

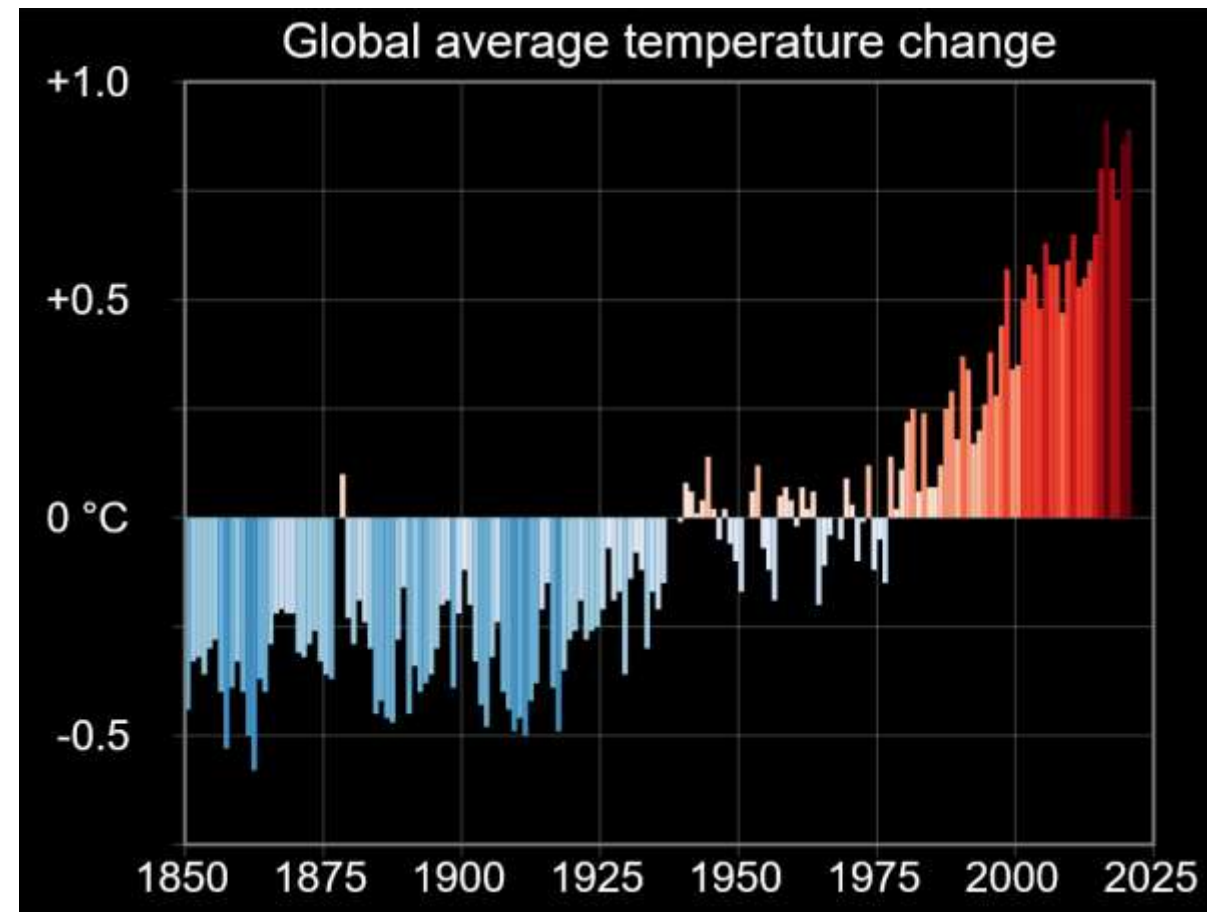
Energetyka przyszłości

Leszek Karlik

l.karlik@ava.waw.pl
<https://leslie.hell.pl/>

"Mój świat, moja Ziemia, jest ruiną. Zrujnował ją człowiek. Rozmnażaliśmy się, objadaliśmy się, toczyliśmy wojny, pókiśmy wszystkiego nie zniszczyli, po czym wymarliśmy. Nie panowaliśmy ani nad apetytem, ani nad przemocą; nie przystosowywaliśmy się. Zniszczyliśmy samych siebie. Ale najpierw zniszczyliśmy nasz świat. Na mojej Ziemi nie ma już lasów. Powietrze jest szare, niebo jest szare, panuje wieczny upał. Można na niej żyć – wciąż jeszcze – ale nie tak jak na tym świecie. To jest świat żywy, świat harmonii, podczas gdy mój jest zgrzytem. Wy, odonianie, wybraliście pustynię; my, Terranie, stworzyliśmy ją... Wegetujemy tam, podobnie jak wy u siebie. Człowiek potrafi wiele wytrzymać! Jest nas obecnie niecałe pół miliarda. Kiedyś liczyliśmy dziewięć miliardów. Stoją jeszcze dawne miasta. Kości i cegły obracają się w proch, kawałki plastiku – nie; one też się nigdy nie przystosowują. Ponieśliśmy klęskę jako gatunek, jako gatunek społeczny."

Urszula K. LeGuin, "Wydziedziczeni", 1974
(przełożył Łukasz Nicpan)

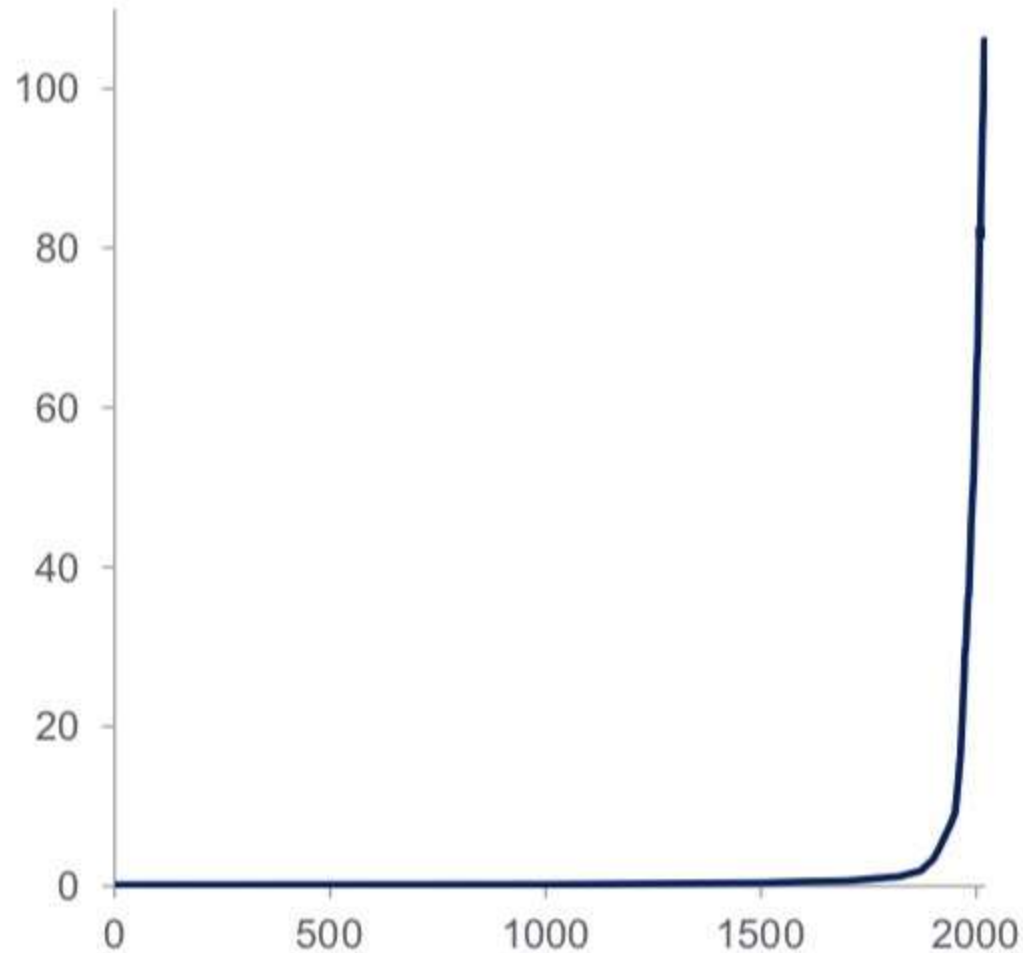


"Przygnębia mnie, kiedy ludzie mi mówią jak niesamowicie byłem dalekowzroczna, mówiąc o zmianie klimatu i destabilizacji klimatu i degradacji środowiska naturalnego w latach 60. Nie byłem! Po prostu słuchałam naukowców."

Urszula K. LeGuin, wywiad dla Boston Globe, 2014 rok.

Finance loves time series like this

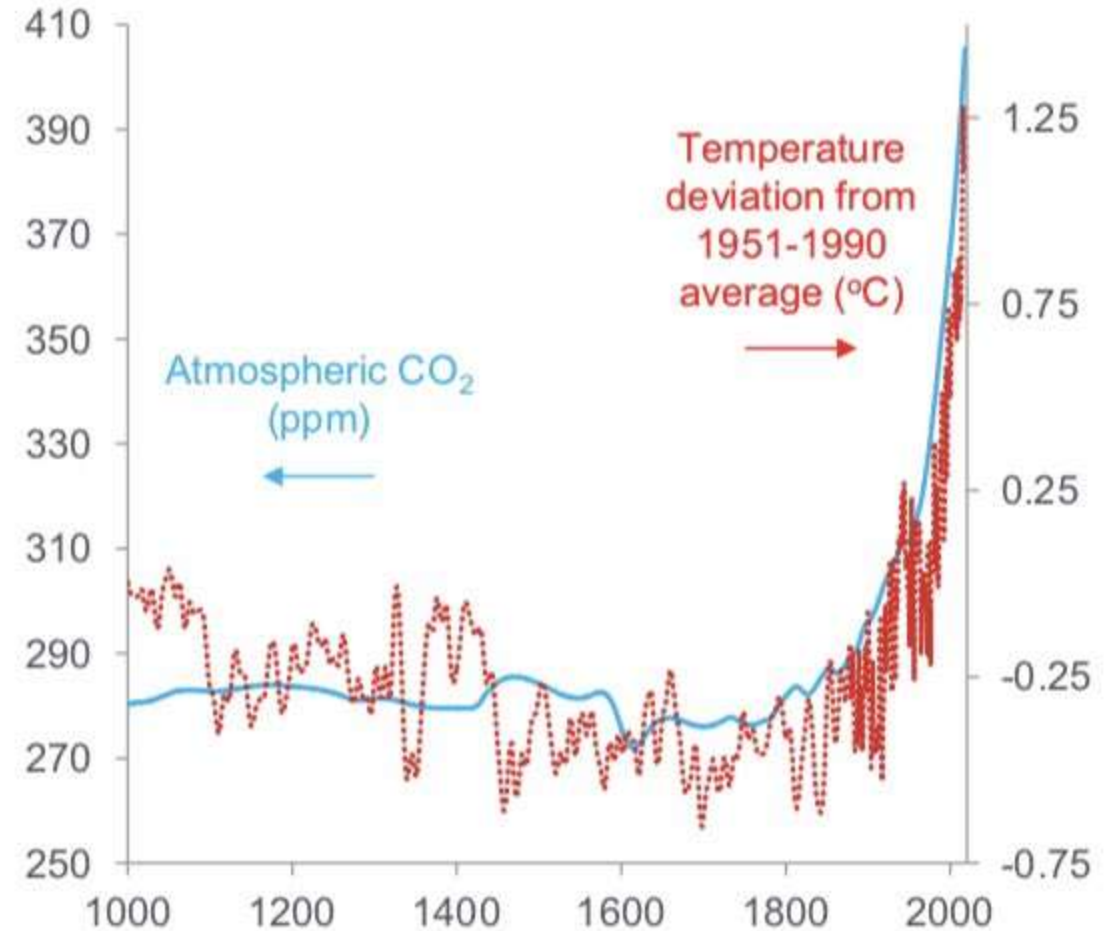
World GDP over two millennia, \$tn



Source: World Bank, New Maddison Project Database.

Nature doesn't

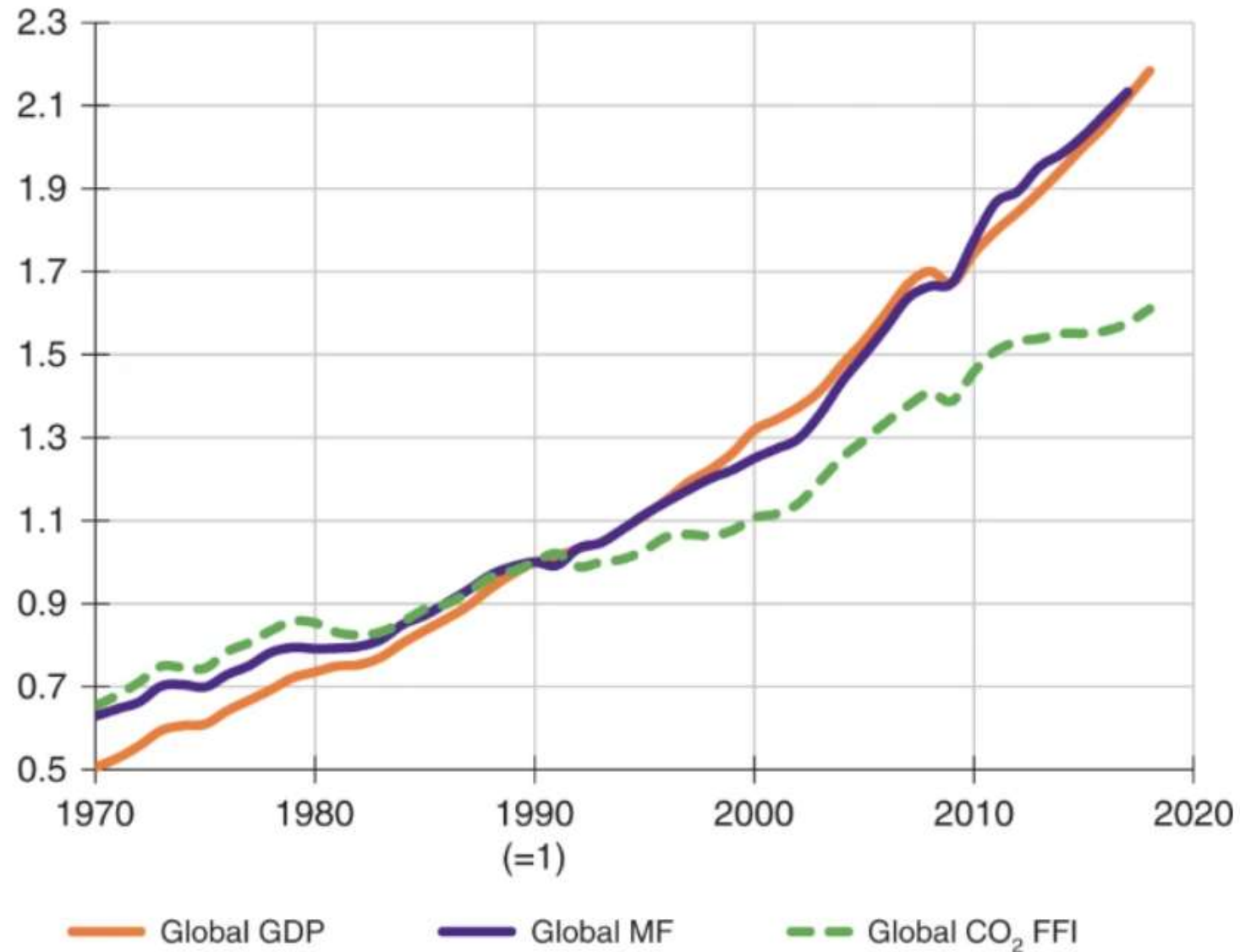
Atmospheric CO₂ concentration vs northern hemisphere temperature



Source: Scripps Institute, NASA, Our World In Data.

Quotation below from David Attenborough, citing Kenneth Boulding

Fig. 1: Relative change in main global economic and environmental indicators from 1970 to 2017.



Scientists' warning on affluence, Nature Communications, <https://doi.org/10.1038/s41467-020-16941-y>

Granice wzrostu

(Limits to Economic Growth, Thomas W. Murphy Jr, Nature Physics)

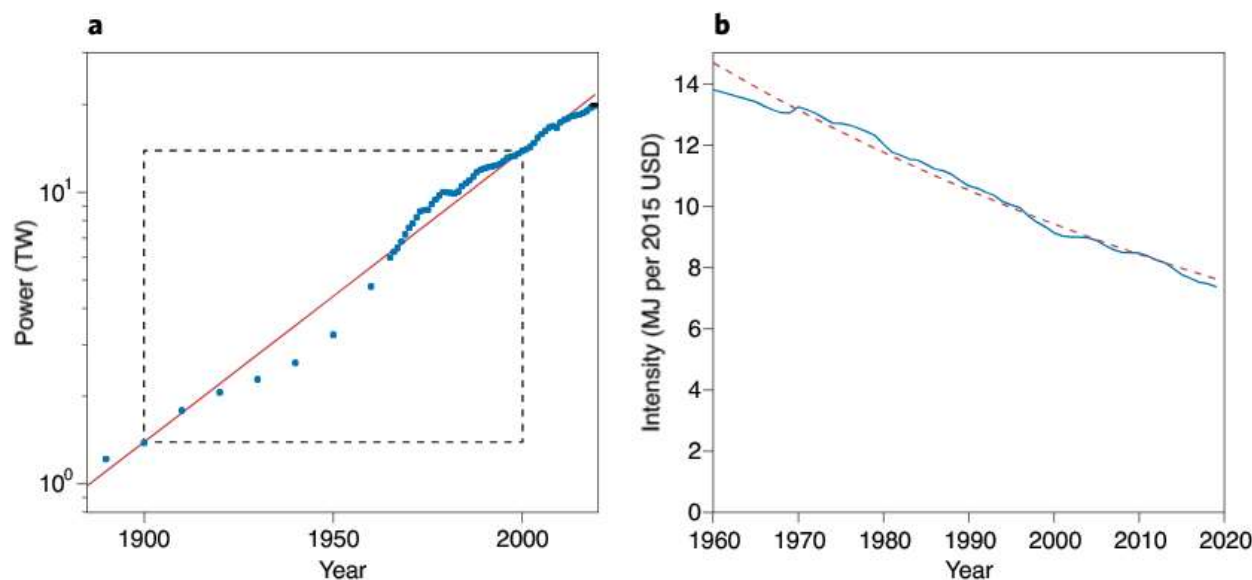
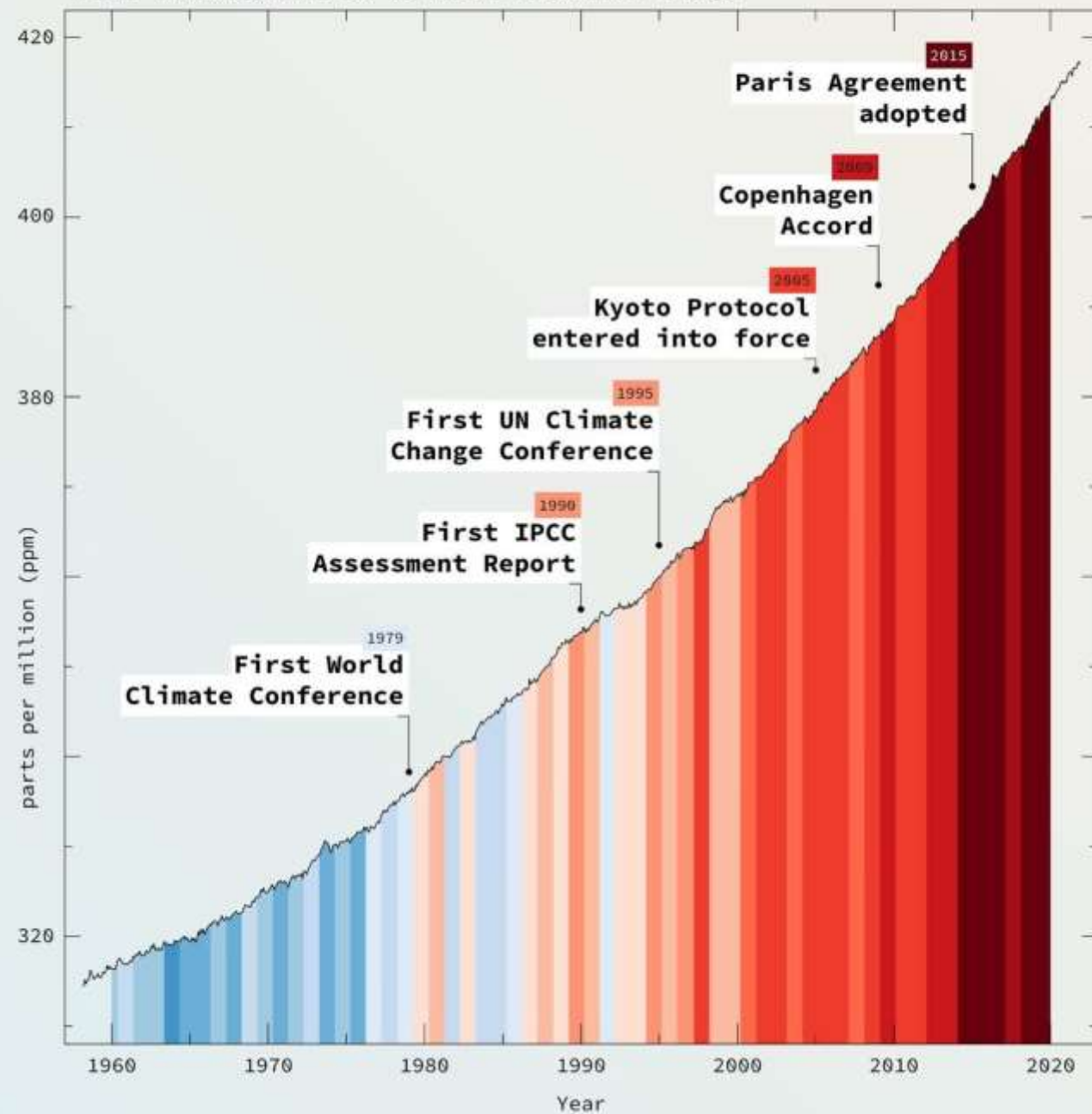


Fig. 1 | Historical energy growth and intensity decline. **a**, Global rate of energy expenditure on a logarithmic scale over the past century, including fossil fuel, renewable, and nuclear resources. The red line represents a 2.3% exponential growth rate, corresponding to a factor of ten per century (dotted box). The line is not a fit to the data, but is selected as a convenient and reasonable representative of global energy growth. **b**, Economic intensity for the world as a function of time (blue curve), in MJ per 2015 constant dollars. The red dashed line is a best-fit exponential function showing a decline of 1.1% per year. Data taken from refs. ^{10,11}.

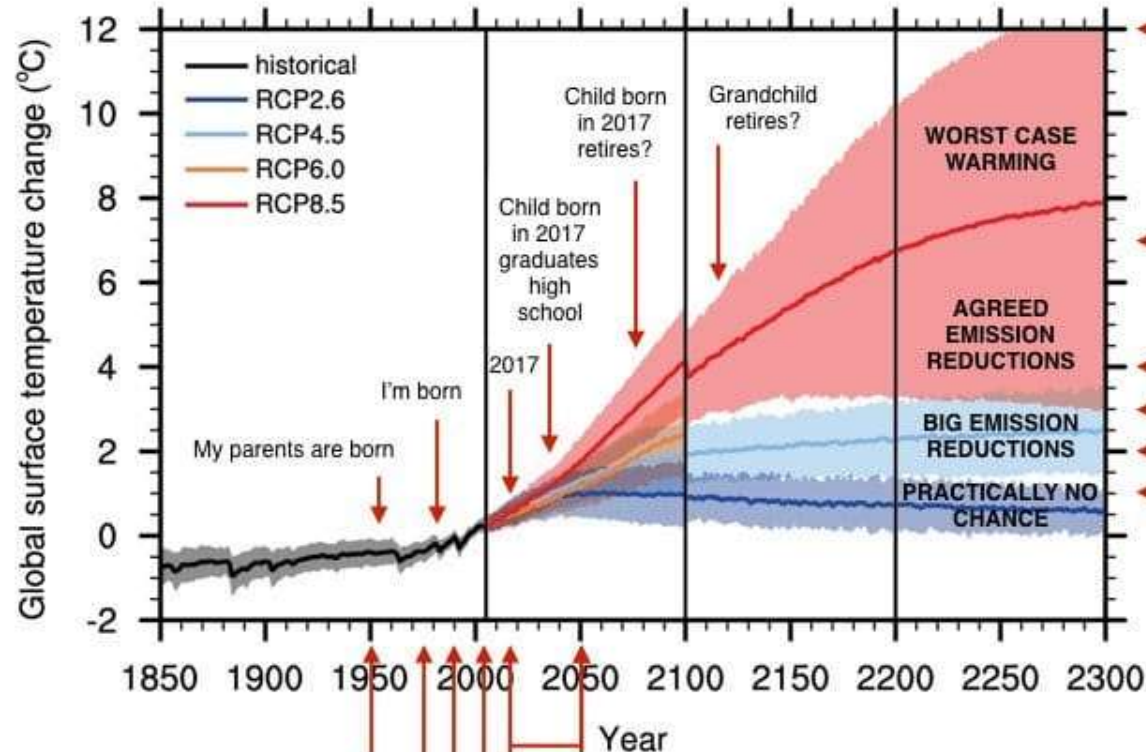
Trends in Atmospheric CO₂ vs Global Temperature Change



Composite Graph of: Atmospheric CO₂ at Mauna Loa Observatory, December 2021 – Scripps Institution of Oceanography & NOAA Global Monitoring Laboratory | #ShowYourStripes – Graphics & Lead Scientist: Ed Hawkins, National Centre for Atmospheric Science, University of Reading; Data: UK Met Office | Design by: sustentio [PG] | Licence: CC-BY

WHY I SUPPORT (ALMOST) ALL SOLUTIONS TO REDUCE EMISSIONS - NUCLEAR POWER INCLUDED

WARMING



POSSIBLE CONSEQUENCES

12°C or more (est.): Half of Earth's surface too hot and humid for unprotected humans to even survive, let alone live

7°C or more (est.): In many areas, summer heat & humidity so high that unprotected humans cannot survive
Vast areas become uninhabitable due to heat; death of oceans and forest loss may reduce oxygen content of atmosphere

4°C or more (est.): World's food supply critically endangered; civilisation's survival uncertain

3°C (est.): Major loss of food production; corals die; oceans at risk

2°C: Poor coastal and island nations will drown eventually

1°C: 30% of world's fresh water supply at risk

Graph: IPCC AR5 WG1, Fig. 12-05 (2013)

Based on original idea by Sophie Lewis
(Twitter: @aviandelights)

Nuclear buildup in France and Sweden between ca. 1975-90; by 1990, both have 80% low-carbon electricity & very low emissions per capita - **BY ACCIDENT**

Germany's "energiewende" begins in 2002; **if all goes perfectly, Germany may have 80% low-carbon electricity in 2050**

Additional information collected and added by
J. M. Korhonen
jmkorhonen.net
climategamble.net
Twitter: @jmkorhonen

Power corrupts, but we all need electricity

1/5

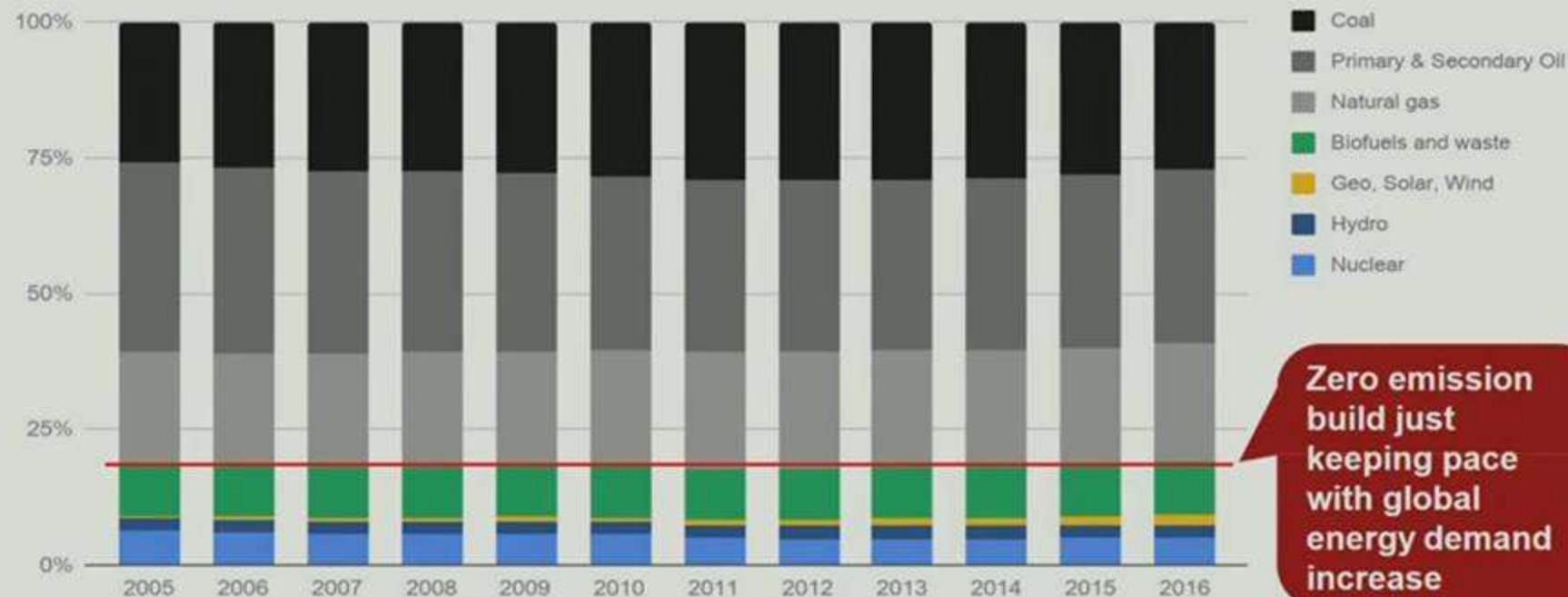


Zagadka: co to za mapa?

Humanity is not yet transitioning to a zero emission energy system

Share of total primary energy supply by fuel type

% of total (originally in ktoe)

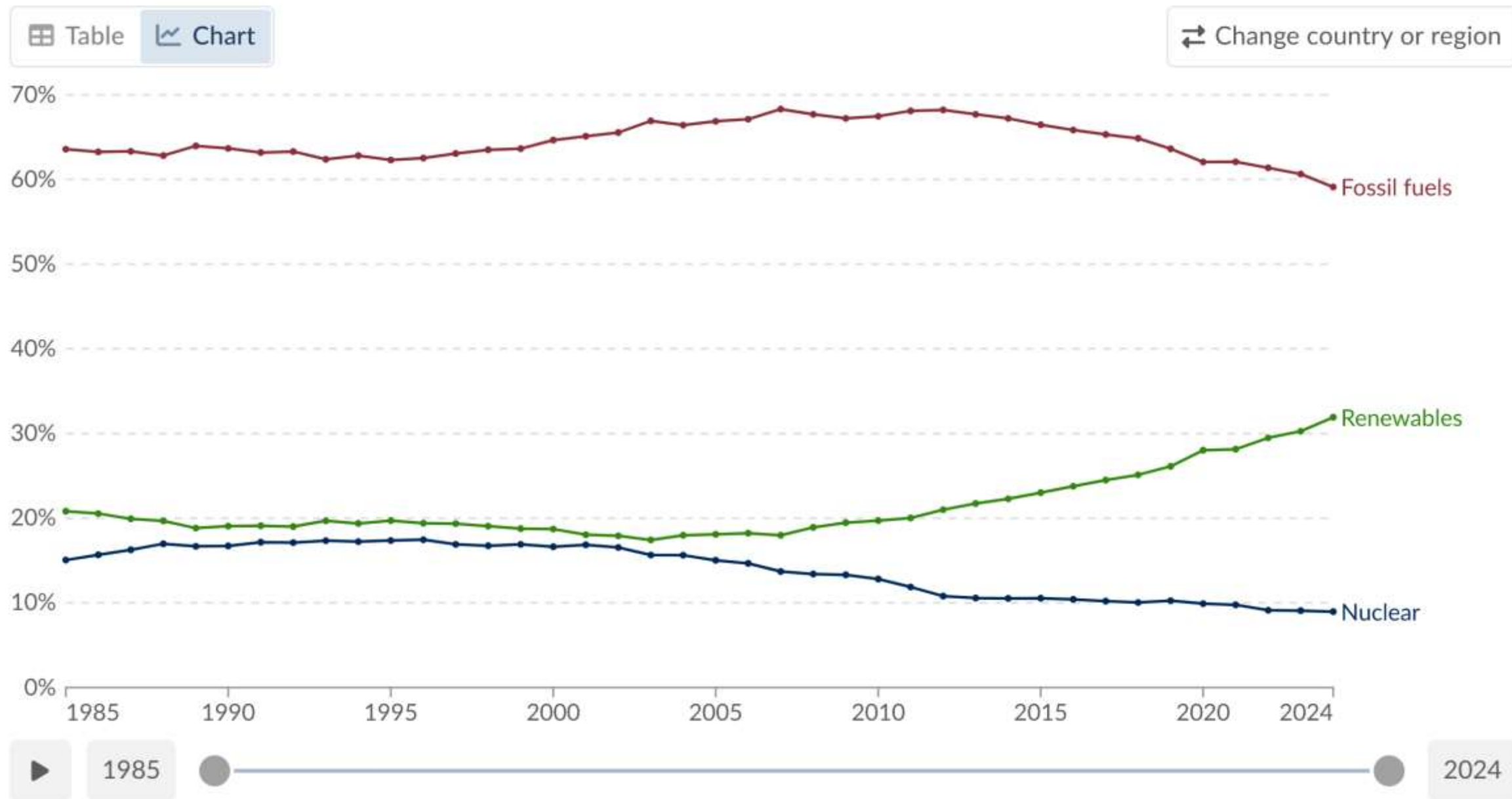


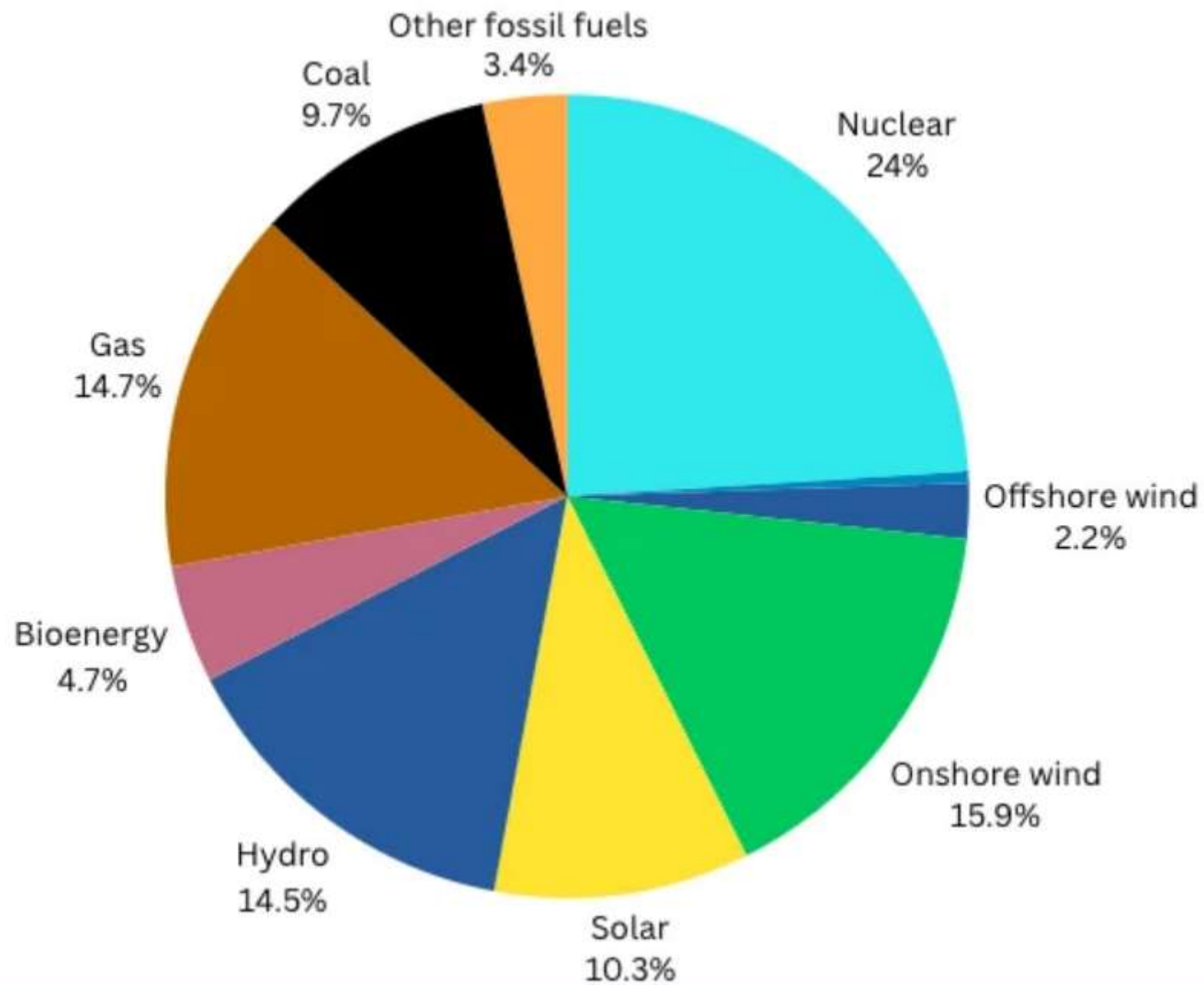
Source: [International Energy Agency World Energy Balances 2018](#)



Share of electricity generation from fossil fuels, renewables and nuclear, World

Measured as a percentage of total electricity produced in the country or region. Fossil fuels include coal, oil, and gas. Renewables include solar, wind, hydropower, bioenergy, geothermal, wave, and tidal.



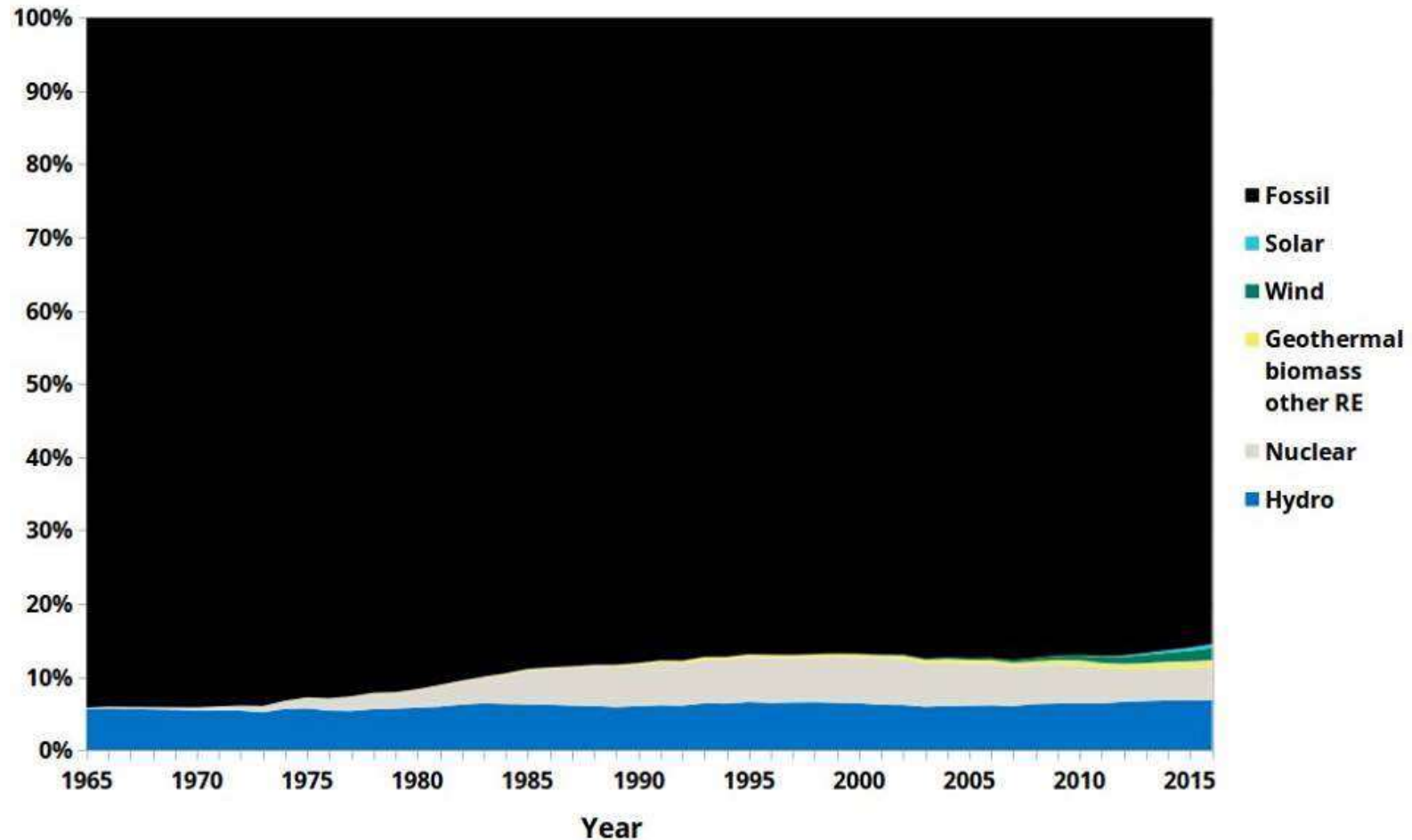


Graphic: The EU's power generation mix in 2024

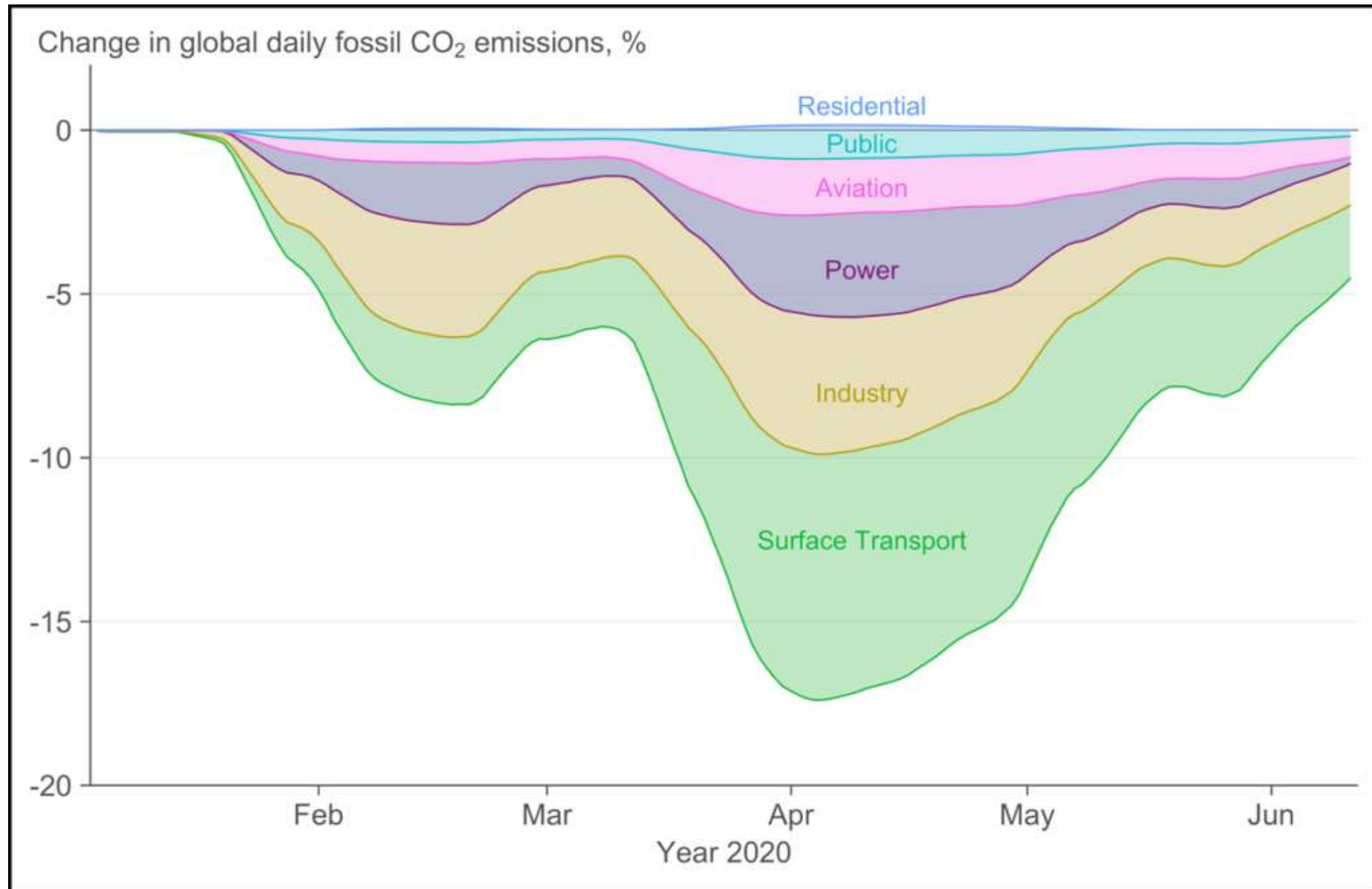
Energia pierwotna kontra elektryczność

Global energy consumption 1965-2016

Source: BP Statistical Review of World Energy 2017

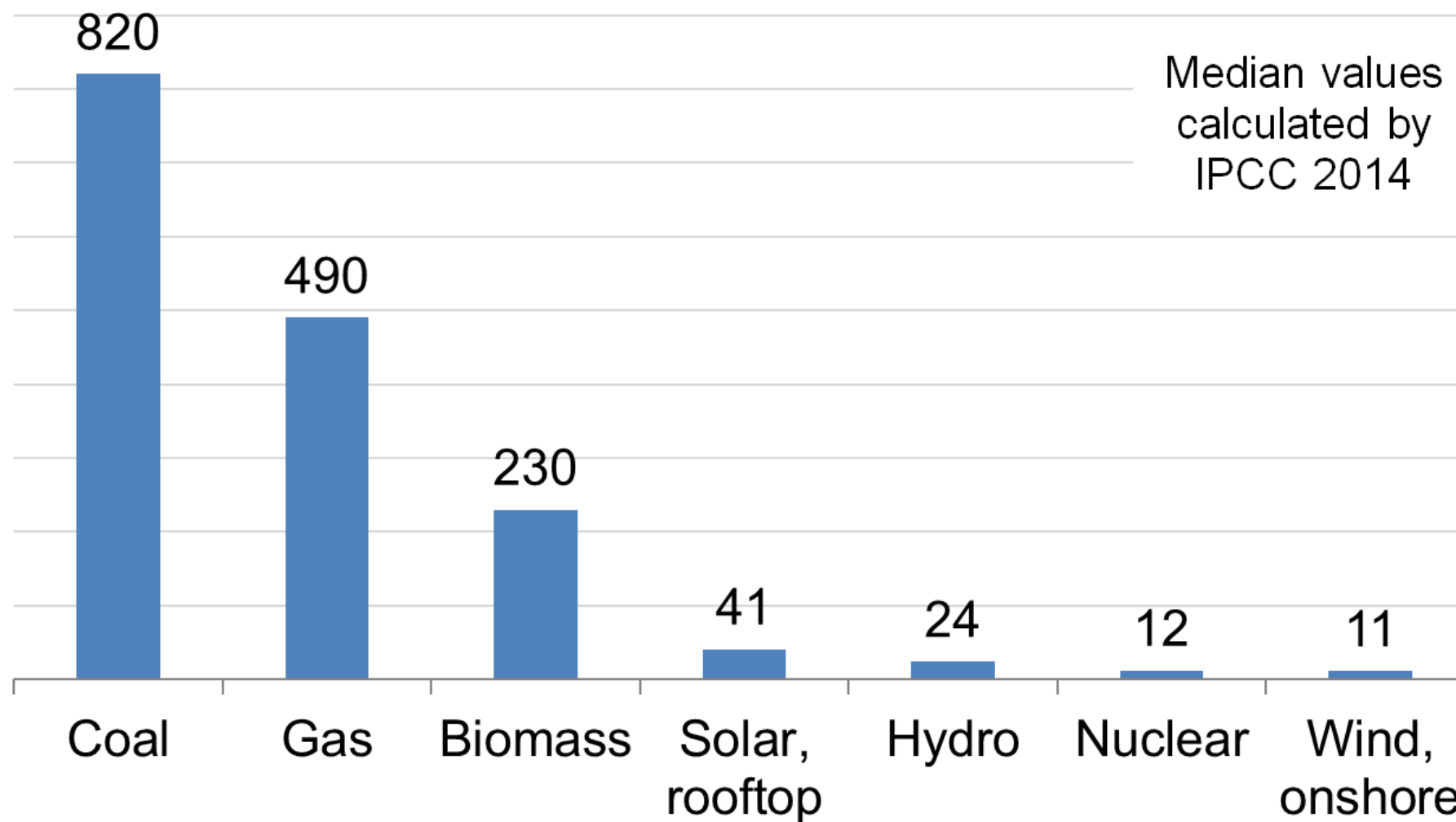


Zmiany systemowe i eksperyment naturalny



Dostępne opcje dekarbonizacji

Lifecycle CO₂-equivalent emissions (g/kWh)

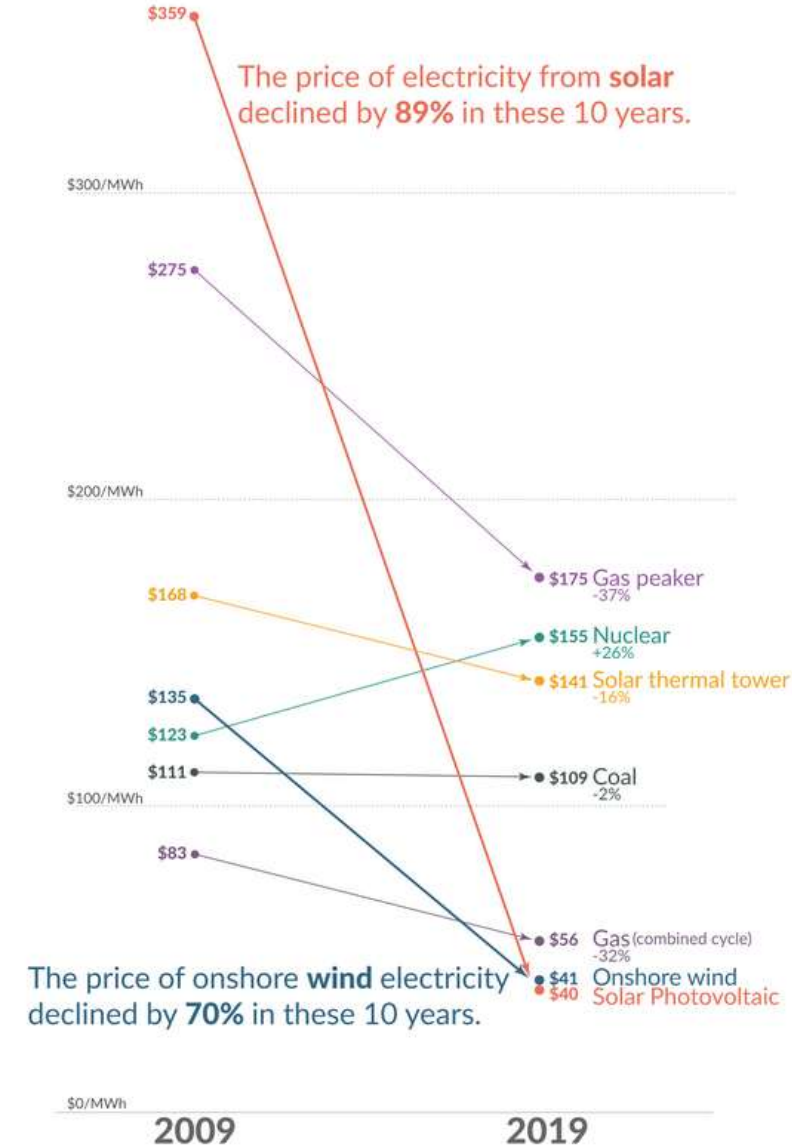


The price of electricity from new power plants

Electricity prices are expressed in 'levelized costs of energy' (LCOE). LCOE captures the cost of building the power plant itself as well as the ongoing costs for fuel and operating the power plant over its lifetime.

Our World
in Data

SOLARPUNK!

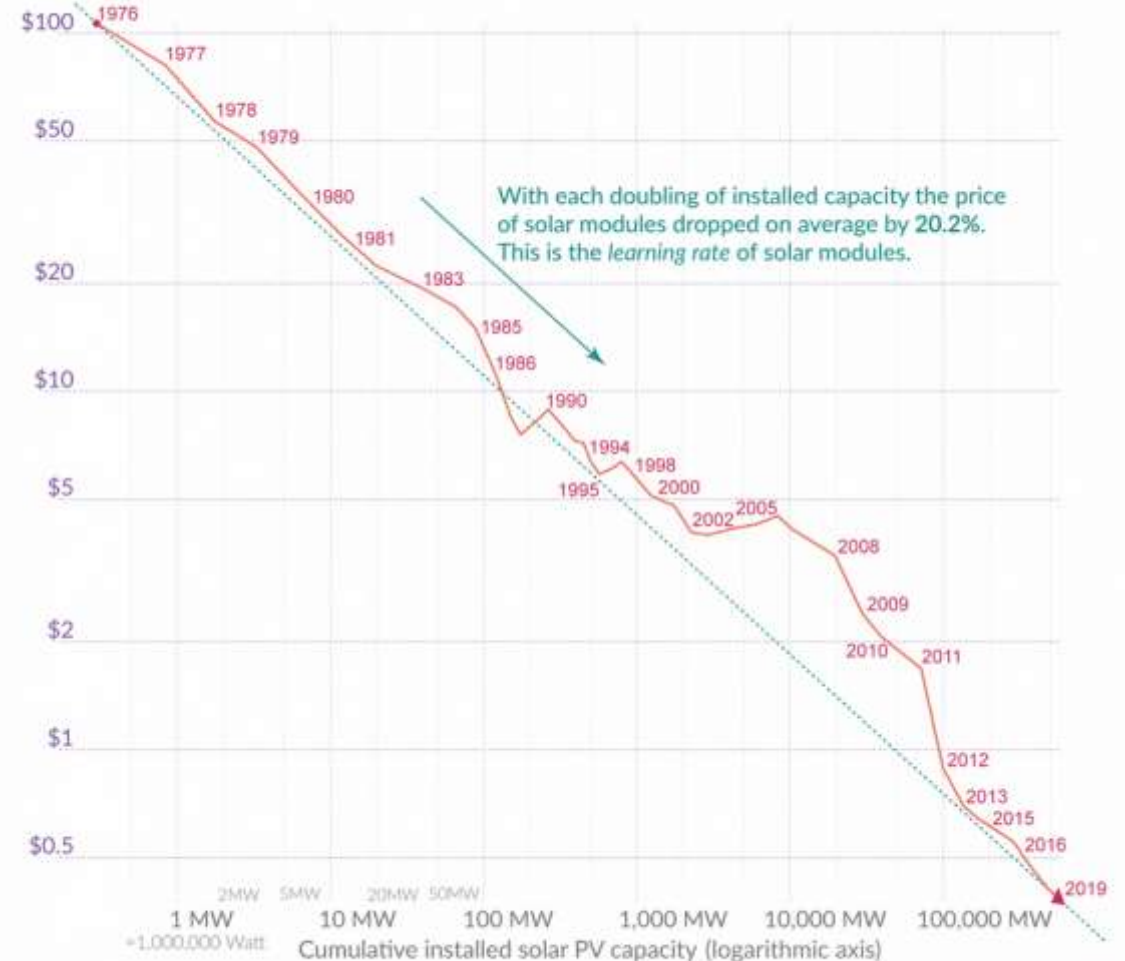


Data: Lazard Levelized Cost of Energy Analysis, Version 13.0
OurWorldinData.org - Research and data to make progress against the world's largest problems. Licensed under CC-BY by the author Max Roser.

The price of solar modules declined by 99.6% since 1976

Our World
in Data

Price per Watt of solar photovoltaics (PV) modules (logarithmic axis)
The prices are adjusted for inflation and presented in 2019 US-\$.

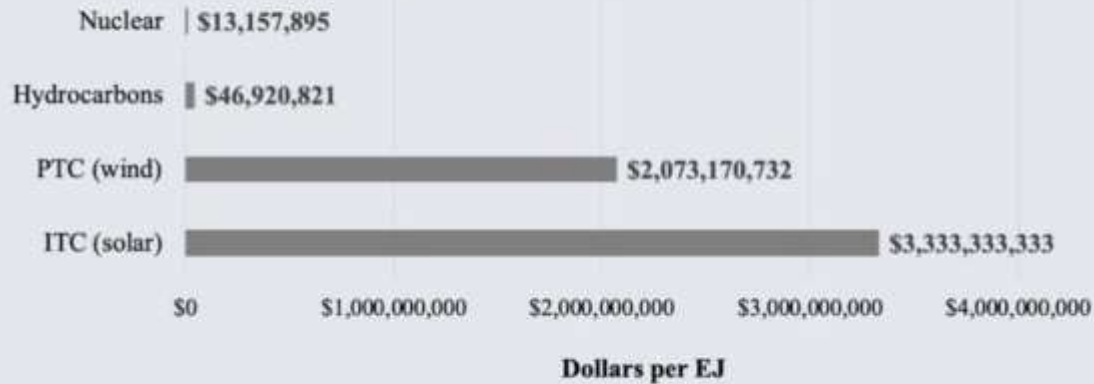


Data: Lafond et al. (2017) and IRENA Database; the reported learning rate is an average over several studies reported by de La Tour et al (2013) in Energy. The rate has remained very similar since then.

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Subwencje i rodzaj tworzonych miejsc pracy

Federal Energy-Related Tax Incentives, Per Unit of Energy Produced, 2018



When compared on the amount of energy produced, solar energy is getting more than 250 times as much ... [+] SOURCES: CRS, BP, AUTHOR CALCULATIONS.

2010 - 2016

**INVEST
MENTS**
↓ 92%

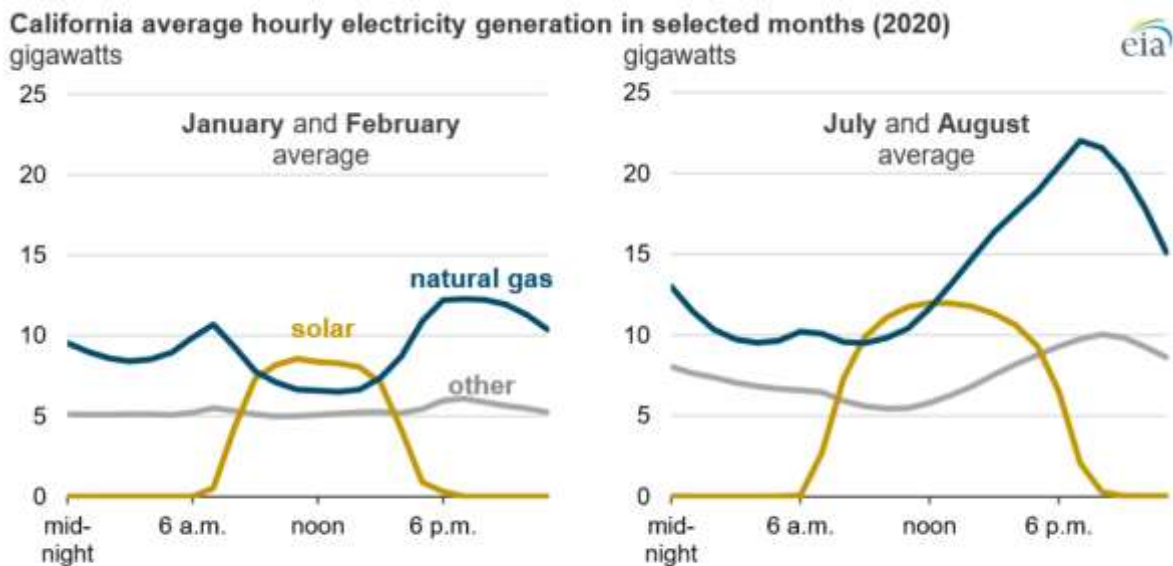
**FEED-IN
TARIFFS**
↓ 64%

SOLAR JOBS

2007 - 2015

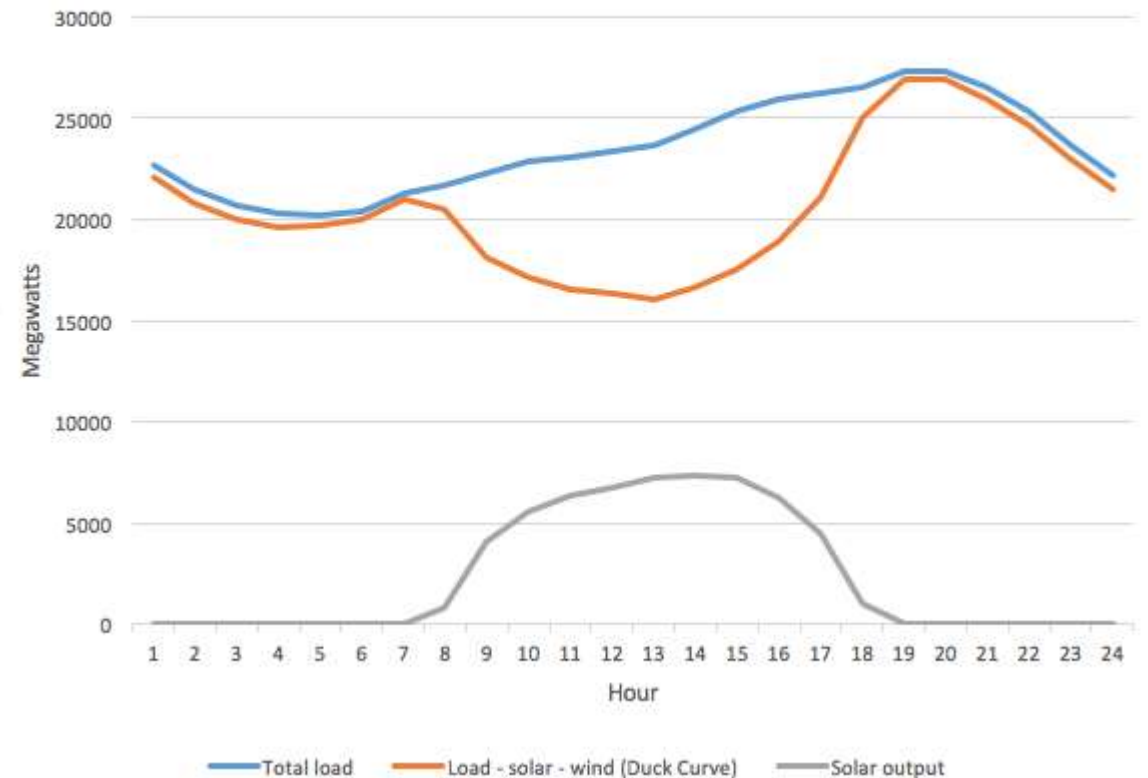


Problem 1 - “Krzywa kaczki”

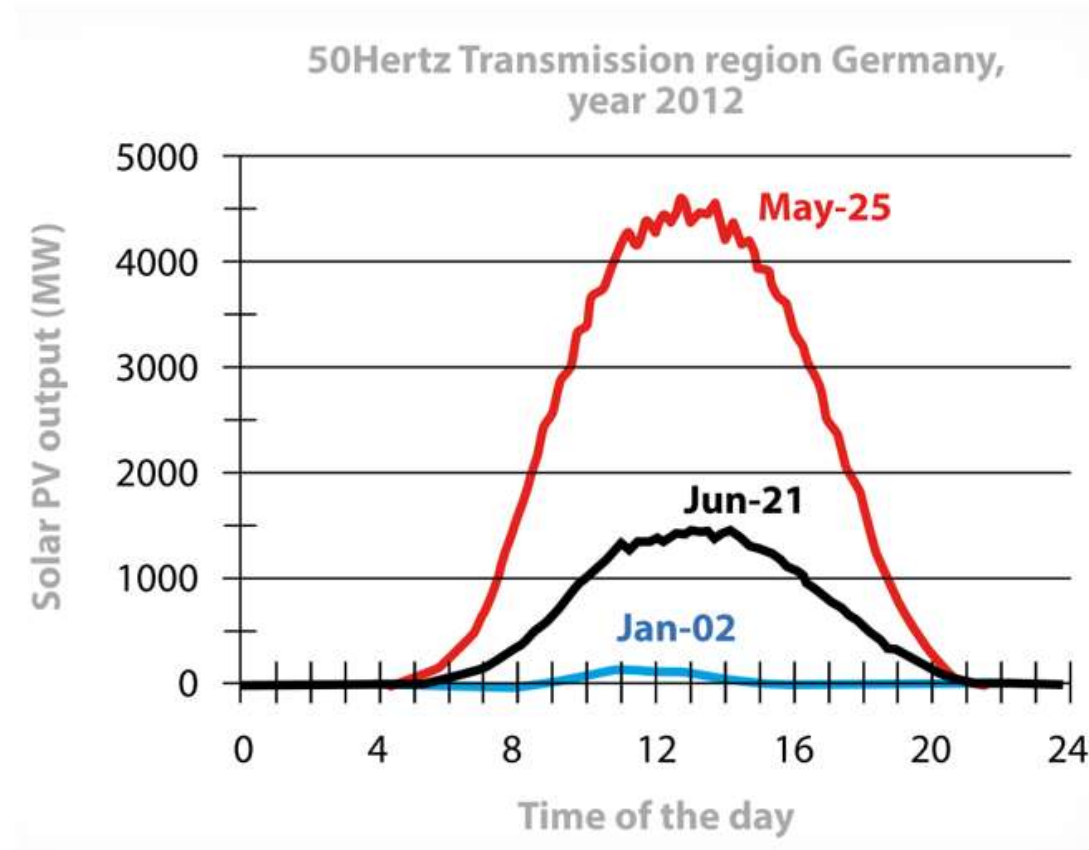


Source: U.S. Energy Information Administration, [Hourly Electric Grid Monitor](#)
Note: Data are for the [California](#) region, which includes electric power markets regulated by the California Independent System Operator (CAISO) and other balancing authorities operating largely in California.

California hourly electric load vs.
load less solar and wind (Duck Curve)
for October 22, 2016



Problem 2 – nachylenie osi obrotu planety





Wiatr



European wind energy generation in 2018

Wind[•]
EUROPE

GW

200

180

160

140

120

100

90

80

70

60

50

40

30

20

10

0



178 GW Installed capacity



8 December
Record in wind production

Jan

Feb

Mar

Apr

May

Jun

Jul

Aug

Sep

Oct

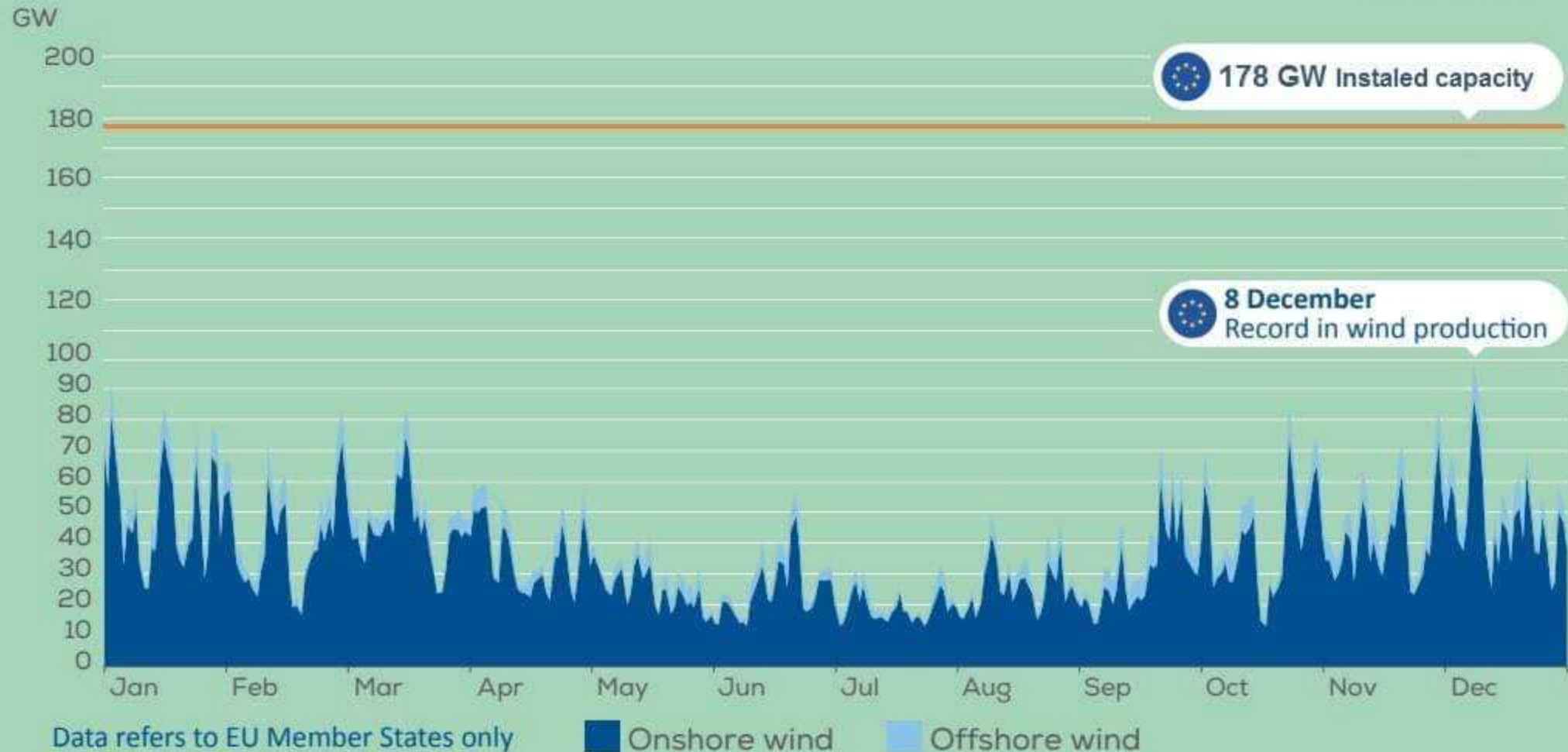
Nov

Dec

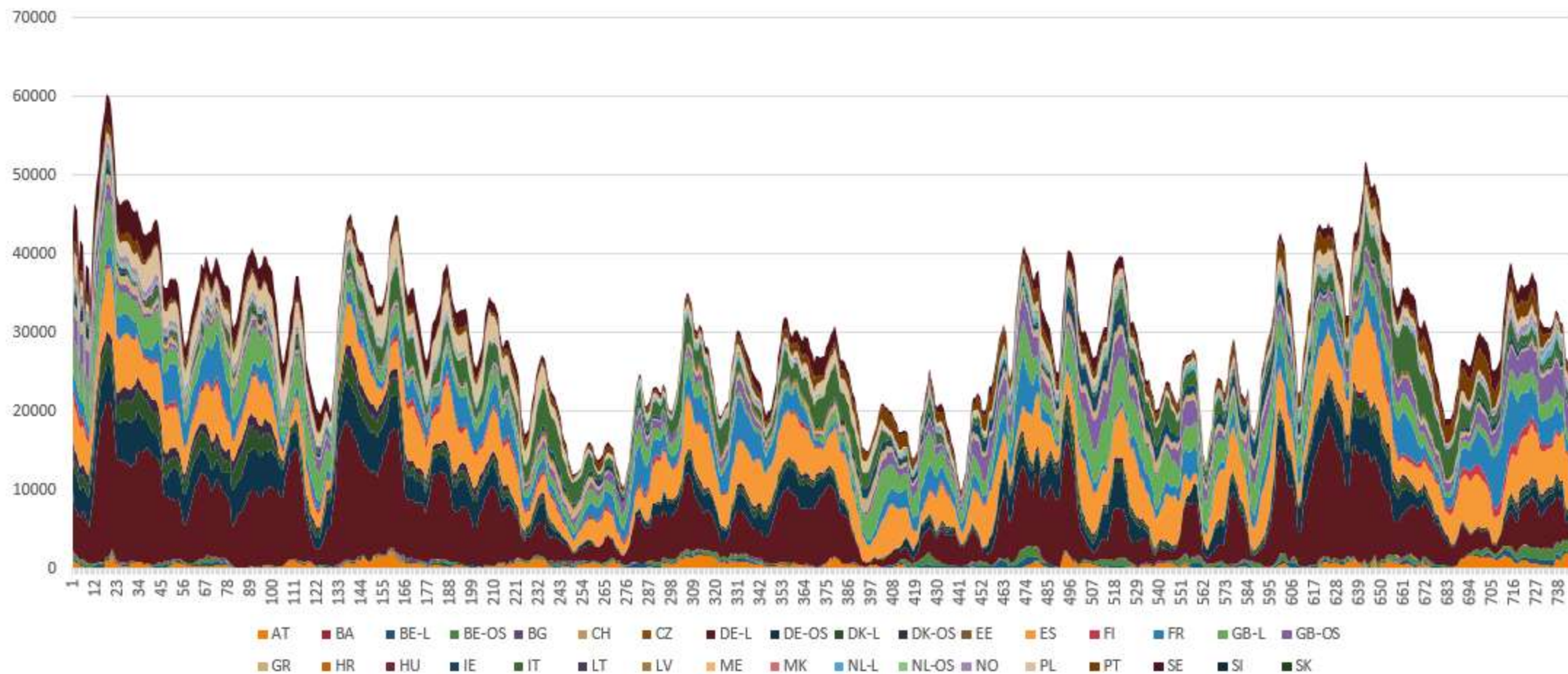
Data refers to EU Member States only

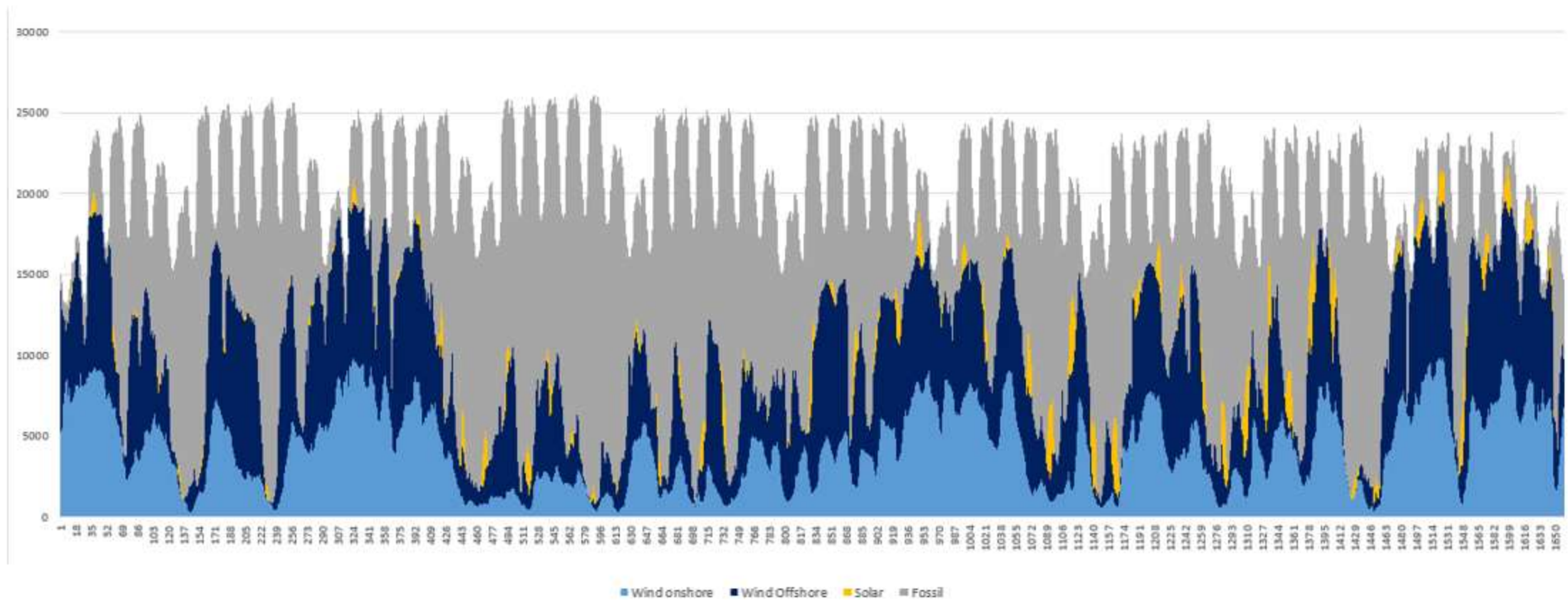
■ Onshore wind

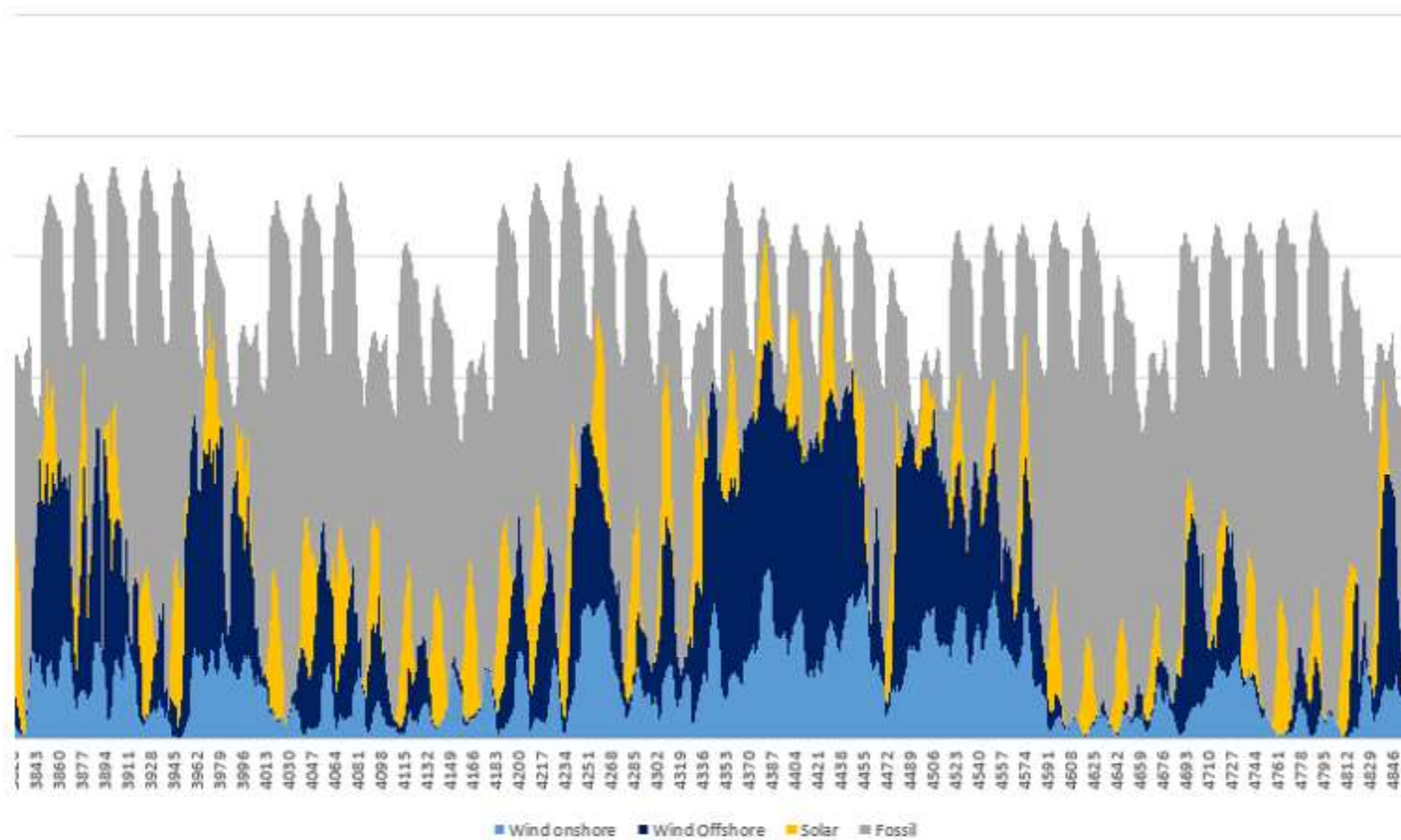
■ Offshore wind



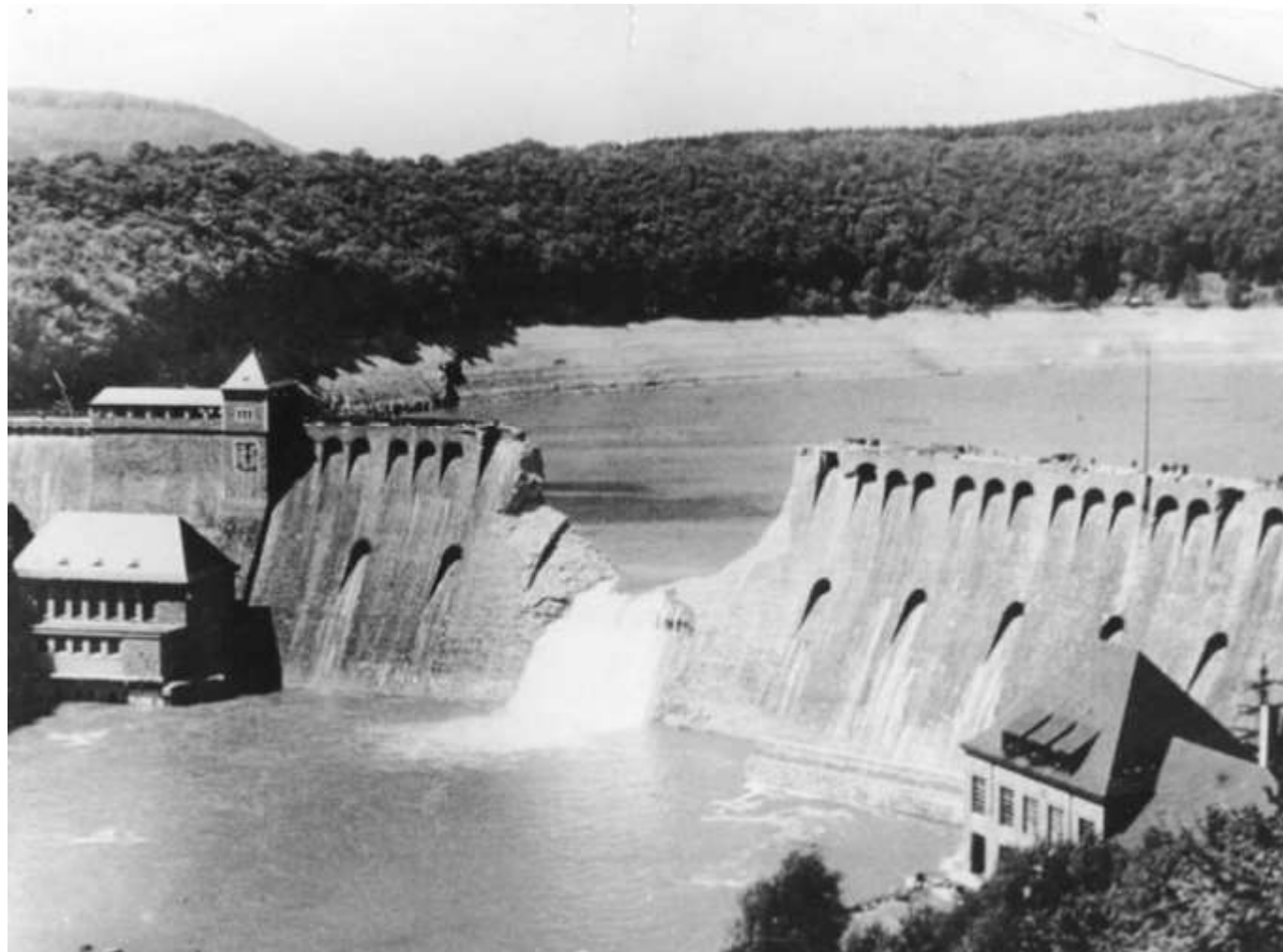
Energetyka wiatrowa w Europie, lipiec 2019







Hydroelektrownie



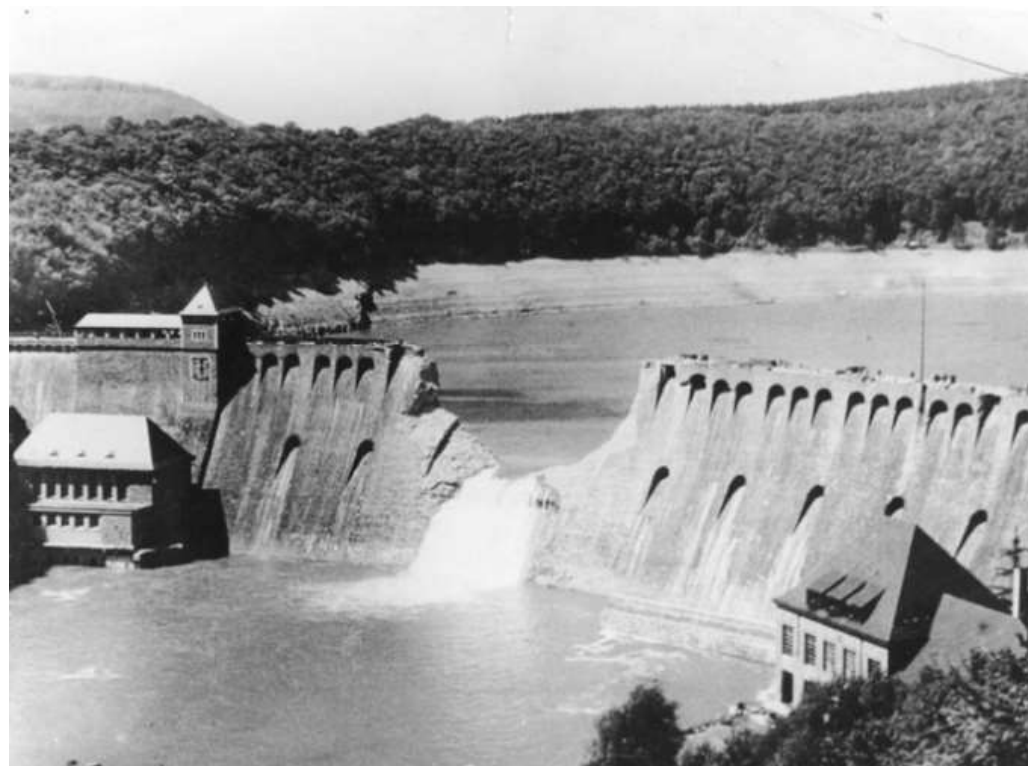
Hydroelektrownie



Vajont – 1900-2500 ofiar



Machchu-2 - 1800 do 25 000 ofiar



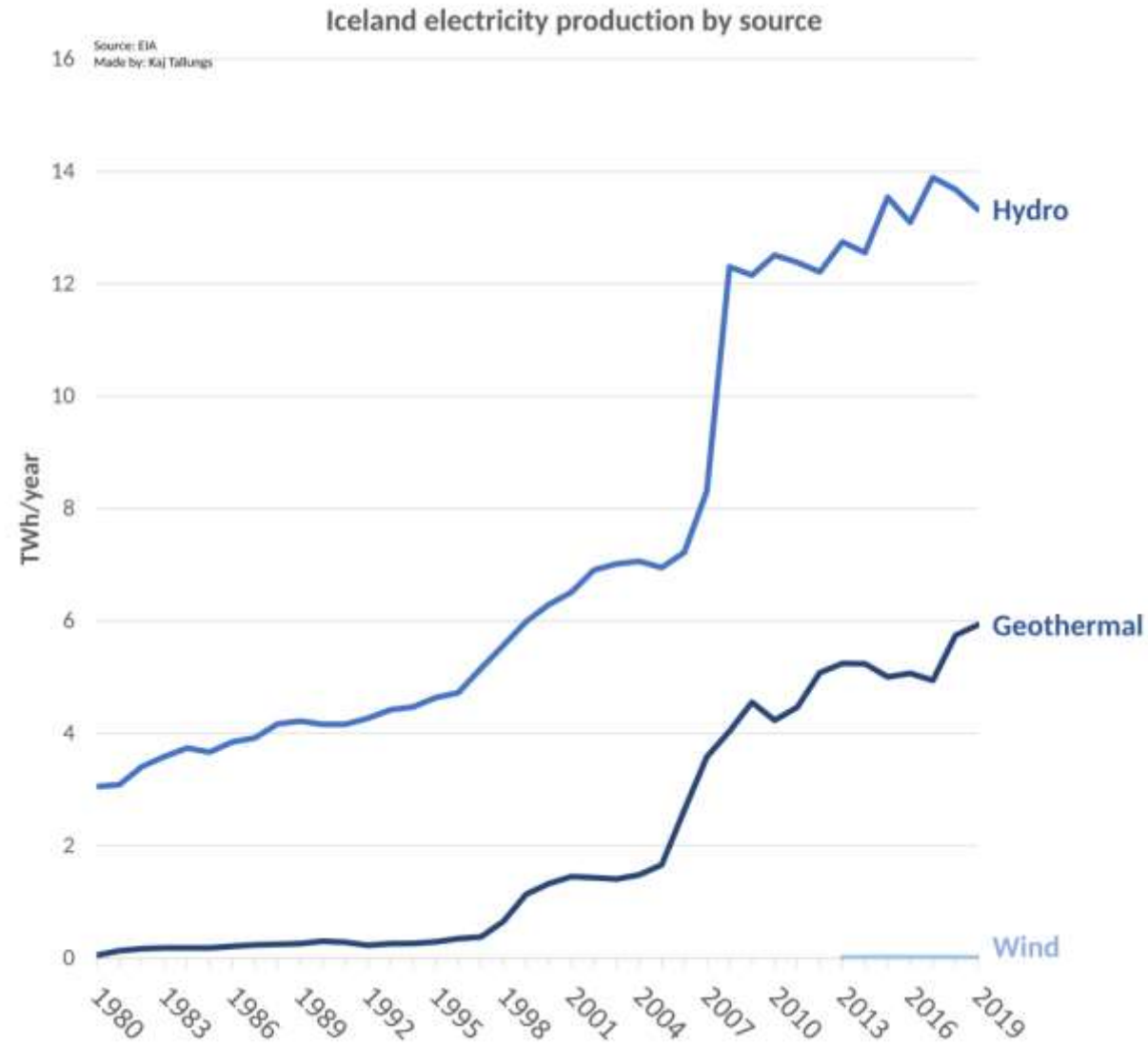
Banqiao - 171 000-250 000 ofiar



Geotermia



Miks energetyczny Islandii



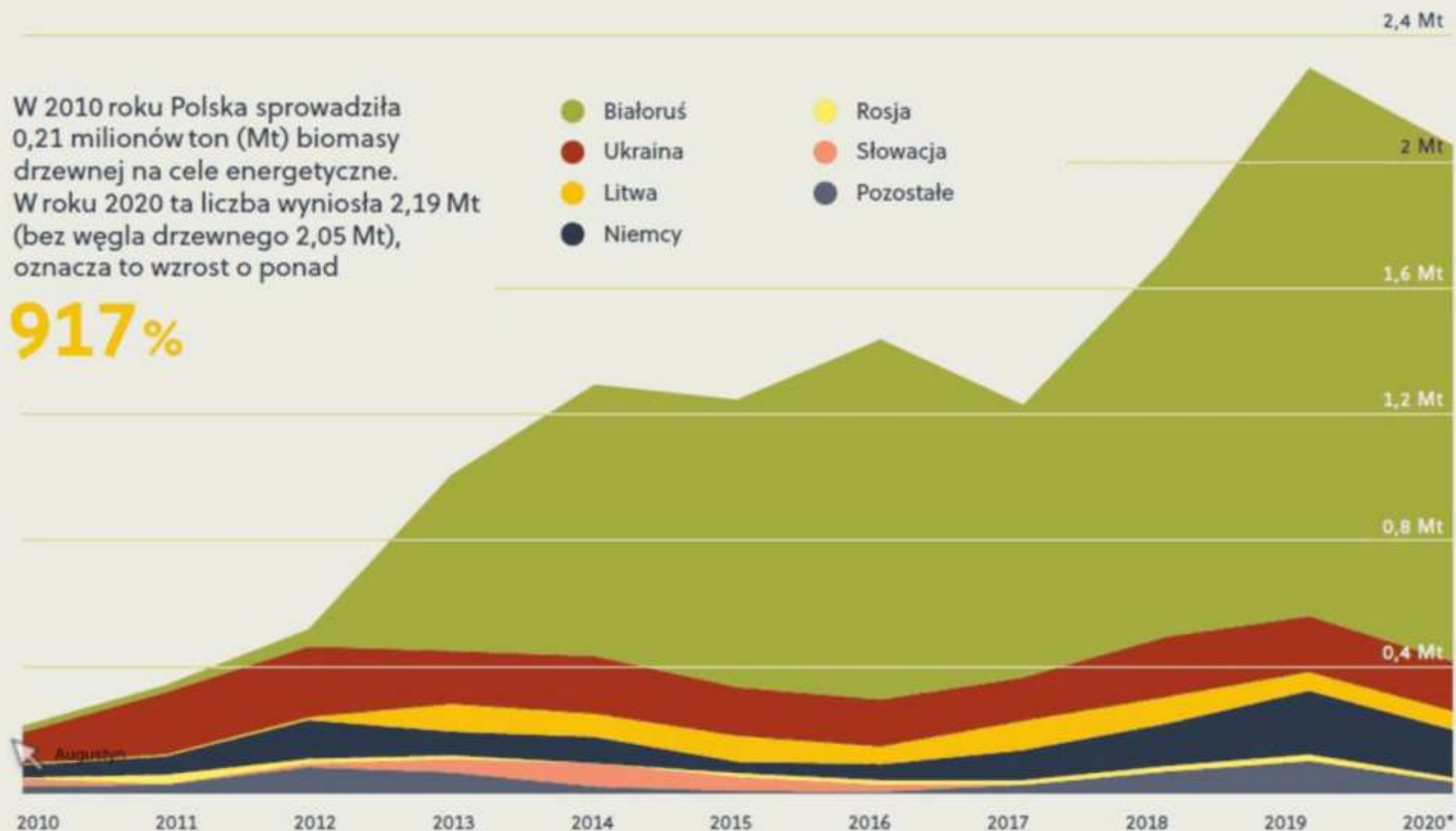
Biomasa



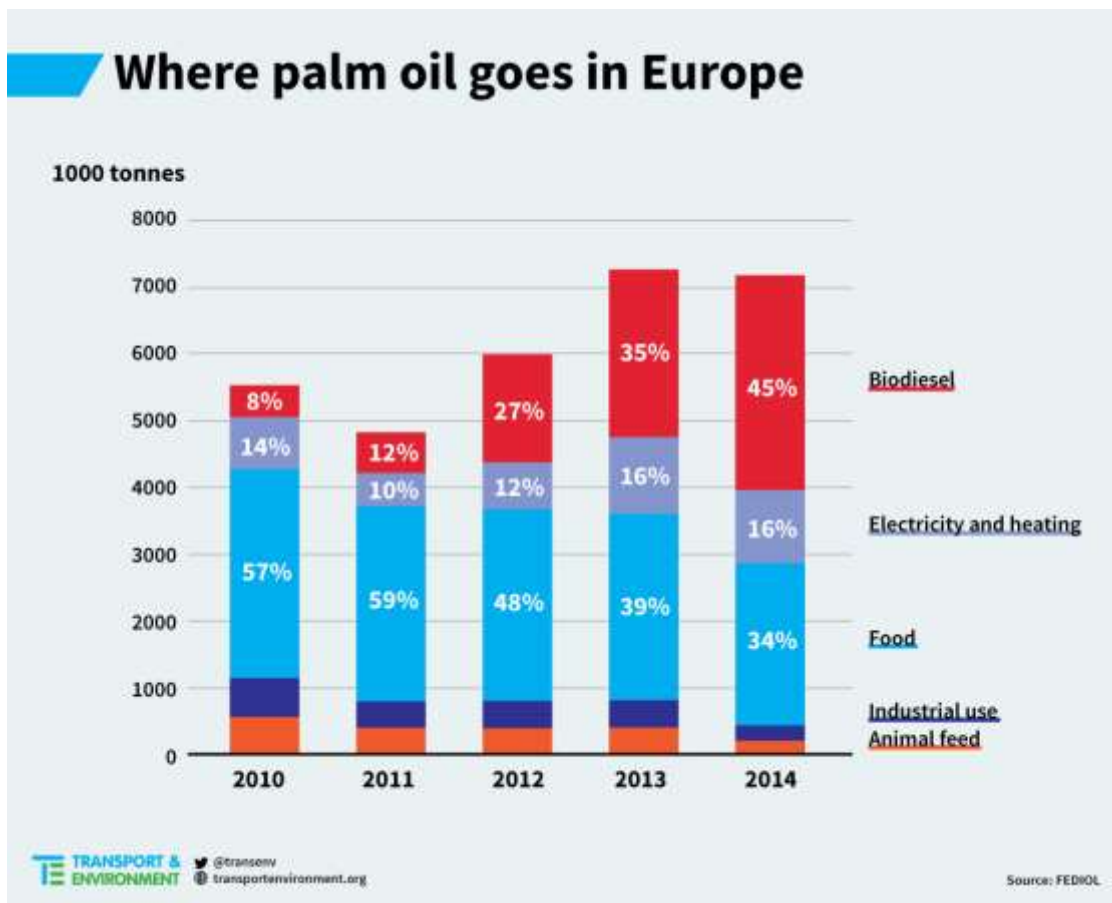
Ilość importowanej biomasy drzewnej (bez węgla drzewnego) z podziałem na państwa

W 2010 roku Polska sprowadziła 0,21 milionów ton (Mt) biomasy drzewnej na cele energetyczne. W roku 2020 ta liczba wyniosła 2,19 Mt (bez węgla drzewnego 2,05 Mt), oznacza to wzrost o ponad

917%



“Ekologiczne biopaliwa”



Magazyny energii



Solar Choice Battery Price Index



Ile magazynowania potrzebuje Energiewende?

Same Niemcy - 15 (superoptymistycznie) do 25 (pesymistyczne) TWh

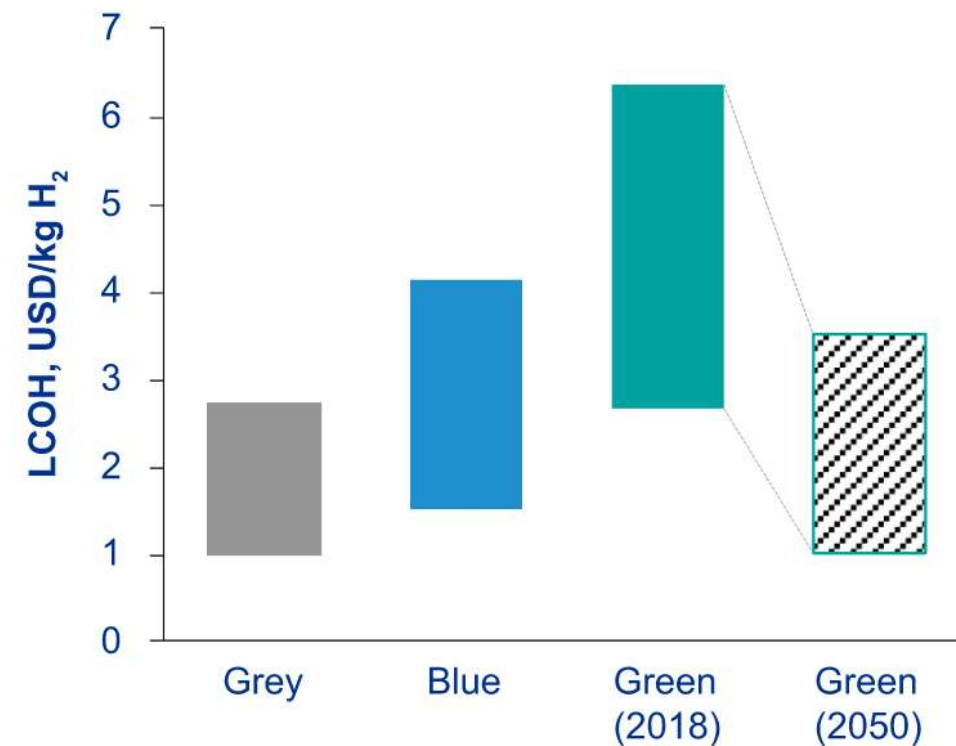
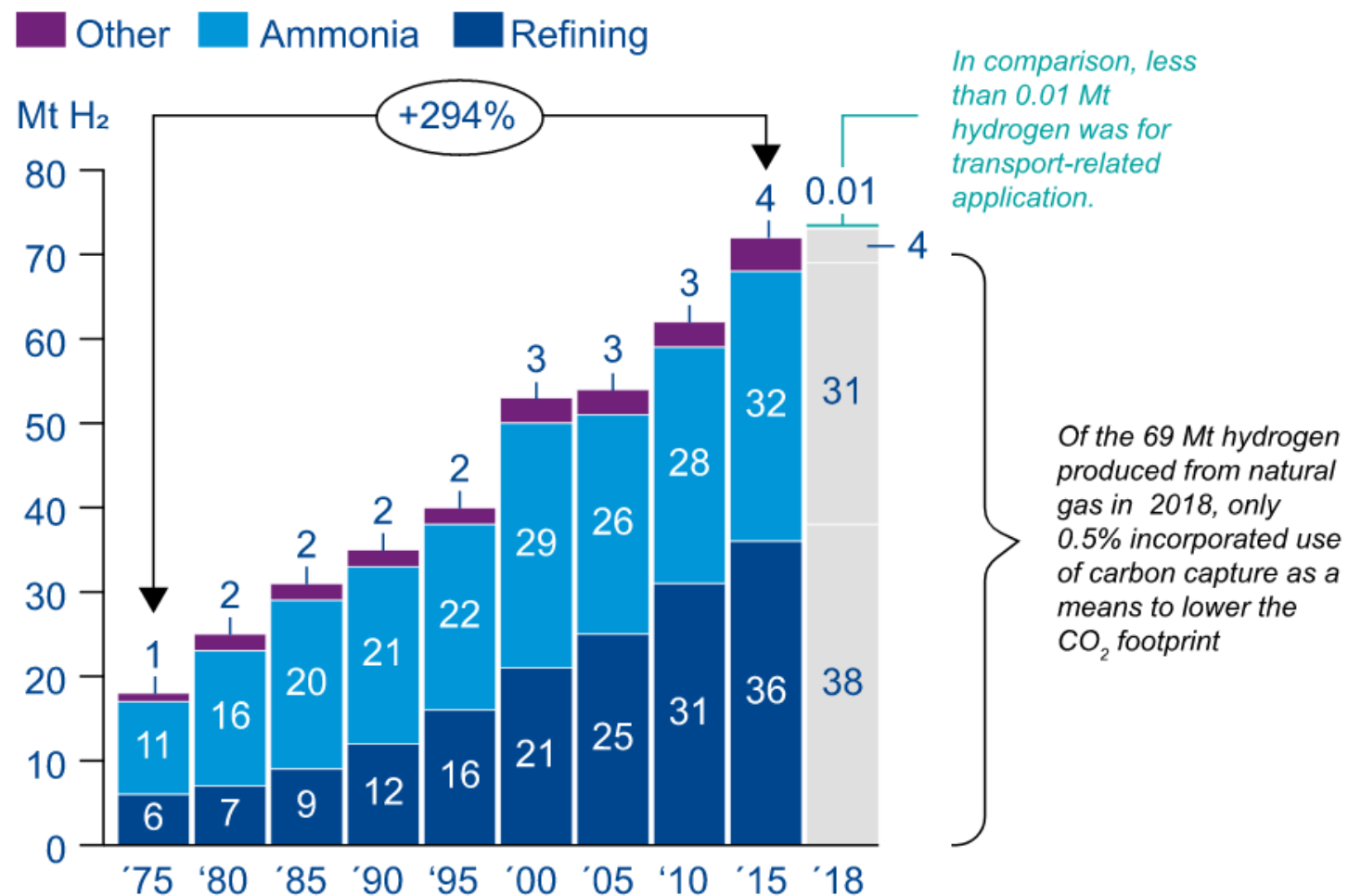
25 Twh to 25 000 000 MWh

ESP Żarnowiec - 3600 MWh (potrzeba ~6945).

Niemcy mają 30 ESP (37 700 MWh)

Hornsedale Power Reserve - 194 MWh (potrzeba ~128 850)

“Zielony” wodór



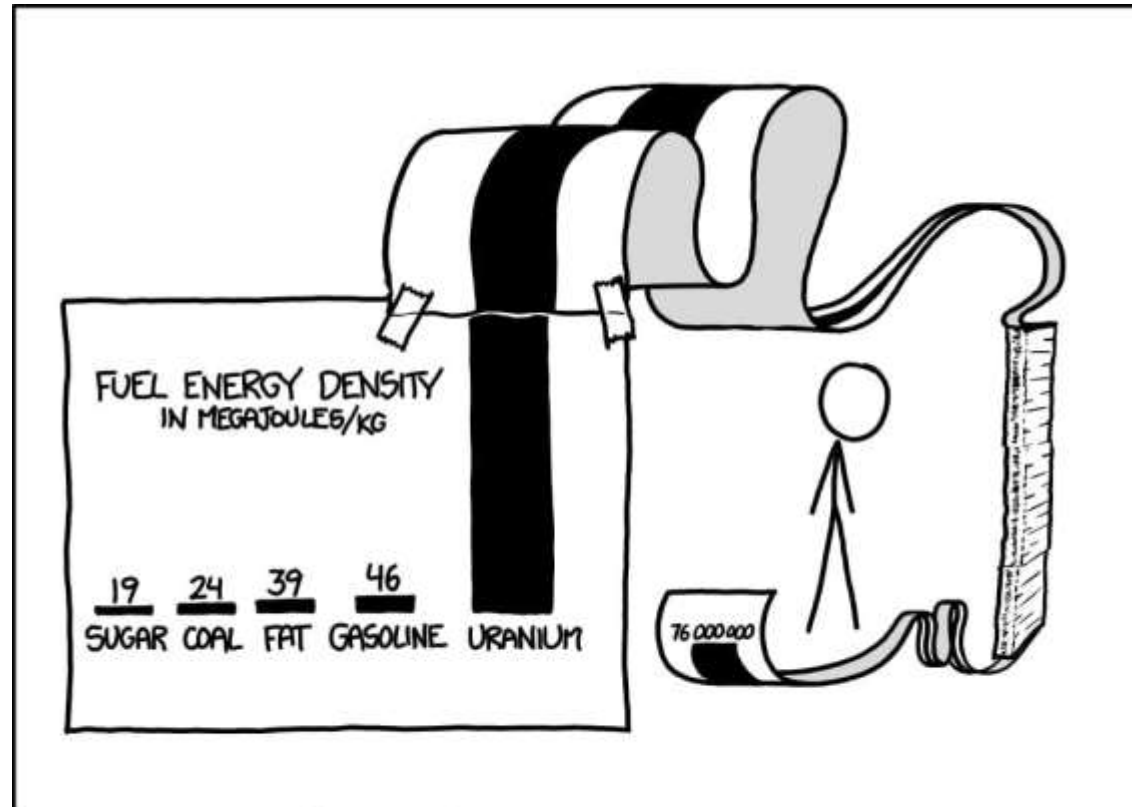
100% OZE? Solarpunk!



Efektywność energetyczna



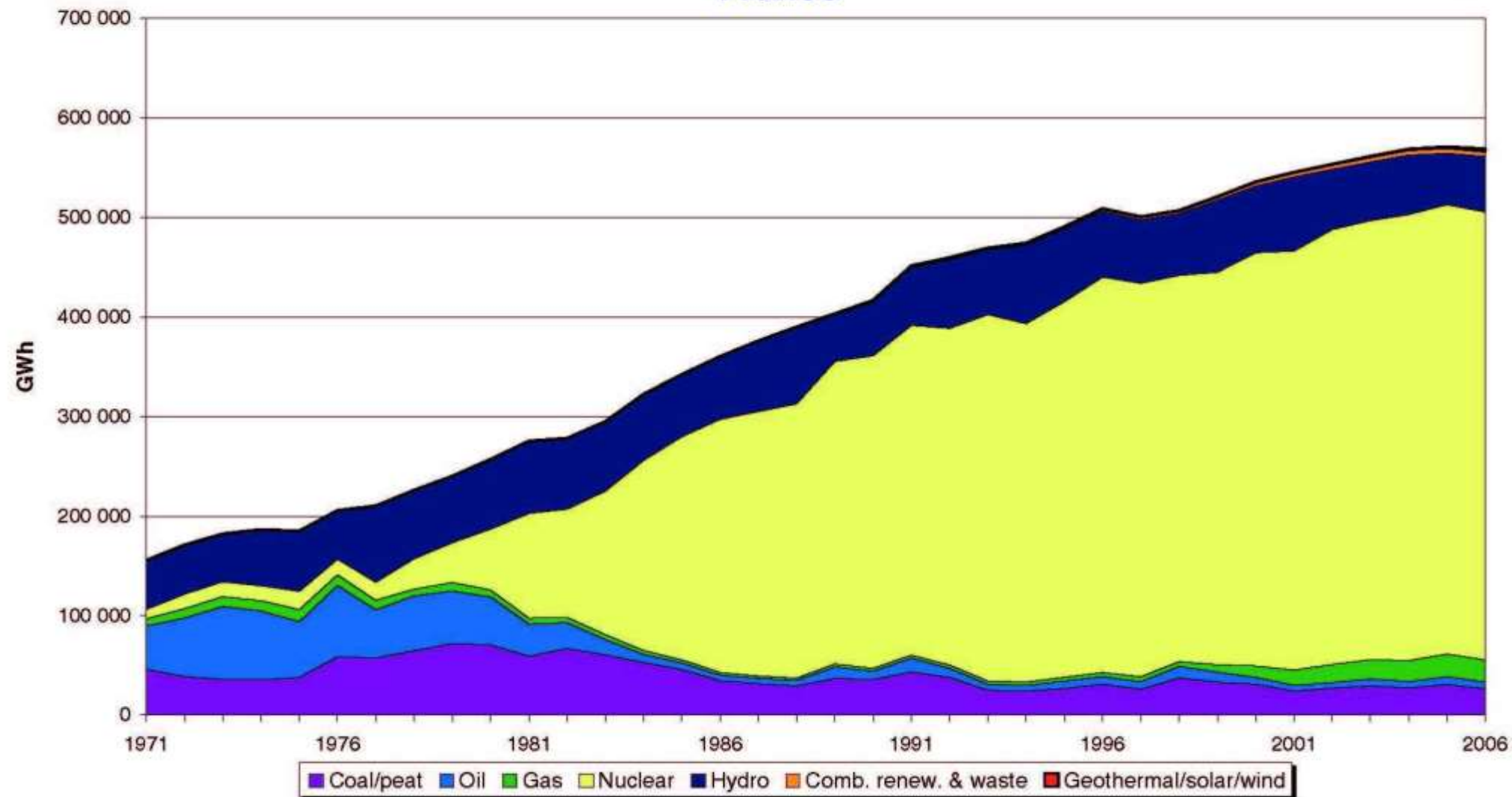
Energetyka jądrowa



SCIENCE TIP: LOG SCALES ARE FOR QUITTERS WHO CAN'T
FIND ENOUGH PAPER TO MAKE THEIR POINT *PROPERLY*.



Electricity generation by fuel

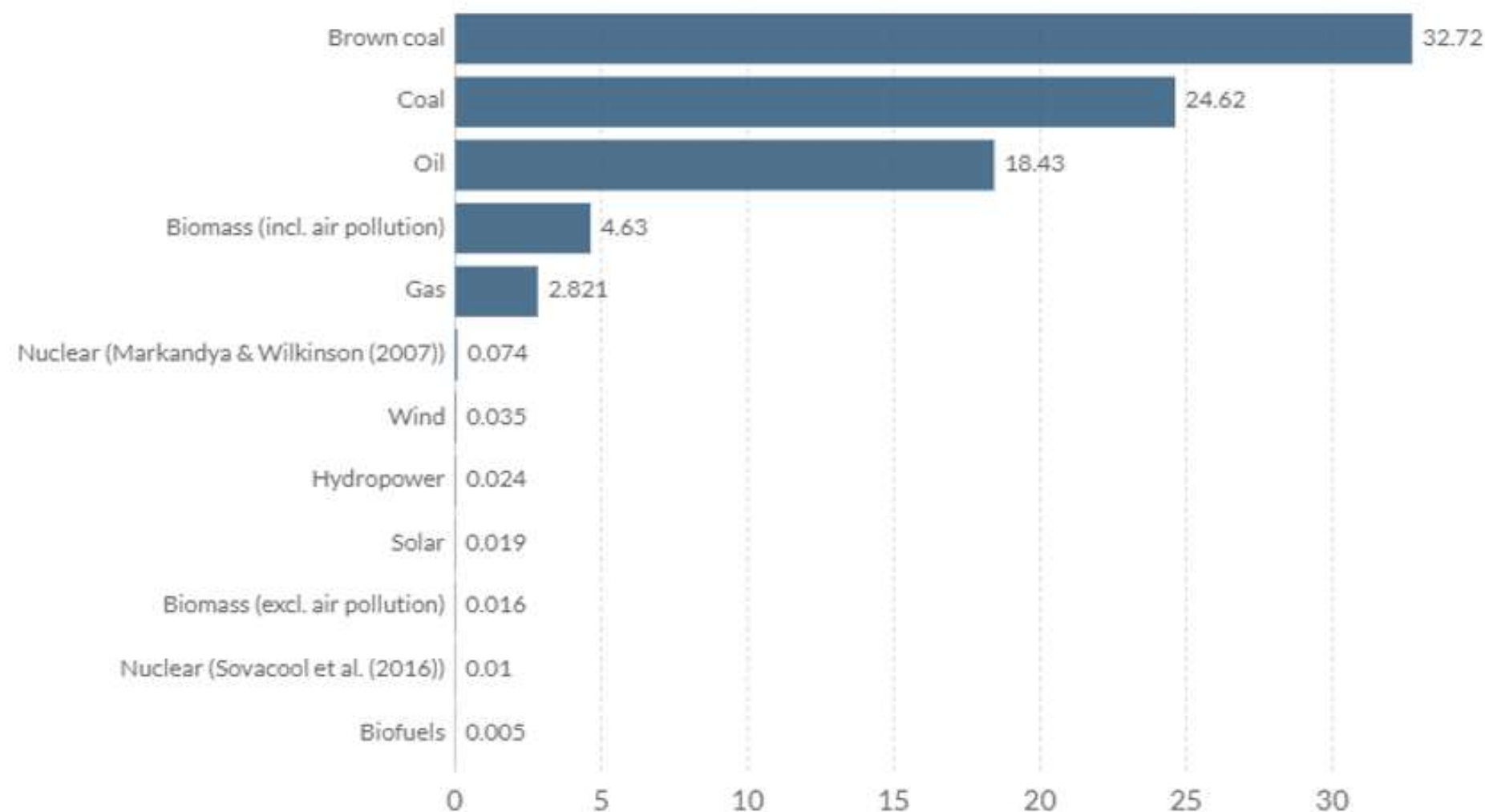
France

BEZPIECZEŃSTWO

	Ilość śmierci na petawatogodzinę (1 000 000 000 000 kWh)
Węgiel	100 000 (41% globalnej produkcji elektryczności)
Węgiel w Chinach	170 000 (75% chińskiej produkcji elektryczności)
Węgiel w USA	10 000 (32% amerykańskiej produkcji elektryczności)
Olej	36 000 (33% energii, 4% elektryczności)
Gaz ziemny	4000 (22% globalnej elektryczności)
Biopaliwa/biomasa	24 000 (21% globalnej energii/2% elektryczności)
Słońce	440 (< 1% globalnej elektryczności)
Wind	150 (2% globalnej elektryczności)
Hydro	1400 (16% globalnej elektryczności)
Hydro w USA	5 (6% amerykańskiej elektryczności)
Energetyka jądrowa	90 (11% globalnej elektryczności)
Atom w USA	0,1 (19% amerykańskiej elektryczności)

Death rates from energy production

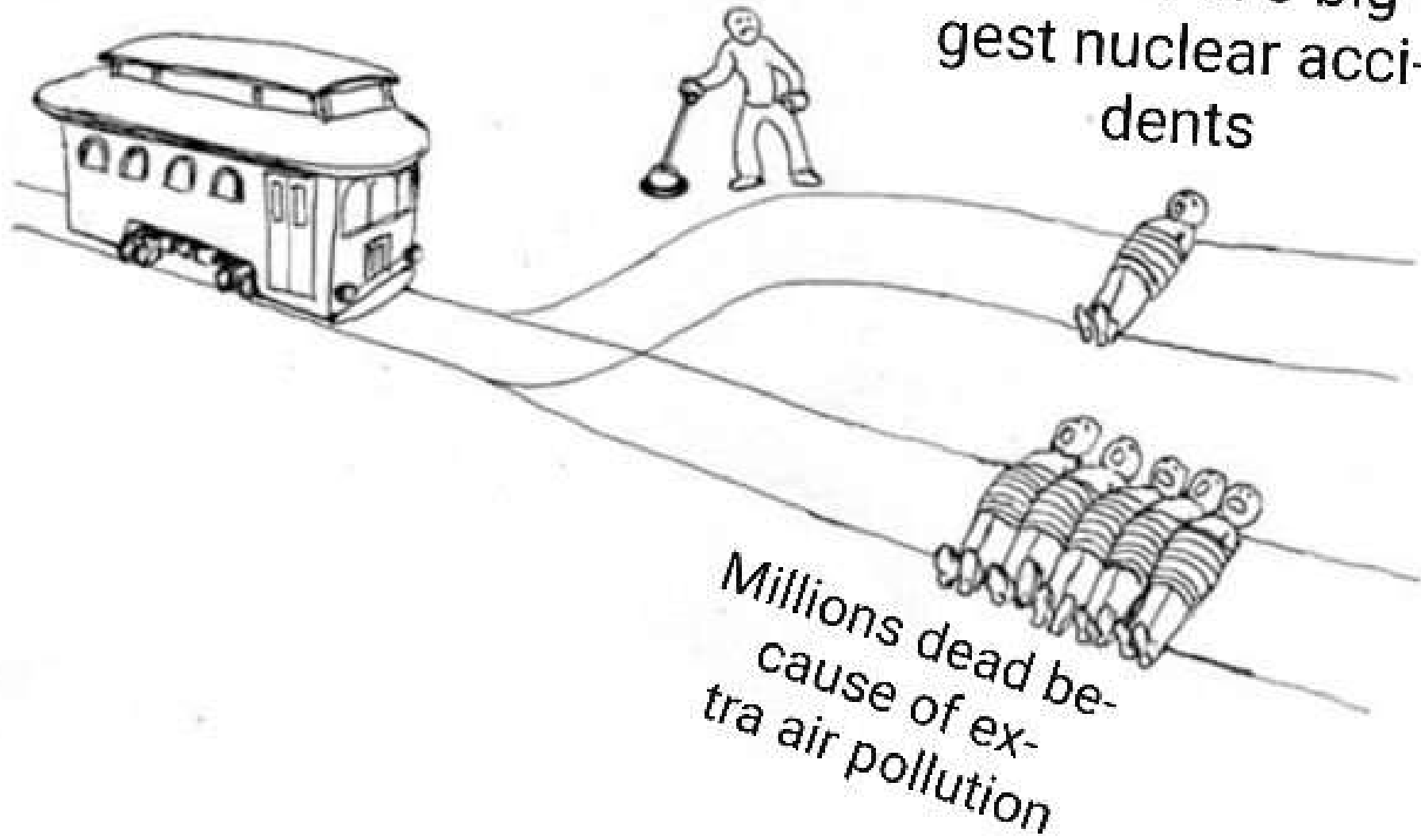
Death rates from energy sources is measured as the number of deaths from air pollution and accidents per terawatt-hour (TWh) of energy production.



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

CC BY

50 dead in 3 biggest nuclear accidents



Do nuclear accidents result in uninhabitable wastelands?

Ecologists, the WHO: Chernobyl has become "a unique sanctuary for biodiversity."



With >400 thriving populations of vertebrates, including wolf, elk, deer, wild horse, lynx, white-tailed eagle, boar, badger, black crane, otter, fox, woodpecker, bison, bear, beaver, raccoon dog, and marten, the Chernobyl Zone is hardly a wasteland.

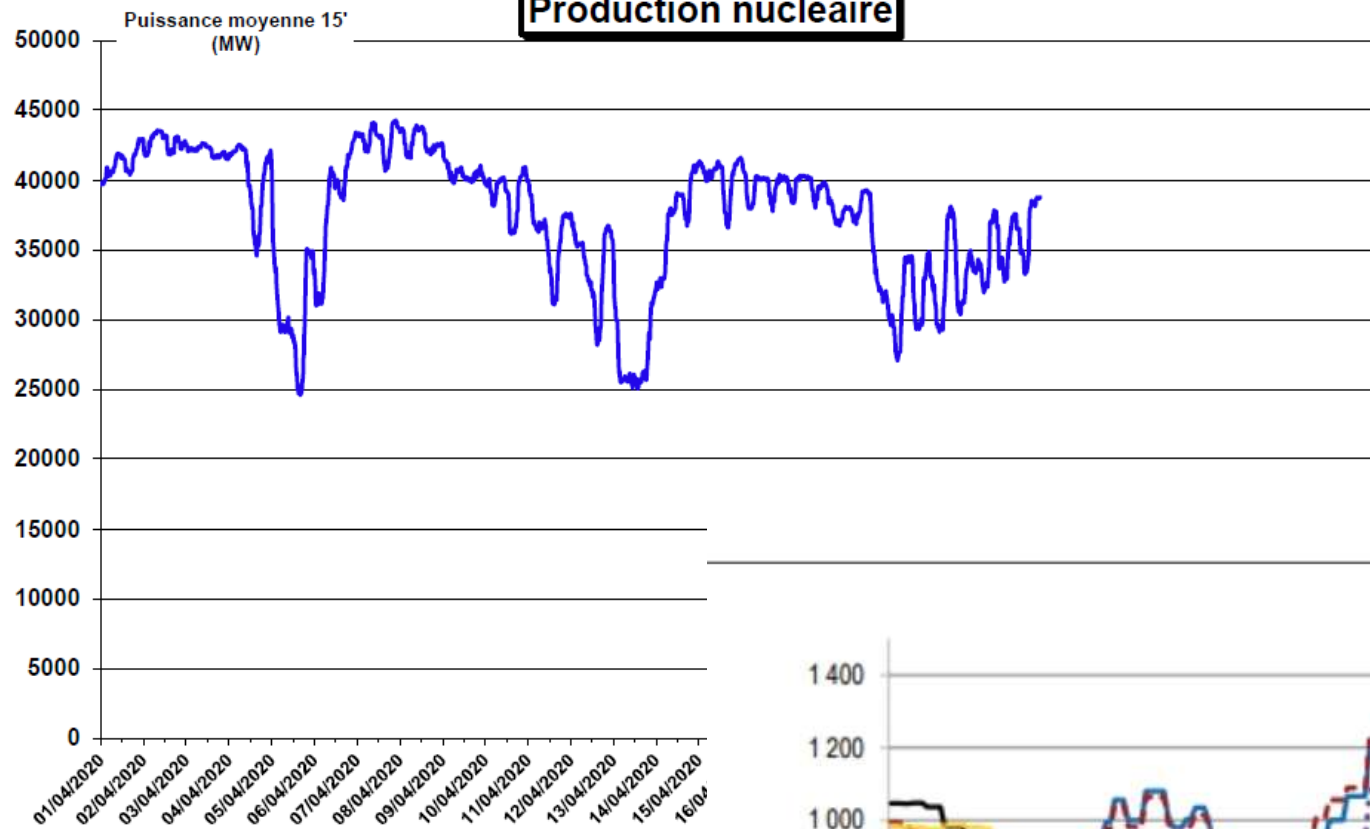


Sources: Deryabina et al 2015, *Long-term census data reveal abundant wildlife populations at Chernobyl*, Schlichting et al 2019, *Efficiency and composition of vertebrate scavengers at the land-water interface in the Chernobyl Exclusion Zone*, and the webcams of the TREE project.

Read more at:
thoughtscapism.com

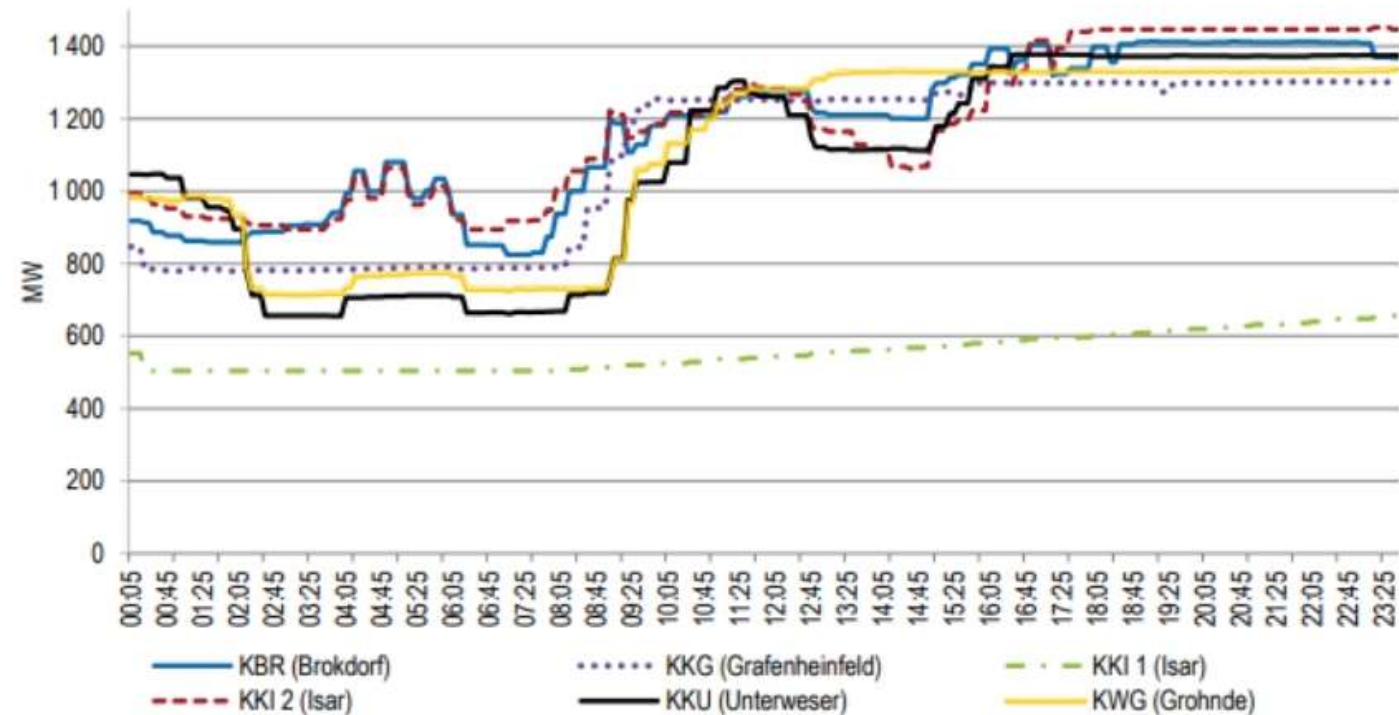


Production nucléaire

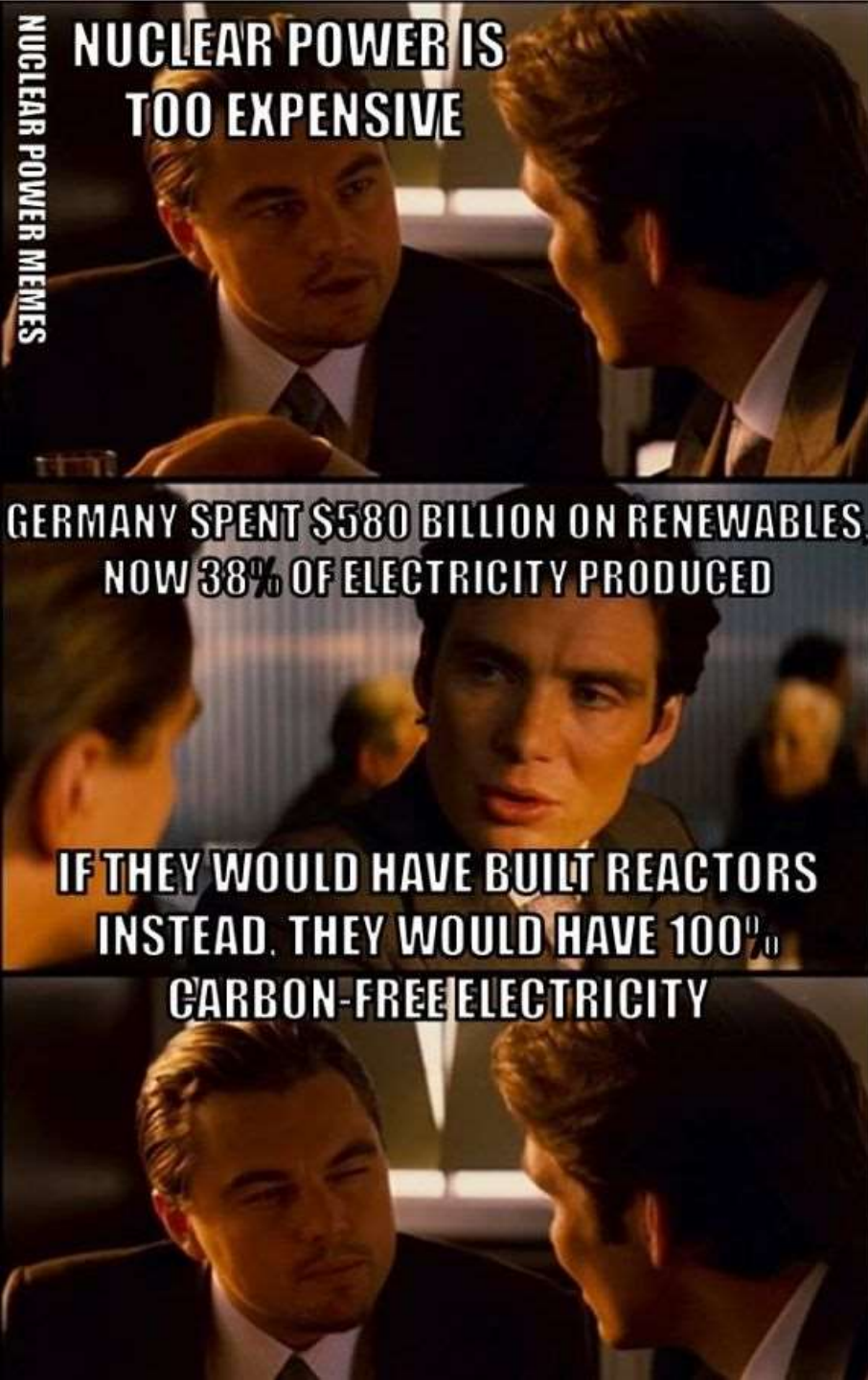


Atom bez problemu współpracuje z OZE

A. Rajewski, *Mity o energetyce jądrowej*

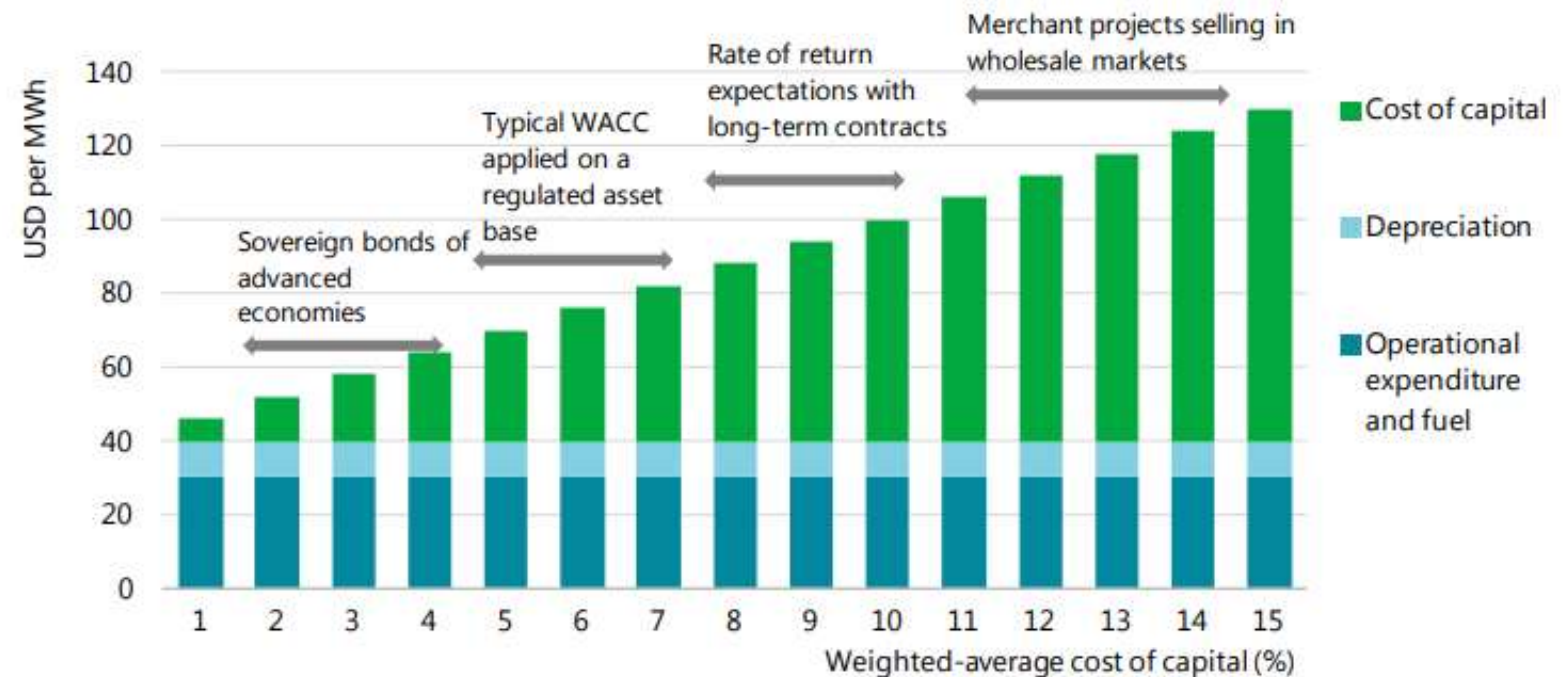


Ryc. 3. Przykład dobowego przebiegu zmienności mocy wybranych niemieckich bloków jądrowych [20]



Atom mógłby być tani

Figure 38. Illustrative LCOE of a new nuclear power plant project according to the cost of capital



IEA (2019). All rights reserved.

Note: Based on a 1 GW plant with an investment cost of USD 4.5 billion.

Access to cheap capital makes a huge difference to the cost of producing electricity for a new nuclear power project.

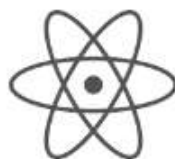
Długoterminowo,
atom jest
najtańszym
źródłem energii

Building-costs of low-carbon electricity

We can't afford to only think short-term.

					
	Nuclear Korea	Nuclear Finland	Wind EU Onshore	Wind EU Offshore	Solar PV Germany
Capital, billion €/GWe	2.0	3.4	1.6	3.3	1.4
Capacity factor	90%	90%	25%	40%	10%
Lifetime (years)	60	60	20	20	25
Capital, cents/kWh	0.4	0.7	3.7	4.7	6.2

We can't
dismiss
nuclear.



Best lifetime investment (cents/kWh)
is one that will keep providing clean
energy for our kids and grandkids.



Thoughtscapism

#NuclearForClimate
#MothersForNuclear

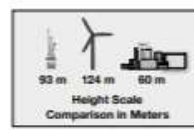
Sources and more:
thoughtscapism.com

2077 2-Megawatt Wind Generators:

9,098,136 Megawatt Hours of electricity per year.

25% Capacity factor, variable output based on weather conditions.

20 year life span.

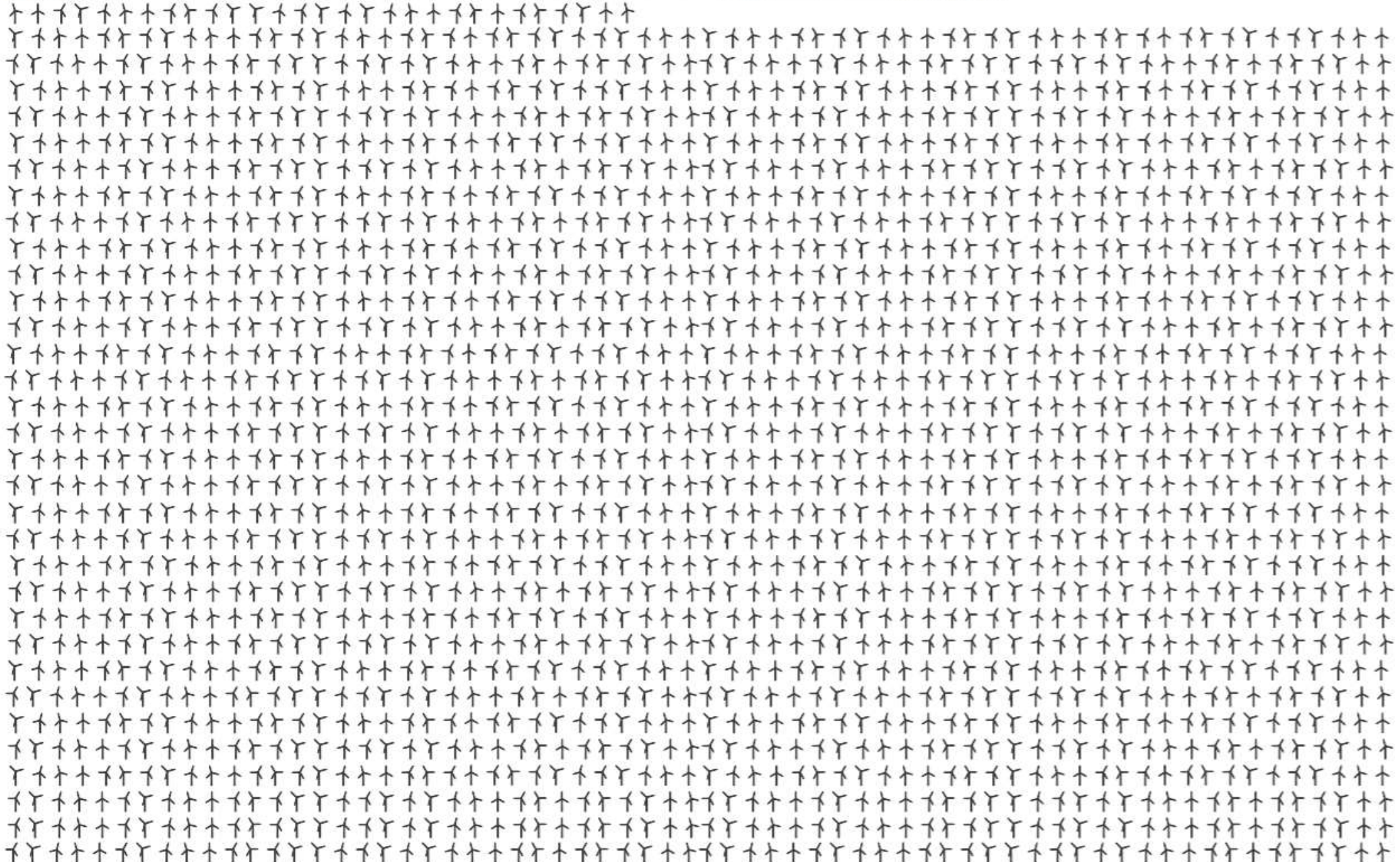


One 1154-Megawatt Nuclear Power Plant:

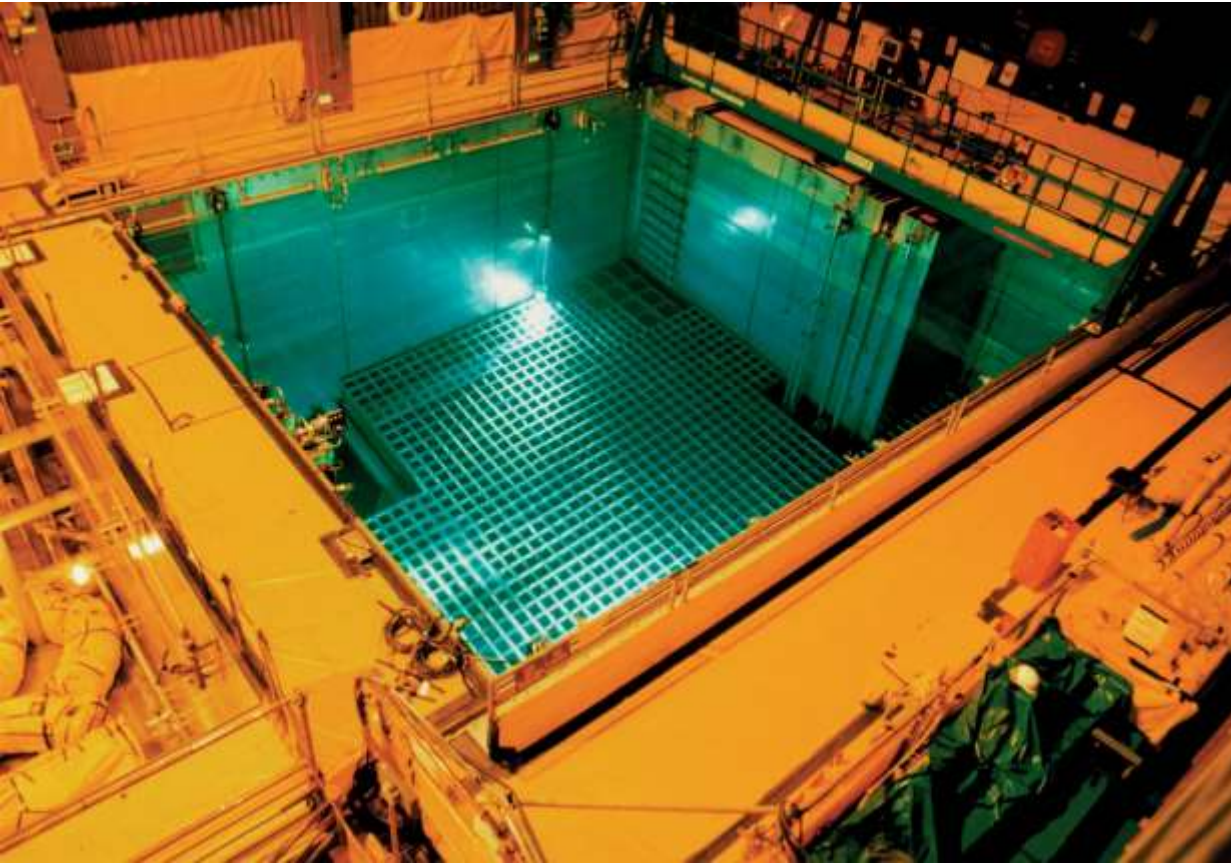
9,098,136 Megawatt Hours of electricity per year.

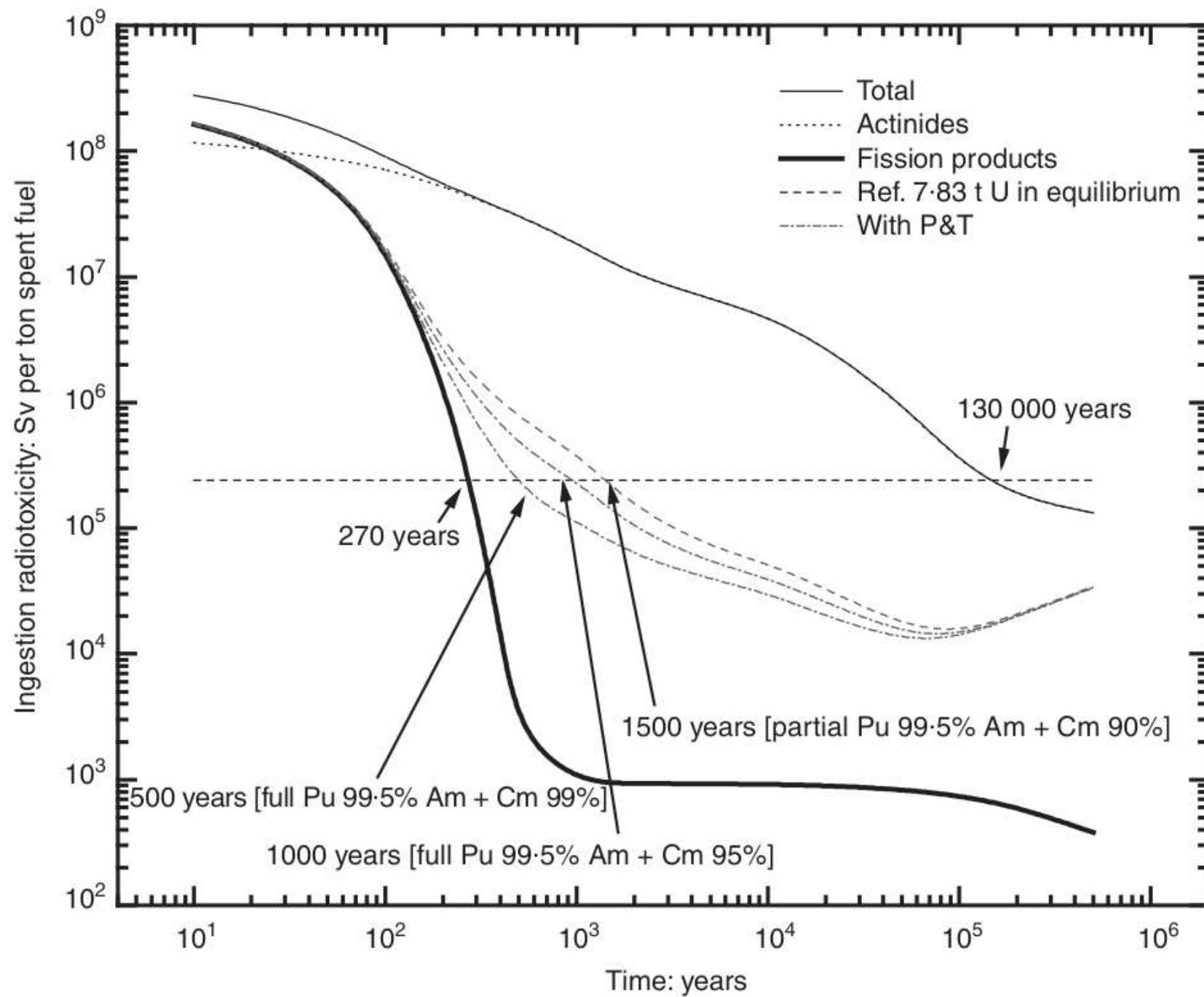
90% Capacity factor, constant output, offline for refueling, maintenance.

60 Year life span.

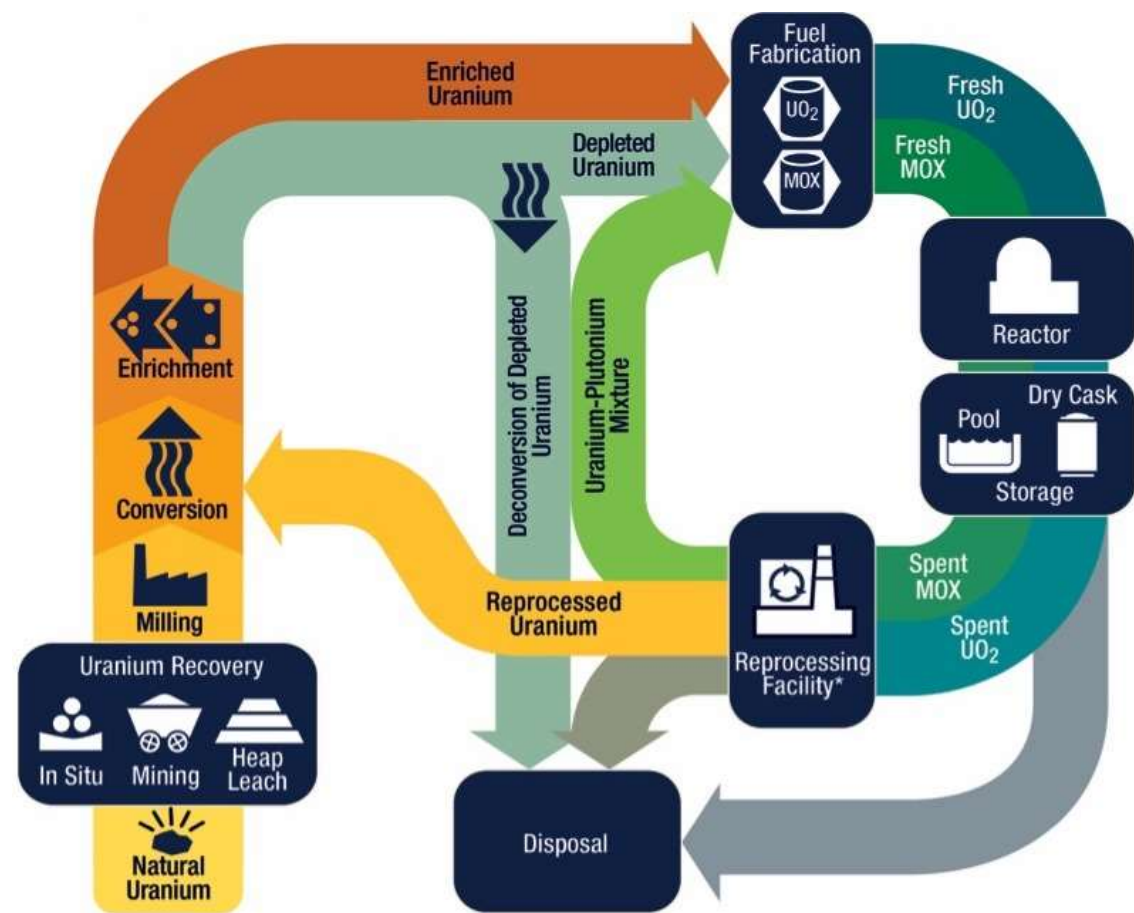
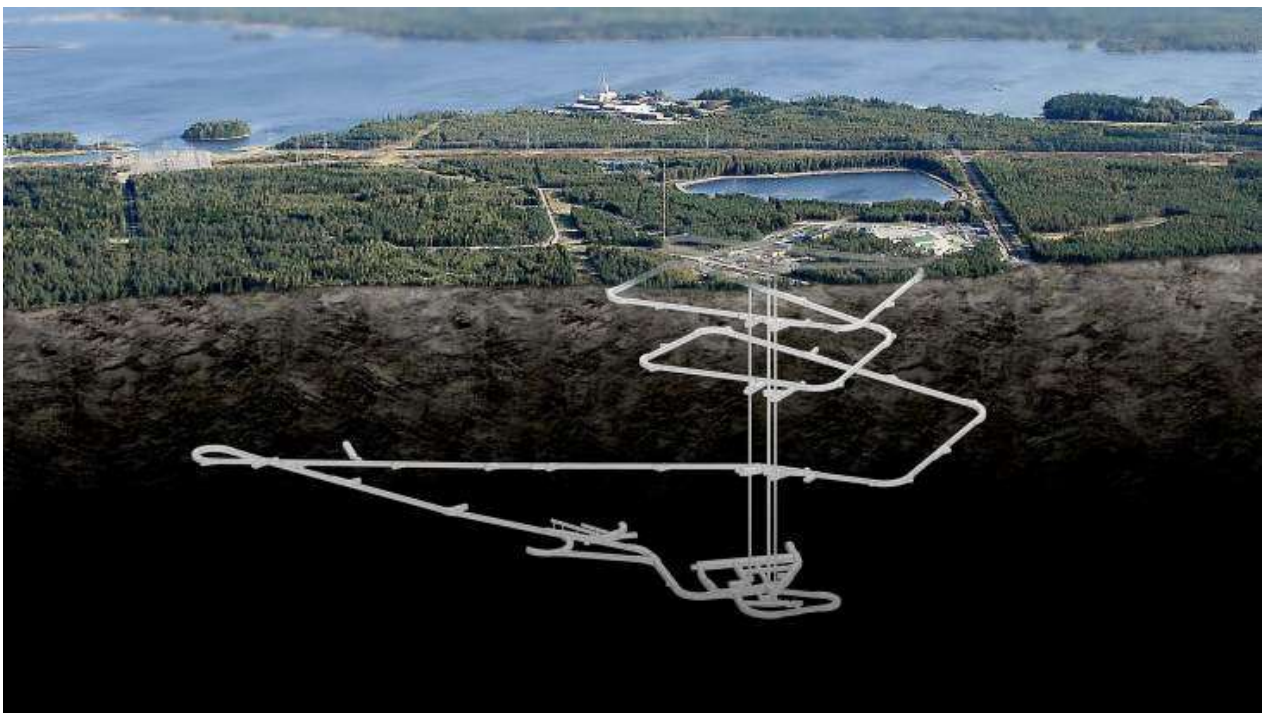


Odpady radioaktywne

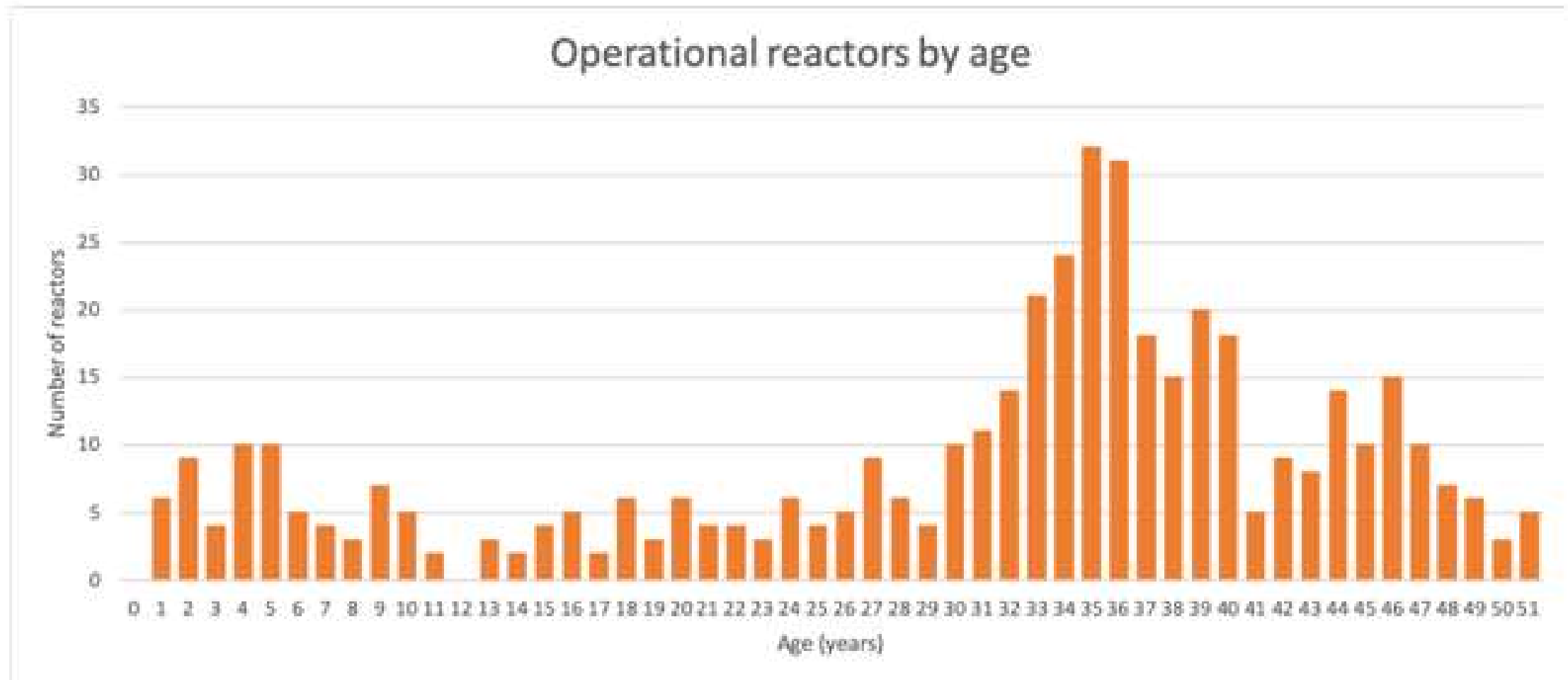




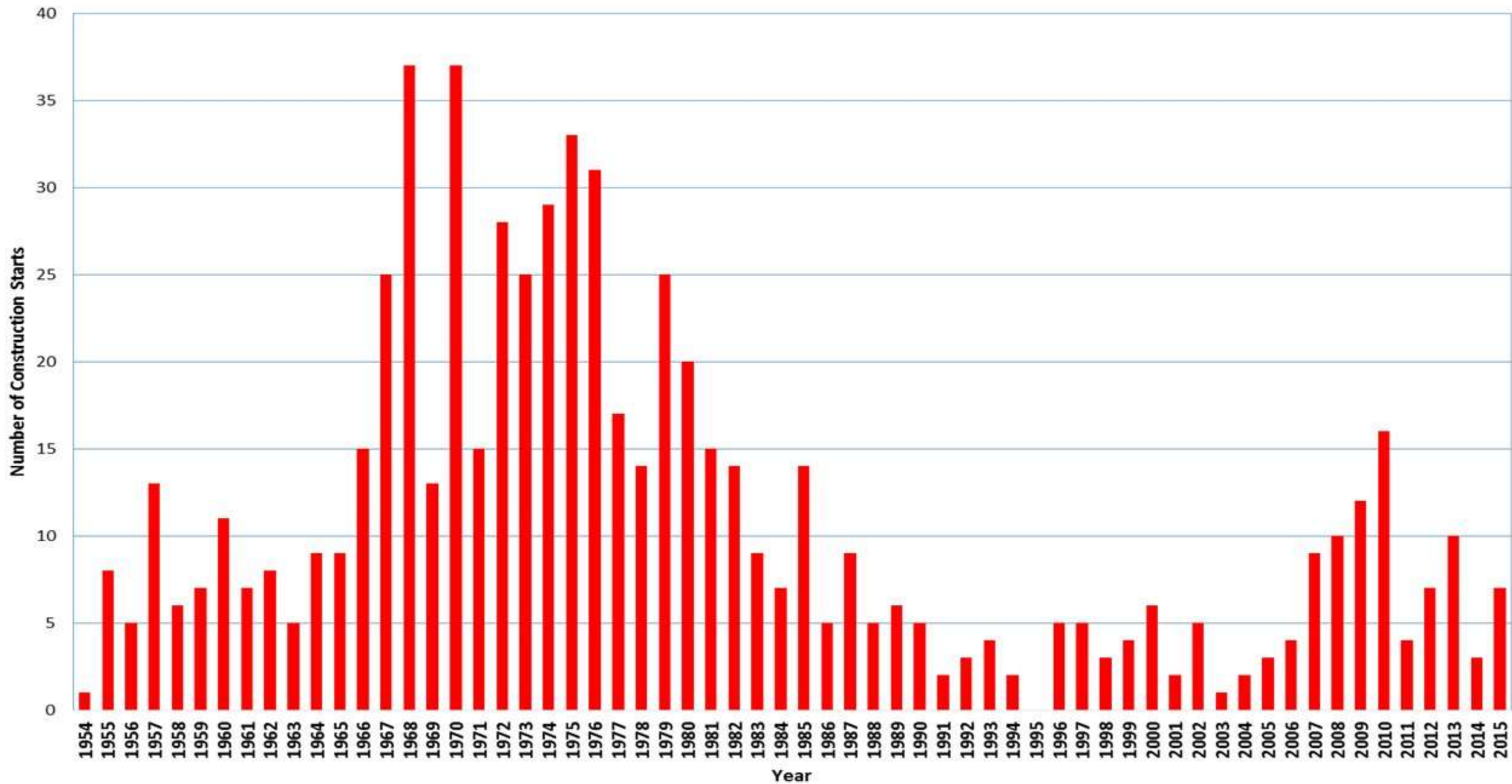
Magazynowanie lub ponowne wykorzystanie



Prawdziwy problem energetyki jądrowej



Nuclear Power Plant Construction

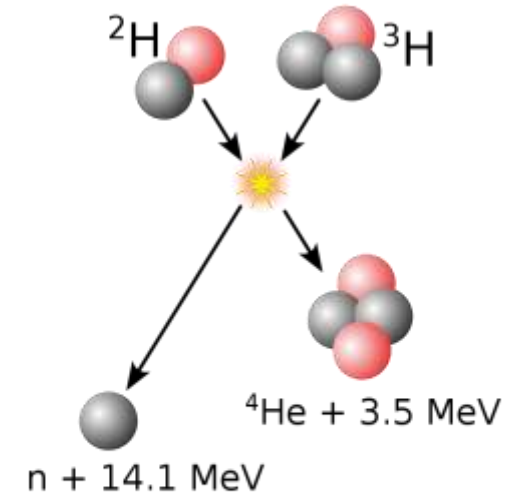


Fuzja termojądrowa



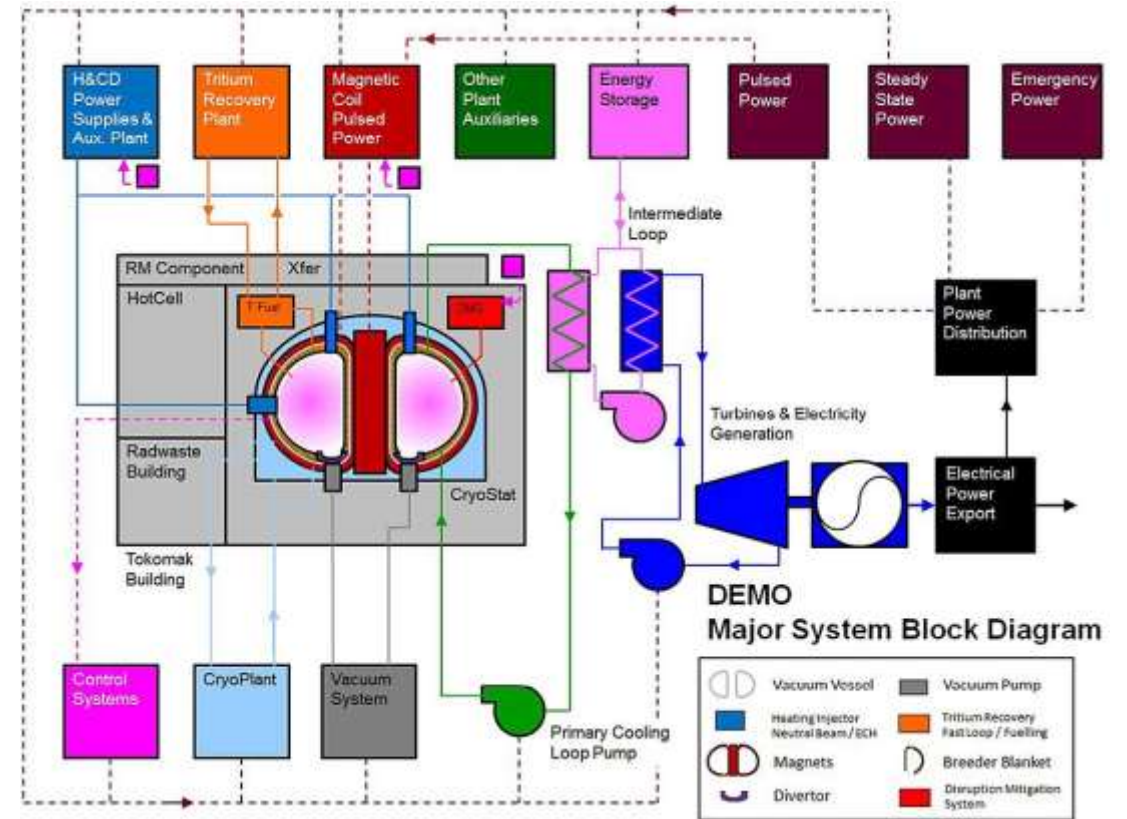
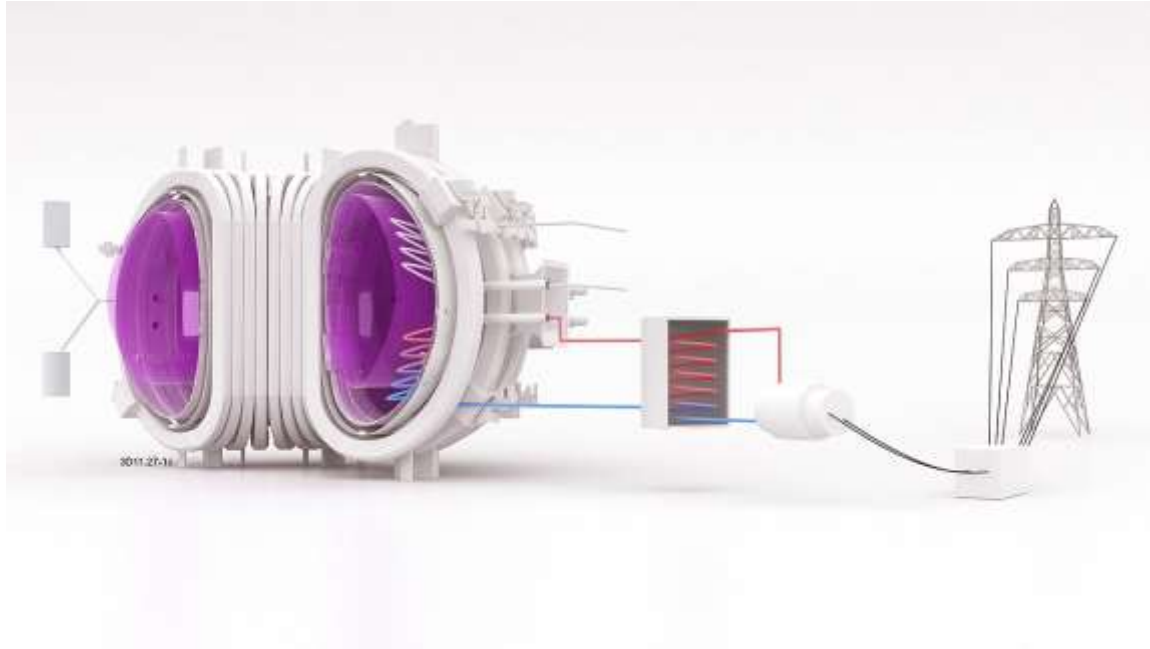


ITER



Proton 
Neutron 

DEMO





Dlaczego jest tak źle?

What #ExxonKnew	What #ExxonDid
 of Exxon's climate research agree humans are causing global warming	Funded \$31 million to organisations manufacturing doubt about climate change



Zaoranie energetyki
jądrowej

American
Petroleum
Institute

Greenpeace
i Zieloni



Jan Haverkamp

@janhaverkamp

+ Follow

Replying to @JvDorp @Greenpeace

I have never said nuclear is not low carbon.
That Greenpeace would say so is another propaganda claim from the industry.

10:36 AM - 5 Jun 2017 from Amsterdam, The Netherlands

GREENPEACE

Greenpeace International

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Home > News > Blogs > Making Waves > Nuclear Delusions

Nuclear Delusions

Blogpost by Rex Weyler - 7 July, 2011 at 11:34

17 comments

Why nuclear power is not a solution to our energy challenge

The heating of Earth remains the most urgent symptom of humanity's mismanagement of our technological civilization. Desperately seeking answers for a low carbon energy regime, some observers propose a "nuclear renaissance" to replace hydrocarbons. Nuclear companies, nations, and advocates offer nuclear as a possible "low-carbon" energy path. However, the evidence in hand shows that nuclear energy is not the solution to humanity's energy needs that many hope for. Here are the reasons:

1. Nuclear energy is not low carbon

The industry claims that nuclear energy is "carbon free" because while a nuclear plant operates, it does not directly burn hydrocarbons. However, from a life-cycle analysis, nuclear energy is a carbon hog. Plant construction – cement, steel, and complex electronics – is carbon intensive. The nuclear fuel cycle – mining, milling, enriching, fabrication, transport, and processing nuclear waste – is carbon intensive. Halogenated compounds used in uranium refining have a greater impact on global heating than carbon dioxide. Finally, when a nuclear plant's 40-to-60 year life is over, decommissioning adds more carbon costs and leaves a radioactive, lifeless blotch on the landscape. Many studies confirm that nuclear electricity is not low-carbon; here are three:

Jan Haverkamp

@janhaverkamp

Expert consultant nuclear energy and energy policy for @Greenpeace and WISE (@BeWiseNoNuclear). Vice-chair @NTWeurope. Facilitator.



Jan H

@janh

Replying to @KCEl65 and @EnergyJvd

Sabotaging nuclear is a vital part of any successful attempt to save the climate. Nuclear diverts the political attention without being able to add to the solution. What it might add is too expensive, too risky and comes too late.

10:36 pm - 15 Feb 2019 from Leeuwarden, Nederland - Twitter for Android

Say No to Nuclear Bailouts

Bailing out the nuclear industry means higher energy rates for consumers like you. These billion dollar companies don't need bailouts, they need to compete with other energy companies on a level playing field.

➔ **GET INVOLVED!** ➔

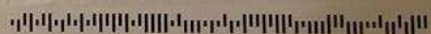
TWITTER:
@NoNukeBailout

**NO NUCLEAR
BAILOUT**

FACEBOOK:
facebook.com/
nonukebailout

Paid for by The American Petroleum Institute
1220 L Street, NW
Washington, DC 20005-4070

PSRT STD
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GARNER
PRINTING



**TAKE ACTION TODAY &
CALL YOUR LEGISLATOR**

**Senator
Bob Mensch
at 717-787-3110**

Tell them competition and lower prices are good for Pennsylvania. A bailout for the billion dollar nuclear industry just won't work.

Protecting Mining Jobs and Communities



A message from Australia's coal miners

Climate change is real and we need a Government that will tackle it. Doing nothing is no longer an option.

Voters have a choice at the election:

Labor

- ☒ Support \$1.5 billion investment in Clean Coal Technology
- ☒ No nuclear power station

Coalition

Continue to neglect Clean Coal Technology
Develop nuclear power stations that would replace the coal industry.

It's a simple choice. Vote to protect coal industry jobs and our local communities.

Nuclear Power Will Kill the Coal Industry

If you care about mining industry jobs and local communities don't support the Liberal and National parties' plans to introduce nuclear power stations.

Using nuclear to generate electricity means the end of our coal industry. Choose a party that will help clean up the coal industry and destroy it.



Submitted by T. Moore UPMU Mining Division, 361 Sussex Street, Sydney NSW

Monday, November 15, 2004 The Government 25



**SOLAR
NOT NUCLEAR**



Sponsored in the public interest by the Oil Heat Institute of Long Island representing 225 independent businessmen who provide 2 billions gallons of oil a year to provide energy for 650,000 families and businesses in Nassau and Suffolk Counties.
LILCO is not the only authority on energy.
Our members have been supplying energy, heat and hot water to Long Island consumers for three generations.
We don't pretend we know all the answers, but one thing is obvious.
Nuclear energy is not the simple, open-and-shut case LILCO says it is.
During the next few weeks, we will present the other side of the nuclear fusion question so every-one can decide for himself and make his feelings known before it is too late.

Paid for the Oil Heat Institute of Long Island, 132 West Cherry St., Hicksville, N.Y. 11801

What you can do to help

- Make your feelings known so other people will become aware.
- Sign the petition below so your Assemblymen and Senators in Albany will know you want action now.

YES!

Oil Heat Institute
132 West Cherry St., Hicksville, N.Y. 11801

- ☐ Here's my \$1. Rush me a bumper sticker so I can help OHI tell the alternatives to nuclear plants.
- ☐ I, the undersigned, petition my representatives in Government to sponsor and actively support (1) a "Nuclear Responsibility Bill," and (2) legislation to develop safe, cost-competitive energy sources (conservation, solar, tidal, wind, etc.)

Name _____ (Students: use address where you vote.)

Street _____

Town _____ State _____ Zip _____



**COMMITTED TO
SOLAR ENERGY**

#MakeThingsBetter
de.total.com



**COMMITTED TO
NATURAL GAS**

#MakeThingsBetter
de.total.com

Natural gas - the perfect
partner for renewables
European gas from Norway



Shell Natural Gas
@Shell_NatGas

Follow

No sun? ☀️ No wind? 🌬️ No problem,
natural gas has it covered. See why #natgas is
a great partner for renewable power sources.



0:18 2,200 views

1:09 AM - 19 Jan 2018

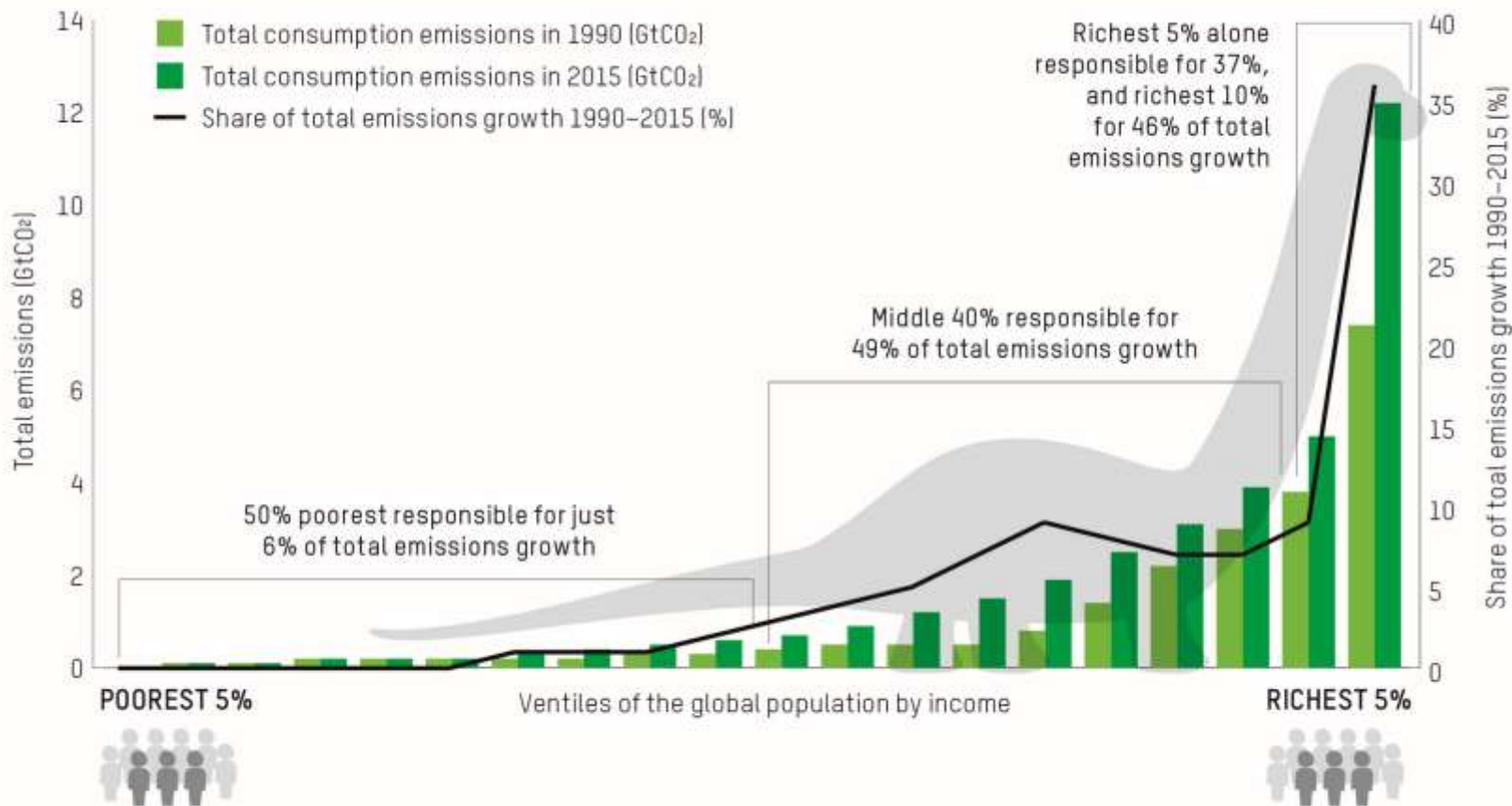
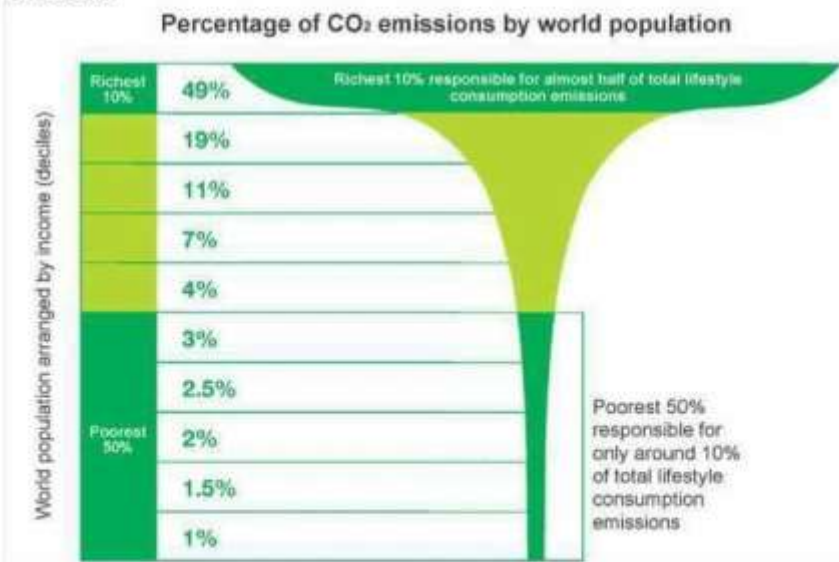
Problemem jest konsumpcja, nie populacja



Sofie Pelsmakers
@SofiePelsmakers

I'm an environmental journalist, but I never write about overpopulation. Here's why. buff.ly/2ycdWiY

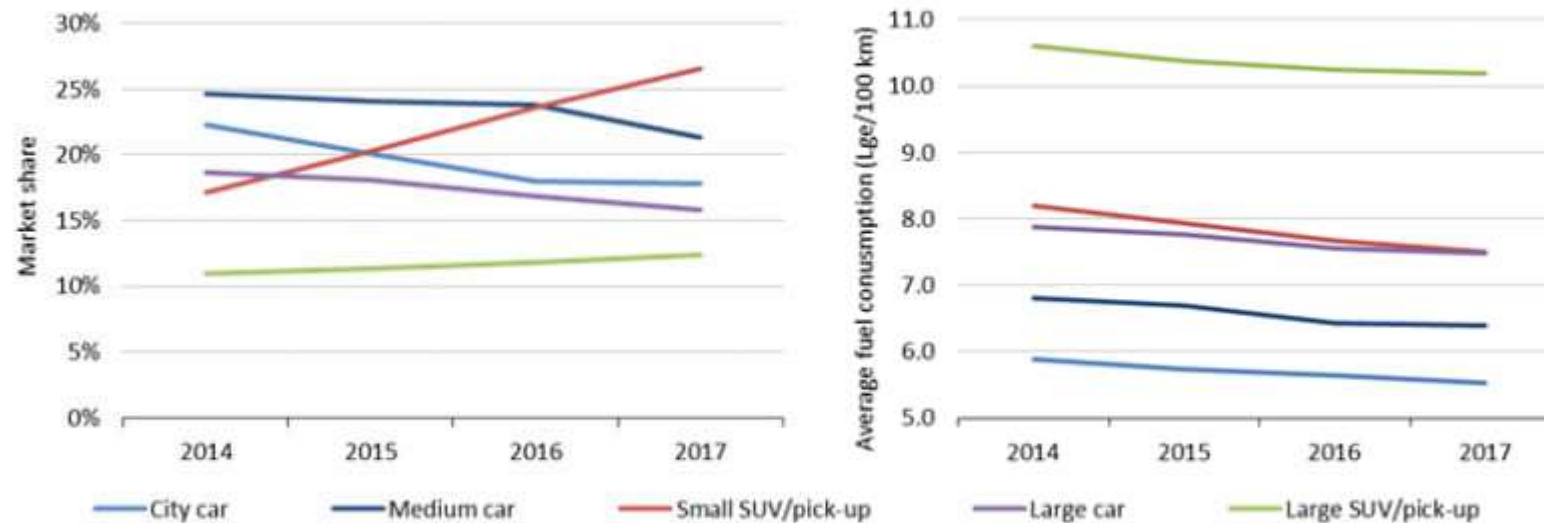
Figure 1: Global income deciles and associated lifestyle consumption emissions



Czy technologia nas uratuje?

Figure KF3

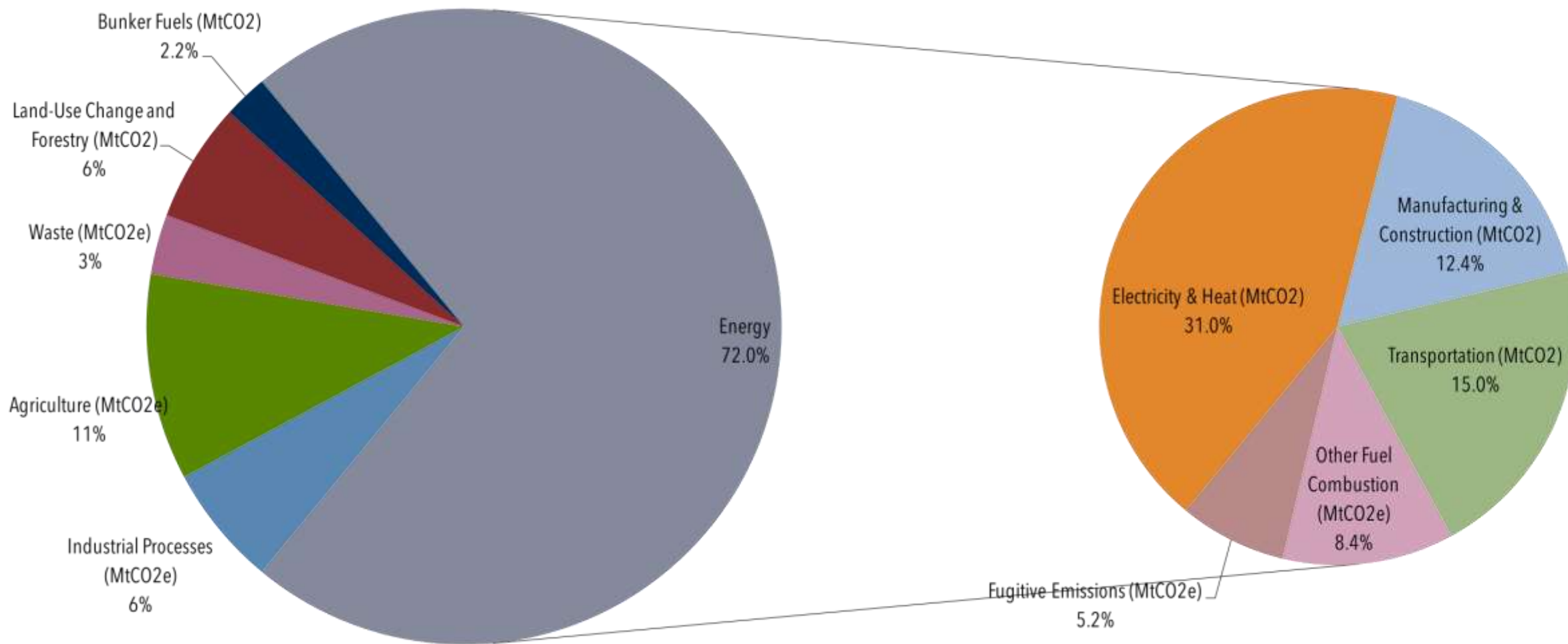
Global average market share per vehicle segment and average fuel consumption per segment, 2014-17



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database (IHS Markit, 2018).

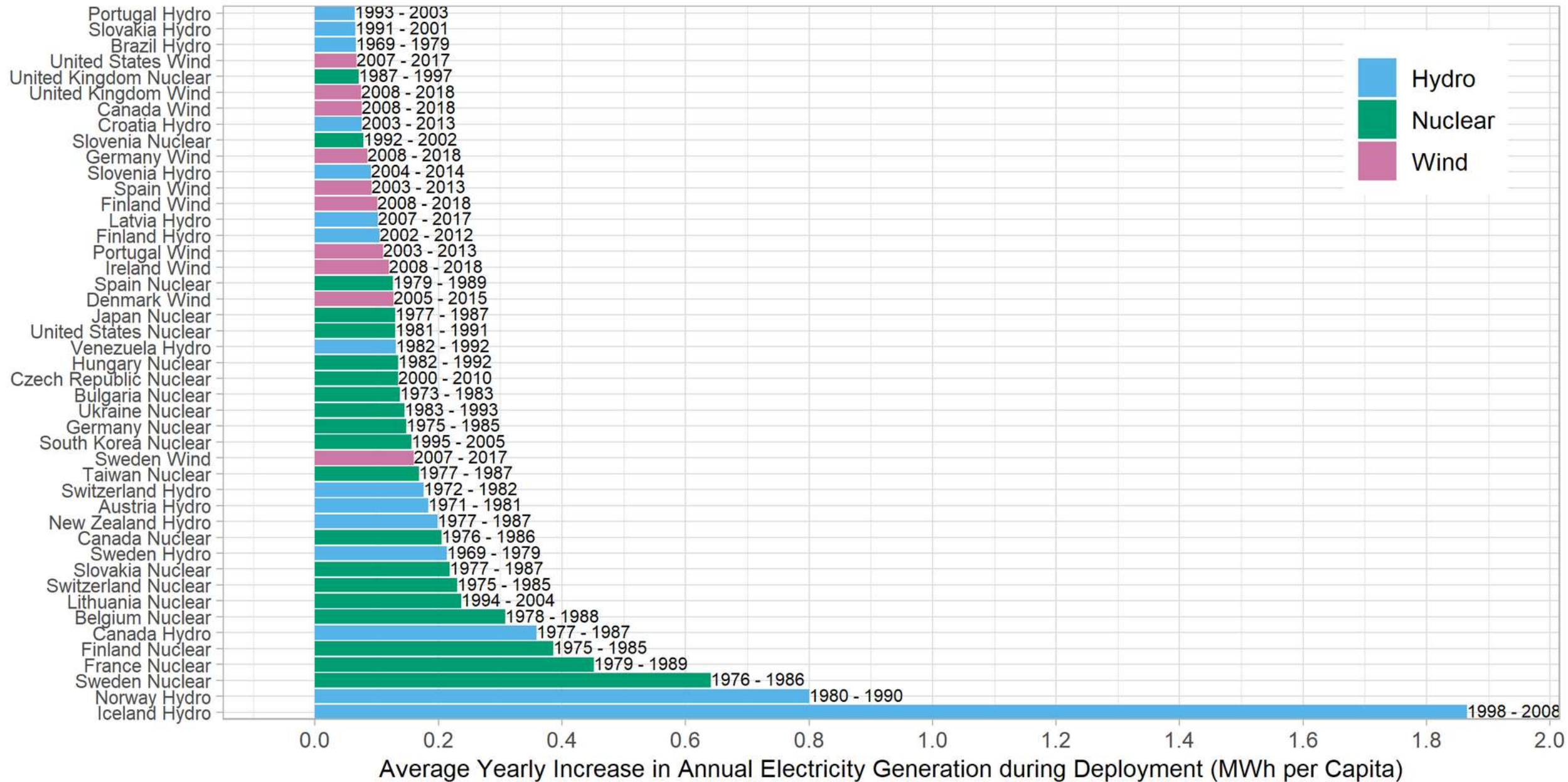
Even if the average fuel consumption of each vehicle segment continues to improve, the overall average fuel consumption is affected by the growing market share of more energy intensive SUVs and pick-ups, taking place at the expense of more fuel efficient passenger car segments.

Emisje z energetyki a całość problemu

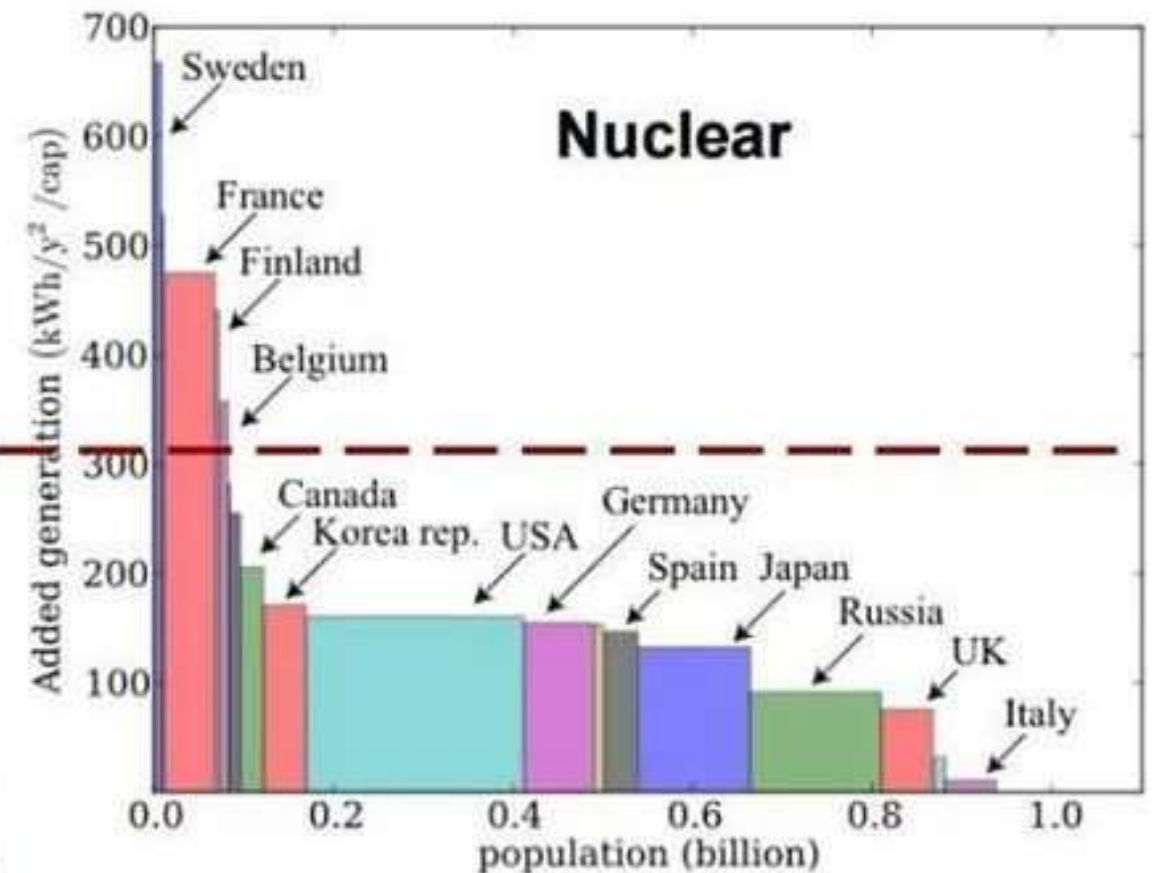
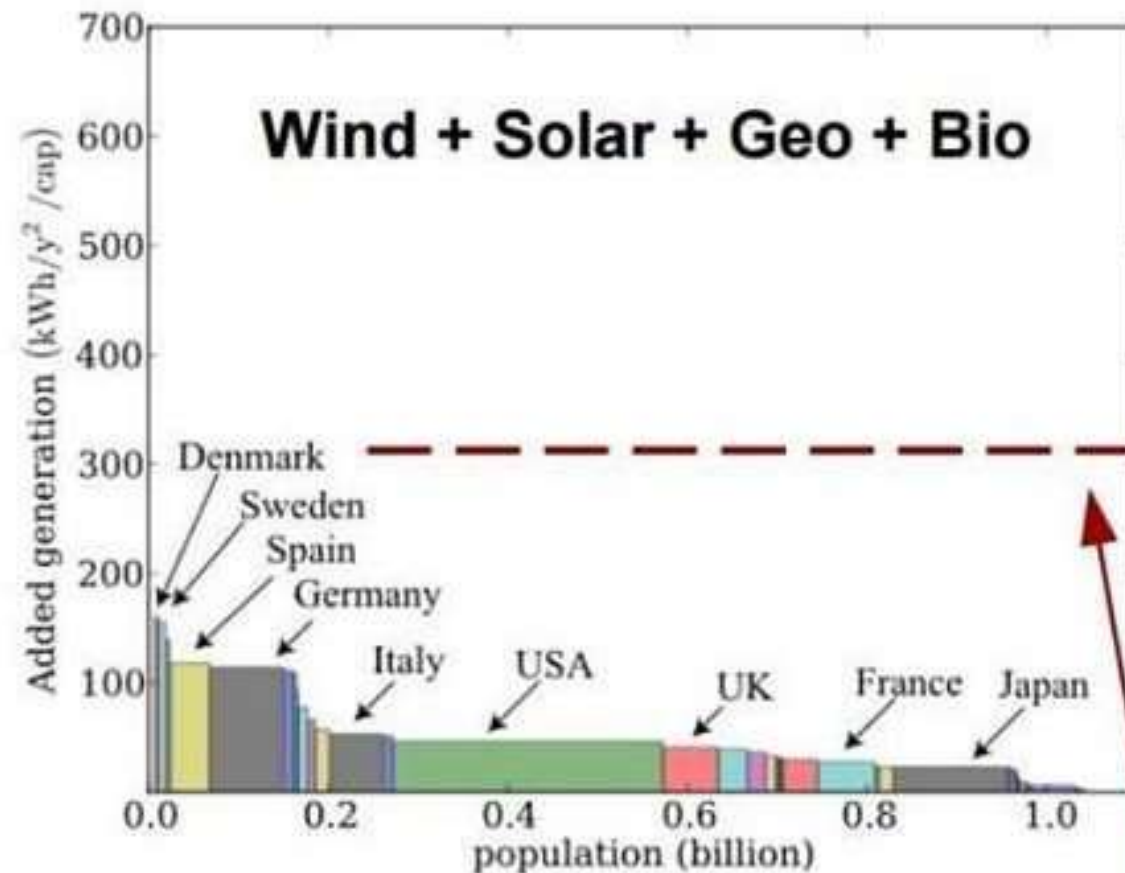


[Climate Analysis Indicators Tool](#) (World Resources Institute, 2017). Stan na 2013

Largest 10-Year Deployments of Low-Carbon Electricity Generation



Fastest added generation of electricity per person and year

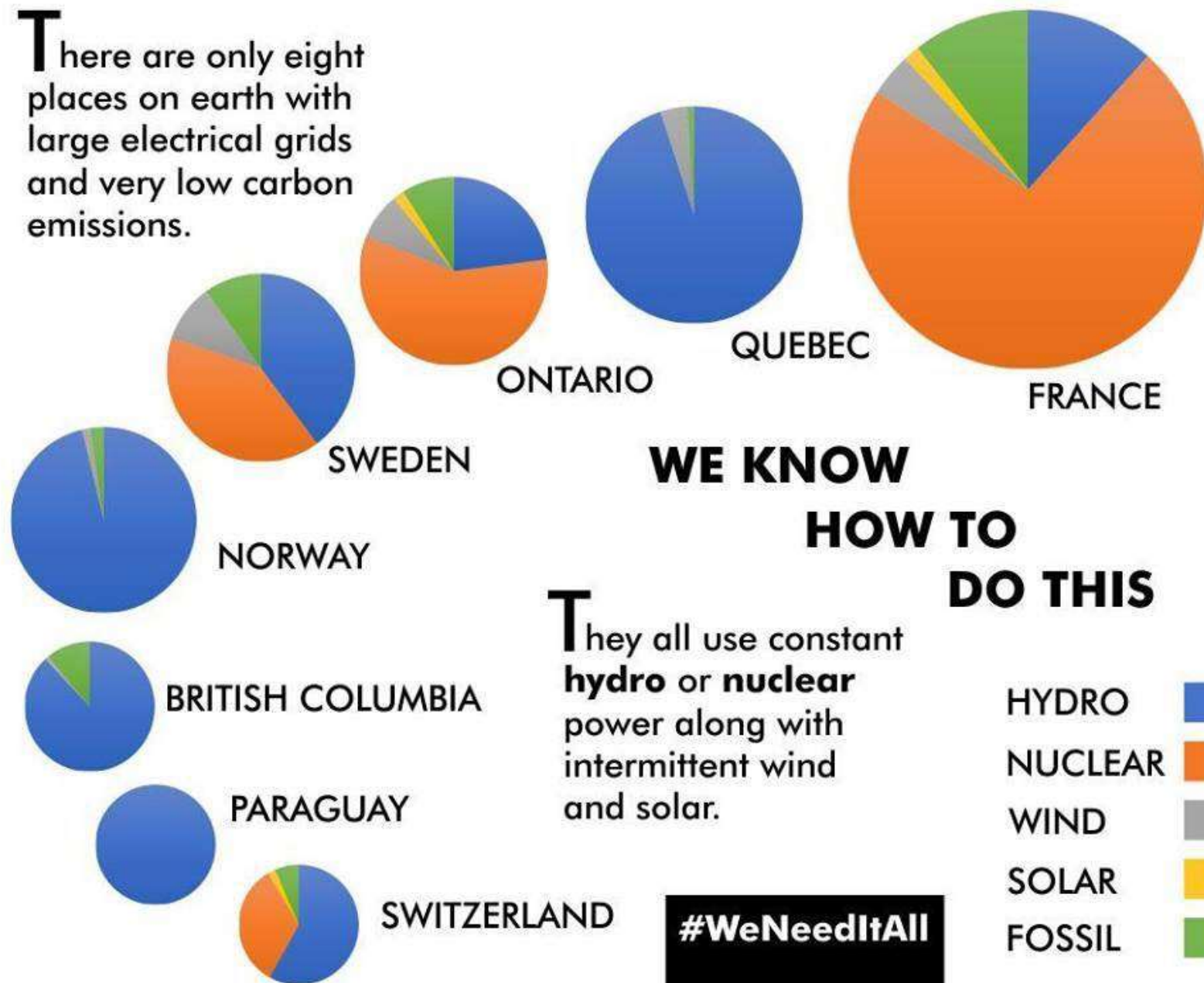


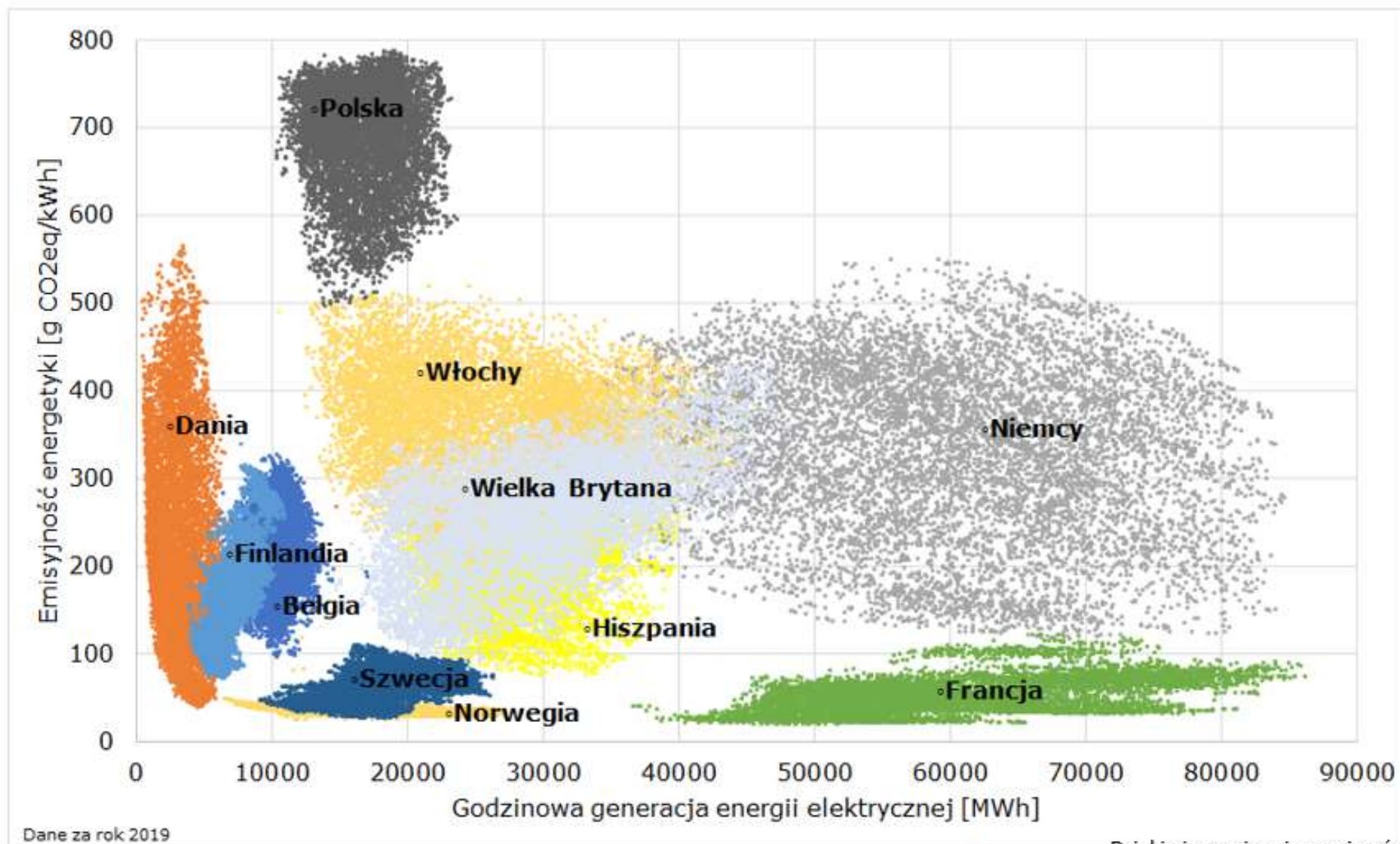
analys.se

Required rate for 2 degree target

Source: World Bank & BP Statistical Review, picture by Carl Hellesen

There are only eight places on earth with large electrical grids and very low carbon emissions.

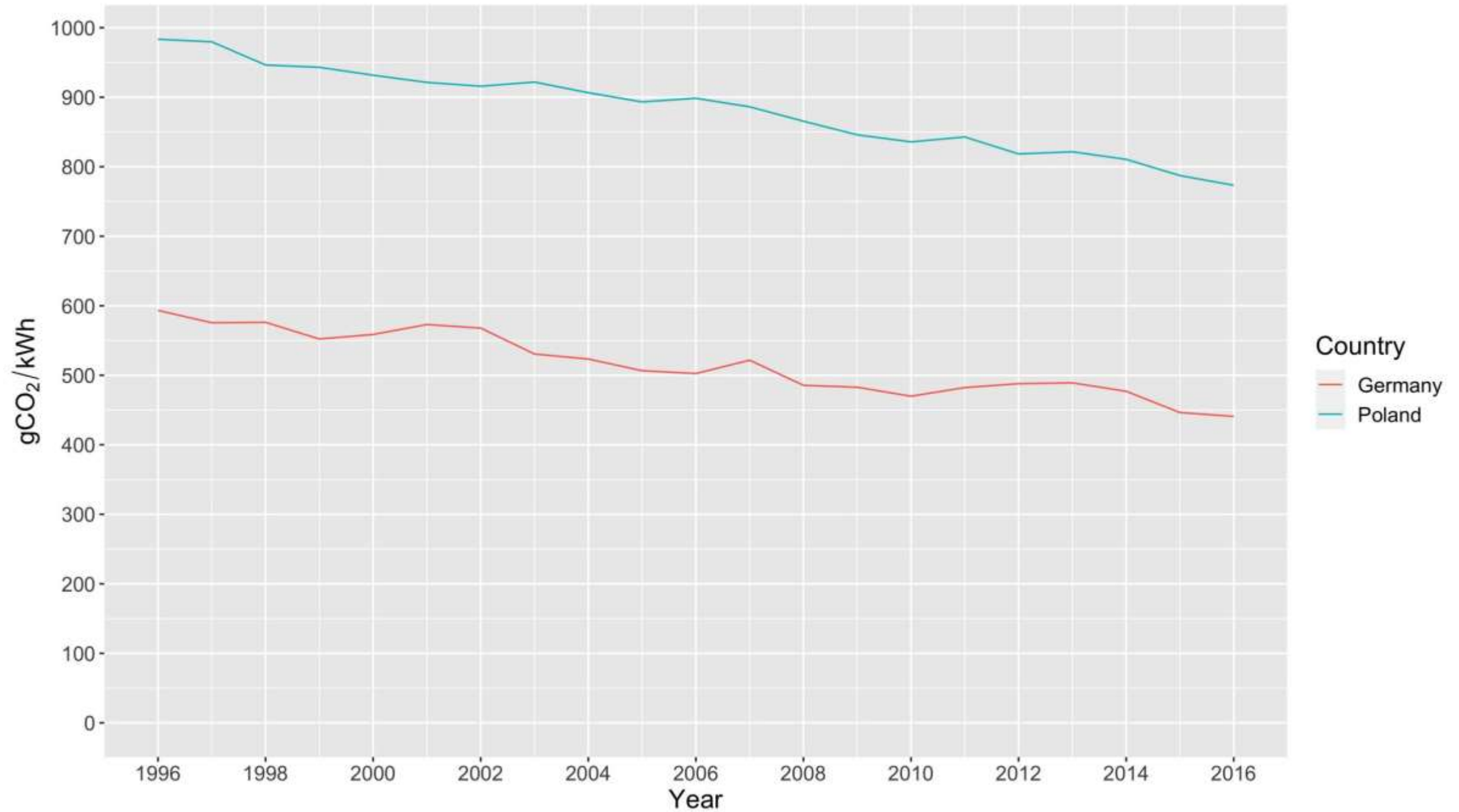




Dane za rok 2019

Dzięki nieocenionej uprzejmości ob. mgr. inż. Macieja Lipki, z.d.E.

Electricity production carbon intensity (gCO₂/kWh/year)





ForAction

O.K., Boomer

Boomer Mistake #1

- Subsidized Fossil Fuels
- Solution: Rising Carbon Fee, Funds → All Citizens

Boomer Mistake #2

- Killed Cleanest Energy (Fission Power)
- Solution: Cooperate With China, India

Boomer Mistake #3

- Helped Corporations Screw Public → Wealth Disparity
- Fix Trade Agreements, Tax Laws, Worker Rights

Dr James Hansen, klimatolog



COP25
CHILE
NOVEMBER 2019

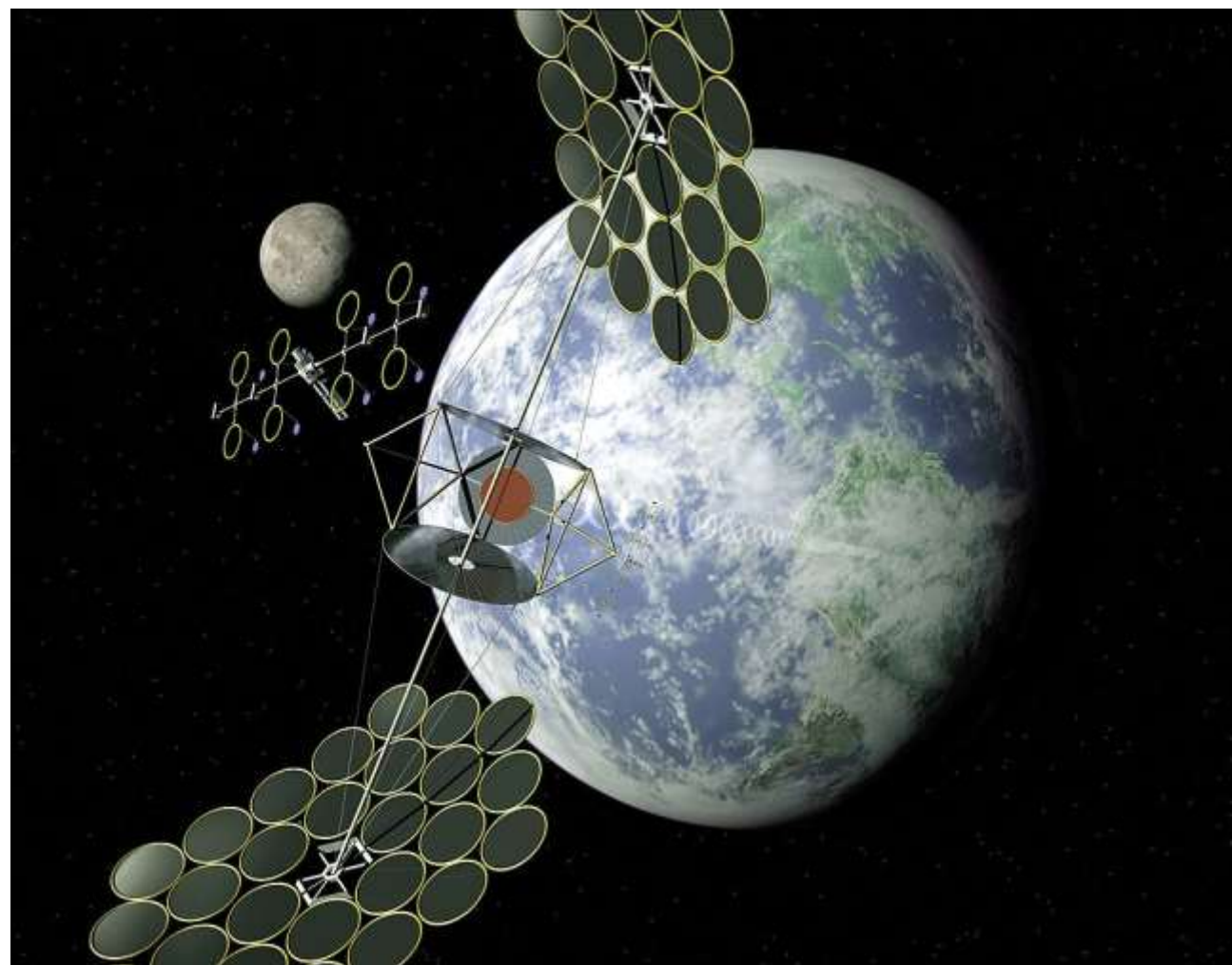
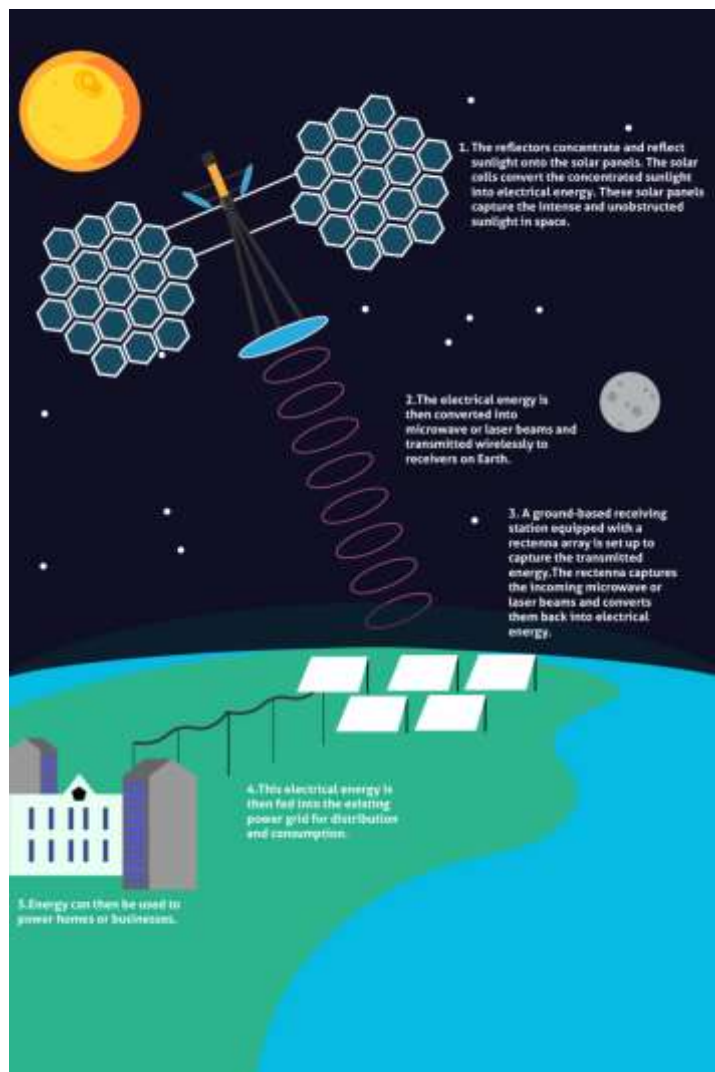
COP25
CHILE
NOVEMBER 2019

COP25
CHILE
NOVEMBER 2019

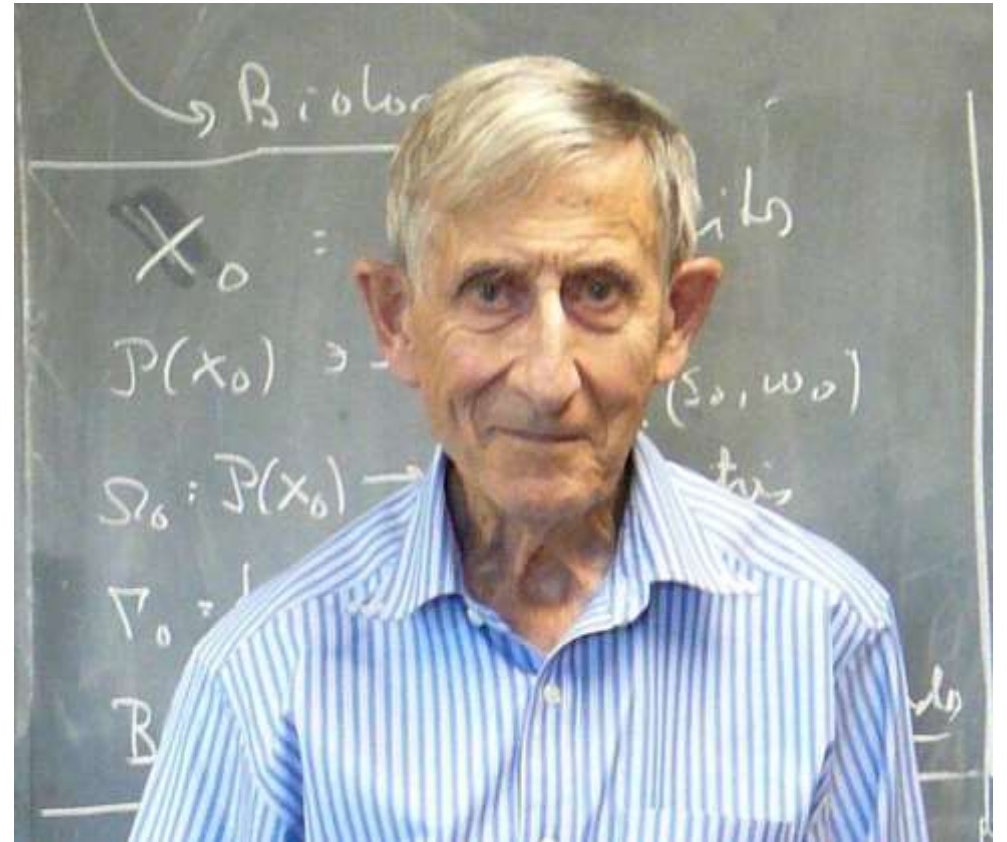
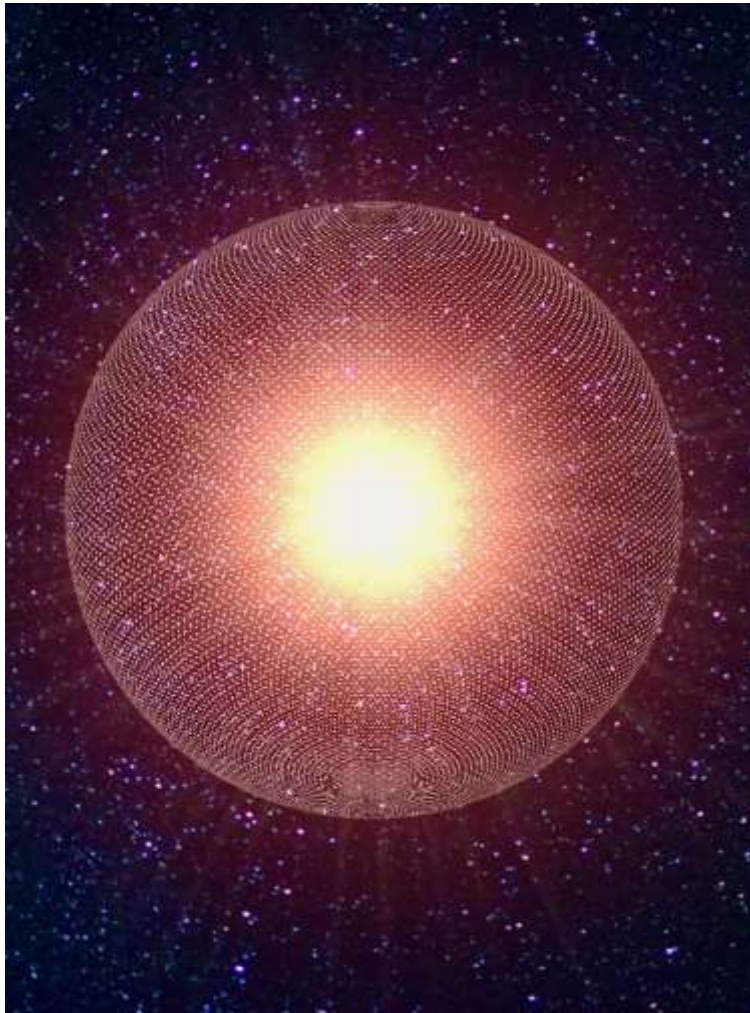
Reaktory przyszłości – atom, synteza termojądrowa czy antymateria?



Energetyka słoneczna... w kosmosie?



Sfera Dysona



Możliwe ścieżki przyszłości



"Yes, the planet got destroyed. But for a beautiful moment in time we created a lot of value for shareholders."





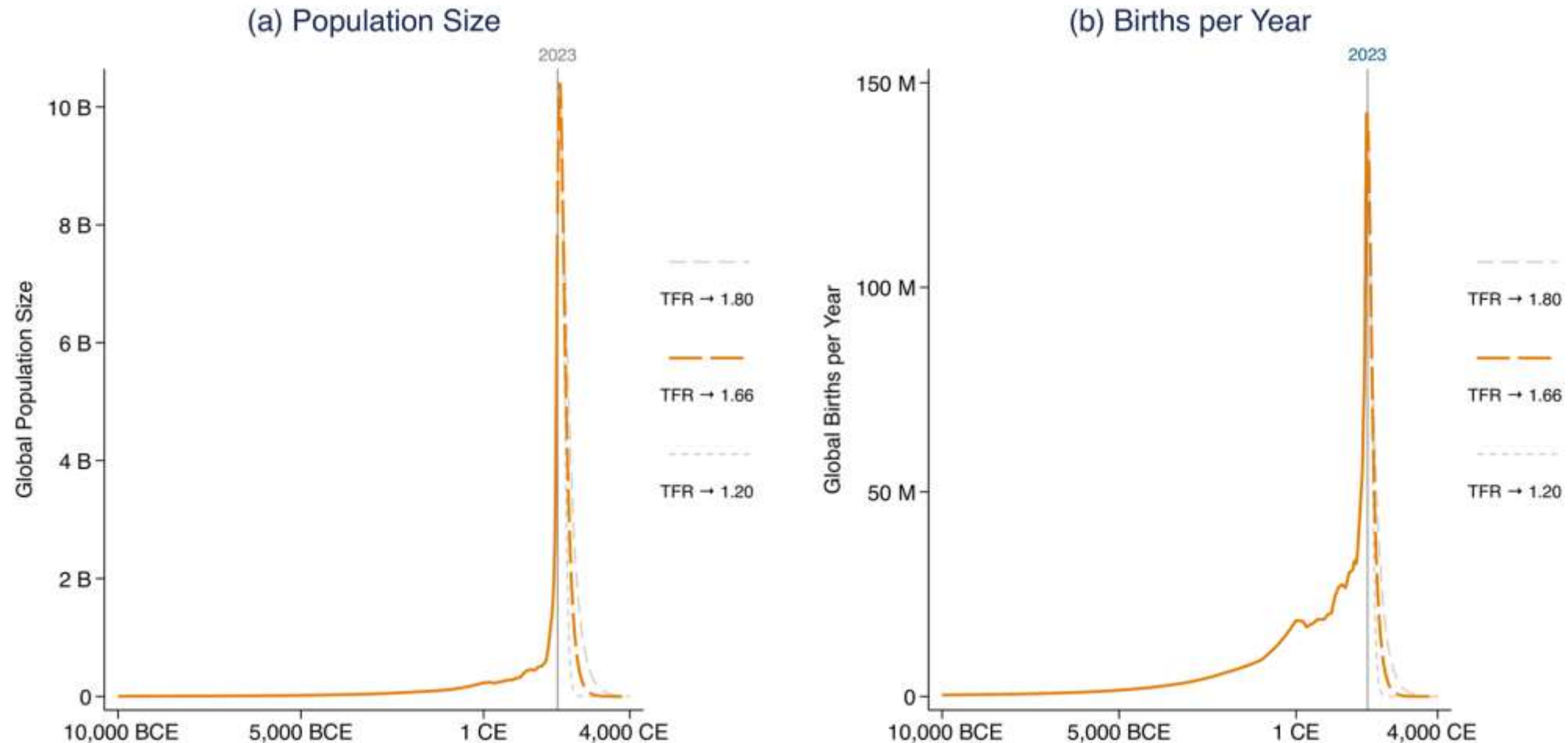
INCORPORATED | Syfy



Long-term population projections: Scenarios of low or rebounding fertility

Spears, Vyas, Weston, Geruso

<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0298190>



Dziękuję :-)

PTH

PHX