Εθνικό Μετσόβιο Πολυτεχνείο

Σχολή Πολιτικών Μηχανικών

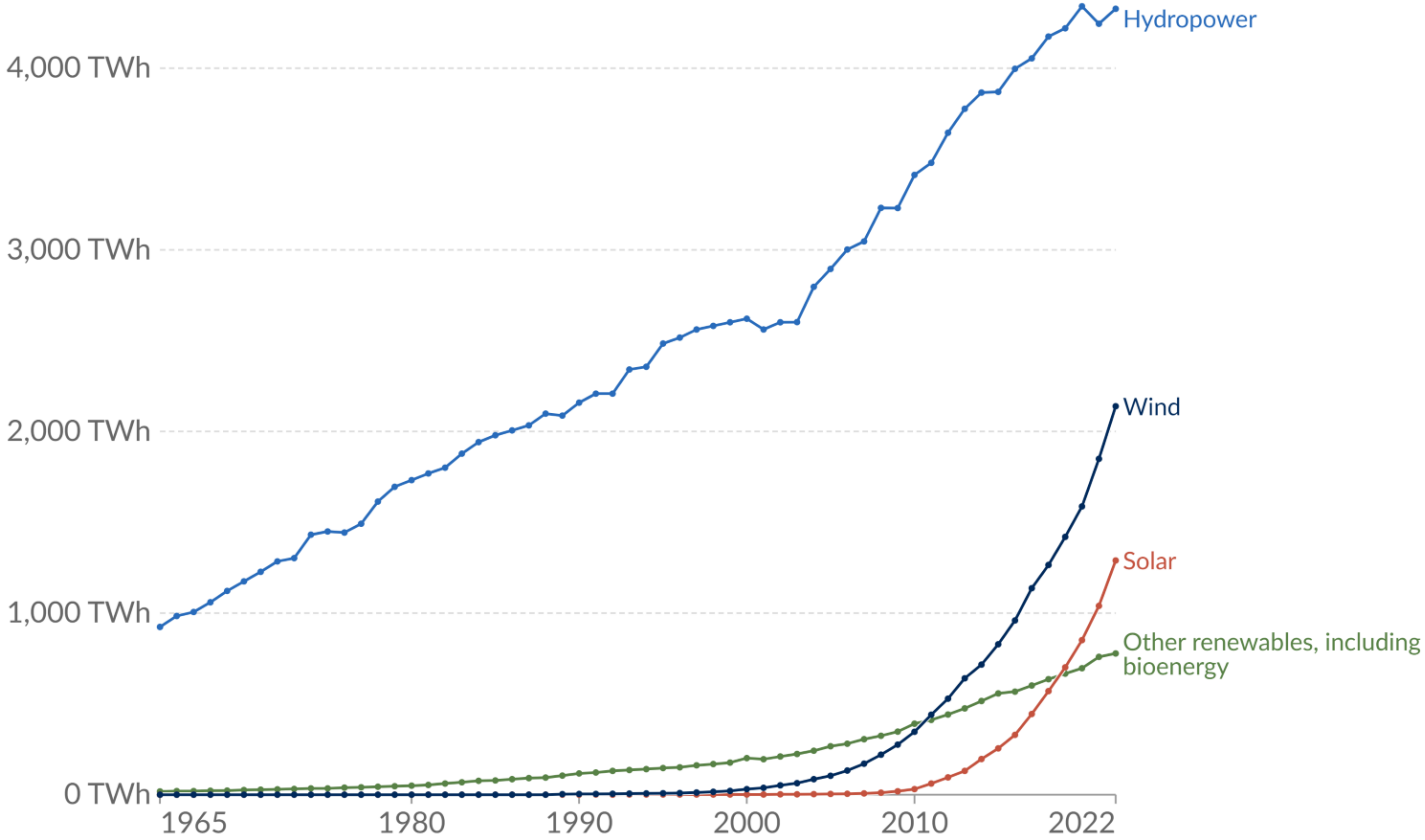
Η σκοπιμότητα των έργων Ανανεώσιμων Πηγών Ενέργειας

Γ.-Φοίβος Σαργέντης

Παρουσίαση: https://youtu.be/NIQKiyPQnYk

Οκτώβριος 2023

Modern renewable energy generation by source, World

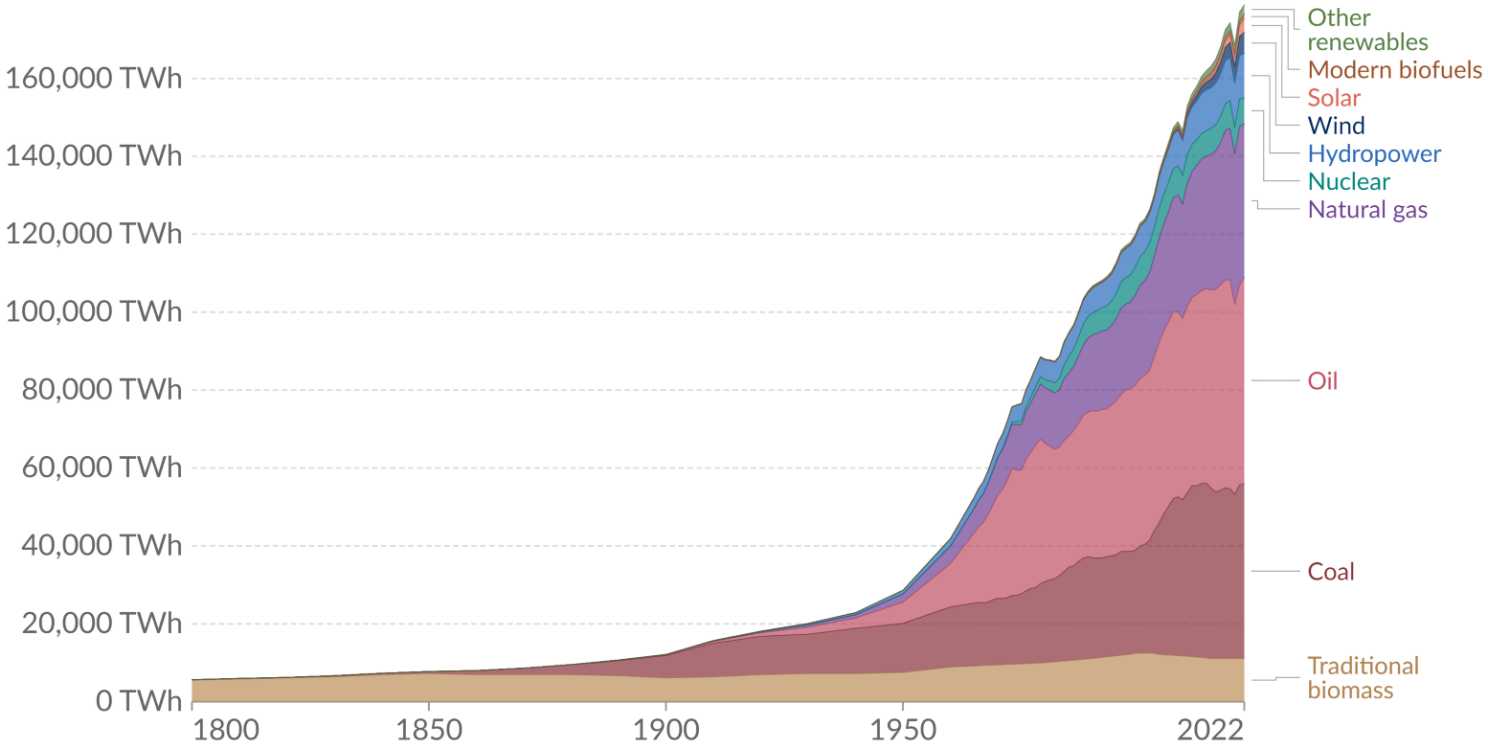


Data source: Ember's Yearly Electricity Data; Ember's European Electricity Review; Energy Institute Statistical Review of World Energy
OurWorldInData.org/renewable-energy | CC BY

Global primary energy consumption by source

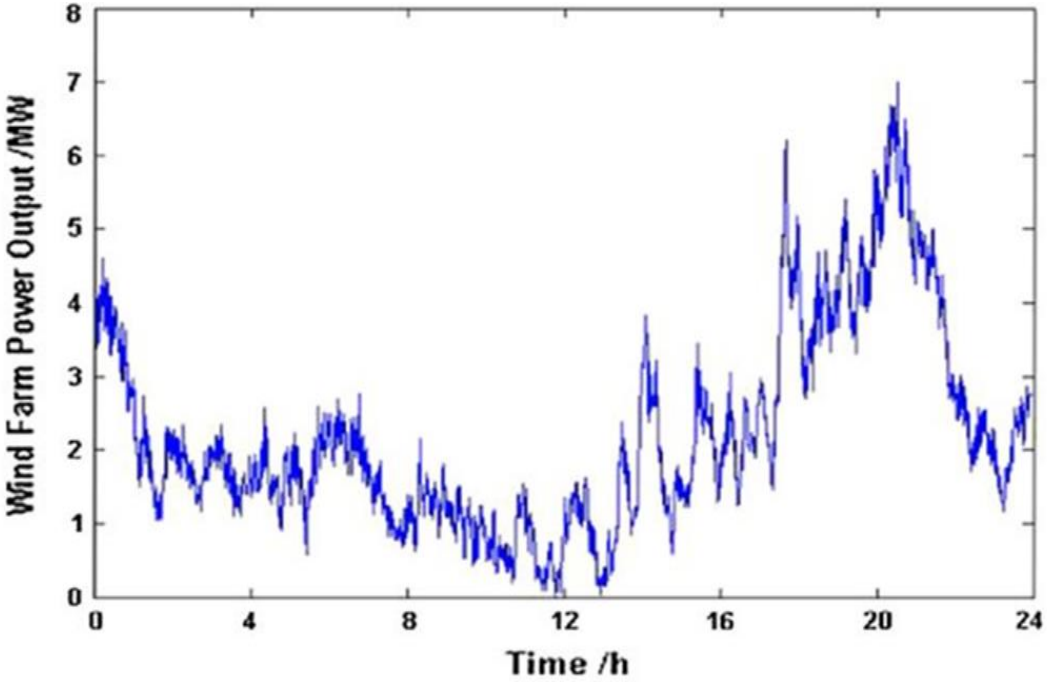
Our World in Data

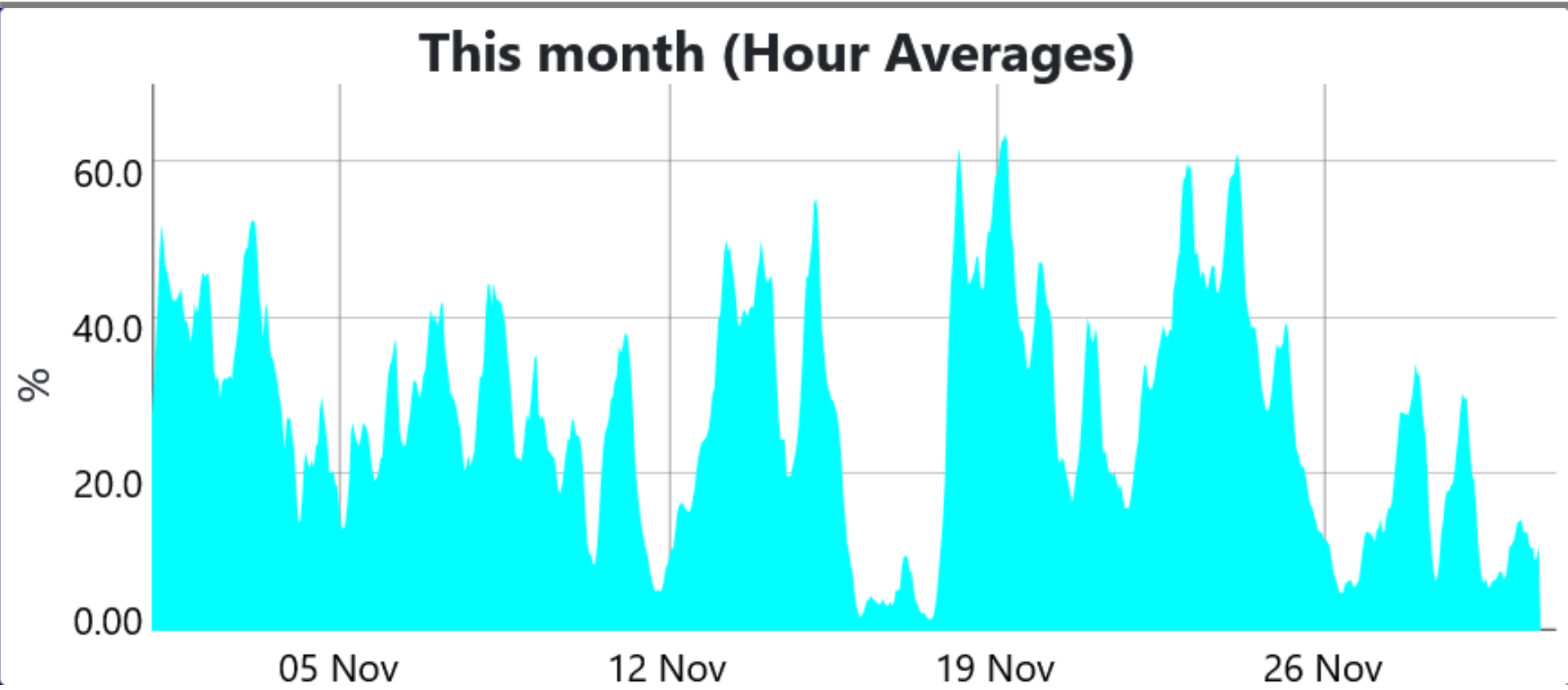
Primary energy is calculated based on the 'substitution method' which takes account of the inefficiencies in fossil fuel production by converting non-fossil energy into the energy inputs required if they had the same conversion losses as fossil fuels.



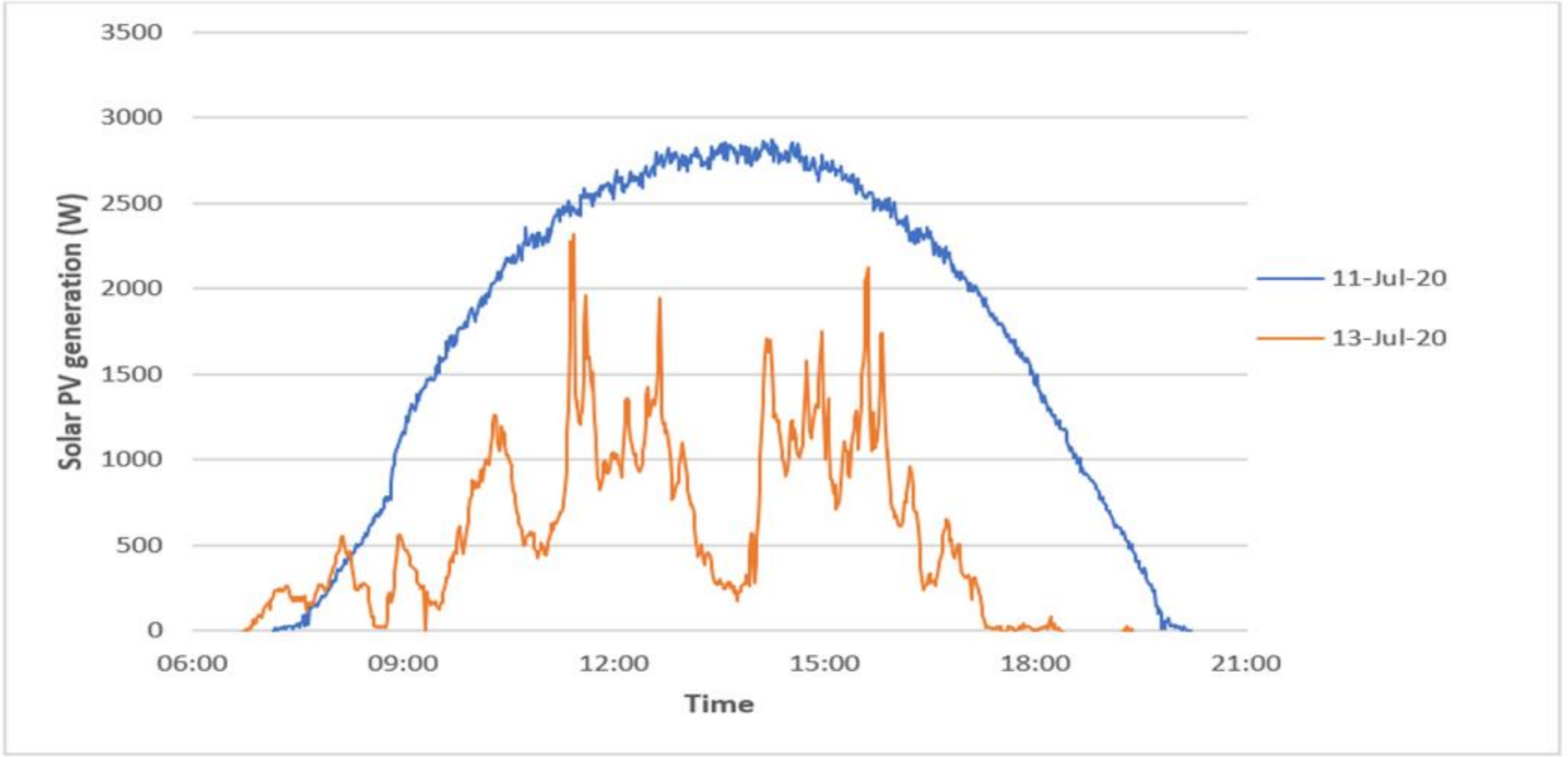
Data source: Energy Institute Statistical Review of World Energy (2023); Vaclav Smil (2017)

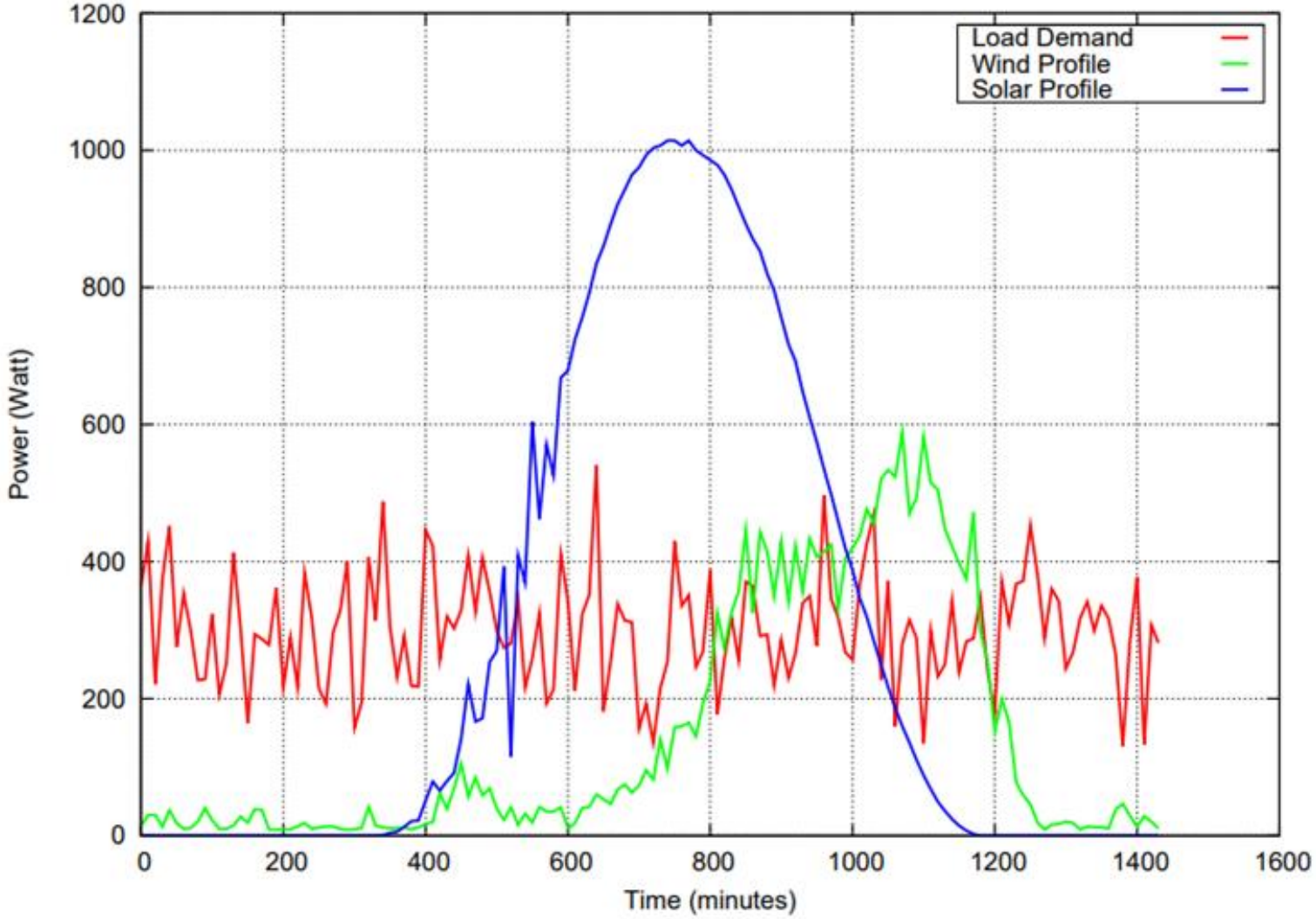
OurWorldInData.org/energy | CC BY


Wind Farm Power Output /MW
Time /h
0
1
2
3
4
5
6
7
8
0
4
8
12
16
20
24



Ενέργεια % του συνόλου, που έδωσαν οι ανεμογεννήτριες στην Αγγλία τον Νοέμβριο του 2023


3500
3000
2500
2000
1500
1000
500
0
Solar PV generation (W)
06:00
09:00
12:00
15:00
18:00
21:00
Time
11-Jul-20
13-Jul-20


Load Demand
Wind Profile
Solar Profile
Power (Watt)
Time (minutes)
0
200
400
600
800
1000
1200
1400
1600

Τι συμβαίνει δεν υπάρχει άνεμος και ήλιος; Μπαταρίες!

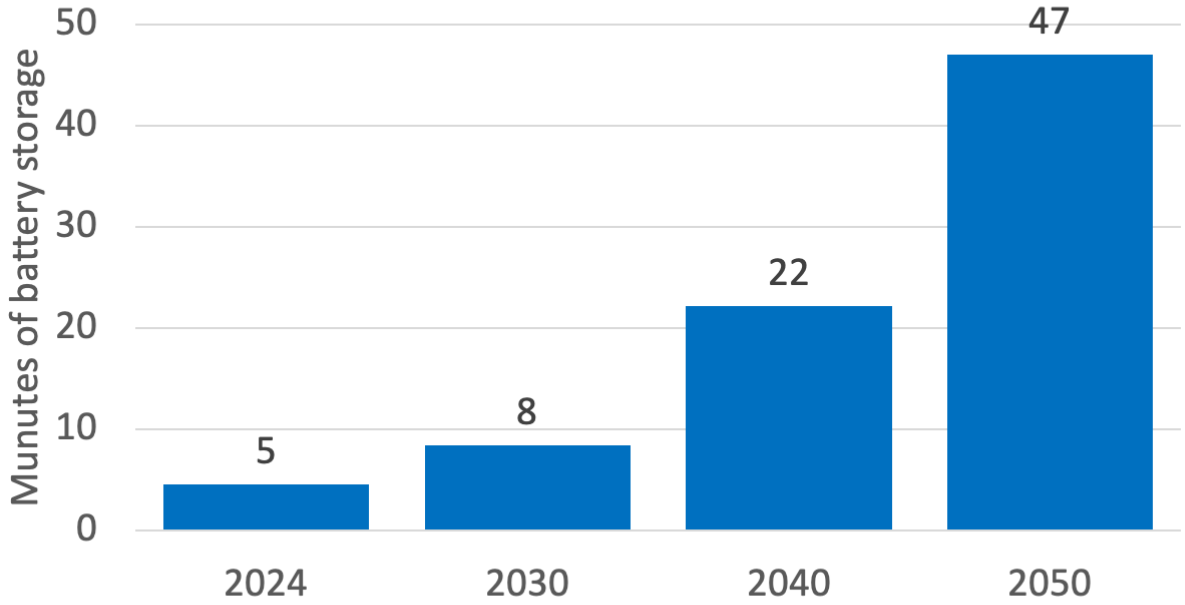
Το 2024, οι διαθέσιμες μπαταρίες μπορούσαν να αποθηκεύσουν μόλις 5 λεπτά της ενέργειας που παράγουν οι ΑΠΕ.

Το 2050 προβλέπεται ότι θα μπορούν να αποθηκεύσουν 47 λεπτά.

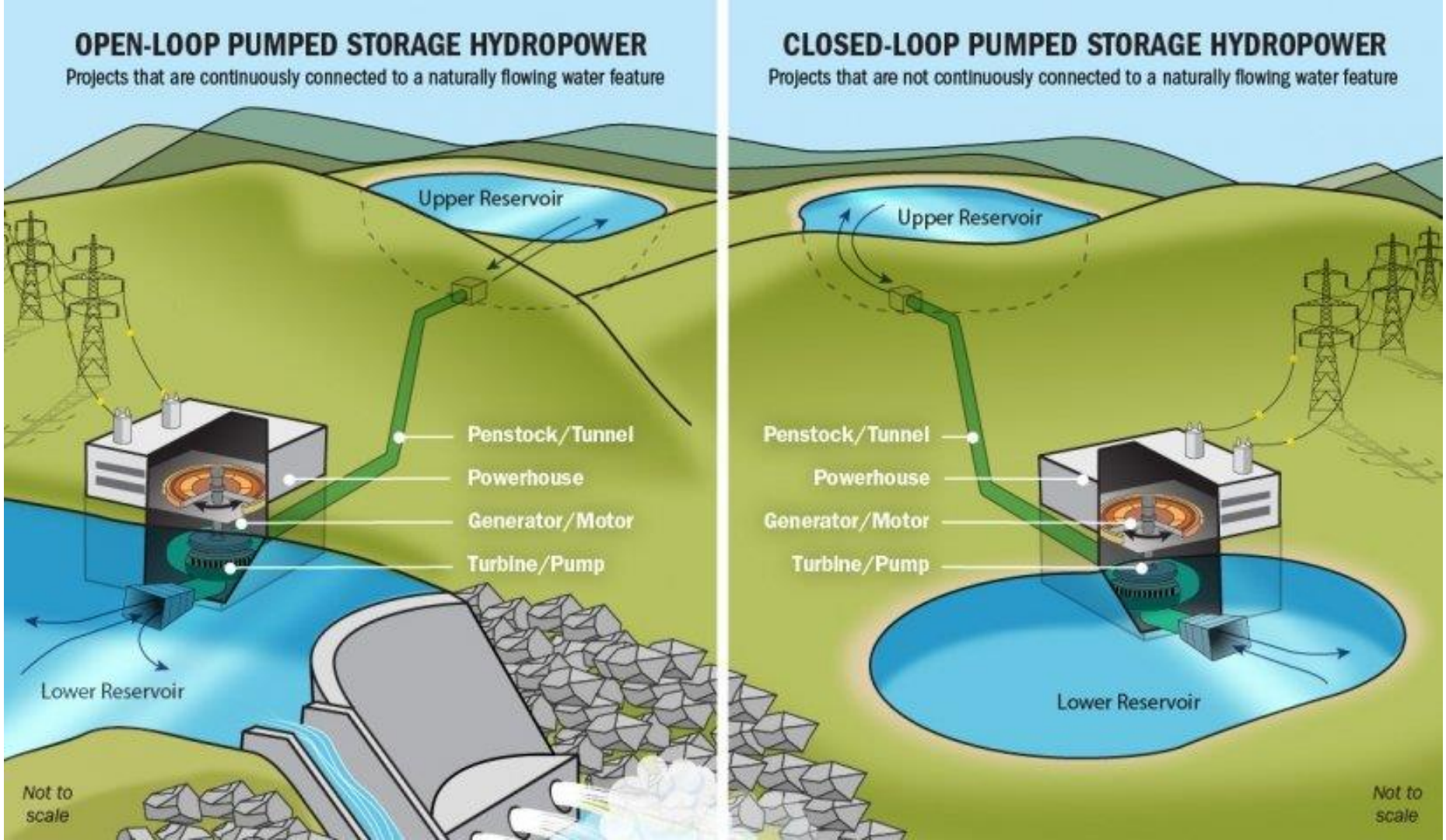
Ωστόσο, για 100% ΑΠΕ χρειάζεται να είναι εξασφαλισμένη η αποθήκευση για 40-50 μέρες.

No, batteries won't save us

In 2024, batteries can supply nearly 5 minutes of world's electricity
Even in 2050, with 15x batteries, they can supply just 47 minutes
Problem? 100% solar and wind needs 3 months, or ~2,600x more



*From Biden's Energy Information Administration's International Energy Outlook, October 2023, https://www.eia.gov/outlooks/ieo/data.php, battery storage from Table E01.cap and global generation from Table E01.gen. In 2024, EIA estimates global battery generation at 62.9GW, and each holds 4 hours (https://www.eia.gov/outlooks/ieo/narrative/index.php), meaning 251.4GWh. Since electricity production is 29,065TWh/year or 55.3GWh/minute, that leaves 4.5 minutes of storage. In reality, throughput is not anywhere close to covering everything. Instead, the total battery capacity will be able to cover 1.9% of all electricity generation for 4 hours (1.9%*4 hours = 4.5 minutes). 2023 paper "Storage requirements to mitigate intermittent renewable energy sources: analysis for the US Northeast" (https://www.frontiersin.org/articles/10.3389/fenvs.2023.1076830), estimates that a renewable energy future solely using solar power needs 22.4% of annual electricity generation in storage, and wind 24.9%. The average is 23.65% or almost three months of storage, 124,390 minutes or 2,647 times more than storage in 2050. Twitter.com/bjornlomborg*


OPEN-LOOP PUMPED STORAGE HYDROPOWER
Projects that are continuously connected to a naturally flowing water feature
Upper Reservoir
Penstock/Tunnel
Powerhouse
Generator/Motor
Turbine/Pump
Lower Reservoir
Not to scale
CLOSED-LOOP PUMPED STORAGE HYDROPOWER
Projects that are not continuously connected to a naturally flowing water feature
Upper Reservoir
Penstock/Tunnel
Powerhouse
Generator/Motor
Turbine/Pump
Lower Reservoir
Not to scale

Το πλέγμα νερού-ενέργειας και τροφίμων

Οι βασικές ανθρώπινες ανάγκες σχετίζονται με το νερό, την ενέργεια και τα τρόφιμα. Αυτά συνθέτουν ένα πλέγμα που όχι μόνο είναι απαραίτητο για την επιβίωση των ανθρώπων, αλλά χαρακτηρίζει και την ευημερία τους.

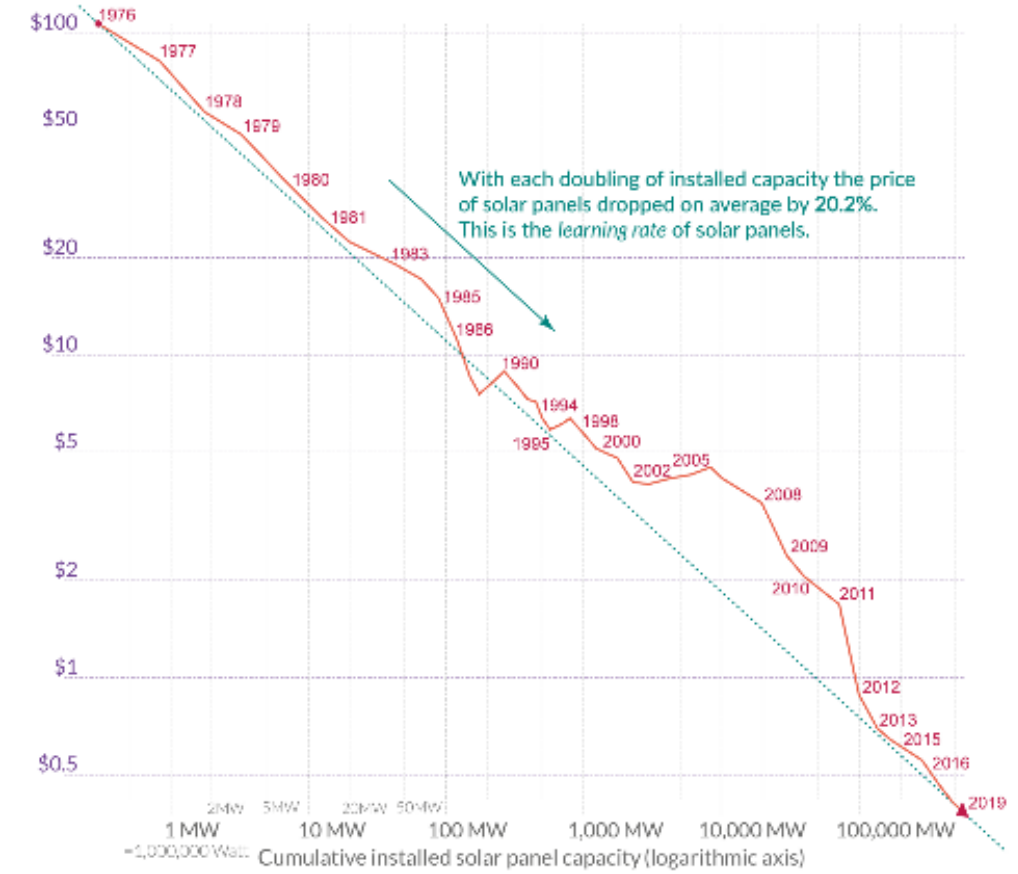
Είναι σημαντικό να σημειωθούν οι αλληλεπιδράσεις στο εσωτερικό του πλέγματος νερού-ενέργειας-τροφίμων: το νερό μπορεί να δώσει ενέργεια (υδροηλεκτρική ενέργεια) και να πολλαπλασιάζει την παραγωγή τροφής (άρδευση), η ενέργεια παράγει τρόφιμα αλλά επίσης χρειάζεται ενέργεια για να αντληθεί υπόγειο νερό, τα τρόφιμα μπορούν να θεωρηθούν ως πηγή ενέργειας (για ζώα και ανθρώπους) και περιέχουν νερό.

Η χρήση γης είναι ανταγωνιστική για τα μέρη του πλέγματος.

Following Wright's Law: the price of solar panels declined by 20% with each doubling of global cumulative capacity

Our World in Data

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

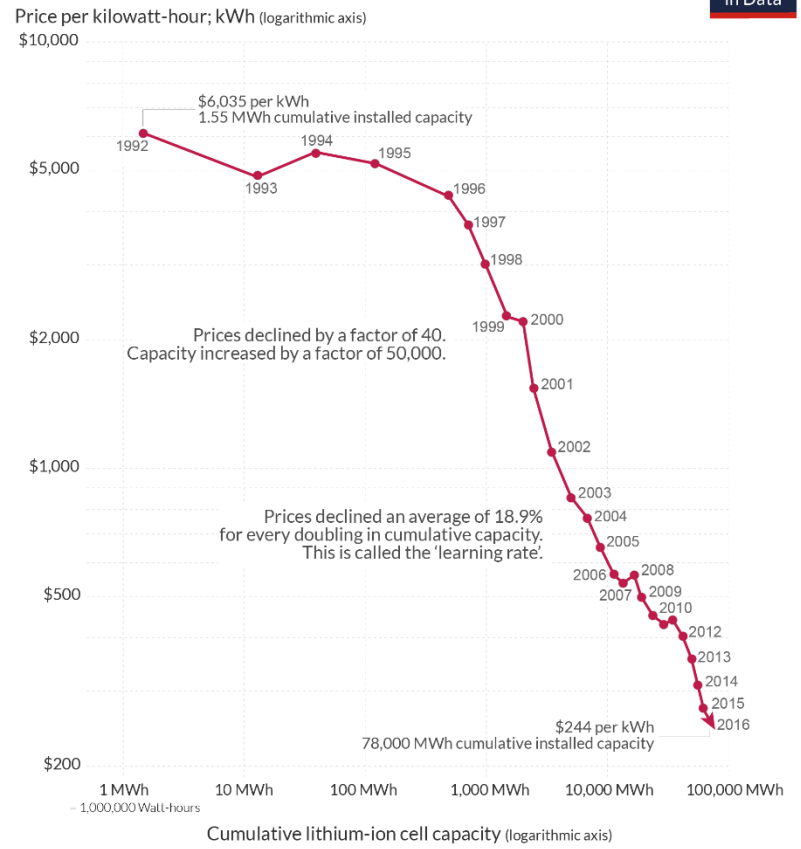


Data: Lafond et al. (2017) and IRENA Database; the reported learning rate is an average over several studies reported by de La Tour et al (2013) in Energy. The rate has remained very similar since then.

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

Price and market size of lithium-ion batteries since 1992

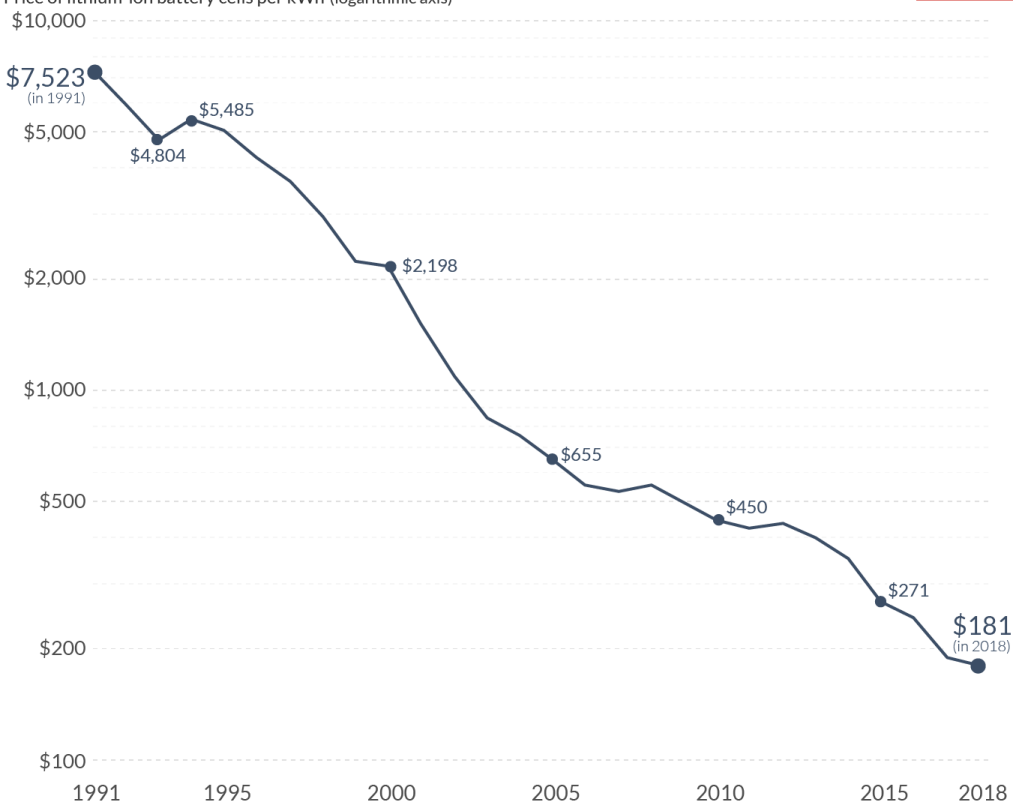
Our World in Data



Prices are adjusted for inflation and given in 2018 US-$ per kilowatt-hour (kWh).
Source: Micah Ziegler and Jessika Trancik (2021). Re-examining rates of lithium-ion battery technology improvement and cost decline.
OurWorldinData.org – Research and data to make progress against the world's largest problems. Licensed under CC-BY by the author Hannah Ritchie.

The price of lithium-ion batteries fell by 97%

Our World in Data

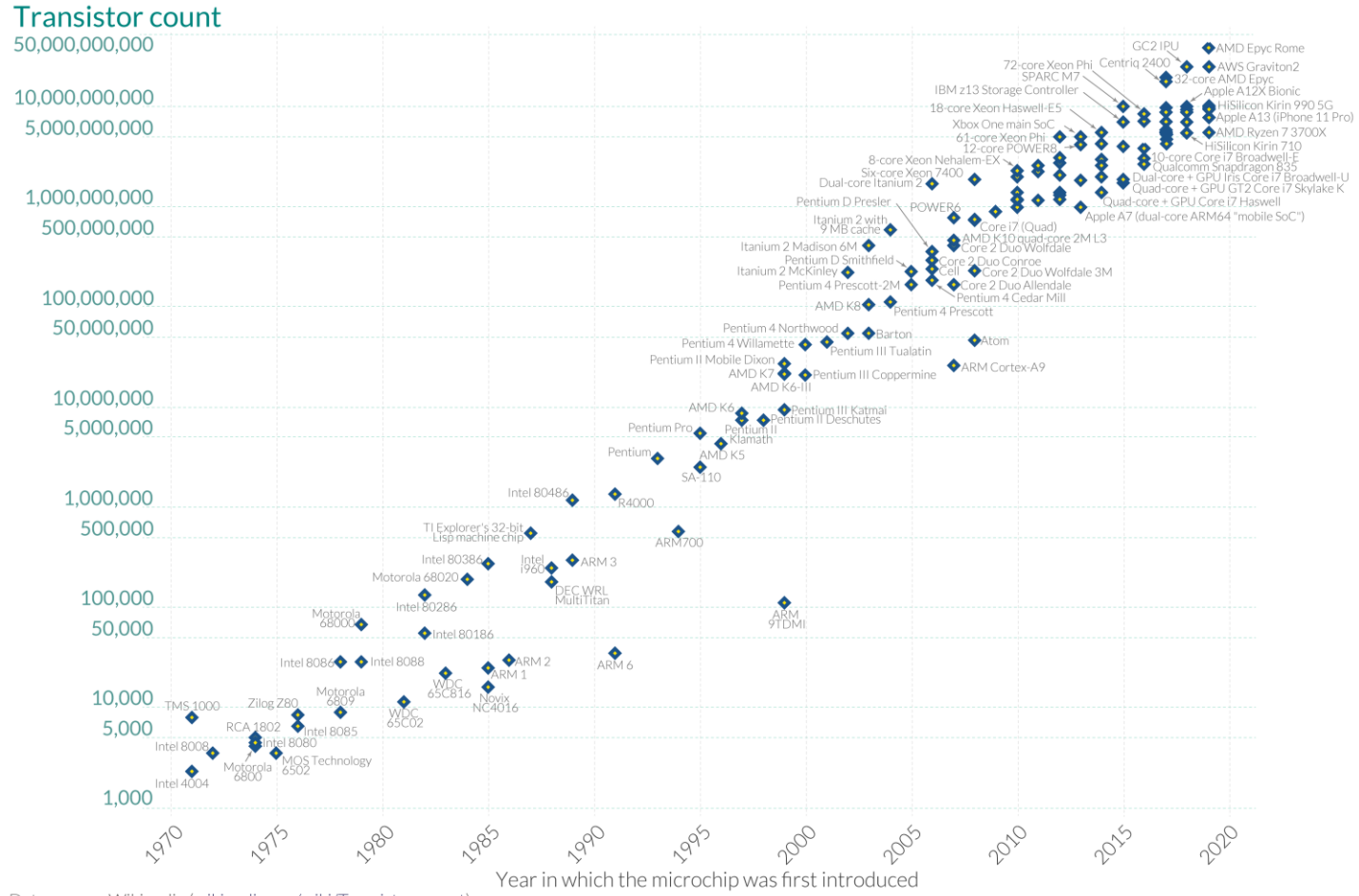


Prices are adjusted for inflation and given in 2018 US-$ per kilowatt-hour (kWh).
Source: Micah Ziegler and Jessika Trancik (2021). Re-examining rates of lithium-ion battery technology improvement and cost decline.
OurWorldinData.org – Research and data to make progress against the world's largest problems. Licensed under CC-BY by the author Hannah Ritchie.

Moore's Law: The number of transistors on microchips has doubled every two years

Our World in Data

Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years.
This advancement is important for other aspects of technological progress in computing – such as processing speed or the price of computers.

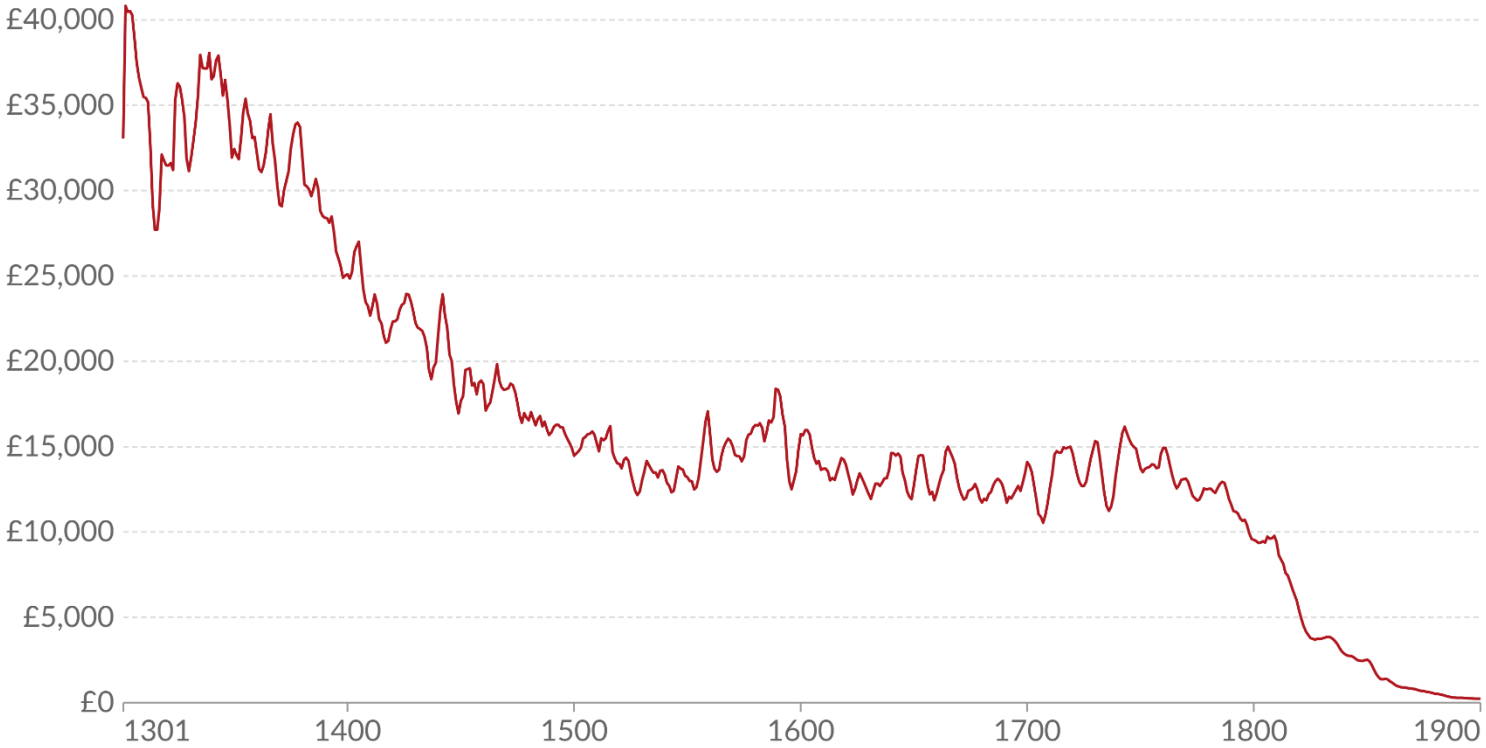


Data source: Wikipedia (wikipedia.org/wiki/Transistor_count)

The price for lighting in the United Kingdom

Our World in Data

The price per million lumen-hours in British Pound. 1 lumen-hour is equal to the luminous energy emitted in 1 hour by a light source emitting a luminous flux of 1 lumen. For comparison: a standard 100W incandescent light bulb emits around 1700 lumen.



Data source: Fouquet and Pearson (2012)

OurWorldInData.org/light-at-night | CC BY

Note: The price is adjusted for inflation and expressed in prices for the year 2000. Shown is a 5-year moving average.

The price for lighting in the United Kingdom

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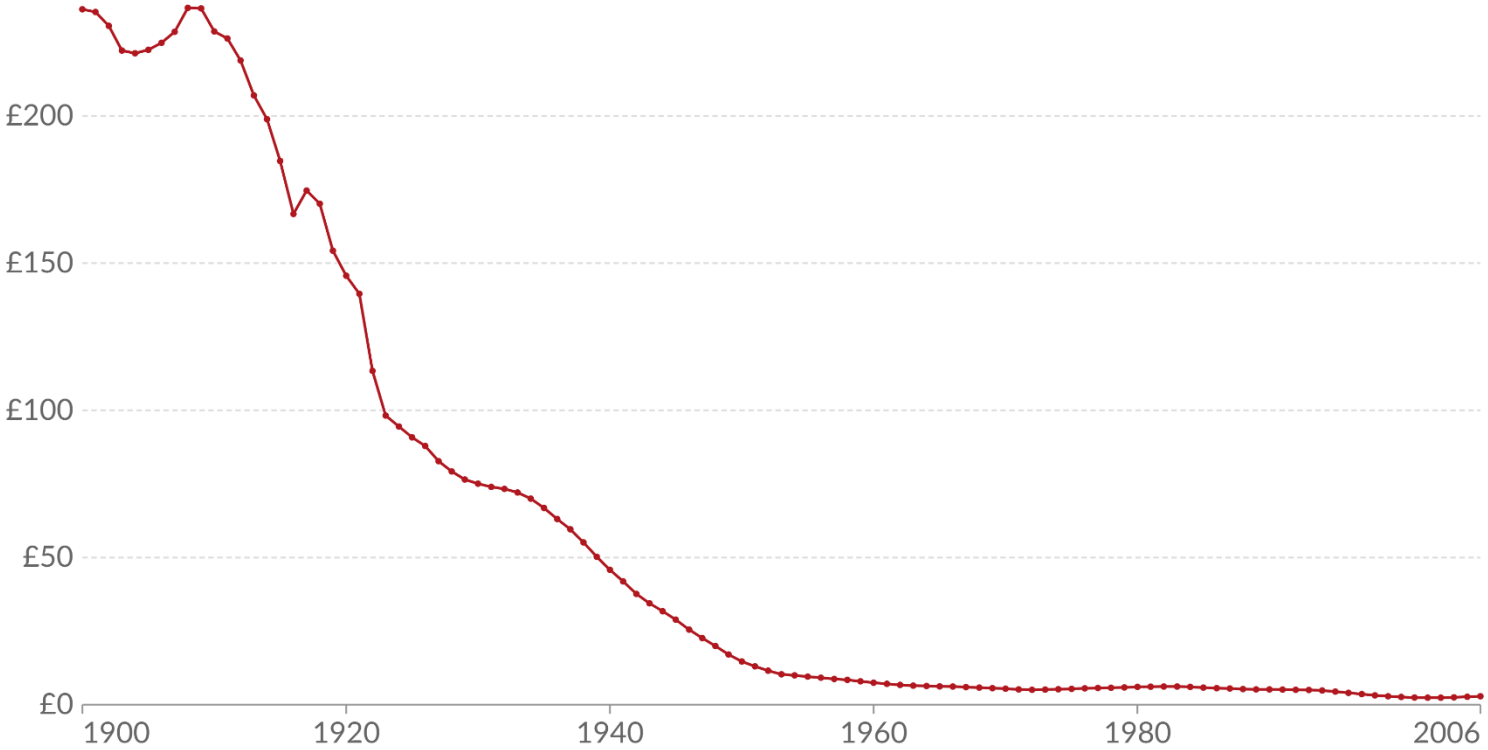


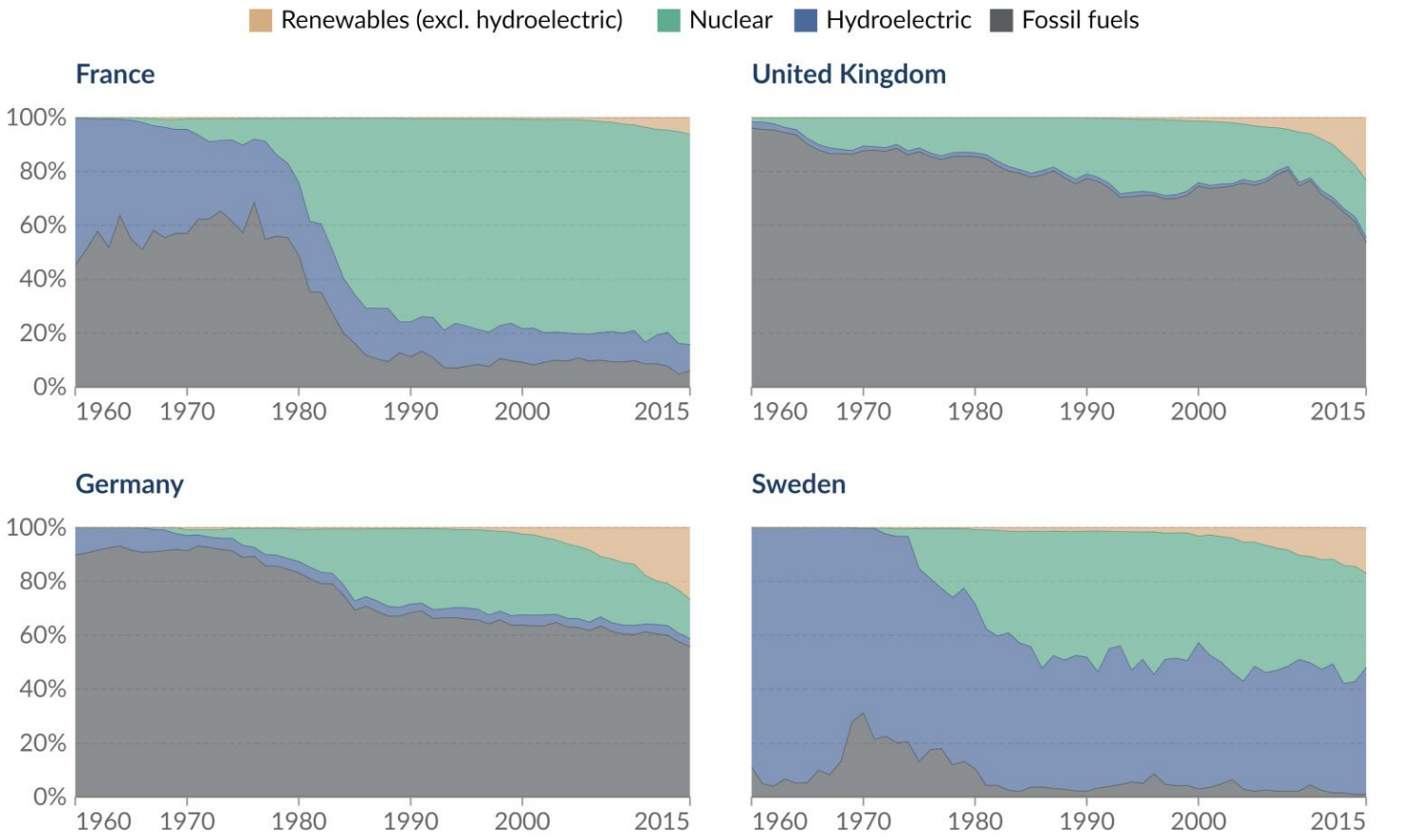
Data source: Fouquet and Pearson (2012)

OurWorldInData.org/light-at-night | CC BY

Note: The price is adjusted for inflation and expressed in prices for the year 2000. Shown is a 5-year moving average.

Electricity production by source, 1960 to 2015

Our World in Data



Data source: International Energy Agency (via World Bank)

OurWorldInData.org/electricity-mix | CC BY

Europe | Energie-wander

Angst mounts over Germany's green transition

Meeting its targets looks hard

IMAGE: GETTY IMAGES

Sep 21st 2023 | BERLIN

WHEN ROBERT HABECK, co-leader of the Green party and the economy tsar in Germany's ruling coalition, floated a bill last spring that mandated replacing gas and oil boilers with cleaner heat pumps, he got more heat than he bargained for. Tabloids screamed his "heat hammer" would push millions into debt. Whipped-up fury against "Green fascism" boosted ratings for the hard-right Alternative for Germany (AfD) party. The minister spent much of the summer tweaking his bill. His patience paid off. In early September the Bundestag passed it by a cosy 397-275 votes.

FEATURED

Sweden abandons 100% renewable energy goal as EU reconsiders climate policies

By Shaun Polczer Jun 24, 2023

Courtesy investopedia.com

By Dave Naylor

They're baaack!

More than 40 years after the country voted to phase out nuclear power, Sweden is now looking to build more nuclear reactors after its parliament formally abandoned its 100% renewable energy target to meet net-zero by 2045.

On Tuesday the country modified its net zero targets to 100% "fossil-free" which its right-leaning government creates the conditions for the return of nuclear power to the country's energy mix.

HEARD ON THE STREET

Clean Energy's Latest Problem Is Creaky Wind Turbines

Shares in Siemens Energy plunged by a third after it said turbine components are degrading faster than expected

By Carol Ryan Follow

June 23, 2023 10:36 am ET

Share Resize Listen (2 min)

Clean Energy's Latest Problem Is Creaky Wind Turbines

THE WALL STREET JOURNAL.

Shares in Siemens Energy plunged by a third after it said turbine components are degrading faster than expected

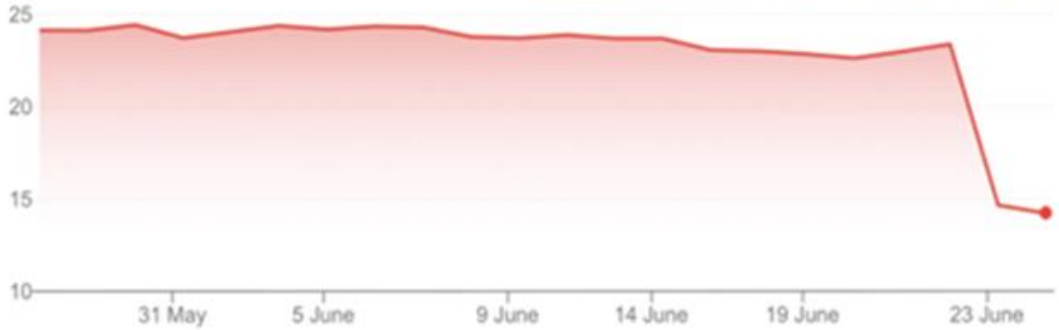
Market Summary > Siemens Energy AG

14.22 EUR

-9.95 (-41.16%) ↓ past month

26 June, 10:08 am GMT+2 • Disclaimer

1D | 5D | 1M | 6M | YTD | 1Y



Energy | Fuel Oil | Wind

Siemens Energy shares slide 39% after company seeks guarantees from German govt

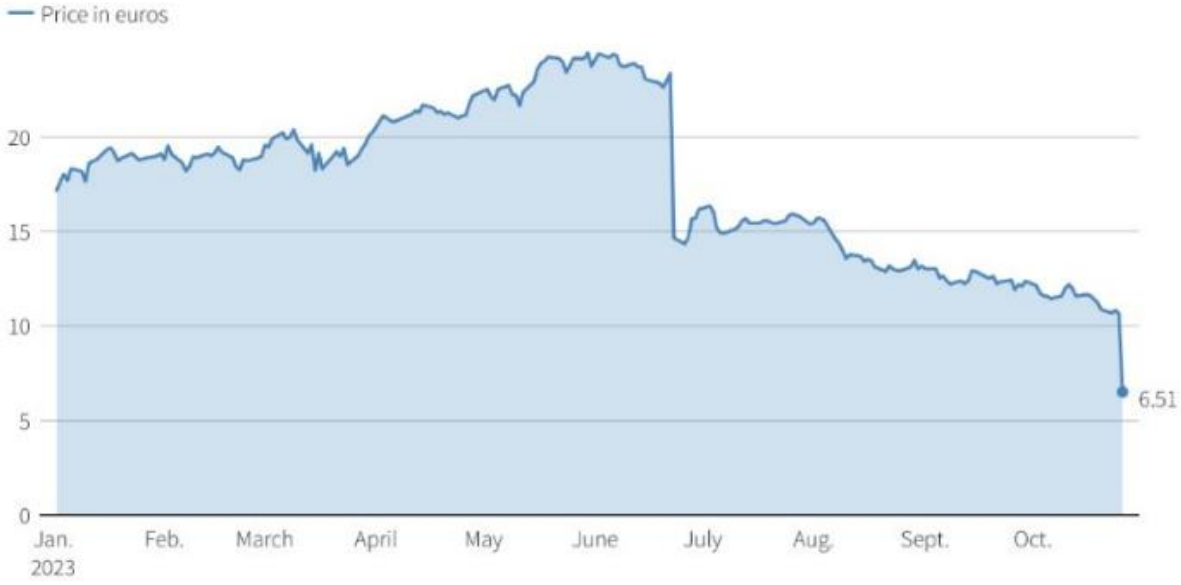
Reuters

October 26, 2023 6:45 AM CDT · Updated 10 min ago

The logo of energy technology company Siemens Energy is displayed during the LNG 2023 energy trade show in Vancouver, British Columbia, Canada, July 12, 2023. REUTERS/Chris Helgren/File Photo *Acquire Licensing Rights*

Siemens Energy shares

Shares of the power engineering company plunged after it revealed it was in talks with the German government about state guarantees.



Source: LSEG | Reuters, Oct. 26, 2023 | By Tom Sims

pv magazine

Weekend Read: A 10 GW time bomb

It is estimated that 10 GW of solar modules in Germany suffer from prematurely aging backsheets, with sites of all sizes affected. **pv magazine Germany**'s **Cornelia Lichner** looks at how to detect and repair such defects.

SEPTEMBER 9, 2023 CORNELIA LICHNER

INSURANCE MODULES & UPSTREAM MANUFACTURING QUALITY UTILITY SCALE PV GERMANY

If the back foil tears, it is only a matter of time before the stability of a module fails completely.

Photo: Bernhard Weinreich, HaWe Engineering

ParisTech REVIEW

ABOUT US

INDUSTRIES BUSINESS SOCIETY SCIENCE & TECHNOLOGY

The German solar energy crisis: looking for the right incentive scheme

ParisTech Review / Editors / April 13th, 2012

green economy renewable energy technology adoption technology and business

The German photovoltaic industry is in chaos. Overwhelmed by the boom of solar home systems, the government has had to brutally halt subsidies whose costs were threatening to... go through the roof. Caught between Chinese competition and the falling price of solar panels, several of the flagships of this young industry are now on the brink of bankruptcy. After having enjoyed a heyday of several years, the sector suddenly has to adjust to new conditions. And, if it hopes to recover, must adapt.

3. Sustainable Development

27. Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits - not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organization can be both managed and improved to make way for a new era of economic growth. The Commission believes that widespread poverty is no longer inevitable. Poverty is not only an evil in itself, but sustainable development requires meeting the basic needs of all and extending to all the opportunity to fulfil their aspirations for a better life. A world in which poverty is endemic will always be prone to ecological and other catastrophes.

να καλύπτουμε τις ανάγκες του παρόντος χωρίς να υπονομεύουμε τις ανάγκες του μέλλοντος

Fragments of wind turbine blades await burial at the Casper Regional Landfill in Wyoming. *Photographer: Benjamin Rasmussen for Bloomberg Green*

Green | Energy & Science

Wind Turbine Blades Can't Be Recycled, So They're Piling Up in Landfills


© Benjamin Rasmussen/Getty Images

ENVIRONMENT FEBRUARY 15, 2021 / 5:05 AM / UPDATED 3 YEARS AGO

Icy weather chills Texas wind energy as deep freeze grips much of U.S.

By Steve Gorman

3 MIN READ

(Reuters) - Ice storms knocked out nearly half the wind-power generating capacity of Texas on Sunday as a rare deep freeze across the state locked up turbine towers while driving electricity demand to record levels, the state's grid operator reported.

RENEWABLE ENERGY Published February 15, 2021 7:07pm EST

Texas electric grid operator says frozen wind turbines are hampering state's power output: report

Over 2.5 million people in Texas have been left without power from the storm's frigid temperatures

SCIENCE • CLIMATE

The Texas Winter Storm And Power Outages Killed Hundreds More People Than The State Says

A BuzzFeed News analysis shows the catastrophic failure of Texas's power grid in February killed hundreds of medically vulnerable people.


Peter Aldhous
BuzzFeed News Reporter


Stephanie M. Lee
BuzzFeed News Reporter


Zahra Hirji
BuzzFeed News Reporter

Posted on May 27, 2021 at 1:09 am

View 56 comments

The true number of people killed by the disastrous winter storm and power outages that devastated Texas in February is likely four or five times what the state has acknowledged so far. A BuzzFeed News data analysis reveals the hidden scale of a catastrophe that trapped millions of people in freezing darkness, cut off access to running water, and overwhelmed emergency services for days.

The state's tally currently stands at 151 deaths. But by looking at how many more people died during and immediately after the storm than would have been expected — an established method that has been used to count the full toll of other disasters — we estimate that 700 people were killed by the storm during the week with the worst power outages. This astonishing toll exposes the full consequence of officials' neglect in preventing the power grid's collapse despite repeated warnings of its vulnerability to cold weather, as well as the state's failure to reckon with the magnitude of the crisis that followed.

Αναφορές (1)

- Μαμάσης Ν. Η τραγωδία του ενεργειακού μίγματος στην Ελλάδα. Από την ανάπτυξη στην εξάρτηση https://youtu.be/u8xXq8J6SEE?si=DNvm6FwDwC_v5vqo
- Moath Jarrah, Modeling and Simulation of Renewable Energy Sources in Smart Grid Using DEVS Formalism, Procedia Computer Science, Volume 83, 2016, Pages 642-647, ISSN 1877-0509, https://doi.org/10.1016/j.procs.2016.04.144
- Modern renewable energy generation by source, World https://ourworldindata.org/grapher/modern-renewable-prod
- Global primary energy consumption by source https://ourworldindata.org/grapher/global-energy-substitution
- How much electricity do solar panels produce? https://www.nea.org.uk/who-we-are/innovation-technical-evaluation/solarpv/how-much-electricity-solar-produce/
- Anvari, M., Proedrou, E., Schäfer, B. et al. Data-driven load profiles and the dynamics of residential electricity consumption. Nat Commun 13, 4593 (2022). https://doi.org/10.1038/s41467-022-31942-9
- William Zappa, Machteld van den Broek, Analysing the potential of integrating wind and solar power in Europe using spatial optimization under various scenarios, Renewable and Sustainable Energy Reviews, Volume 94, 2018, Pages 1192-1216, ISSN 1364-0321, https://doi.org/10.1016/j.rser.2018.05.071
- What is Pumped Hydro https://youtu.be/_PH0IJ-_qOI?si=o72cUgnvlP1RuVie
- Pumped Storage Hydropower | Department of Energy https://www.energy.gov/eere/water/pumped-storage-hydropower
- William Zappa, Machteld van den Broek, Analysing the potential of integrating wind and solar power in Europe using spatial optimisation under various scenarios, Renewable and Sustainable Energy Reviews, Volume 94, 2018, Pages 1192-1216, ISSN 1364-0321, https://doi.org/10.1016/j.rser.2018.05.071
- Sargentis, G.-F.; Siamparina, P.; Sakki, G.-K.; Efstratiadis, A.; Chiotinis, M.; Koutsoyiannis, D. Agricultural Land or Photovoltaic Parks? The Water–Energy–Food Nexus and Land Development Perspectives in the Thessaly Plain, Greece. Sustainability 2021, 13, 8935. https://doi.org/10.3390/su13168935

Αναφορές (2)

- The price of batteries has declined by 97% in the last three decades https://ourworldindata.org/battery-price-decline
- Electricity production by source https://ourworldindata.org/energy-mix
- Why did renewables become so cheap so fast? https://ourworldindata.org/cheap-renewables-growth
- Learning curves: What does it mean for a technology to follow Wright's Law? https://ourworldindata.org/learning-curve
- The Economist. Angst mounts over Germany's green transition https://www.economist.com/europe/2023/09/21/angst-mounts-over-germanys-green-transition
- Western Standard. Sweden abandons 100% renewable energy goal as EU reconsiders climate policies https://www.westernstandard.news/business/sweden-abandons-100-renewable-energy-goal-as-eu-reconsiders-climate-policies/article_c74a30be-11fd-11ee-a507-4b098c97c6f5.html
- WSJ Clean Energy's Latest Problem Is Creaky Wind Turbines https://www.wsj.com/articles/clean-energys-latest-problem-is-creaky-wind-turbines-9c865aa0?mod=e2tw
- Reuters. Siemens Energy shares slide 39% after company seeks state guarantees https://www.reuters.com/business/energy/siemens-energy-seeking-billions-euros-state-guarantees-wiwo-2023-10-26/
- PV magazine. Weekend Read: A 10 GW time bomb https://www.pv-magazine.com/2023/09/09/weekend-read-a-10-gw-time-bomb/
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- Reuters. Icy weather chills Texas wind energy as deep freeze grips much of U.S. https://www.reuters.com/article/us-usa-weather-idUSKBN2AF066
- Texas electric grid operator says frozen wind turbines are hampering state's power output: report https://www.foxbusiness.com/energy/texas-electric-grid-operator-says-frozen-wind-turbines-are-hampering-states-power-output-report