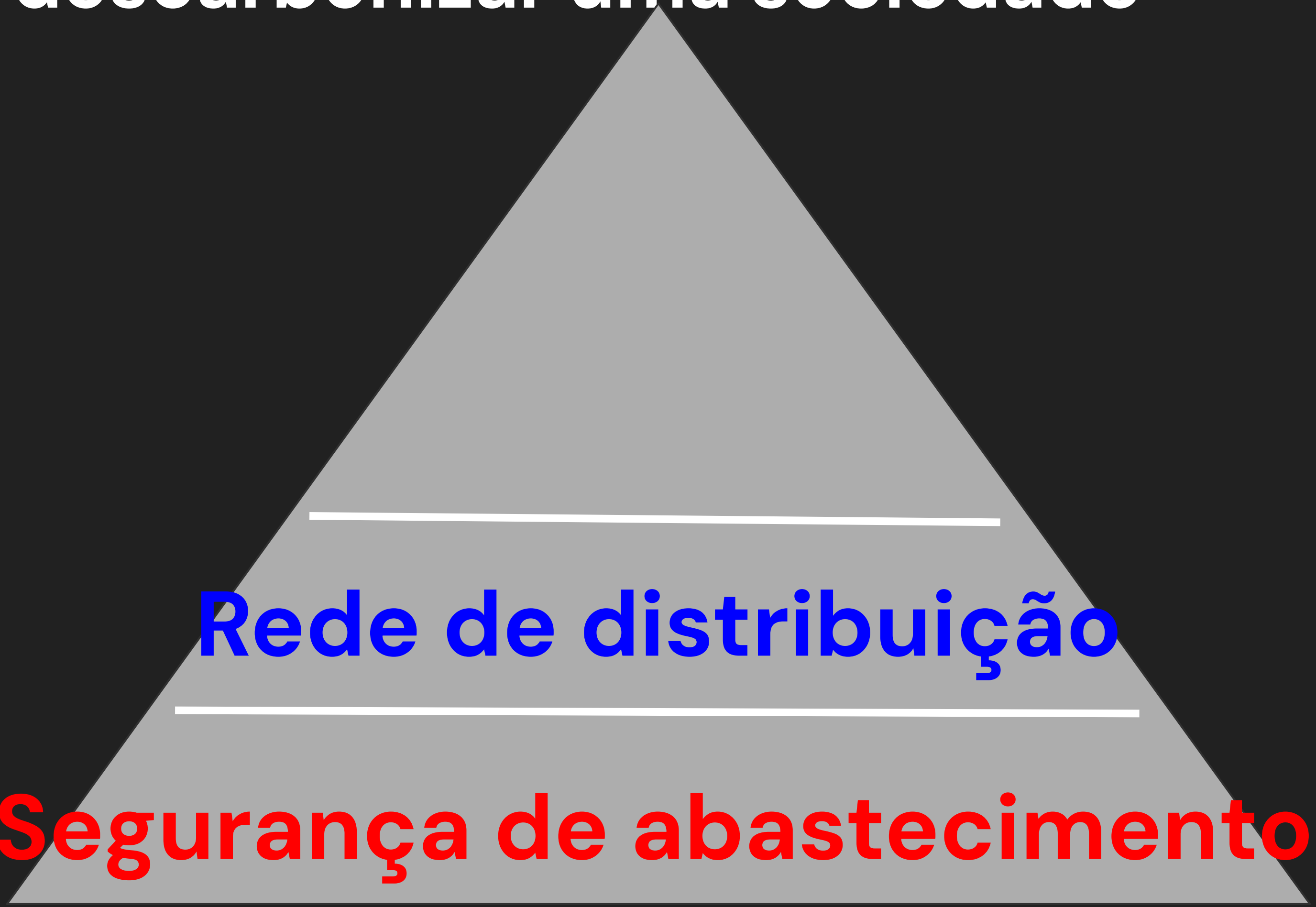
Our World in Data



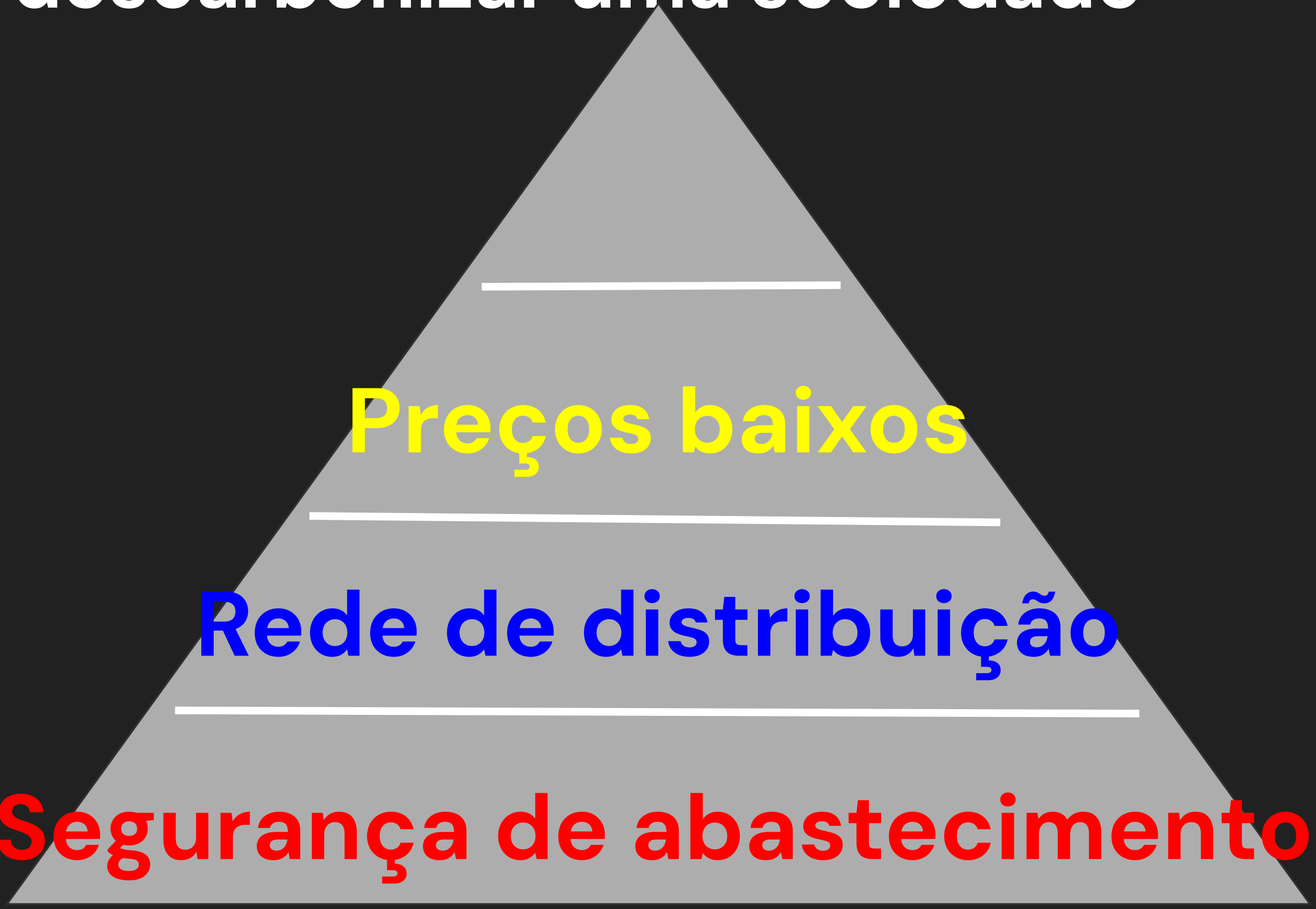
Inovação; Renováveis; Nuclear; Carvão → GN

Como descarbonizar uma sociedade

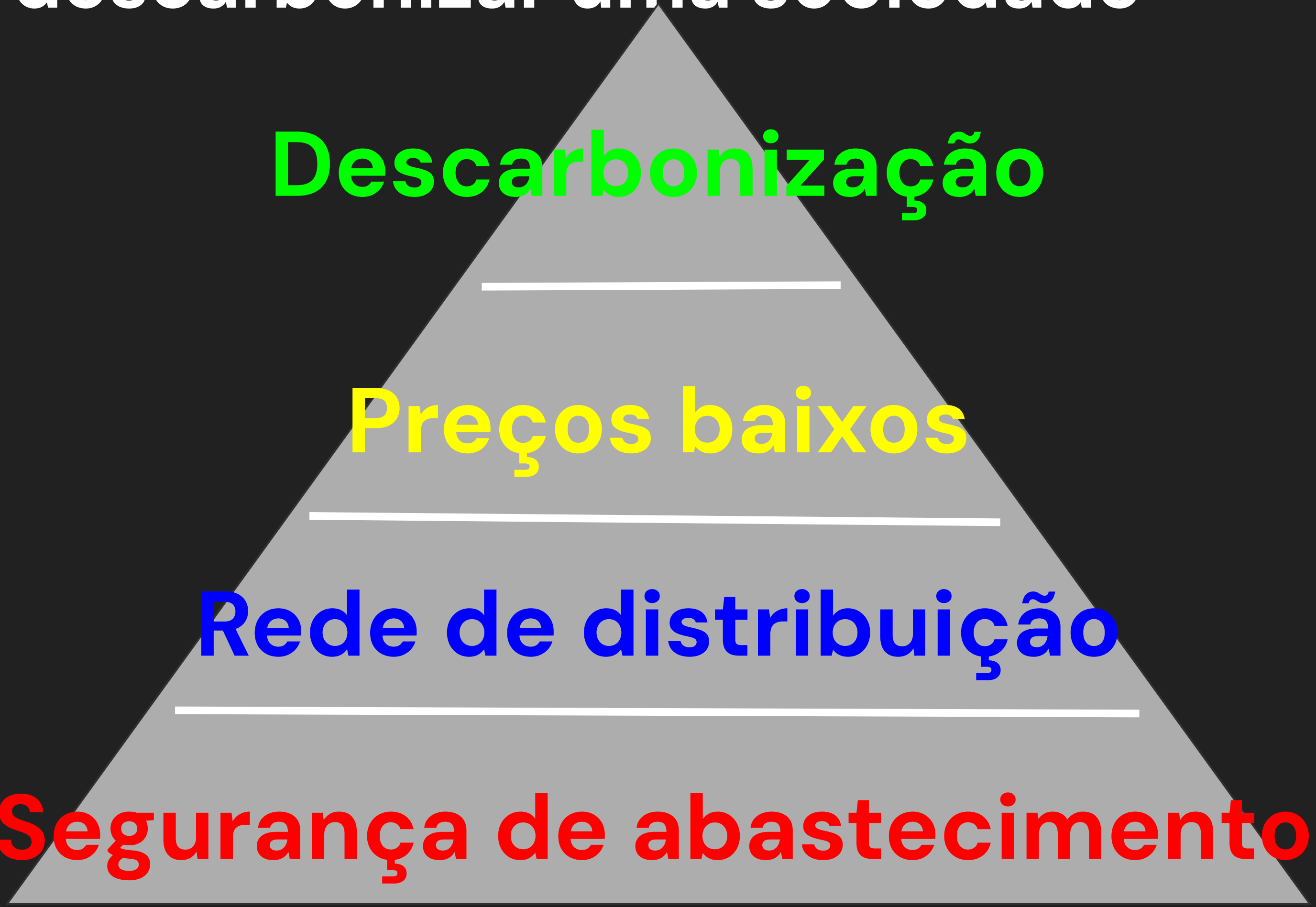
Como descarbonizar uma sociedade



Como descarbonizar uma sociedade



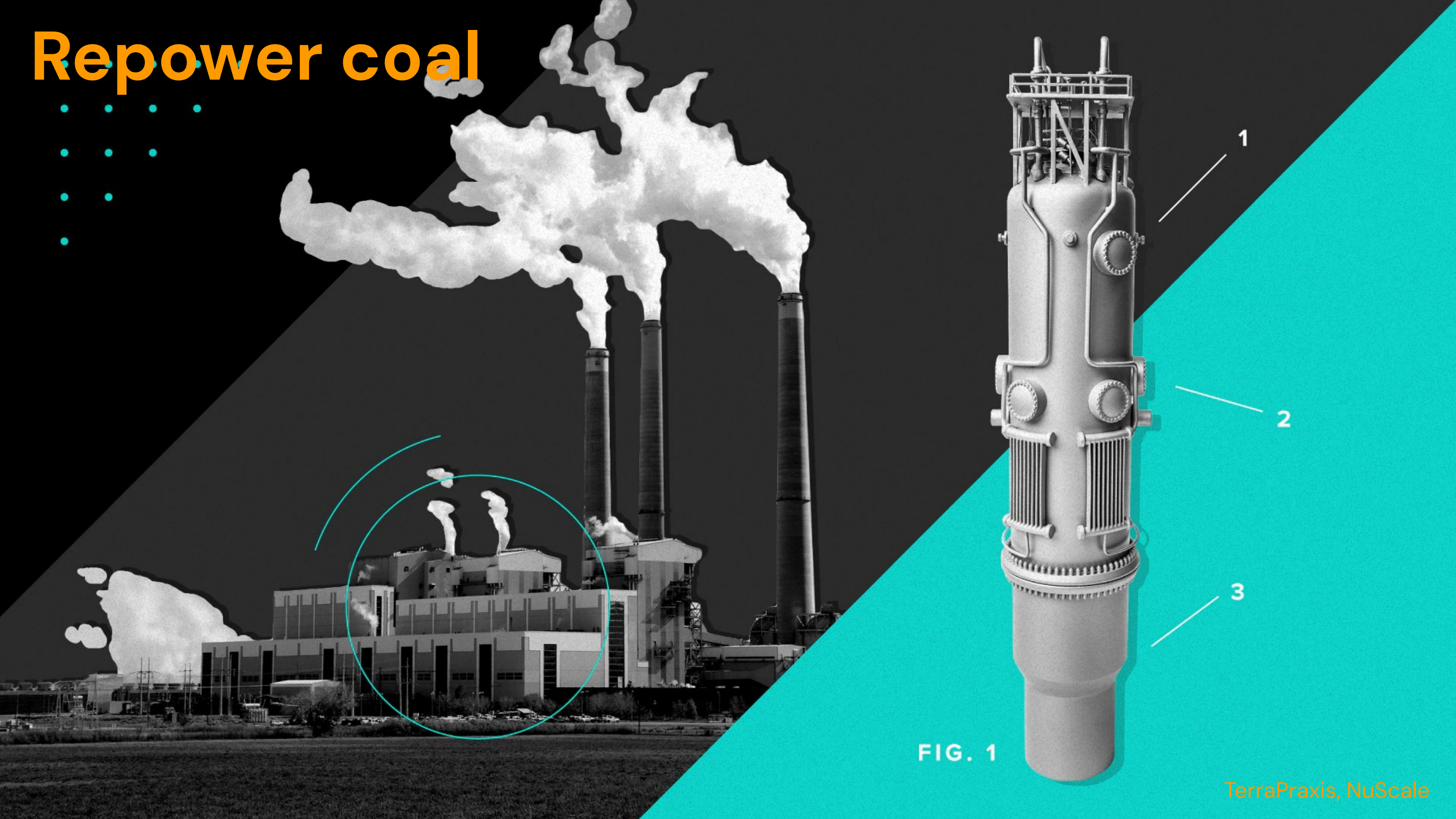
Como descarbonizar uma sociedade



Apoiada na faceta energética, uma indústria nuclear abre as portas para muitas mais valias industriais e trabalhos bem remunerados.

- Calor industrial de baixo carbono (papel, têxteis,...)
- Dessalinização de água do mar
- *District heating*
- Isótopos médicos produzidos em reatores: radioterapia
- Isótopos para monitorização de qualidade da água e dos solos
- Esterilização de Equipamento médico (PPE)
- Irradiação de bens alimentares: aumento do tempo de prateleira
- Eletrólise de Hidrogénio (fertilizantes, aço, feedstock químicos)
- Shipping nuclear

Repower coal

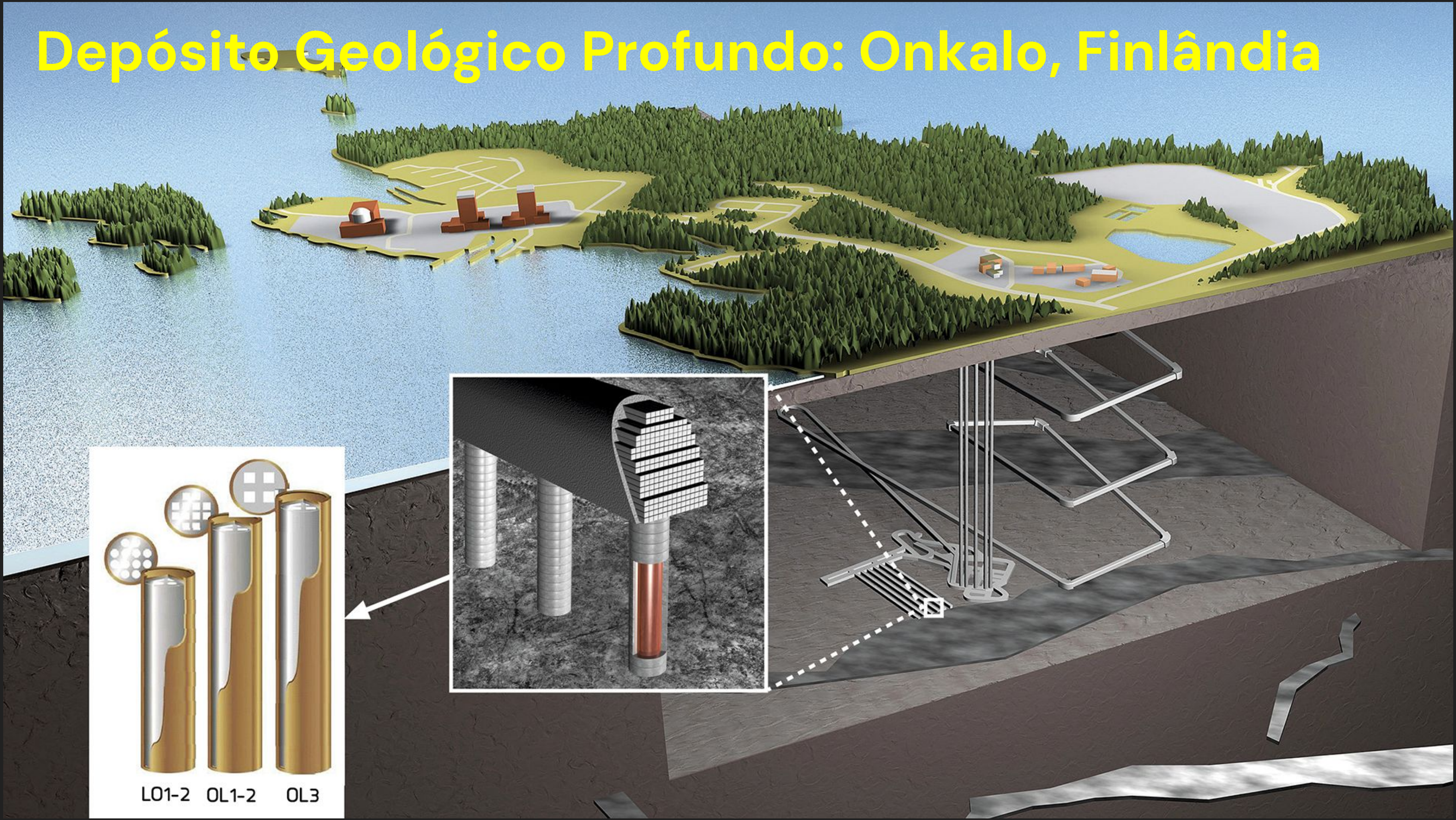


TerraPraxis, NuScale

Dry-Casks:
repositório de combustível gasto

Cada contentor representa:
2 milhões de toneladas de CO_2 evitadas
4TWh de eletricidade, Portugal = 13 contentores/annum

Depósito Geológico Profundo: Onkalo, Finlândia



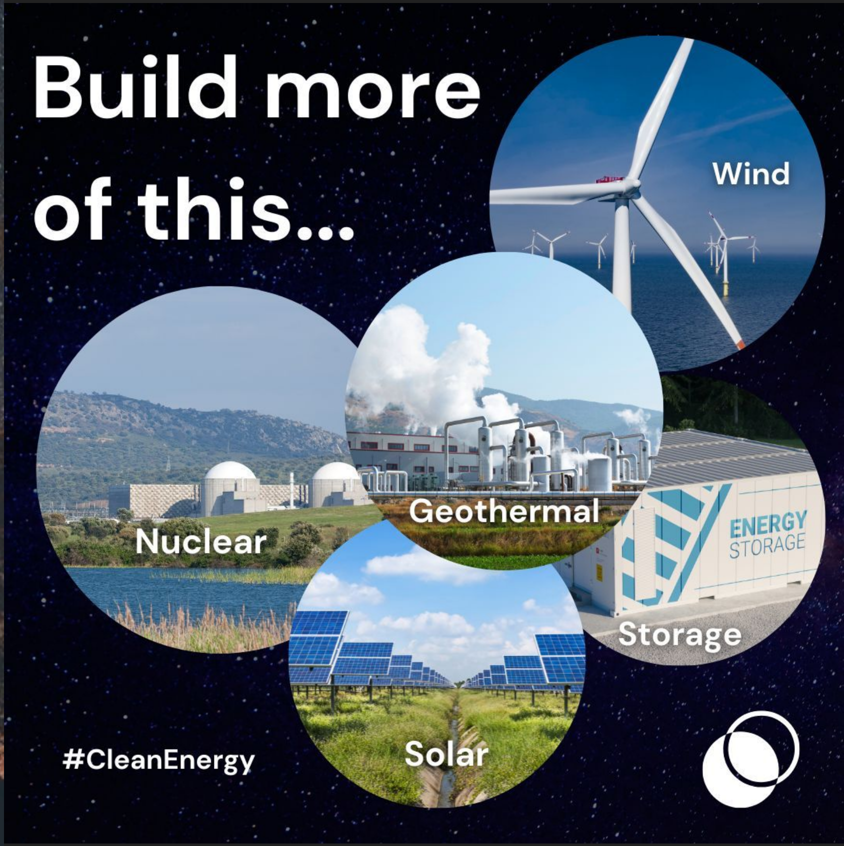
WHAT A WASTE

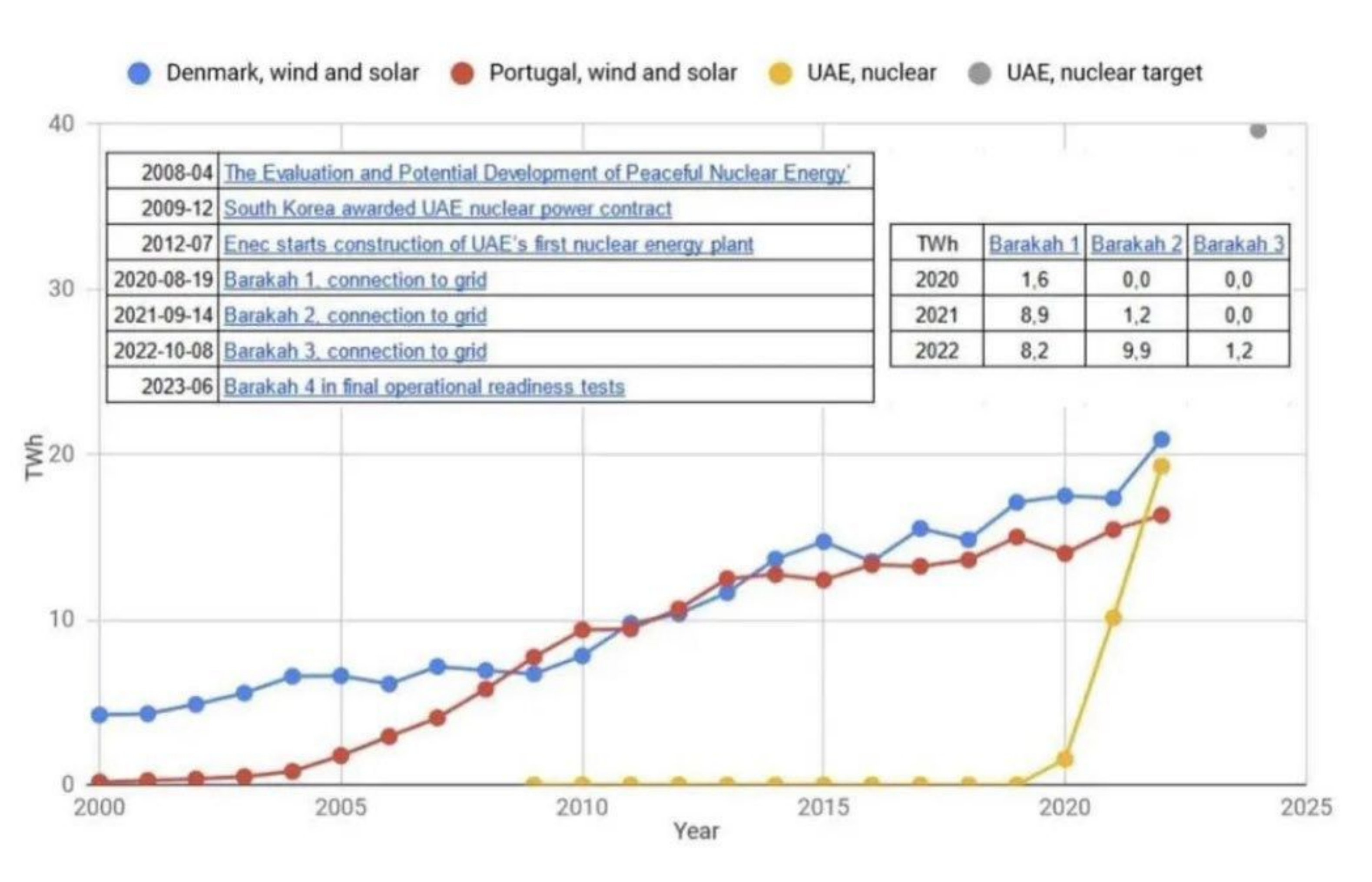
How fast-fission power
can provide clean energy
from nuclear waste

- Apenas 5% da energia do combustível nuclear foi usada.
- Há imenso potencial energético no combustível nuclear gasto.
- Investir em reatores de nova geração (fast breeder reactors) para reduzir os “resíduos nucleares”.
- Divergir fundos de Deep Geological Repositories para investigar o “fecho do ciclo do combustível nuclear”.
- Combater a pobreza energética com eletricidade barata e de baixo carbono.

Assinem a nossa petição!


Nothing in life is to be feared, it is only to be understood.
Now is the time to understand more, so that we may fear less.
Marie Curie
REPLANET


Build more of this...
Wind
Nuclear
Geothermal
ENERGY STORAGE
Storage
Solar
#CleanEnergy



2008-04	The Evaluation and Potential Development of Peaceful Nuclear Energy'
2009-12	South Korea awarded UAE nuclear power contract
2012-07	Enec starts construction of UAE's first nuclear energy plant
2020-08-19	Barakah 1, connection to grid
2021-09-14	Barakah 2, connection to grid
2022-10-08	Barakah 3, connection to grid
2023-06	Barakah 4 in final operational readiness tests

TWh	Barakah 1	Barakah 2	Barakah 3
2020	1,6	0,0	0,0
2021	8,9	1,2	0,0
2022	8,2	9,9	1,2

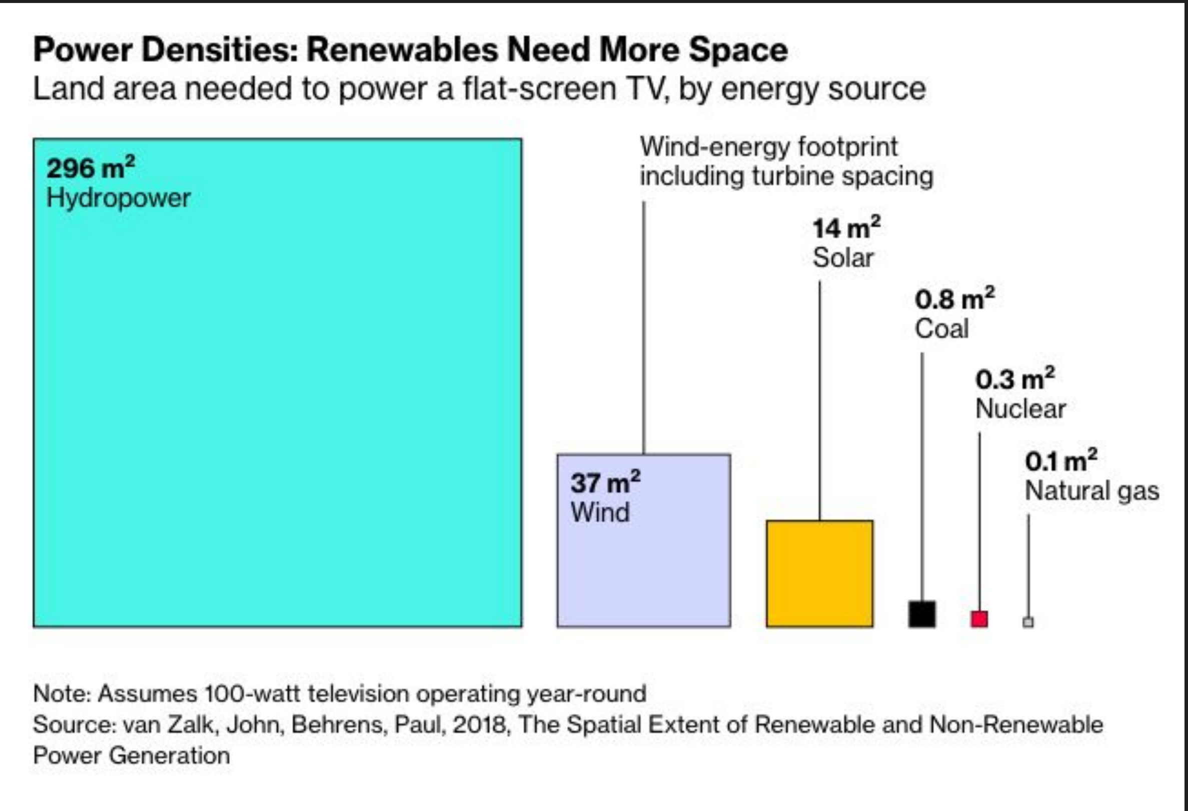
45 anos de operação Suíça

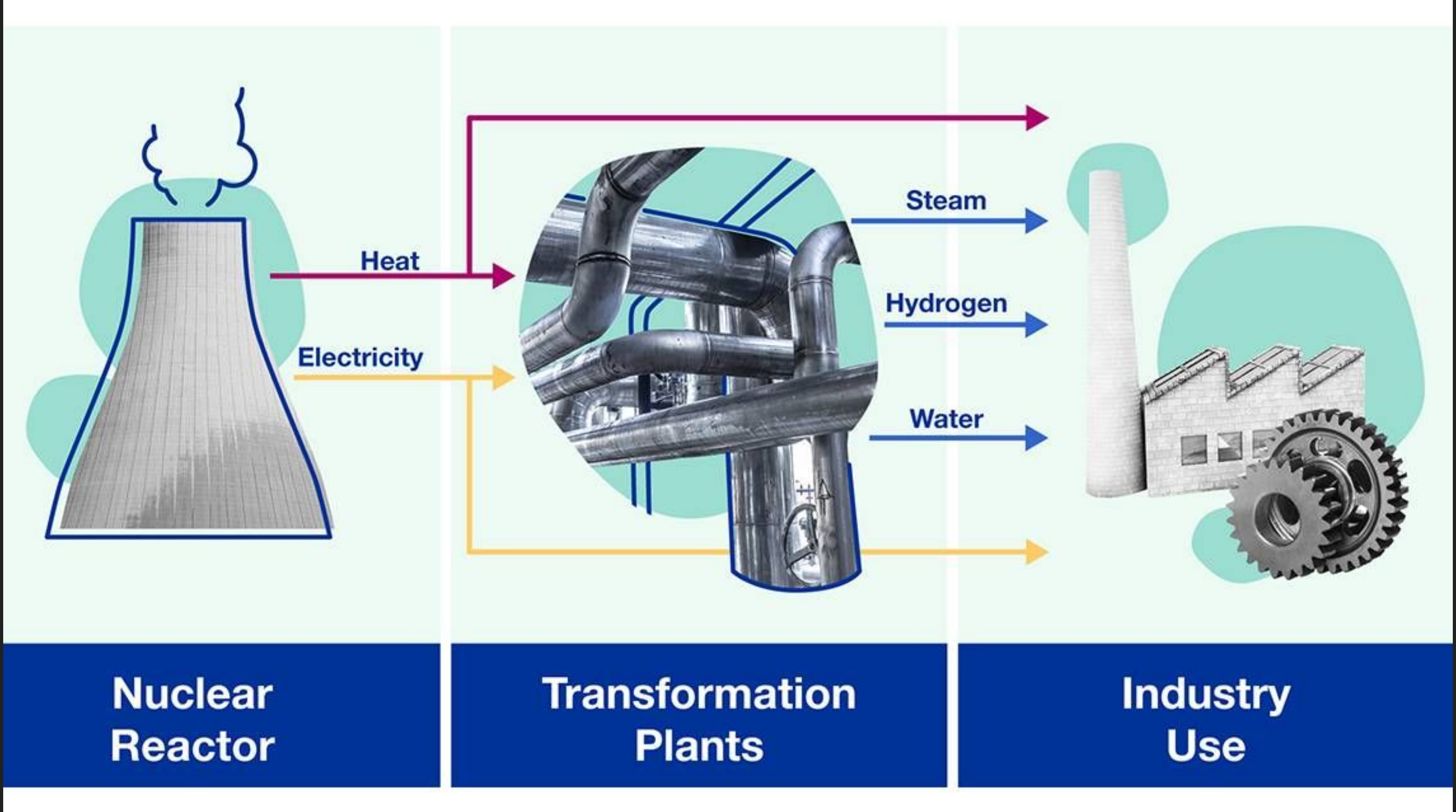
1000TWh: 20 anos de consumo de eletricidade em Portugal ao ritmo atual

Orano, França

©Orano, BOEUF CHRISTIAN, EUROSCRIPT

Requisitos de área por fonte de eletricidade




Heat
Electricity
Steam
Hydrogen
Water
Nuclear Reactor
Transformation Plants
Industry Use

Requisitos materiais por fonte de eletricidade

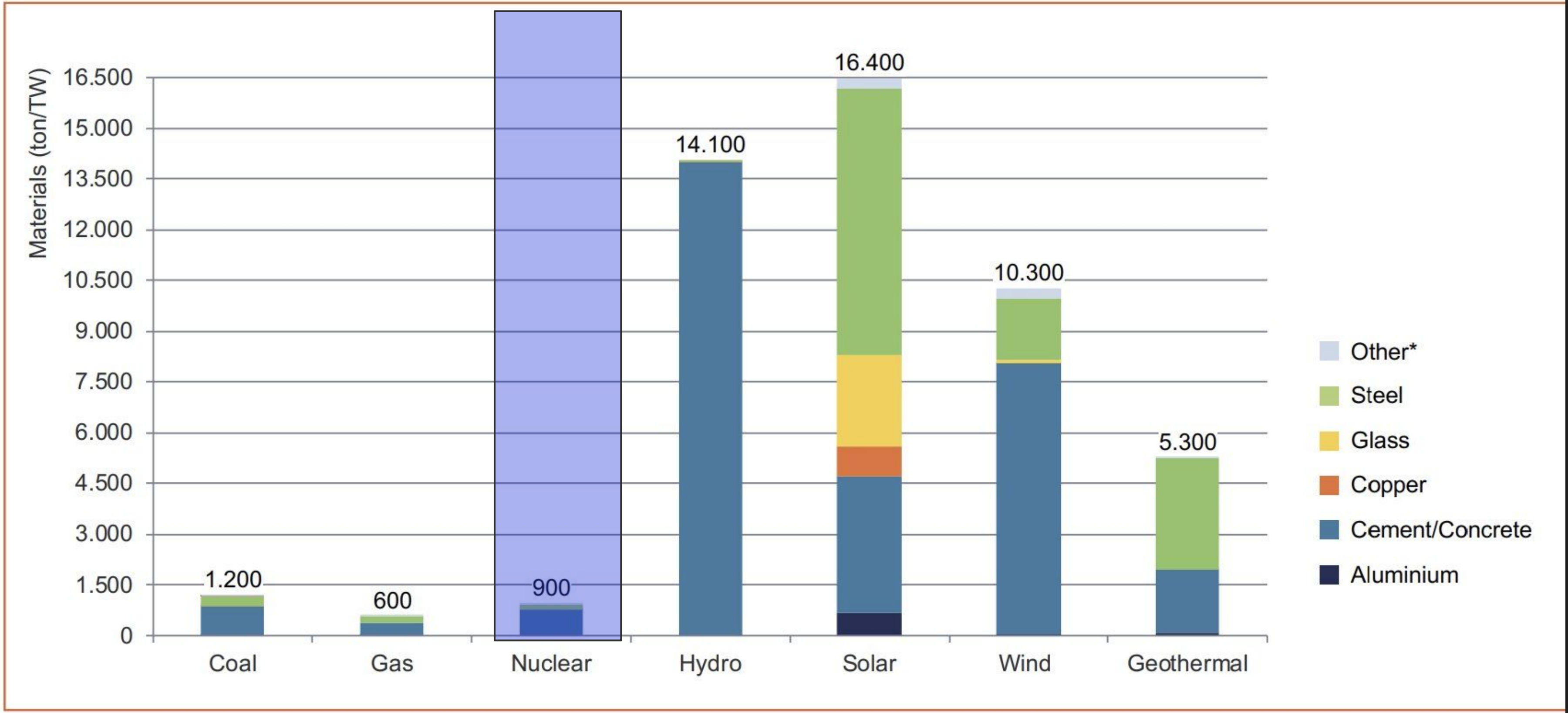
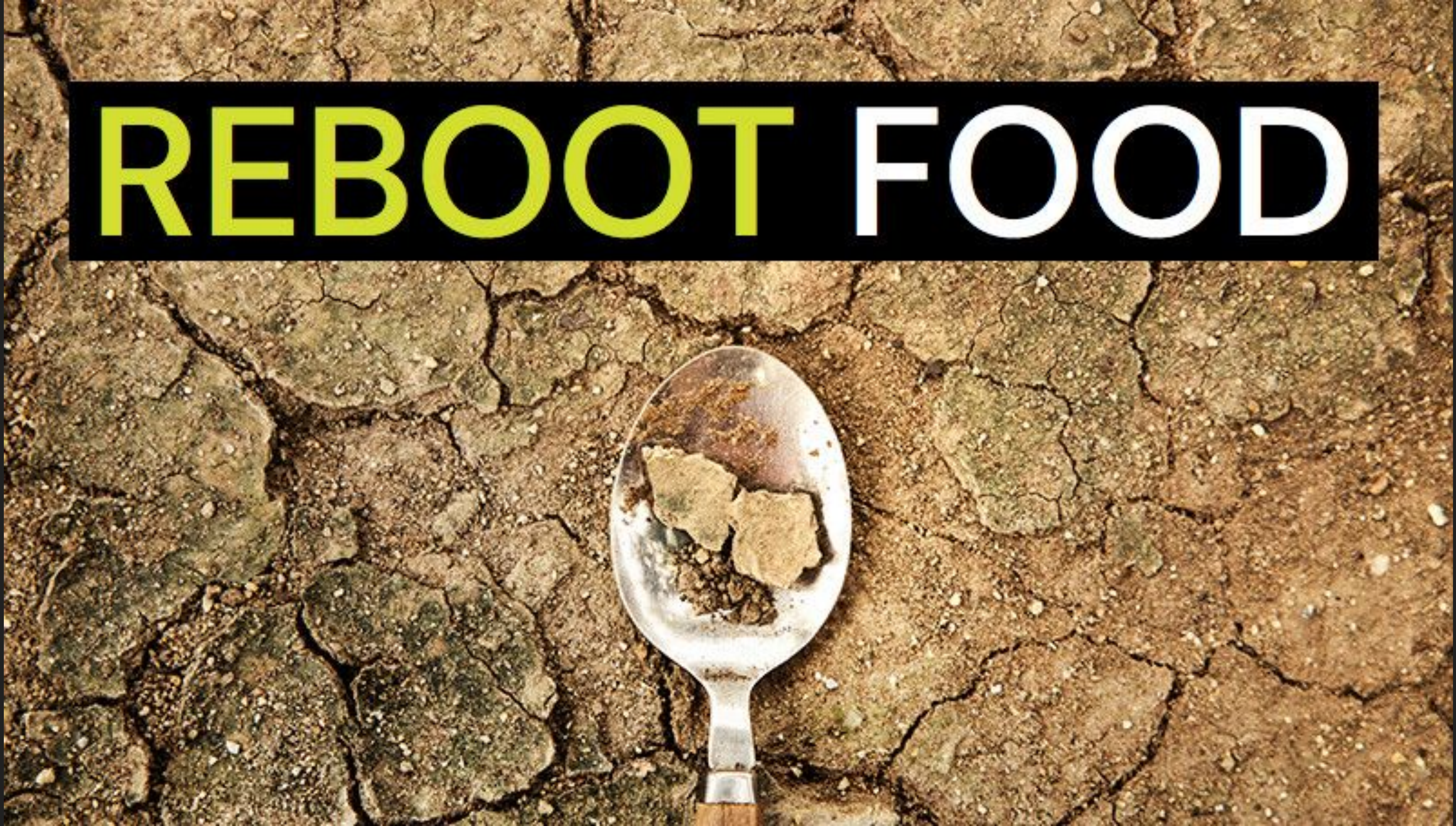


Figure 4: Base-Material Input per 1 TW Generation

Note: Other includes iron, lead, plastic, and silicon.; Schernikau assumes this is based on average US capacity factors

Source: Adapted from DOE 2015, Table 10.4, p390


REBOOT FOOD

A proteína consumida em todo o mundo pode ser produzida numa área inferior à área do distrito de Lisboa

LEITE ✅
PERFECT DAY DAIRY

A *Perfect Day* é uma empresa Californiana que produz duas proteínas cruciais no leite: caseína e soro de leite. É possível comprar este leite nos USA sob a efígie de "the Bored Cow brand".

CARNE DE VACA ✅
IMPOSSIBLE

A *Impossible Foods* produ 'hamburgers que sangram' utilizando um produto da Fermentação de Precisão chamado Heme. Heme é a molécula que faz com que a carne saiba a carne. disponível nos USA, chegou recentemente ao mercado do Reino Unido.

CLARAS DE OVO✅
THE EVERY COMPANY

The Every Company (antes, *Clara Foods*) usou FP para criar claras de ovos – mas sem galinhas. Em Março de 2022 lançaram os seus primeiros macaroons FP com a chef pasteleira de renome, Chantal Guillon.

NATAS ✅
BRAVE ROBOT

Brave Robot produz uma gama de sabores de gelado utilizando proteínas de leite sem animais criadas pela Perfect Day. Já disponível nos USA, tem planos para se expandir.

INSULINA

99% da produção mundial

COALHO

80% da produção mundial

mas até lá…


SWITCH OFF PUTIN

Três pontos para as estratégias de conservação e agrícola nacionais

1. Permitir a introdução de GMOs resistentes à seca em território nacional e na UE.
2. Apoiar a inclusão de PES: Payments for Ecosystem Services na União Europeia, seguindo o exemplo da Costa Rica.
3. Apoiar a investigação em métodos de produção de proteínas alternativas na UE, como já o fazem China, Japão, Coreia do Sul, Singapura, Reino Unido, USA, etc..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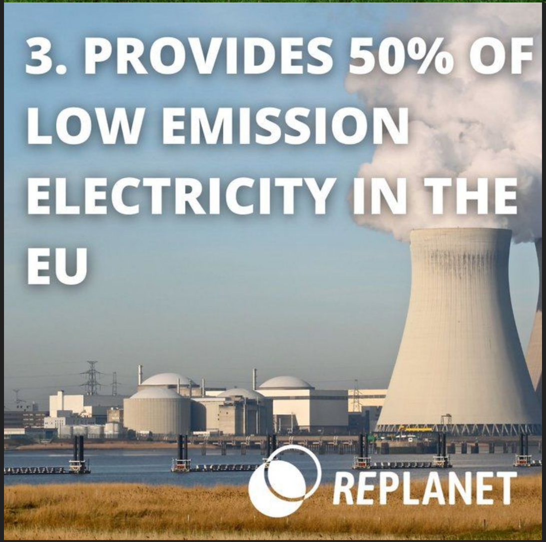
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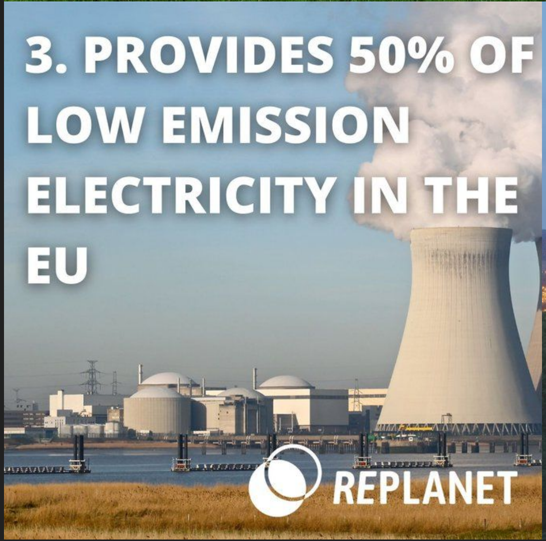
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Lei de Brandolini

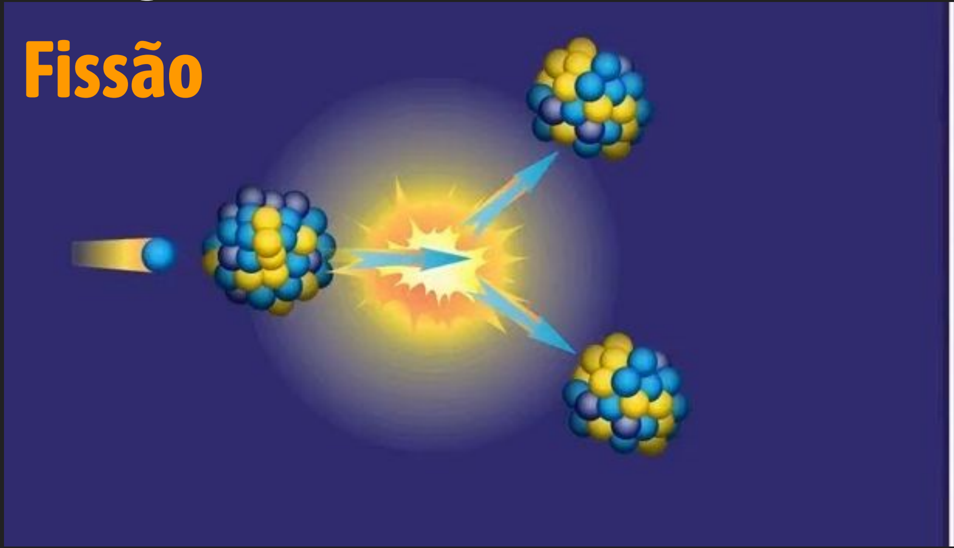
Dimensão dos resíduos de alta atividade FR no porto de Marselha

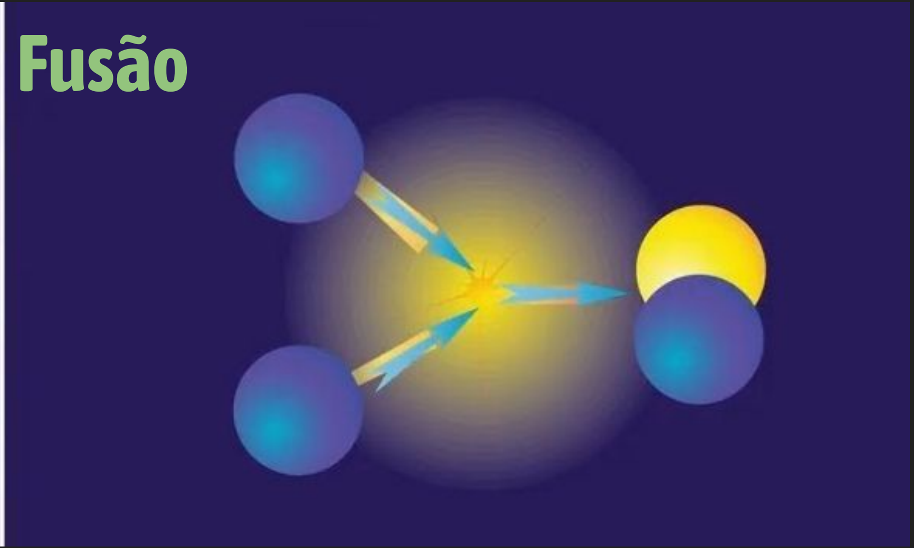
Lei de Brandolini

Princípio de assimetria da informação falsa.

"A quantidade de energia necessária para refutar uma informação falsa é uma ordem de grandeza maior do que a energia necessária para produzi-la."

Energia nuclear





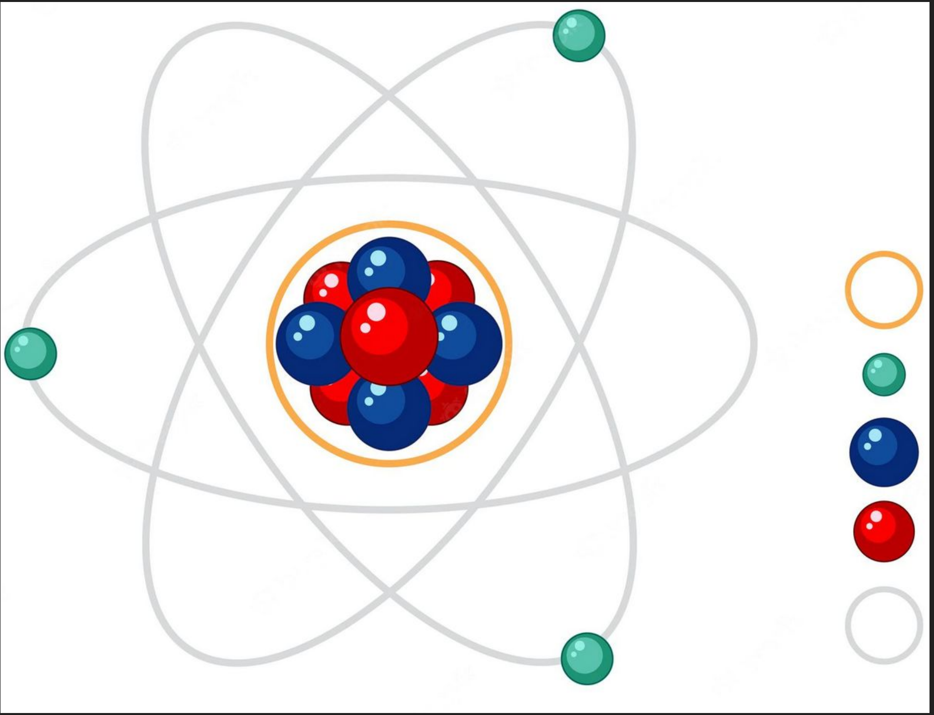
- Um átomo pesado “parte-se” em dois ou mais átomos mais pequenos.
- Todas as centrais nucleares atuais no mundo utilizam este processo.

- Dois átomos leves unem-se para formar um mais pesado.
- Ainda em fase experimental.

Group → Period ↓	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	* 71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	** 103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
			* 57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb		
			** 89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No		

$$E=mc^2$$

$E=mc^2$



Núcleo

Eletrão

Neutrão

Protão

Orbital

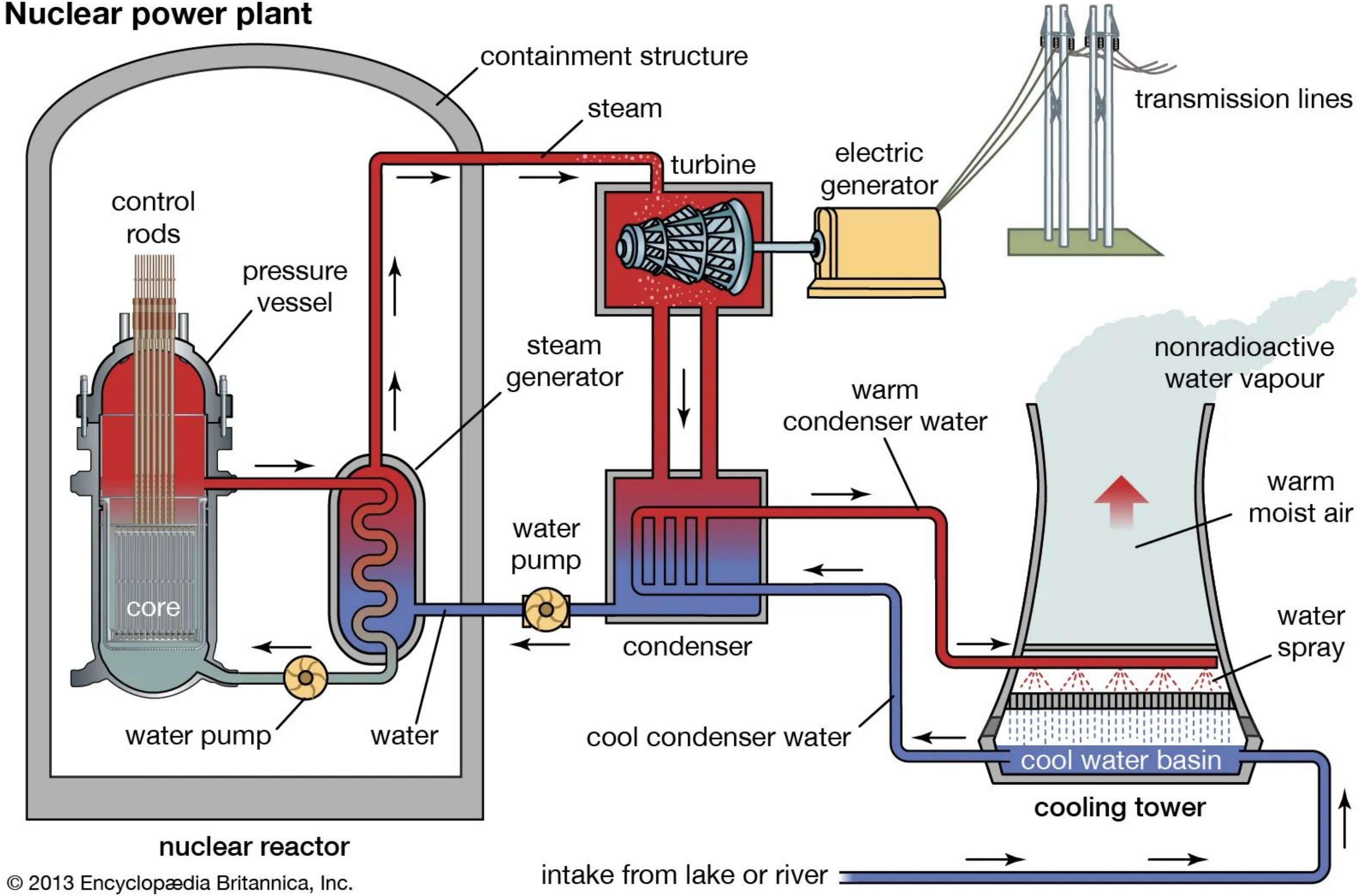
Combustão

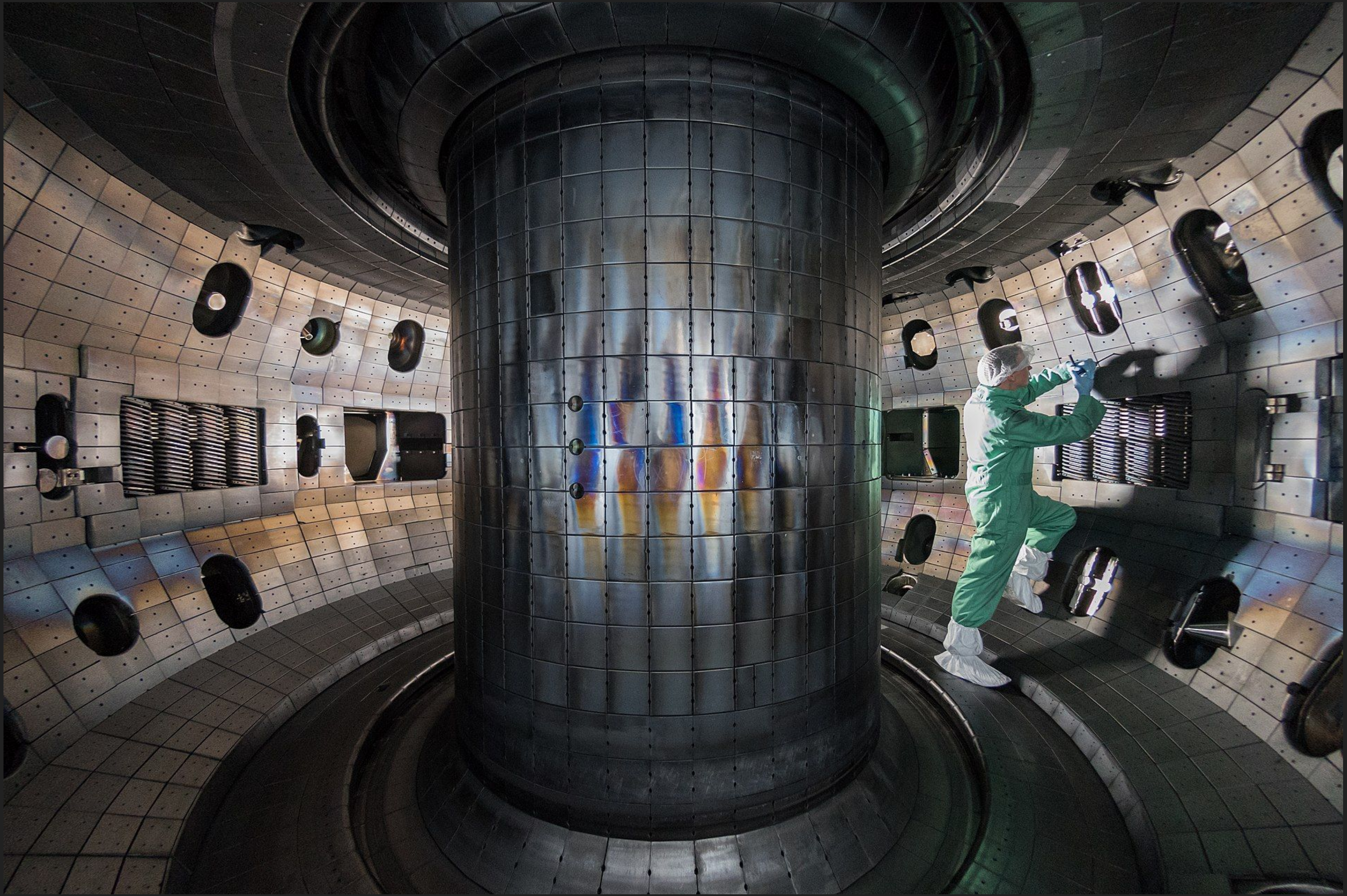
Reorganizar as orbitais

Processo nuclear

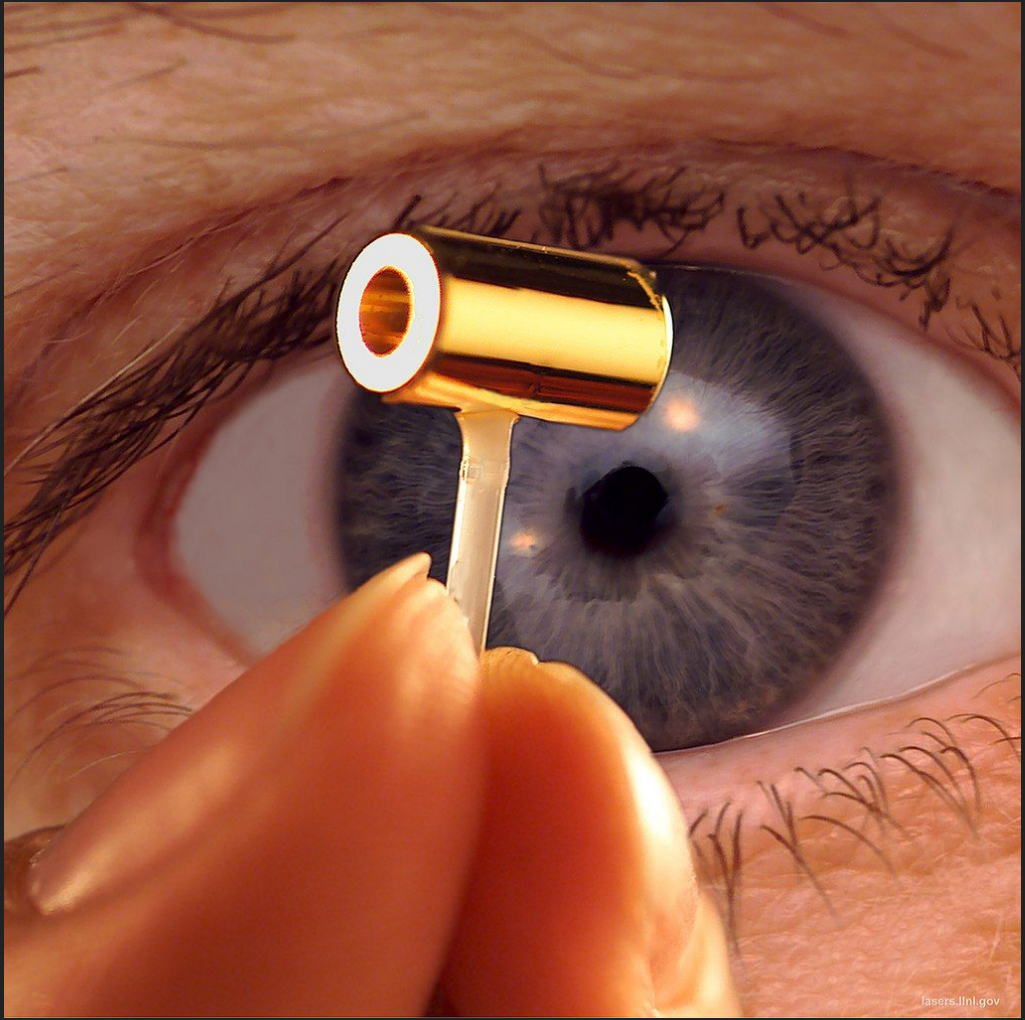
Alteram-se os conteúdos dos núcleos, que são milhões de vezes mais maciços que as orbitais.

Nuclear power plant





Videos


lasers.llnl.gov

Pegada ambiental e densidade energética

Fast Facts on NUCLEAR ENERGY

Nuclear fuel is **extremely energy dense.**

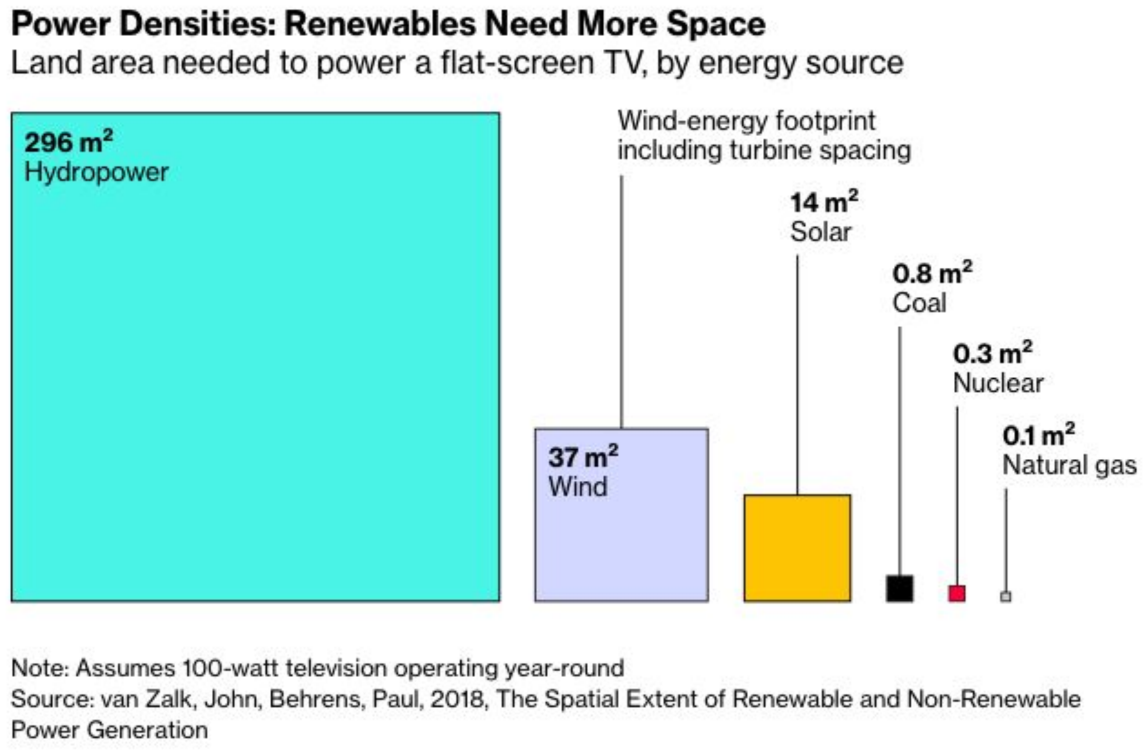
1 uranium pellet	=	17,000 cubic ft	120 gallons	1 ton
(~1 inch tall)		of natural gas	of oil	of coal
		~480 metros cúbicos	**~550 litros**	

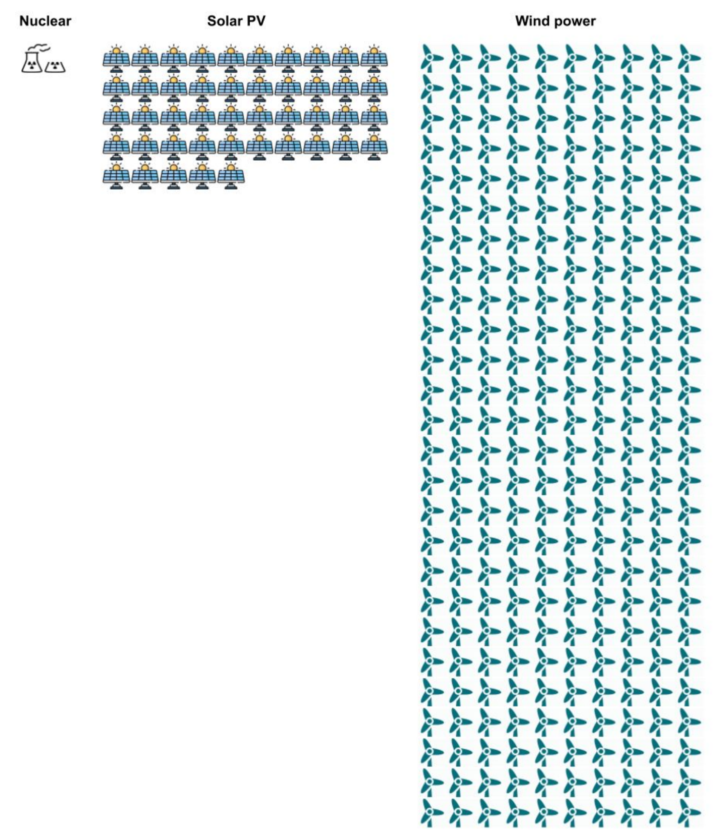
U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

LEARN MORE energy.gov/ne

Data source: U.S. Energy Information Administration

Requisitos de área por fonte de eletricidade





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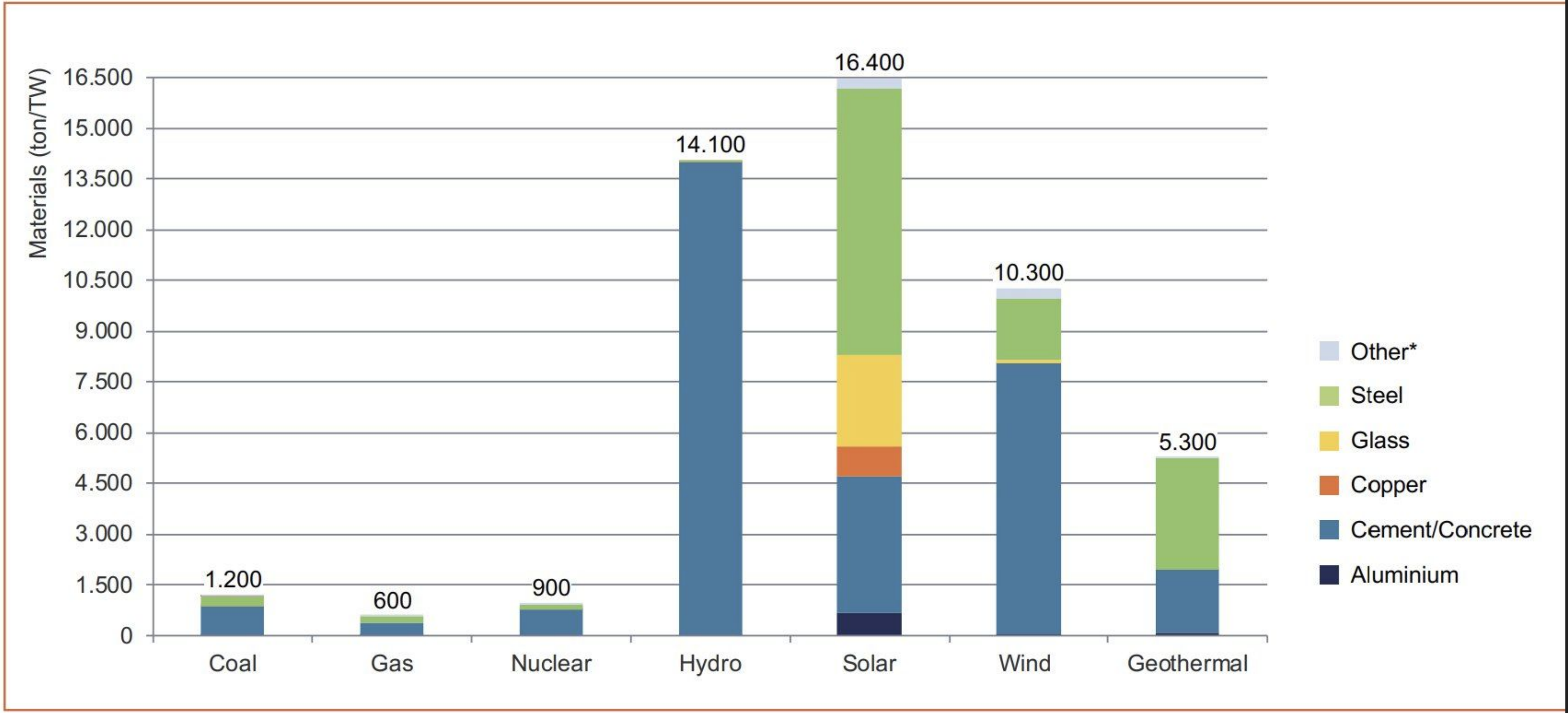


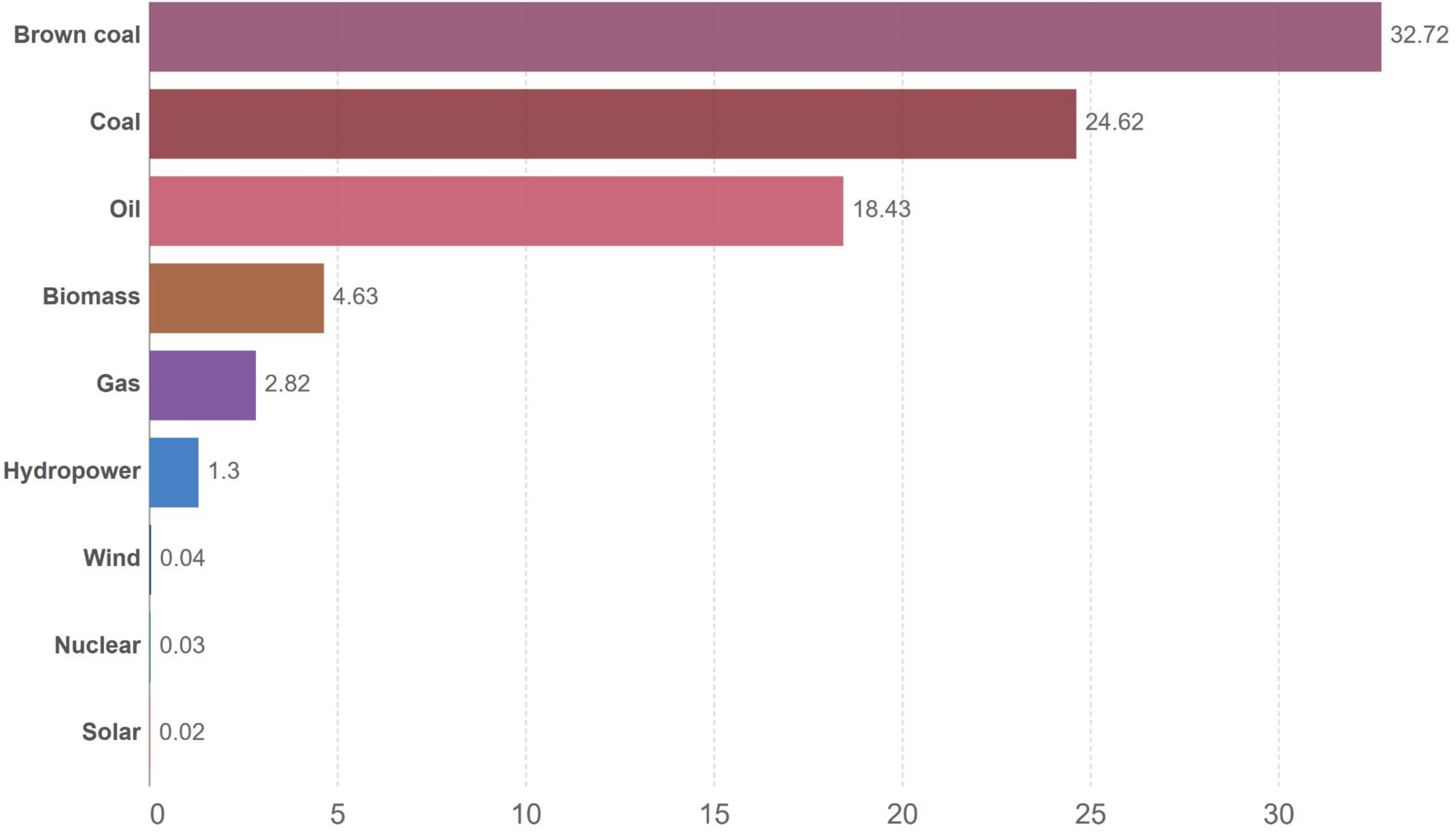
Figure 4: Base-Material Input per 1 TW Generation
Note: Other includes iron, lead, plastic, and silicon.; Schernikau assumes this is based on average US capacity factors
Source: Adapted from DOE 2015, Table 10.4, p390


Diablo Canyon, California
Fornece eletricidade para >2M habitações

Segurança

Death rates per unit of electricity production

Death rates are measured based on deaths from accidents and air pollution per terawatt-hour (TWh) of electricity.



Source: Markandya & Wilkinson (2007); Sovacool et al. (2016); UNSCEAR (2008; & 2018)

Fukushima

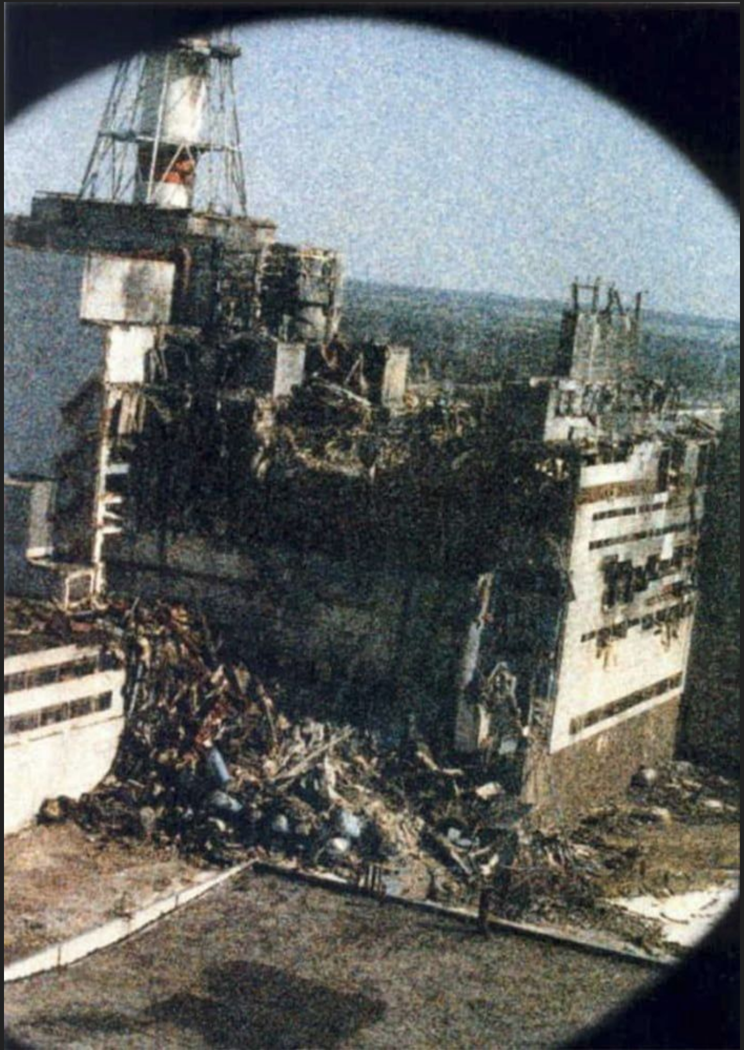
Direct and cancer deaths from the accident

No one died directly from the disaster. However, 40 to 50 people were injured as a result of physical injury from the blast, or radiation burns.

In 2018, the Japanese government reported that **one worker has since died** from lung cancer as a result of radiation exposure from the event.

Over the last decade, many studies have assessed whether there has been any increased cancer risk for local populations. **There appears to be no increased risk of cancer or other radiation-related health impacts.**

In 2016, the World Health Organization noted that there was a very low risk of increased cancer deaths in Japan.[16]

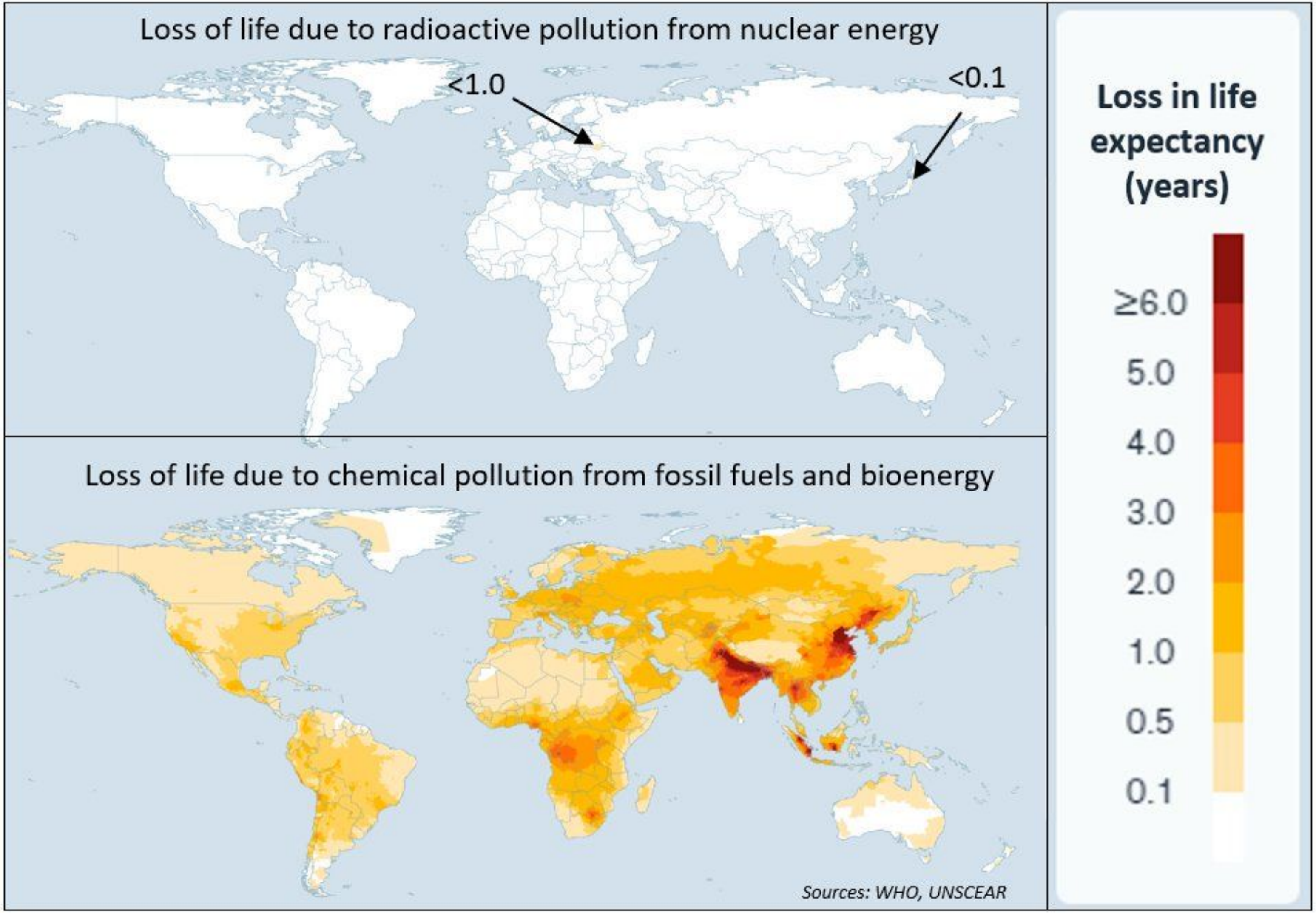


Chornobyl

Combined death toll from Chernobyl

To summarize the previous paragraphs:

- **2 workers died in the blast.**
- **28 workers and firemen died in the weeks that followed from acute radiation syndrome (ARS).**
- **19 ARS survivors had died later, by 2006**; most from causes not related to radiation, but it's not possible to rule all of them out (especially five that were cancer-related).
- **15 people died from thyroid cancer due to milk contamination.** These deaths were among children who were exposed to ^{131}I from milk and food in the days after the disaster. This could increase to between 96 and 384 deaths, however, this figure is highly uncertain.
- **There is currently no evidence of adverse health impacts in the general population across affected countries, or wider Europe.**


Loss of life due to radioactive pollution from nuclear energy
<1.0
<0.1
Loss of life due to chemical pollution from fossil fuels and bioenergy
Sources: WHO, UNSCEAR
Loss in life expectancy (years)
≥6.0
5.0
4.0
3.0
2.0
1.0
0.5
0.1

Newsweek

TECH & SCIENCE

Chernobyl Exclusion Zone Was a Wildlife Haven—Before Russia Attacked

BY ROBYN WHITE ON 1/19/23 AT 7:44 AM EST

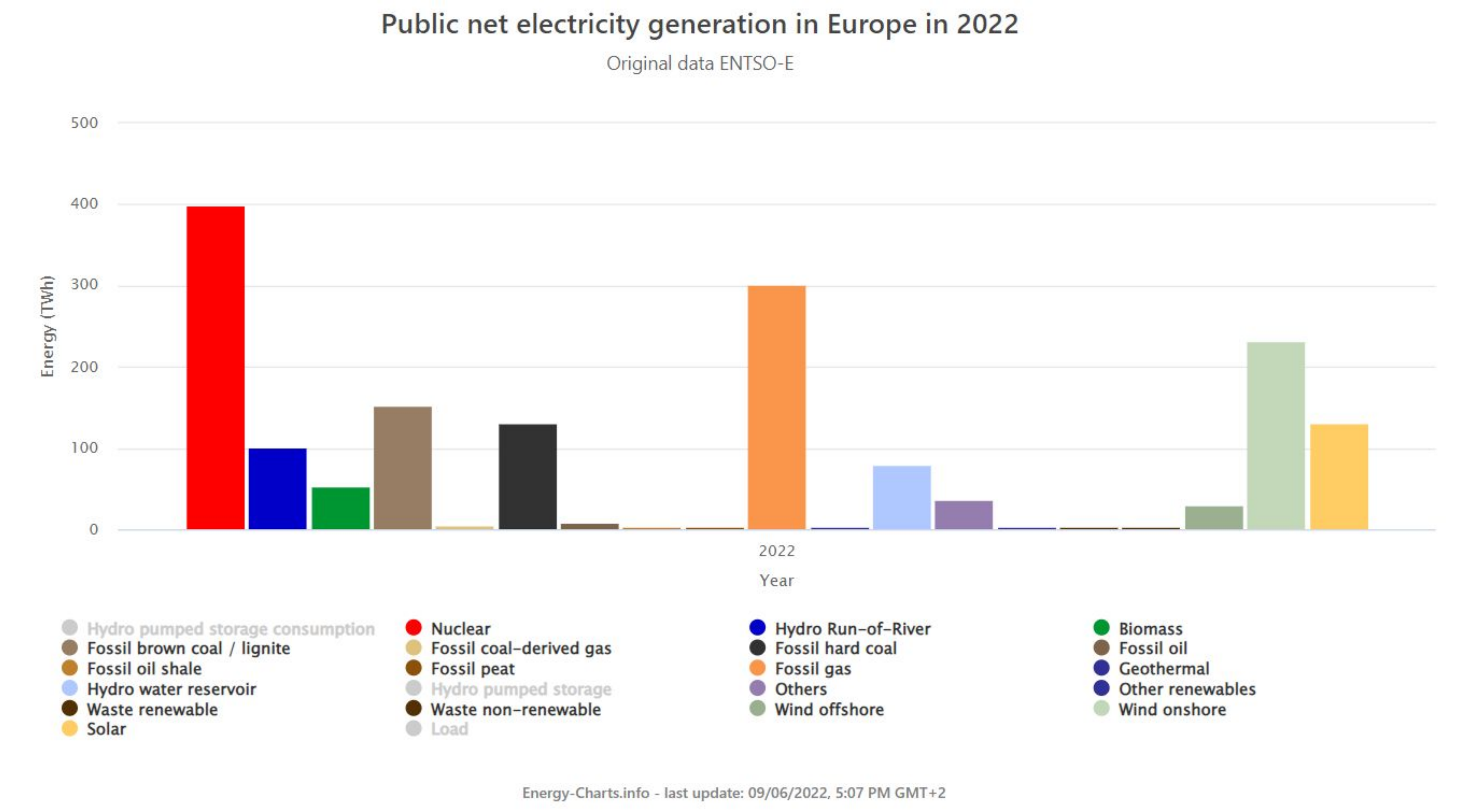
50% da eletricidade de baixo carbono da UE

Energia primária:

Todas as formas de obter energia; impacto sobre o mundo: Combustíveis (gasolina, diesel, ...), lenha, renováveis, nuclear, etc..

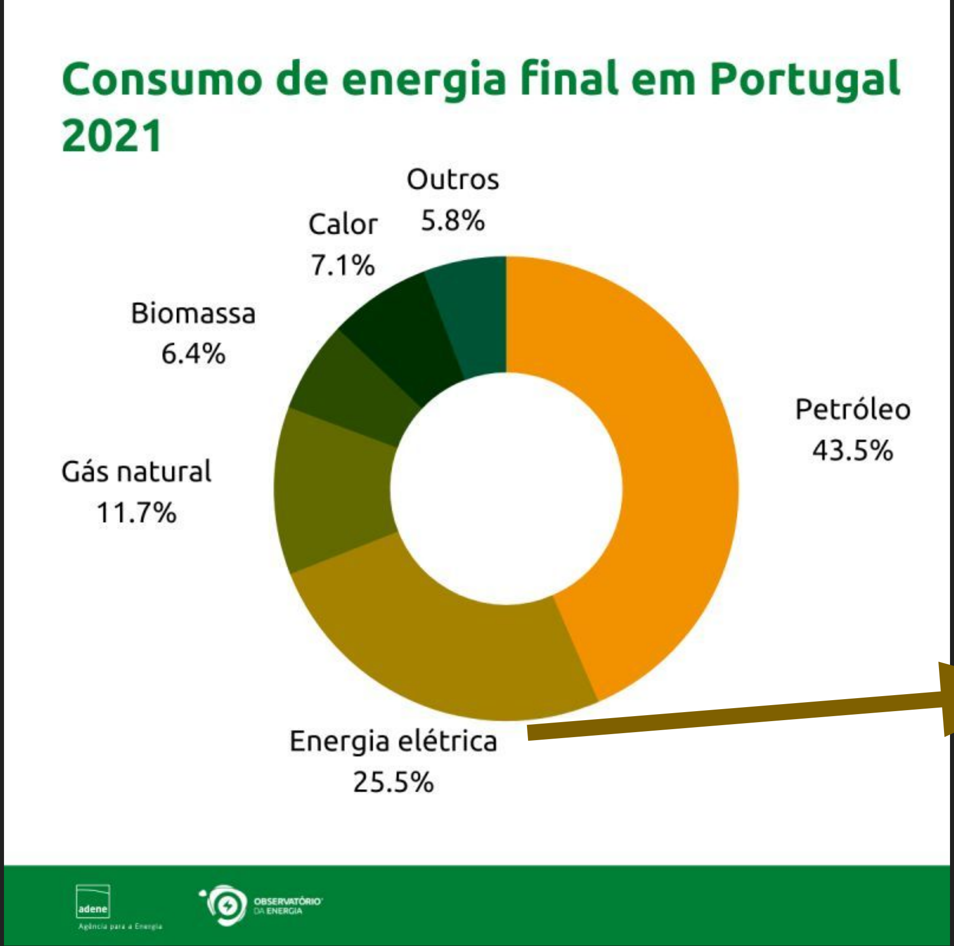
Energia elétrica:

Parcela da energia primária só referente a geração elétrica.

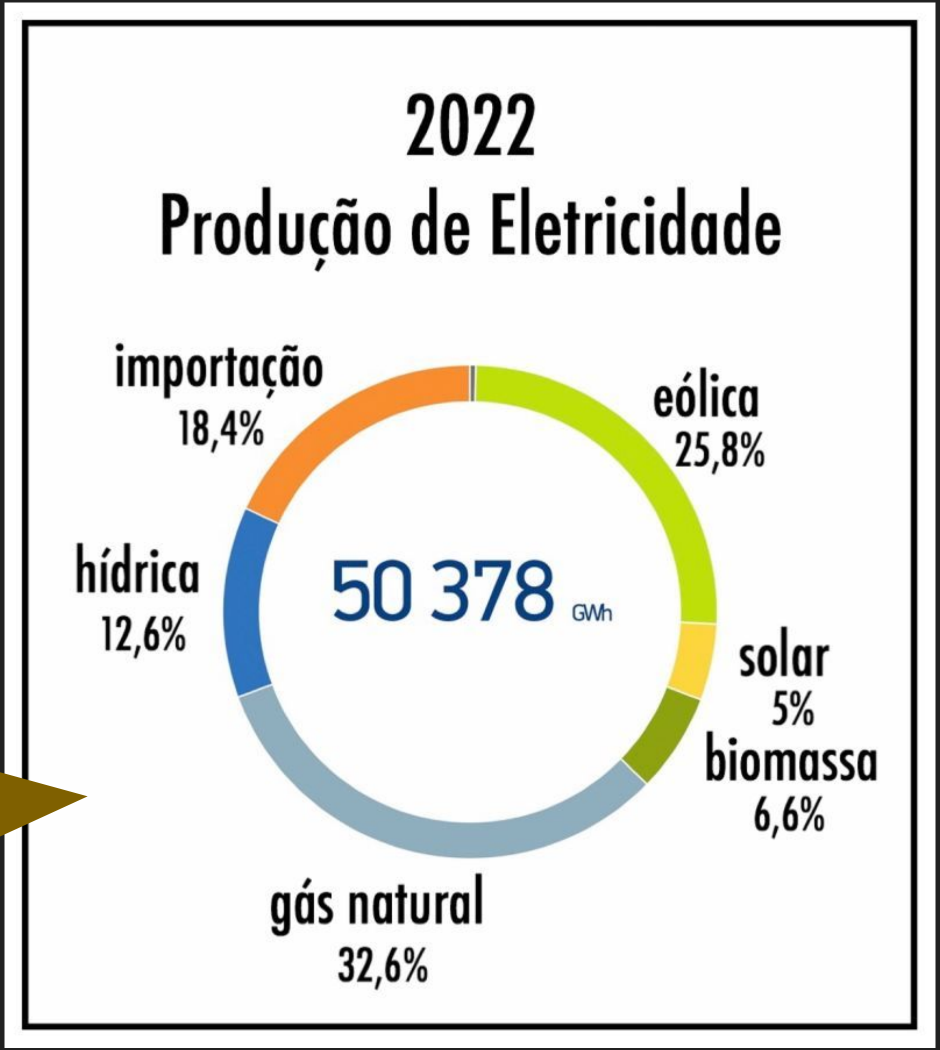


Public net electricity generation in Europe in 2022
Original data ENTSO-E
500
400
300
200
100
0
Energy (TWh)
2022
Year
Hydro pumped storage consumption
Nuclear
Hydro Run-of-River
Biomass
Fossil brown coal / lignite
Fossil coal-derived gas
Fossil hard coal
Fossil oil
Fossil oil shale
Fossil peat
Fossil gas
Geothermal
Hydro water reservoir
Hydro pumped storage
Others
Other renewables
Waste renewable
Waste non-renewable
Wind offshore
Wind onshore
Solar
Load
Energy-Charts.info - last update: 09/06/2022, 5:07 PM GMT+2

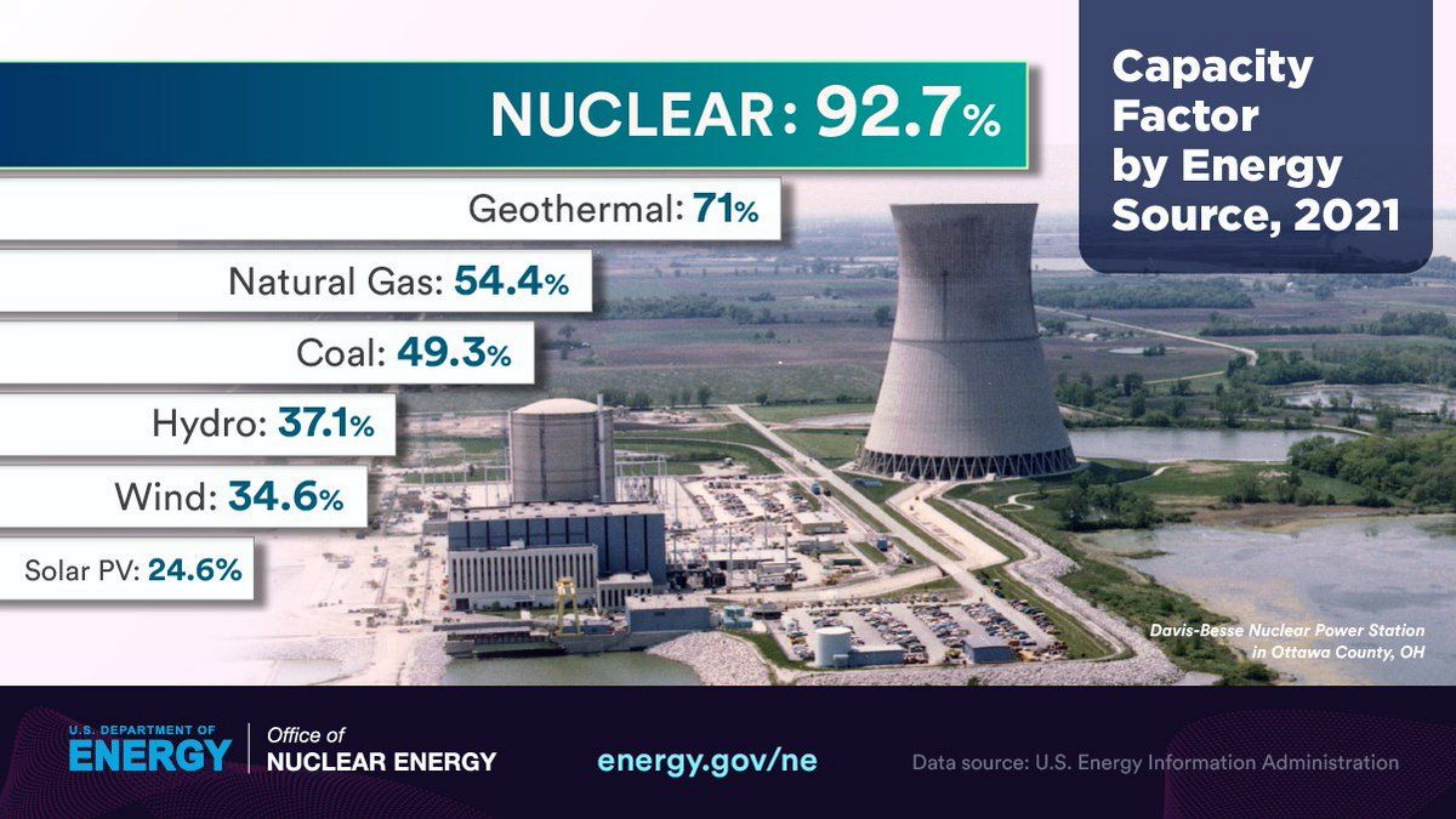
E Portugal?



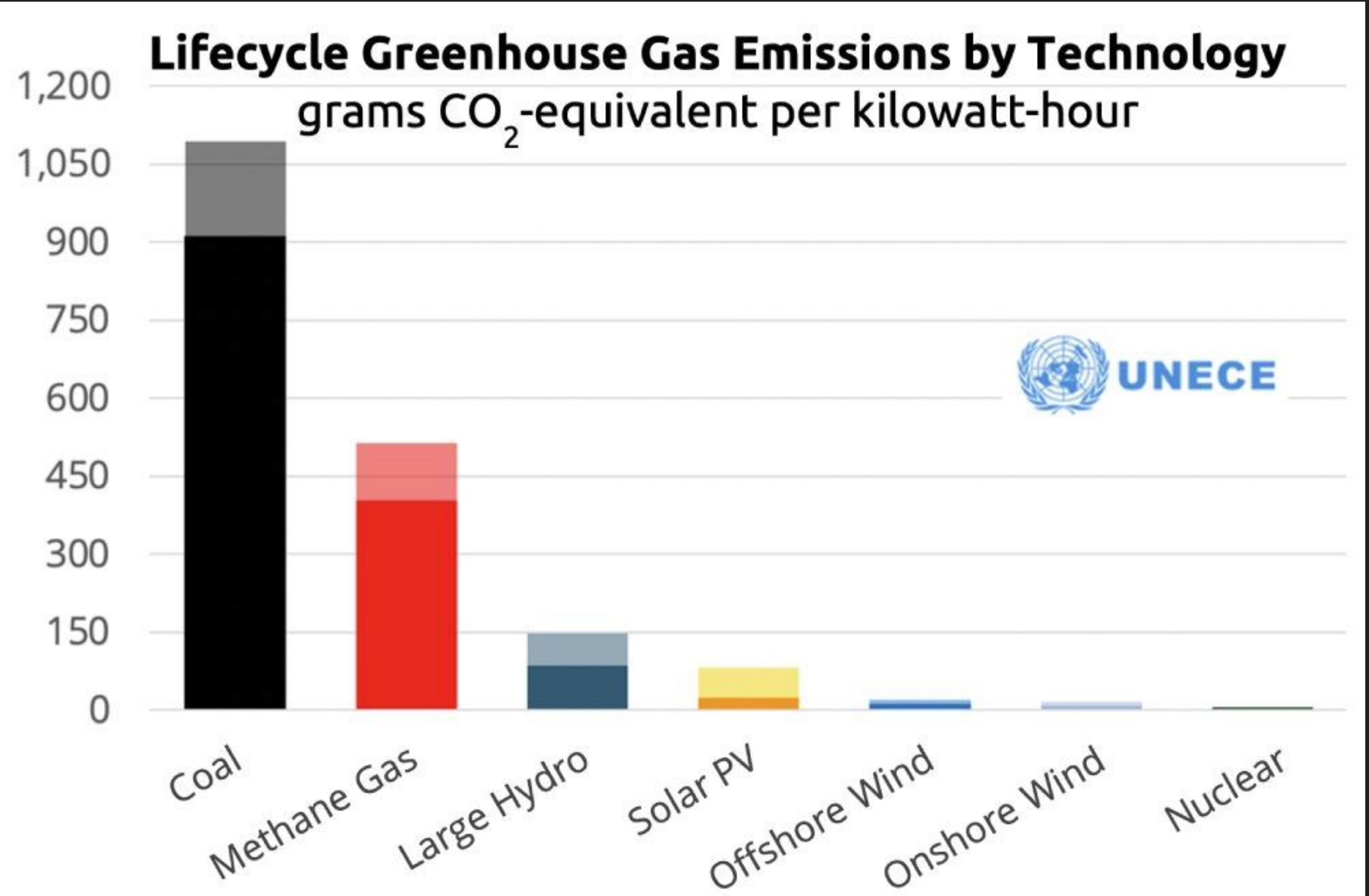
Consumo de energia final em Portugal 2021
Outros 5.8%
Calor 7.1%
Biomassa 6.4%
Petróleo 43.5%
Gás natural 11.7%
Energia elétrica 25.5%
adene
Agência para a Energia
OBSERVATÓRIO DA ENERGIA



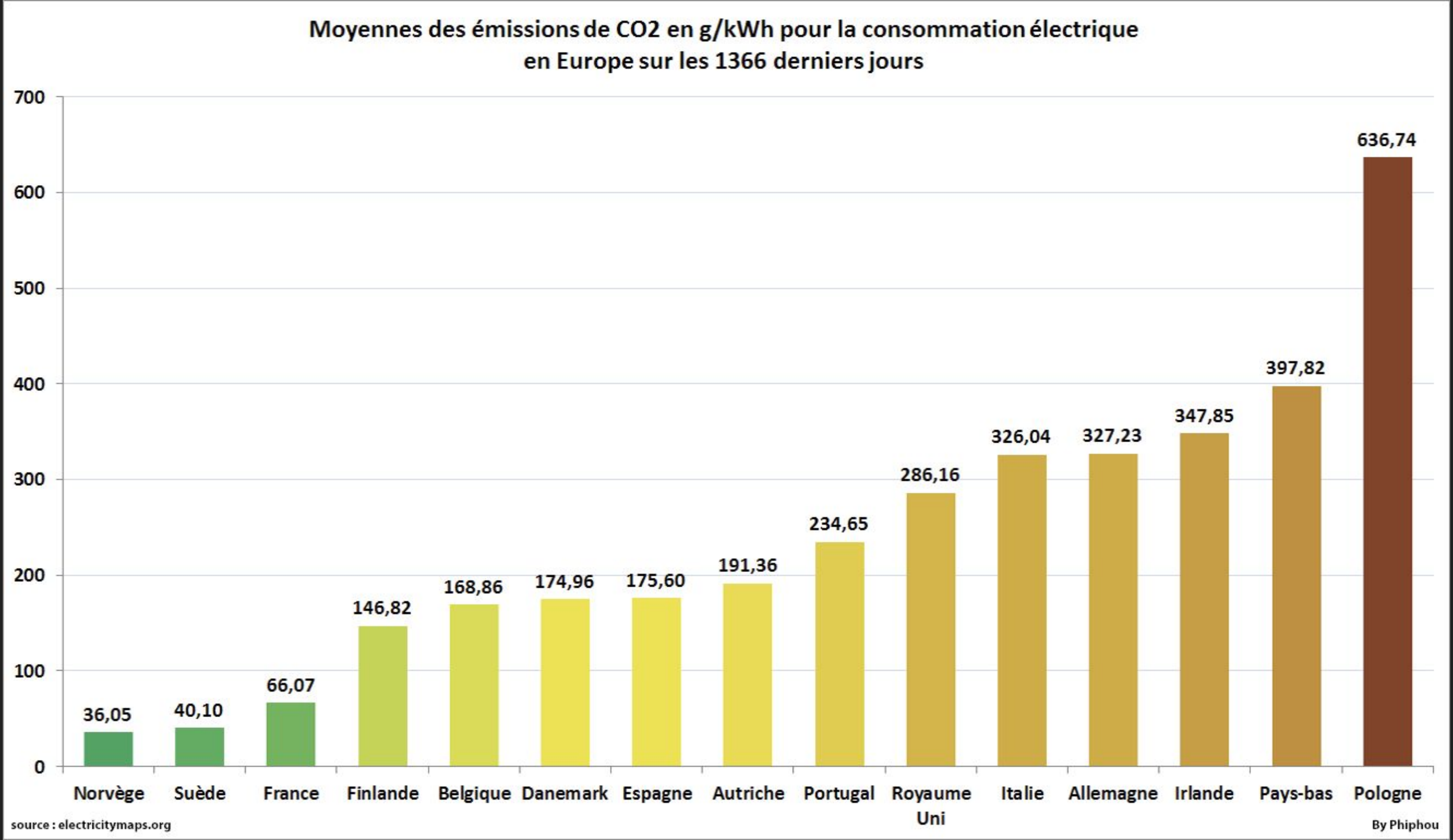
2022
Produção de Eletricidade
importação 18,4%
eólica 25,8%
hídrica 12,6%
50 378 GWh
solar 5%
biomassa 6,6%
gás natural 32,6%


Capacity Factor by Energy Source, 2021
NUCLEAR: 92.7%
Geothermal: 71%
Natural Gas: 54.4%
Coal: 49.3%
Hydro: 37.1%
Wind: 34.6%
Solar PV: 24.6%
Davis-Besse Nuclear Power Station in Ottawa County, OH
U.S. DEPARTMENT OF ENERGY
Office of NUCLEAR ENERGY
energy.gov/ne
Data source: U.S. Energy Information Administration

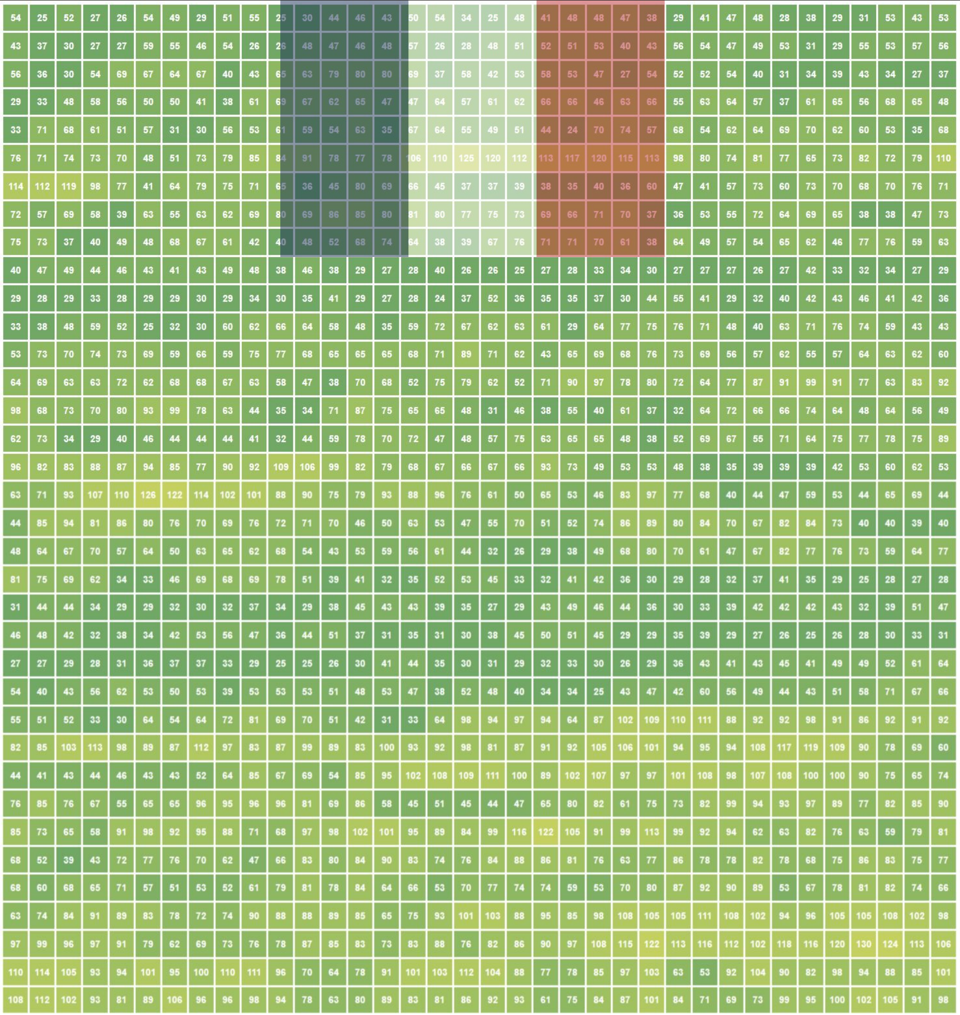
Emissões de CO_2 (e equivalente)

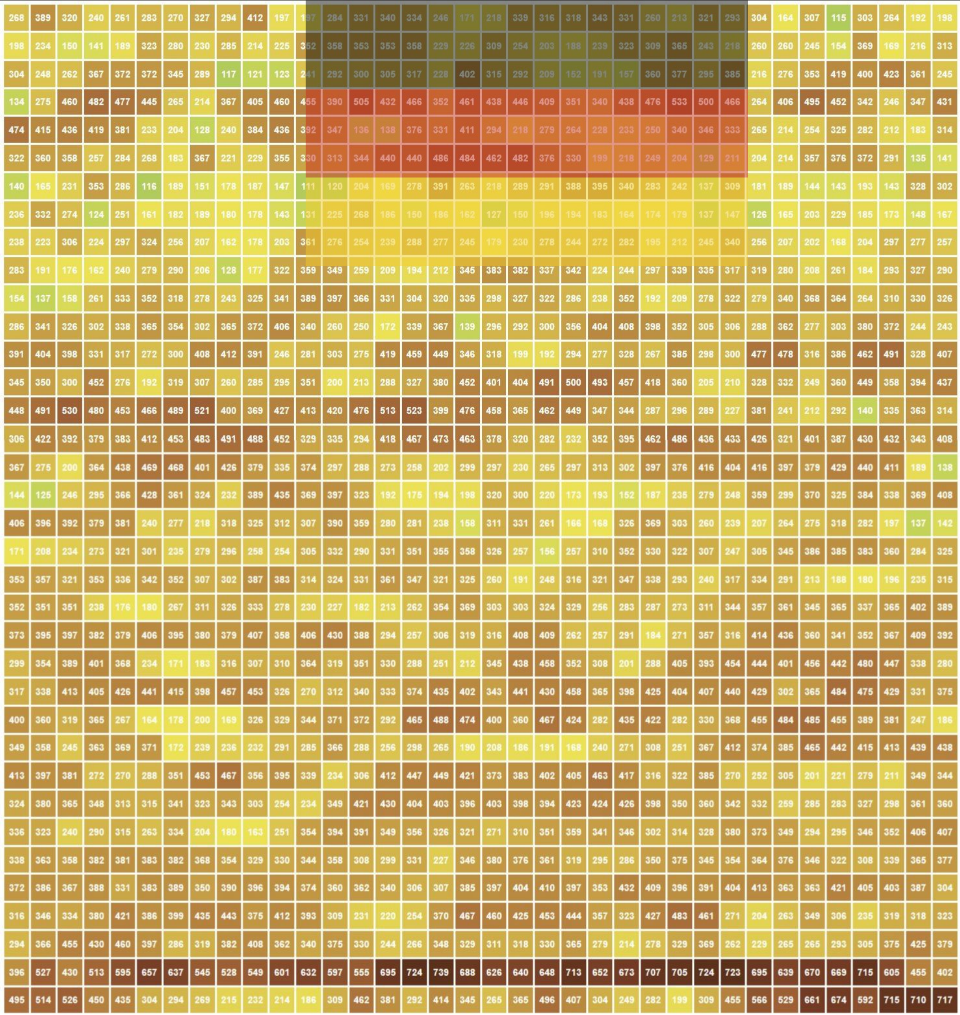


Lifecycle Greenhouse Gas Emissions by Technology
grams CO2-equivalent per kilowatt-hour
1,200
1,050
900
750
600
450
300
150
0
UNECE
Coal
Methane Gas
Large Hydro
Solar PV
Offshore Wind
Onshore Wind
Nuclear

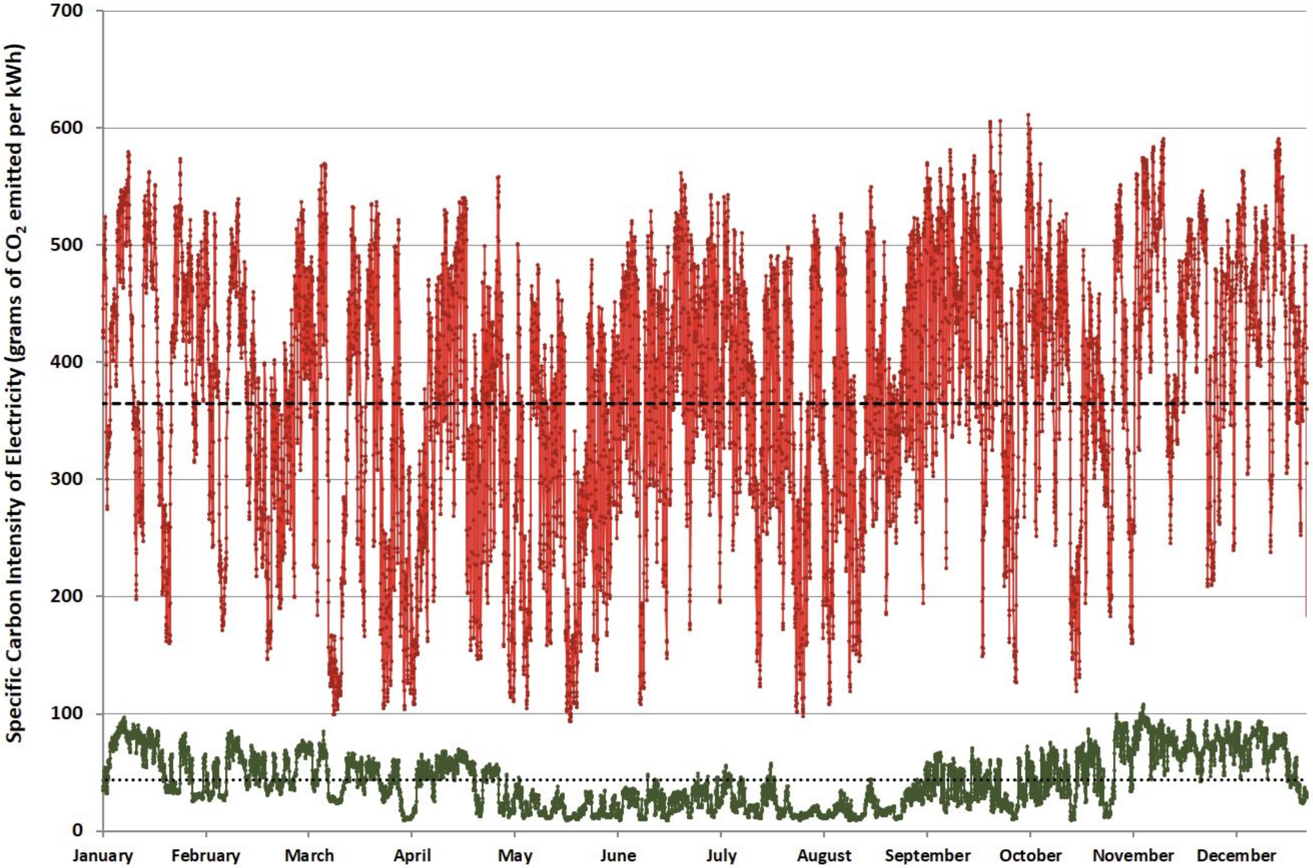

Moyennes des émissions de CO2 en g/kWh pour la consommation électrique
en Europe sur les 1366 derniers jours
700
600
500
400
300
200
100
0
36,05
40,10
66,07
146,82
168,86
174,96
175,60
191,36
234,65
286,16
326,04
327,23
347,85
397,82
636,74
Norvège
Suède
France
Finlande
Belgique
Danemark
Espagne
Autriche
Portugal
Royaume Uni
Italie
Allemagne
Irlande
Pays-bas
Pologne
source : electricitymaps.org
By Phiphou

Comparação de emissões FR-DE para os últimos 4 anos





How dirty was French and German electricity production in 2021?
A Comparison of Hourly Specific Carbon Intensity



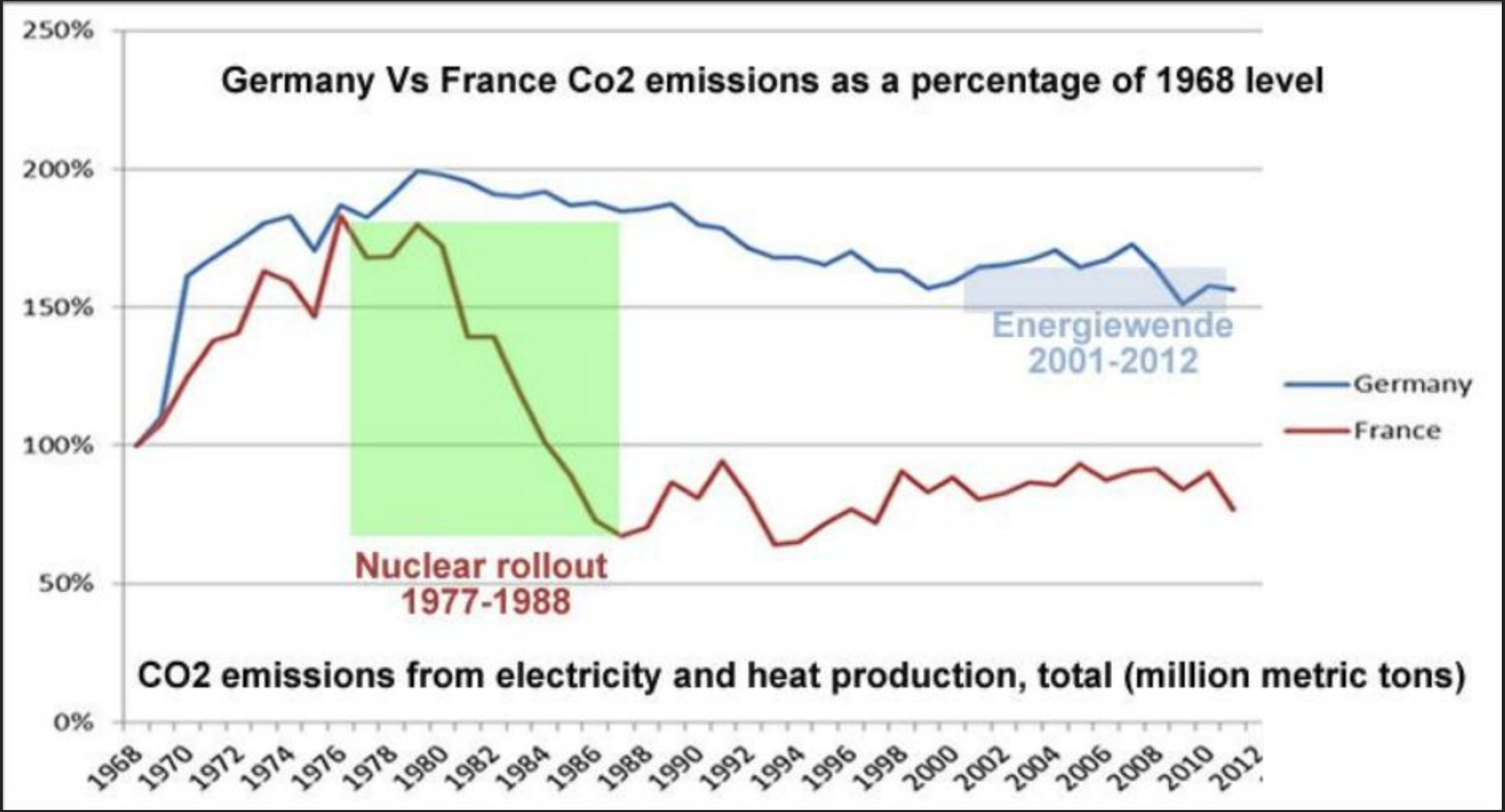
RADIANT
ENERGY GROUP

Germany in 2021:
500 TWh of electricity generated at an average rate of approximately **365 grams of CO_2** emitted per kWh

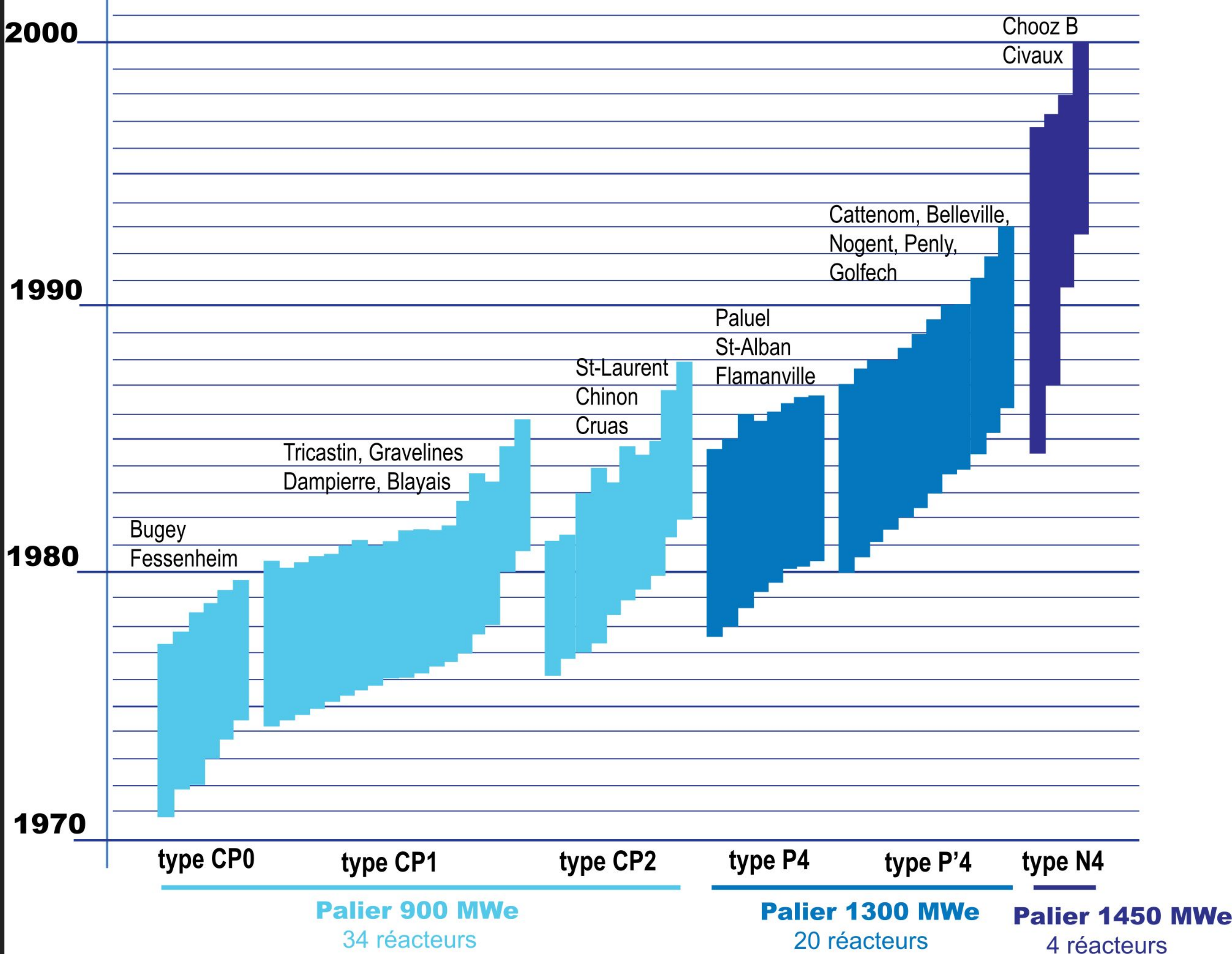
France in 2021:
511 TWh of electricity generated at an average rate of approximately **44 grams of CO_2** emitted per kWh

Hourly generation data from ENTSO-E Transparency Platform as of 12 31 2021. German Specific Carbon Intensity calculated using emissions factors of 1050g, 850g, 400g, and 250g of CO2 per kWh for lignite, hard coal, natural gas, and biomass (respectively). French Specific Carbon Intensity uses RTE-France emissions factors of 486g, 986g, 777g, and 494g for natural gas, coal, oil, and waste (respectively).

MARK NELSON + SID BAGGA
RADIANTENERGYGROUP.COM

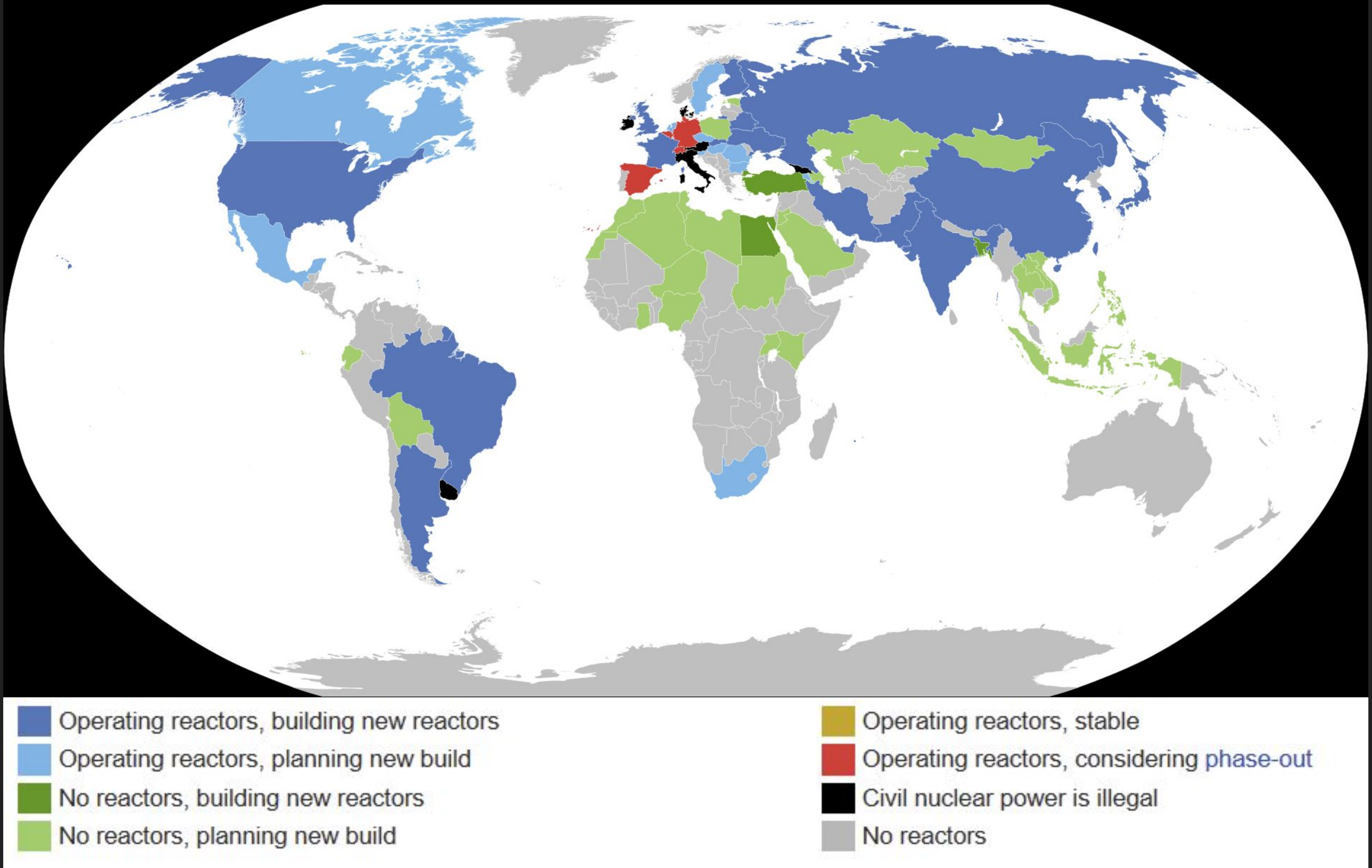

Germany Vs France Co2 emissions as a percentage of 1968 level
250%
200%
150%
100%
50%
0%
Energiewende
2001-2012
Nuclear rollout
1977-1988
Germany
France
CO2 emissions from electricity and heat production, total (million metric tons)
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012

Construção da frota nuclear Francesa



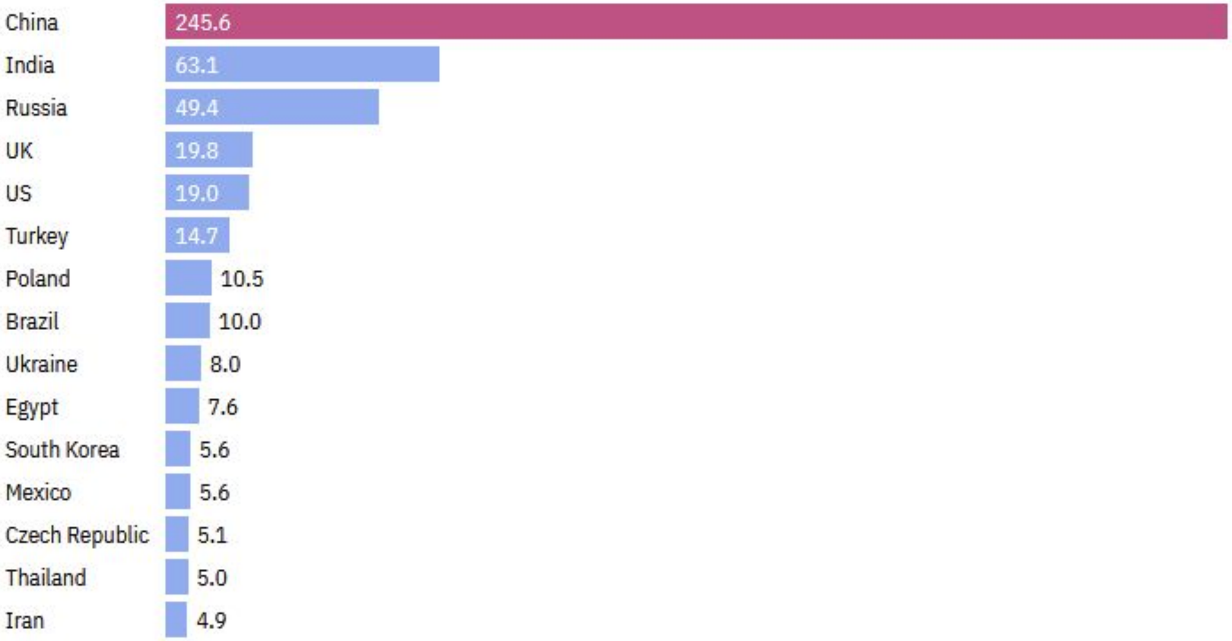
~~Resíduos~~
Combustível Nuclear Gasto
Ou
Combustível de Reatores de Geração IV

Opinião pública


Operating reactors, building new reactors
Operating reactors, planning new build
No reactors, building new reactors
No reactors, planning new build
Operating reactors, stable
Operating reactors, considering phase-out
Civil nuclear power is illegal
No reactors

China's pipeline of new nuclear power is the size of the rest of the world's combined

Countries by new nuclear power capacity pipeline, as of December 2021 (GW)



Data is the aggregate of plants listed by GlobalData as 'under construction', 'announced', 'permitting' and 'financed'.

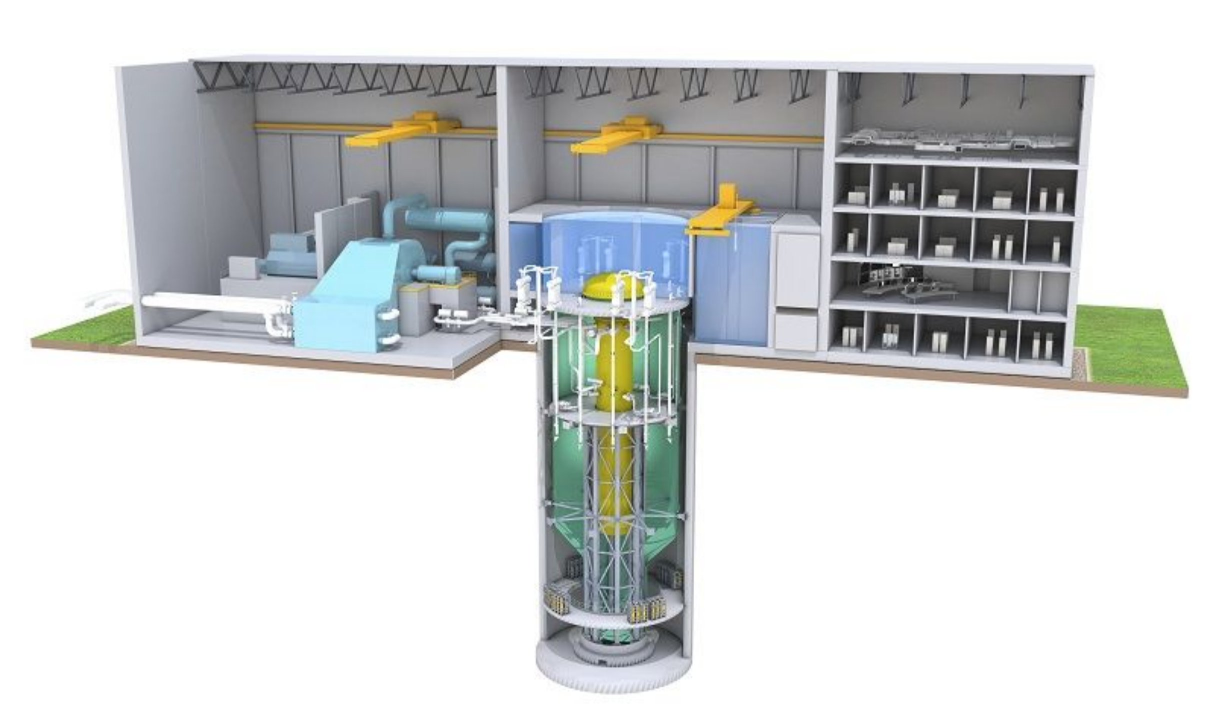
Source: GlobalData

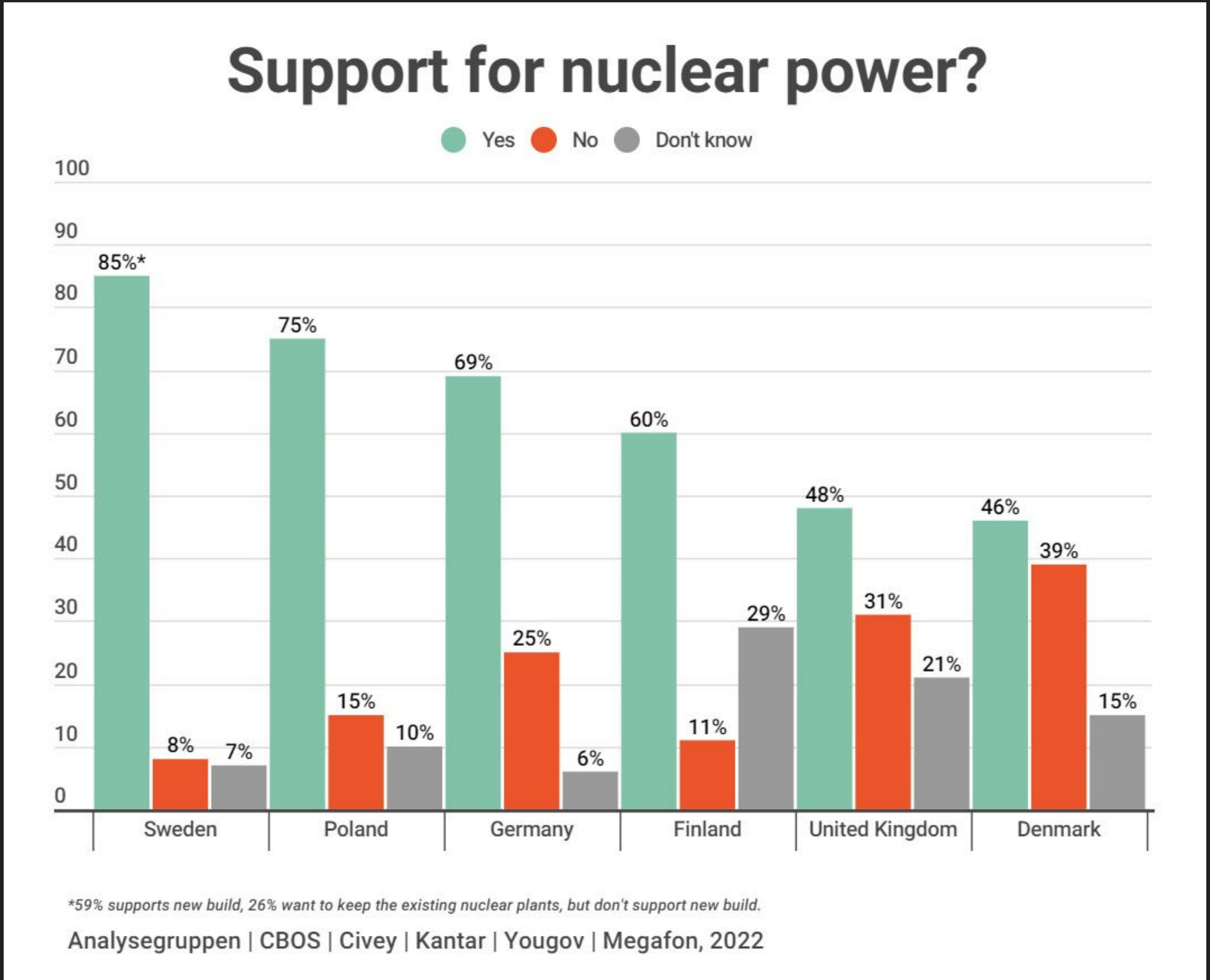
SMRs: Small Modular Reactors

Construídos em série, numa linha de montagem.

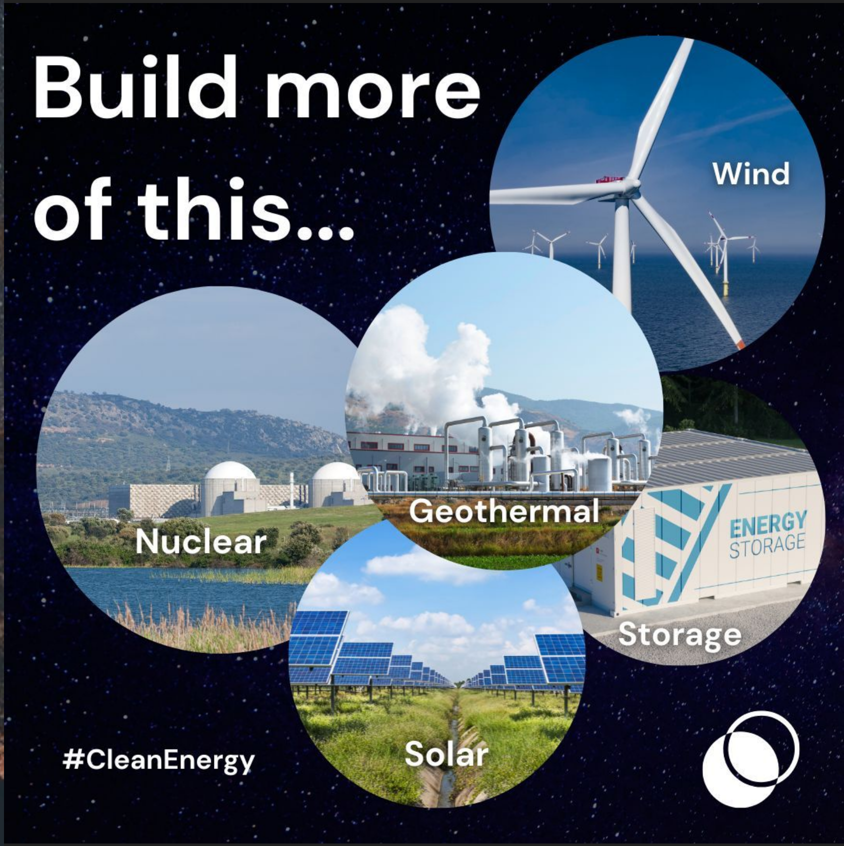
Mais acessíveis para países com menos capital desenvolverem a sua indústria nuclear.

Modelos mais pequenos idealizados para zonas remotas ou nações-ilha.




Support for nuclear power?
Yes
No
Don't know
100
90
80
70
60
50
40
30
20
10
0
85%*
8%
7%
75%
15%
10%
69%
25%
6%
60%
11%
29%
48%
31%
21%
46%
39%
15%
Sweden
Poland
Germany
Finland
United Kingdom
Denmark
*59% supports new build, 26% want to keep the existing nuclear plants, but don't support new build.
Analysegruppen | CBOS | Civey | Kantar | Yougov | Megafon, 2022

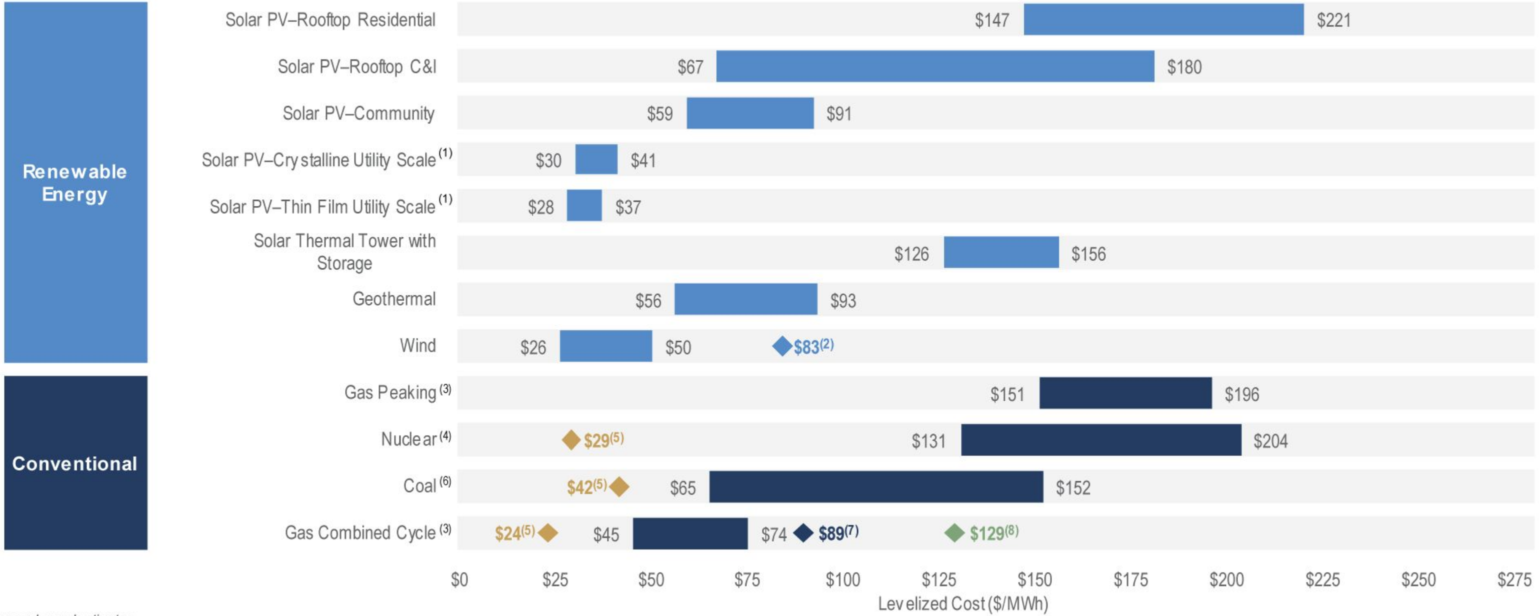

Nothing in life is to be feared, it is only to be understood.
Now is the time to understand more, so that we may fear less.
Marie Curie
REPLANET


Build more of this...
Wind
Nuclear
Geothermal
ENERGY STORAGE
Storage
Solar
#CleanEnergy

Custos

Levelized Cost of Energy Comparison—Unsubsidized Analysis

Selected renewable energy generation technologies are cost-competitive with conventional generation technologies under certain circumstances



Source: *Lazard estimates.*

Note: Here and throughout this presentation, unless otherwise indicated, the analysis assumes 60% debt at 8% interest rate and 40% equity at 12% cost. Please see page titled "Levelized Cost of Energy Comparison—Sensitivity to Cost of Capital" for cost of capital sensitivities. These results are not intended to represent any particular geography. Please see page titled "Solar PV versus Gas Peaking and Wind versus CCGT—Global Markets" for regional sensitivities to selected technologies.

(1) Unless otherwise indicated herein, the low case represents a single-axis tracking system and the high case represents a fixed-tilt system.

(2) Represents the estimated implied midpoint of the LCOE of offshore wind, assuming a capital cost range of approximately $2,500 – $3,600/kW.

(3) The fuel cost assumption for Lazard's global, unsubsidized analysis for gas-fired generation resources is $3.45/MMBTU.

(4) Unless otherwise indicated, the analysis herein does not reflect decommissioning costs, ongoing maintenance-related capital expenditures or the potential economic impacts of federal loan guarantees or other subsidies.

(5) Represents the midpoint of the marginal cost of operating fully depreciated gas combined cycle, coal and nuclear facilities, inclusive of decommissioning costs for nuclear facilities. Analysis assumes that the salvage value for a decommissioned gas combined cycle or coal asset is equivalent to its decommissioning and site restoration costs. Inputs are derived from a benchmark of operating gas combined cycle, coal and nuclear assets across the U.S. Capacity factors, fuel, variable and fixed operating expenses are based on upper- and lower-quartile estimates derived from Lazard's research. Please see page titled "Levelized Cost of Energy Comparison—Renewable Energy versus Marginal Cost of Selected Existing Conventional Generation" for additional details.

(6) High end incorporates 90% carbon capture and storage. Does not include cost of transportation and storage.

(7) Represents the LCOE of the observed high case gas combined cycle inputs using a 20% blend of "Blue" hydrogen, (i.e., hydrogen produced from a steam-methane reformer, using natural gas as a feedstock, and sequestering the resulting CO_2 in a nearby saline aquifer). No plant modifications are assumed beyond a 2% adjustment to the plant's heat rate. The corresponding fuel cost is $5.20/MMBTU, assuming $1.39/kg for Blue hydrogen.

(8) Represents the LCOE of the observed high case gas combined cycle inputs using a 20% blend of "Green" hydrogen, (i.e., hydrogen produced from an electrolyzer powered by a mix of wind and solar generation and stored in a nearby salt cavern). No plant modifications are assumed beyond a 2% adjustment to the plant's heat rate. The corresponding fuel cost is $10.05/MMBTU, assuming $4.15/kg for Green hydrogen.

Unsubsidized Levelized Cost of Energy Comparison (cont'd)

(1) Analysis excludes integration (e.g., grid and conventional generation investment to overcome system intermittency) costs for intermittent technologies.

(2) Low end represents single-axis tracking system. High end represents fixed-tilt design. Assumes 30 MW system in a high insolation jurisdiction (e.g., Southwest U.S.). Does not account for differences in heat coefficients within technologies, balance-of-system costs or other potential factors which may differ across select solar technologies or more specific geographies.

(3) Low and high end represent a concentrating solar tower with 10-hour storage capability. Low end represents an illustrative concentrating solar tower built in South Australia.

(4) Illustrative "PV Plus Storage" unit. PV and battery system (and related bi-directional inverter, power control electronics, etc.) sized to compare with solar thermal with 10-hour storage on capacity factor basis (52%). Assumes storage nameplate "usable energy" capacity of ~400 MWhdc, storage power rating of 110 MWac and ~200 MWac PV system. Implied output degradation of ~0.40%/year (assumes PV degradation of 0.5%/year and battery energy degradation of 1.5%/year, which includes calendar and cycling degradation). Battery round trip DC efficiency of 90% (including auxiliary losses). Storage opex of ~$8/kWh-year and PV O&M expense of ~$9.2/kW DC-year, with 20% discount applied to total opex as a result of synergies (e.g., fewer truck rolls, single team, etc.). Total capital costs of ~$3,456/kW include PV plus battery energy storage system and selected other development costs. Assumes 20-year useful life, although in practice the unit may perform longer. Illustrative system located in Southwest U.S.

(5) Diamond represents an illustrative solar thermal facility without storage capability.

(6) Represents estimated implied midpoint of levelized cost of energy for offshore wind, assuming a capital cost range of $2.36 – $4.50 per watt.

(7) Represents distributed diesel generator with reciprocating engine. Low end represents 95% capacity factor (i.e., baseload generation in poor grid quality geographies or remote locations). High end represents 10% capacity factor (i.e., to overcome periodic blackouts). Assumes replacement capital cost of 65% of initial total capital cost every 25,000 operating hours.

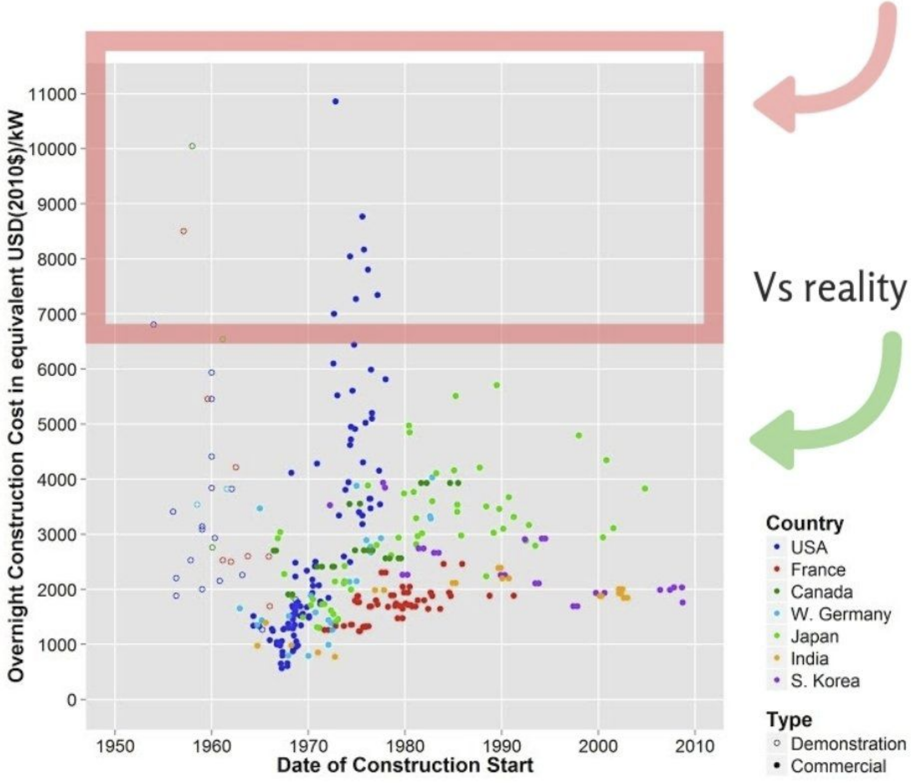
(8) Represents distributed natural gas generator with reciprocating engine. Low end represents 95% capacity factor (i.e., baseload generation in poor grid quality geographies or remote locations). High end represents 30% capacity factor (i.e., to overcome periodic blackouts). Assumes replacement capital cost of 65% of initial total capital cost every 60,000 operating hours.

(9) Does not include cost of transportation and storage. Low and high end depicts an illustrative recent IGCC facility located in the U.S.

(10) Does not reflect decommissioning costs or potential economic impact of federal loan guarantees or other subsidies. Low and high end depicts an illustrative nuclear plant using the AP1000 design.

(11) Reflects average of Northern Appalachian Upper Ohio River Barge and Pittsburgh Seam Rail coal. High end incorporates 90% carbon capture and compression. Does not include cost of transportation and storage.

Lazard's assumption of capital cost of nuclear

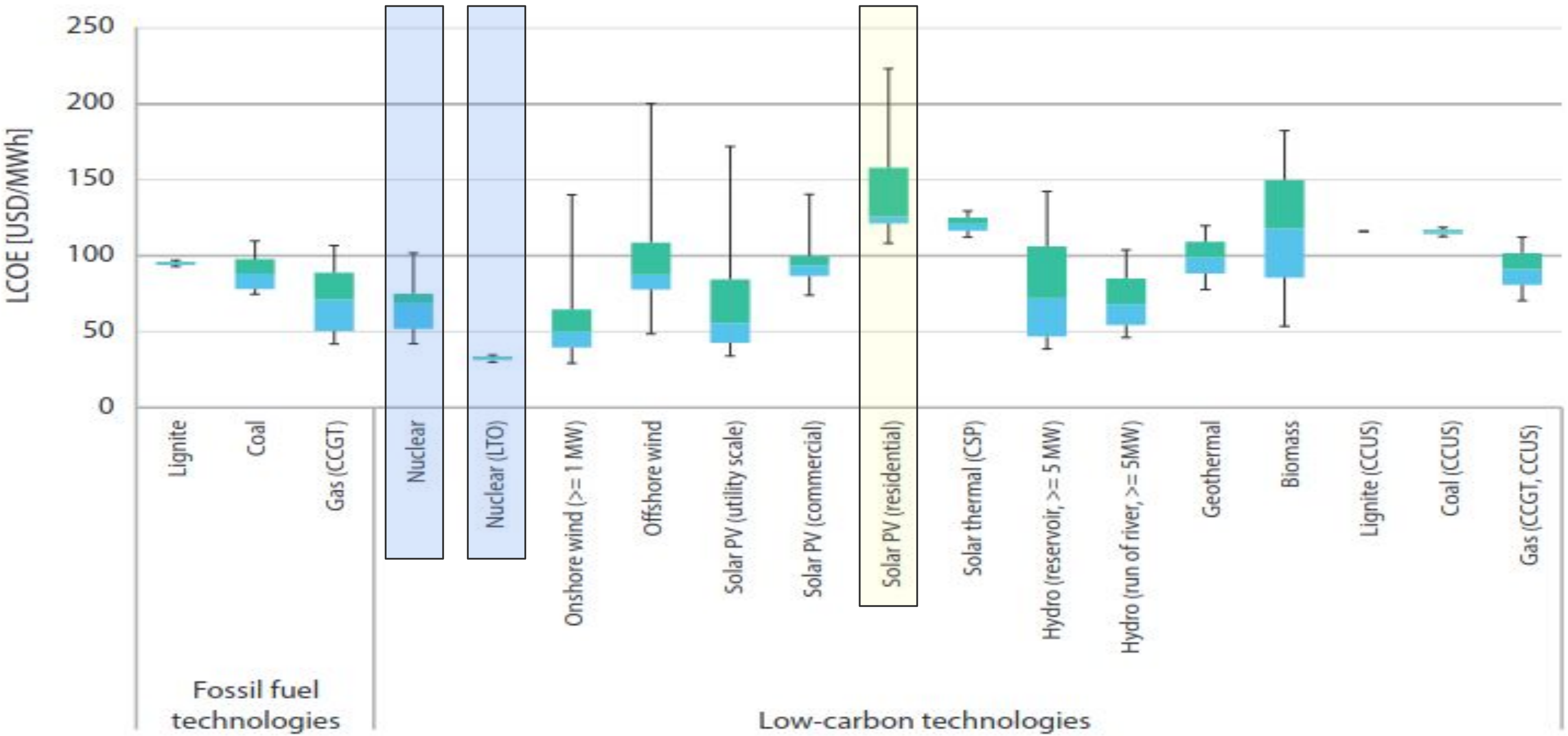


Source: Lovering et al 2016: *Historical construction costs of global nuclear power reactors*

Thoughtscapism

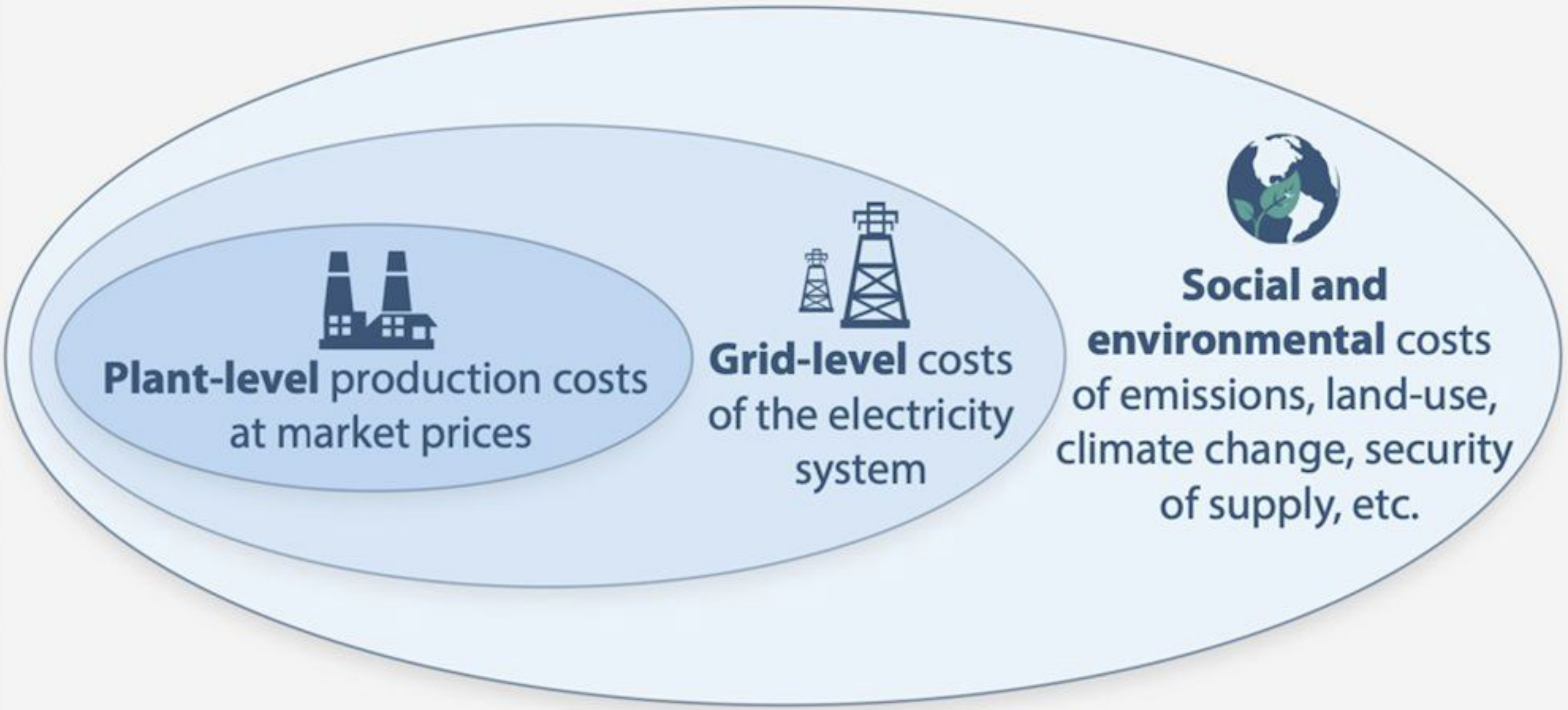
IEA: Projected Costs of Generating Electricity, 2020 Edition

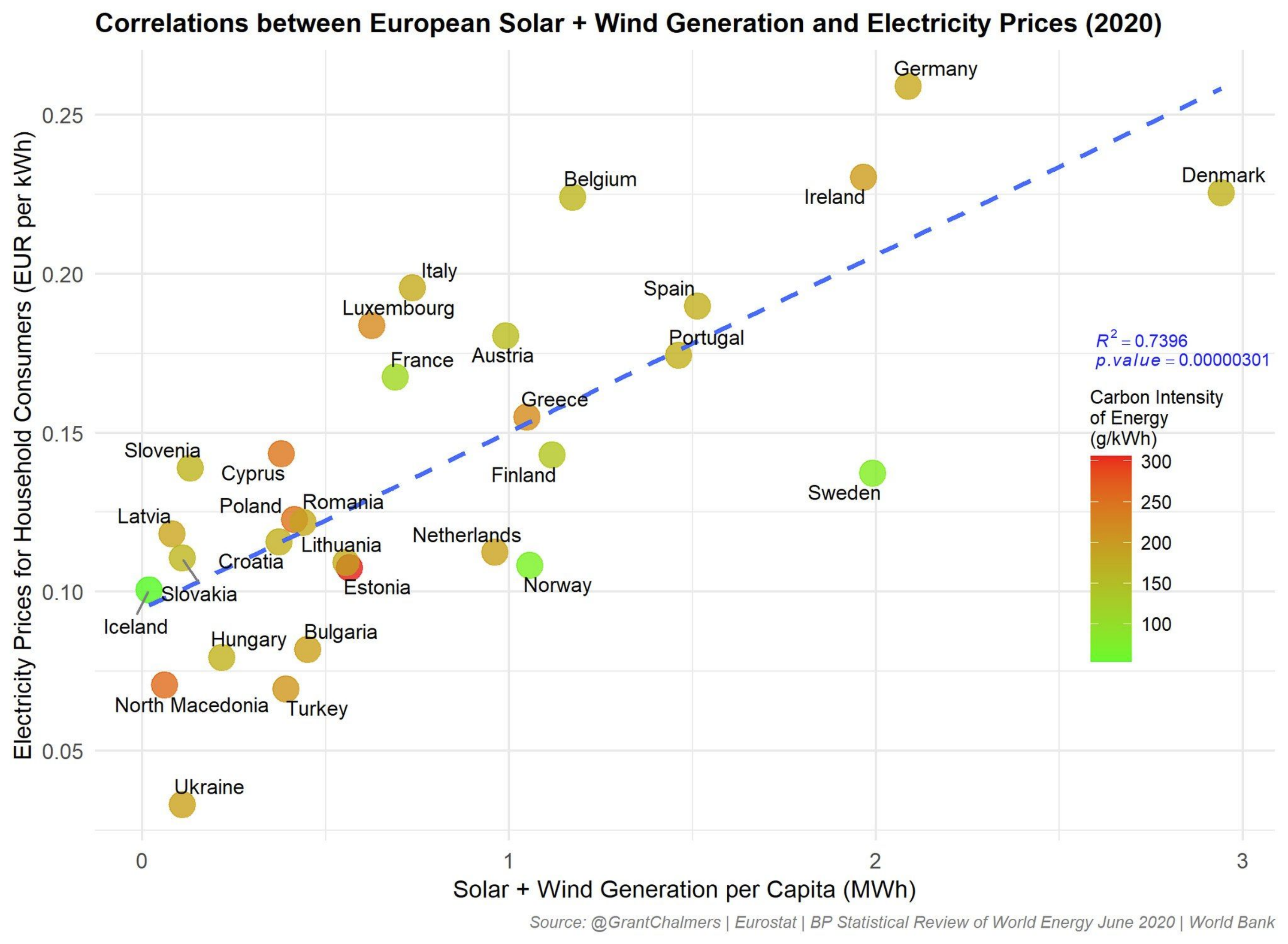
Figure ES1: LCOE by technology



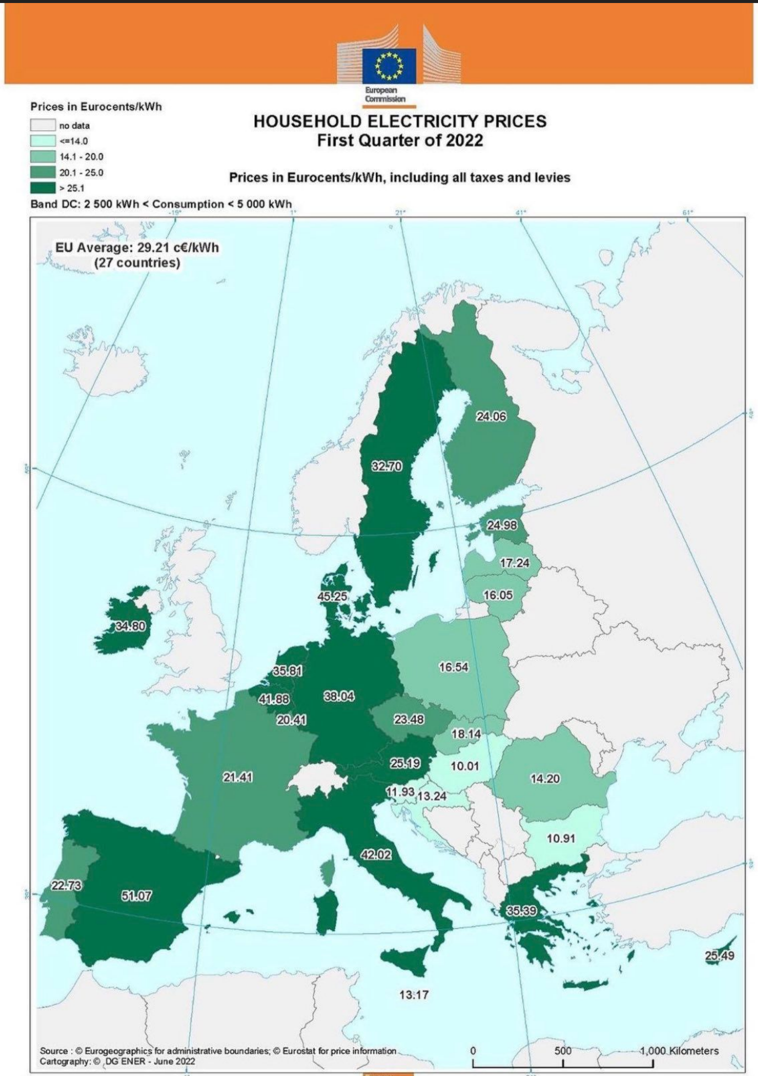
Note: Values at 7% discount rate. Box plots indicate maximum, median and minimum values. The boxes indicate the central 50% of values, i.e. the second and the third quartile.

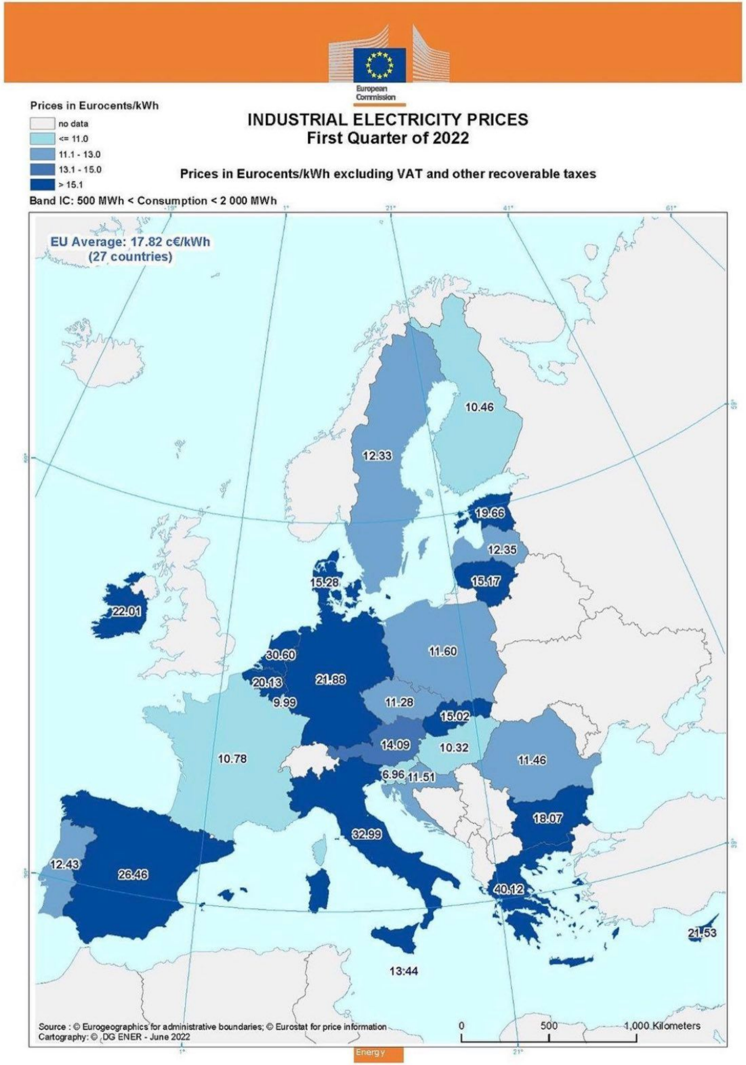
System Costs of Electricity



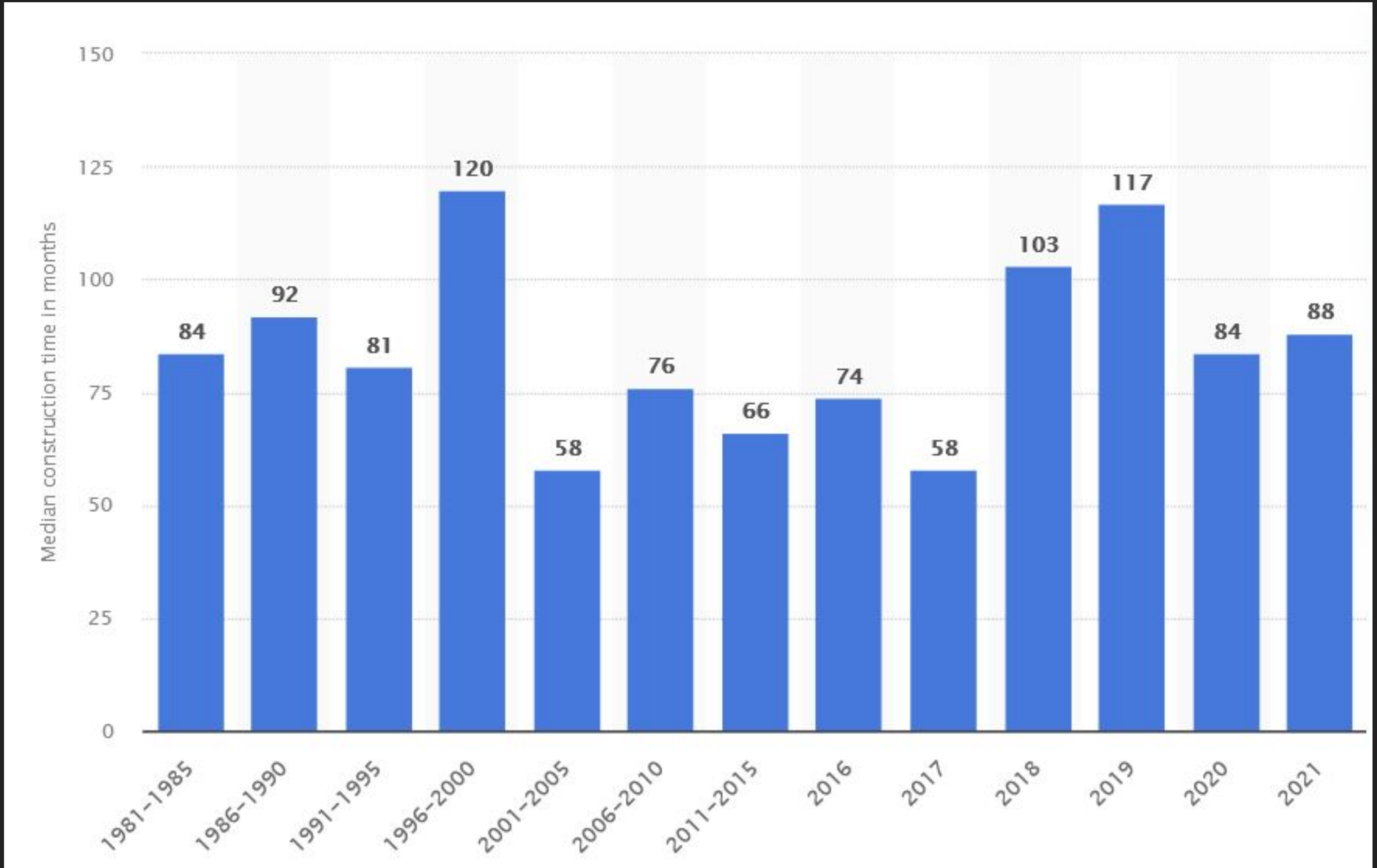


Correlations between European Solar + Wind Generation and Electricity Prices (2020)
Electricity Prices for Household Consumers (EUR per kWh)
0.25
0.20
0.15
0.10
0.05
Solar + Wind Generation per Capita (MWh)
0
1
2
3
Germany
Belgium
Ireland
Denmark
Italy
Luxembourg
Spain
Portugal
Austria
France
Greece
Slovenia
Cyprus
Finland
Sweden
Latvia
Poland
Romania
Lithuania
Netherlands
Croatia
Estonia
Norway
Slovakia
Iceland
Hungary
Bulgaria
North Macedonia
Turkey
Ukraine
$R^2 = 0.7396$
$p.value = 0.00000301$
Carbon Intensity of Energy (g/kWh)
300
250
200
150
100
Source: @GrantChalmers | Eurostat | BP Statistical Review of World Energy June 2020 | World Bank

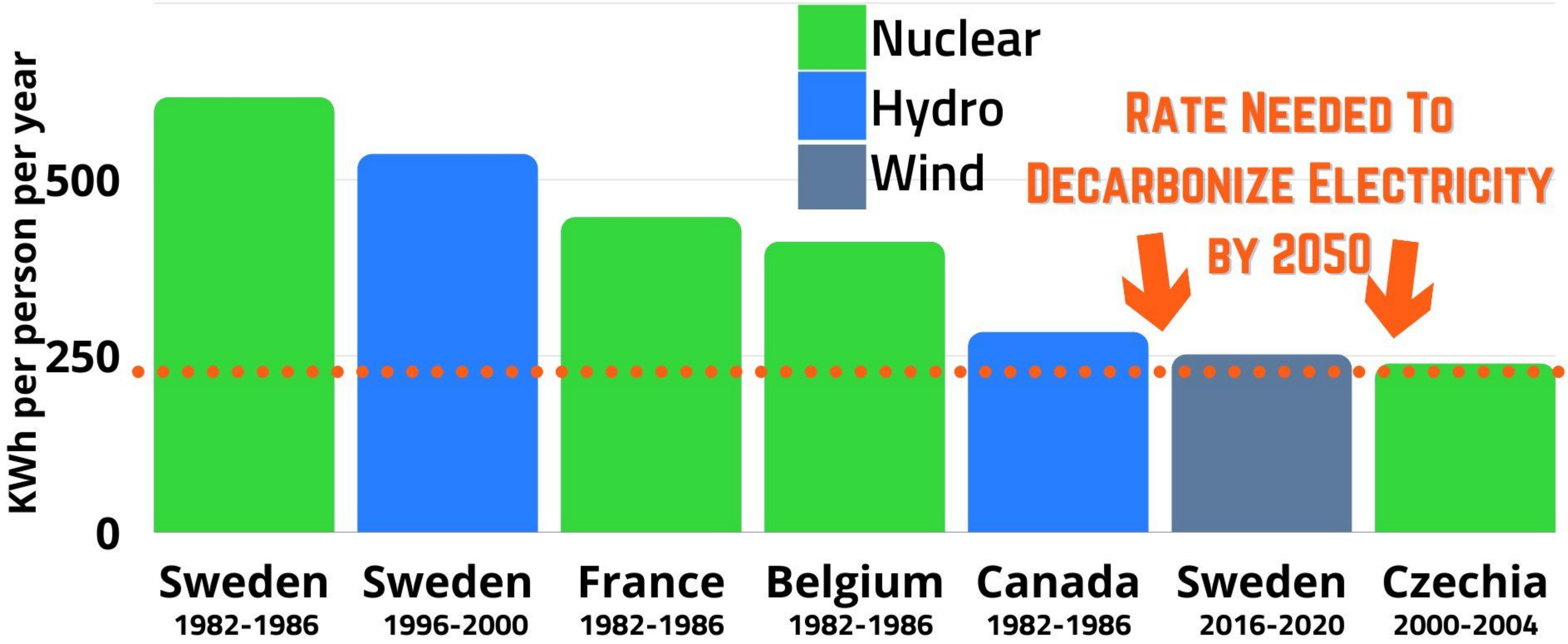

European Commission
HOUSEHOLD ELECTRICITY PRICES
First Quarter of 2022
Prices in Eurocents/kWh
no data
<=14.0
14.1 - 20.0
20.1 - 25.0
> 25.1
Prices in Eurocents/kWh, including all taxes and levies
Band DC: 2 500 kWh < Consumption < 5 000 kWh
EU Average: 29.21 c€/kWh
(27 countries)
24.06
32.70
24.98
17.24
16.05
45.25
34.80
35.81
38.04
16.54
41.88
20.41
23.48
18.14
21.41
25.19
10.01
14.20
11.93
13.24
10.91
42.02
22.73
51.07
35.39
25.49
13.17
Source : © Eurogeographics for administrative boundaries; © Eurostat for price information
Cartography: © DG ENER - June 2022
0
500
1,000 Kilometers


European Commission
INDUSTRIAL ELECTRICITY PRICES
First Quarter of 2022
Prices in Eurocents/kWh
no data
<= 11.0
11.1 - 13.0
13.1 - 15.0
> 15.1
Prices in Eurocents/kWh excluding VAT and other recoverable taxes
Band IC: 500 MWh < Consumption < 2 000 MWh
EU Average: 17.82 c€/kWh
(27 countries)
10.46
12.33
19.66
12.35
15.28
15.17
22.01
30.60
11.60
20.13
21.88
9.99
11.28
15.02
14.09
10.32
10.78
11.46
6.96
11.51
18.07
32.99
12.43
26.46
40.12
21.53
13.44
Source : © Eurogeographics for administrative boundaries; © Eurostat for price information
Cartography: © DG ENER - June 2022
0
500
1,000 Kilometers
Energy

Tempo mediano em meses para a construção de reatores - IAEA

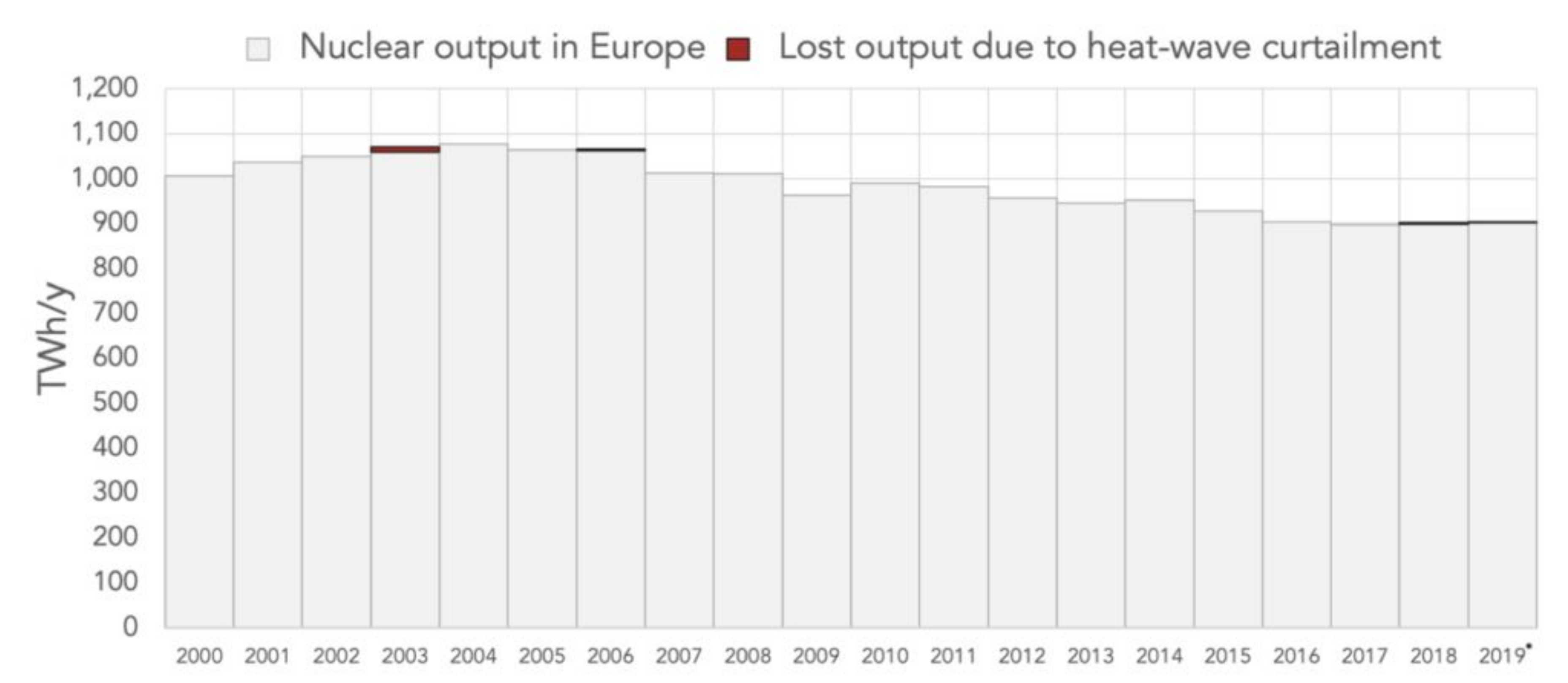


FASTEST CLEAN ENERGY BUILDS IN HISTORY*

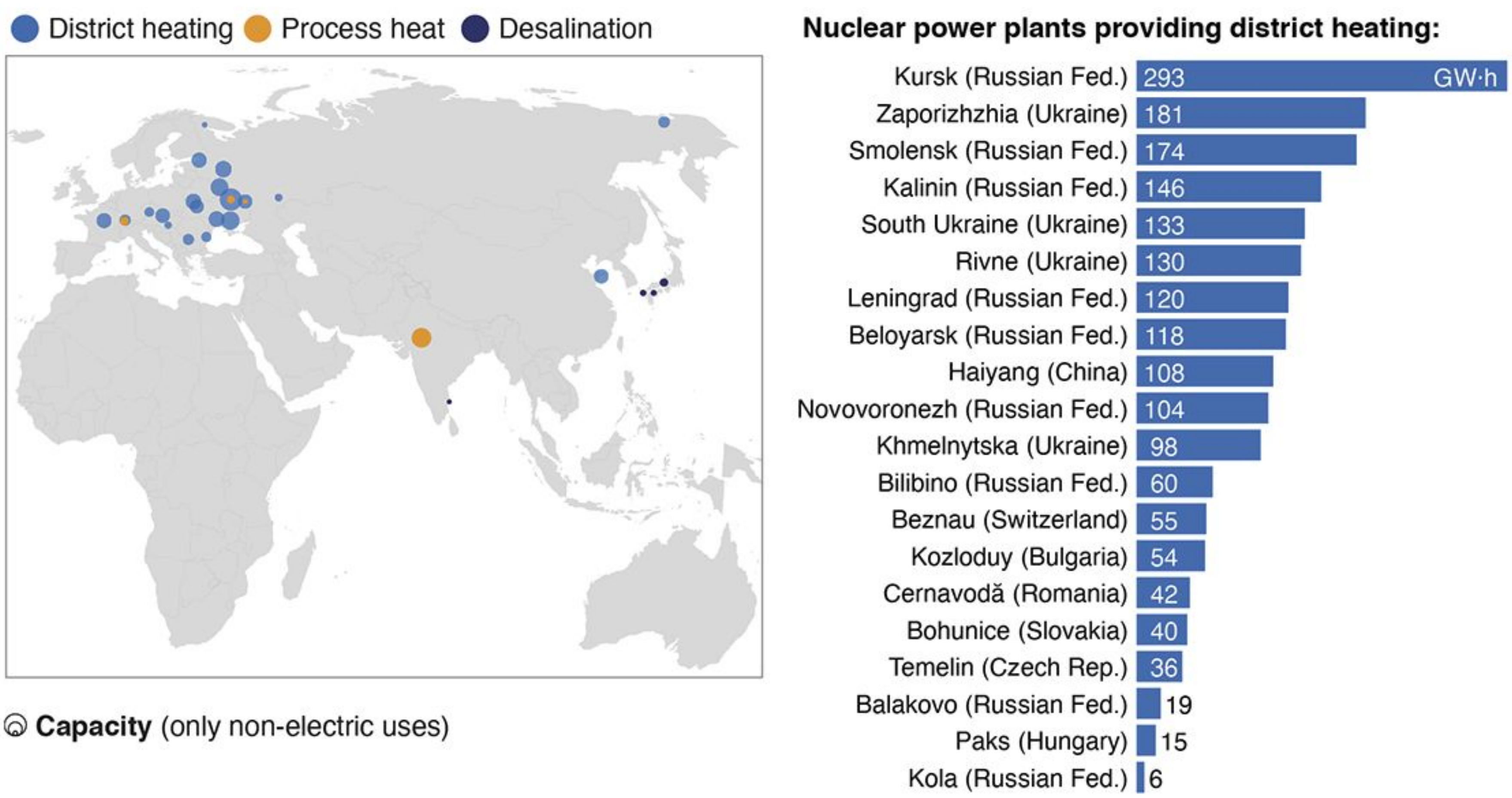


*Countries of more than ten million people.

Sources: BP World Energy Review, 2021.
Assuming all existing generation is retired by 2050.
Data: https://bit.ly/energygrowthrate. Analysis by volunteer engineers.



Nuclear output in Europe
Lost output due to heat-wave curtailment
TWh/y
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019*

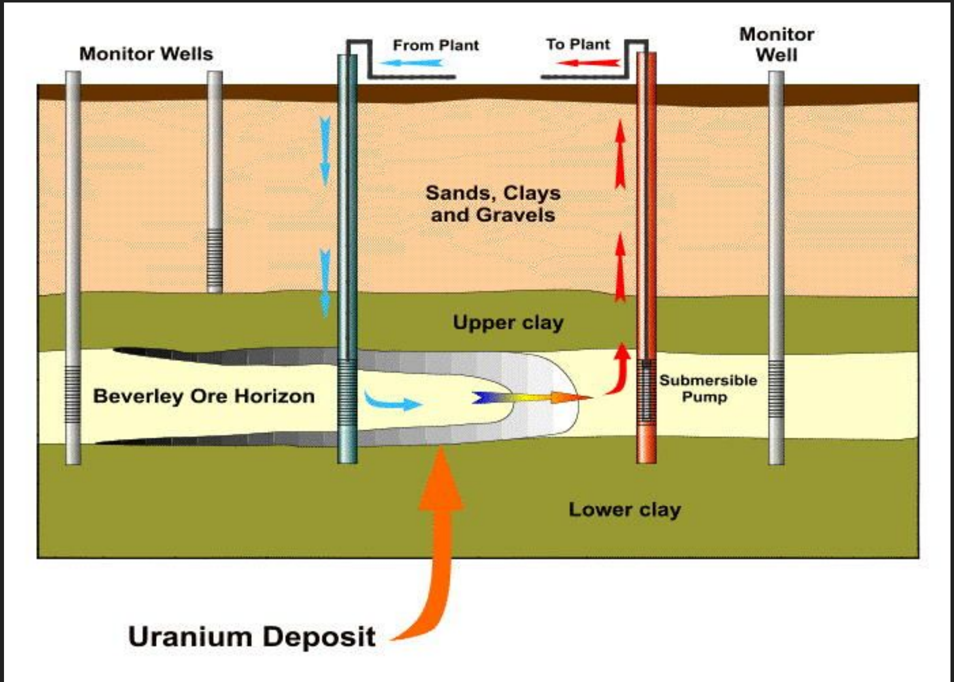


District heating
Process heat
Desalination
Capacity (only non-electric uses)
Nuclear power plants providing district heating:
Kursk (Russian Fed.) 293 GW·h
Zaporizhzhia (Ukraine) 181
Smolensk (Russian Fed.) 174
Kalinin (Russian Fed.) 146
South Ukraine (Ukraine) 133
Rivne (Ukraine) 130
Leningrad (Russian Fed.) 120
Beloyarsk (Russian Fed.) 118
Haiyang (China) 108
Novovoronezh (Russian Fed.) 104
Khmelnytska (Ukraine) 98
Bilibino (Russian Fed.) 60
Beznau (Switzerland) 55
Kozloduy (Bulgaria) 54
Cernavodă (Romania) 42
Bohunice (Slovakia) 40
Temelin (Czech Rep.) 36
Balakovo (Russian Fed.) 19
Paks (Hungary) 15
Kola (Russian Fed.) 6


SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS

Mineração de Urânio

Maior mina de Urânio dos USA.
Utiliza *In-Situ Leeching*.
Impacto ambiental mínimo.




55
61
55
MSC Arnoldsweiler 1969 eV
Elsdorf
Jabiru Aerodrome
Aussichtspunkt - Terra Nova 1
Kakadu
Forêt de Hambach
Mine d'Uranium Ranger
Aussichtspunkt Tagebau Hambach
Haus Forst Deponie
Niederzier
thyssenkrupp Stützpunkt Tagebau...
55
4

Electricity from Vattenfall Nordic Nuclear Power Plants

https://www.environdec.com/library/epd923

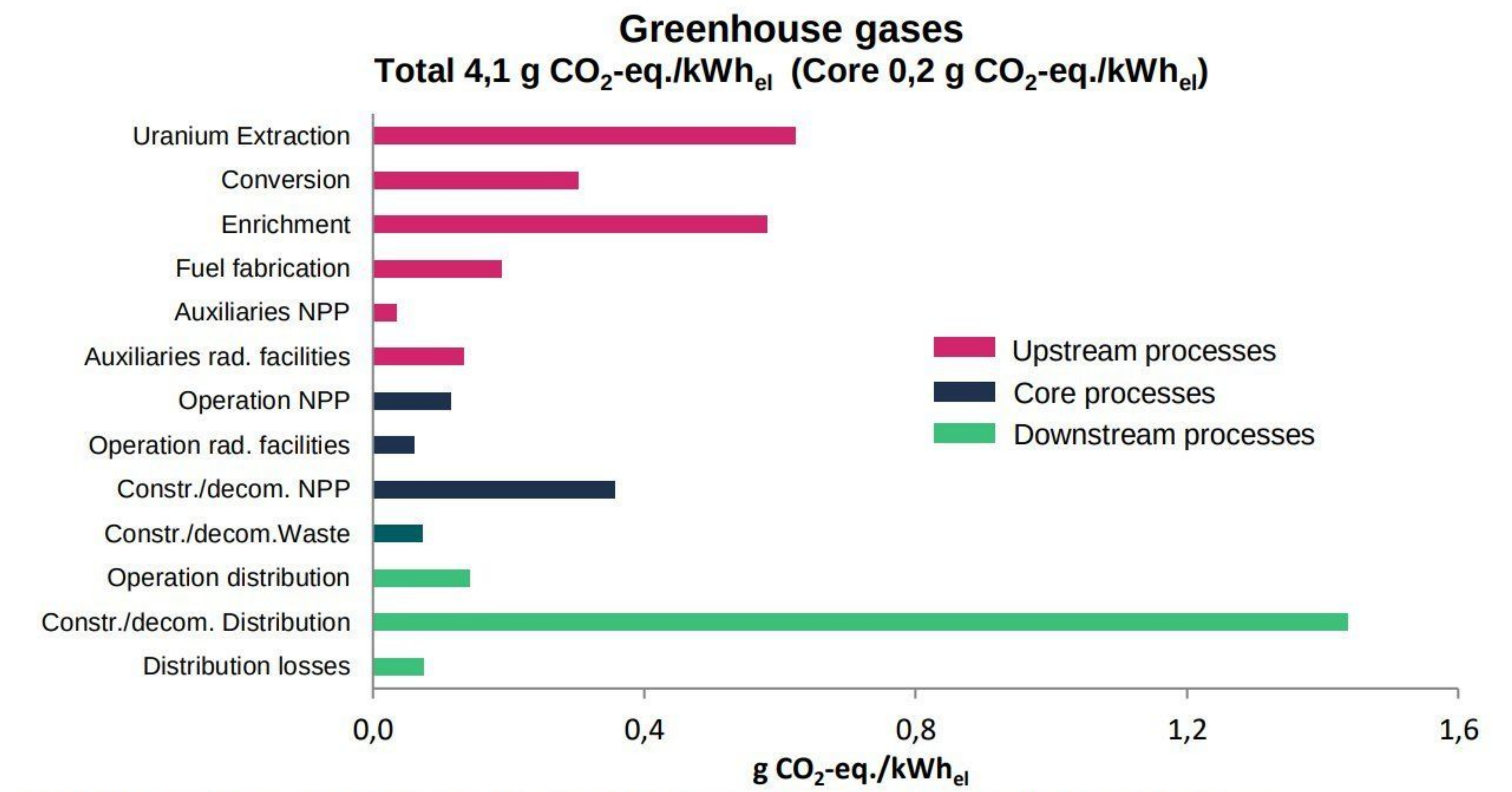
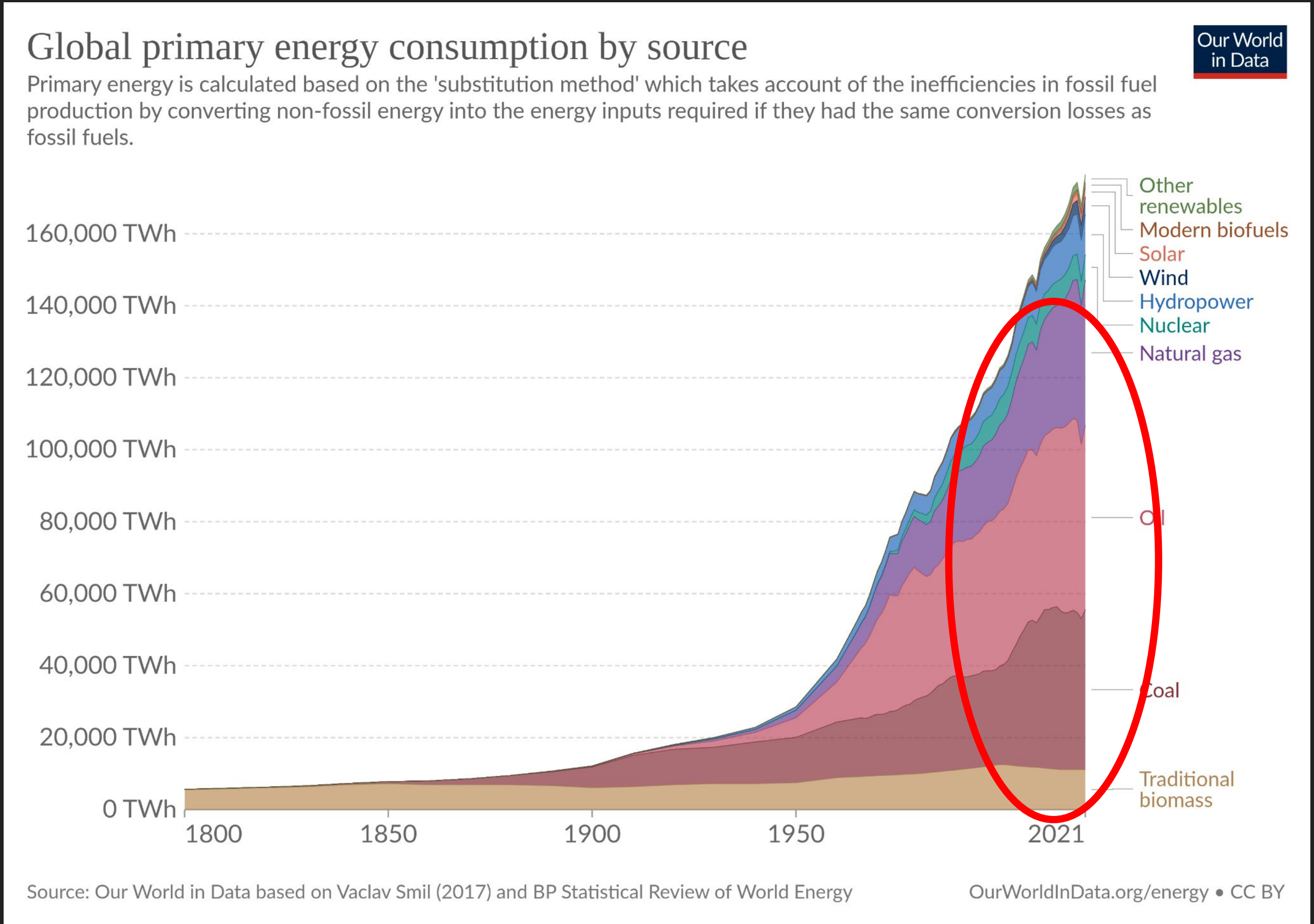


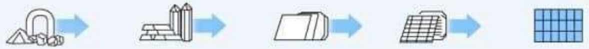
Figure 8 Greenhouse gas emissions (biogenic CO_2 is excluded) distributed on the life cycle stages

É isto que deve ser substituído



Who Controls the Solar Panel Supply Chain?

The Manufacturing Process for Solar PV Panels



POLYSILICON — The primary material for solar PV manufacturing which is melted and cast into ingots.

INGOT — Polysilicon ingots are sliced into thin wafer sheets ranging from 150-280 micrometers in thickness.

WAFER — The wafer is then cleaned and doped to manufacture a crystalline solar cell.

CELL — Multiple cells are wired together and laminated to form modules, before being connected to panels.

MODULE / PANEL

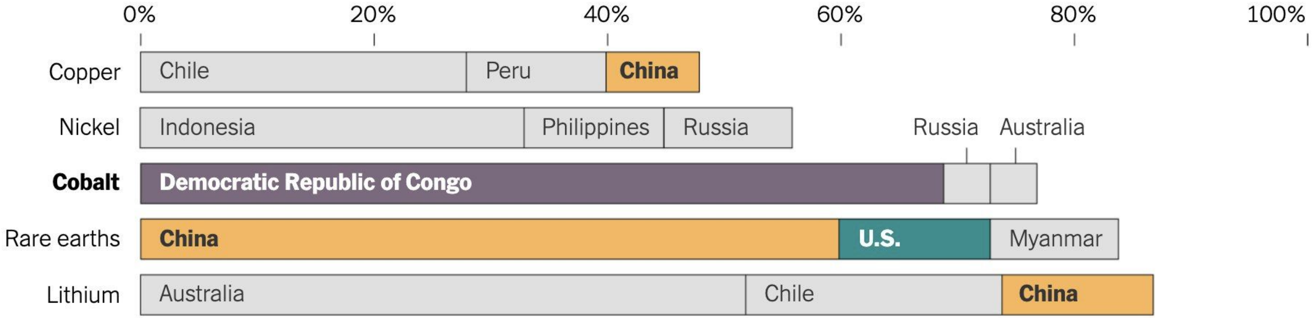
Share of Manufacturing Capacity by Country/Region in 2021

China made up **55%** of global solar panel manufacturing capacity in 2010, with its share rising to **84%** in 2021.

The total value of global solar PV related trade increased by more than **70%** YoY to reach over **$40B** in 2021.

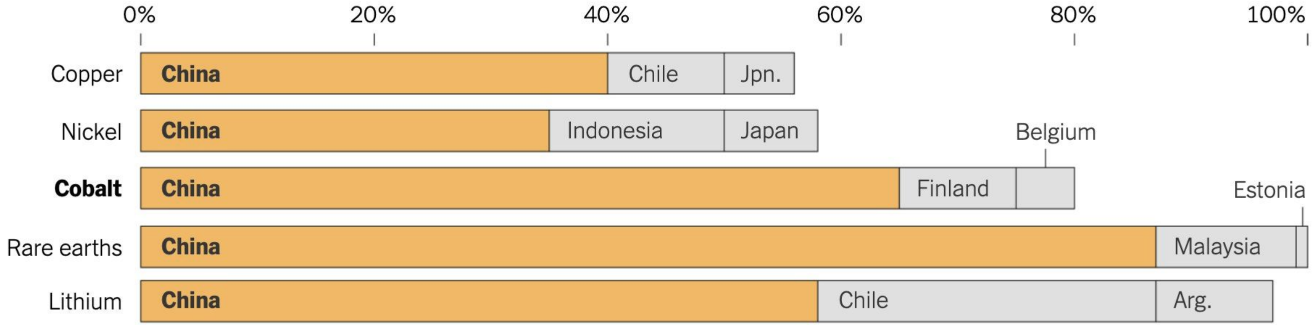
Where Clean Energy Metals Are Produced

Production of key resources is highly concentrated today. Charts show the top three producers.



And Where They Are Processed

China dominates the refining and processing of key metals.



Source: International Energy Agency • By The New York Times

China leads world in production of minerals needed for clean energy

Share of top three countries for extraction and processing of key minerals and fossil fuels

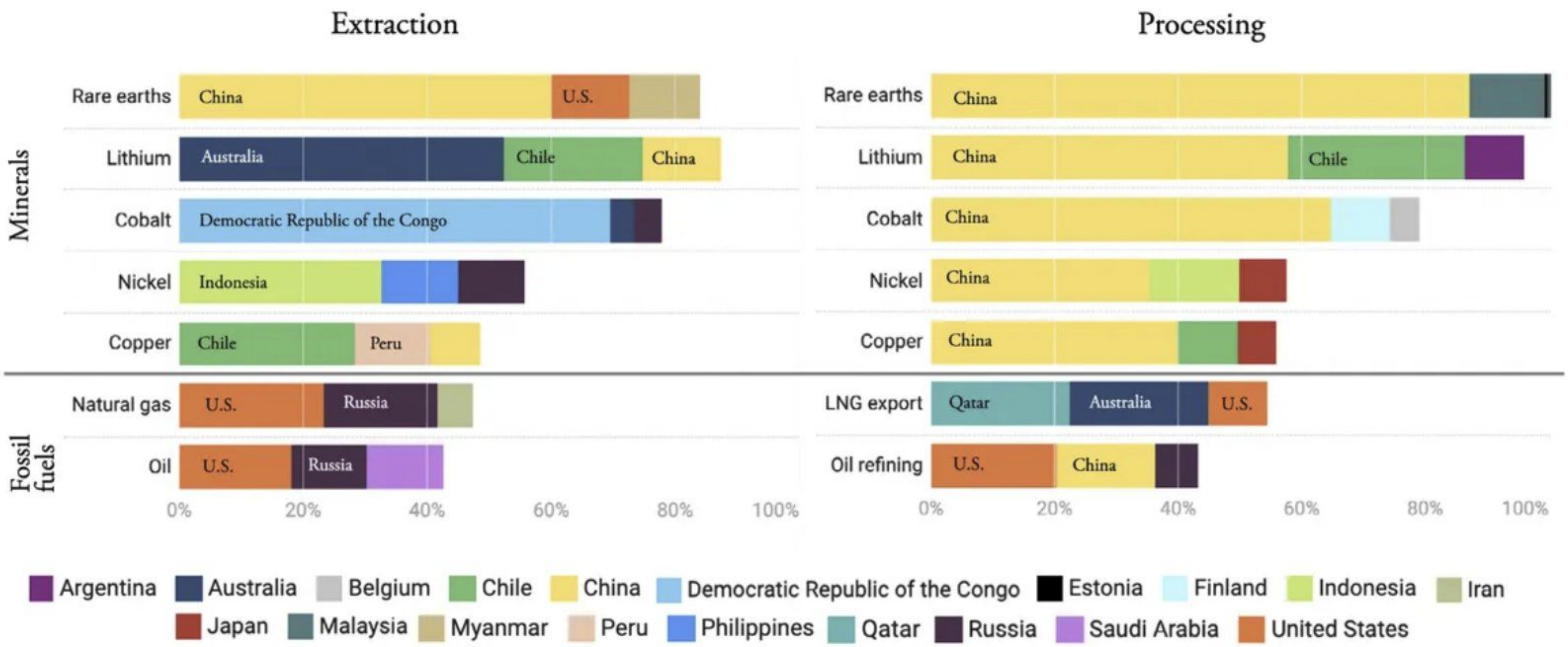
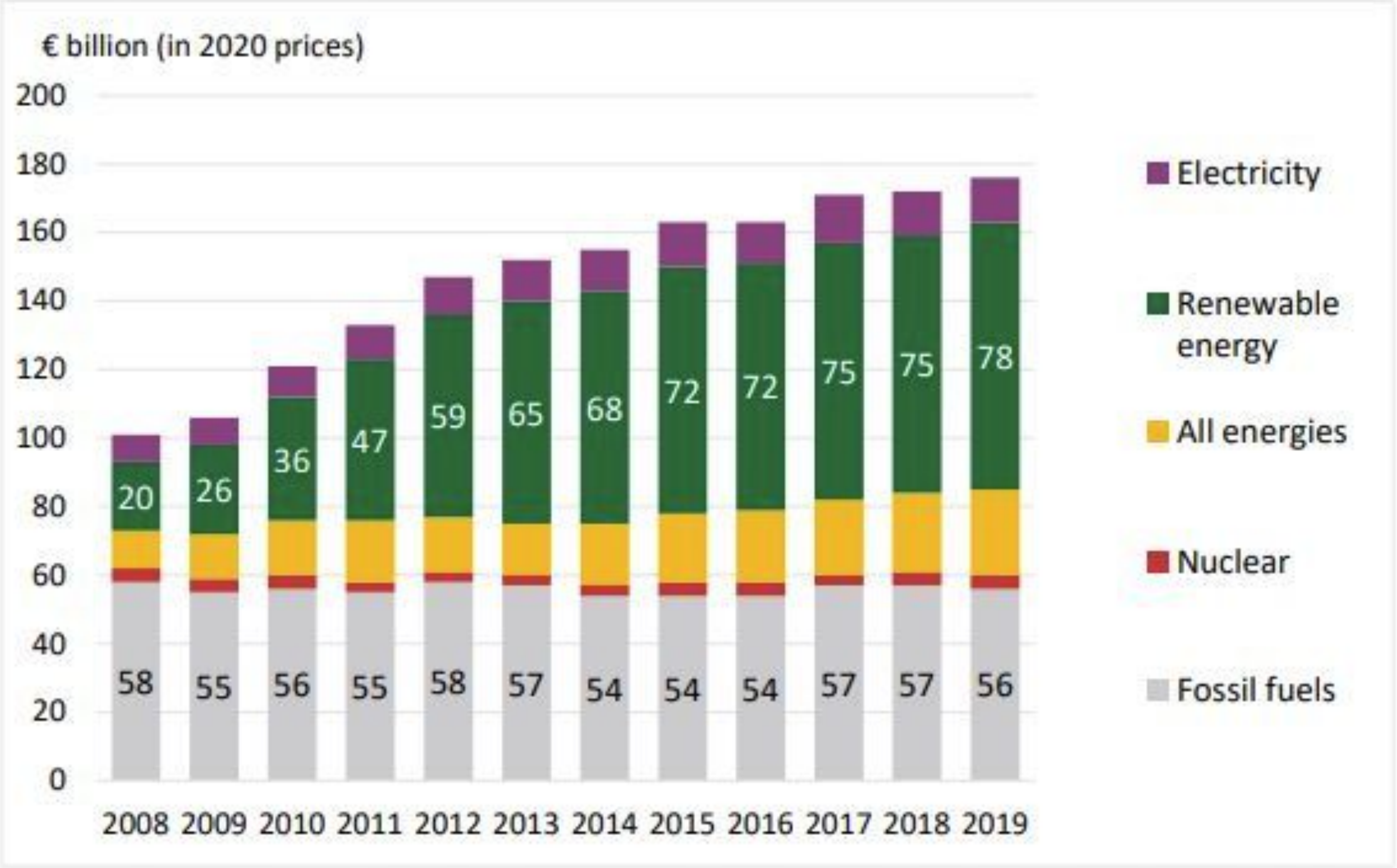
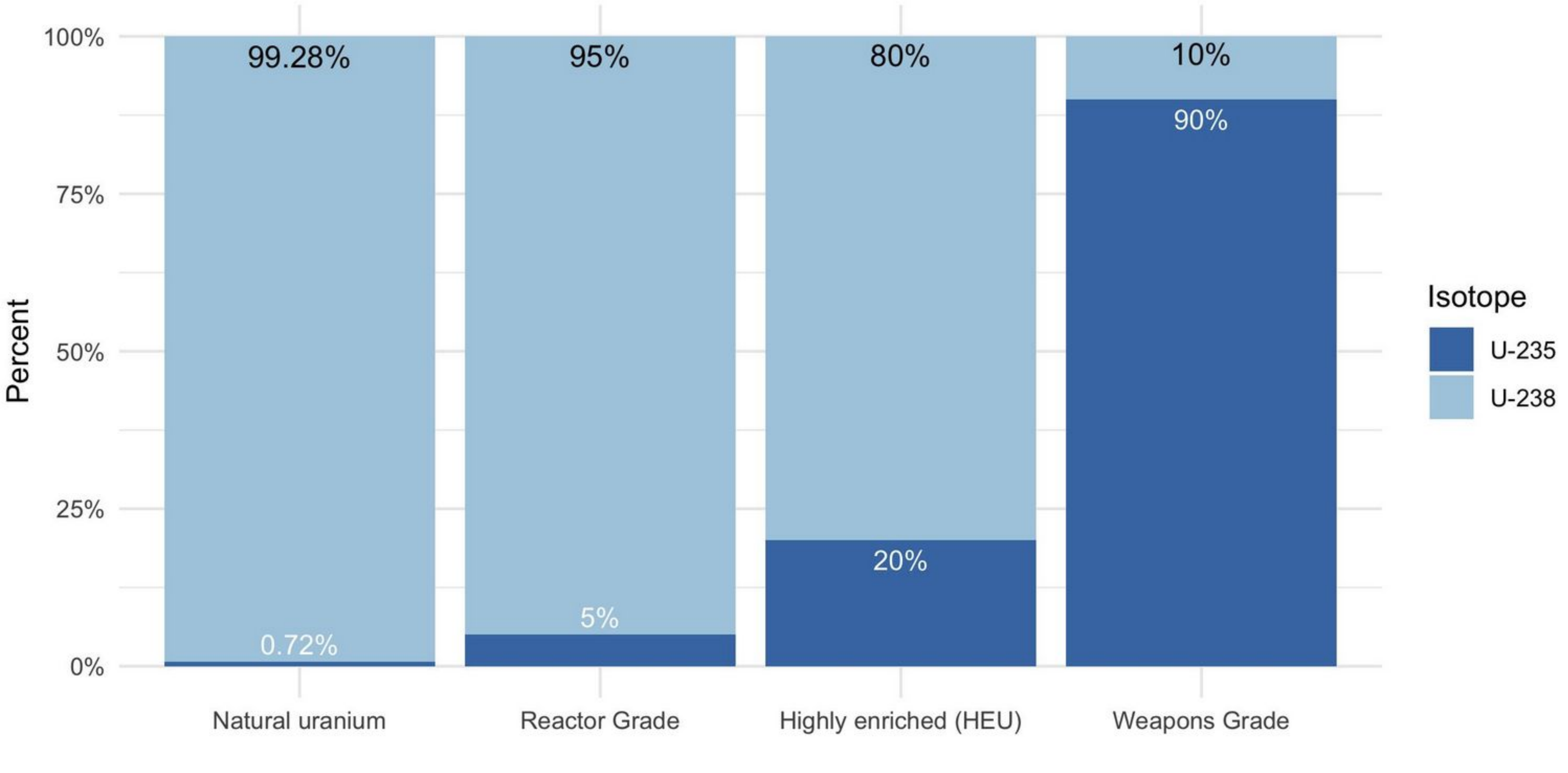


Chart: Canary Media • Source: IEA, The Role of Critical Minerals in Clean Energy Transitions

Figure 10 – Energy subsidies by category between 2008 and 2019



Source: ECA based on the *Study on energy subsidies and other government interventions in the European Union*, October 2021.


99.28%
0.72%
95%
5%
80%
20%
10%
90%
100%
75%
50%
25%
0%
Percent
Natural uranium
Reactor Grade
Highly enriched (HEU)
Weapons Grade
Isotope
U-235
U-238

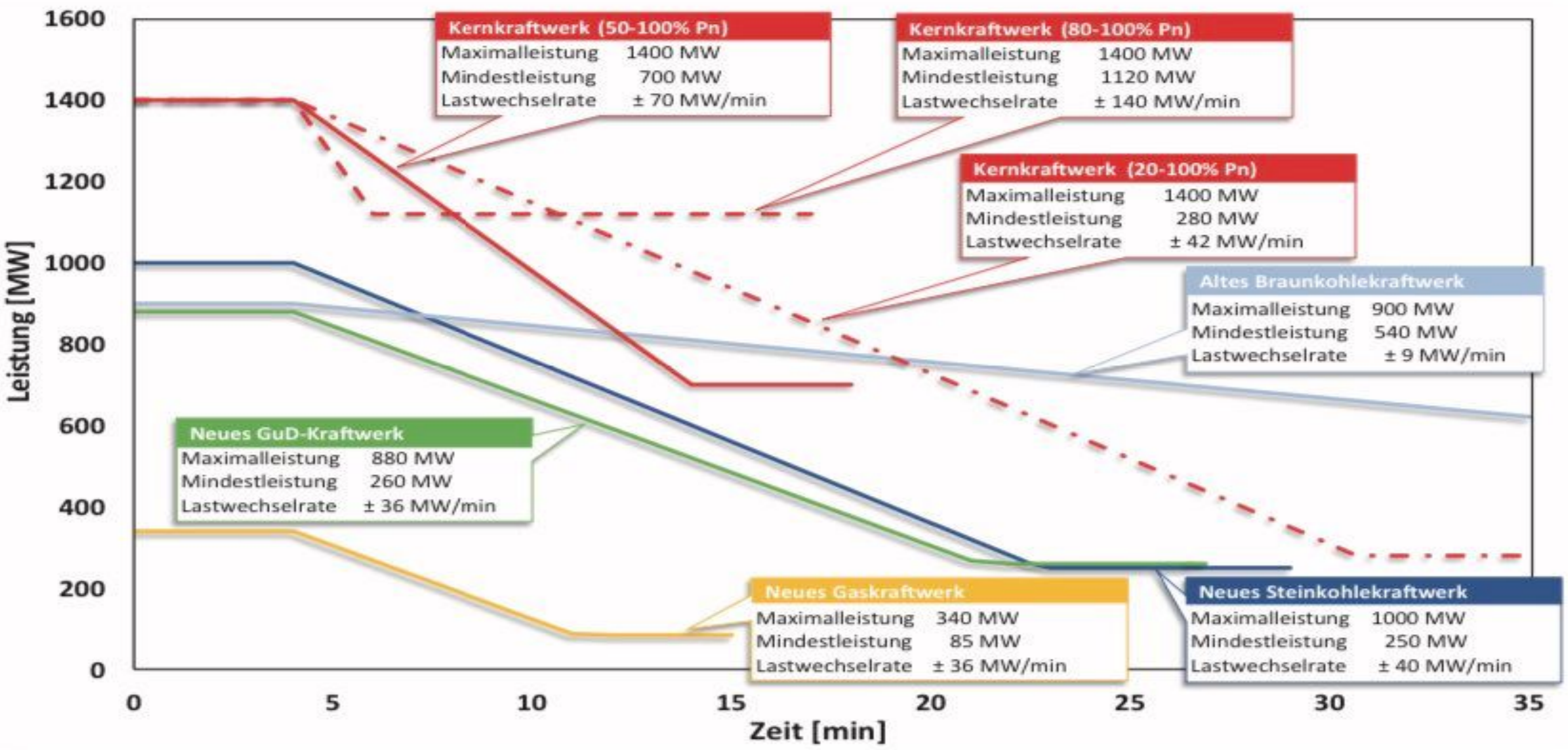
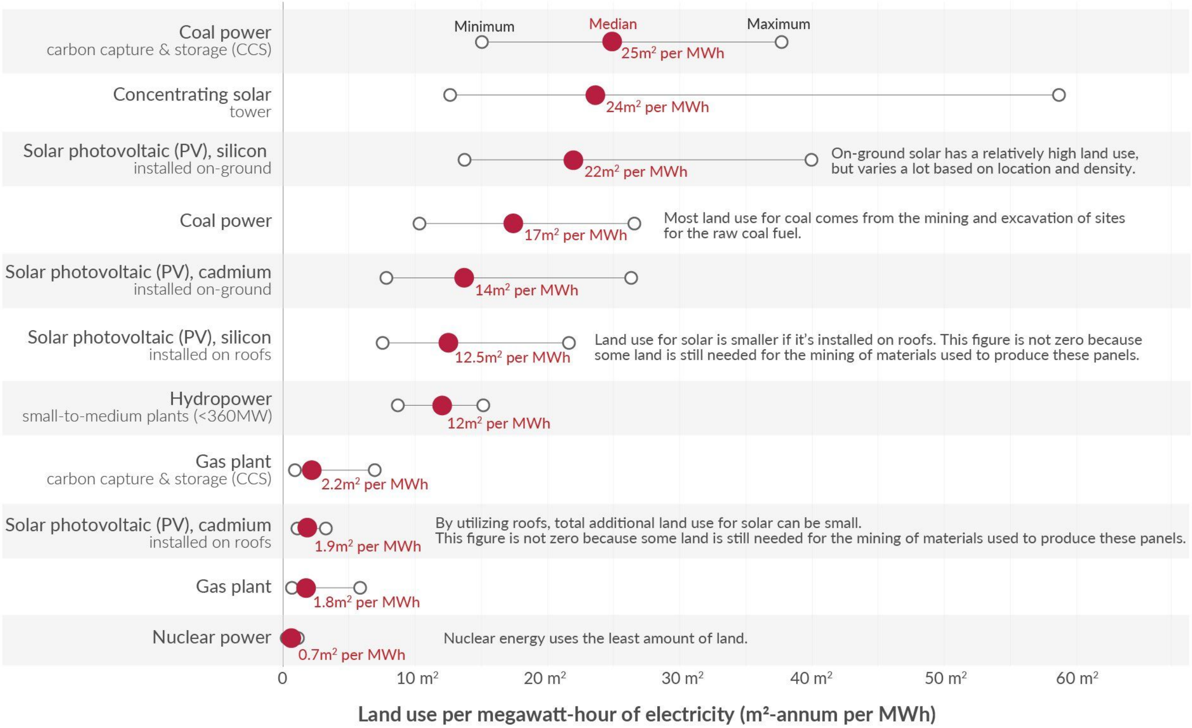


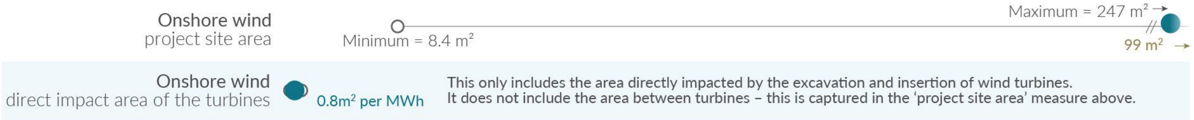
Abb. 4.
Vergleich der Laständerungsraten konventioneller Erzeugungseinheiten (adaptiert von [33] mit Daten aus [32] und [34]).

Land use of energy sources per unit of electricity

Land use is based on life-cycle assessment; this means it does not only account for the land of the energy plant itself but also land used for the mining of materials used for its construction, fuel inputs, decommissioning, and the handling of waste.



The land use of onshore wind can be measured in several ways, and is distinctly different from land use of other energy technologies. Land between wind turbines can be used for other purposes (such as farming), which is not the case for other energy sources. The spacing of turbines, and the context of the site means land use is highly variable.



Note Capacity factors are taken into account for each technology which adjusts for intermittency. Land use of energy storage is not included since the quantity of storage depends on the composition of the electricity mix.

Source: UNECE (2021). Lifecycle Assessment of Electricity Generation Options. *United Nations Economic Commission for Europe* for all data except wind. Wind land use calculated by the author.

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

Figure 1 Lifecycle greenhouse gas emission ranges for the assessed technologies

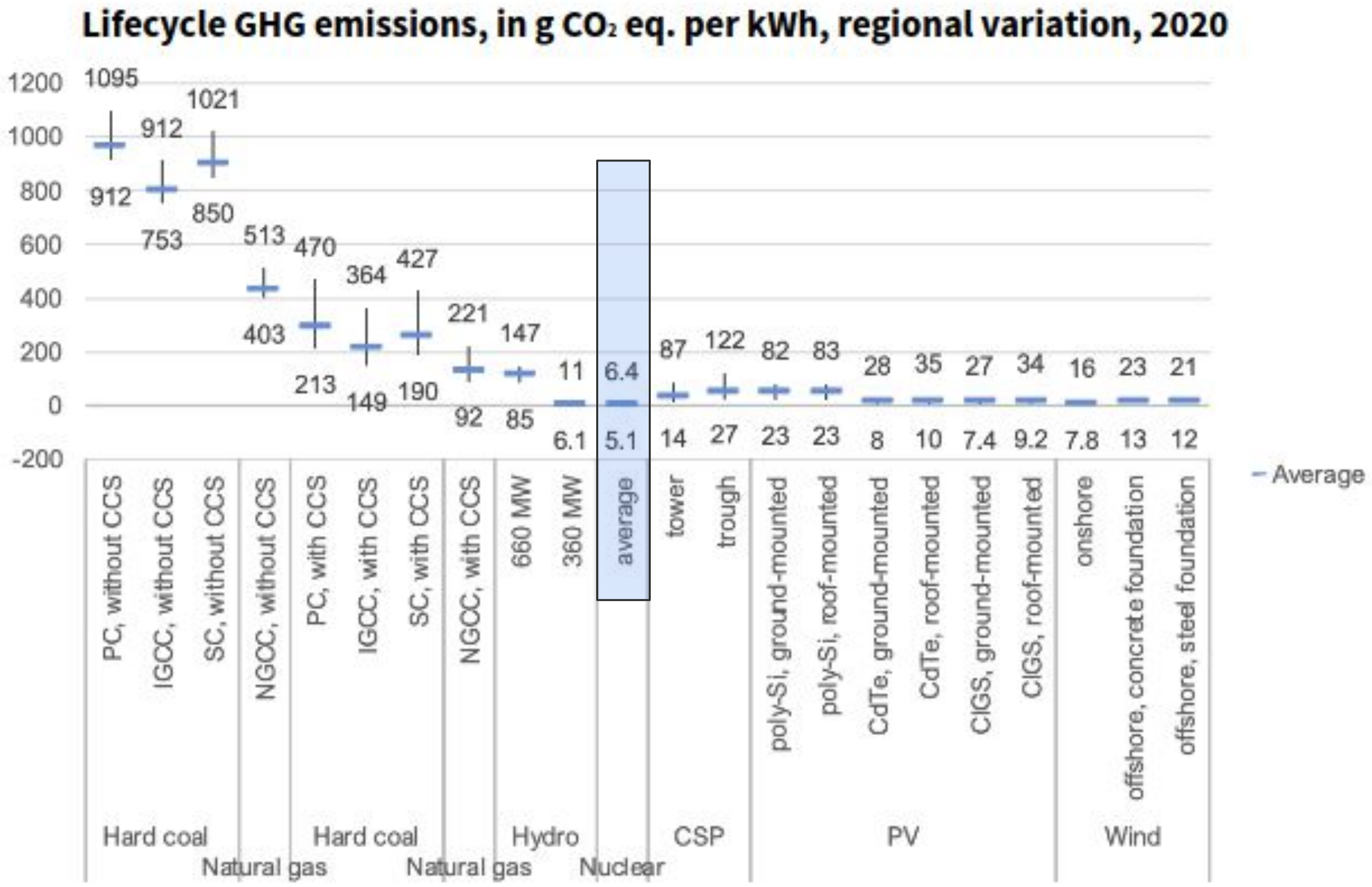
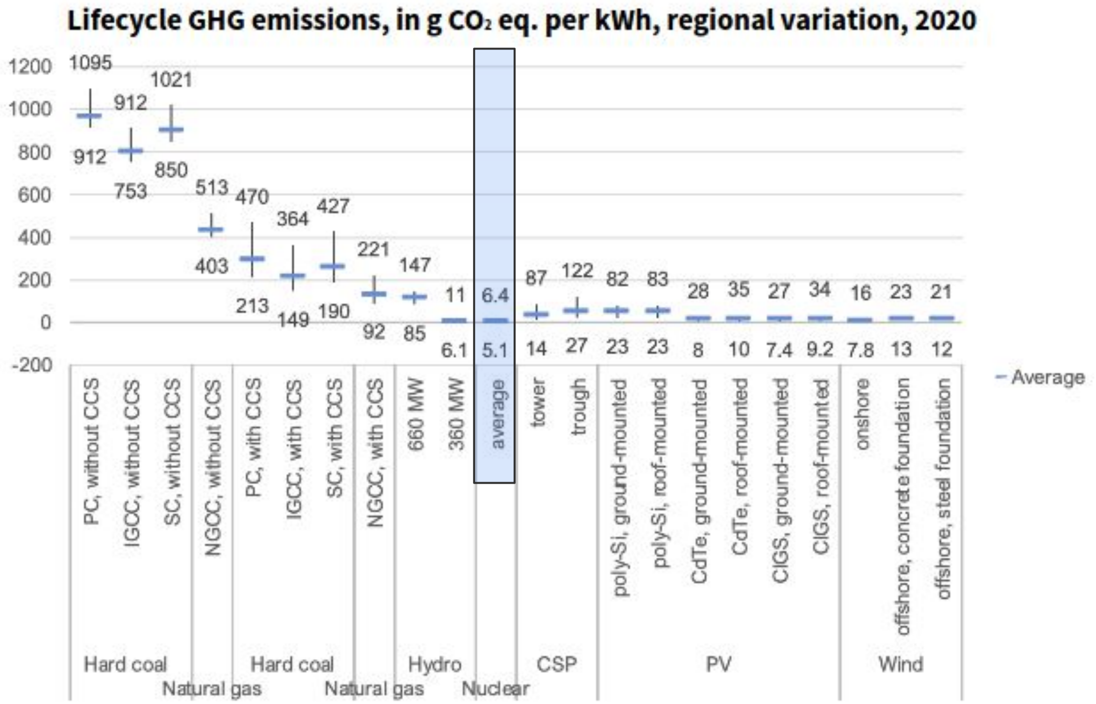
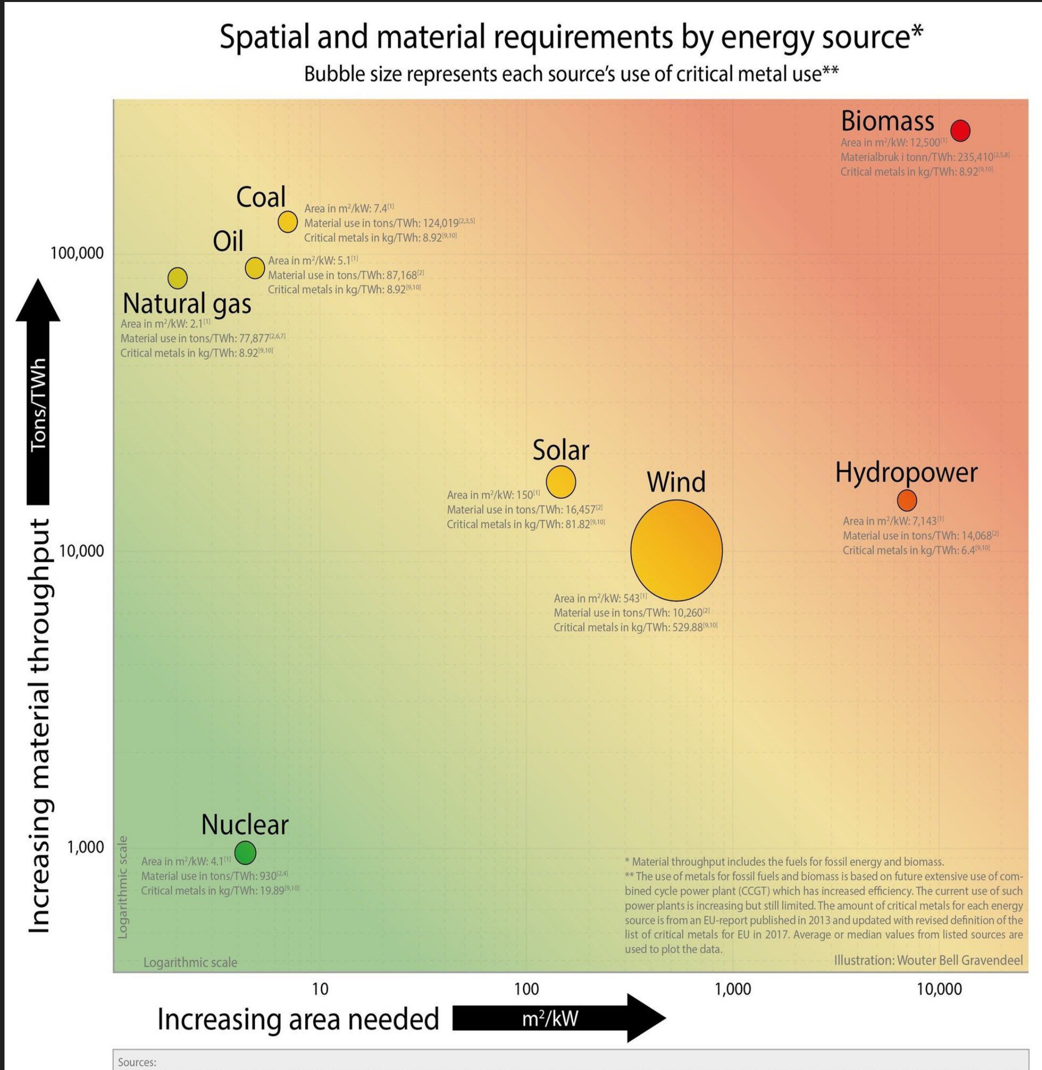


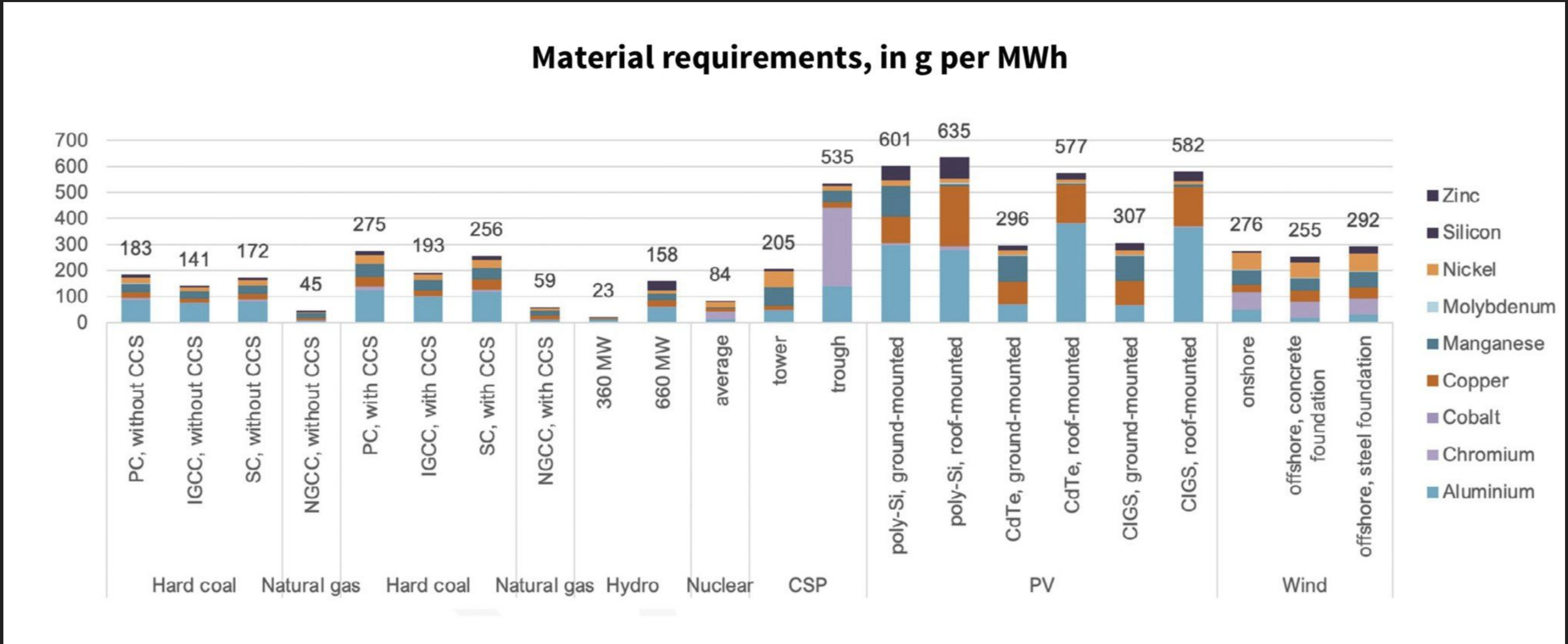
Figure 1 Lifecycle greenhouse gas emission ranges for the assessed technologies



UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE
Carbon Neutrality in the UNECE Region: Integrated Life-cycle Assessment of Electricity Sources

https://energy.glex.no/feature-stories/area-and-material-consumption




Material requirements, in g per MWh
700
600
500
400
300
200
100
0
183
141
172
45
275
193
256
59
23
158
84
205
535
601
635
296
577
307
582
276
255
292
PC, without CCS
IGCC, without CCS
SC, without CCS
NGCC, without CCS
PC, with CCS
IGCC, with CCS
SC, with CCS
NGCC, with CCS
360 MW
660 MW
average
tower
trough
poly-Si, ground-mounted
poly-Si, roof-mounted
CdTe, ground-mounted
CdTe, roof-mounted
CIGS, ground-mounted
CIGS, roof-mounted
onshore
offshore, concrete foundation
offshore, steel foundation
Hard coal
Natural gas
Hard coal
Natural gas
Hydro
Nuclear
CSP
PV
Wind
Zinc
Silicon
Nickel
Molybdenum
Manganese
Copper
Cobalt
Chromium
Aluminium

Evolution du taux de CO2 en g/kWh pour la consommation électrique en Europe sur les 12 derniers mois

Norvège

33	31	29	32
31	34	33	42
40	35	37	39

Suède

42	37	40	48
43	41	42	43
36	26	24	25

France

49	51	91	86
87	71	90	74
72	74	93	92

Finlande

163	141	158	218
184	179	167	160
135	85	71	83

Belgique

130	109	191	162
174	117	166	116
117	147	168	168

Danemark

177	147	184	235
187	169	206	179
153	142	109	151

Espagne

191	188	210	189
199	187	173	156
162	214	222	216

Autriche

178	232	283	258
245	229	274	184
152	123	163	184

Portugal

256	240	228	186
209	237	201	186
223	260	264	263

Royaume-Uni

313	278	305	310
311	248	299	284
285	273	265	272

Italie

334	330	372	334
344	310	329	275
309	295	324	320

Allemagne

369	322	384	375
362	278	390	323
324	348	341	380

Pays-Bas

429	399	420	435
404	287	333	288
310	307	312	339

Irlande

469	346	417	408
406	240	366	338
335	353	320	321

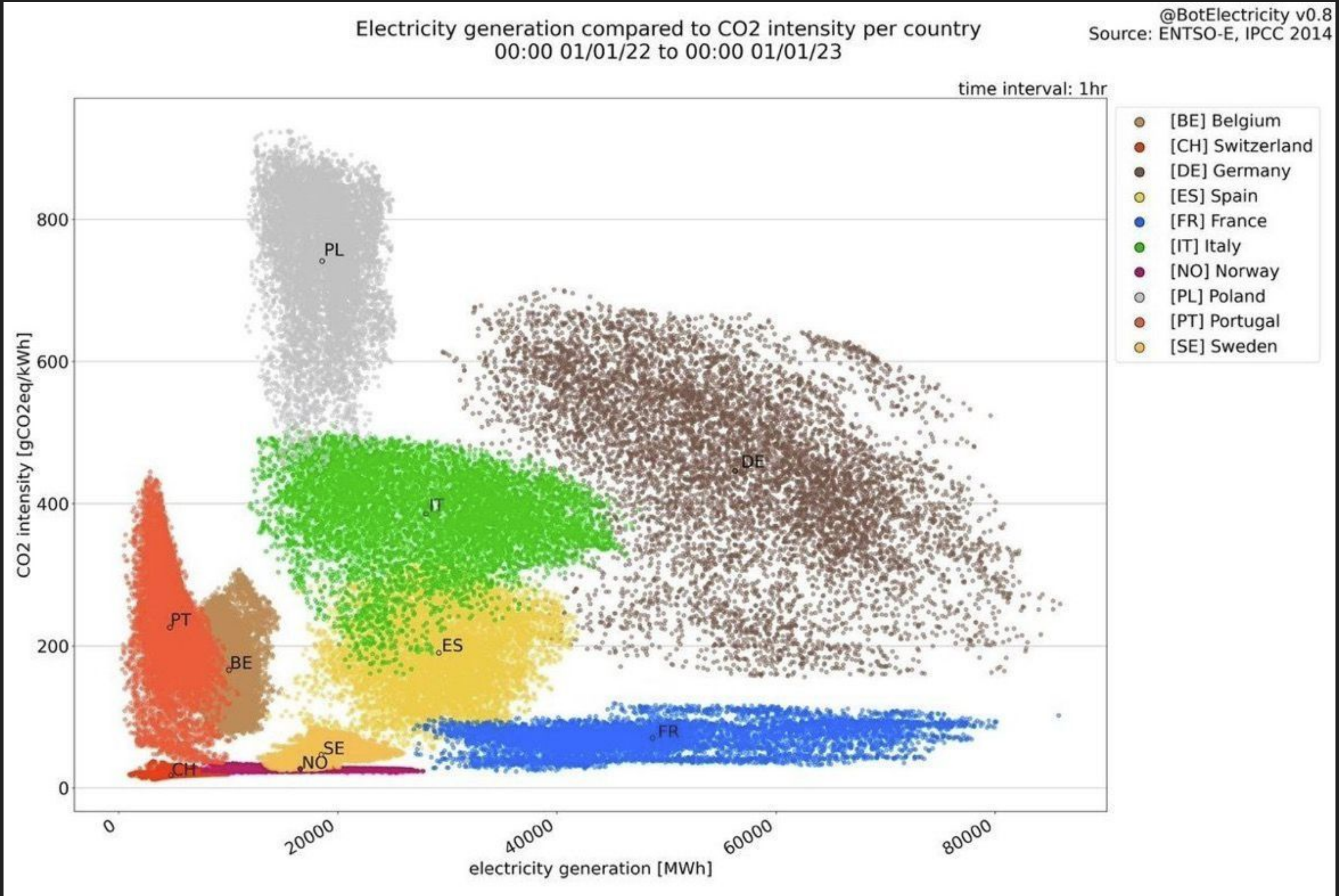
Pologne

661	612	640	650
599	569	637	583
580	590	575	619

source : electricitymap.org

31/08/22

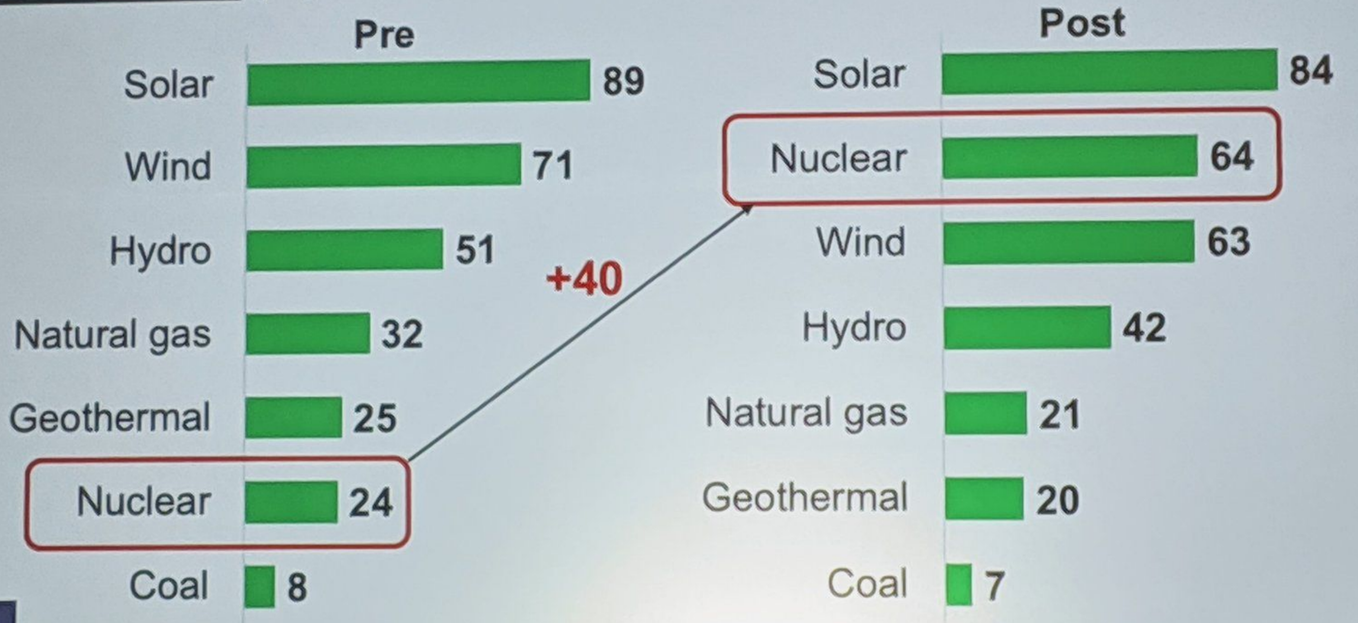
By Phiphou



@BotElectricity v0.8
Source: ENTSO-E, IPCC 2014
Electricity generation compared to CO2 intensity per country
00:00 01/01/22 to 00:00 01/01/23
time interval: 1hr
[BE] Belgium
[CH] Switzerland
[DE] Germany
[ES] Spain
[FR] France
[IT] Italy
[NO] Norway
[PL] Poland
[PT] Portugal
[SE] Sweden
PL
DE
IT
PT
BE
ES
FR
SE
NO
CH
CO2 intensity [gCO2eq/kWh]
0
200
400
600
800
0
20000
40000
60000
80000
electricity generation [MWh]

Impact of 10-Minute Interview with Millennials: Nuclear as Energy Source of the Future Jumped

Now, from this list of electricity sources, select <u>three</u> that you envision as an **<u>energy source of the future.</u>** (%)



BRi

Bisconti Research, Inc. survey of U.S. millennials February 2019

ANS

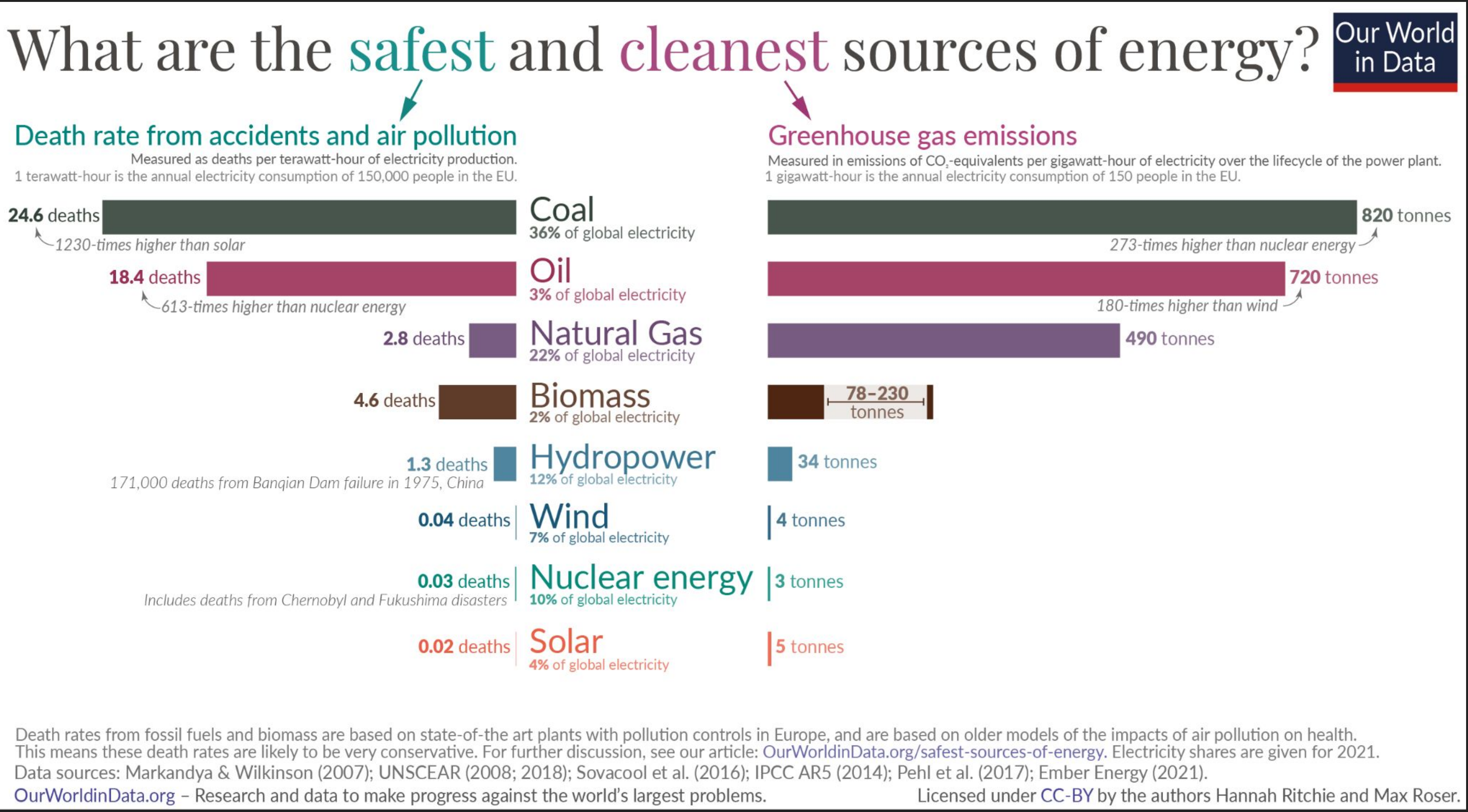
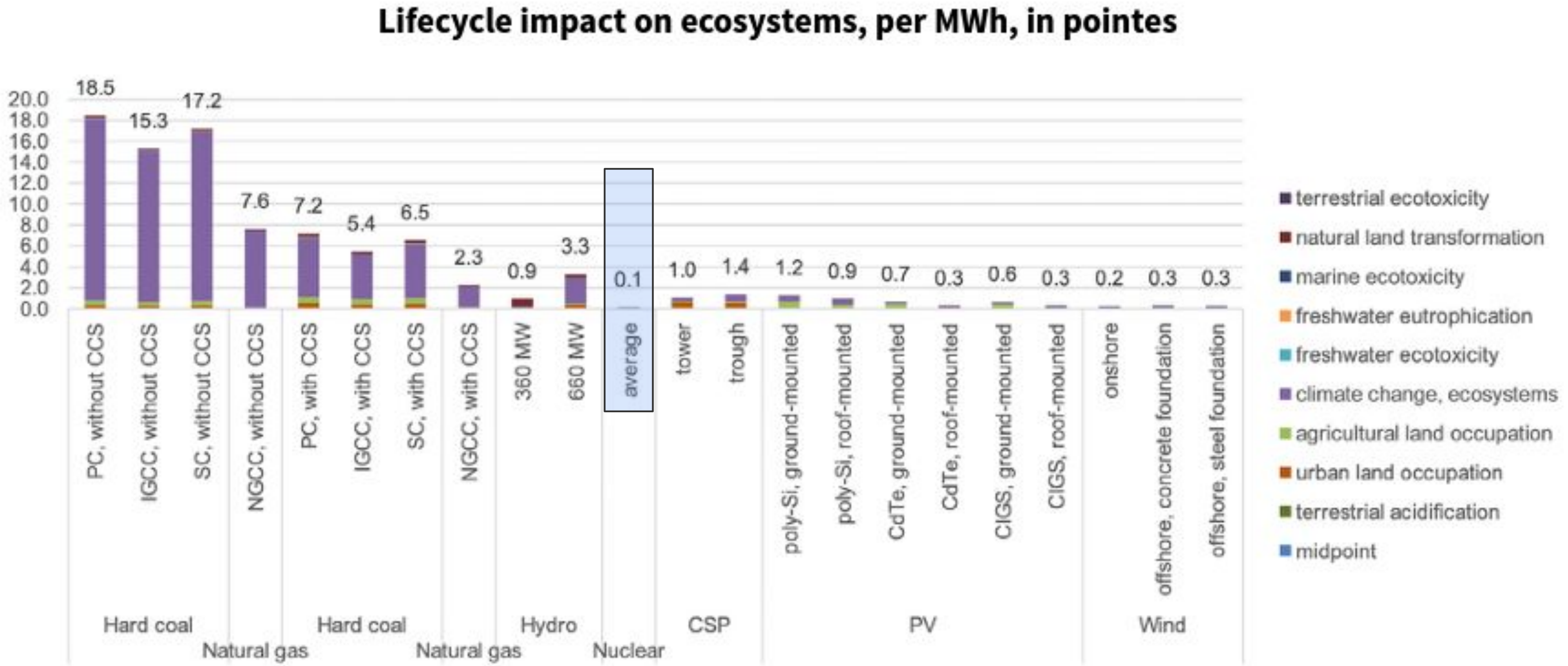
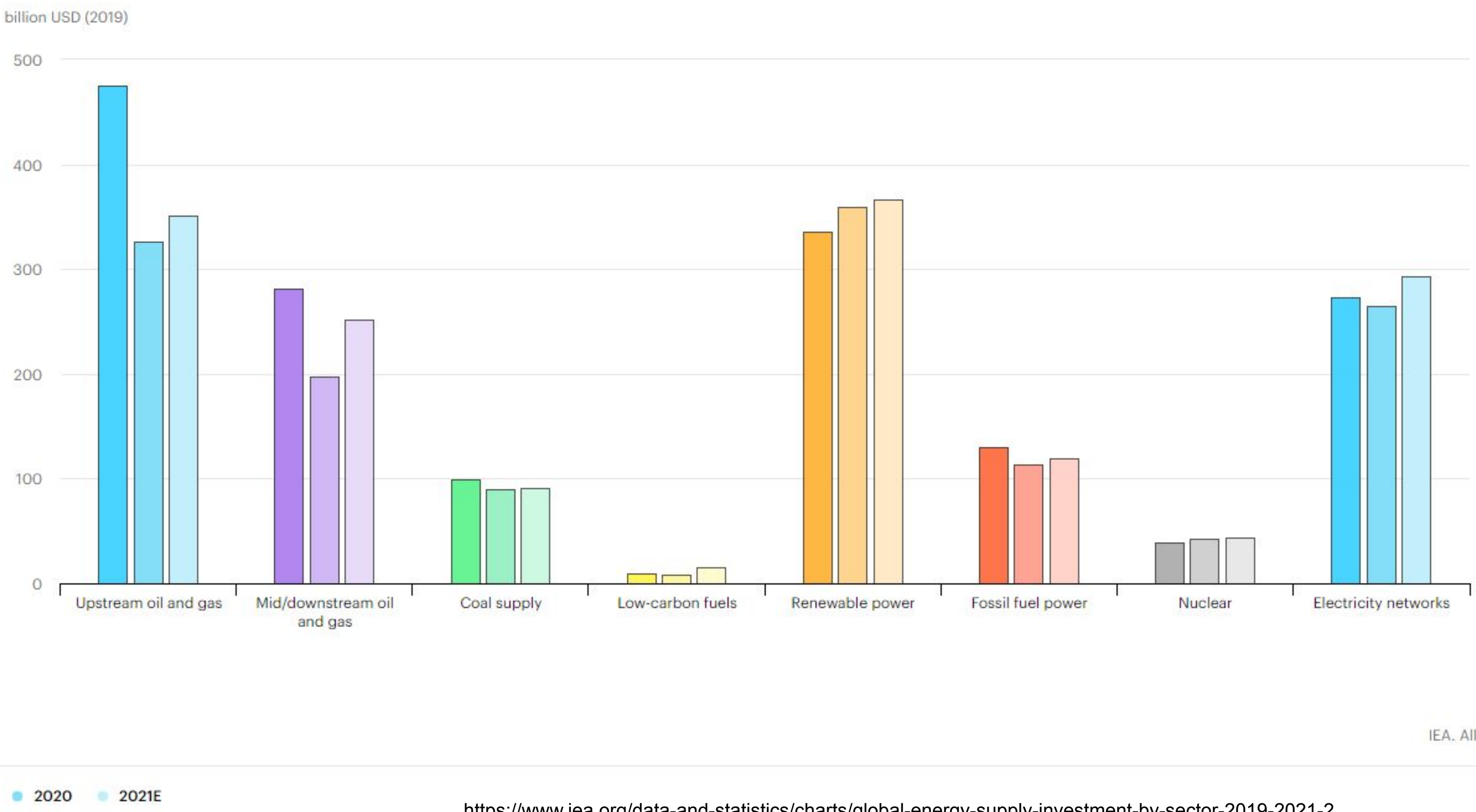

What are the safest and cleanest sources of energy?
Our World in Data
Death rate from accidents and air pollution
Measured as deaths per terawatt-hour of electricity production.
1 terawatt-hour is the annual electricity consumption of 150,000 people in the EU.
Greenhouse gas emissions
Measured in emissions of CO₂-equivalents per gigawatt-hour of electricity over the lifecycle of the power plant.
1 gigawatt-hour is the annual electricity consumption of 150 people in the EU.
24.6 deaths
1230-times higher than solar
Coal
36% of global electricity
820 tonnes
273-times higher than nuclear energy
18.4 deaths
613-times higher than nuclear energy
Oil
3% of global electricity
720 tonnes
180-times higher than wind
2.8 deaths
Natural Gas
22% of global electricity
490 tonnes
4.6 deaths
Biomass
2% of global electricity
78–230 tonnes
1.3 deaths
171,000 deaths from Banqian Dam failure in 1975, China
Hydropower
12% of global electricity
34 tonnes
0.04 deaths
Wind
7% of global electricity
4 tonnes
0.03 deaths
Includes deaths from Chernobyl and Fukushima disasters
Nuclear energy
10% of global electricity
3 tonnes
0.02 deaths
Solar
4% of global electricity
5 tonnes
Death rates from fossil fuels and biomass are based on state-of-the art plants with pollution controls in Europe, and are based on older models of the impacts of air pollution on health.
This means these death rates are likely to be very conservative. For further discussion, see our article: OurWorldinData.org/safest-sources-of-energy. Electricity shares are given for 2021.
Data sources: Markandya & Wilkinson (2007); UNSCEAR (2008; 2018); Sovacool et al. (2016); IPCC AR5 (2014); Pehl et al. (2017); Ember Energy (2021).
OurWorldinData.org – Research and data to make progress against the world's largest problems.
Licensed under CC-BY by the authors Hannah Ritchie and Max Roser.

Figure 48 **Lifecycle impacts on ecosystems, in points, including climate change.**
Note on unit: 1 point is equivalent to the impacts (in species-year) of 1 person (globally) over one year.

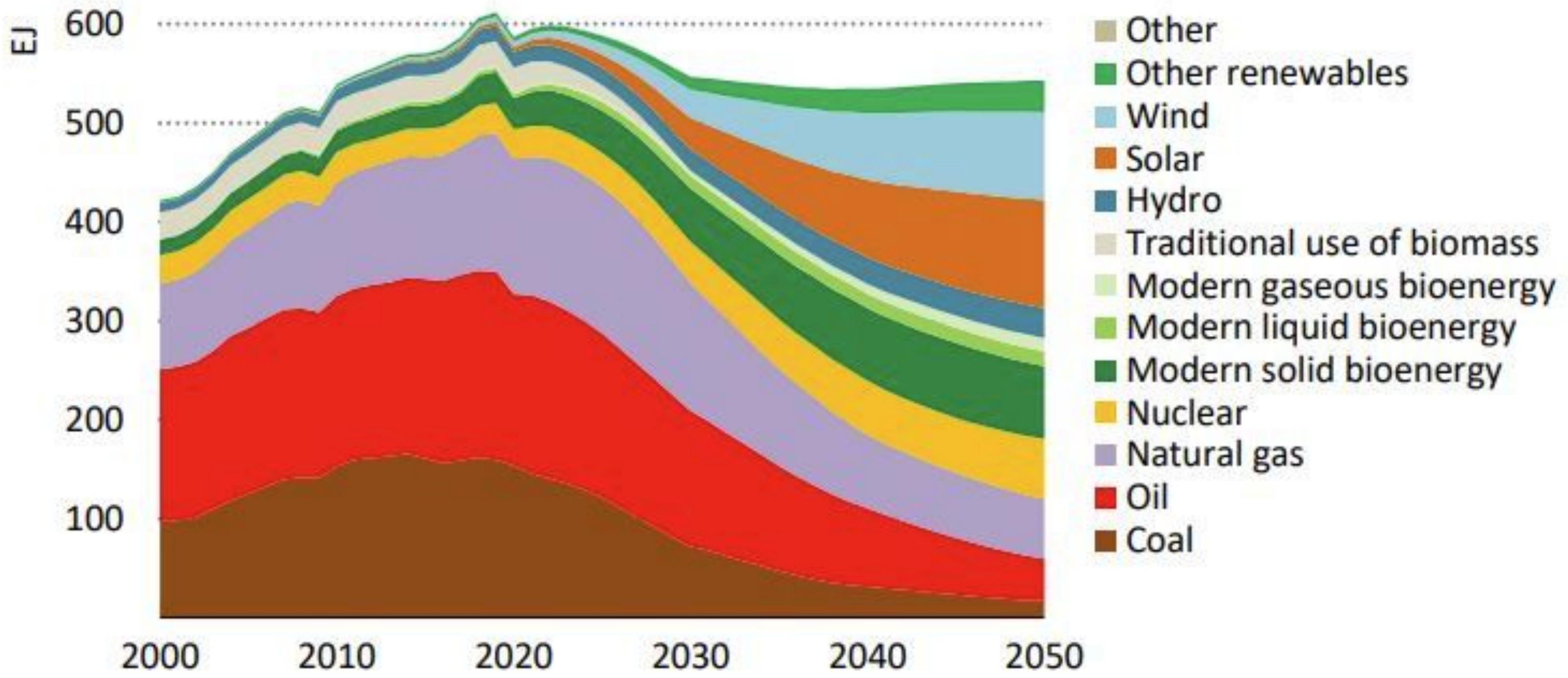


Global energy supply investment by sector, 2019-2021



https://www.iea.org/data-and-statistics/charts/global-energy-supply-investment-by-sector-2019-2021-2

Figure 2.5 ▹ Total energy supply in the NZE



Renewables and nuclear power displace most fossil fuel use in the NZE, and the share of fossil fuels falls from 80% in 2020 to just over 20% in 2050

NATURE AND ENVIRONMENT

Slovakia delays nuclear plant expansion

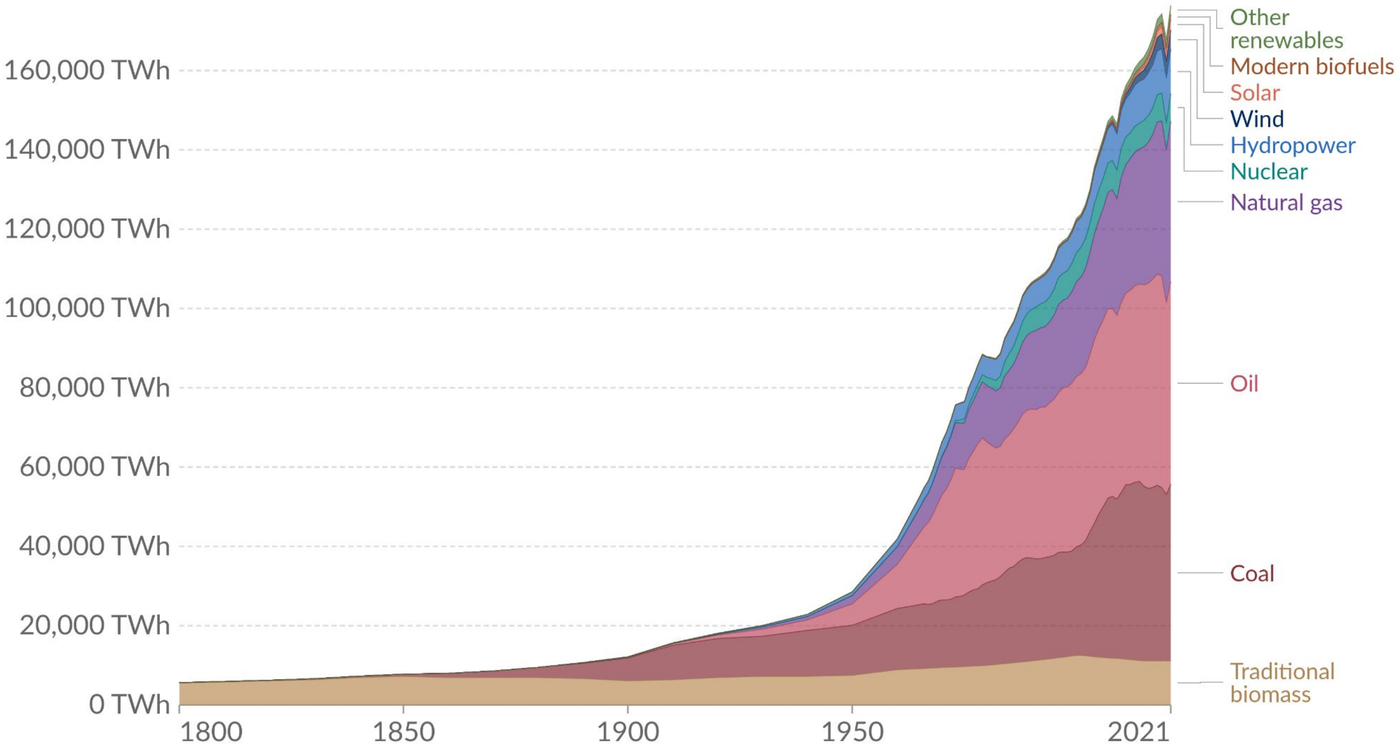
Darko Janjevic

05/07/2019

Amid complaints from Austria, Slovakia has decided to push back the long-awaited opening of two new nuclear reactors. Activists claim to have evidence that the reactors' safety structures are damaged and could fail.

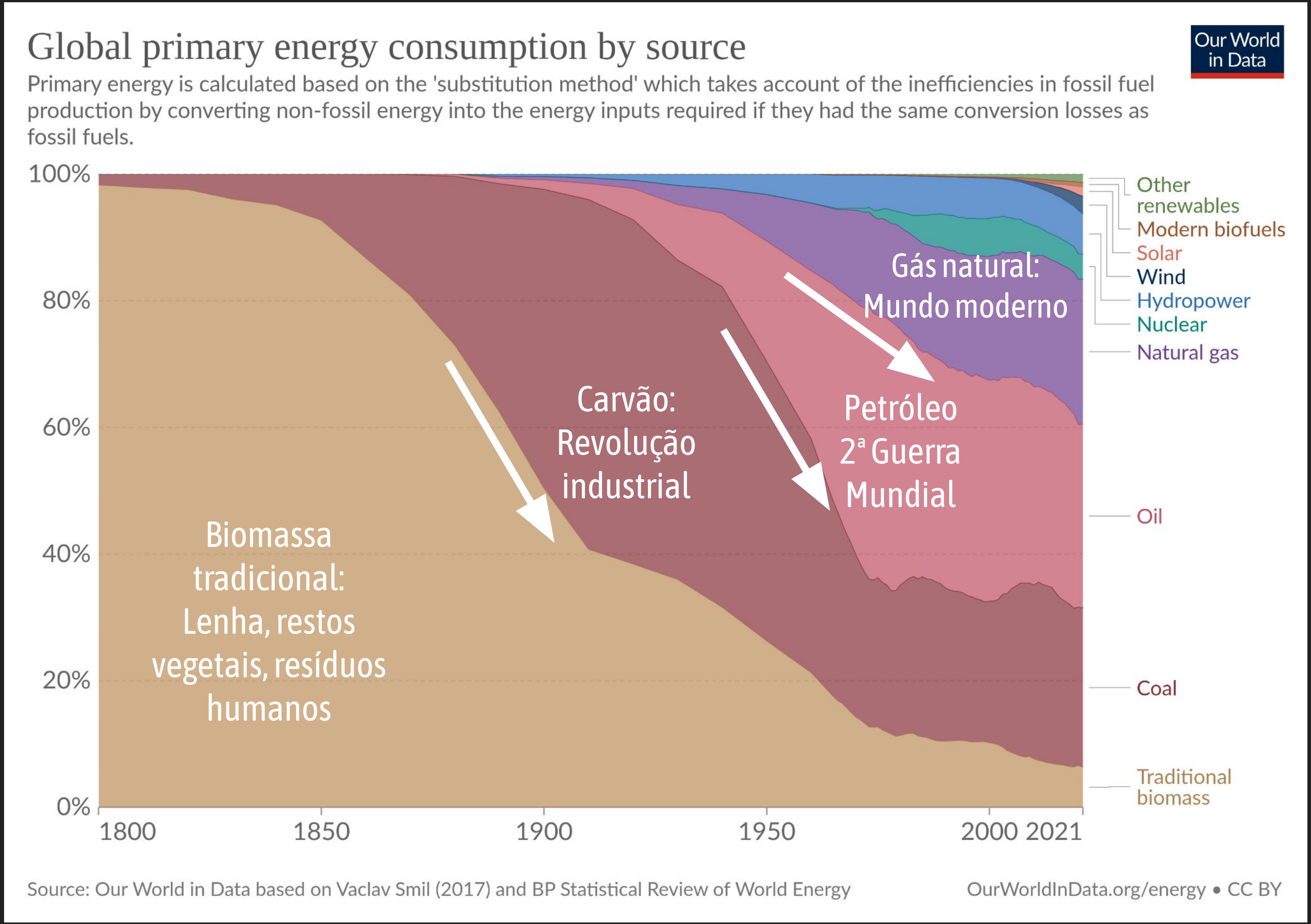
Global primary energy consumption by source

Primary energy is calculated based on the 'substitution method' which takes account of the inefficiencies in fossil fuel production by converting non-fossil energy into the energy inputs required if they had the same conversion losses as fossil fuels.



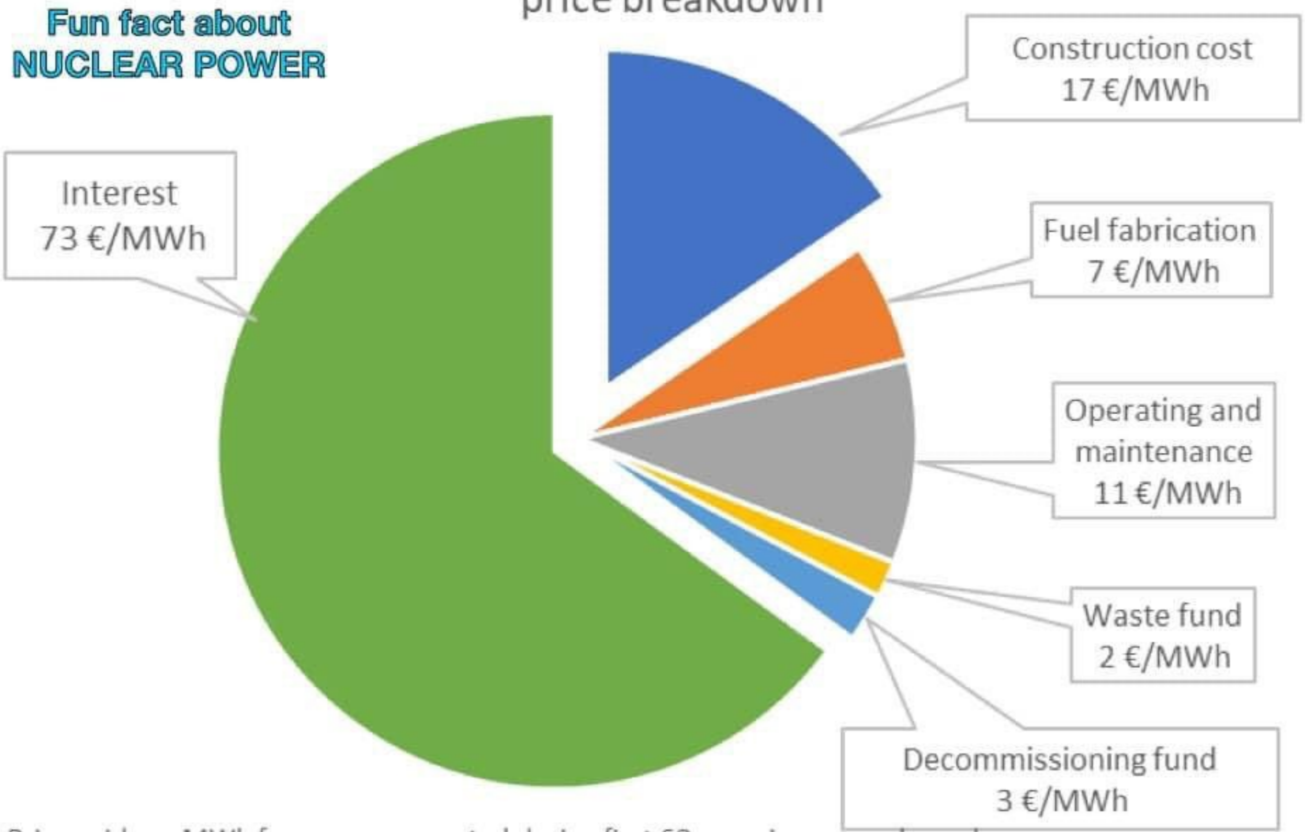
Source: Our World in Data based on Vaclav Smil (2017) and BP Statistical Review of World Energy

Transições energéticas



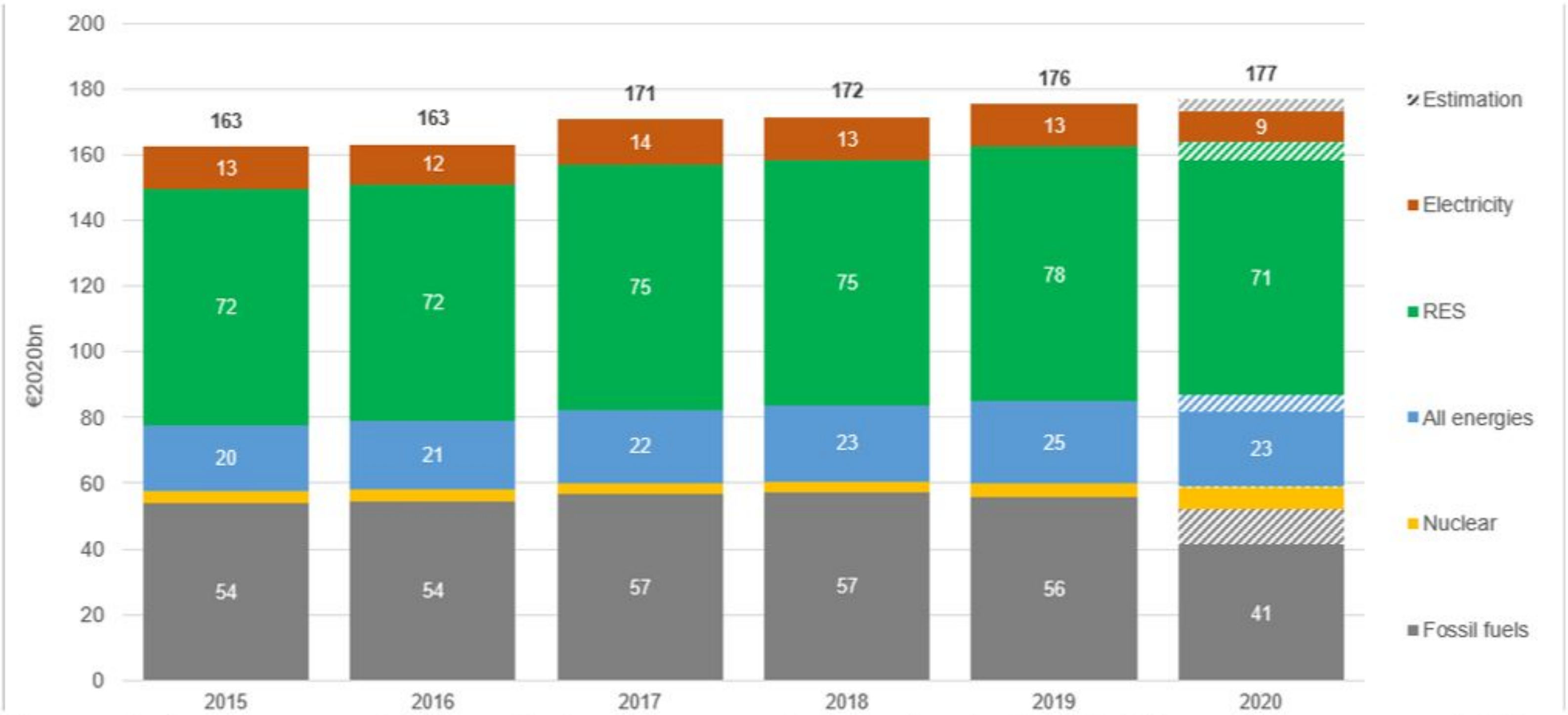
Hinkley Point C nuclear power plant

price breakdown



Price paid per MWh for power generated during first 60 years is assumed equal to the CfD Strike Price (113 €/MWh in 2019 prices).

Figure 3 – EU energy subsidies by fuel type

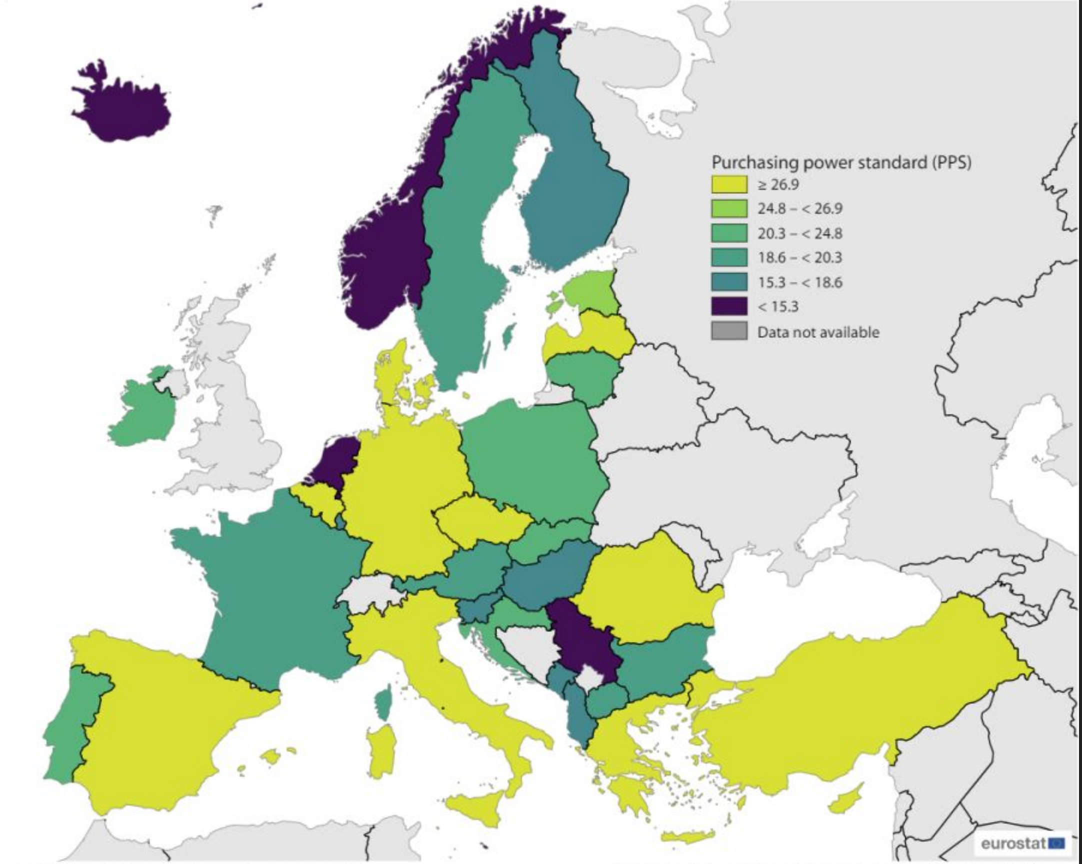


Source: Study on energy subsidies and other government interventions in the EU. All energies represent subsidies not directly attributable to energy carriers or fuels (e.g. energy efficiency measures, energy demand/consumption incentives, irrespectively of the energy carrier, investment grants, and particular R&D expenditures)

ANNEX to the Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - 2021 report on the State of the Energy Union - Contribution to the European Green Deal and the Union's recovery 2021
https://ec.europa.eu/energy/sites/default/files/annex_to_the_state_of_the_energy_union_report_on_energy_subsidies_in_the_eu.pdf

Electricity prices for household consumers, 2021S2

PPS



Measurement unit: Purchasing power standard (PPS)
dataset nrg_pc_204, 2022 Semester 1

Administrative boundaries: © EuroGeographics © UN–FAO © Turkstat
Cartography: Eurostat – IMAGE, 10/2022

change of fuel price.

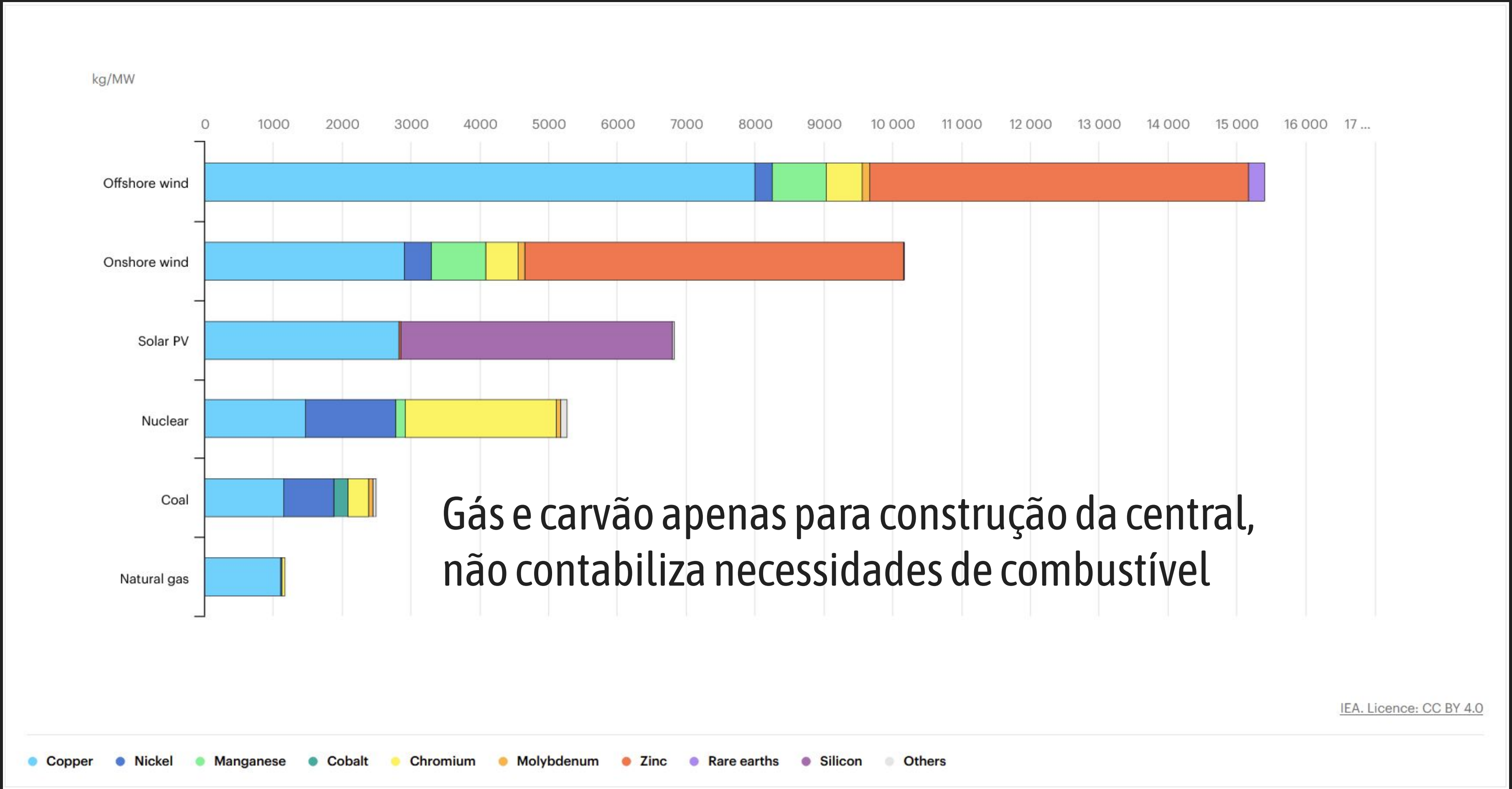
Front end fuel cycle costs of 1 kg of uranium as UO_2 fuel

Process	Amount required x price*	Cost	Proportion of total
Uranium	8.9 kg U_3O_8 x $94.6/kg	$842	51%
Conversion	7.5 kg U x $16	$120	7%
Enrichment	7.3 SWU x $55	$401	24%
Fuel fabrication	per kg	$300	18%
Total		$1663	

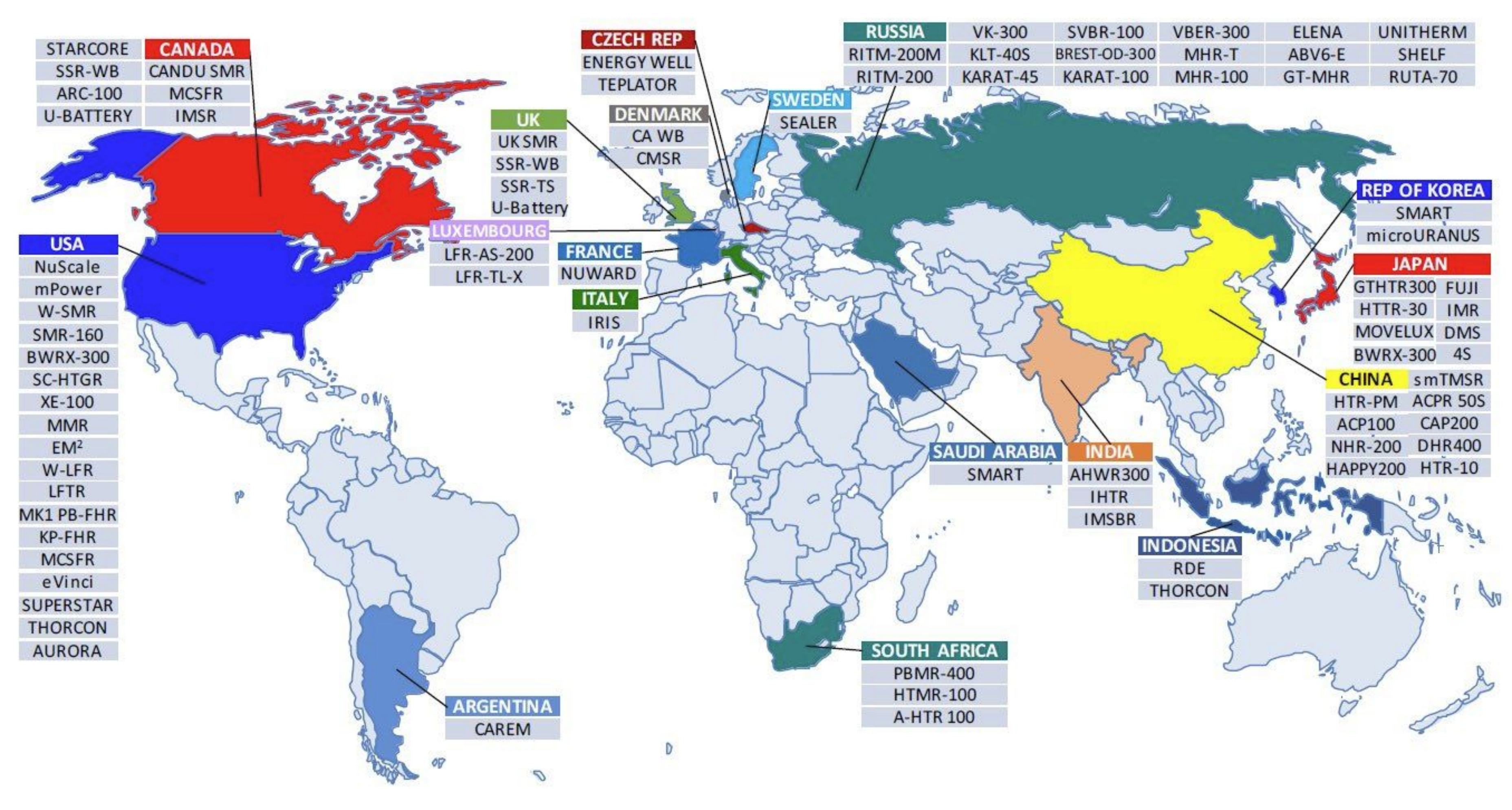
* Prices are approximate and as of September 2021.

At 45,000 MWd/t burn-up this gives 360,000 kWh electricity per kg, hence fuel cost = 0.46 ¢/kWh.

Requisitos materiais por fonte de eletricidade



Gás e carvão apenas para construção da central, não contabiliza necessidades de combustível


STARCORE
SSR-WB
ARC-100
U-BATTERY
CANADA
CANDU SMR
MCSFR
IMSR
USA
NuScale
mPower
W-SMR
SMR-160
BWRX-300
SC-HTGR
XE-100
MMR
EM²
W-LFR
LFTR
MK1 PB-FHR
KP-FHR
MCSFR
eVinci
SUPERSTAR
THORCON
AURORA
ARGENTINA
CAREM
CZECH REP
ENERGY WELL
TEPLATOR
UK
UK SMR
SSR-WB
SSR-TS
U-Battery
DENMARK
CA WB
CMSR
SWEDEN
SEALER
LUXEMBOURG
LFR-AS-200
LFR-TL-X
FRANCE
NUWARD
ITALY
IRIS
RUSSIA
RITM-200M
RITM-200
VK-300
KLT-40S
KARAT-45
SVBR-100
BREST-OD-300
KARAT-100
VBER-300
MHR-T
MHR-100
ELENA
ABV6-E
GT-MHR
UNITHERM
SHELF
RUTA-70
REP OF KOREA
SMART
microURANUS
JAPAN
GTHTR300
HTTR-30
MOVELUX
BWRX-300
FUJI
IMR
DMS
4S
CHINA
HTR-PM
ACP100
NHR-200
HAPPY200
smTMSR
ACPR 50S
CAP200
DHR400
HTR-10
SAUDI ARABIA
SMART
INDIA
AHWR300
IHTR
IMSBR
INDONESIA
RDE
THORCON
SOUTH AFRICA
PBMR-400
HTMR-100
A-HTR 100

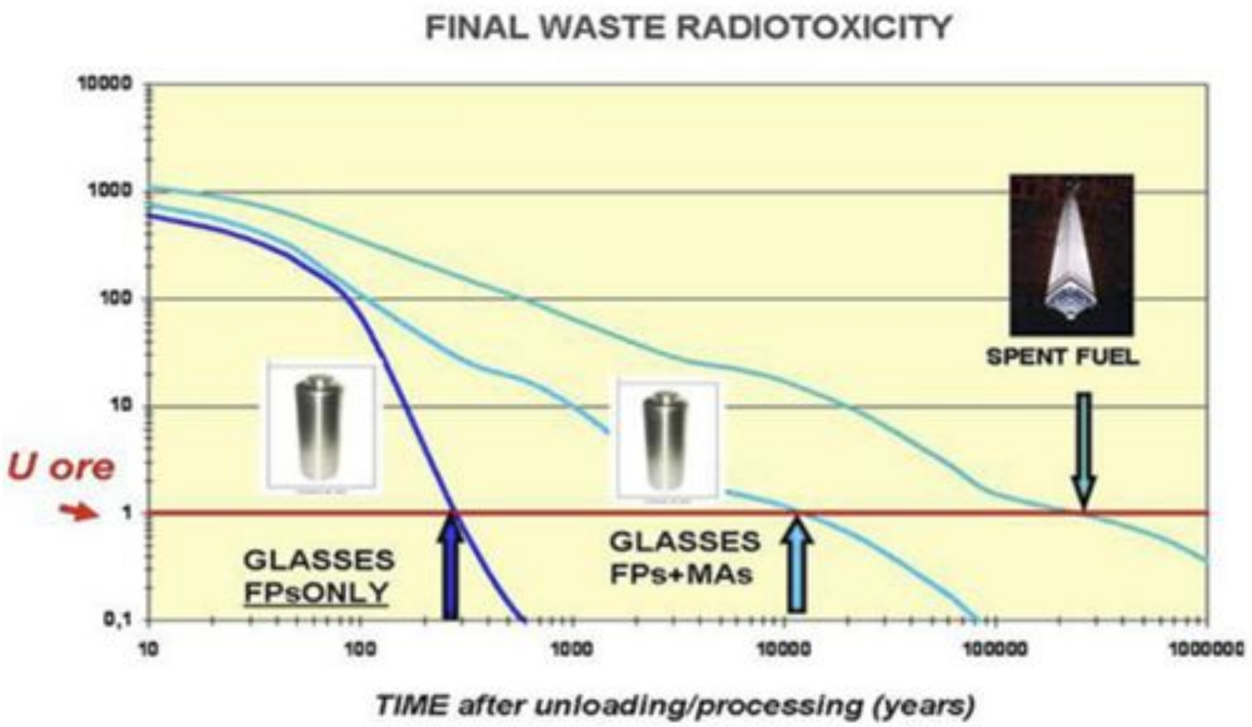
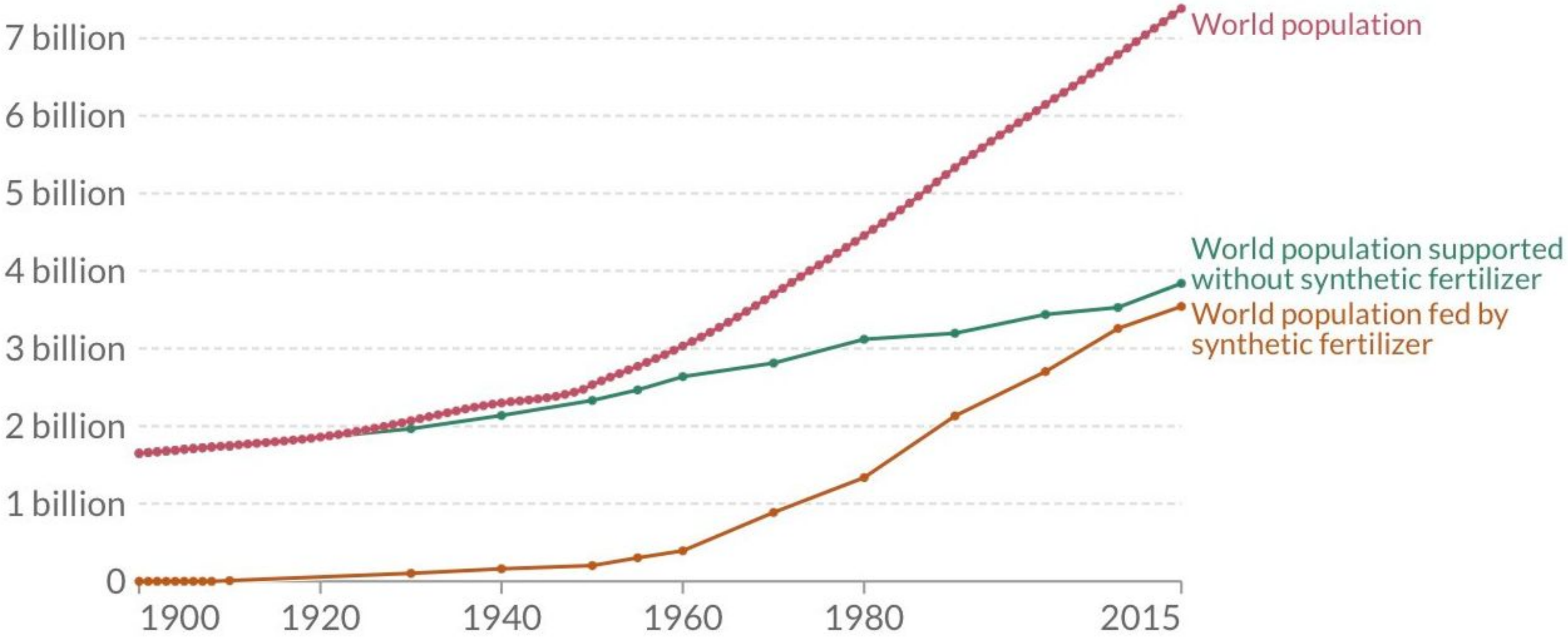


Figure 4.6 Graph showing how long high level radioactive waste stays radioactive. The y-axis measures how radioactive the waste is as multiples of the radioactivity of uranium ore. Without recycling spent fuel stays radiotoxic (i.e. more radioactive than mined uranium ore) for about 250 thousand years. If uranium and plutonium are recycled – leaving fission products (FP) and minor actinides (MA) – then waste stays radioactive for about ten thousand years. If minor actinides are removed then the vitrified fission products will stay radioactive for only about 200 years.

World population with and without synthetic nitrogen fertilizers

Estimates of the global population reliant on synthetic nitrogenous fertilizers, produced via the Haber-Bosch process for food production. Best estimates project that just over half of the global population could be sustained without reactive nitrogen fertilizer derived from the Haber-Bosch process.



Source: Erisman et al. (2008); Smil (2002); Stewart (2005)
OurWorldInData.org/how-many-people-does-synthetic-fertilizer-feed/ •

Que um número de países cada vez maior já decidiu avançar para esta realidade, e que há que avaliar que papel a Europa (que já liderou esta tecnologia) quer jogar no futuro. E aí falar sobre os grandes reatores (com a Coreia do Sul, e a China a liderarem por velocidade na construção e no preço, dando o exemplo dos Emiratos, e os US, o Canadá e a França a tentarem recuperar. AvRusdia com uma boa carteira de encomendas. Depois se quiser entrar nas razões dos atrasos de Olkiluoto, de Flamanville e de Hinkley Point, e na possibilidade de recuperar com o programa dos 14 reactores em França. E que essa opção deixa poucas dúvidas de que a França vá reforçar as interligações para a sua rede ser destabilizada por vagas de energia intermitente que poderia pôr em causa a rentabilidade do parque electronuclear francês. Isto seria o que eu diria, mas é total livre de apresentar como entender melhor! E não esquecer uma referência aos SMR e 4a geração, ainda em fase experimental. Um abraço

Coal 2 Nuclear
Descarbonização WNA processos industriais
IEA manter potência firme
https://www.nucnet.org/news/head-of-iea-says-nuclear-is-essential-in-times-of-crisis-3-1-2020
https://www.iea.org/reports/nuclear-power-and-secure-energy-transitions/executive-summary