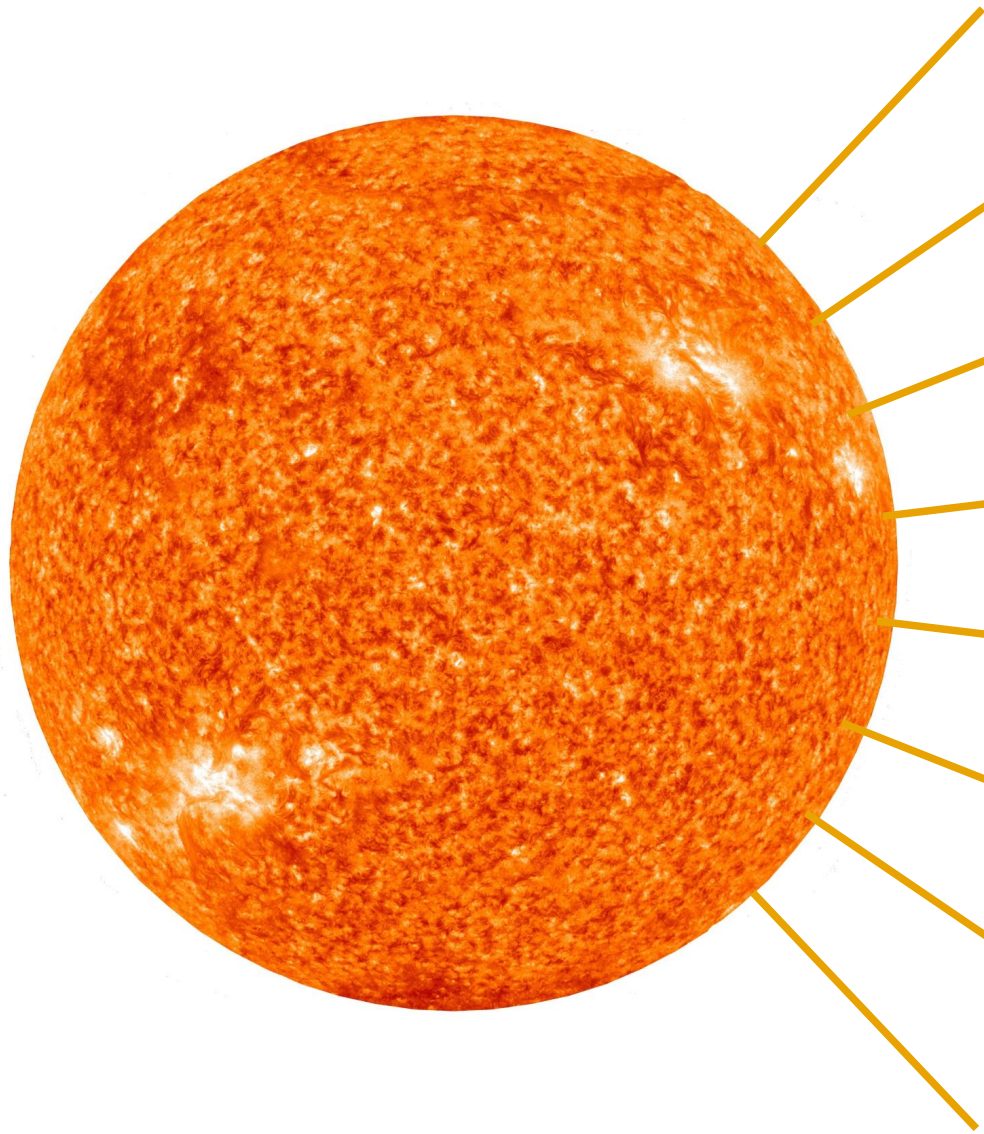


Renewable Energy: An Overview

University College Dublin Physics 62, May 21, 2026

John K. White

www.johnkwhite.ie



The Sun and all its Glory

University College Dublin Physics 62, May 21, 2026

John K. White

www.johnkwhite.ie

0. The Sun and All its Glory

Sufficient to sustain life, directly as sunlight and through chemical and physical processes:

1. solar energy trapped by **photosynthesis** is stored in plants and animals, forming fossil fuels over long periods of time, a.k.a. “fossilized sunshine” in peat, coal, oil, and natural gas (as well as plant biomass)
2. **differentially heating** the earth’s atmosphere and oceans, giving rise to **wind**, currents, and weather
3. **thermally heating** various storage media (e.g., rock, sand, water, **earth**)
4. **converting photons to electrons in a modern photovoltaic (PV) solar cell**

The sun’s energy also increases and decreases during the day as the earth rotates – strongest when the sun is highest in the sky (local noon) and weakest at sunrise and sunset – as well as throughout the year depending on the day of the year and one’s latitude.

Teaser quiz 1/5

Quizzes -- Energy

8 quizzes: [Physics](#) | [Energy](#) | [Geography](#) | [Spain](#) | [Math](#) | [History](#) | [Arts](#) | [Letters](#)
50 questions of increasing difficulty. Can you get to level 5?

Random questions?

0/0
Level 1

Select a choice: +1 for a correct answer, -1 for a wrong answer. The correct answer appears here.

How far away is the sun?



100 km



10,000 km



1.5 million km



150 million km

Teaser quiz 2/5

Quizzes -- Energy

8 quizzes: [Physics](#) | [Energy](#) | [Geography](#) | [Spain](#) | [Math](#) | [History](#) | [Arts](#) | [Letters](#)
50 questions of increasing difficulty. Can you get to level 5?

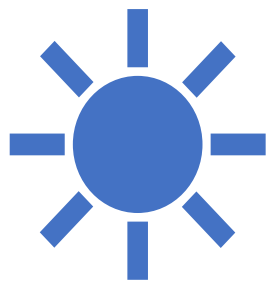
Random questions?

0/0
Level 1

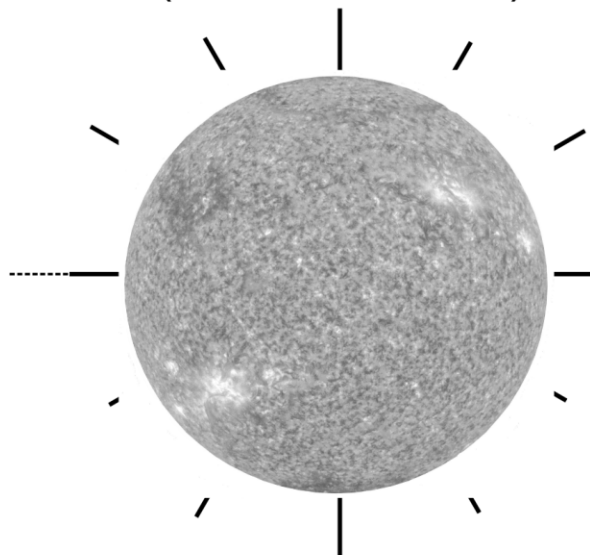
Select a choice: +1 for a correct answer, -1 for a wrong answer. The correct answer appears here.

How much of the sun's radiated power reaches the earth?

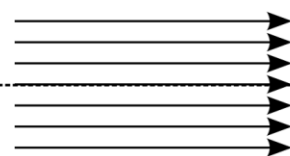
- 1 thousandth
- 1 millionth
- 1 billionth
- 1 2 billionth



$\sim 380 \times 10^{24}$ watts
(in all directions)

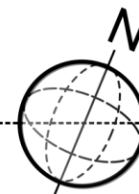


$\sim 1/2$ billionth
of solar energy
(directed toward earth)



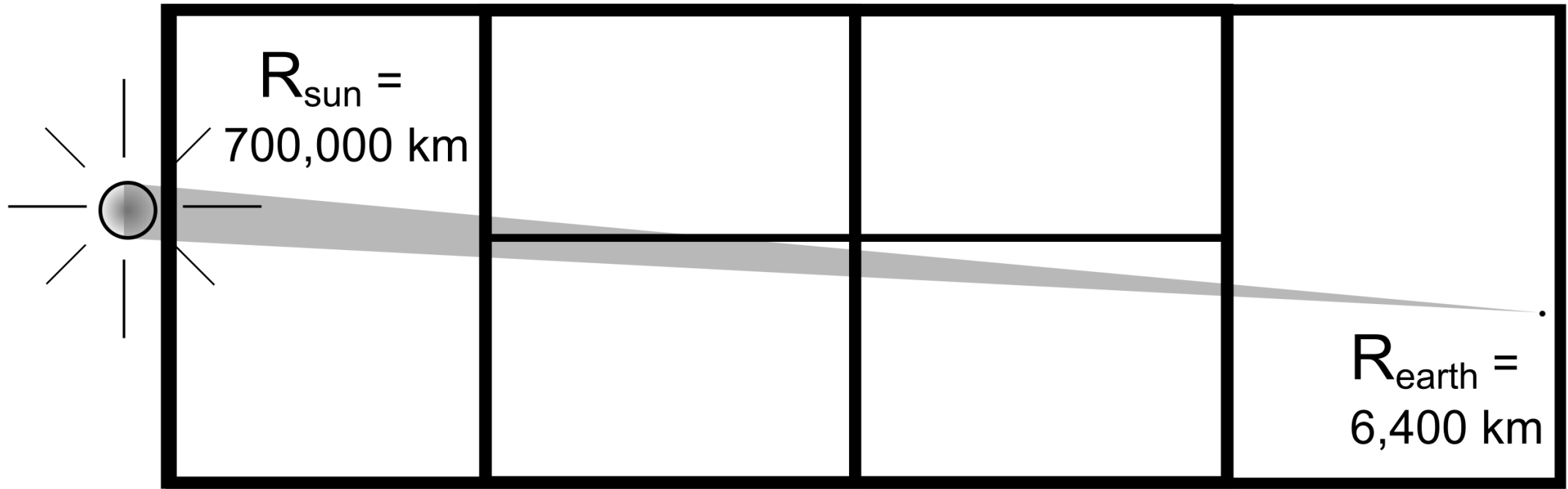
~ 170 petawatts

1,370 watts per
square metre



$$P = f(R, T) = P = 4\pi R^2 \sigma T^4 \text{ (Stefan-Boltzmann)}$$

Figure 4.4 The Truth About Energy



$1 \text{ AU} = 150 \text{ million km}$

$1 / 2$ billionth of the sun's energy
makes it to earth

Figure 4.2 The Truth About Energy

Teaser quiz 3/5

Quizzes -- Energy

8 quizzes: [Physics](#) | [Energy](#) | [Geography](#) | [Spain](#) | [Math](#) | [History](#) | [Arts](#) | [Letters](#)
50 questions of increasing difficulty. Can you get to level 5?

Random questions?

0/0
Level 1

Select a choice: +1 for a correct answer, -1 for a wrong answer. The correct answer appears here.

How long does it take for the sun's rays to reach earth?

- 8.3 seconds**
- 8.3 minutes**
- 8.3 hours**
- 8.3 days**

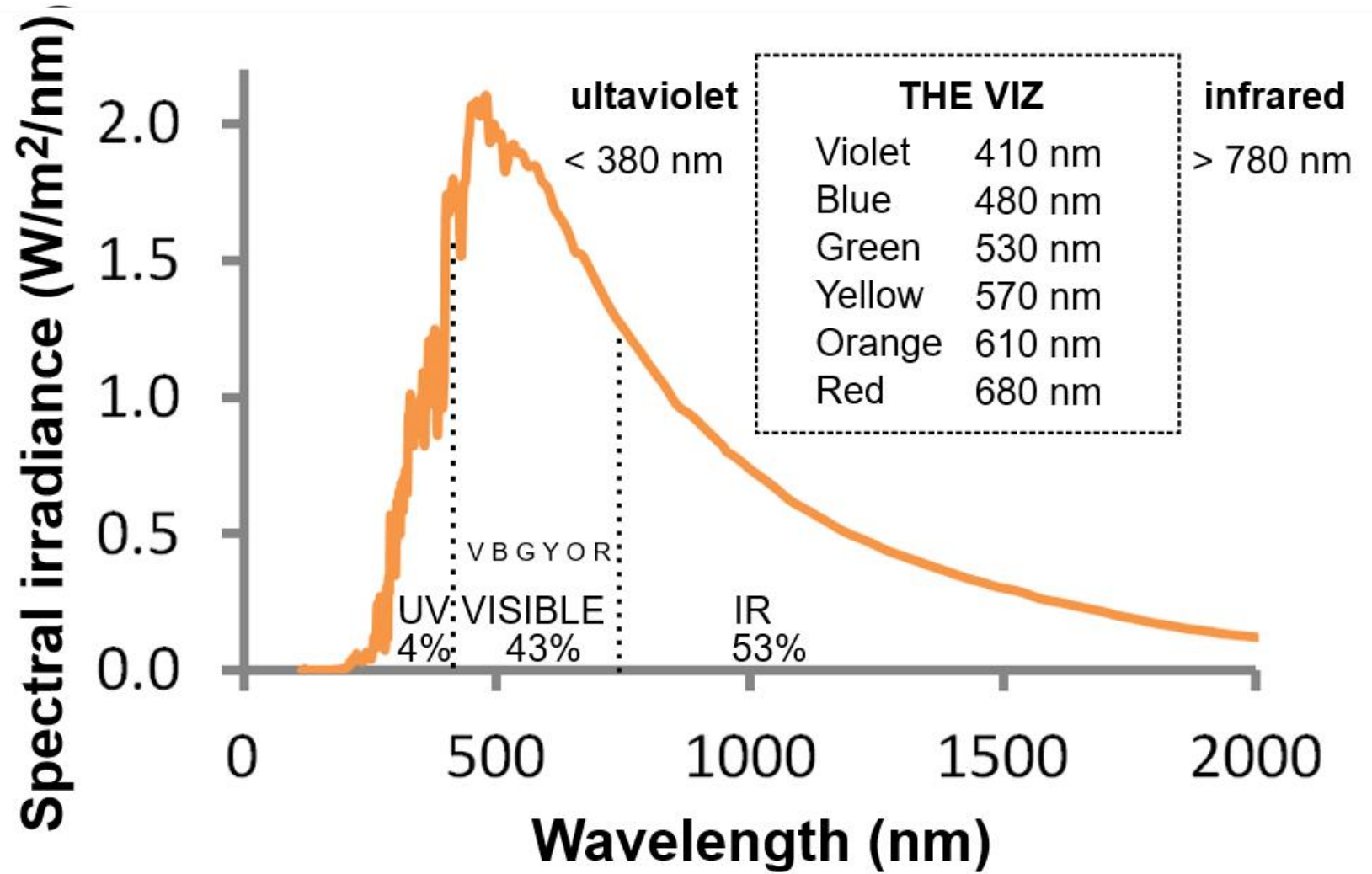
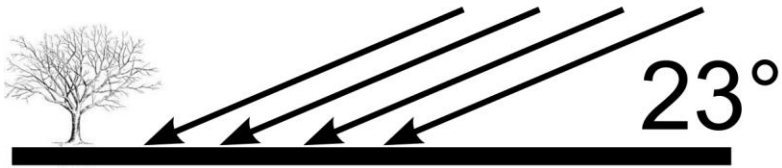


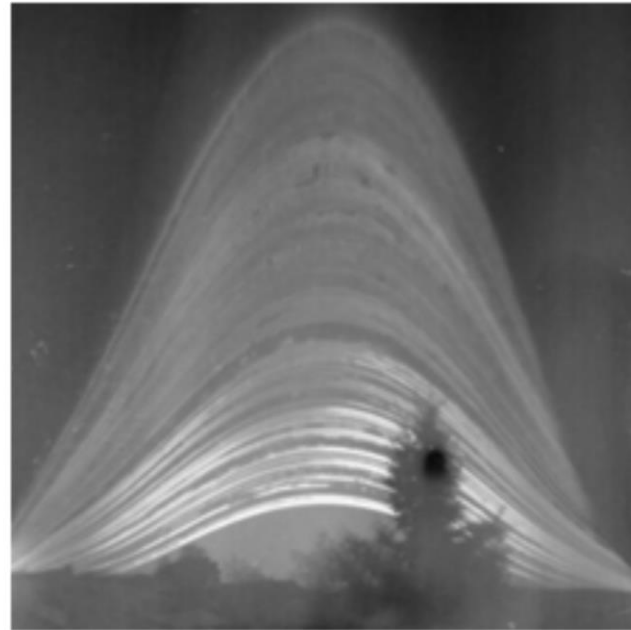
Figure 4.1 The Truth About Energy

minimum angle $90 - (L + 23.4)^\circ$ to maximum angle $90 - (L - 23.4)^\circ$

winter
solstice
(~December 21)

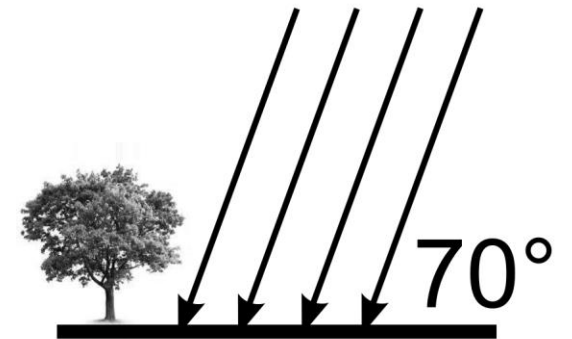


max summer



max winter

summer
solstice
(~June 21)



panel output =
area under curve

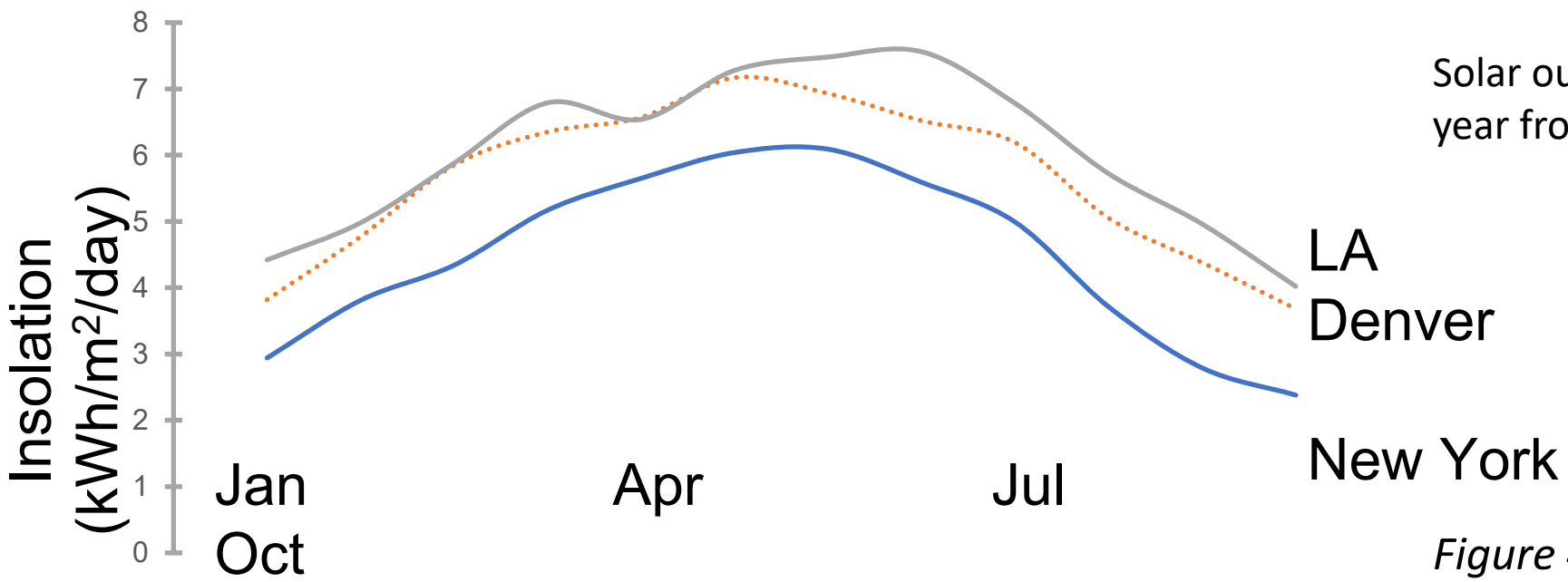
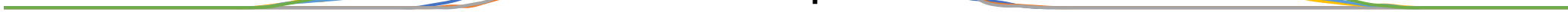
summer/winter
ratio = 10.6

summer

winter

local
noon

Solar output during the day from a fixed
rooftop PV panel in summer and winter



Solar output (kWh/m²/day during the
year from 3 fixed rooftop PV panels

LA
Denver
New York

Figure 4.8/9 The Truth About Energy

Teaser quiz 4/5

Quizzes -- Energy

8 quizzes: [Physics](#) | [Energy](#) | [Geography](#) | [Spain](#) | [Math](#) | [History](#) | [Arts](#) | [Letters](#)
50 questions of increasing difficulty. Can you get to level 5?

Random questions?

0/0
Level 1

Select a choice: +1 for a correct answer, -1 for a wrong answer. The correct answer appears here.

How thick would the earth's atmosphere be if the earth was the size of a basketball?

1.9 mm

1.9 cm

1.9 m

1.9 km

Teaser quiz 5/5

Quizzes -- Energy

8 quizzes: [Physics](#) | [Energy](#) | [Geography](#) | [Spain](#) | [Math](#) | [History](#) | [Arts](#) | [Letters](#)
50 questions of increasing difficulty. Can you get to level 5?

Random questions?

0/0
Level 1

Select a choice: +1 for a correct answer, -1 for a wrong answer. The correct answer appears here.

How thick would the earth's crust be if the earth was the size of a basketball?

0.9 mm

9 mm

9 cm

9 m



The story of the 20th century

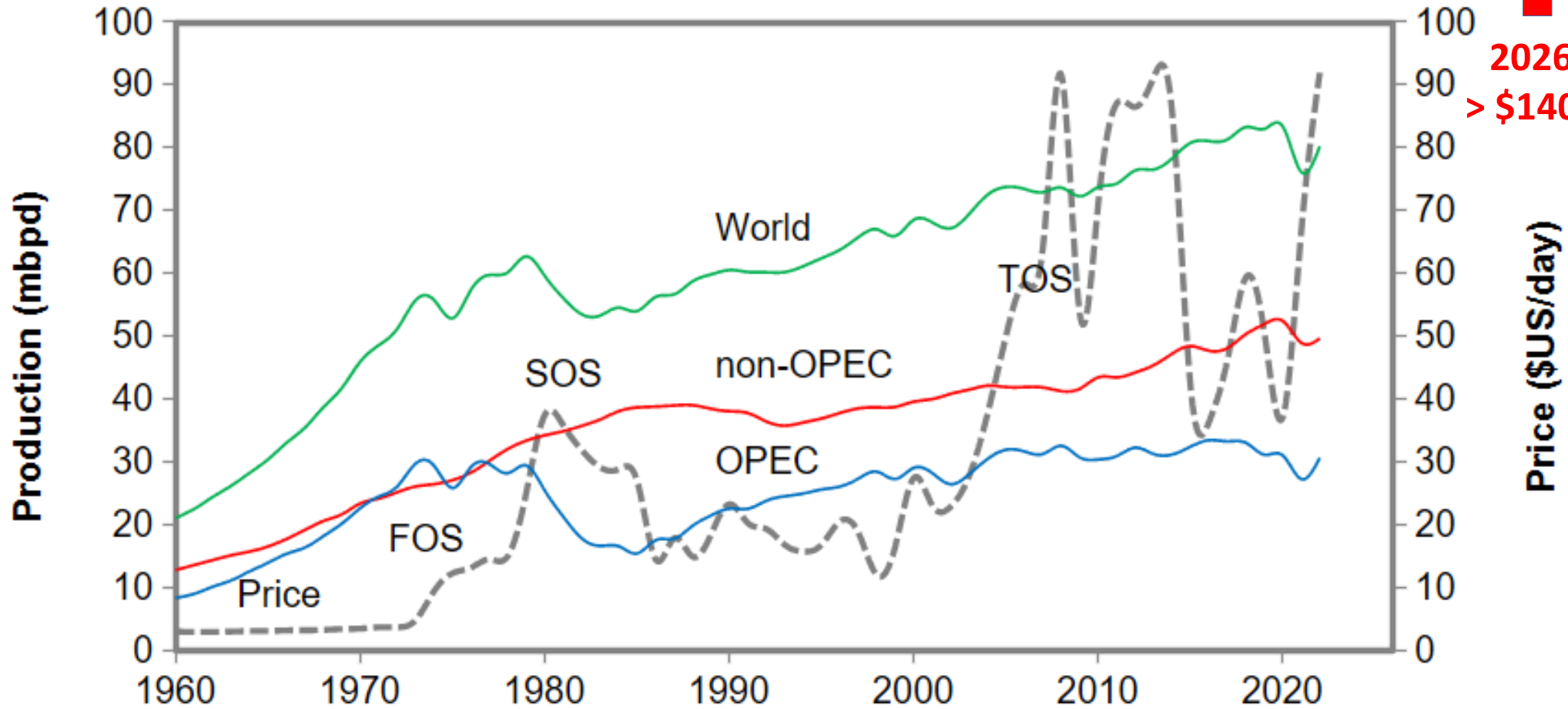


Figure 2.10 The Truth About Energy

How did we get here? – Oil prices



The story of the 20th century

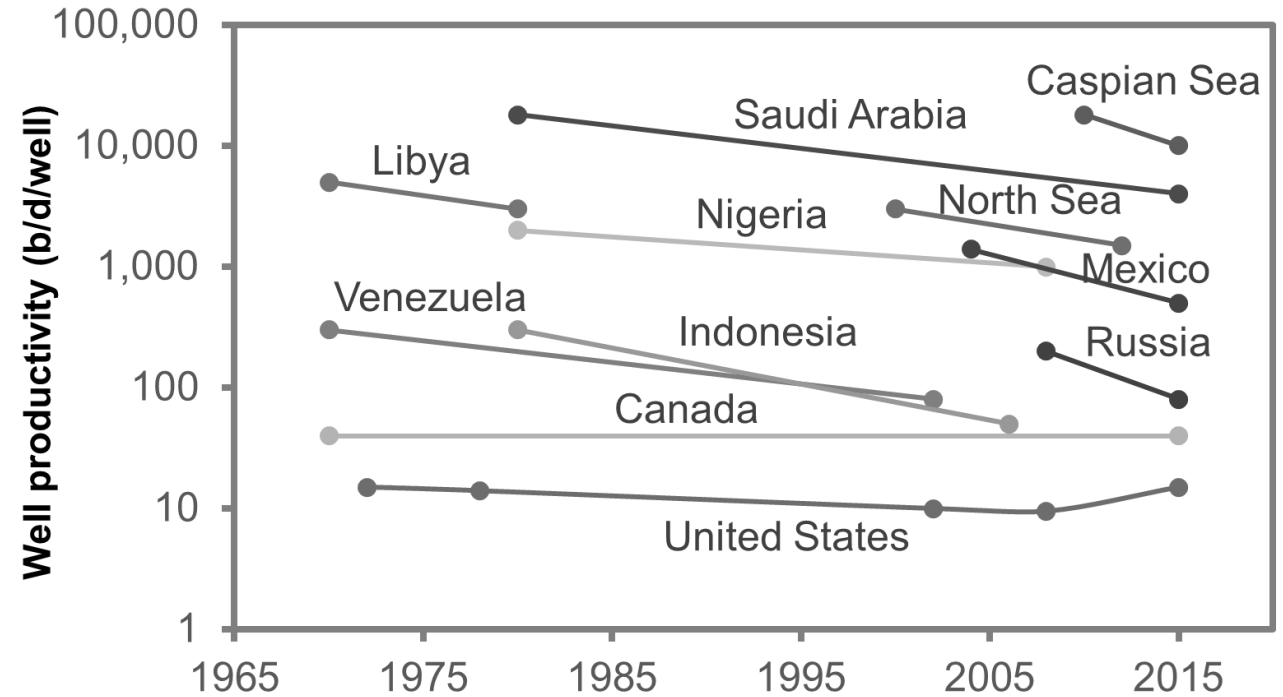
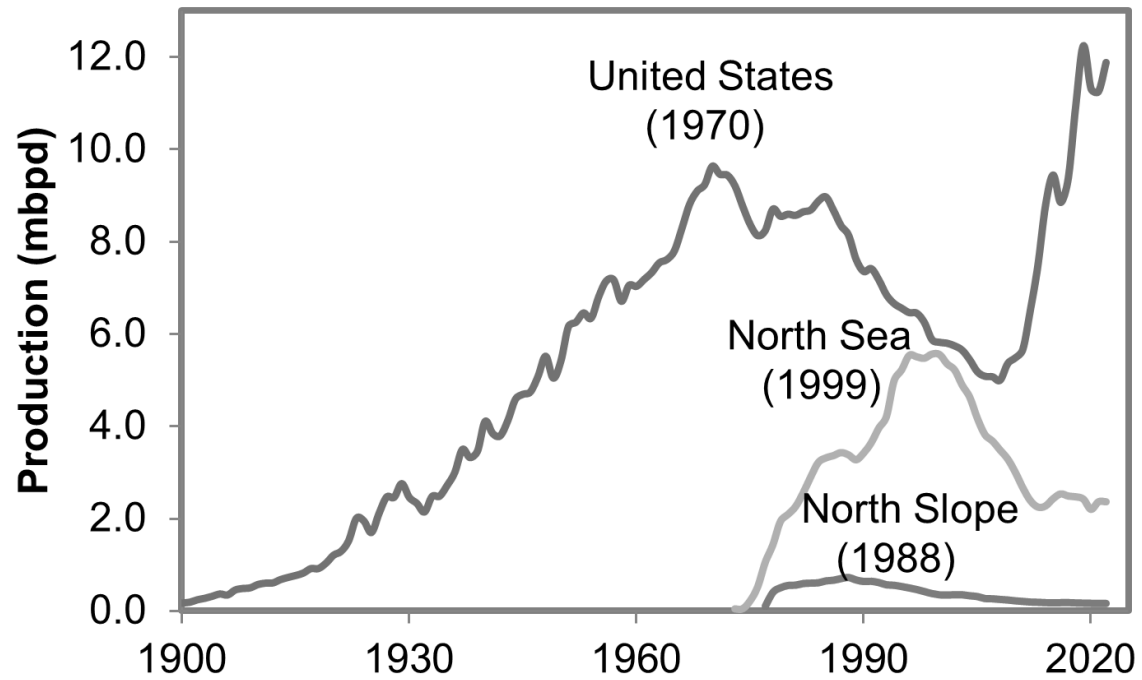


Figure 2.17 The Truth About Energy

Why are we doing this? – “Peak Oil”



The story of the 20th century

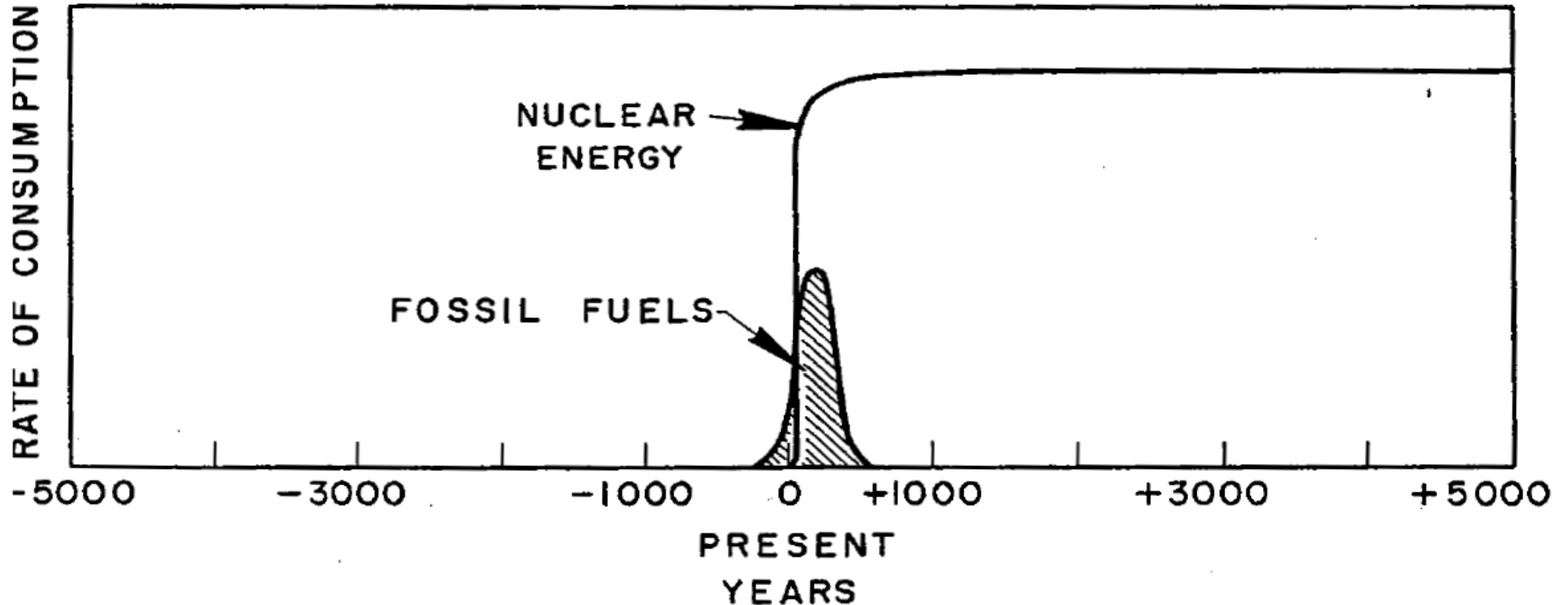


Figure 30 – Relative magnitudes of possible fossil-fuel and nuclear-energy consumption seen in time perspective of minus to plus 5000 years.



Energy intensity

If the energy intensity of the countries on the bottom left — essentially Asia, Africa, and South America — rise to the top right without transitioning to clean energy, the atmosphere and the climate are doomed.

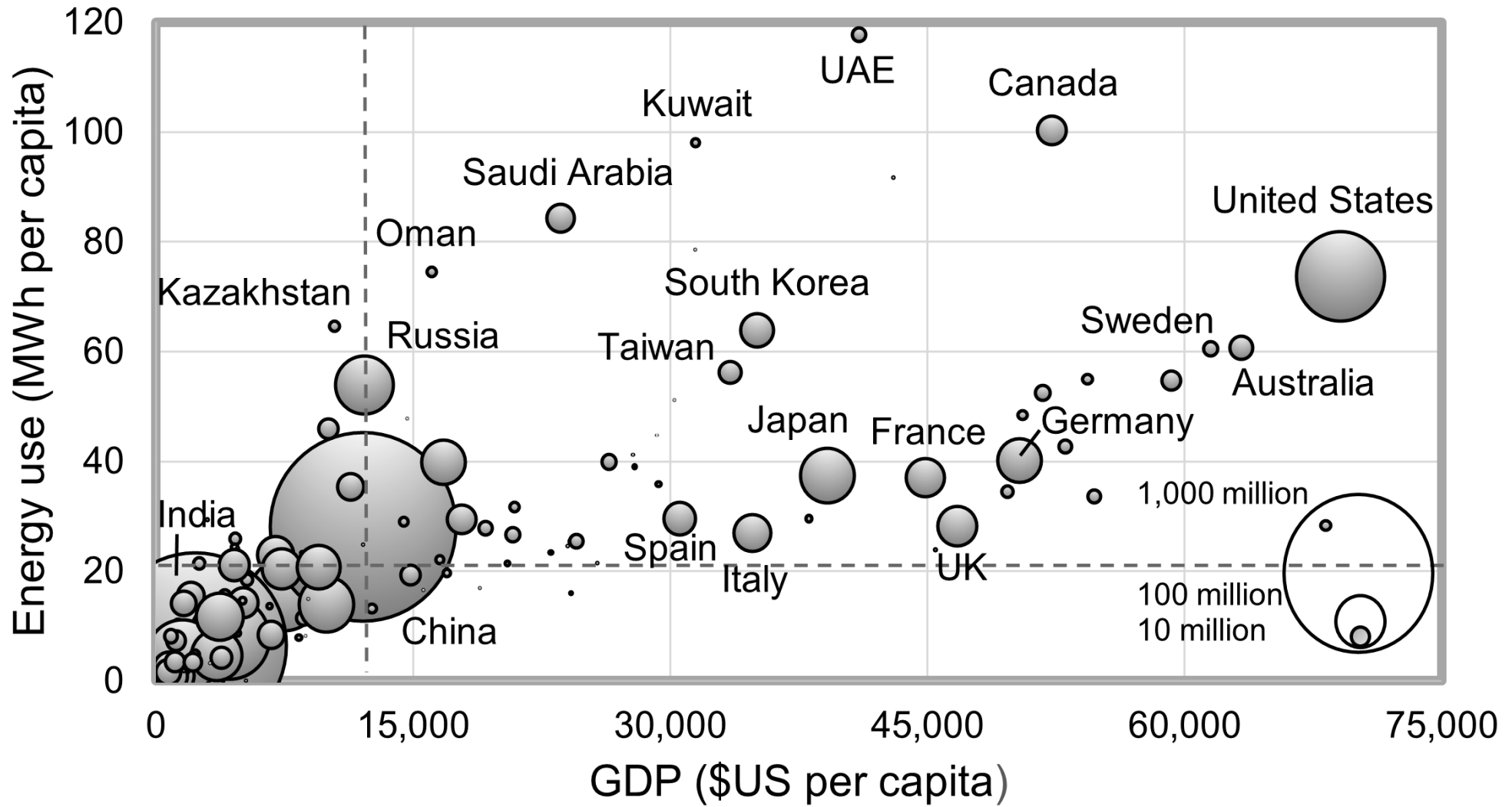
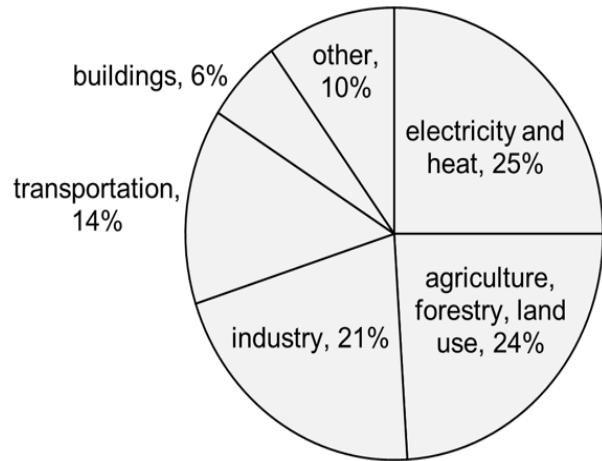


Figure 2.12 The Truth About Energy



Global warming / Global warning

50 gigatons GHG (76% CO₂)
CH₄ 80 times GWP of CO₂

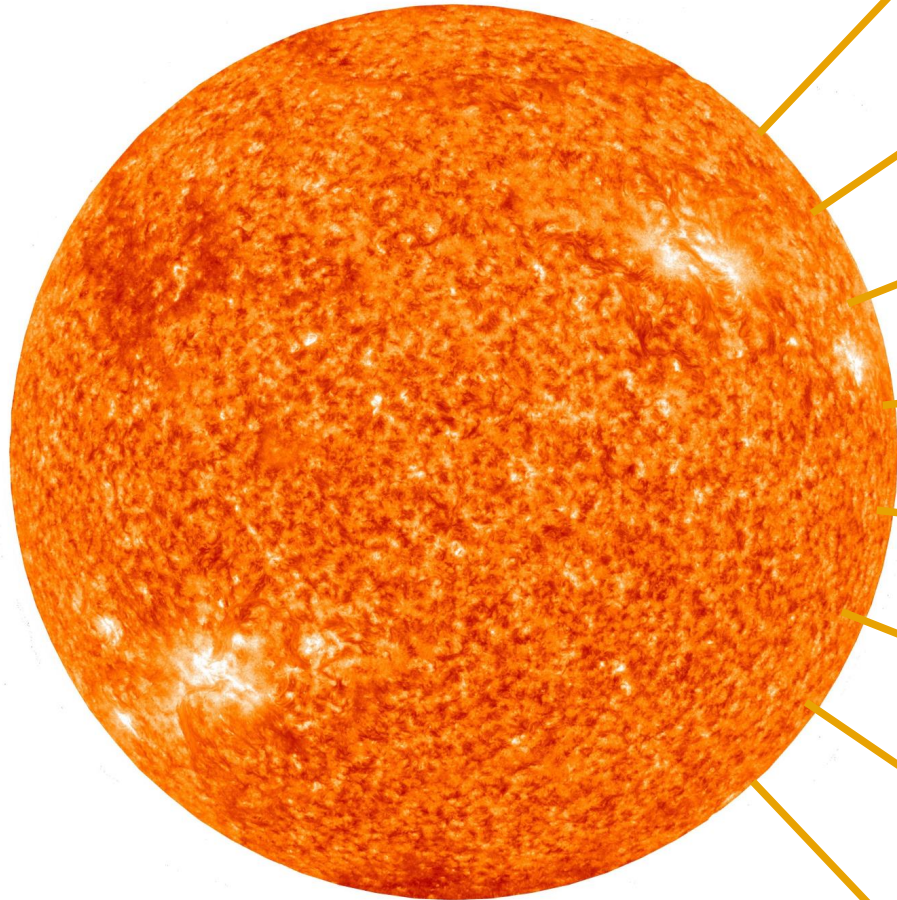


economic sector

Reduce/Reuse/Recycle/...



climate change versus habit change



0. Introduction (quiz, scale, peak, global warming/warning)

1. *The Truth About Energy* (bad/good, brown/green, old/new)

2. A little history (“Energy Dominoes”)

3. Examples!!! from the **bottom up** (E21NS)

Spain, Ireland, the world

4. How much? from the **top down** (data, data, data)

Cost (\$/MWh), green grid, real-time grids (Spain, Ireland)

5. Myths

6. What can we do? RRRrrr ...

THE TRUTH ABOUT ENERGY

Our Fossil-Fuel
Addiction and the Transition
to Renewables

JOHN K. WHITE

PART I (Out with the Old)

1. Wood to Coal: A Short History of the Industrial Revolution
2. Oil and Gas: Twentieth-Century Prosperity
3. The Nuclear World: Atoms for Peace

PART II (In with the New)

4. Old to New: The Sun and all its Glory
5. The Old becomes New Again: More Sustainable Energy
6. Driving the Revolution Revolution: From Volta to Tesla and Back

PART III (Less is More)

7. Rethink, Rebuild, Rewire

www.johnkwhite.ie

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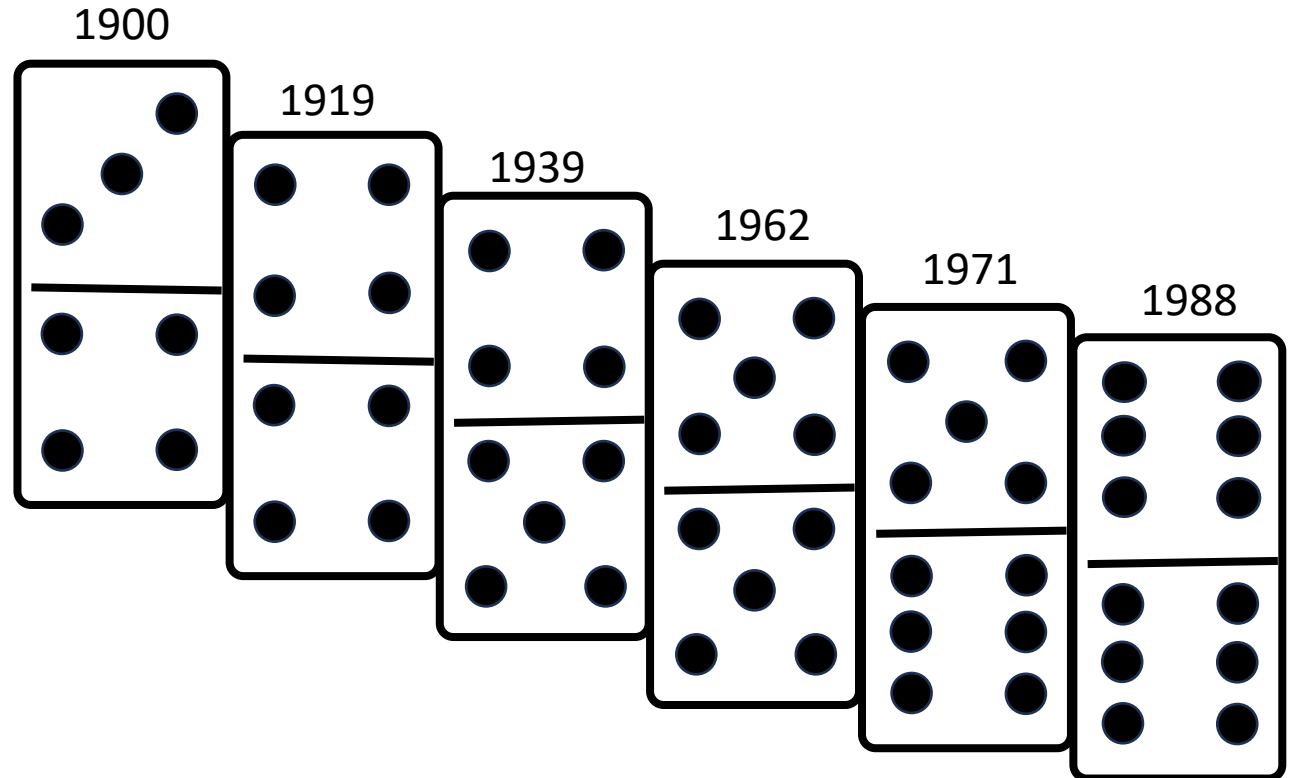
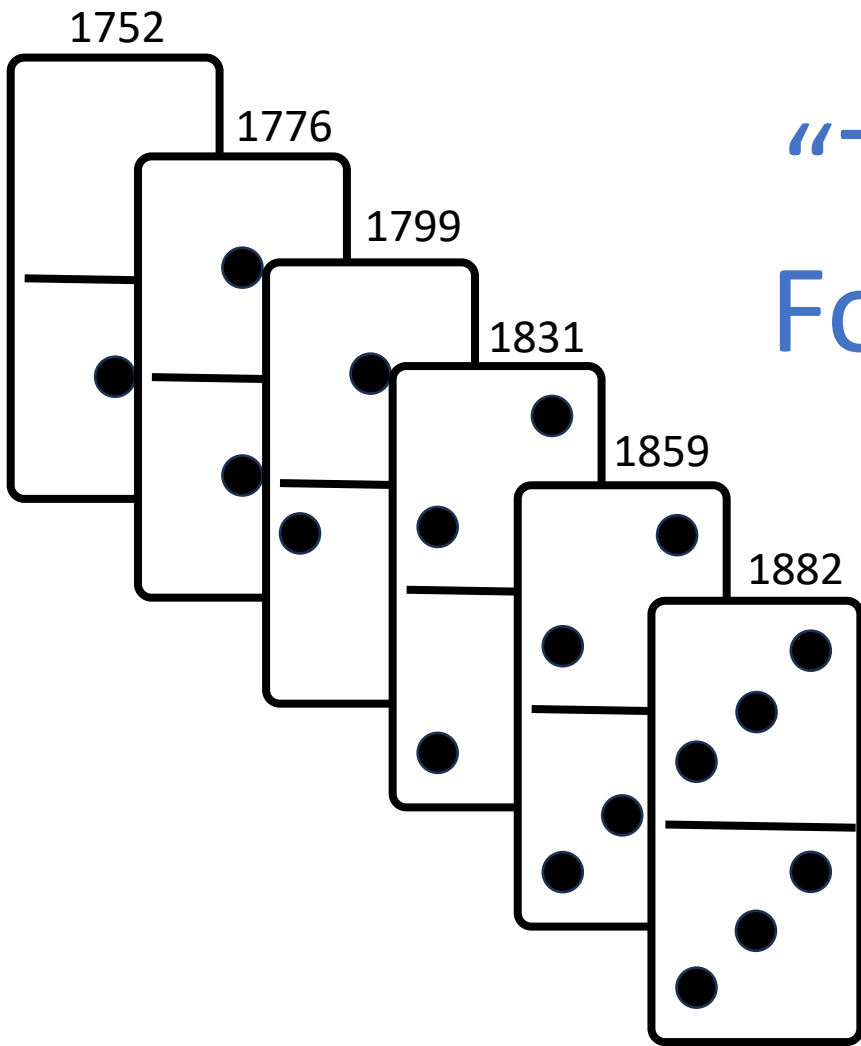
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“THE ENERGY DOMINOES”

Fossil Fuels versus Electricity



People and Place

The Truth About Energy,
Escuela Oficial de Idiomas de Gijón, April 2024



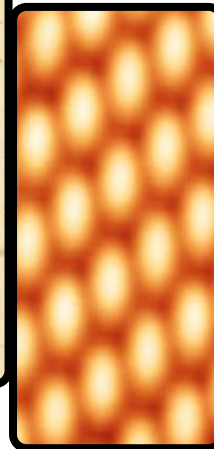
Niagara Falls
1900



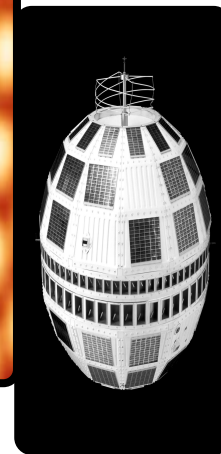
Buddinge
1919



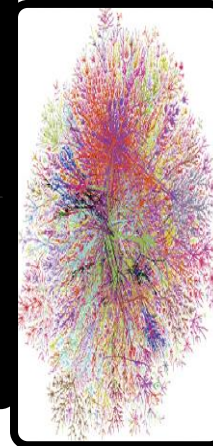
New Jersey
1939



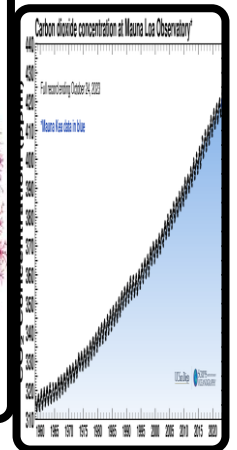
New Jersey
1962



California
1971



Washington
1988

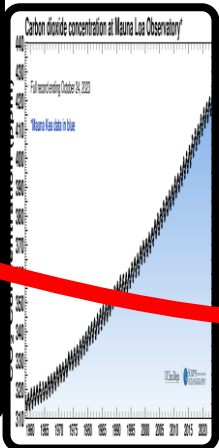


Linear versus Exponential

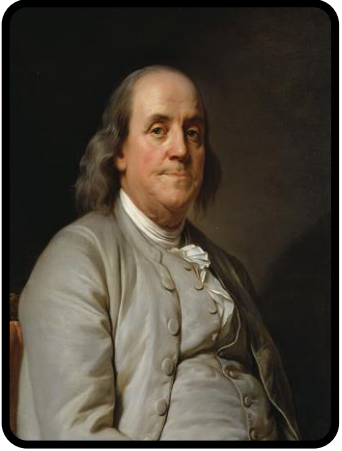
The Truth About Energy,
Escuela Oficial de Idiomas de Gijón, April 2024

1752 Benjamin Franklin
1776 James Watt
1799 Alessandro Volta
1831 Michael Faraday
1859 Edwin Drake
1882 "TA" Edison

Niagara Falls 1900
Buddinge 1919
New Jersey 1939
New Jersey 1962
California 1971
Washington 1988



1752

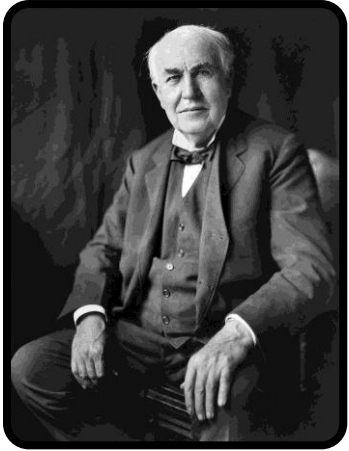


[Benjamin Franklin and the kite experiment](#)

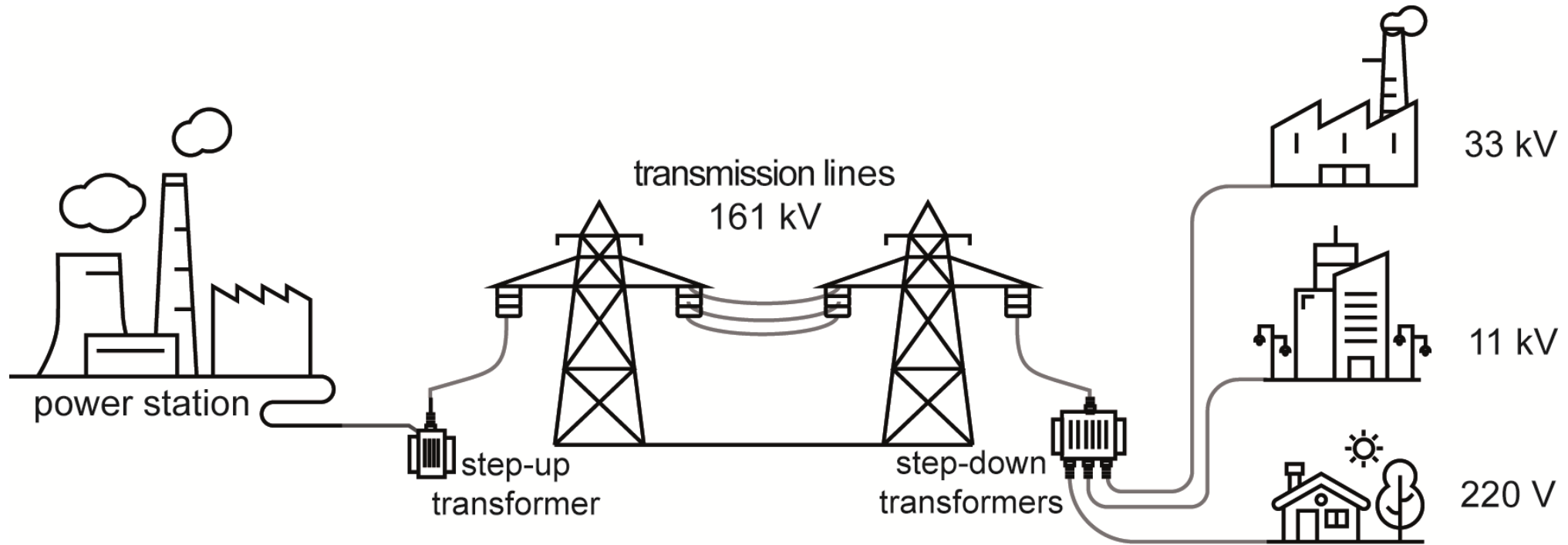


Benjamin Franklin waited for ideal stormy conditions to demonstrate the electrical nature of lightning. He used a silk kite, hemp and silk string, metal house key, and a Leyden jar to store electrical charge. The kite was not struck by lightning, but picked up **ambient electrical charge** in the storm. When a storm cloud neared, a spark was produced.

1882

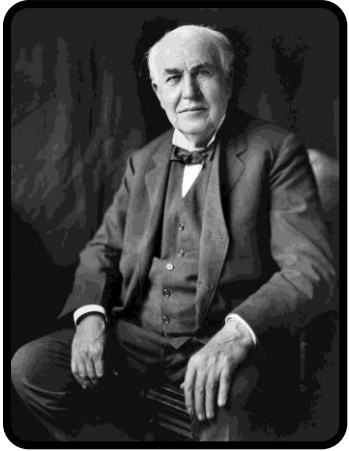


[Historical
drama *Edison,
the Man,*
directed by
Clarence
Brown \(MGM\)](#)

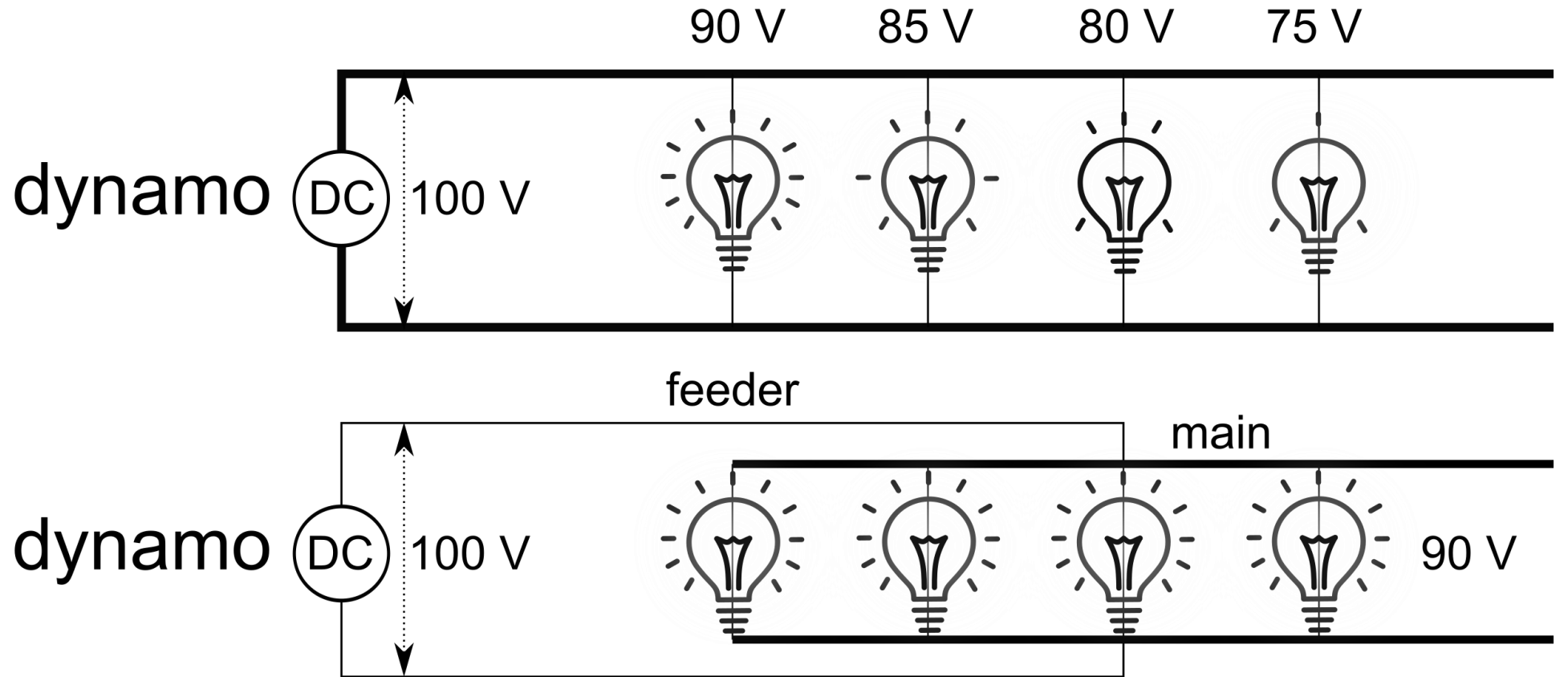


Six, 27-ton, 100-kW “Jumbo” dynamos generated the coal-fueled electric power, **Thomas Edison’s Pearl Street Station** transmitting 100 volts of **direct-current electricity** underground to 400 lights in a one-square-mile area of Lower Manhattan’s First District (bounded by Wall Street, Nassau Street, Spruce Street, and Ferry Street).

1882



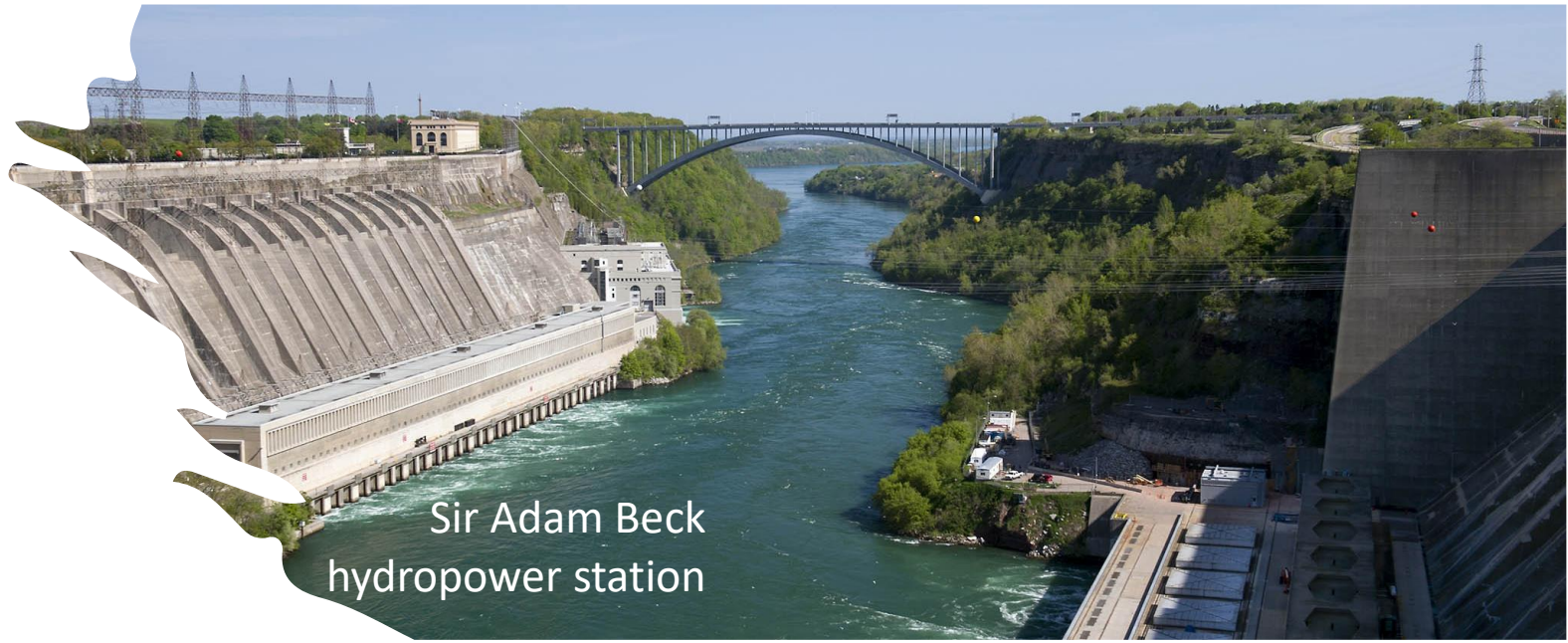
[Historical drama *Edison, the Man*, directed by Clarence Brown \(MGM\)](#)



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1900: Niagara Falls – Westinghouse, Nikola Tesla, Edison, Alcoa, ...

- Canada and the US signed a treaty to keep the beauty of Niagara Falls intact.
- The international pact limits the amount of diverted water for power production, stipulating that at least **100,000 cubic feet of water per second** must flow over the Falls from 8 a.m. to 10 p.m. each day during the tourist season.
- Otherwise, the flow can be reduced to half that.



Sir Adam Beck
hydropower station

1900: Niagara Falls – Westinghouse, Nikola Tesla, Edison, Alcoa, ...

→ TVA (1924), Hoover Dam (1935),
Grand Coulee Dam (1942)

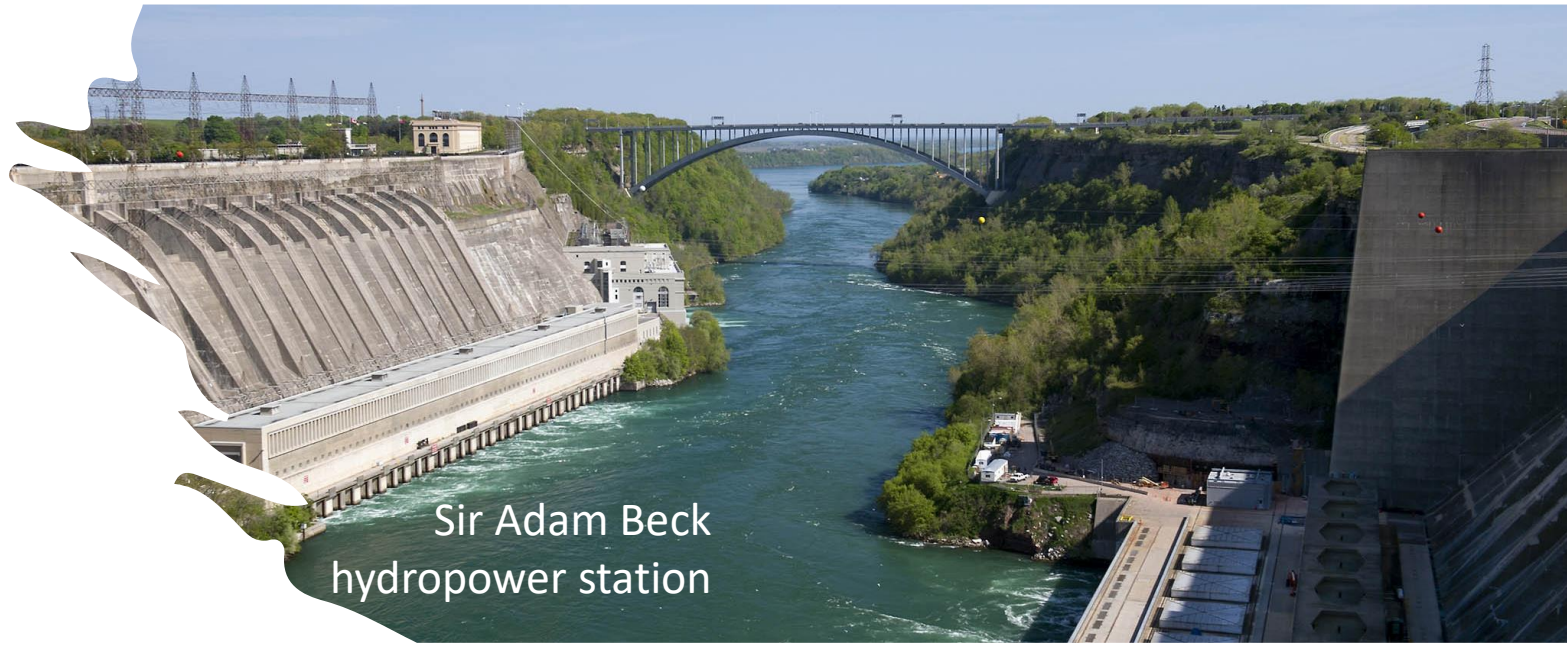
→ Aswan (1960), GERD (2022),

→ James Bay (1971, 1984, ...)

→ Three Gorges Dam (2012)

...

Oscar Wilde (1882)



Sir Adam Beck
hydropower station

1939+: New Jersey (Bell Labs)

– p-n junction, transistor, PV, satellites, Telstar, ...

- At Bell Telephone's radio lab in Holmdel, New Jersey, electrochemist **Russell Ohl** discovered a large voltage in a piece of commercial-grade silicon during his radar research on signal detectors after a current flowed under flashlight illumination.
- The signal was varied, but Walter Brattain, working at Bell's main labs in nearby Murray Hill, noted, "this was the first time that anybody had ever found a **photovoltaic effect** in elementary material."
- **The "doped" p-n junction was born.**

II	III	IV	V	VI
	5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen
	13 Al Aluminum	14 Si Silicon	15 P Phosphorus	16 S Sulphur
30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium
48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium

Group III, IV, V elements

1939+: New Jersey (Bell Labs)

– p-n junction, transistor, PV,
satellites, Telstar, ...



semiconductor materials (silicon,
germanium)



solid-state diode, transistor



PV solar cell



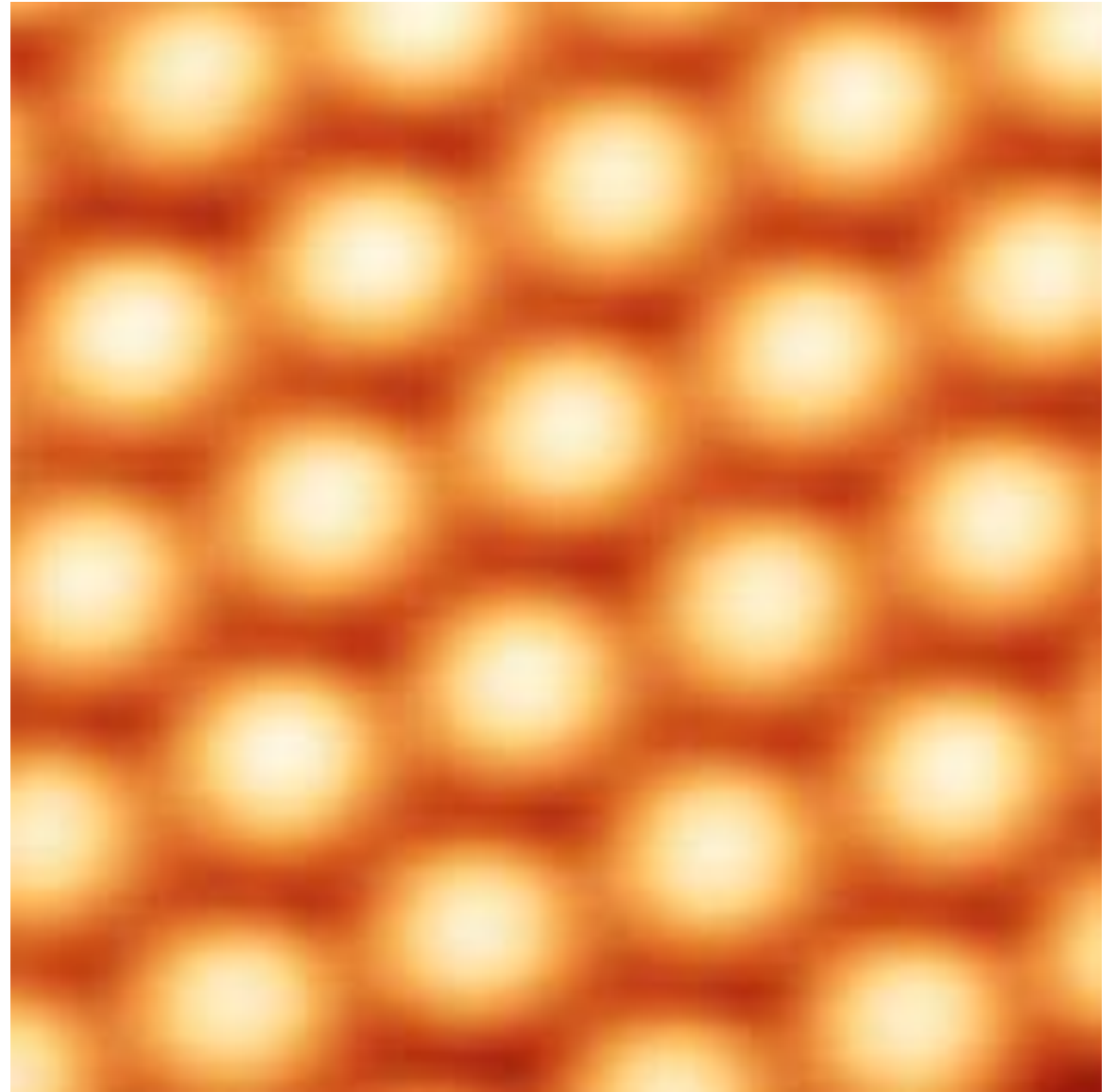
satellites (*Explorer, Vanguard,
Telstar, ...*)



IC (chip), LED, diode laser, CCD



solar panels

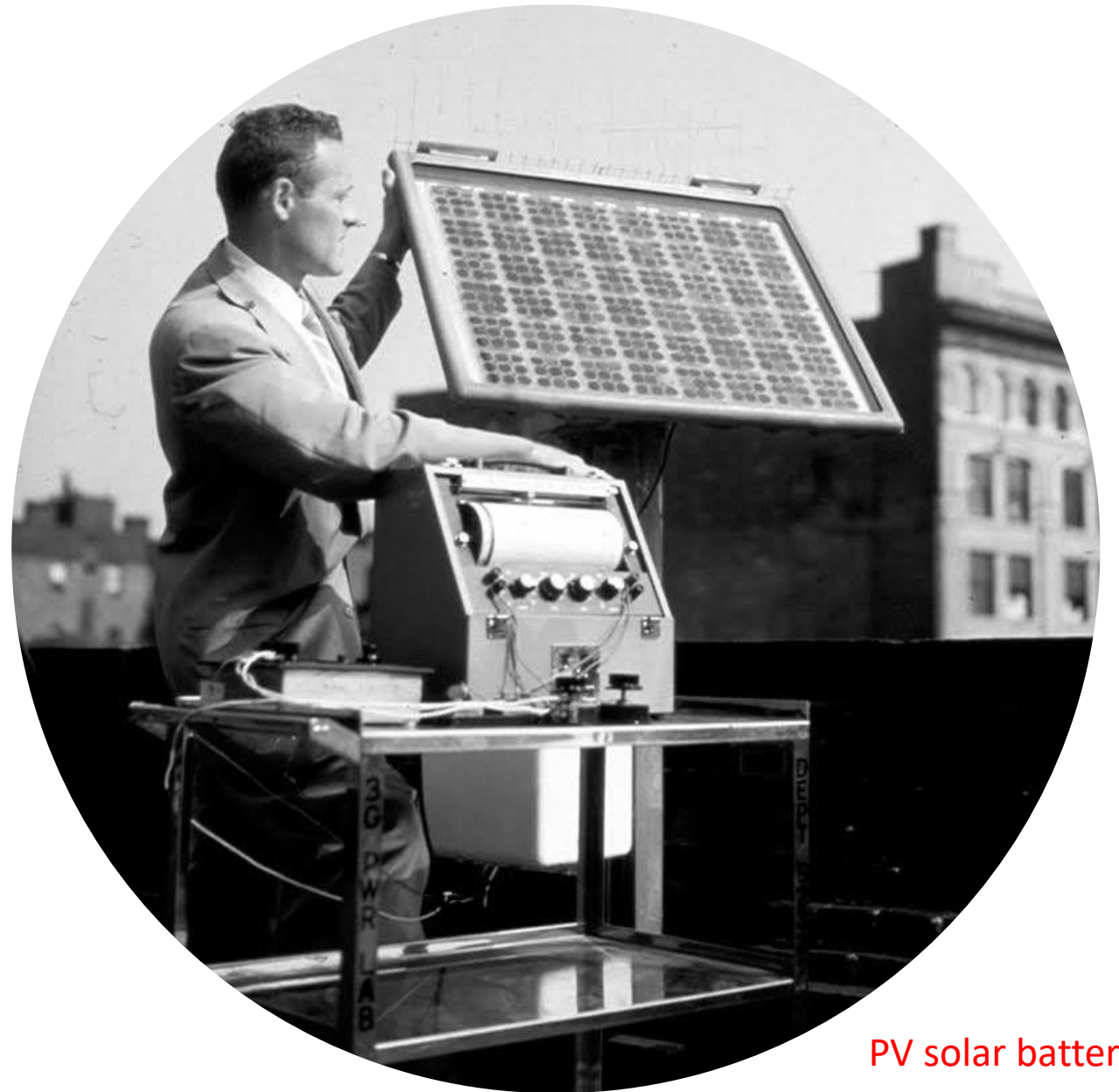


14 Silicon (2 8 4)

1962: New Jersey (Bell Labs)

– transistor, PV, satellites, Telstar, ...

- 1954: A silicon pnp **transistor** was difficult to mass produce until the crystal was doped by diffusion (high-concentration dopants added to the molten silicon during crystal growth).
- **1954: PV solar battery:** thin, silicon-doped wafer converts light into electricity at 6% efficiency (“compares favorably with the efficiency of steam and gasoline engines”).
- 1962: AT&T’s 1962 **Telstar** generated 14 watts from 3,600 modules.

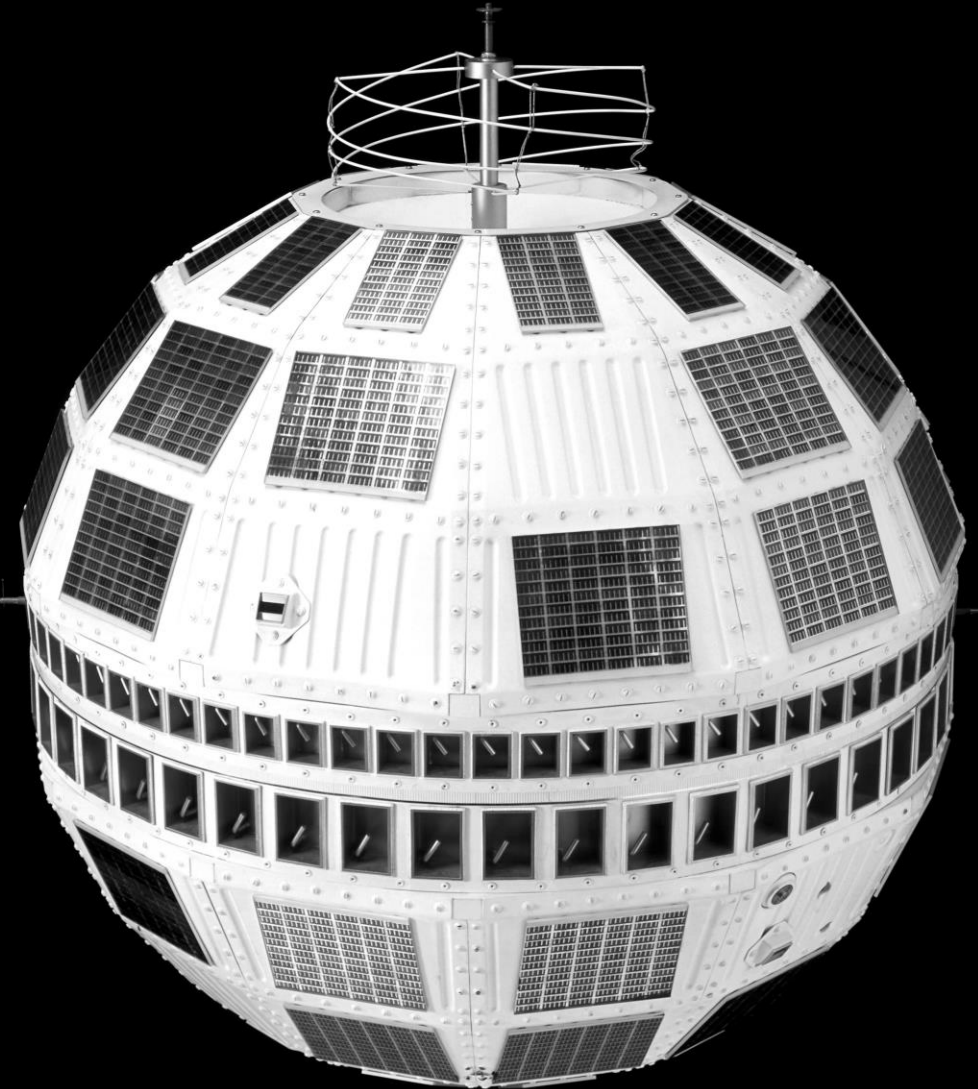


PV solar battery

1962: New Jersey (Bell Labs)

– transistor, PV, satellites,
Telstar, ...

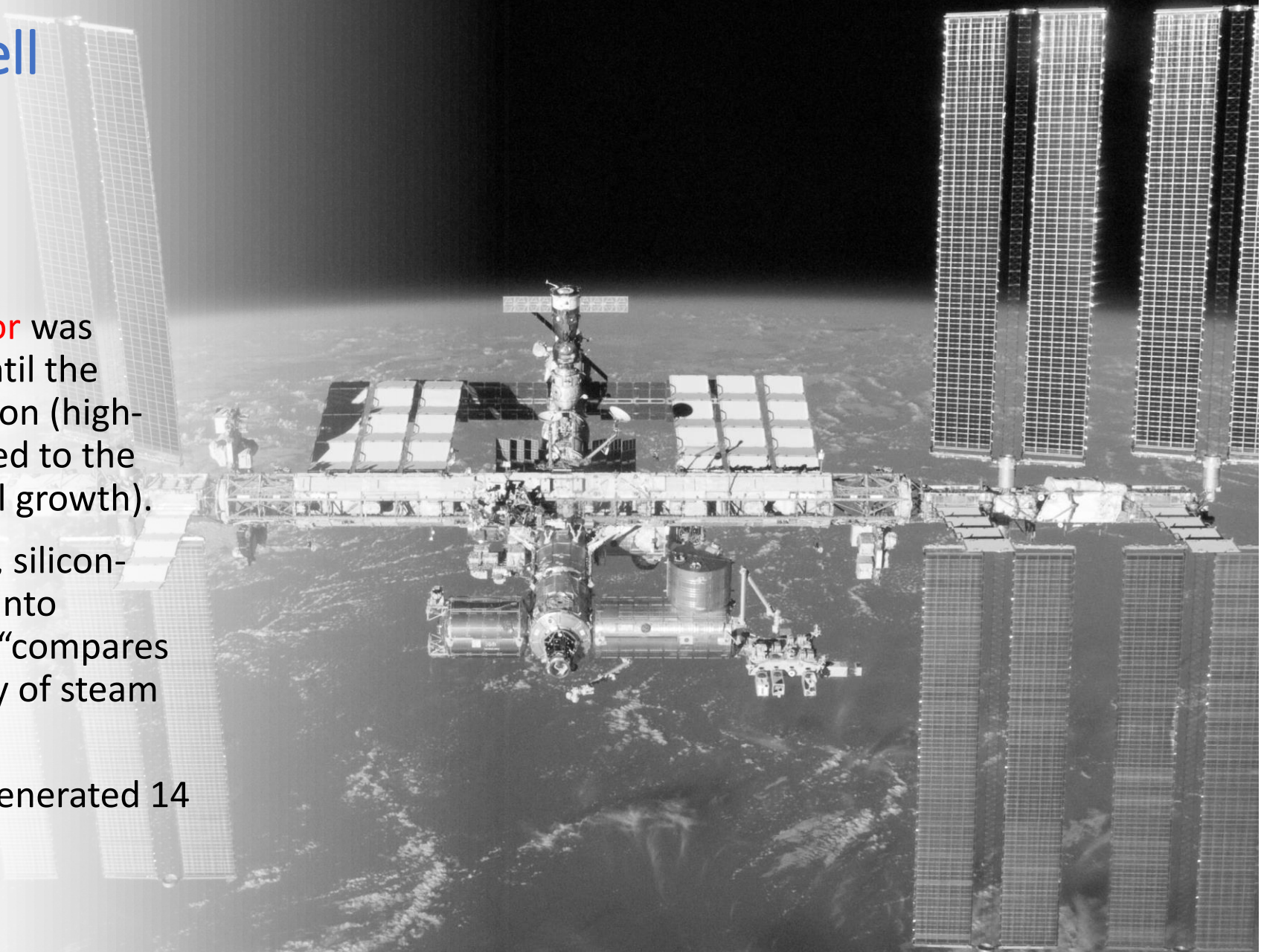
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Telstar

1962+: New Jersey (Bell Labs) – transistor, PV, satellites, Telstar, ...

- 1954: A silicon pnp **transistor** was difficult to mass produce until the crystal was doped by diffusion (high-concentration dopants added to the molten silicon during crystal growth).
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1962+: New Jersey (Bell Labs) – transistor, PV, satellites, Telstar, ...

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- 1954: **PV solar battery**: thin, silicon-doped wafer converts light into electricity at 6% efficiency (“compares favorably with the efficiency of steam and gasoline engines”).
- 1962: AT&T’s 1962 **Telstar** generated 14 watts from 3,600 modules.



Other Dominoes?

- 1500 Leonardo da Vinci designs rotating turret windmill
- 1666 Isaac Newton splits white light into component colours
- 1830 George Stephenson *Northumberland* train service (Liverpool – Manchester)
- 1864 Nikolaus Otto designs a 4-stroke ICE run on piped-in coal gas
- 1865 James Clerk Maxwell 4 EM equations
- 1884 Charles Parsons designs rotating steam-powered turbine at Holborn
- 1887 James Blyth builds first electricity-generating wind turbine
- 1900 Max Planck quantum theory ($E = hf$)
- 1905 Albert Einstein *Annus Mirabilis* ($E = mc^2$), photons → electrons
- 1932 James Chadwick discovers the neutron
- 1945 Alamogordo/Hiroshima/Nagasaki → uranium trace, arms race
- 1957 Soviet Union launches *Sputnik* via ballistic-missile carrier rocket
- 1960 OPEC is created after talks between Venezuela and Saudi Arabia → oil shocks
- 1960 Rachel Carson *Silent Spring* → EPA → Earth Day
- 1976 Sharp makes the first solar calculator
- 1984 Chernobyl reactor meltdown → end of USSR
- 2008 Tesla Roadster launched with chained Panasonic 18-650 Li-ion batteries
- 2020 Bhadla Solar Park in Rajasthan, India, generates 2 GW
- 2022 US Congress passes the Inflation Reduction Act (\$369 billion/10 years)

Some Spanish examples

a)



b)



a) El Hierro 100% renewable from 5 2.2-MW WTs and 2 PSH pools (700 m)

b) Mutriku wave energy plant (OWC) (300 kW)

c)



c) Seville pantograph

d)



d) La Mancha windmills

Some Irish examples

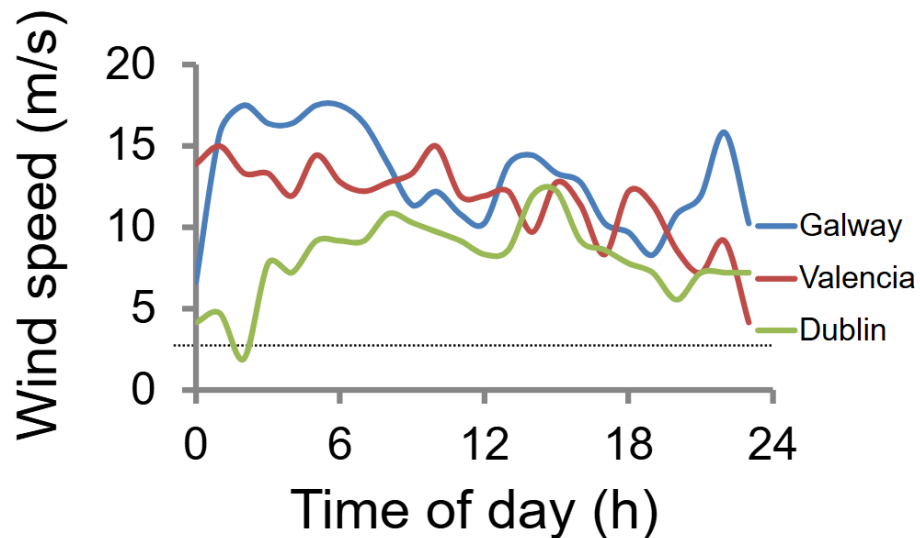
a)



b)



c)



d)



a) Turlough Hill pumped storage hydro (292 MW/70 s, 285 m, 75% round trip)

b) Turf was a grid fuel from the 1930s to 2023 – worse than coal (and biomass!)

c) Sample wind speeds at 3 locations

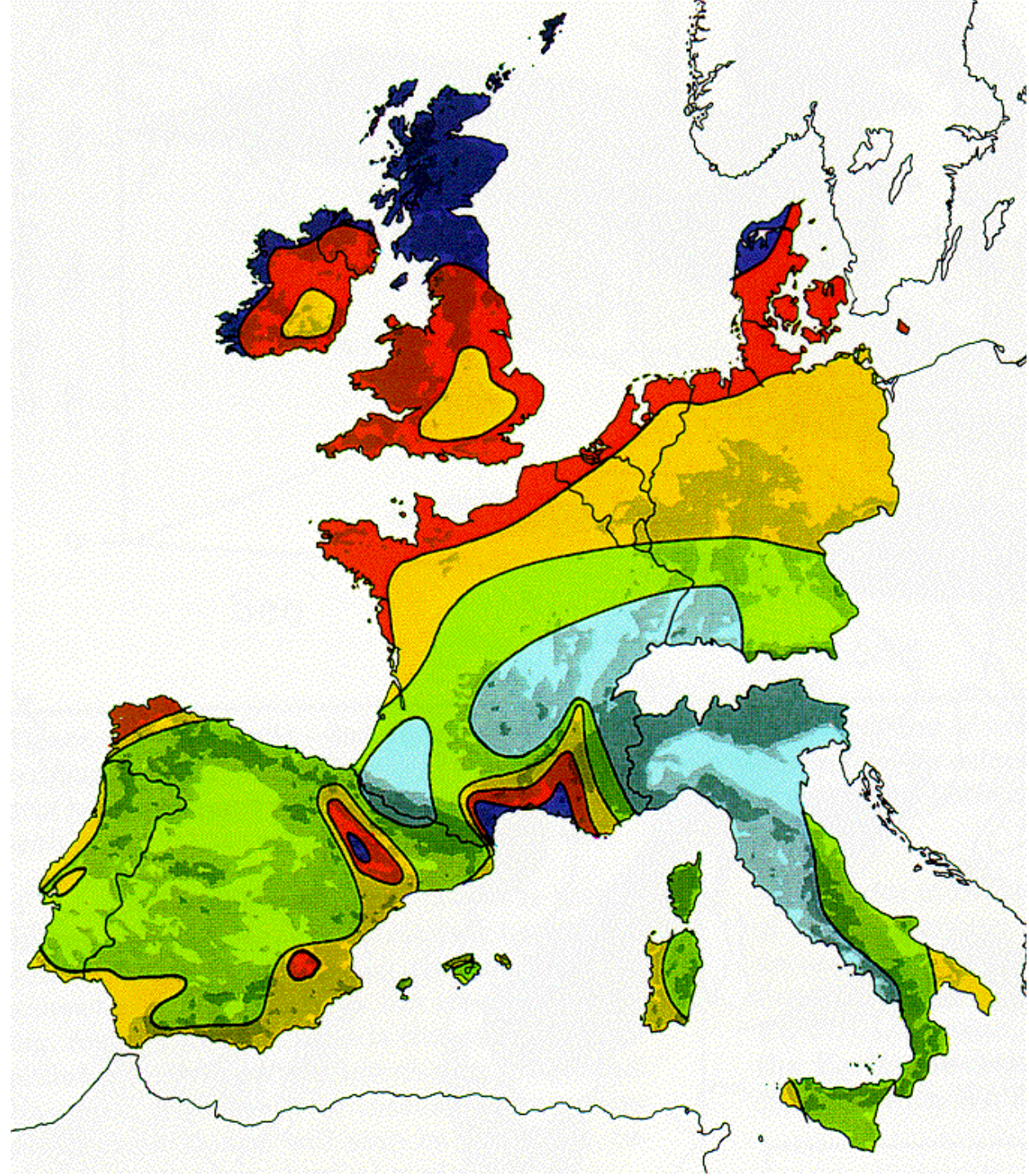
d) 2020: wind (44%) > gas (42%), 700,000 homes



Spain breezes into record books as wind power becomes main source of energy - 2014!

Sector covered 20.9 percent of total demand last year followed by country's nuclear plants, which met 20.8 percent

[El País, January 15, 2014](#)

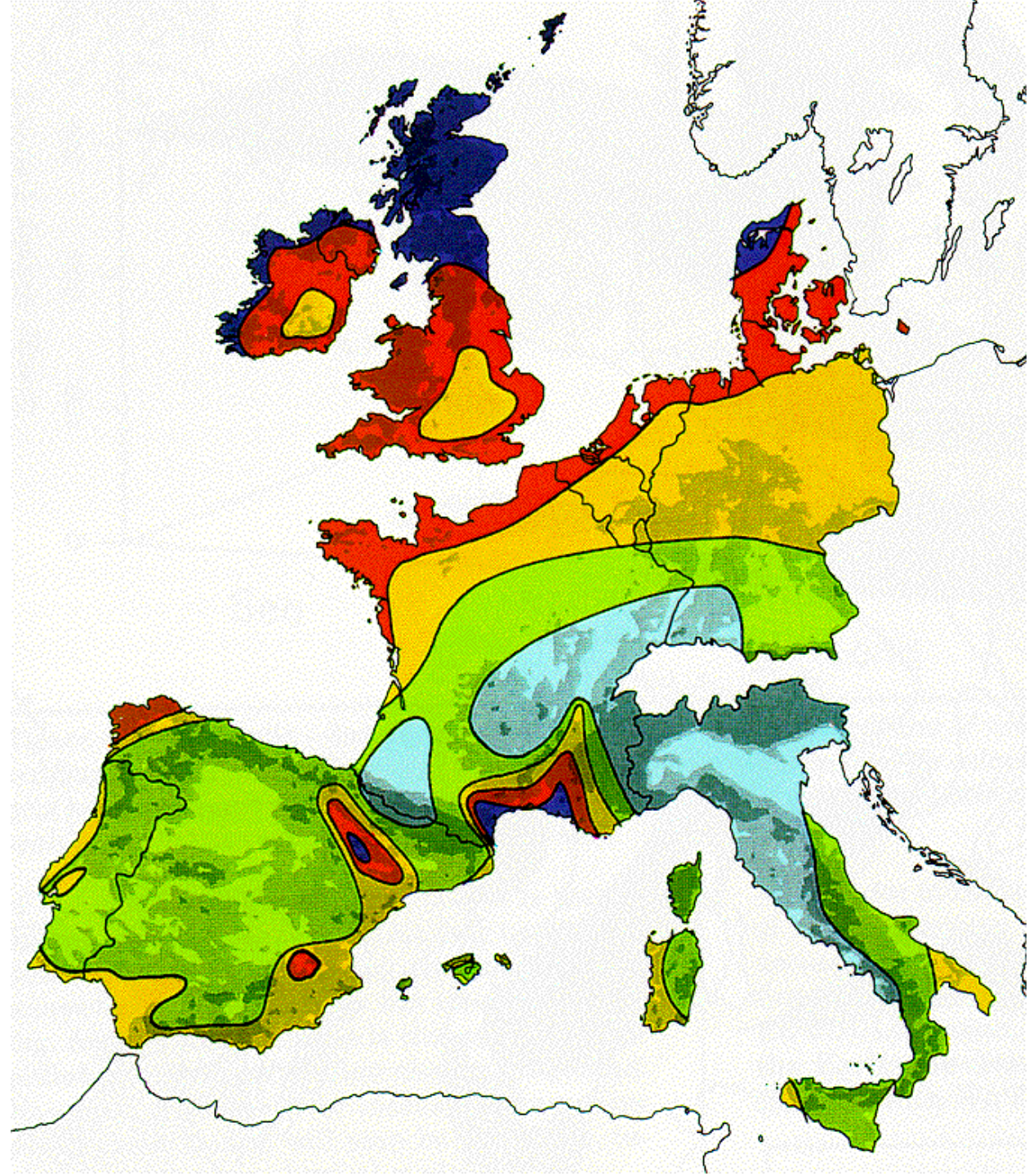




Wind energy overtakes gas to be leading source of electricity in **Ireland** - 2020!

Wind (44%) produced more electricity in Ireland than gas (42%) for the first time, powering over 700,000 homes

[Renew Economy, April 30, 2020](#)





El ingenioso hidalgo don Quijote de la Mancha

“Destiny guides our fortunes more favourably than we could have expected. Look there, Sancho Panza, my friend, and see those thirty or so wild giants, with whom I intend to do battle and kill each and all of them, so with their stolen booty we can begin to enrich ourselves. This is noble, righteous warfare, for it is wonderfully useful to God to have such an evil race wiped from the face of the earth.”

“What giants?” asked Sancho Panza.

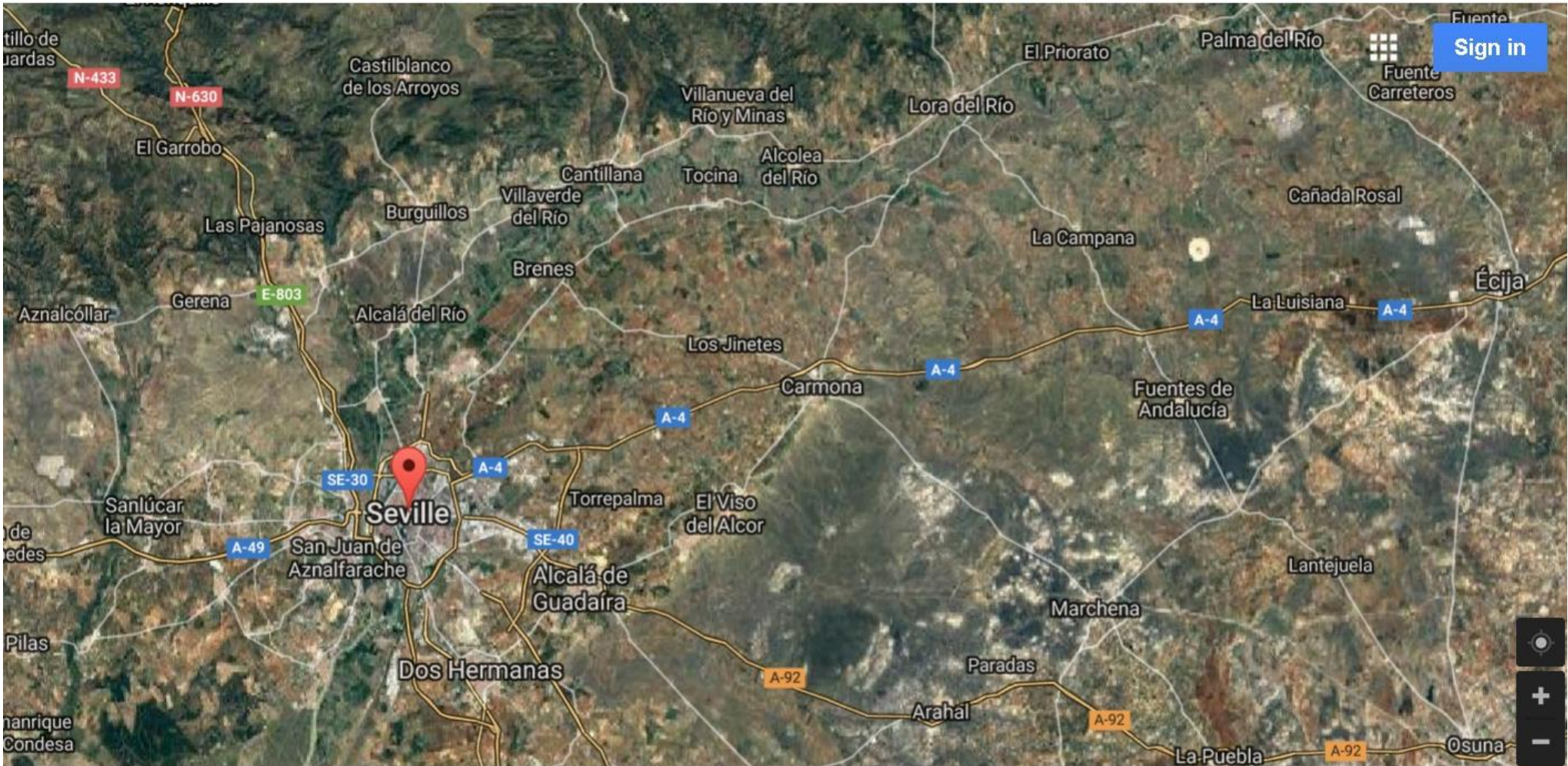
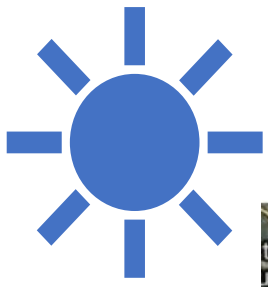
“The ones you can see over there,” answered his master, “with the huge arms, some of which are very nearly two leagues long.”

“Now look, your grace,” said Sancho, “what you see over there aren’t giants, but windmills, and what seems to be arms are just their sails, that go around in the wind and turn the millstone.”

“Obviously,” replied Don Quijote, “you don’t know much about adventures.”

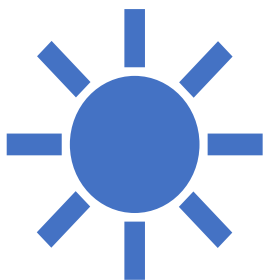
— Miguel de Cervantes Saavedra



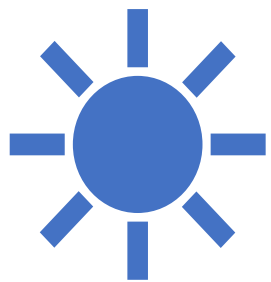


Google Maps (satellite): Andalusia, Spain

Renewables: sun



Google Maps (satellite): Andalusia, Spain



PS10/PS20

First commercial
power tower CSP

3,000 hours of
sun/year



Google Maps (satellite): Andalusia, Spain

How big an area is 10,000 square miles?



In **1997**, NREL's acting director Roland Hulstrom calculated the area of PV solar farms needed to power U.S. energy use. He included a telling picture of a 100-mile by 100-mile square in the middle of Nevada to simplify the concept: 10,000 square miles (~ 0.3% of US land).

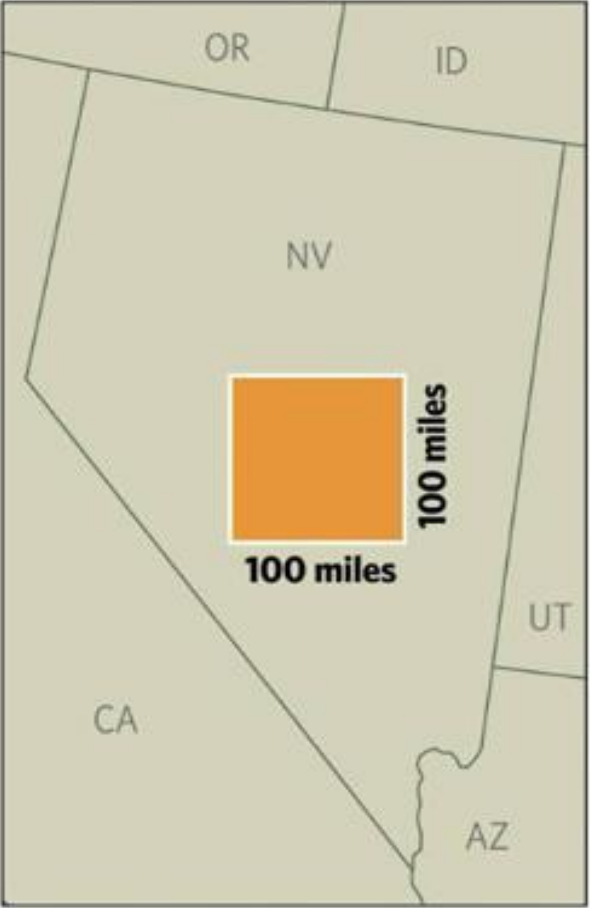
Of course, one can spread out the sun on rooftops instead ("**small-scale embedded solar**").

Update: prorated by population, sun, efficiency?

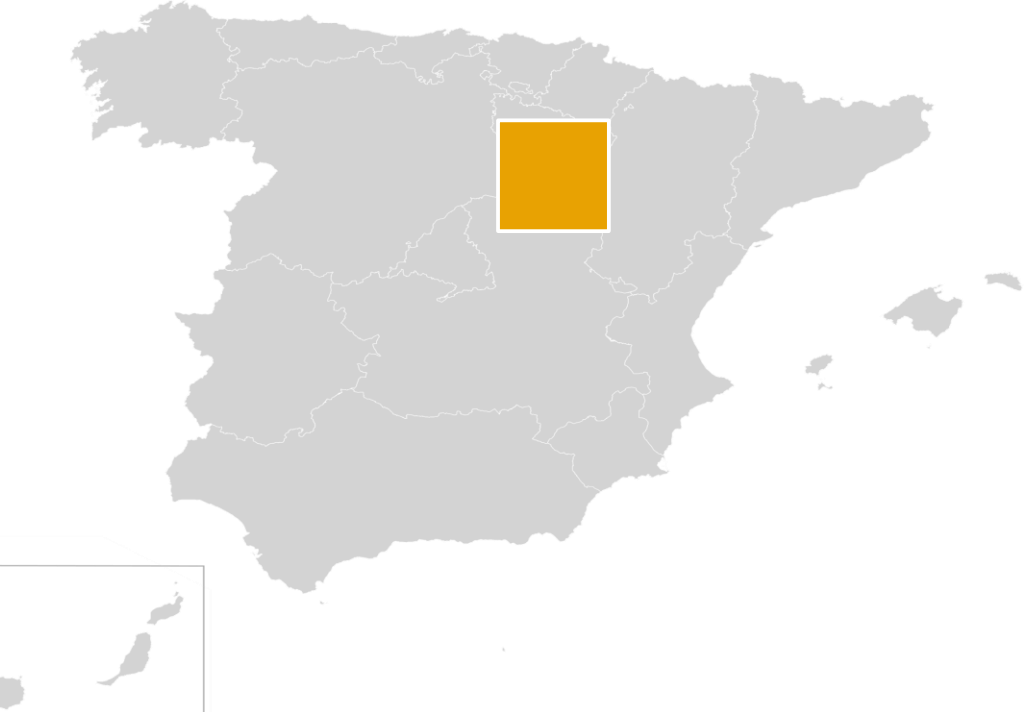
1997: 280 million, 36.1°, 12-15% →

2026: 342 million, 36.1°, 22-24%

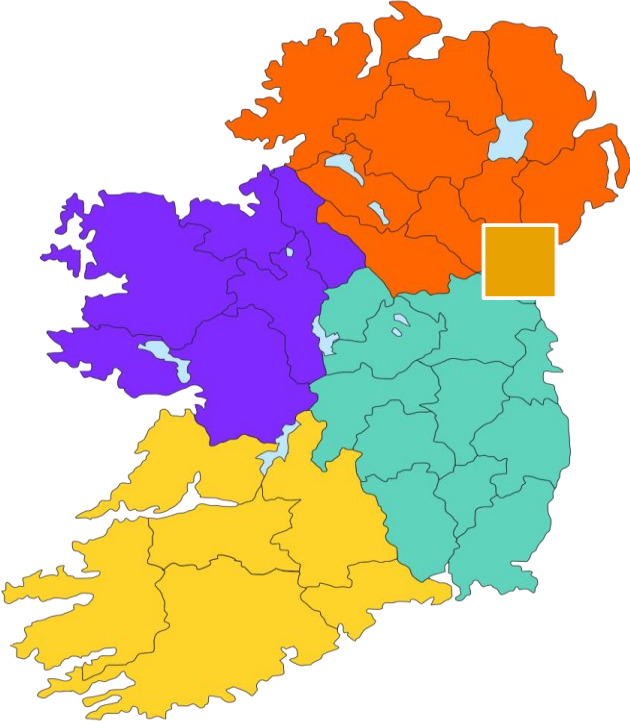
How big an area is 10,000 square miles?



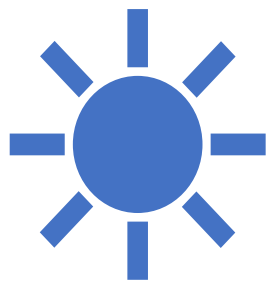
$\times \frac{6}{5} \times \frac{1}{1} \times \frac{1}{2}$
 6,000 mi² (80 x 80)



$\times \frac{1}{7} \times \frac{5}{4} \times \frac{1}{2}$
 900 (30 x 30)



$\times \frac{1}{60} \times \frac{3}{1} \times \frac{1}{2}$
 250 (16 x 16)



Huawei (2016)

4 million panels over
25 km²

Tibetan Plateau

“rooftop of the world”



1-GW Yanchi PV solar plant in Qinghai, China

The Truth About Energy – How many PV solar panels?



The Middelgrunden Offshore Wind Farm [pdf]

March 2003 MWT Co-operative | Denmark | renewables: wind

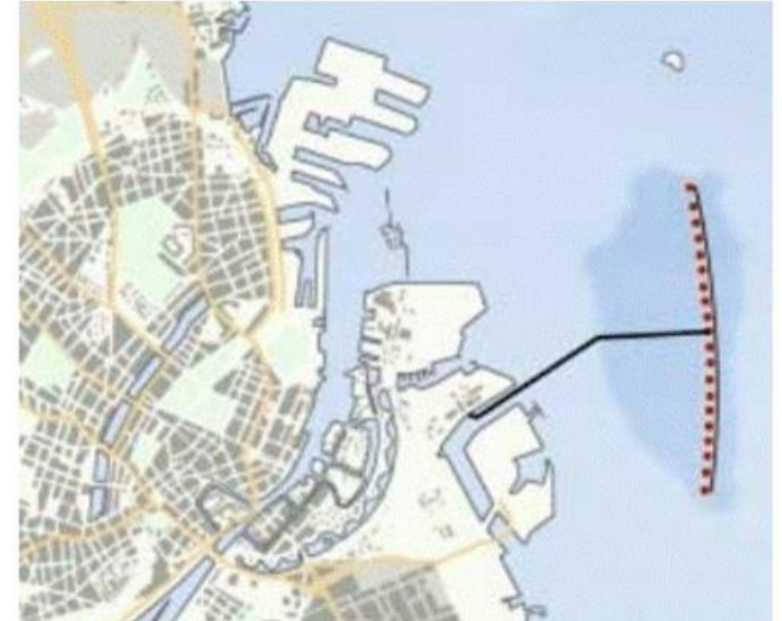
40-MW Middelgrunden Offshore Wind Farm

2005: 12.7 million, 4-MW
(200,000 MJ/year/person)
(Alaska)

John Fanchi,
Colorado School of Mines

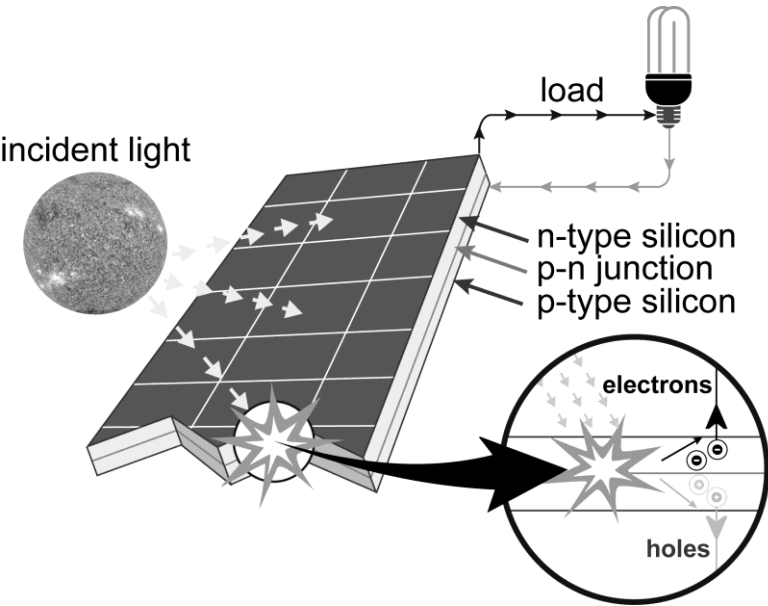
Today?: 2 million+, 24-MW
(2.5 x France)

But ... double grid size



The cooperatively owned Middelgrunden Wind Farm is a 40-MW, 20-turbine offshore installation in the shallow coastal waters of Copenhagen, the world's largest upon construction in 2000. With 10 other onshore turbines in the neighbouring seaport, the 30 turbines operate at over 90% efficiency and provide about 6% of Copenhagen's electric power.

A few more demos



Photons to electrons

1954 PV solar battery (**Bell Labs**)
–thin, silicon-doped wafer converts light into electricity at **6% efficiency** (“compares favorably with the efficiency of steam and gasoline engines”).
1962 AT&T’s Telstar generated **14 watts** from 3,600 modules.



Sanlúcar la Mayor (Sevilla)

The world’s first commercial solar thermal power plant, **PS10** uses 624 **heliostats** over 10 ha and a 114-m-high solar tower to produce 11 MW. **PS20** uses 1255 **heliostats** on 80 ha and a 165-m-high tower to generate 20 MW. Both PS10 and PS20 are located northwest of Sevilla and are owned by Atlantica Yield with Abengoa heliostats.



Tesla Roadster

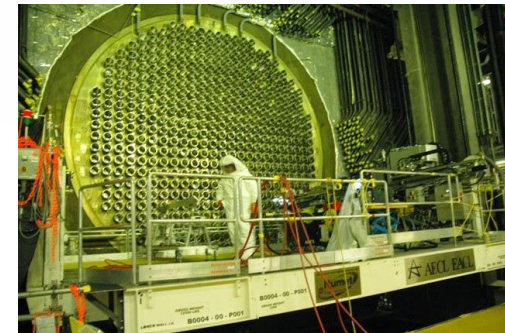
The first electric vehicle to use Li-ion batteries and travel over 200 miles on a single charge. Only 2,450 were made, including Elon Musk's red Roadster, employed as a unique dummy payload in a 2018 SpaceX Falcon Heavy test launch driven by a mannequin called Starman.

The transition from brown to green [in pictures](#)



Gijón, Asturias

Esta furgoneta es verde. The Spanish post office colours are yellow and blue. One always needs a sense of humour when dealing with slow mail and slow transitions, but it is good to see they are doing their bit to reduce toxic exhaust pollution in our cities via electric vehicles and help jumpstart the Revolution Revolution. (Chapter 6)



The Truth About Energy – Consumption

Solar

Coal

Oil

Wind



Gas

Hydro

Nuclear

Coal



Oil

Gas

Wind

Hydro

Nuclear

Coal

Solar

Oil

Wind



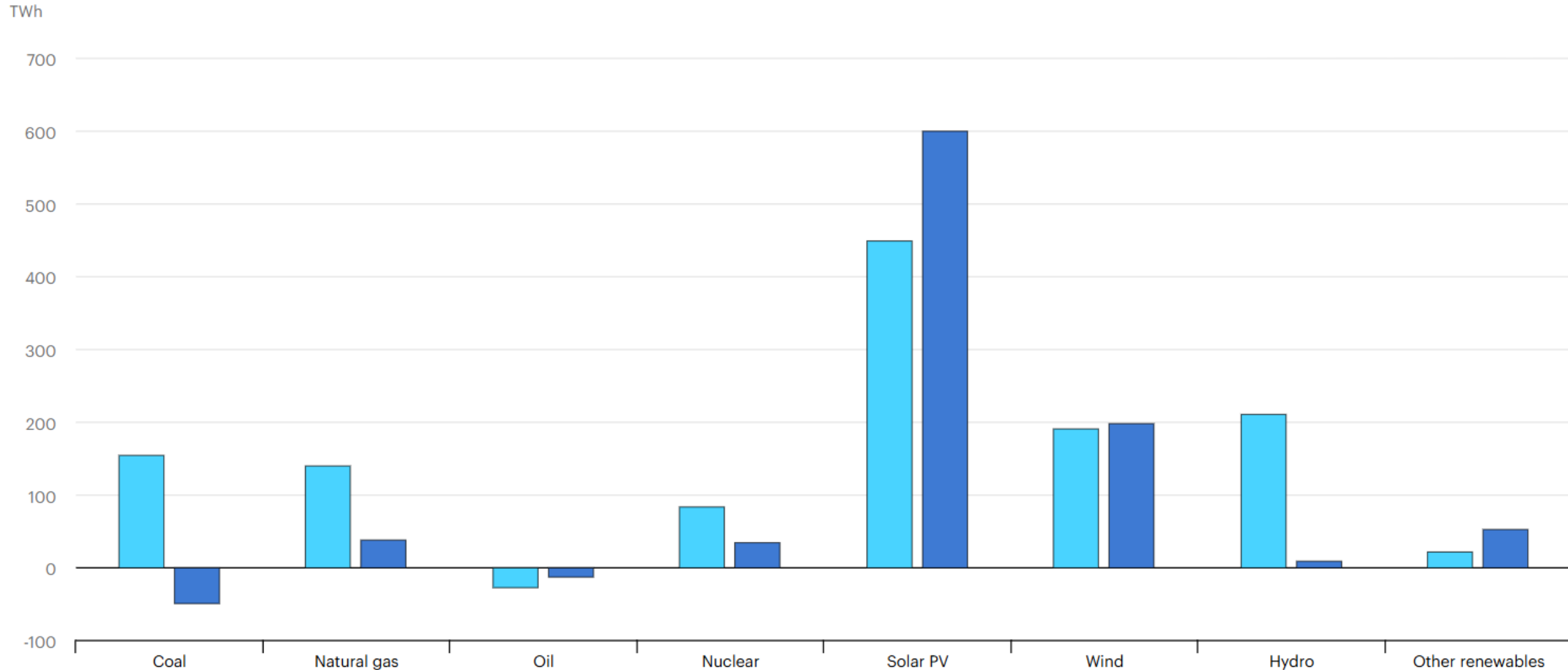
Gas

Hydro

Nuclear

Electricity supply: The increase in low-emissions power generation in 2025 outstripped total electricity supply growth!

Annual change in global electricity generation by source, 2024-2025



Energy in the 21st Century News Service | Welcome

E21NS is a link library directing readers to articles from news outlets around the world, citing the headline, date, source, location, and topic, with an image, contents précis, and links.

All articles are on energy, especially modern renewables (solar, wind, water, geothermal, ...), biomass, fossil fuels (coal, oil, and gas), nuclear power, and conservation. Links to educational resources, data, and tools are given as are a list of acronyms, biographies, and companies (under construction).

E21NS is powered by quicpic to generate a chronologically clickable collection of curated links (a virtual museum). Source images are used according to Fair Use regarding news services.



Topics
Topics
RRR
Solar
Wind
Other
Future
Storage
EVs
Fossil fuels
Nuclear
Climate Change
Art

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1844 (National Gallery, London) [Rain, Steam and Speed - The Great Western Railway](#)
1882 (Kröller-Müller Museum, Otterlo) [Miners' Wives Carrying Sacks of Coal](#)
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People (nya)	
Companies (nya)	

Windmill at Wijk bij Duurstede



c. 1668-1670 [Jacob van Ruisdael](#) | Rijksmuseum, Amsterdam | art: painting



OLD

The cylindrical windmill was located in the town of Wijk bij Duurstedein, south east of Utrecht on the north bank of the Lek river, a distributary branch of the Rhine river that flows into the North Sea at Rotterdam. Dutch Golden Age. Oil on canvas. On loan to the Rijksmuseum (Amsterdam).

Benjamin Franklin and the Kite Experiment



June, 1752 The Franklin Institute | Philadelphia | energy: electricity



OLD

Benjamin Franklin waited for ideal stormy conditions to demonstrate the electrical nature of lightning. He used a silk kite, hemp and silk string, metal house key, and a Leyden jar to store electrical charge. The kite was not struck by lightning, but picked up ambient electrical charge in the storm. When a storm cloud neared, a spark was produced.

Edison, the Man



1940 Clarence Brown | MGM | art: film



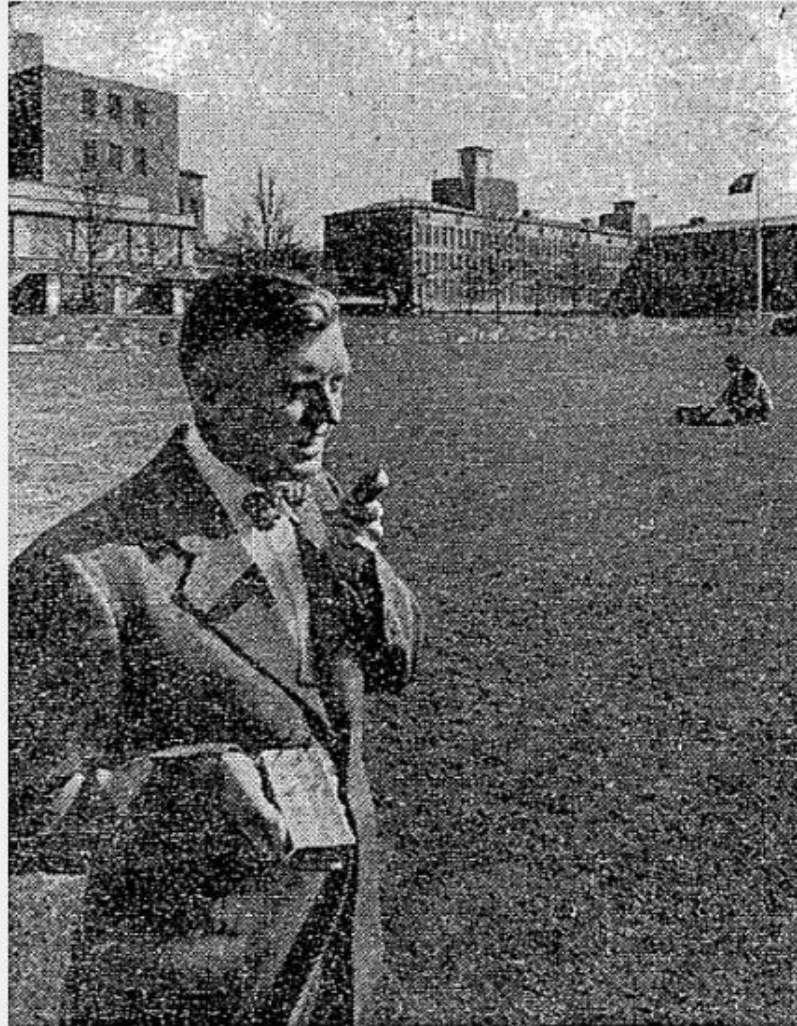
NEW

Historical drama about Thomas Edison and his invention of the first long-lasting incandescent light bulb in Menlo Park, NJ, on October 21, 1879 (stars Spencer Tracy). America's favourite inventor uses all his legendary skill and determination to perfect artificial light: "Wow. Looks as if this one is going to last." - Thomas Edison. (1:25:32/1:46:34)

Vast power of the sun is tapped by battery using sand ingredient



April 26, 1954 [New York Times](#) | United States | renewables: solar

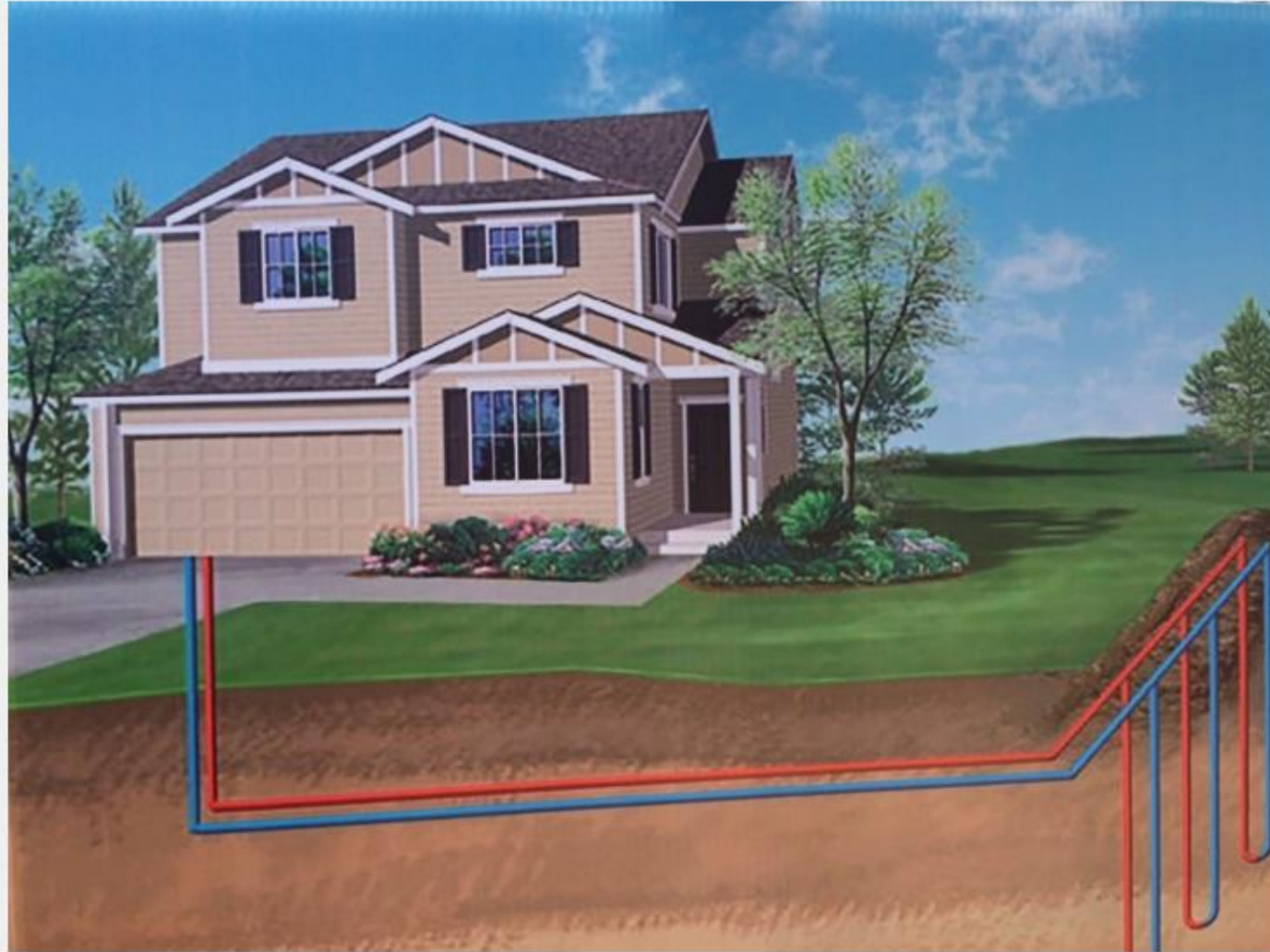


A 6%-efficient "solar energy battery" (solar cell) was demonstrated at Bell Labs in Murray Hill, New Jersey. Developed by physicist G.L. Pearson, chemist C.S. Fuller, and electrical engineer D.M. Chapin, a solar cell functions via a "p-n" (positive-negative) junction with impurities introduced at the silicon surface in a similar process to transistor fabrication.

NEW

Geothermal heating co-op shares warmth among Montreal neighbours

January 20, 2022 CBC | Montreal | renewables: geothermal



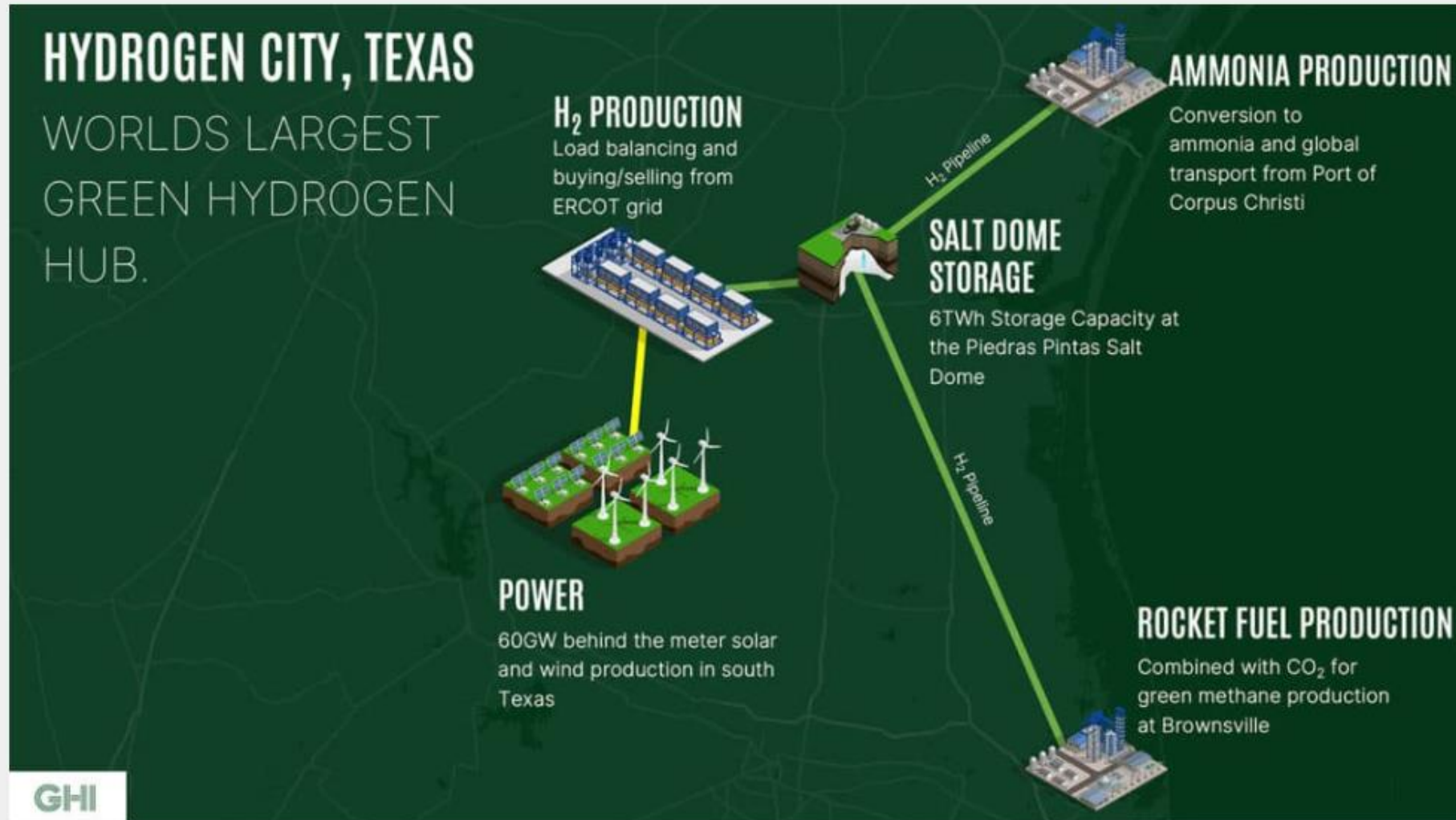
SMALL

A neighbourhood Montreal co-op began heating 7 homes retrofitted with geothermal heat pumps (aka ground source heat pumps or geoexchange systems). To reduce costs and comply with laws, 8 150-m-deep geothermal wells were dug in a private backyard rather than a public alleyway, and are shared. The goal is to connect 50 homes. AC is also available.

World's largest green hydrogen plant planned to open in South Texas

March 8, 2022 [InceptiveMind](#) | Texas | renewables: hydrogen

BIG



Green hydrogen (GH₂) will be made via a 60-GW electrolyzer powered by wind, solar, and renewables from the ERCOT grid at off-peak times. Stored in existing caverns, the GH₂ will be piped to port cities to make green ammonia, aviation fuel, and rocket fuel. The first phase in 2026 uses 2 GW and 2 salt-dome caverns, growing to 50 to provide 6 TWh.

Plug-in balcony solar panels could mean cheaper power

⏪ ⏴ 📄 ⏵ ⏩ August 30, 2025 CBC | Canada | renewables: solar

SMALL



If a \$20,000 rooftop solar array is beyond the budget, hard to install, or difficult to permit, a DIY plug-in balcony solar panel can power home appliances and devices cheaper than the grid. Popular in Europe, 100-W balcony panels are similar to camping or cabin units. A 200-W kit can cost \$400 with 120-V plug to connect to the home electrical system.

China's world-beating solar farm is almost as big as Macau, Nasa satellite images reveal

February 24, 2017 South China Morning Post | China | renewables: solar



BIG

NASA released Landsat 8 satellite photos of the world's largest solar farm, the 850-MW Longyangxia Dam Solar Park on the Tibetan Plateau in Qinghai, China. The site boasts 4 million panels over a 27-square-km area, roughly the size of Macau. China is the world's top producer of solar power with an installed capacity of 77.4 GW as of 2016.

New bladeless wind turbine generates clean, quiet, bird-safe power



July 25, 2025 [The Brighter Side](#) | Spain | renewables: wind



SMALL

A Spanish startup designed a new wind turbine using a vibrating upright cylinder to catch the wind, a.k.a. “the Skybrator.” No blades, gears, or oil needed; only vortex shedding as the swaying is converted by an alternator into electricity- smaller, quieter, and less invasive.

States sign deal for “world’s largest energy hub” to wean off fossil imports and say no to Trump



January 28, 2026 [RenewEconomy](#) | Europe | renewables: wind



BIG

Germany, France, the UK, Luxembourg, Iceland, Norway, Belgium, Ireland, the Netherlands and Denmark will spend €1 trillion to increase offshore wind, hydrogen production, and international grid connectors, helping Europe to cut fossil fuel imports, especially from Russia. The goal is 15 GW/year and 300 GW by 2050 in the world’s largest energy hub.

Spain: Badajoz deploys 15 BYD electric buses

May 13, 2019 Electrive | Badajoz | electric vehicles: sales



<http://www.johnkwhite.ie/e21/E21NS20190513EM1.html>

15 BYD electric buses were delivered to Badajoz's public transport operator, now the largest EV bus system in Spain. The 12-metre-long EV buses are powered by iron-phosphate (FePO₃) batteries with a 250-km range, each with a dedicated charge point. 8 more are coming to Badalona near Barcelona and Coimbra, Portugal, with orders for Madrid and Valencia.

SMALL

BYD's 5-Minute EV fast charging: We tried it. It's a game-changer

May 7, 2025 [InsideEVs](#) | China | electric vehicles: charging



BIG

BYD's "Megawatt" charger gives 1 MW at 1 kV, twice the fastest US chargers, providing a "nearly full" 400 km in 5 minutes. The Super-E platform uses new electrical architecture, battery, and 1 kV charging that beats other EVs at 400 V or 800 V (Lucid is tops at 900 V). There are 400 existing MW chargers in China with plans for 4,000.

California completes solar canopy over irrigation canal



September 16, 2025 [CleanTechnica](#) | California | renewables: solar



SOLAR

A \$20 million, 1.6 MW solar array now covers part of the Turlock Irrigation District canal system in California's Central Valley, providing power to farmers, keeping panels cool, and limiting evaporation in drought-prone areas. 8,000 miles of federally owned canals and aqueducts could generate 25 GW and lower evaporation by tens of billions of gallons.

The obligation to install photovoltaic panels on large outdoor car parks adopted in the Senate



November 4, 2022 [Public Senat](#) | France | renewables: solar

SOLAR



The French senate passed a bill mandating that all parking lots of at least 80 spaces be covered with PV solar panels by 2028 (over 400 spaces by 2026). The new law is expected to stimulate solar energy production in France, especially in the commercial sector and will amount to a power saving of 11 GW, equivalent to 10 nuclear power plants.

Power generation you can see through



August 25, 2021 [MSU](#) | Michigan | renewables: solar



SOLAR

A 100-square-foot transparent solar array was installed above the entryway of an MSU campus building. The unique glass panels let visible light in but convert invisible UV and near-IR to electricity. Indistinguishable from traditional windows, the glass panels were designed by Ubiquitous Energy and generate enough power to light the atrium.

A patented solar window wins the award for Best Protected Invention in Spain



June 17, 2024 PV Magazine (in Spanish) | Spain | renewables: solar



Asturian company SolReina won a Spanish patent award for a solar shutter made of glass/thermal-acoustic insulating BIPV C-Si cells. The adjustable photovoltaic solar shutter is resistant to hail and heat, generates up to 225 W/m^2 , and can produce 15% more PV power than a rooftop solar panel and decrease aircon 80%.

SOLAR

Octopus reports sharp rise in solar panel sales since start of Iran war

March 26, 2026 The Guardian | Global | renewables: solar



BIPV

Tired of high fossil fuel prices from the Iran war, UK families are switching to predictable solar, including “supersize” rooftop systems (12 instead of 10 panels). Heat pump sales have risen 50% and EV chargers 20%. Plug-in solar kits will also soon add to locally sourced sun. In 2025, more renewables lowered wholesale electricity prices by a third.

New solar tiles from Germany



October 6, 2022 [PV Magazine](#) | Germany | renewables: solar

BIPV



The BIPV company Autarq has designed an attractive solar tile, based on the Domino black tile by Creaton. The smooth, flat brick uses small monocrystalline PV elements covered by a 3.2-mm hardened single pane of safety glass. The weather-resistant tiles connect to each other with plugs hidden under the bricks and function from -40 to 85 °C.

Spain hits first weekday of 100% renewable power on national grid

⏪ ⏩ 📄 ▶️ 📌 April 22, 2025 PV Magazine | Spain | renewables: solar

BIPV



Spain's grid operator Red Eléctrica announced that renewable energy sources met 100% of electrical demand for the first time on Wednesday, April 16 (wind 46%, solar 27%, hydro 23%, solar thermal 2%, other renewables 2%). Solar power also reached a record of 20 GW (62% of the grid) 5 days later.

Electricity-generating windows? Swiss scientists design more efficient transparent solar panels

November 5, 2022 [euronews](#) | Switzerland | renewables: solar



BIPV

Swiss scientists have increased the efficiency of transparent dye-sensitized solar cells (DSCs) to 15% for direct light and 30% for ambient light. DSCs are flexible, low cost, and come in various colours, perfect for skylights, greenhouses, and glass-clad buildings. Windows in Lausanne, Copenhagen, and Lansing now employ solar cells to generate power.

Switzerland turns train tracks into solar power plants

⏪ ⏩ 📄 ▶ ⏮ April 29, 2025 [SwissInfo](#) | Switzerland | renewables: solar



BIPV

Swiss start-up Sun-Ways installed 48 test solar panels between train rails, producing 16 MWh/year (4-6 homes). More panels can be placed or removed in a few hours for easy maintenance and cleaned by passing trains to generate 2% of grid power from 5,320 km of Swiss rail (1 billion kWh/year, 300,000 homes). Stations and platform roofs can also be used.

Solar fences in Germany are cheaper than wood—and generate electricity too



June 25, 2025 Startup Selfie | Germany | renewables: solar



BIPV

Dual-purpose PV generates power in fences, barriers, and retaining walls, reducing high wood and brick prices. A garden-friendly, 335-W plug-in kit costs €400, while larger bifacial fences capture light from both sides. 300 GW potentially exists on German highways, including PV-integrated noise barriers 1.5 m above ground to limit debris, snow, and vandalism.

Vertical bifacial vs. stilted agrivoltaics



March 5, 2024 [PV Magazine](#) | Austria | renewables: solar

Agri-
voltaics



Researchers in Austria compared vertical bifacial to stilted agrivoltaics systems, using sugar beet, winter wheat, and soybean crops. Vertical bifacial panels (produce between modules) has lower environmental impacts than a stilted system (produce underneath), because of less mounting material and glass-glass versus glass-foil modules.

In Georgia, sheep on a solar farm is not a baaad idea



June 30, 2025 [grist](#) | United States | renewables: solar



Agri-
voltaics

Beside providing needed power to remote regions, solar panels on farms offer shade to sheep and bees, essential on hot summer days. The American Farmland Trust (AFT) projects that 80% of solar power can come from farms. The sheep also cut the grass for free.

ABB electrifies the Niagara Falls' iconic Maid of the Mist ferries

May 6, 2019 CleanTechnica | Canada | electric vehicles: conversion



Li-ion

The iconic Niagara Falls *Maid of the Mist* tour boat is getting an electric makeover, Swiss-Swedish utility company ABB announced. A 316-kWh battery pack will charge in 7 minutes during passenger changeovers on 2 new boats, good to run a 563-hp motor and reduce diesel emissions at the world's most famous cataract.

All systems go: 1st all-electric commercial seaplane takes flight in B.C.



December 10, 2019 CBC | Canada | electric vehicles: airplane



Li-ion

An historic first short-haul all-electric test airplane stayed aloft for 3 minutes above the Fraser River east of Vancouver. The joint Harbour Air and MagniX 11 e-plane was powered by NASA-approved lithium-ion batteries and a standard-design though lightweight electric motor. As batteries improve, the sky is literally the limit.

These homes generate power for the grid – and residents don't worry about blackouts

September 7, 2025 CBC | Canada | renewables: solar

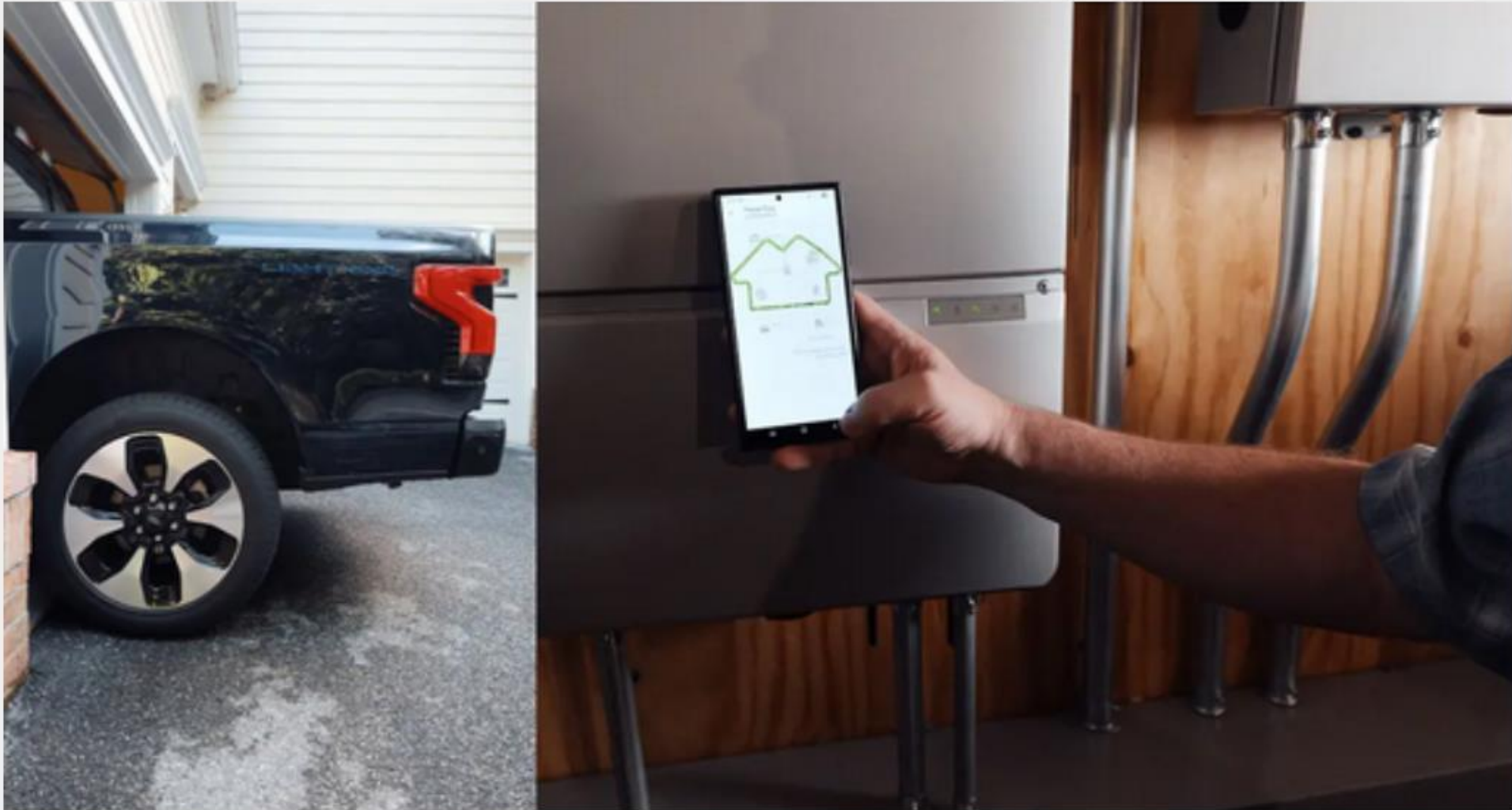


VPP

As part of a 100-home Alberta virtual power plant (VPP), stored solar power runs household appliances, thermostats, EV charging, and sells electricity to the grid. Rooftop panels and basement batteries help stabilize the grid by matching supply with demand and limiting the need for more physical power plants, especially as electricity use grows.

How EVs can fix the grid and lower your electric bill

October 17, 2025 [grist](#) | United States | electric vehicles: battery

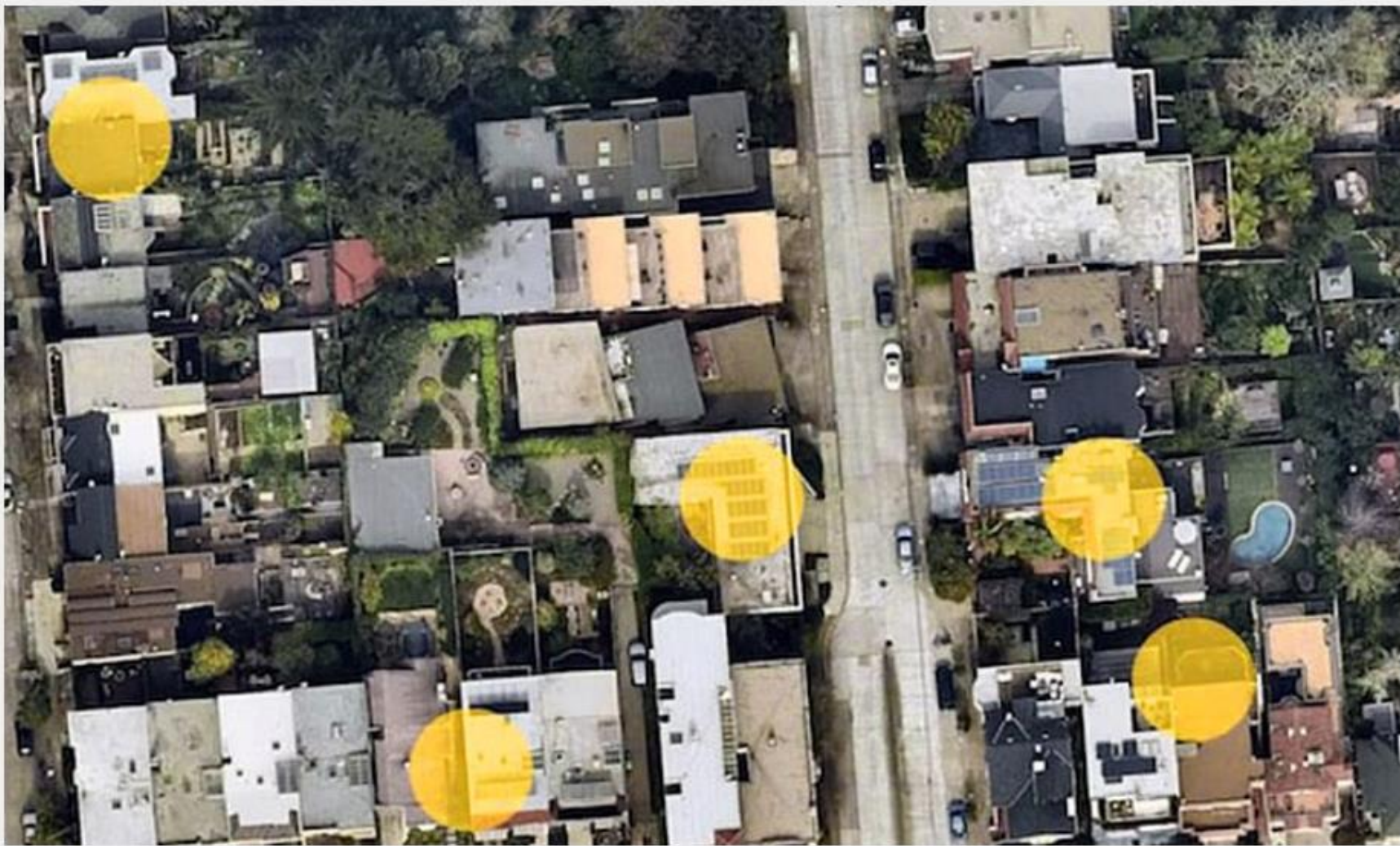


V2G

Vehicle-to-grid technology (V2G) or directional charging counters intermittency of wind and solar, requiring one-third of drivers to opt in. Baltimore Gas and Electric Company, Sunrun, and Ford are part of the first US residential V2G project using home solar and Ford's F-150 Lightning EV, whose batteries are 10 x a typical home pack and 90% dormant.

Forget cats, this neural network spots solar panels

December 19, 2018 [IEEE Spectrum](#) | United States | renewables: solar



SOLAR

A Stanford University machine-learning algorithm has analyzed satellite images to count the number of solar panels across the US. Correctly identifying 93% of panels in 370,000 100-square-foot images, DeepSolar counted almost 1.5 million solar installations. Tied to GPS and census data, future uptake can be predicted.

Energy Vault completes 25 MW/100 MWh gravity-based storage tower in China

August 3, 2023 PV Magazine | China | storage: gravity



Energy Vault will grid-tie a commercial-scale gravity-energy storage system in 2023. The world's first non-PSH gravity-based storage plant located by a wind farm near Shanghai will provide 25 MW/100 MWh via solar-powered electric lifting. Large blocks are raised and lowered to dispatch electricity as needed with 75% round-trip efficiency.

STORAGE

We've been talking about climate change for a hundred years

January 4, 2018 [Popular Mechanics](#) | Global | climate change: emissions



With rising global temperatures and disinformation about the effect of GHG emissions in the industrial era, *Popular Mechanics* reprints past articles on climate change, including Remarkable Weather of 1911 (1912), Is Our Climate Changing? (1930), Coal Dust Speeds Melting of Ice by Absorbing Sun's Heat (1940), and What's Happening to the Weather

The energy transition in five charts and not too many numbers



May 3, 2023 RMI | Global | energy: future

Technologies beat commodities

The arc of energy history bends towards efficiency

The Age of Carbon

- Commodity-based system
- No learning curve (or decreasing returns)
- Geographically concentrated
- Finite
- Continuous material flow required
- Energy return on investment falling
- Heavy
- Fiery molecules
- Low efficiency
- Pervasive negative externalities
- Trillions of dollars of rent for oligarchs
- Concentrates power

The Age of Renewables

- Technology-based system
- Learning curve (increasing returns)
- Everywhere
- Abundant
- Zero marginal cost
- Energy return on investment rising
- Light
- Obedient electrons
- High efficiency
- Much lower impact on nature
- No superprofits
- Distributes power

RMI – Energy. Transformed.

Source: RMI

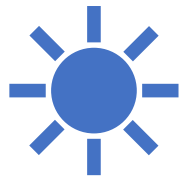
Solar, wind, EVs, and heat pumps are growing exponentially and will be so cheap fossil fuels can't compete as seen in 5 charts: 1) tech > commodities, 2) 2^x not $2x$, 3) Chinese domination, 4) 2020s "s-curve", and 5) even cheaper renewables create new markets). Fossil fuels can't get cheaper and are geographically restricted versus manufactured renewables.

RECAP: ELECTRIFY EVERYTHING

The potential is limitless: electric buses, ferries, short-haul planes, solar shingles, windows, awnings, cladding, car parks, BIPV, railway tracks, rotating sunflowers, water heating, canal canopies, floating, agrivoltaics (3 x peppers), expanded bi-directional rooftop solar, P2P trading, household electrical storage, networked microgrids, smart buildings, home retrofits, district heating, and induction stoves, along with more sharing, the circular economy, zero-waste programs, right-to-repair, no to plastic, and decentralization.

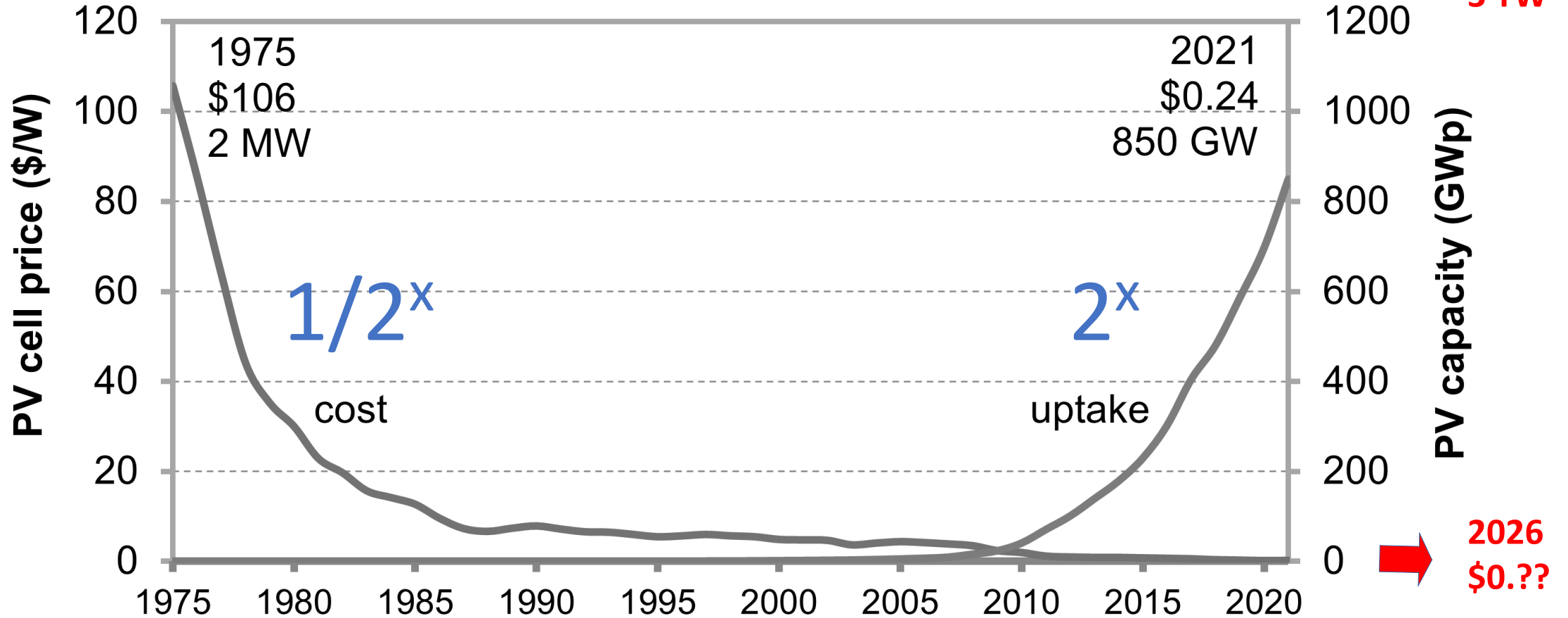
The steel and cement industries are also slowly being decarbonized (Stegra, HYBRIT), while electric vehicle sales are rising despite a recent slow-down other than in China (half of all new car sales) as are gasmobile-electric refits.

[“Oil Wars: Speeding the Transition to Renewable Energy,”](#) *CounterPunch*, March 28, 2026



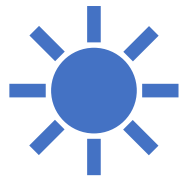
The story of the 21st century

2026
3 TW

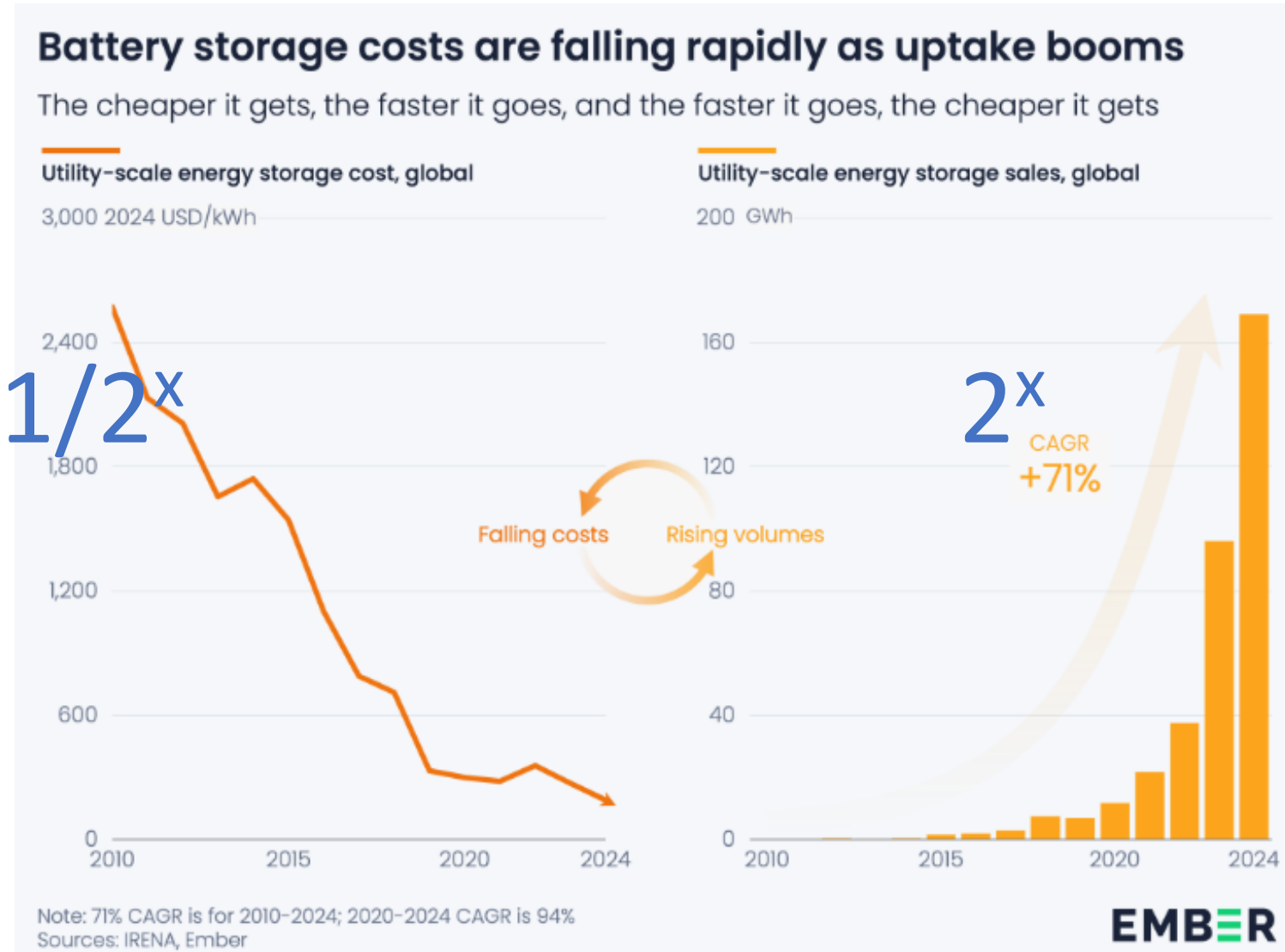


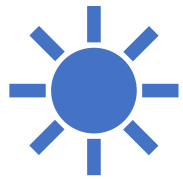
Solar panel price per watt (\$/W) versus global installation (GW) (1975–2021)

Figure 4.25 The Truth About Energy

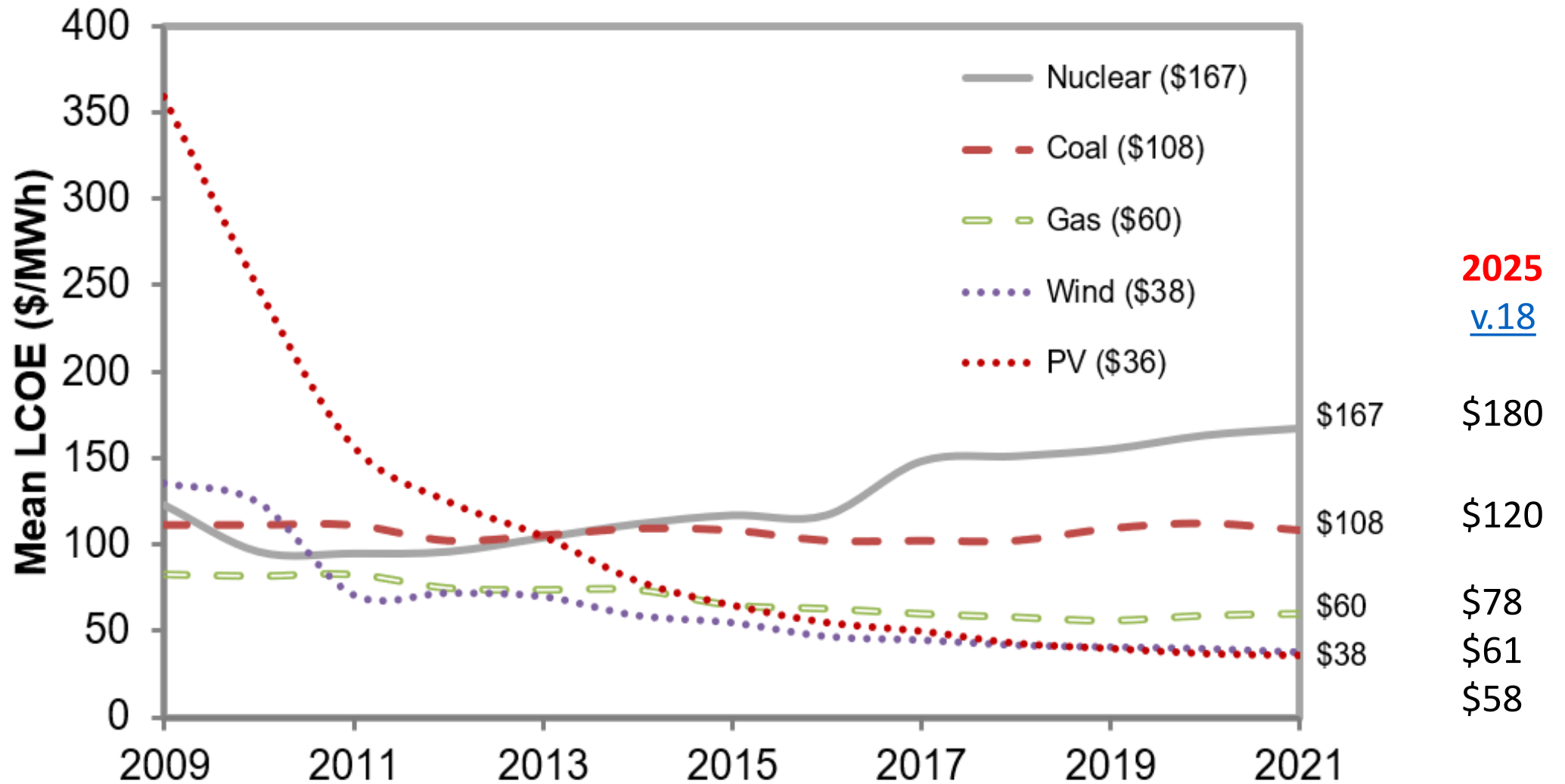


The story of the 21st century



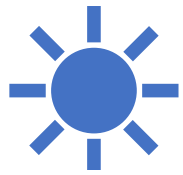


The story of the 21st century



Average levelized cost of energy (LCOE) from 2009 to 2021, Lazard [v.15](#)

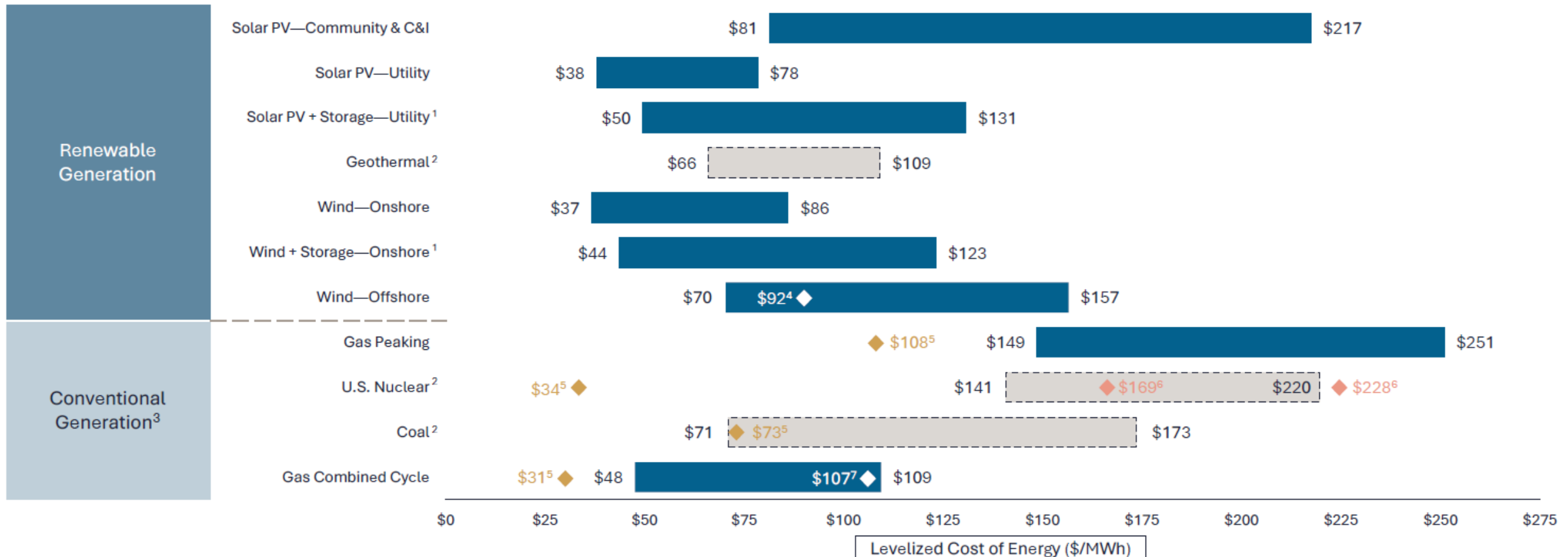
Figure 3.7 *The Truth About Energy*



The story of the 21st century

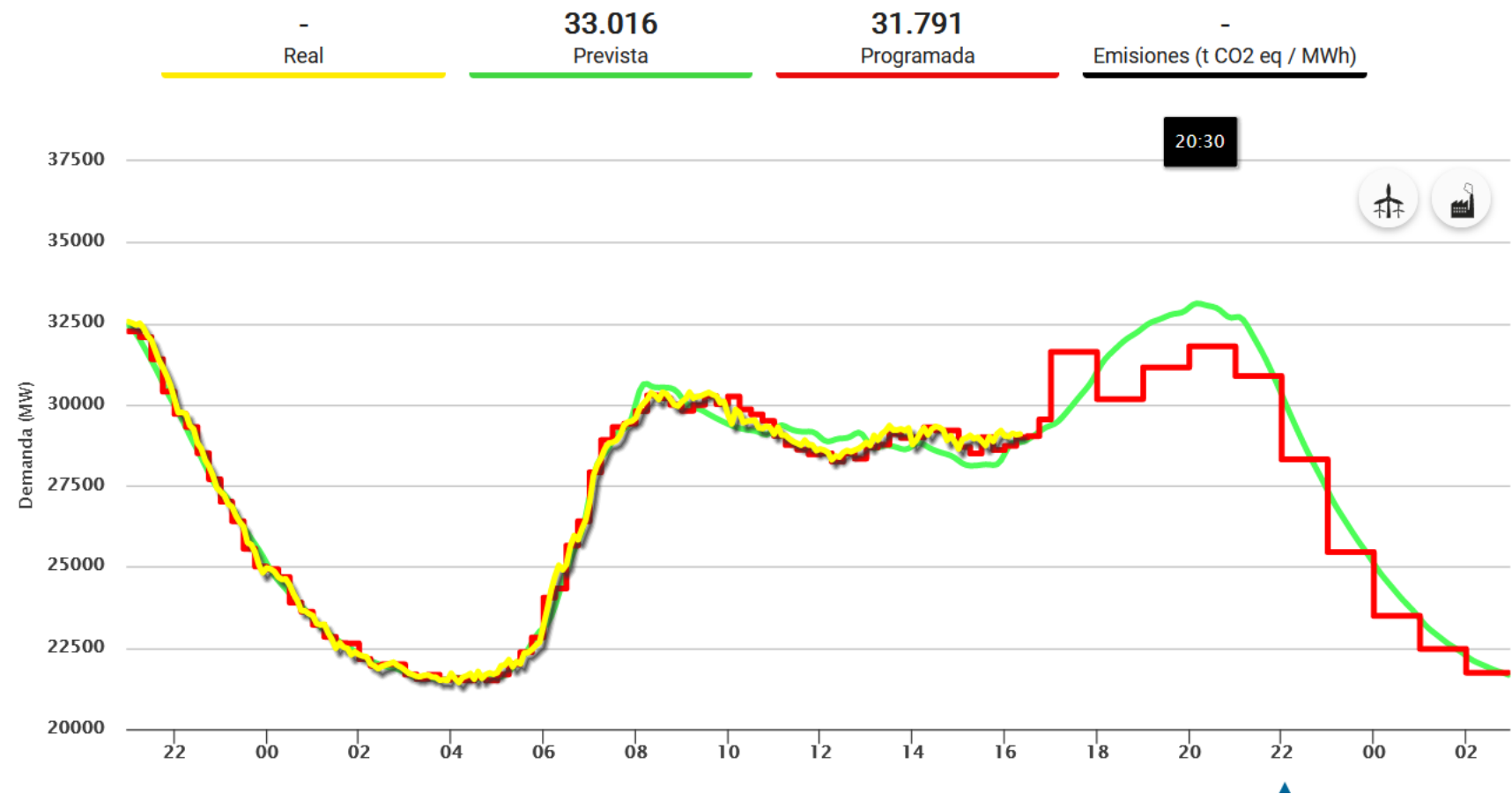
Levelized Cost of Energy Comparison—Version 18.0

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



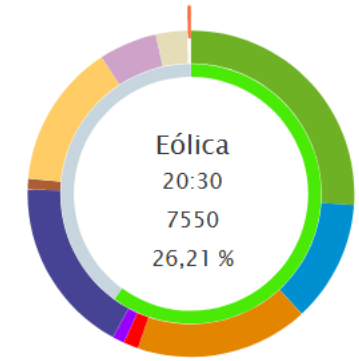
Average levelized cost of energy (LCOE) 2025, Lazard [v.18](#))

Demanda (MW) a las 20:30 - 08/11/2023

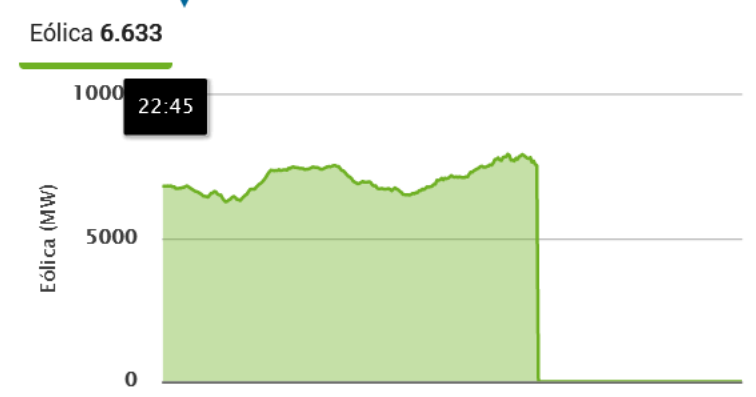


Yellow: actual instantaneous demand (updated every 15 minutes)
Green: demand forecast from historical consumption data
Stepped red: operating schedule from day-ahead and intraday markets, managed by Red Eléctrica

Estructura de generación (MW)

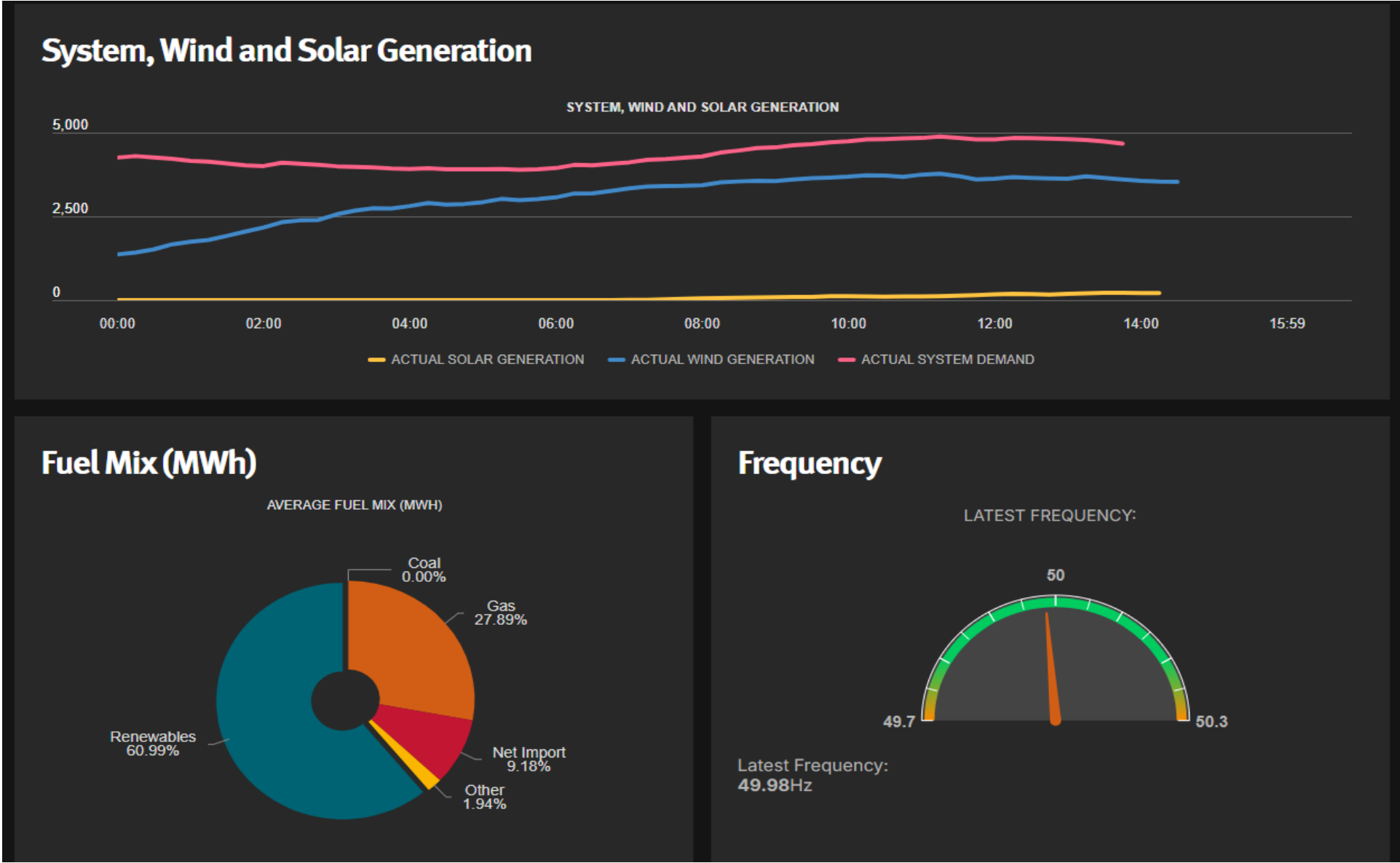


Generación | **CO2 eq. asociado**



[Demanda y producción en tiempo real](#)

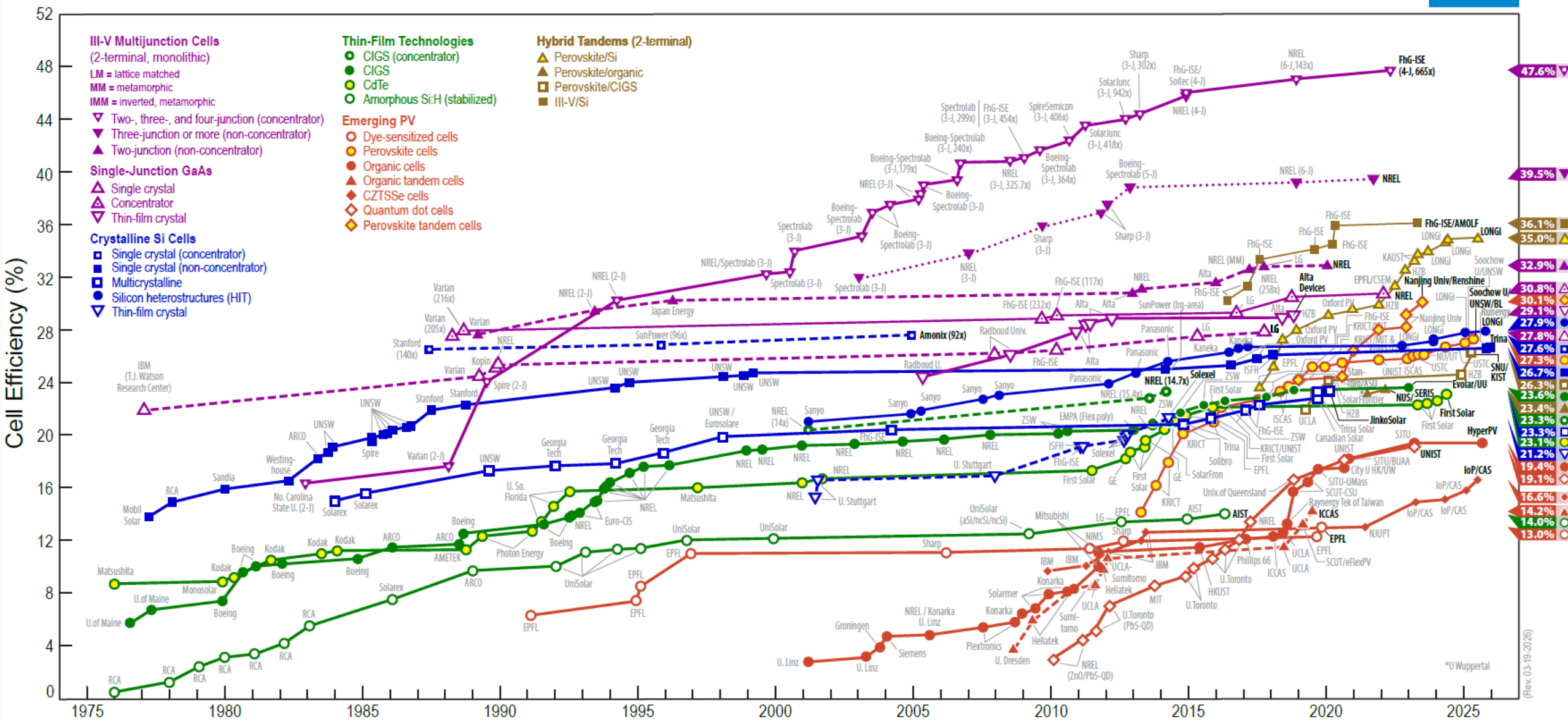
Learn about the demand on the energy system and see how much energy is being generated, all in real time.



[Eirgrid Smart Grid Dashboard](#)

Energy in the 21st Century – top-down (data, data, data)

Best Research-Cell Efficiencies



Energy in the 21st Century – top-down (data, data, data)

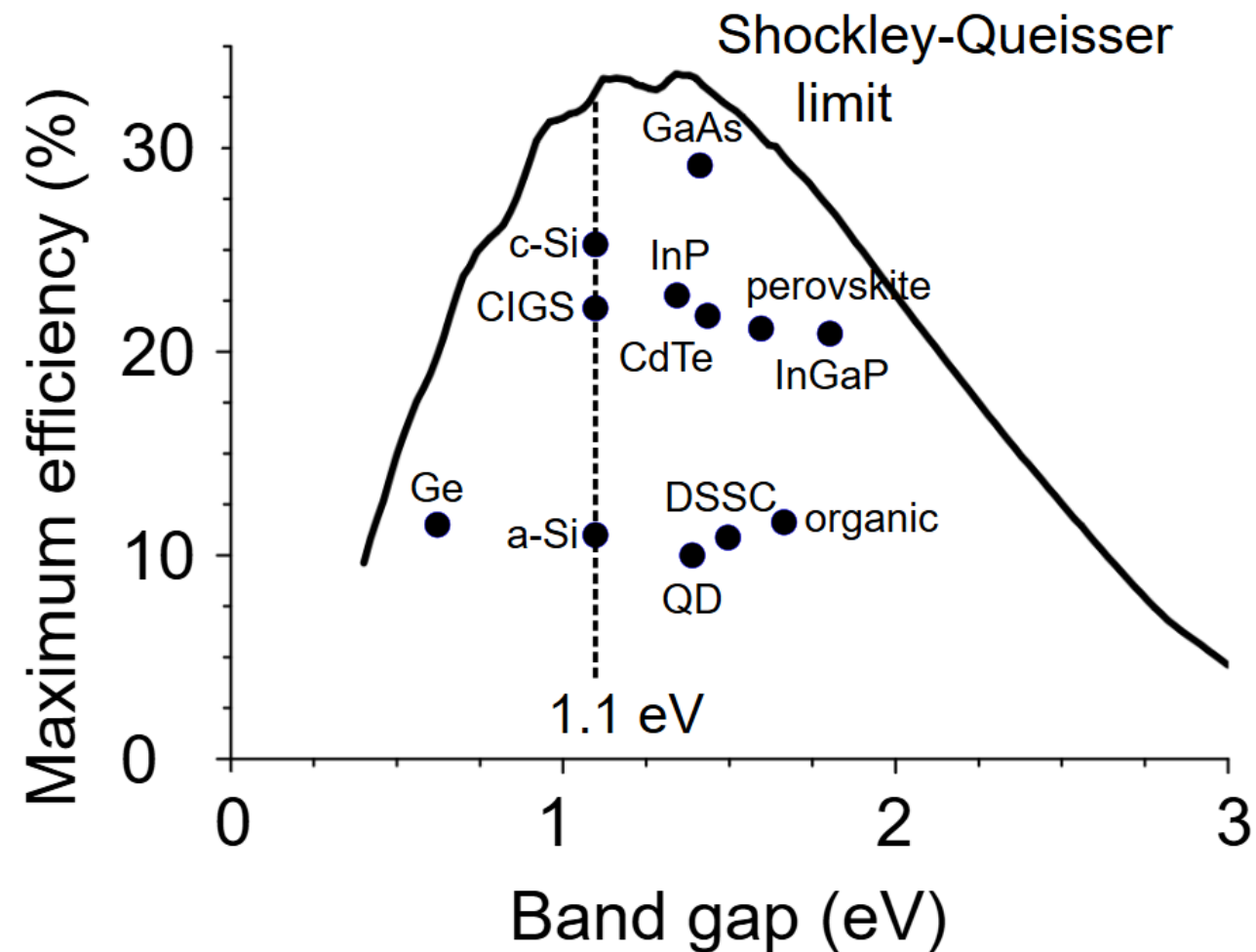
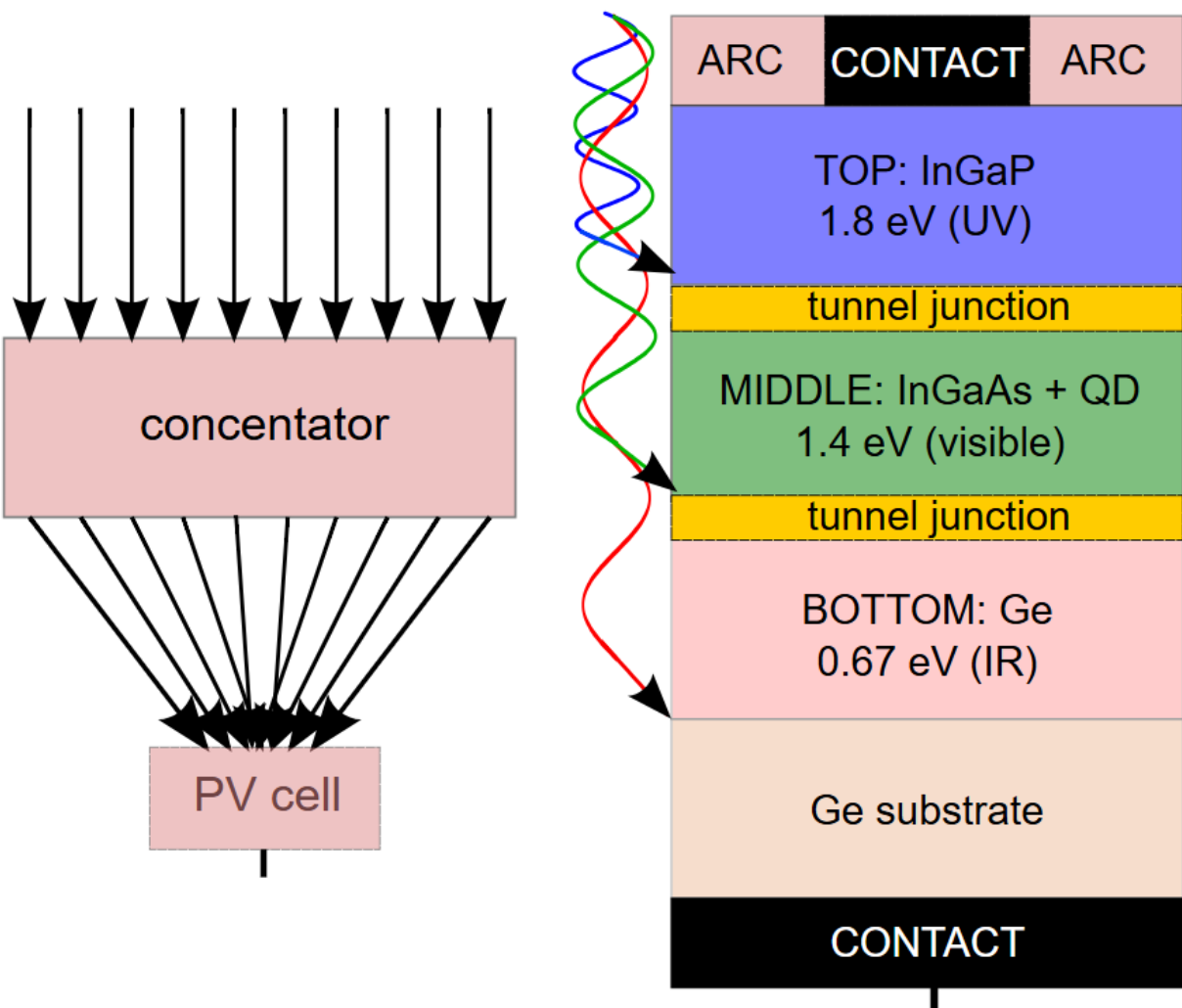
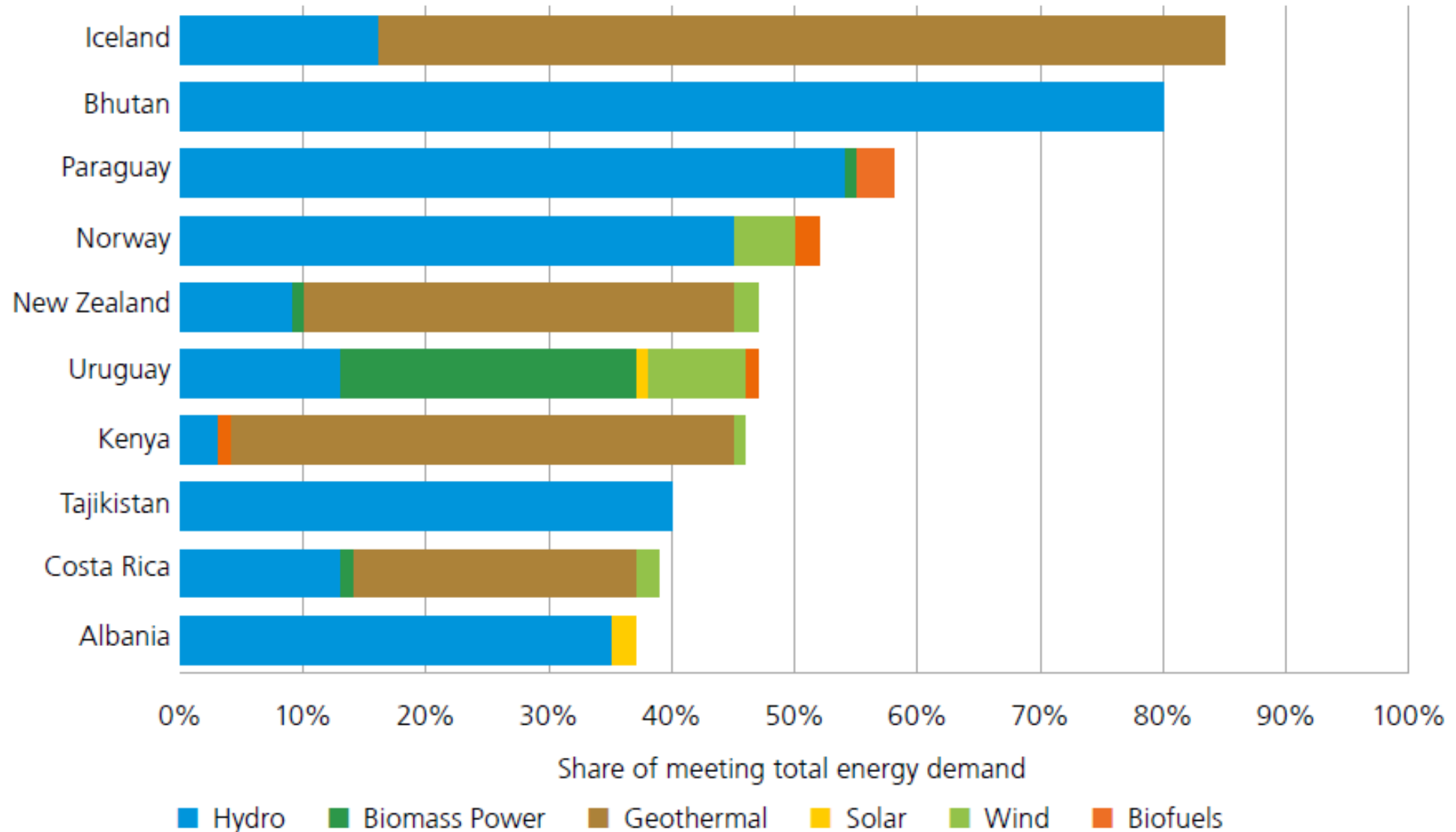
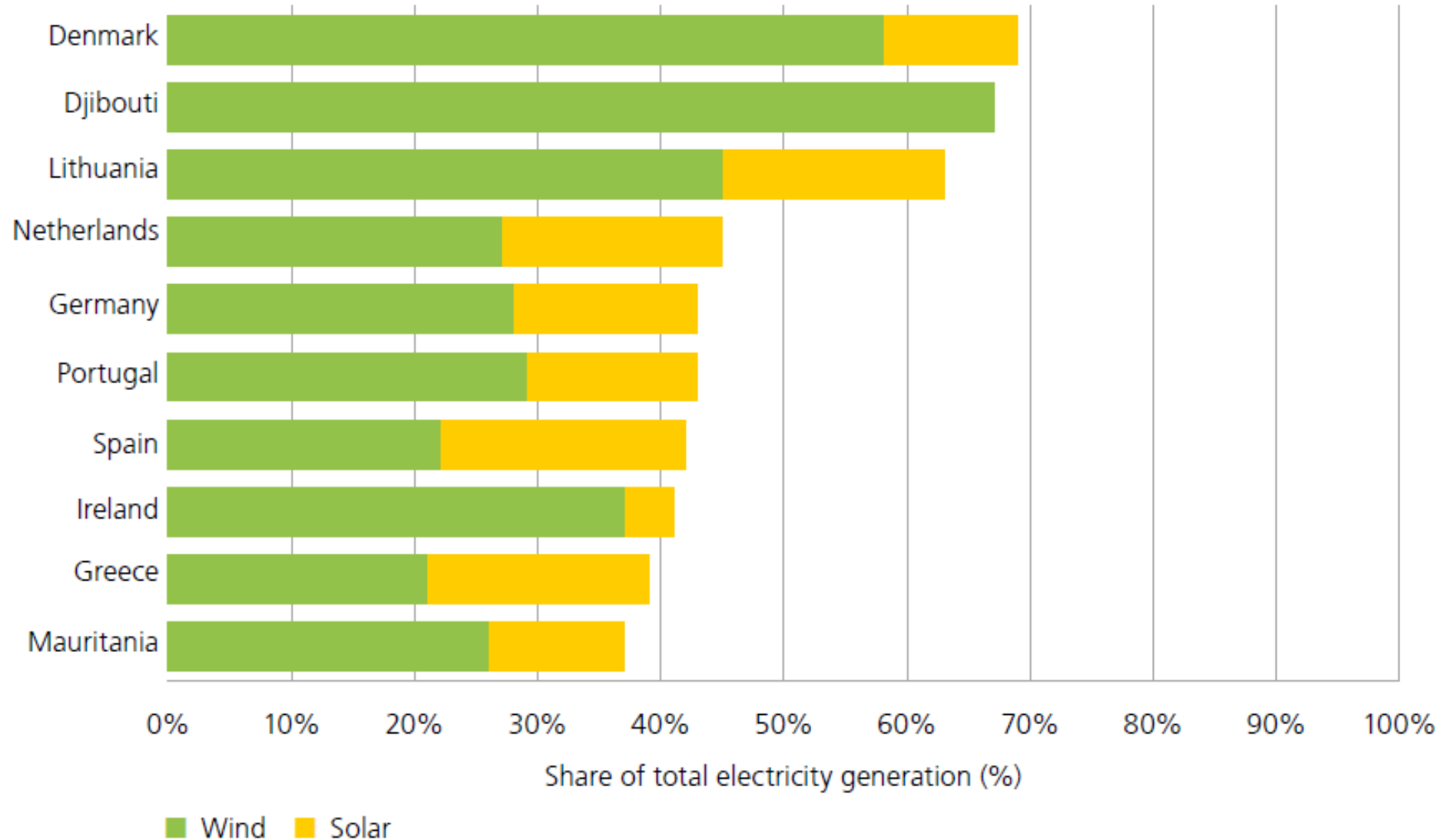


Figure 4.24 The Truth About Energy

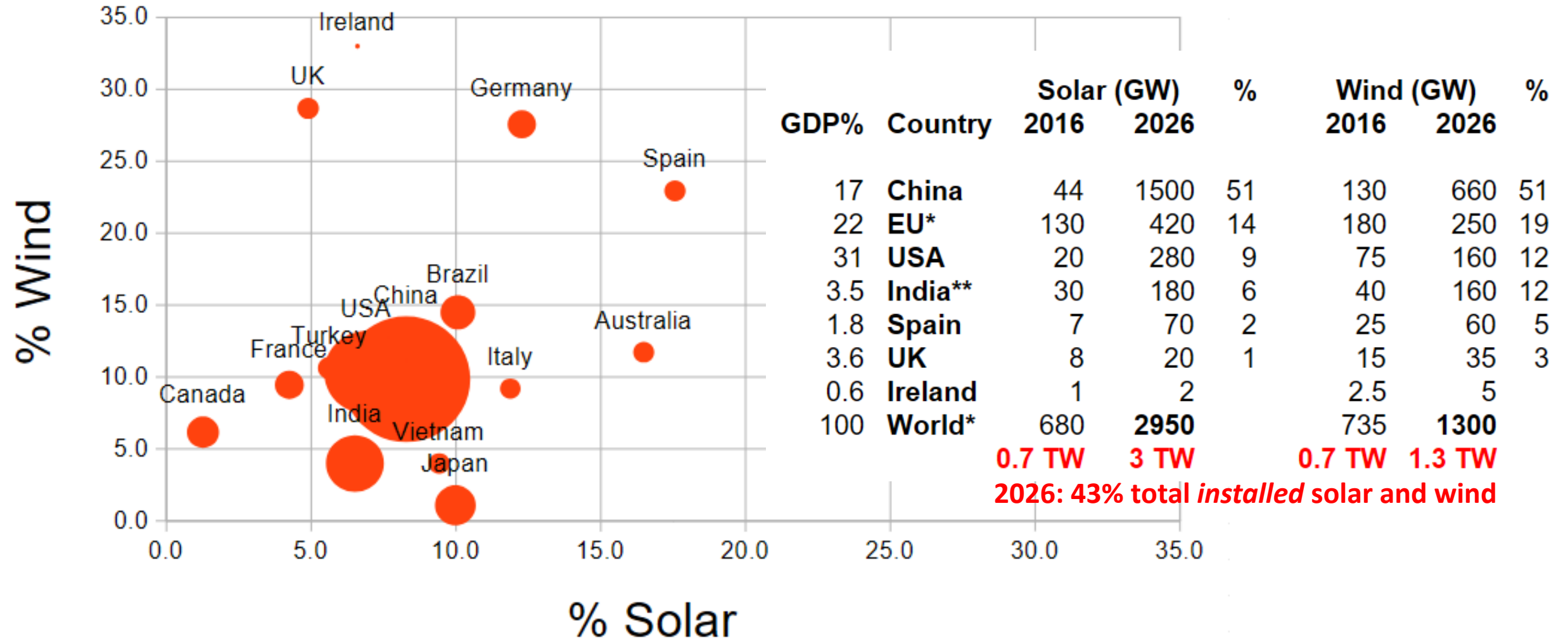
Top ten countries percentage renewables (2024)



Top ten countries percentage wind solar (2024)



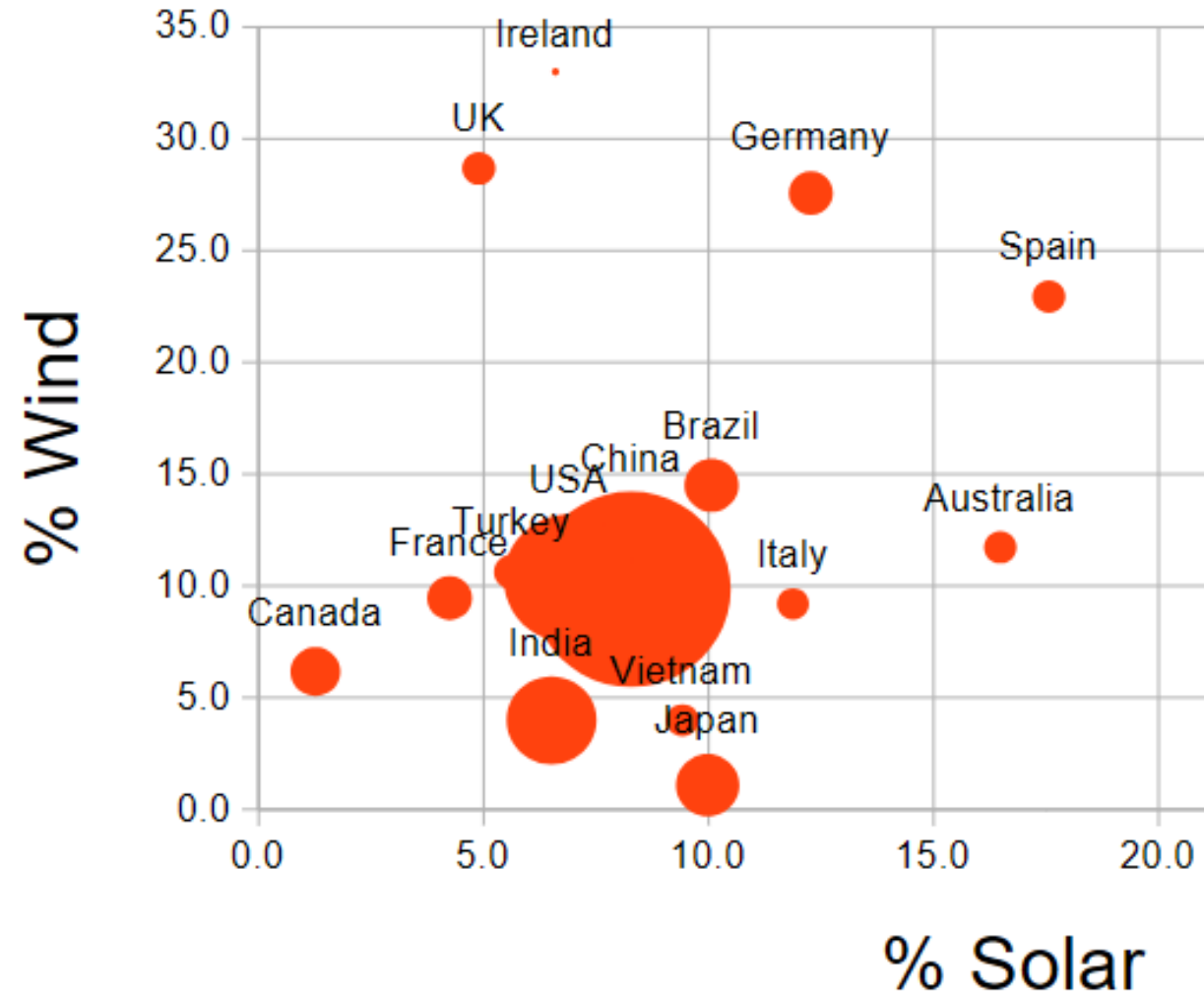
Top 20 countries electrical consumption (2025)



[Global Electricity](#): country annual TWh, % wind and solar bubbles

[Ember](#): installed wind and solar capacity in GW (April 2026)

Top 20 countries electrical consumption (2025)



Most new energy is now renewable

naturally correlates to GDP (70% US, China, EU)

4 x solar since 2020, 2 x wind since 2020

China > 50% solar and > 50% wind

EU/US ~14%/10% solar, ~20%/12% wind

Ireland (~33%) windier than sunny (~6%)

Spain windier (in the north) and sunnier (in the south)

Denmark > 60% wind, France >70% nuclear, Canada > 60% hydro

data verify – correct?, definition?, units?, up to date?, **metred?**

clean/green energy definition? (nuclear, hydro, biomass???)

units? (GW, TWh, TJ, capacity factor less than 100%)



Energy intensity

If the energy intensity of the countries on the bottom left — essentially Asia, Africa, and South America — rise to the top right without transitioning to clean energy, the atmosphere and the climate are doomed.

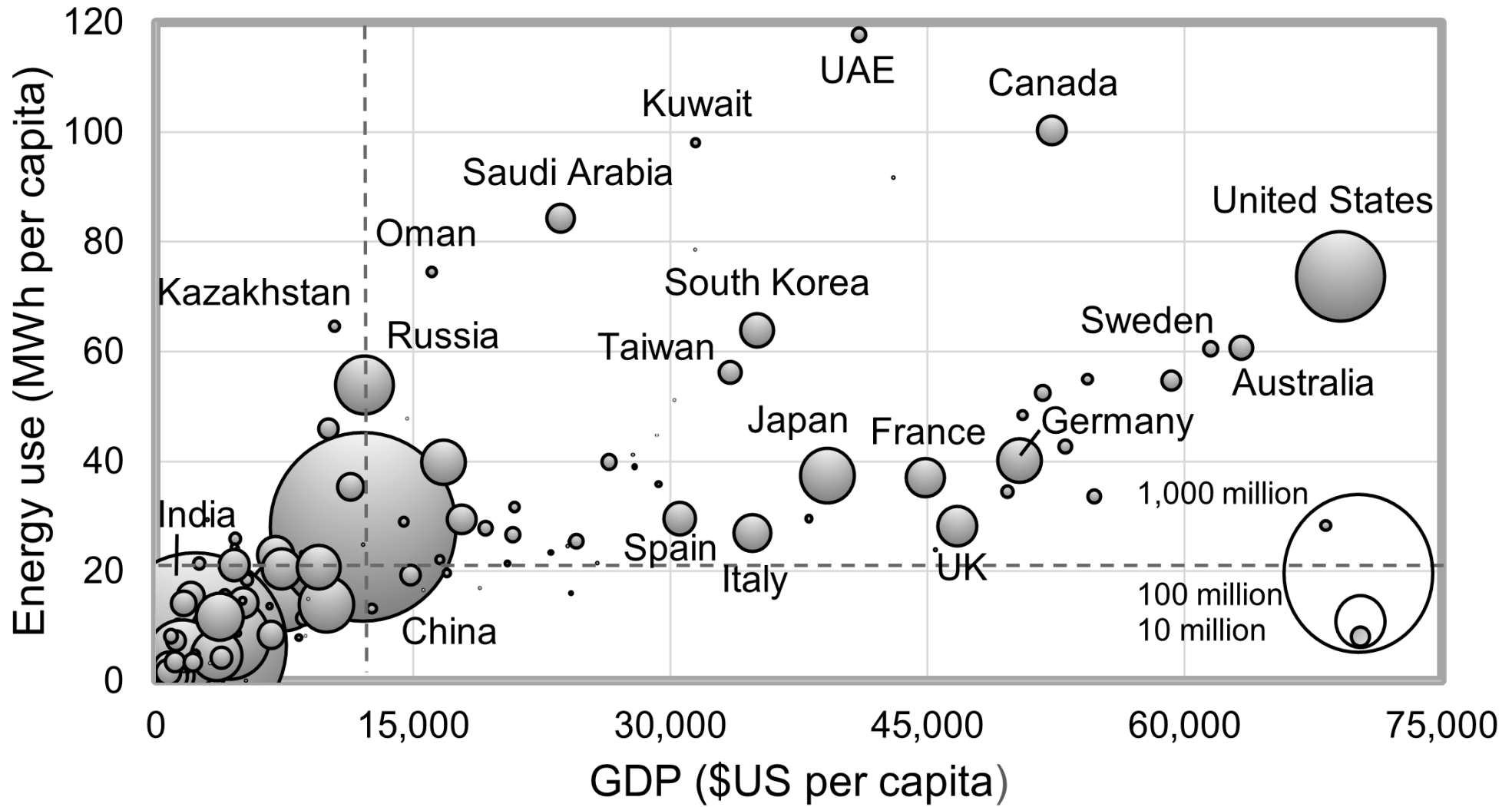


Figure 2.12 The Truth About Energy

B I N G O*

*standard PV, WT, EV, RRR excuses heard around the water cooler

costs an arm and a leg	too cloudy	nada at night	intermittent	I am not an electrician
noisy blades	10-year lifespan	"kills all the birds"	destroys the view	useless if no wind
the grid is still dirty	trees and plants love CO ₂	FREE	It's called weather	I'll eat what I want to
no charging infrastructure	lithium and cobalt mining kills	takes hours to charge	batteries can't be recycled	batteries explode
change takes too long	my recycle bin goes to a landfill	I'm just one person	government control	WHY BOTHER?

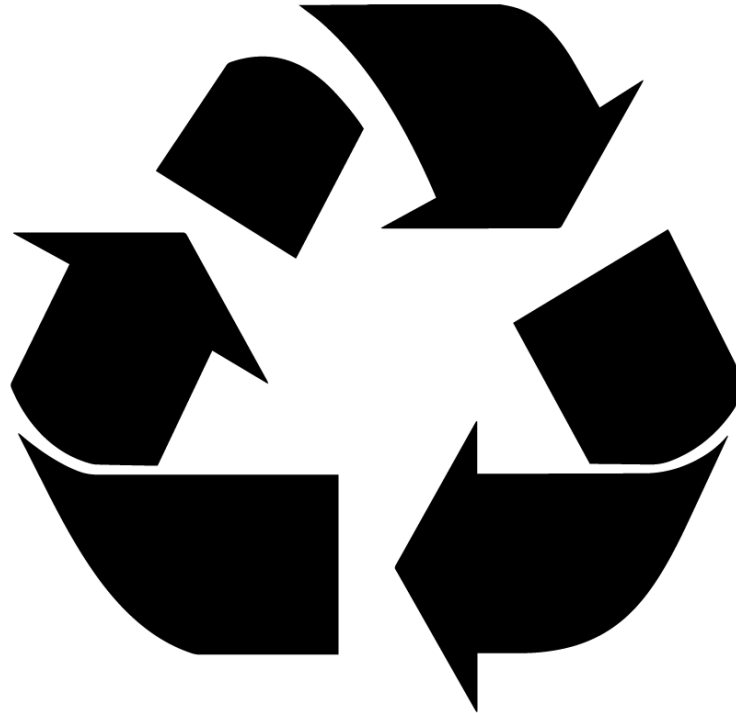
The Truth About Energy

John K. White

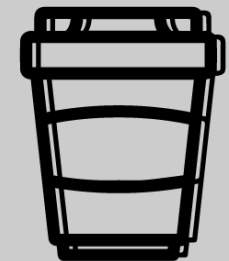


Less is more / Use less or become useless / It's what you do every day

**NO
JUNK
MAIL**



**SAY NO
TO PLASTIC**





Less is more / Use less or become useless / It's what you do every day

Reduce, Reuse, Recycle, refuse (just say “no”), remove (picking up garbage), refill (so simple), rot (organic decomposition), replenish, repair, regenerate, recover, refurbish, repurpose, redistribute, resell, recharge, rewild, rebel, rethink, rebuild, rewire,

“refuse” may be the most important — if you don't let something you don't need into your life in the first place you don't need to get rid of it later! Just say “no.”



Less is more / Use less or become useless / It's what you do every day

Walk, use the stairs, take public transport.
Use a bedtime hot-water bottle.
Recycle as much as possible.
Convert old bulbs to LED.
Dry clothes in the sun.

SHARE

Collect rainwater.
No single-use plastic.
No palm oil (or saturated fats).
No junk fast-food or processed food.
Think twice/thrice before buying anything.



Less is more / Use less or become useless / It's what you do every day



7: Reduce/Reuse/Recycle/...



Less is more / Use less or become useless / It's what you do every day





The Great Bubble Barrier

(Amsterdam)

[The Great Bubble Barrier](#) in Westerdok blocks plastic from escaping to the sea 24/7 via a curtain of rising bubbles emitted from a seabed perforated tube.

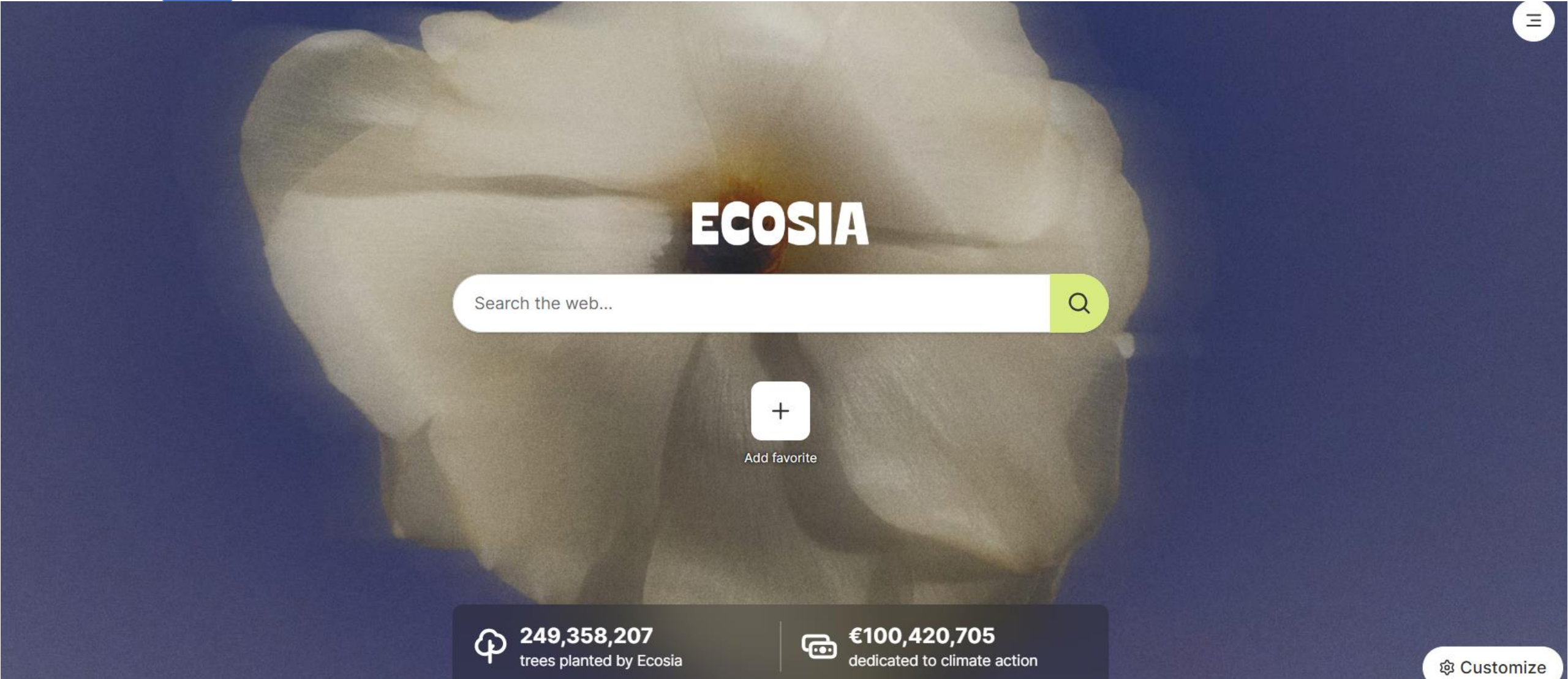
The elegant and simple system was a finalist in the 2023 [Earthshot Prize](#).





An ethical browser plants trees

(Ecosia)



249,358,207
trees planted by Ecosia



€100,420,705
dedicated to climate action

Customize

SILENT SPRING



The CLASSIC *that* LAUNCHED
the ENVIRONMENTAL MOVEMENT

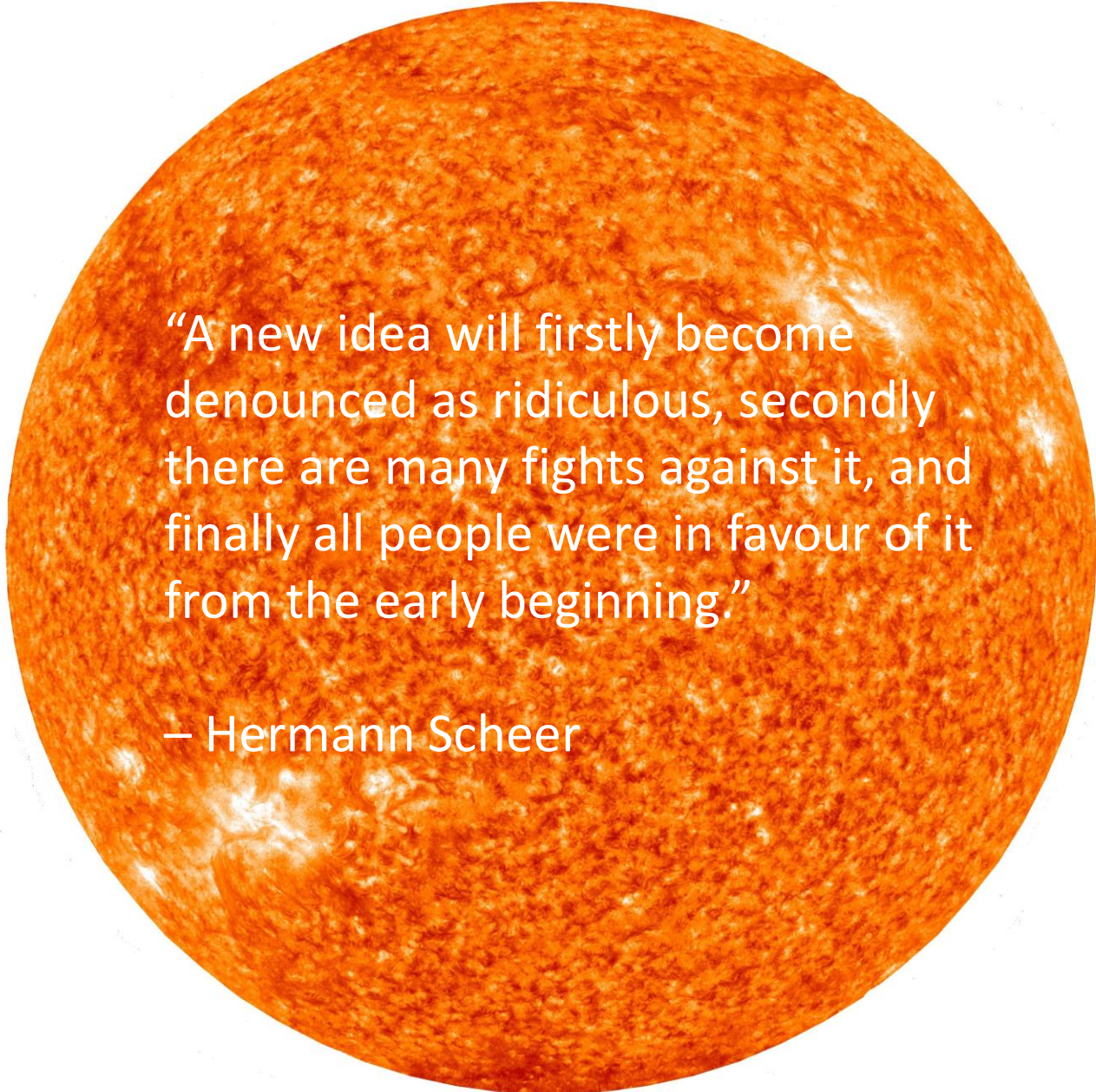
RACHEL CARSON

Introduction by LINDA LEAR *Afterword by* EDWARD O. WILSON

“We stand now where two roads diverge. But unlike the roads in Robert Frost’s familiar poem, they are not equally fair. The road we have long been traveling is deceptively easy, a smooth superhighway on which we progress with great speed, but at its end lies disaster. The other fork of the road – the one “less traveled by” – offers our last, our only chance to reach a destination that assures the preservation of our earth.”

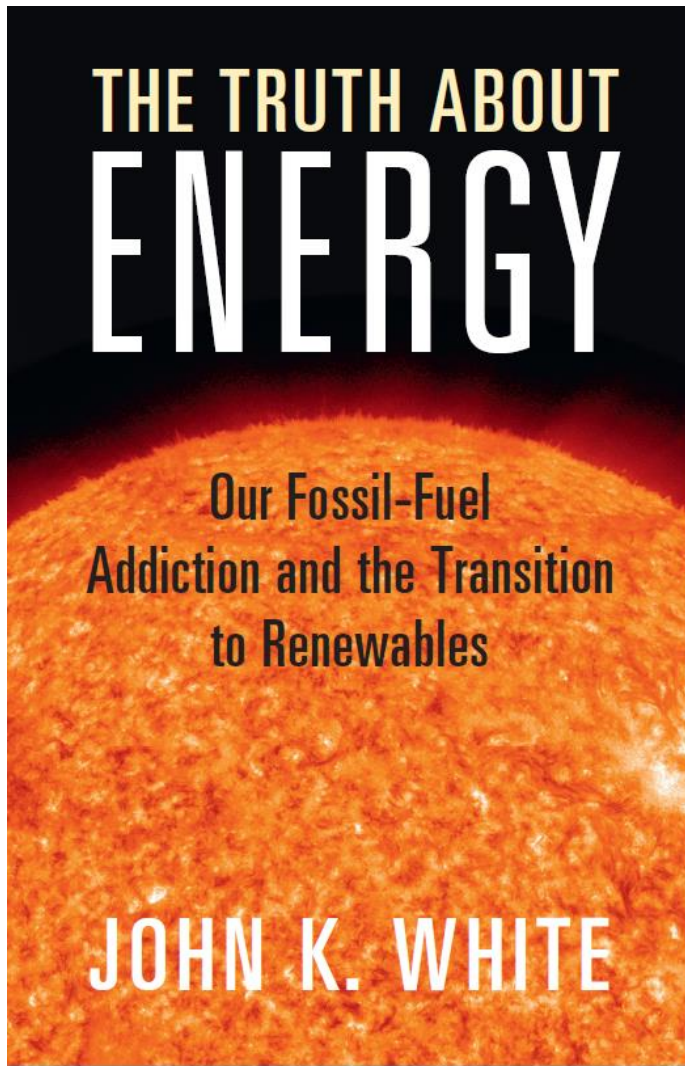


We came all this way to explore the moon, and the most important thing is that we discovered the earth.”
– William Anders, Apollo 8 Astronaut
(and “earthrise” photographer)



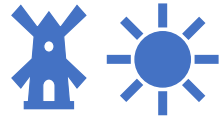
“A new idea will firstly become denounced as ridiculous, secondly there are many fights against it, and finally all people were in favour of it from the early beginning.”

– Hermann Scheer



CONCLUSIONS

electricity versus fossil fuels



clean versus dirty

individual or
company/group

\$\$\$ and the politics of
transition

Pace? / Just? / Who?

The Truth About Energy

is ...

... that we use too much, are insufficiently concerned about deleterious effects (pollution, GHG emissions, global supply chains), and aren't in any hurry to implement cleaner, safer alternatives. After more than two centuries of unchecked growth on the back of cheap fossil fuels, there is no urgency to mend our ways or coral those who would willfully destroy or damage Mother Earth.

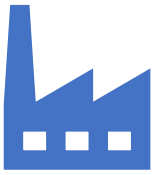
Here are my FIVE Renewable Energy Truths

(a.k.a. PV & Wind >> Oil & Gas)

1. We have no choice – limited petroleum supply and worsening climate
2. PV solar power scales via manufacturing not geology (technology > extraction)
– no moving parts
3. Change is always slow until it isn't (2^x rules)
4. Big Oil is the friction in the system – it's all about the money
5. We are the answer (“You are a crew”) – say “no” to dirty and “yes” to clean

The Truth About Energy: Our Fossil-Fuel Addiction and the Transition to Renewables John K. White ([Cambridge University Press, 2024](#))

MINERO POR UN DÍA



El Entrego



San Martín

El Cadaviu



ECOMUSEO MINERO
VALLE DE SAMUÑO



Feria de Muestras
en Gijón



The transition from brown to green in pictures



Bike sharing, Gijón

Here I am trying out a city bike in Gijón, free for half an hour with a citizen's card (*tarjeta ciudadana*). Or at least they were free before they changed the pedal bikes to electric. Why can't they leave well enough alone? (Chapter 7)

Some useful data sources

- > Daily CO2 ([co2.earth](#)) 1-year: **May 14, 2026** = 431.82 ppm **May 14, 2025** = 430.69 ppm
- > UC San Diego Scripps Institution of Oceanography ([Keeling Curve](#)): **May 15, 2026** 431.57 ppm
- > [MethaneSAT](#) (methane emissions are worse than we think)
- > [350.org](#) (Bill McKibben), [Climate Action Tracker](#) (keeping warming below 2 °C)
- > Lazard's Levelized Cost of Energy ([LCOE+](#), June 2025, v.18)
 - “renewable energy remains the most cost-competitive form of generation”
 - (unsubsidized \$/MWh) – **onshore wind (\$37/MWh)**, **utility solar PV (38)**, CGC (48), geothermal (66), offshore wind (70), coal (71), community solar PV (81), US nuclear (141), gas peaking (149)
- > Global Solar Energy Map (Vaisala), Global Wind Field (Vaisala)
- > [Global Solar Atlas](#) (Spain data point) [Global Wind Atlas](#) ([Ireland data point](#))
- > [Wind Europe](#) (20% Europe's electricity, 370,000 jobs (600,000 in 2030), €10 billion in taxes)
- > World Atlas ([Oil Reserves](#))
- > [National Renewable Energy Lab \(NREL\)](#)
- > NREL [Best Research-Cell Efficiency Chart](#) (1976 to present)
- > [Sustainable Energy Authority of Ireland \(SEA\)](#)
- > US Energy Information Agency (EIA): Global [Electricity Capacity](#) (9.7 TW: 4.8 TW fossil fuels, 4.4 TW renewables)
- > [Real time Irish Grid](#) (46% renewables, 40% gas)
- > [Real-time Spanish Grid](#) (55% solar, 14% wind, 13% nuclear, 10% gas)
- > [Ember Energy](#): Data Into Action

A few suggested links

- > [“Run by falls power,”](#) *Buffalo Express*, November 19, 1896.
- > Hubbert, M. K., “Nuclear energy and the fossil fuels,” American Petroleum Institute, San Antonio, Texas, March 1956.
- > [“Vast power of the sun is tapped by battery using sand ingredient,”](#) *New York Times*, April 26, 1954.
- > Rachel Carson, *Silent Spring*, 1962, Houghton Mifflin.
- > [“The Silent Spring of Rachel Carson”](#) (documentary), April 3, 1963, *CBS Reports*.
- > Wallace S. Broecker, [“Climatic change: Are we on the brink of a pronounced global warming?”](#) *Science*, August 8, 1975.
- > James Hansen, [“Congressional testimony of Dr. James Hansen, June 23, 1988 \(transcript\),”](#) *U.S. Senate*, June 23, 1988.
- > Colin J. Campbell & Jean H. Laherrre, [“The End of Cheap Oil”](#) in *Scientific American Magazine*, 278 No. 3, March 1998.
- > [“7 million premature deaths annually linked to air pollution”](#) (press release), March 25, 2014, *World Health Organization (WHO)*
- > Dominic Zerulla, [“Harvesting Solar Energy”](#) (video), University College Dublin, July 2, 2015.
- > McKuin, B. et al., [“Energy and water co-benefits from covering canals with solar panels,”](#) *Nature Sustainability*, 4, 609–617, March 18, 2021.
- > [“Net Zero by 2050: A Roadmap for the Global Energy Sector,”](#) May 18, 2021, *International Energy Agency (IEA)*.
- > Kruitwagen, L. et al. [“A global inventory of photovoltaic solar energy generating units,”](#) *Nature* 598, 604–610, October 27, 2021.
- > [“The Role of Critical Minerals in Clean Energy Transitions”](#) (revised edition), March 2022, *International Energy Agency (IEA)*.
- > Bill McKibben, [“Heat Pumps for Peace and Freedom,”](#) February 28, 2022, *The Crucial Years*.
- > [“AR6 Synthesis Report: Climate Change 2023,”](#) *UN Intergovernmental Panel on Climate Change*, Switzerland, March 19, 2023.

A few more interesting links

- > [National Geographic](#)
- > [SunShot 2030](#) (US Department of Energy) “New Solar Opportunities for a New Decade”
 - 2011** 3 GW < 0.1%;
 - 2017** 47 GW 1% (\$0.06/kWh 2020 utility-scale PV target **achieved**),
 - 2030** goal **revised** to **\$0.03/kWh** and \$0.05/kWh baseload with minimum 12 hours storage
- > [Ellen MacArthur Foundation](#) – circular economy: critical minerals, reduced plastic (prevent plastic pollution and eliminate waste), fashion (extend use), activate policy
- > [The Great Bubble Barrier](#), Amsterdam
- > [The Ocean Cleanup](#) (The Great Pacific Garbage Patch, Boyan Slat)
- > [The Earthshot Prize](#): [EarthHour](#) (Spain), [Form Energy](#)’s iron-air batteries (Ireland)
- > [Transition Network](#) (uniting communities for a sustainable future)
- > [E21NS](#) (Energy in the 21st Century New Service, 440+ precised articles)
- > Virtual City Science walking tours: [London](#), [New York](#), [Spain](#), [The Netherlands](#)
- > *The Truth About Energy: Our Fossil-Fuel Addiction and the Transition to Renewables* ([Cambridge University Press, 2024](#))
- > [CounterPunch energy articles](#) and [Science Talks](#) (John K. White)
- > [Earth Day](#), April 22 (and every day!)

Thank you

Muchas gracias

Go raibh maith aghat