

The Astonishing Drop in Cost of Renewables: Can Economics Save the Climate?

CLS Marist GS4 & SS4 Sept. 28, 2022 Poughkeepsie NY Lect4: can Economics save climate?

- World 3C likely Future – 40C heat waves ramping till Net Zero CO2 achieved
 - Spectacularly Small Response over 40 years <0.3% of Gross Domestic Product (US & others)
- Disruptive Miracle: Wind, Solar, Battery costs fall exponentially
 - **Renewables are rushing in Breaking the bleak backdrop of the past 40 years**
- Renewables: 20% yearly increases, 755B\$ approaching 1% of World GDP
 - Major 2022 Reports: BloombergNEF Ember McKinsey IEA Renewables
 - Driven by China – Solar, Wind, Batteries, Control of Rare Earths, Congo Cobalt, Nickel, Copper
 - US just starting to follow: Surprise August 2022 passage of historic IRA emphasizing renewables
- **Perspective:**
 - Explosive growth of renewables – world going from budgetary rounding error amount 0.3% of GDP investment to almost 1% of GDP.
 - >7% of GDP needed to stabilize climate at whatever CO2 level the world arrives at, per McKinsey 2022 report

Renewables major progress! Short in magnitude by 7X But train has moved out of the station!



“The 3C Future”

Likely outcome under policies in place

<https://www.economist.com/briefing/2021/07/24/three-degrees-of-global-warming-is-quite-plausible-and-truly-disastrous>

Economist’s projected impact at 3C:

*Accelerated heating 3.5-5C Arctic, Russia, India, China

*Tropical nights America, Europe, Asia

Drives deaths from heatwaves

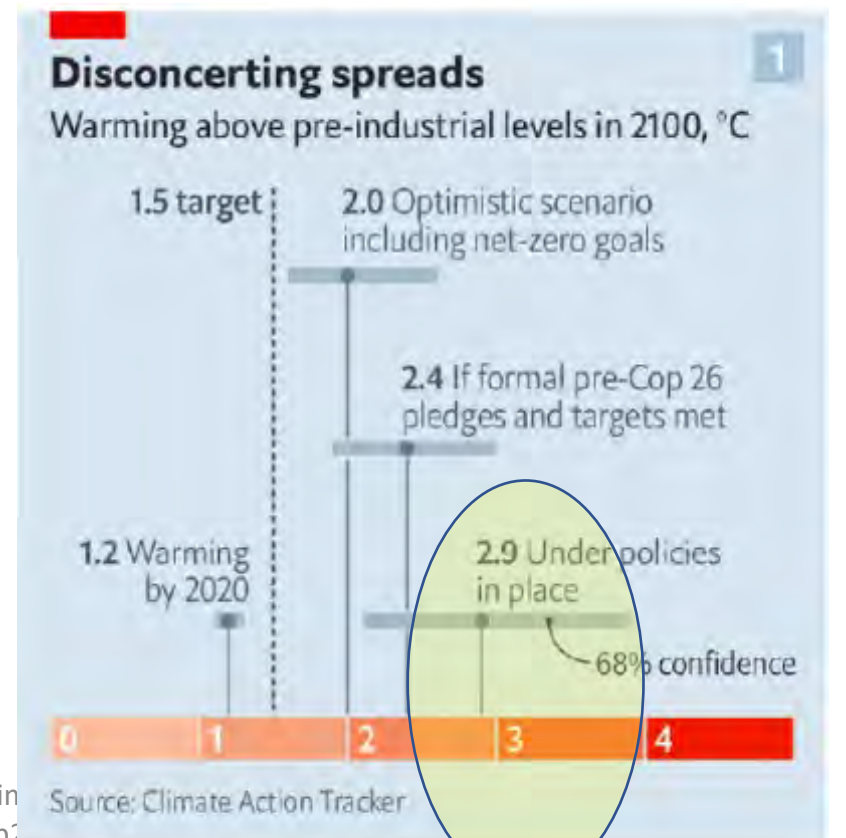
*Wet bulb temperatures become more common → 35C

*Exceptional 100 year drying → every 2-5 years

glimpsed by California’s megadrought

3C West Antarctica & Greenland, could break down quickly

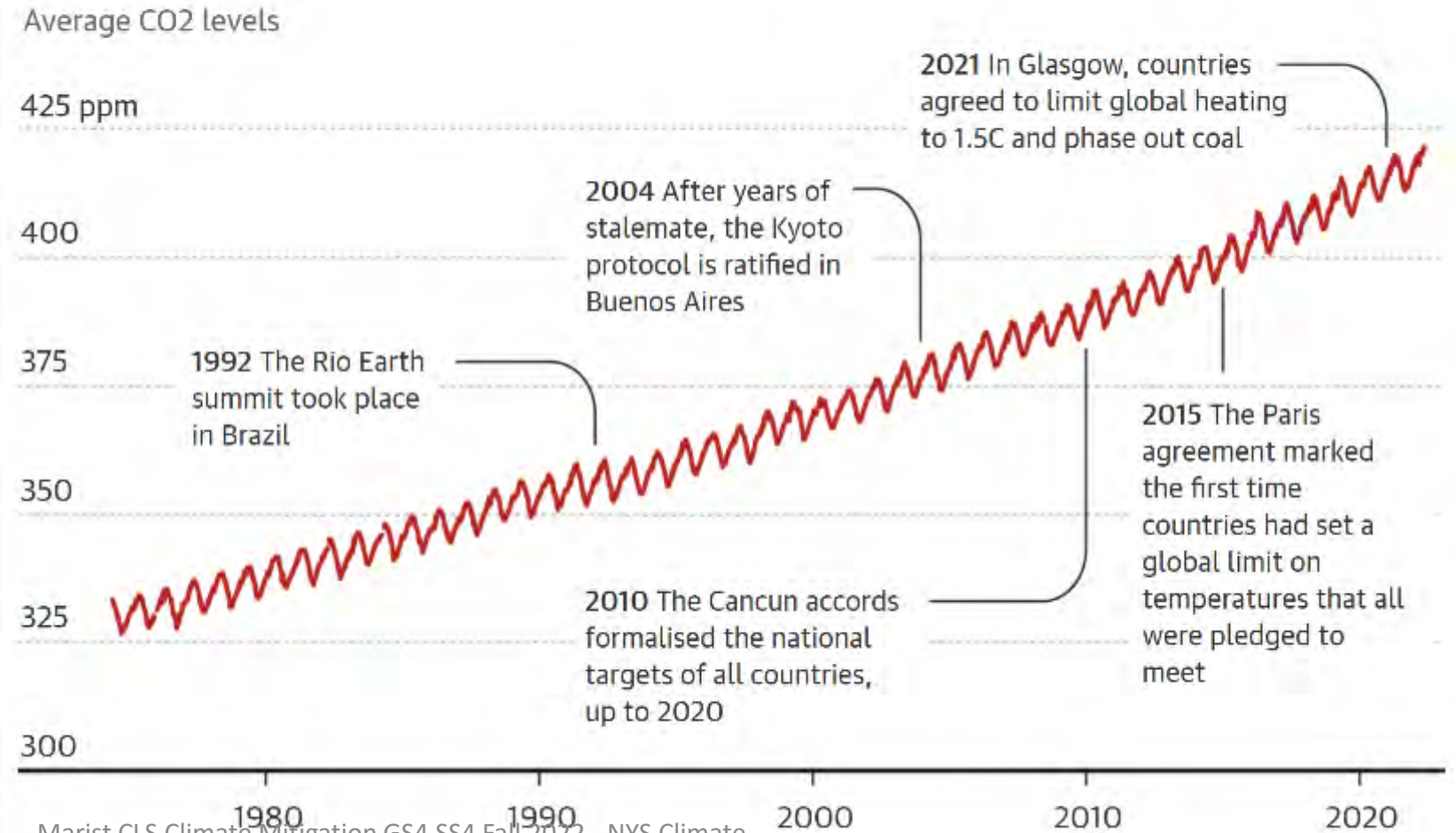
Disappearance of coral reefs, of Amazon rainforest



CO2 Levels since 1975 No Progress at All

<https://www.theguardian.com/environment/2022/jun/11/cop-climate-change-conference-30-years-highlights-lowlights>

Carbon emissions have continued rising over the past 30 years since the Rio Earth summit took place



Marist CLS Climate Mitigation GS4 SS4 Fall 2022 - NYS Climate Act & Astonishing Renewables Price Drop Version 29Sep2022
Guardian graphic. Source: NOAA
C. Parks For Personal Scholarship Only

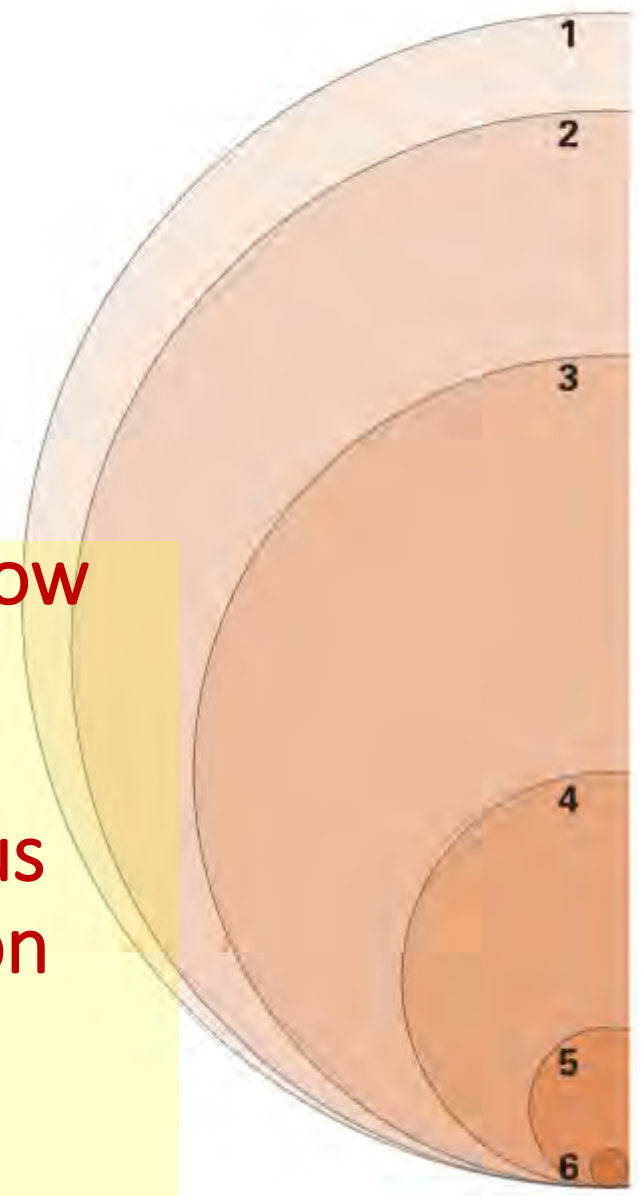


ONE BILLION CHILDREN AT 'EXTREMELY HIGH RISK' OF THE IMPACTS OF THE CLIMATE CRISIS –UNICEF

<https://www.unicef.org.uk/press-releases/onebillion-children-at-extremely-high-risk-of-the-impacts-of-the-climate-crisis-unicef/>
20Aug2021 'The Climate Crisis Is a Child Rights Crisis: Introducing the Children's Climate Risk Index'

It is not given to us to know what will happen a generation from now. Instead, projections tell us what problems to work on

We can and have to change the world



Almost every child on earth (>99 per cent) is exposed to **at least 1** of these major climate and environmental hazards, shocks and stresses.

2.2 billion children are exposed to **at least 2** of these overlapping climate and environmental hazards, shocks and stresses.

1.7 billion children are exposed to **at least 3** of these overlapping climate and environmental hazards, shocks and stresses.

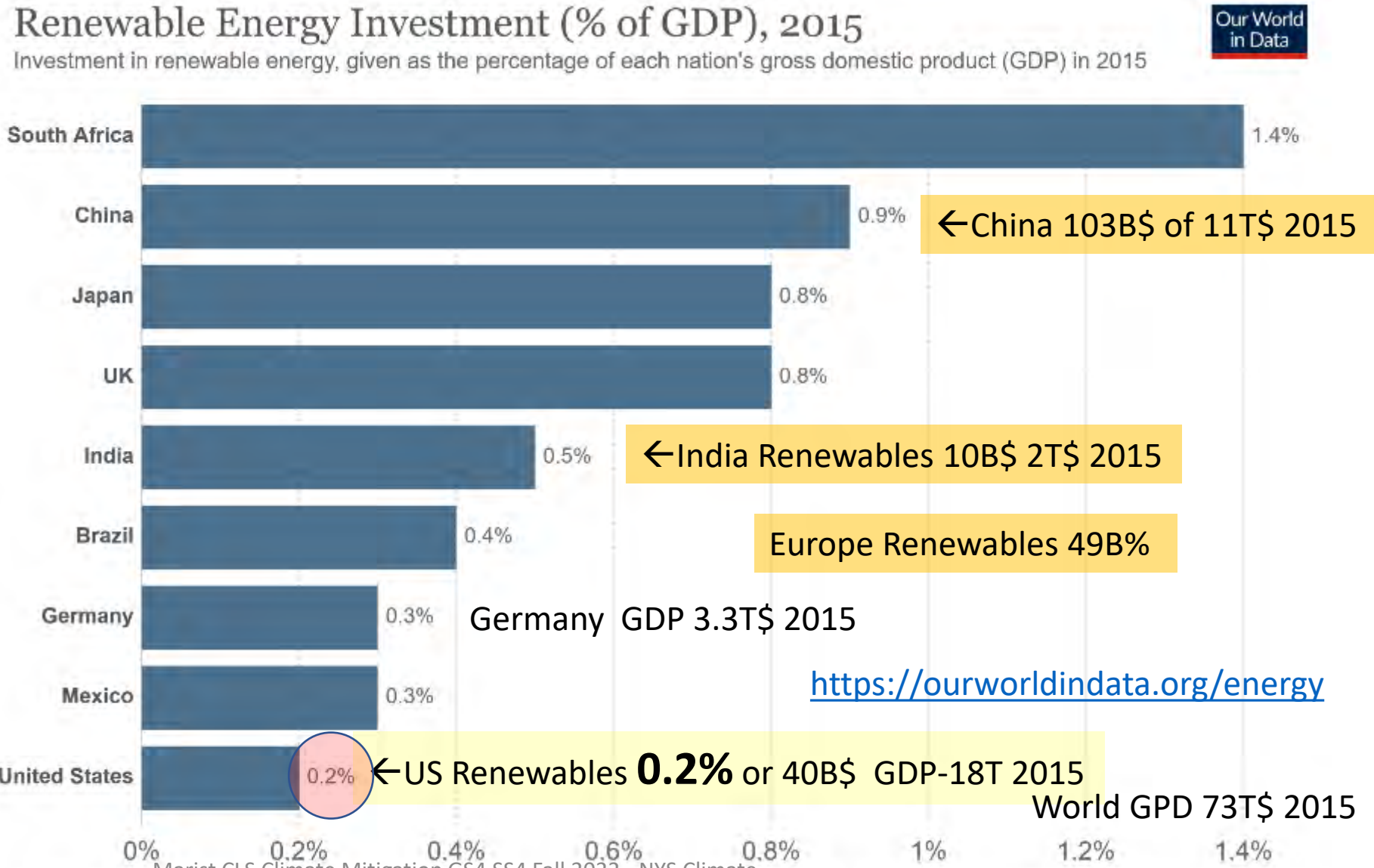
850 million children are exposed to **at least 4** of these overlapping climate and environmental hazards, shocks and stresses.

330 million children are exposed to **at least 5** of these overlapping climate and environmental hazards, shocks and stresses.

80 million children are exposed to **at least 6** of these overlapping climate and environmental hazards, shocks and stresses.



Point of this slide: show tiny (0.3% GDP) world investment in renewables over past 40 years



Climate efforts past 40 years tiny relative to economy size

All renewables efforts of past 40 years extremely tiny compared to economy size in 2015 as percentages of GDP: **Germany-0.3% **US-0.2%** **China-0.9%****

Inflation Reduction Act IRA of Aug. 2022 – tiny compared to economy size
0.19% of Gross Domestic Product of 20 trillion

3% of US Energy Expenditure's of 1.2T\$ in 2017 from EIA

New York State Climate Plan – also tiny compared to NY State economy size

- **Net costs are small relative to economy's size: \$15 billion, or .6% - .7% of Gross State Product (GSP) in 2030; \$45 billion, or 1.4% of GSP in 2050.**
Net costs are small relative to economy's size.

McKinsey report 26Jan2022, unflinching about costs needed for Net Zero
9.2 T\$ or 10% of world GDP



755B\$ World low Carbon Investment in 2021

World GDP 84,710B\$ 2020

Investment is 0.89% of World GDP much higher than past 40 years

Energy Transition Investment by Country

The top 10 countries together invested \$561 billion in the energy transition, nearly three-fourths of the world total.

Country	2021 Energy Transition Investment (US\$)	% of World Total
China 🇨🇳	\$266B 17.7T\$ → 1.5% of GDP China	35.2%
U.S. 🇺🇸	\$114B 22.99T\$ → 0.49% US	15.1%
Germany 🇩🇪	\$47B 4.4T\$ → 1.1% Germany	6.2%
U.K. 🇬🇧	\$31B 3187B\$ → 1.1% UK	4.1%
France 🇫🇷	\$27B 2937B\$ → 0.92% France	3.6%
Japan 🇯🇵	\$26B 4937B\$ → 0.52% Japan	3.4%
India 🇮🇳	\$14B 3050B\$ → 0.46% India	1.9%
South Korea 🇰🇷	\$13B	1.7%
Brazil 🇧🇷	\$12B	1.6%
Spain 🇪🇸	\$11B	1.5%
Total	\$561B 96T\$	74.3%

* /0.75 → 748T\$ 96T → 0.77% World

China increased its overall energy transition investment by 60% from 2020 levels, further cementing its position as a global leader. The country's wind and solar capacity increased by 19% in 2021, with electrified transport also accounting for a large portion of the investment.

Energy transition investment higher than the past 40 years!

Now approaching 1% of world or country GDP

Think a much higher level (7%) of investment needed to change climate outcome!

Spiritual Problem Highlighted by Economics

Spending as fraction of Gross Domestic Product

- “Stadium” of 15,000 children die each day
 - Official Development Aid ODA is 0.2% of Gross Domestic Product
- Lack of concern for those not yet born
 - Renewables spending 0.3% of GDP for past forty years
- As a boy I saw decisions yielding 1 billion cumulative tobacco deaths in 100 years
- Upon retiring I examined my own charitable spending as ratio of salary
A Tolstoy self examination https://en.wikipedia.org/wiki/The_Death_of_Ivan_Ilyich
the spiritual problem is not “out there”
 - Charities a small percentage of my income
<https://www.givewell.org/> save a life for \$4000
 - Wrote **“Ethical Vision with Math at its Center”** and ongoing “Humanity’s Future” series
- Our society makes terrible choices. But also makes exceptionally good choices.
A paradoxical trend to greater world flourishing over past 200 years: a billion rise out of deep poverty <https://www.gapminder.org/factfulness-book/>



Distant Suffering Problem & Invisible Hand

Enlightenment Economist Adam Smith's economic solution to the problem of suffering
Ferociously powerful Enlightenment ethics – reaches billions by bypassing our crippling empathy gap

Adam Smith, Theory of Moral Sentiments, part 3 chapter 1

https://en.wikiquote.org/wiki/Adam_Smith "Wealth of Nations" all time most important economics book

... Let us suppose that the great empire of China, with all its myriads of inhabitants, was suddenly swallowed up by an earthquake, and let us consider how a man of humanity in Europe, who had no sort of connection with that part of the world, would be affected upon receiving intelligence of this dreadful calamity. He would, I imagine, first of all, express very strongly his sorrow for the misfortune of that unhappy people,

... If he was to lose his little finger to-morrow, he would not sleep to-night; but, provided he never saw them, he will snore with the most profound security over the ruin of a hundred millions of his brethren, and the destruction of that immense multitude seems plainly an object less interesting to him, than this paltry misfortune of his own. ...

Climate Change – “Invisible Hand” addresses Future Suffering Problem

We've squandered forty years, the climate deteriorates and seems lost.

Fall of renewables prices – sudden renewables projects – the Invisible Hand

Disruptive Factor: Stunning drop in Renewables Prices;
Explosion of investment in renewables. We are following a new path

Cost vs. Installed Capacity

Miracle of astonishing drop in renewable prices

Learning curve – price drops with installed capacity

<https://ourworldindata.org/cheap-renewables-growth>

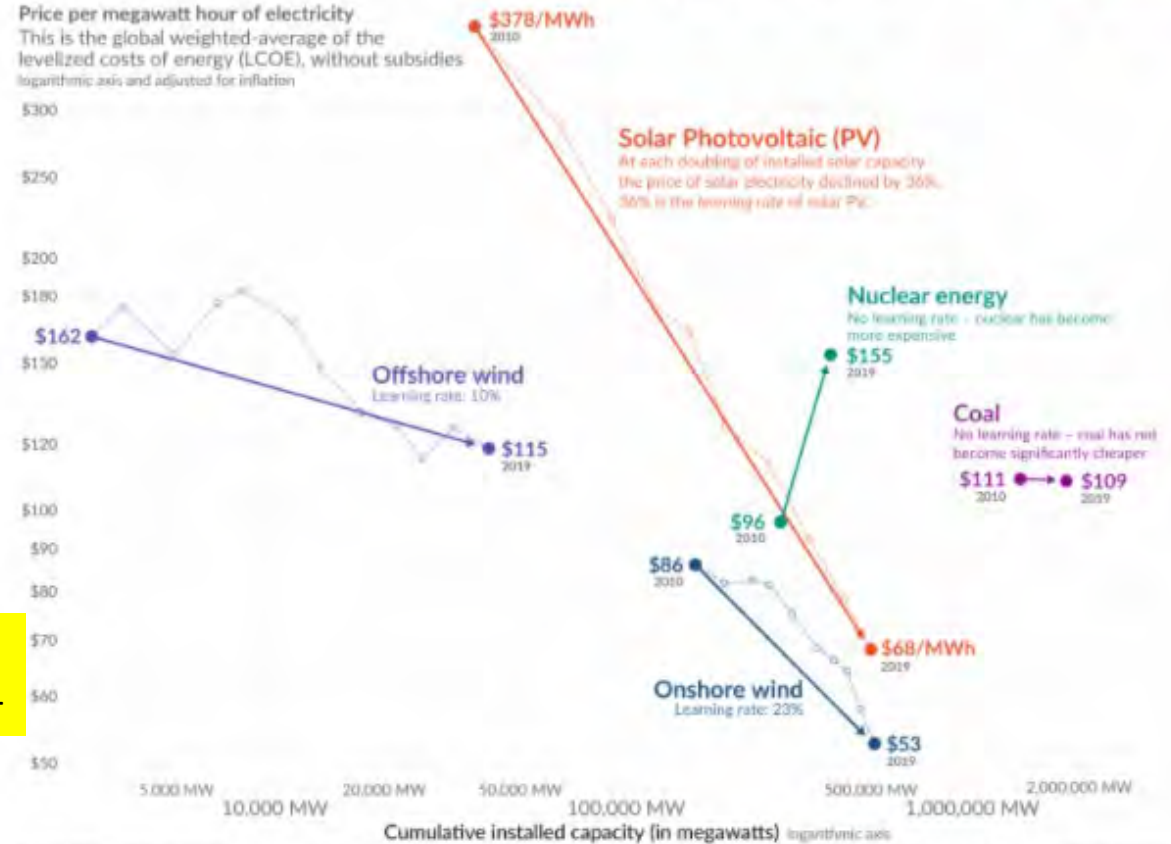
Dec. 2020 **Max Roser**

Very clear and important article – I suggest that you read, especially if you want a more positive outlook!

PRICE
\$378-----

Electricity from renewables became cheaper as we increased capacity – electricity from nuclear and coal did not

Our World in Data



PRICE
\$68-----

-----CUMULATIVE INSTALLED CAPACITY-----log scale-----
| 5000MW | 1000000 MW



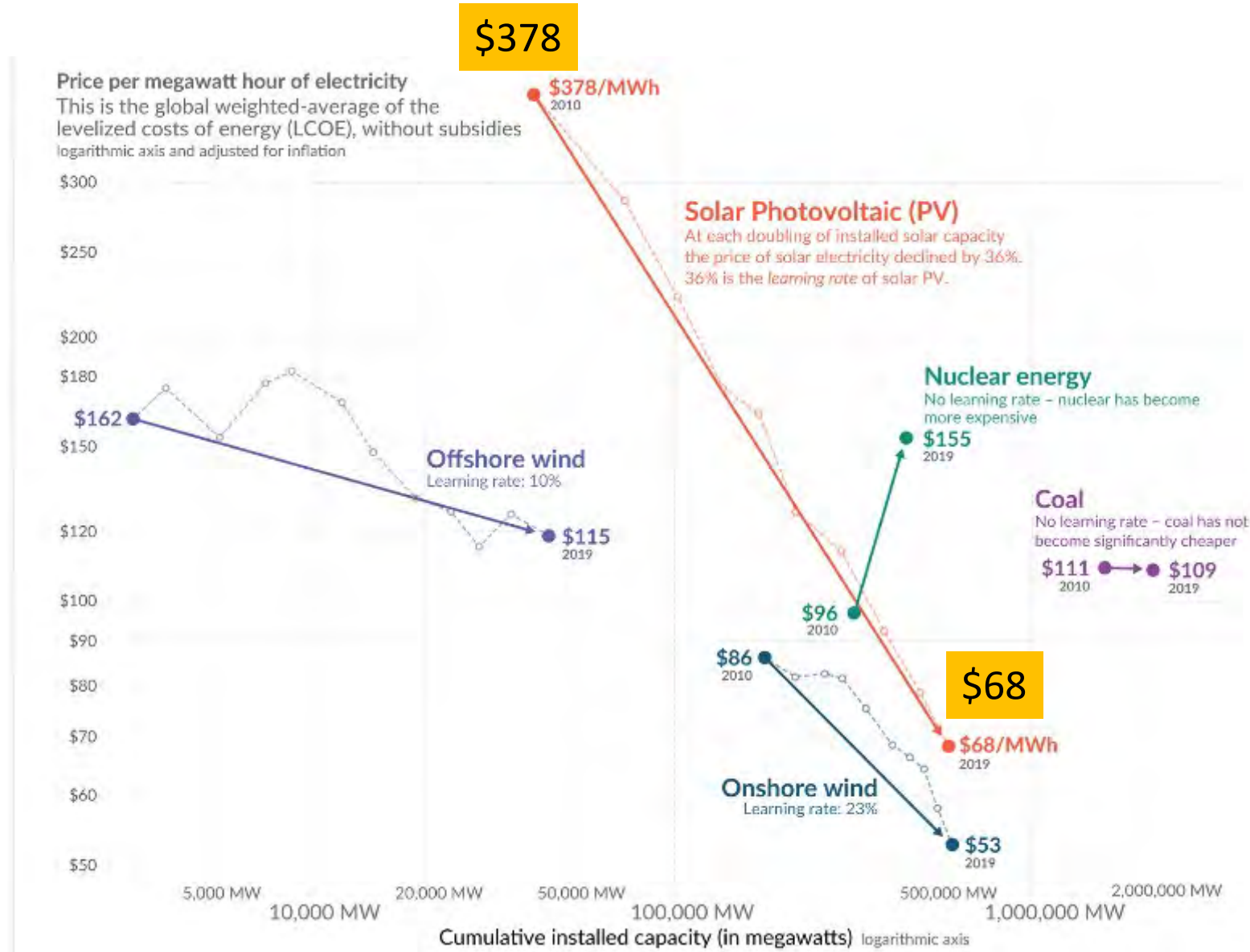
Logarithmic drop in Renewables Prices

PRICE

\$300----

\$100---

\$50--



| 5000

| 100,000

| 1million

INSTALLED CAPACITY = Experience



Lithium Batteries Prices

PRICE
\$5000-----

Diverse battery ecosystem
Prices dropping amidst boom bust cycles

Lithium

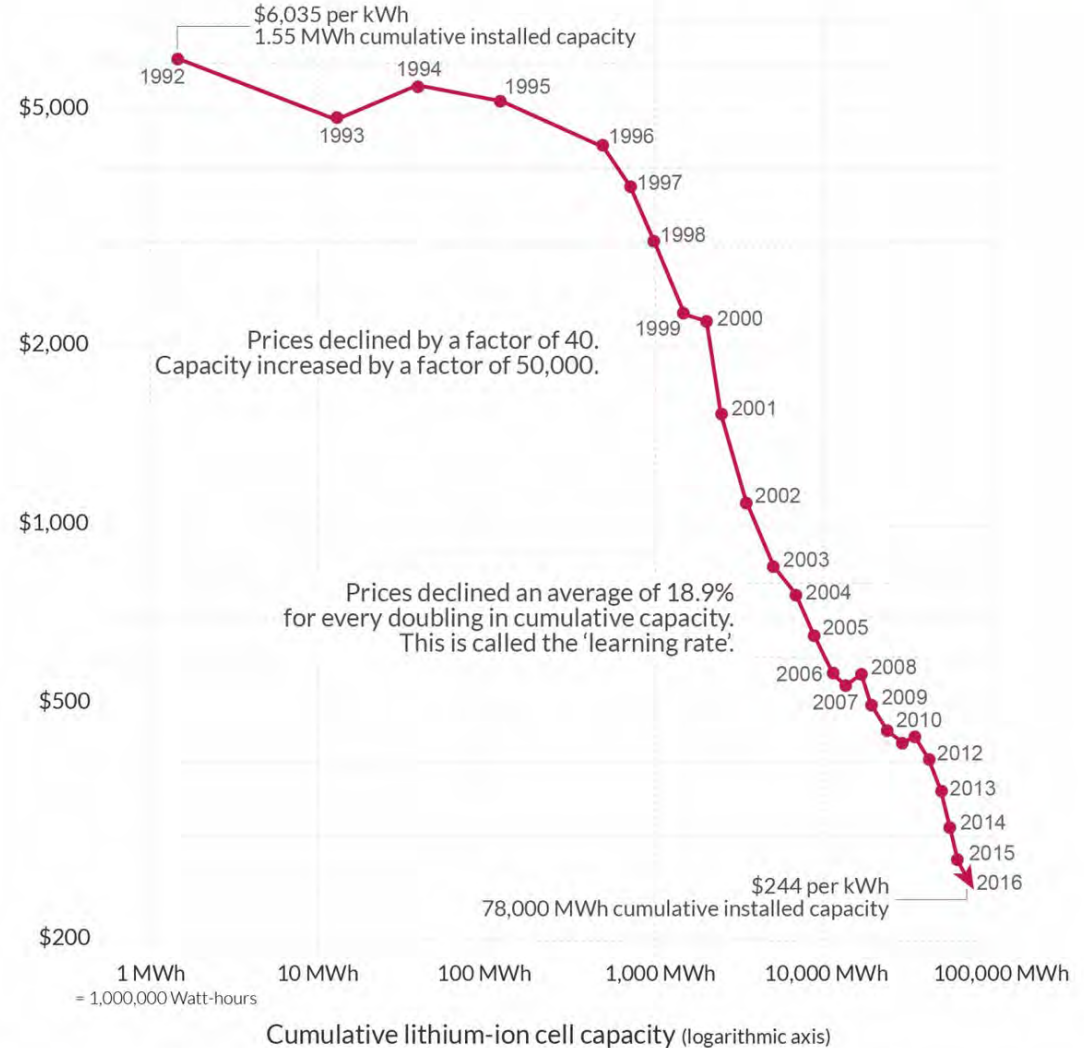
& non-posh metals flow-cell grid storage

PRICE
\$200-----

Price and market size of lithium-ion batteries since 1992



Price per kilowatt-hour; kWh (logarithmic axis)
\$10,000



CUMULATIVE Li-Ion Cell Capacity –log axis

<https://ourworldindata.org/cheap-renewables-growth>

Dec. 2020 Max Roser

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Prices are adjust
Source: Micah Zi
OurWorldinData

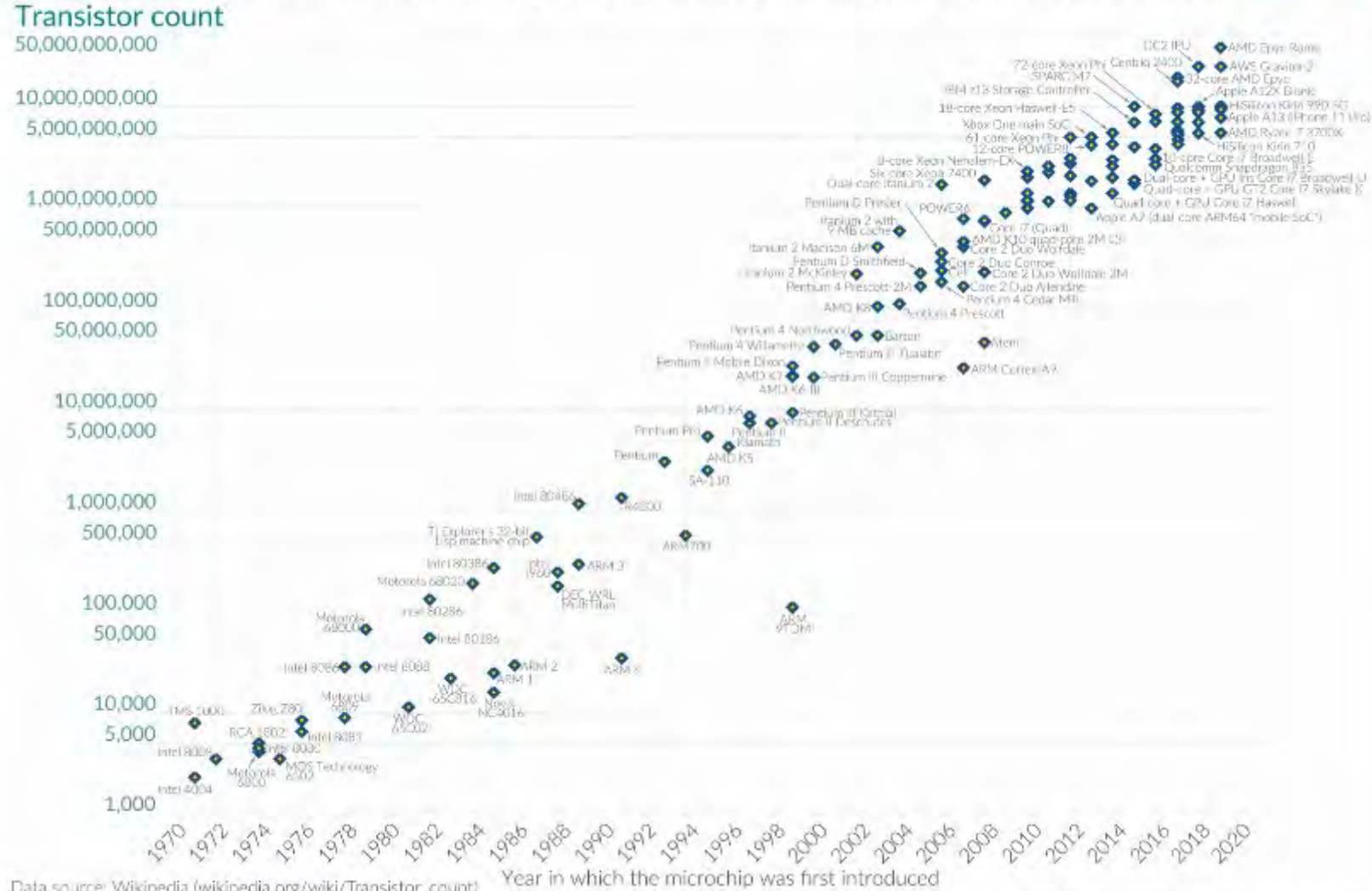


Moore's Law: The number of transistors on microchips doubles every two years

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.

Moore's Law and earlier Wright's Law
 Cost falls with **experience**

Transistor Count
 1000 bottom left
 50 million top left
 From 1970 to 2020



Data source: Wikipedia (wikipedia.org/wiki/Transistor_count)
 OurWorldInData.org – Research and data to make progress against the world's largest problems. Licensed under CC-BY by the authors Hannah Ritchie and Max Roser.

Point of this slide: Renewables Taking off suddenly because of cost drop

BloombergNEF

<https://about.bnef.com/energy-transition-investment/>
<https://assets.bbhub.io/professional/sites/24/Energy-Transition-Investment-Trends-Exec-Summary-2022.pdf>

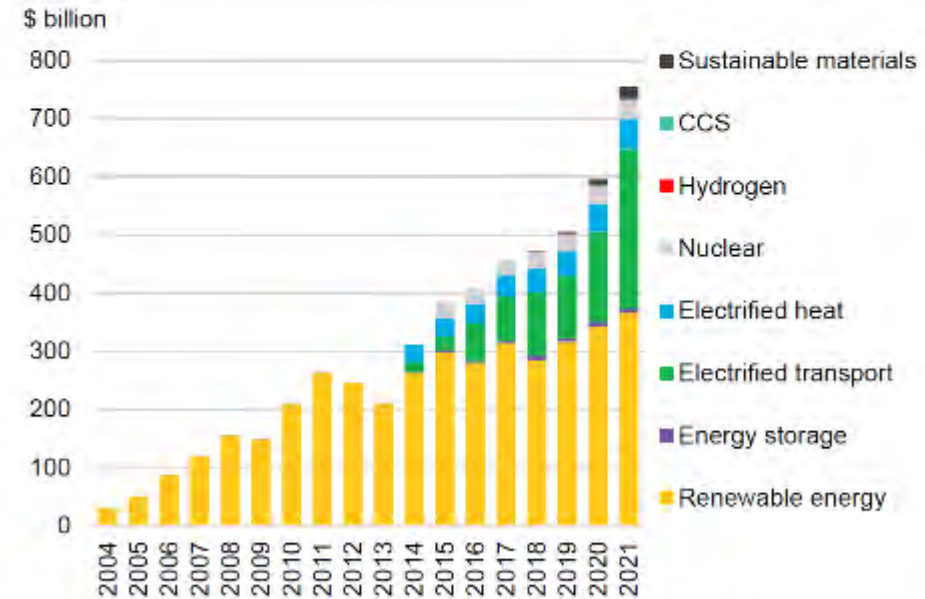
Renewables investment suddenly jumping from 0.3% GDP over past 40 years to 0.8% driven by Cost Drop

\$755 billion Global energy transition investment in 2021

\$165 billion Global climate-tech equity investment in 2021

27% Increase in energy transition investment 2020-2021

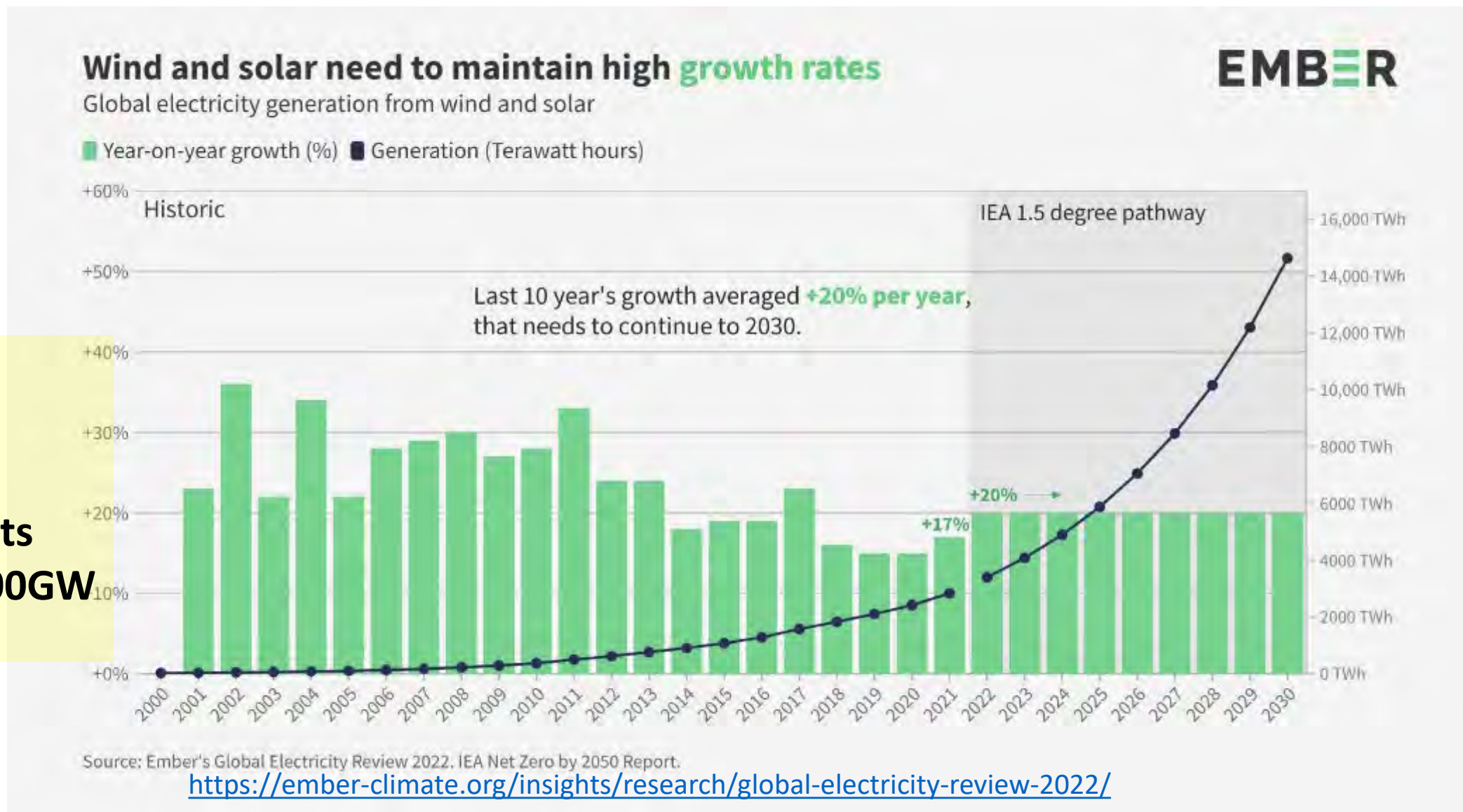
Global investment in energy transition by sector



Source: BloombergNEF. Note: start-years differ by sector but all sectors are present from 2019 onward; see Appendix for more detail.



Wind and Solar Growth Rates – extrapolated in hopeful manner

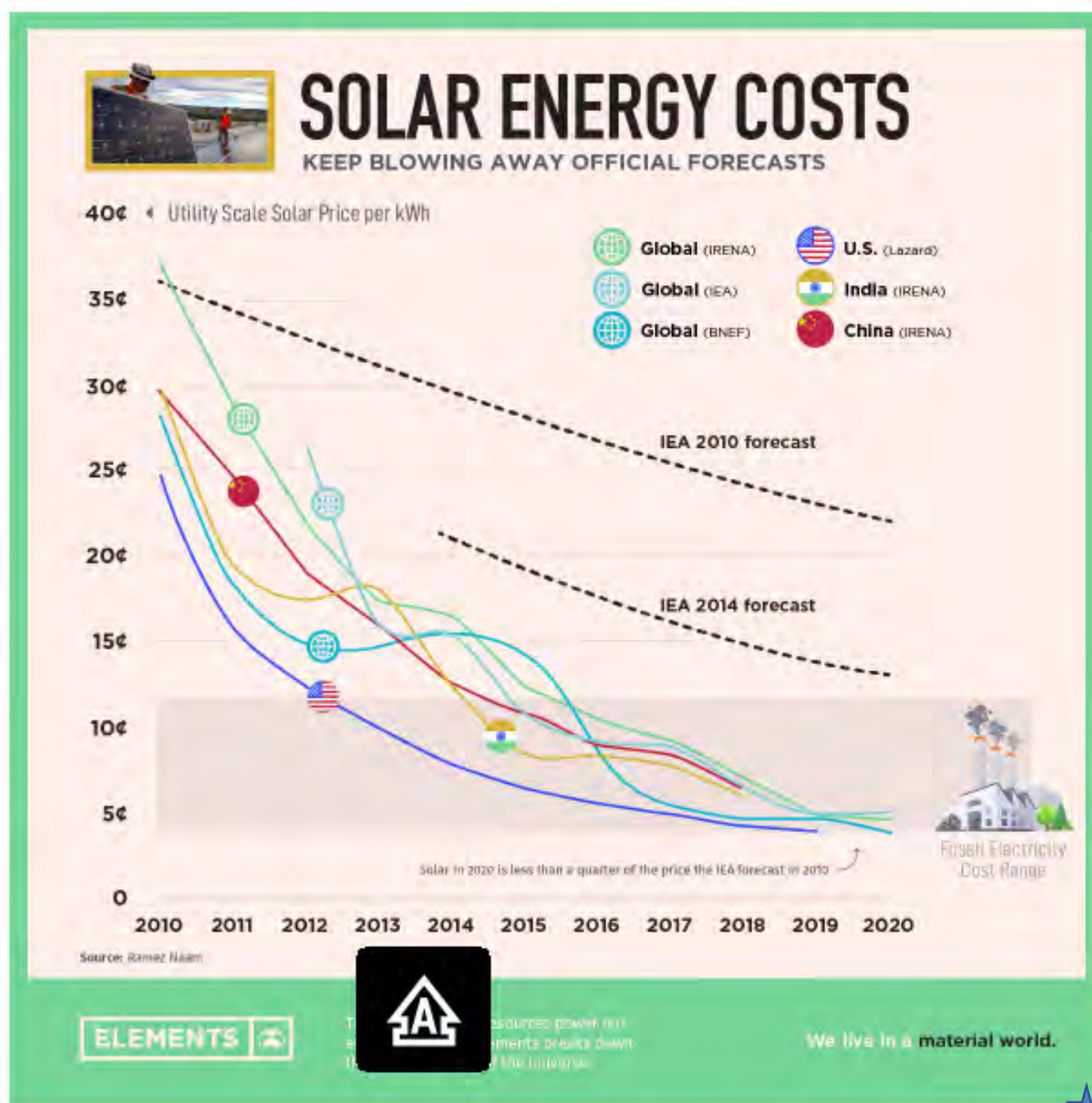


World Renewables

**2030 in TWatts
1.6TW or 1600GW
=14300/24/365**



<https://elements.visualcapitalist.com/the-exponential-view-of-solar-energy/>
25June2021



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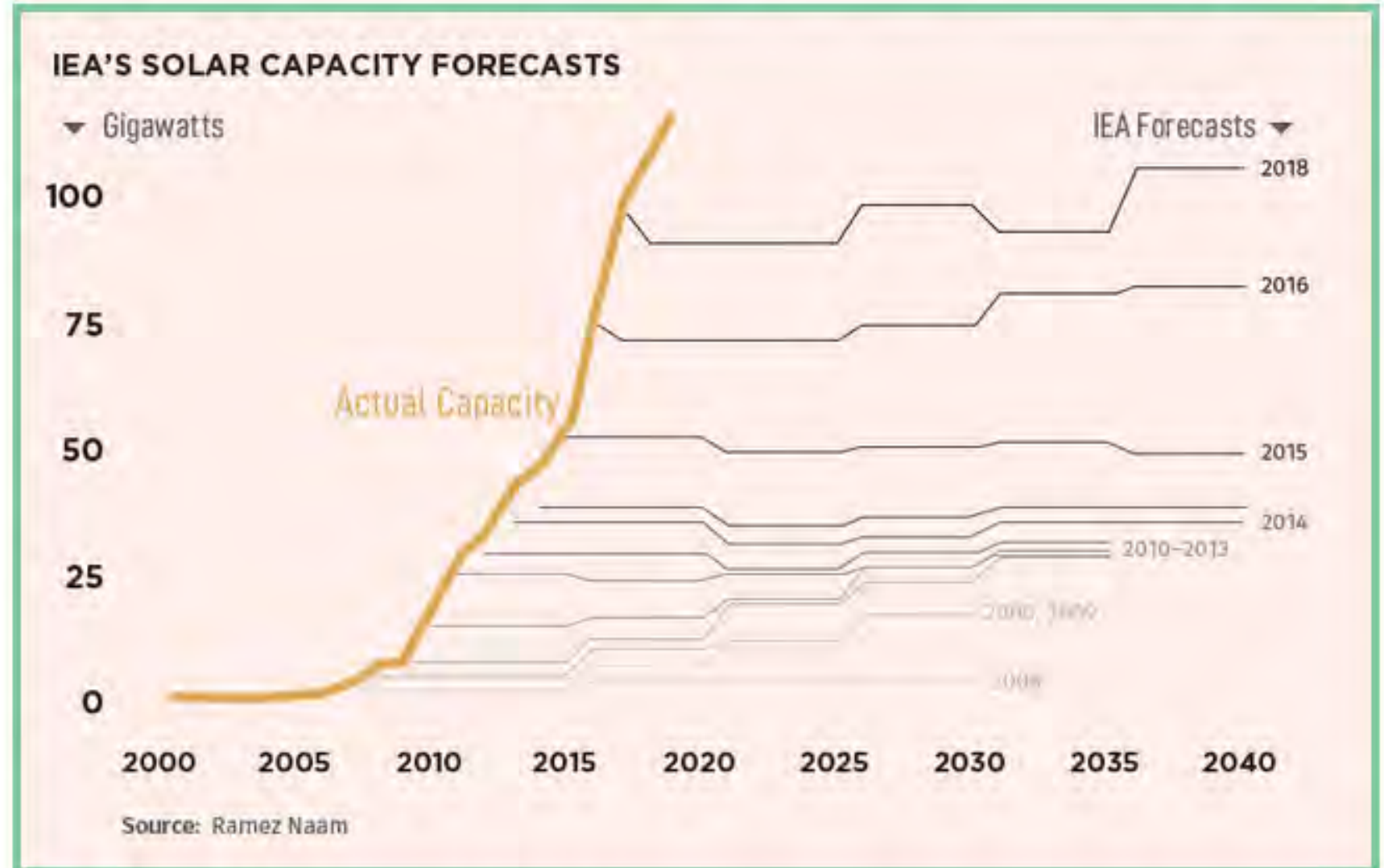
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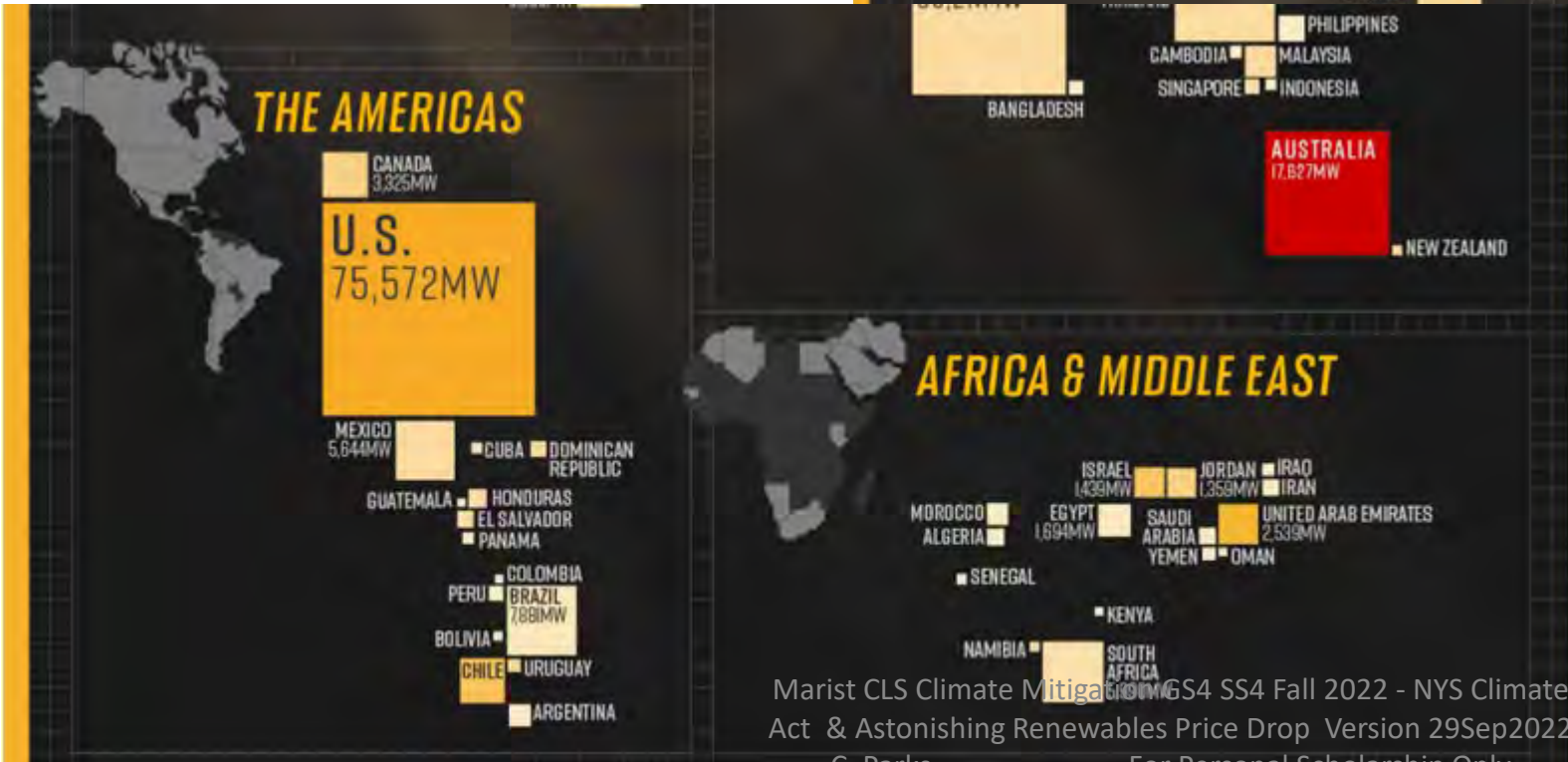
<https://elements.visualcapitalist.com/the-exponential-view-of-solar-energy/> 25June2021

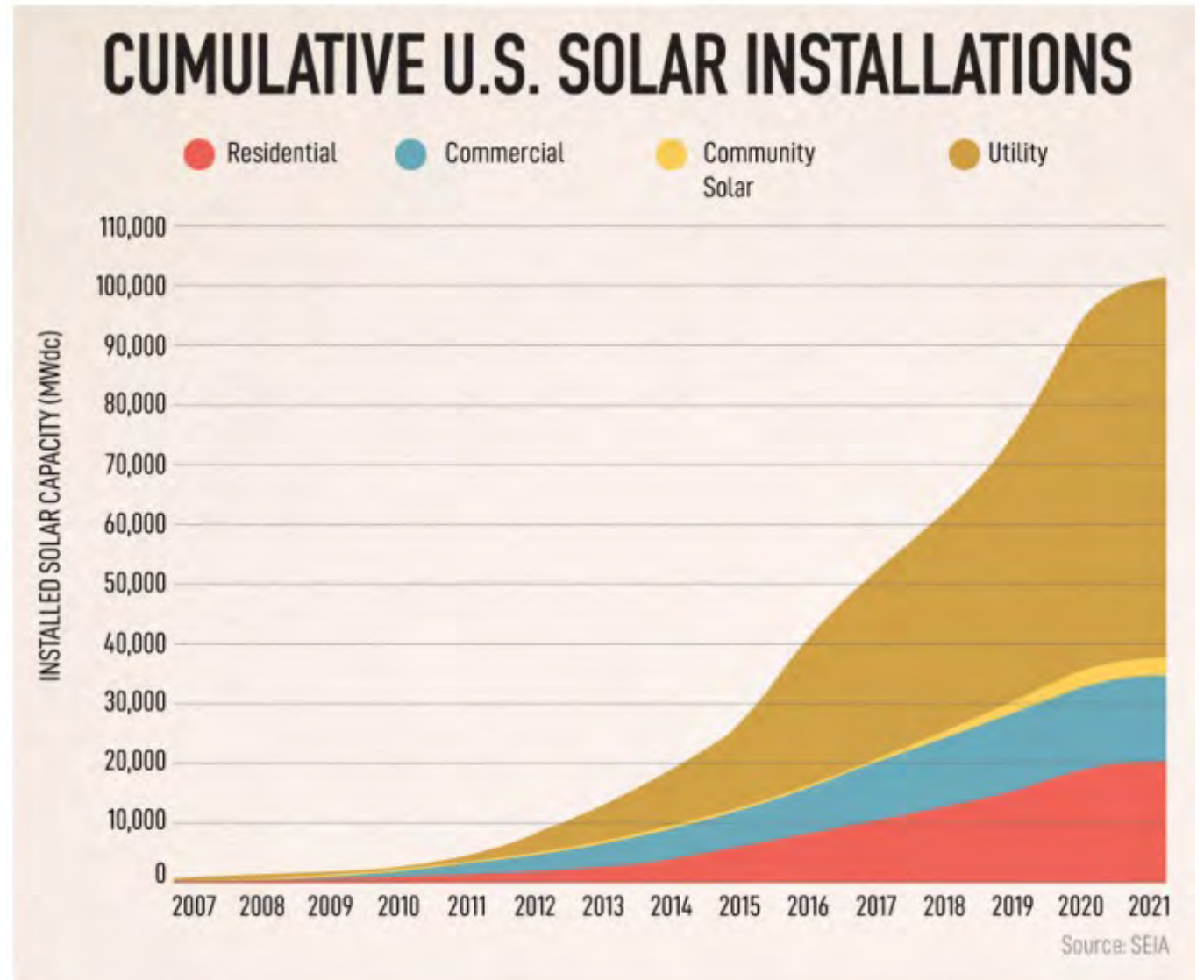
Underestimate Solar No More?

For fun, here's a final look at how IEA projections have constantly underestimated solar installations, which are one of the key factors dictating the "learning rate" under Wright's Law:



<https://elements.visualcapitalist.com/mapped-solar-power-by-country-in-2021/> 15Nov2021





<https://www.nrel.gov/docs/fy13osti/56290.pdf> Land-Use Requirements for Solar Power Plants in the United States June 2013

<https://www.energy.gov/eere/solar/solar-energy-united-states> Mitigation GS4 SS4 Fall 2022 - NYS Climate Act & Astonishing Renewables Price Drop Version 29Sep2022

generic, not dated

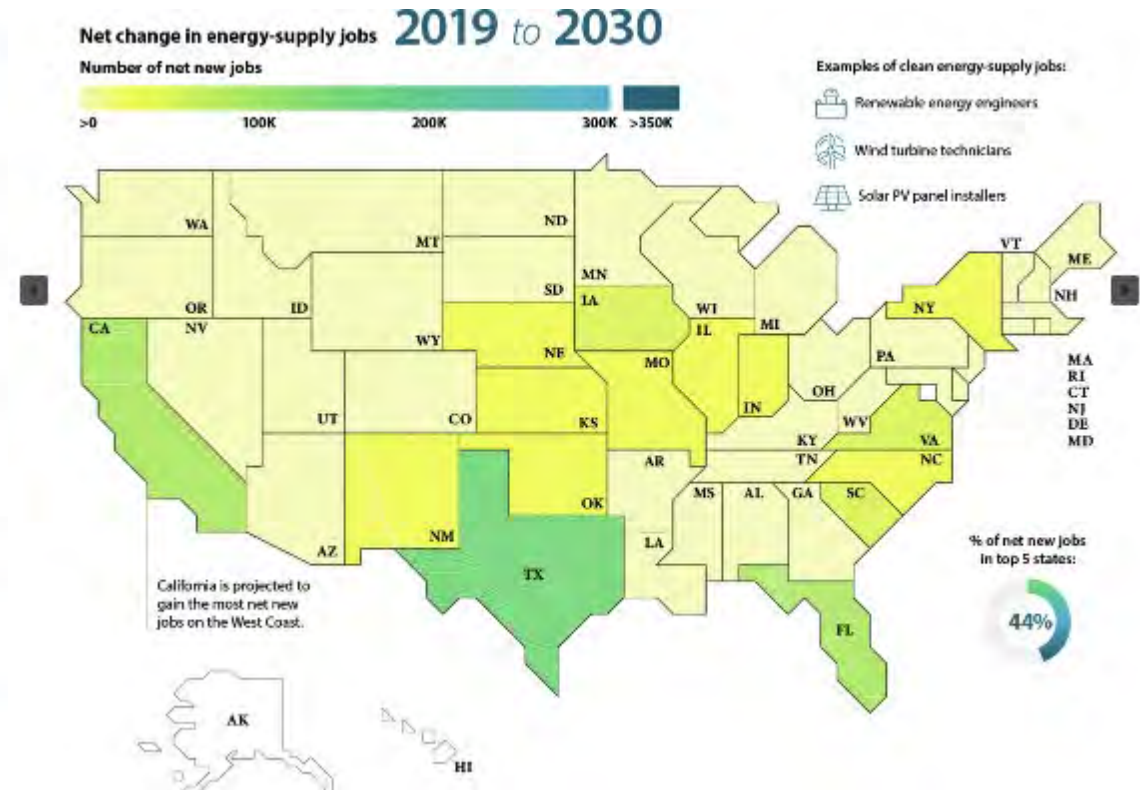


17June2022

Search:

State	Forecasted Net Change in Energy-supply Jobs (2019-2030)
Texas	134,446
California	73,259
Florida	65,754
South Carolina	55,058
Iowa	46,295
Virginia	43,250
New Mexico	39,548
Indiana	38,908
Missouri	33,786
Oklahoma	30,953
Total U.S.	852,651

Previous Next



Search:

State	Forecasted Net Change in Energy-supply Jobs (2019-2030)
New York	26,063
Total U.S.	852,651

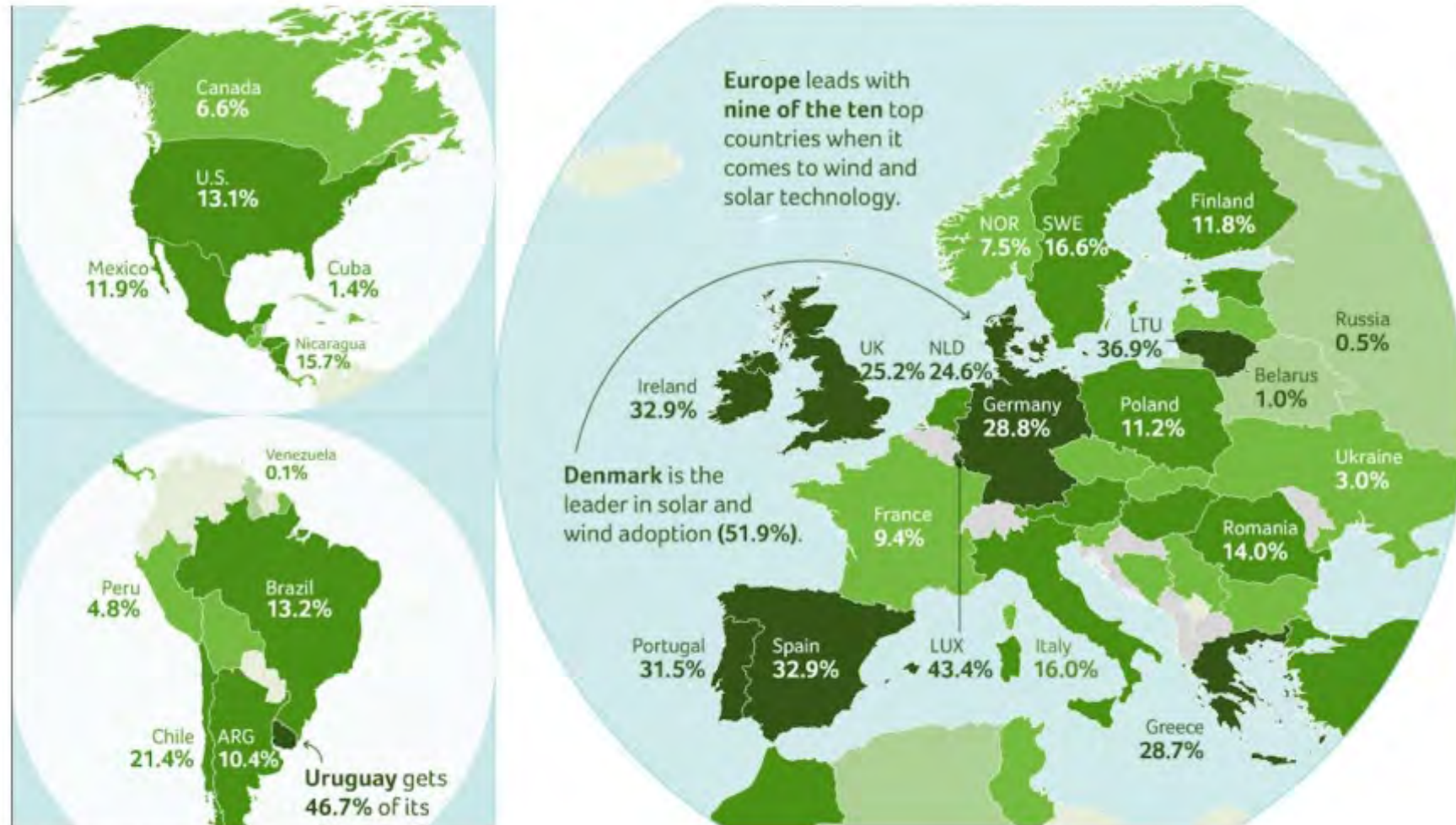
Previous Next

Texas leads in net change in energy supply jobs
Texas also very big in Wind

New York rather small at 26,063

World map reveals wind and solar power winners (and losers)

Best in class: Denmark and Uruguay. Worst in class: Papua New Guinea, Venezuela, and Russia.



Best in class: Denmark and Uruguay. Worst in class: Papua New Guinea, Venezuela, and Russia. (Credit: Visual Capitalist)

Wind and solar at 70% by 2050

That rapid escalation provides some hope that, for once, an international climate target might be met.

In 2020, electricity generation emitted more greenhouse gases than any other industry. According to the International Energy Agency, wind and solar must hit 20% of global energy by 2025 (and 70% by 2050) if we want to reach overall net-zero carbon by the 2050 target set by the Paris Agreement.

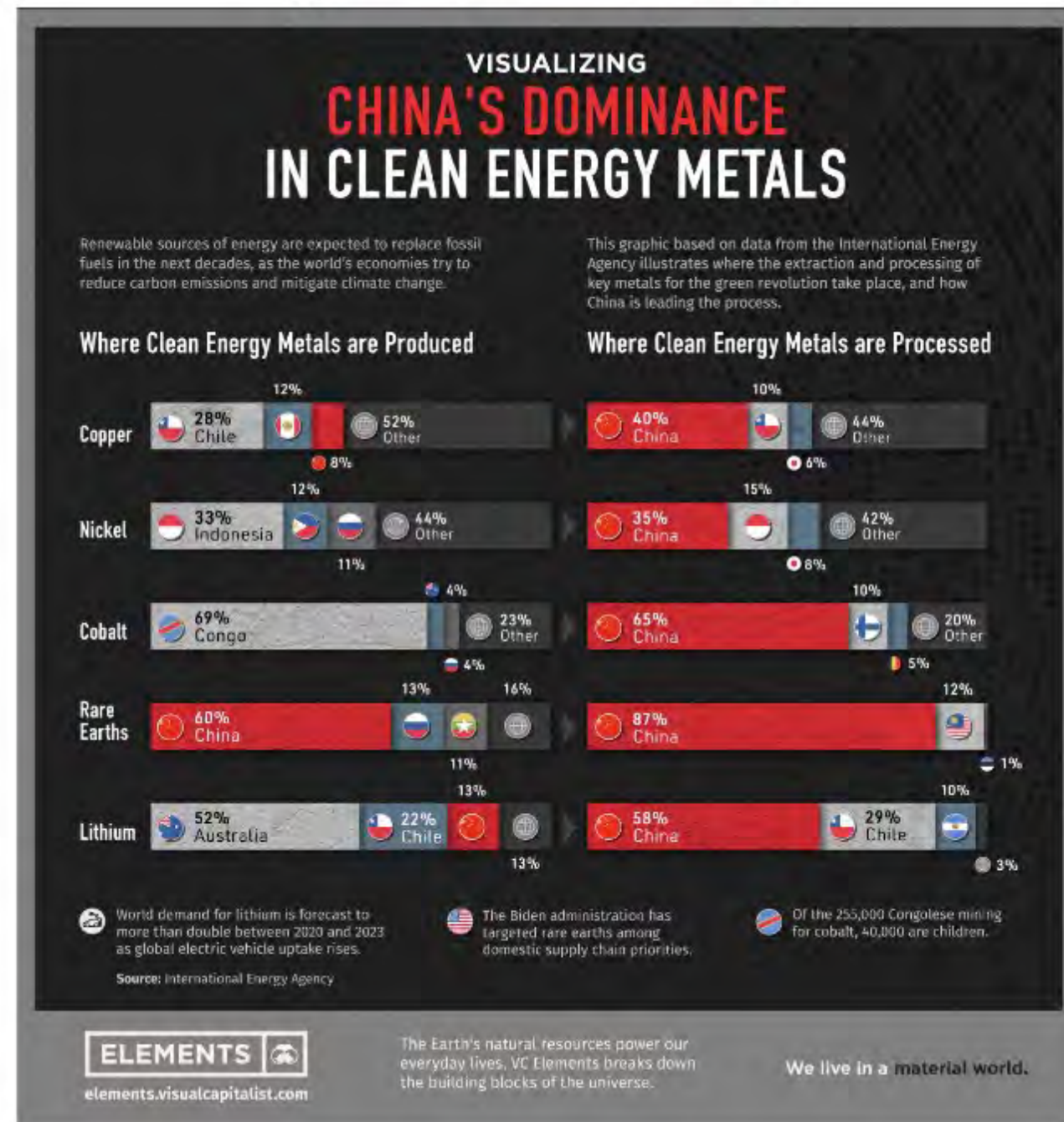
China – careful to dominate all aspects of the clean energy transition

China snapped up Congo Cobalt

China controls rare earths used for wind power

China gets copper and nickel from elsewhere and dominates refining

<https://www.visualcapitalist.com/chinas-dominance-in-clean-energy-metals/>

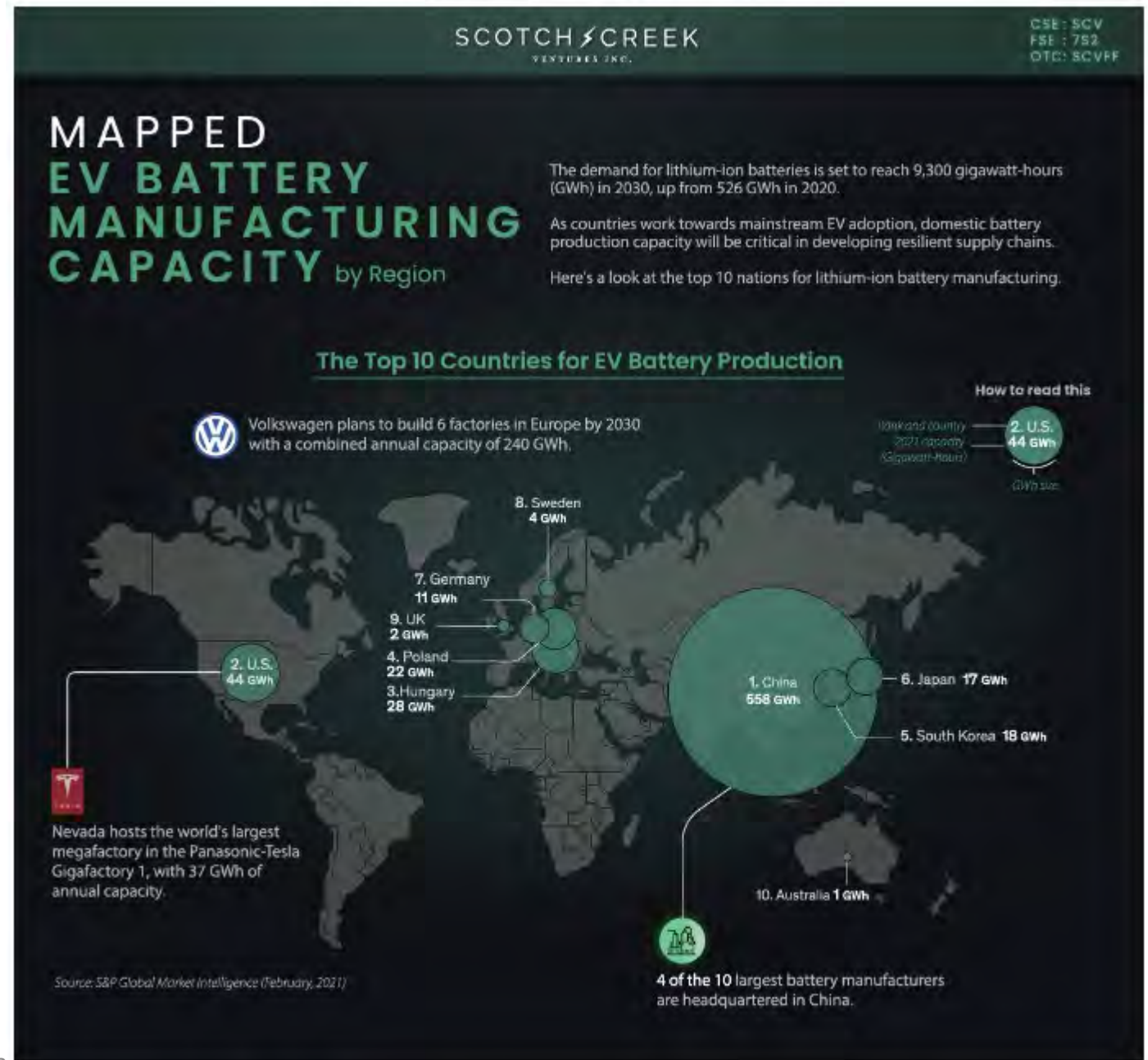


China – careful to dominate all aspects the clean energy transition

EV Batteries

<https://www.visualcapitalist.com/mapped-ev-battery-manufacturing-capacity-by-region/>

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The Megafactory Pipeline

There are 200 battery megafactories in the pipeline to 2030, located in various regions.

Number of battery megafactories (2030P) by region

China – coal plants and massive solar and wind

<https://oilprice.com/Energy/Energy-General/China-Accounts-For-Nearly-Half-Of-The-Worlds-Renewable-Energy-Capacity.html> 21Aug2022

<https://www.pv-magazine.com/2022/07/22/chinese-pv-industry-brief-china-may-install-up-to-100-gw-of-solar-this-year/>

However, China achieved \$380 billion in public and private sector clean energy investments in 2021 alone. In addition, thanks to its strong manufacturing and construction industries, China can build large-scale wind and solar farms at a rapid pace. And this is just the latest in China's green energy achievements, having been investing in clean energy for years.

BloombergNEF (BNEF) head of China analyst Nannan Kou stated "Green infrastructure is the most important investment area that China is relying on to boost its weak economy in the second half of 2022." China has seen \$41 billion in solar investments in the first six months of 2022, supporting its goal of 1,200 GW of wind and solar capacity by 2030. By comparison, the U.S. invested \$7.5 billion in solar over the same period.

Chinese PV Industry Brief: China may install up to 100 GW of solar this year

Wind's Share of Net Electricity Generation



Texas generates more than double the wind power of any other state, and is the state that generates and consumes the most electricity in America.

California pioneered utility-scale wind farms and provided tax rebates for wind power in the 1980s.



Generation by State (2020-2021)

Wind Electricity

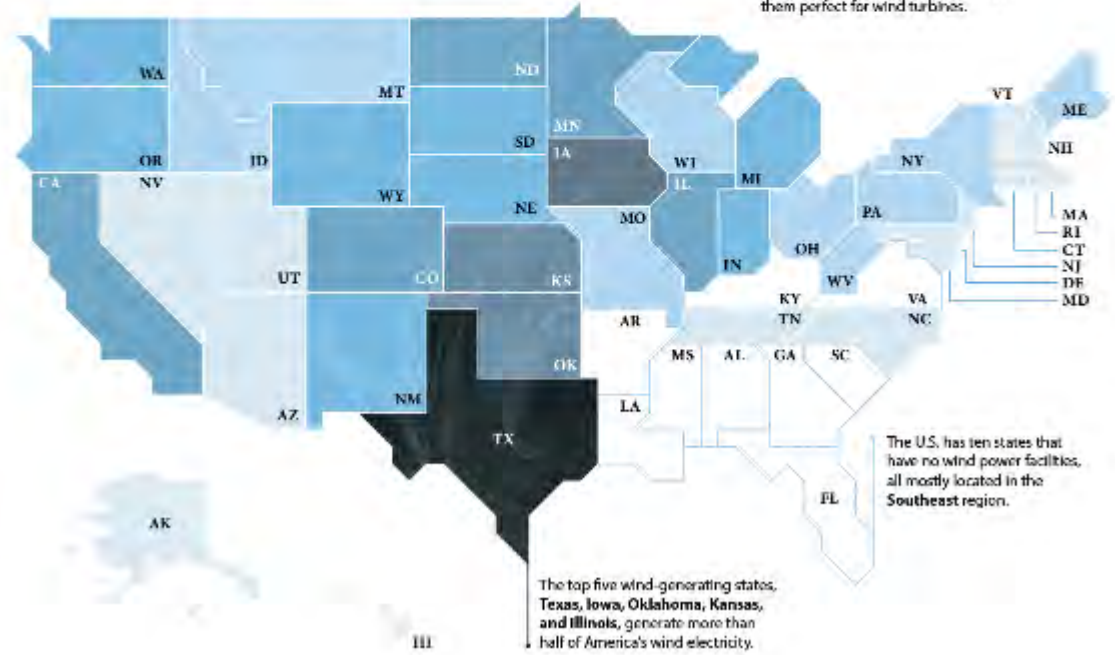
Wind power makes up 8.4% of America's electricity generation, and is the country's largest renewable source of electricity.

Here's a look at how states compare in terms of utility-scale wind generation.

Terawatt hours



Texas, the Midwest, and the Central regions of the U.S. are home to open plains and high wind speeds, making them perfect for wind turbines.



The top five wind-generating states, Texas, Iowa, Oklahoma, Kansas, and Illinois, generate more than half of America's wind electricity.

The U.S. has ten states that have no wind power facilities, all mostly located in the Southeast region.

Texas 92.9 TWh Wind
/365 /24 → 10.6GW
or 20% of usage

Texas usage 464TWh
/365/24 → 53GW
28.64Million pop
1870Watts/person

US electricity usage 2020

452 GWatts or 1400 Watts per US person

Renewables was 95 GWatt

Renewables growth explosive

Substantial offshore wind power coming online

30-40 GWatts up-coming Offshore Wind East Coast

27 GWatts Midwest Wind 2020

28 GWatts Texas 2020

US 118 GWatts by end of 2020 (eia)

25 GWatts California deep water offshore by 2045

<https://cleantechnica.com/2022/08/04/the-u-s-power-grid-added-15-gw-of-capacity-in-1st-half-of-2022/>

<https://www.eia.gov/todayinenergy/detail.php?id=48896> 834 billion kilowatthours (kWh) of electricity, or about 95 GWatts renewables in 2020

Operable utility-scale generating units (June 2022)



Data source: U.S. Energy Information Administration, *Preliminary Monthly Electric Generator Inventory*, June 2022. Note: Utility generating units are those with at least 1 megawatt of nameplate capacity.

Next-generation deep offshore turbines

Standard design has very top heavy tower
& requires lots of C-intensive steel and materials

A period of wild innovation is coming in all areas

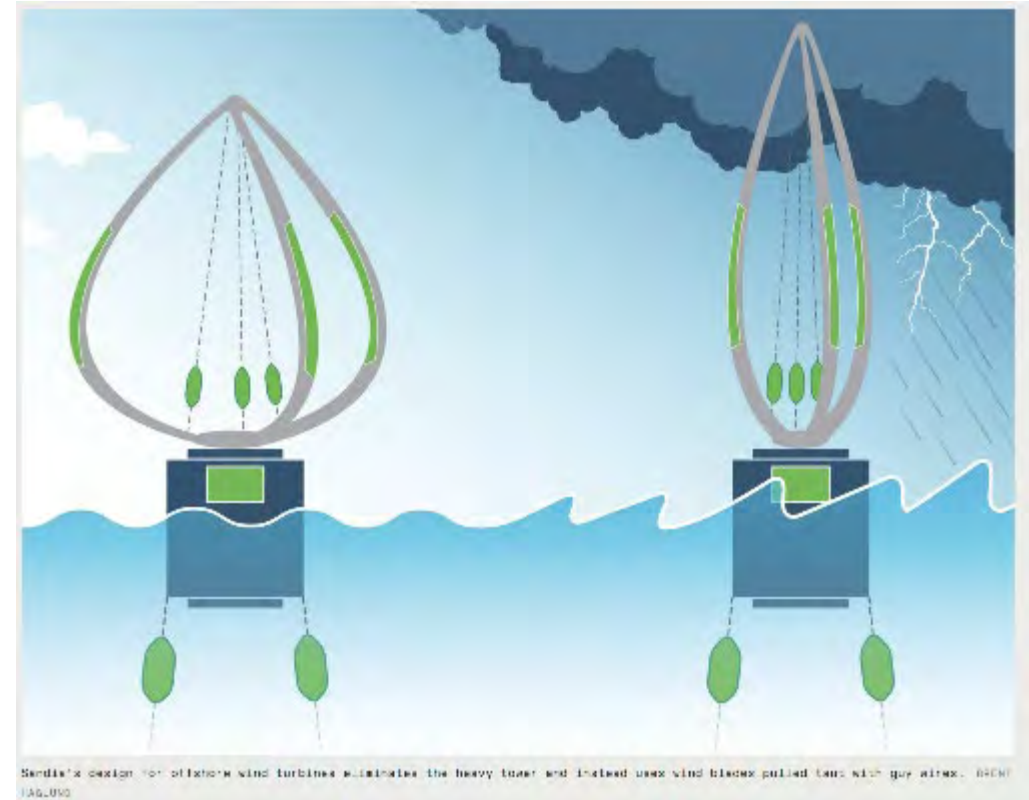


The company says this design leaves much less turbulence behind it, allowing a much higher density of towers per given

site. World Wide Wind

<https://newatlas.com/energy/coaxial-vertical-floating-wind-turbines/>

30Aug2022 World Wide Wind Contra Rotating Turbines



<https://spectrum.ieee.org/vertical-axis-wind-turbine>

24Aug2022 Sandia Labs towerless design

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Vaclav Smil: **cement, steel, plastics and ammonia** – ... need enormous fossil fuels indefinitely

Smil rains on the parade – surge in renewables may not much change CO2 trajectory

<https://www.weforum.org/agenda/2022/08/climate-emissions-speed-scale-tracker-net-zero/>

<https://www.nytimes.com/interactive/2022/04/25/magazine/vaclav-smil-interview.html>

<https://www.nytimes.com/2022/05/11/books/review/how-the-world-really-works-vaclev-smil.html>

... loaf of sourdough ... 5.5 tablespoons of diesel fuel,
... supermarket tomato ... about six tablespoons of diesel.

1kg sourdough -> 250ml diesel 1kg chicken -> 300ml oil p58

Catastrophists wrong, time after time ..

Techno-optimists .. similarly poor record

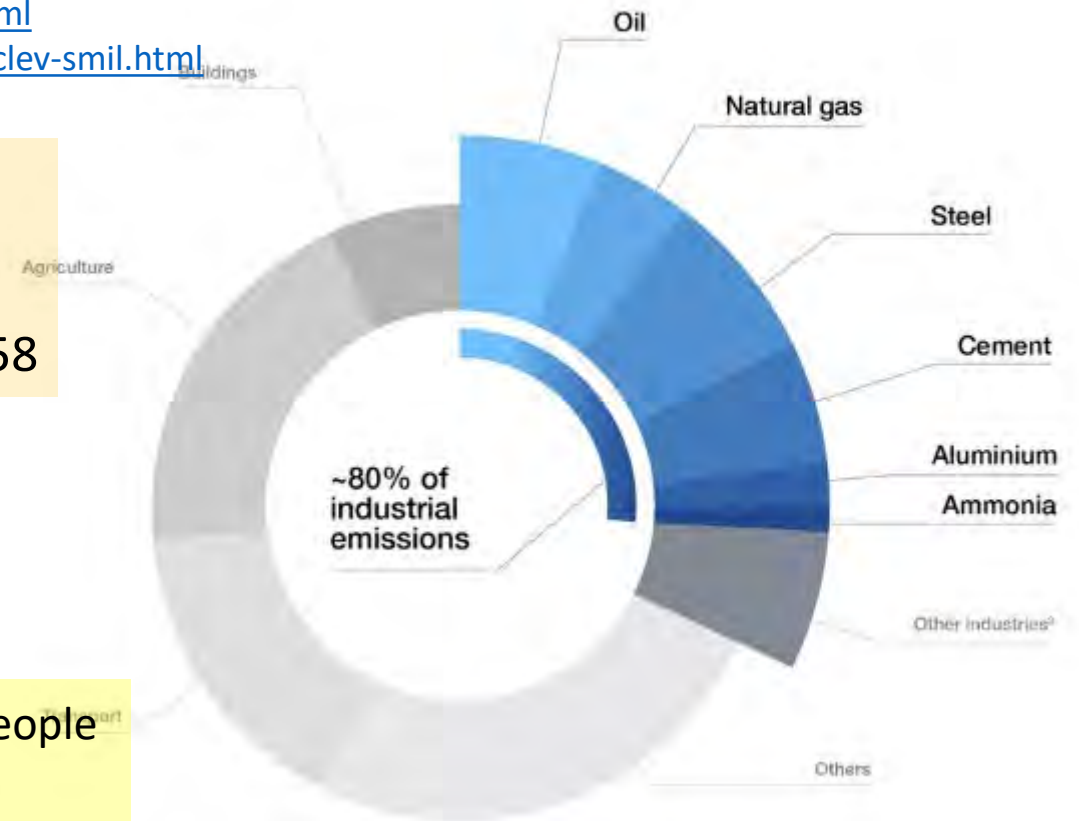
p211 *Smil has no confidence in our ability to project a generation out*

Africa population boom mid 21st century – 1-2 billion extra people

Consuming vast amounts of cement, steel, plastics, and ammonia

→ huge CO2 burden

Global GHG emissions by sector (scope 1 and 2)¹



When Will Renewable Energy Take Over?

...

The [IEA](#) forecasts that, by 2026, global renewable electricity capacity is set to grow by **60%** from 2020 levels to over 4,800 gigawatts—equal to the current power output of fossil fuels and nuclear combined.

...

<https://www.iea.org/news/renewable-electricity-growth-is-accelerating-faster-than-ever-worldwide-supporting-the-emergence-of-the-new-global-energy-economy> 1Dec2021

IEA 2021 Forecast to 2026 – enormous renewable growth, but significantly short of Net Zero by 2025

IEA Renewables Forecast to 2026

International Energy Agency confirms enormous growth of renewables

Level needed for Net Zero

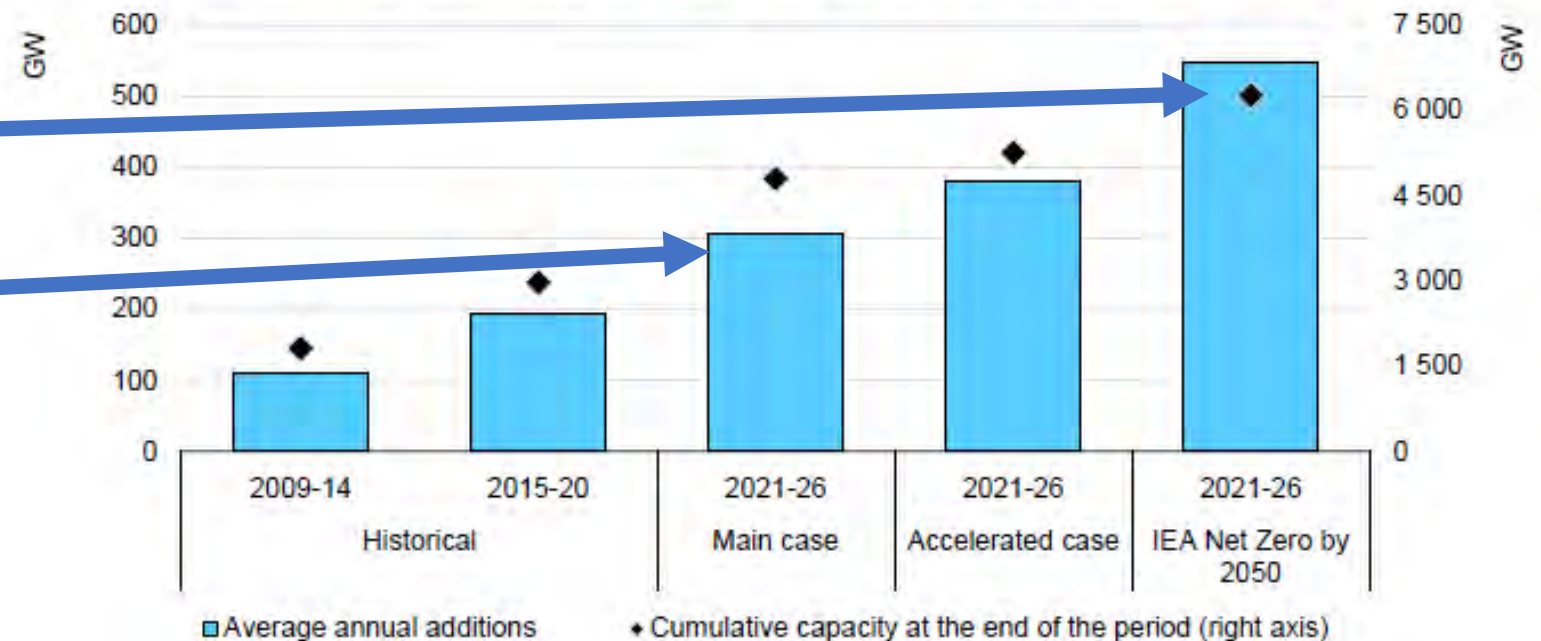
“Main Case Forecast” levels are much lower than needed to stabilize the climate

Forecast summary

Renewable capacity additions are set to grow faster than ever in the next five years, but the expansion trend is not on track to meet the IEA Net Zero by 2050 Scenario

Annual additions to global renewable electricity capacity are expected to average around 305 GW per year between 2021 and 2026 in the IEA main case forecast.

Figure 1.1 Average annual renewable capacity additions and cumulative installed capacity, historical, forecasts and IEA Net Zero Scenario, 2009-2026



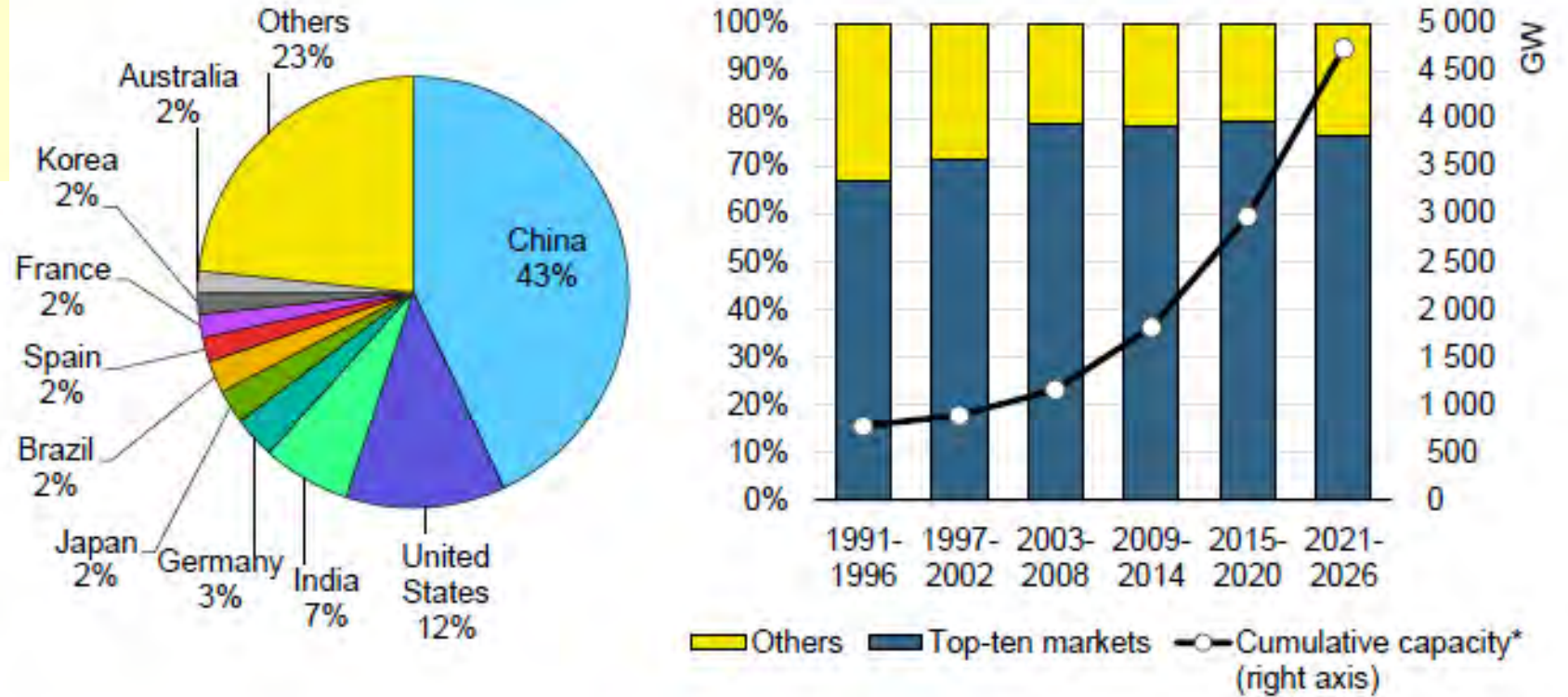
IEA 2021 Forecast to 2026 – enormous renewable growth, but significantly short of Net Zero by 2025

IEA Renewables Forecast to 2026

China dominates total installed renewable capacity

5000 GWatts coming soon that's a lot! 5 TeraWatts

Figure 1.5 Top-ten countries' share of total installed renewable capacity, historical and main case forecast, 1991-2026



IEA. All rights reserved.

* Cumulative capacity = installed renewable capacity at the end of each five-year period.

5000GWatts / 1000watts/person → “1 billion people” if used energy like in US
 Want energy for 10 billion people, or the Net Zero Scenario 6500GWatts by 2026

<https://www.iea.org/reports/renewables-2021/renewable-electricity?mode=market®ion=World&publication=2021&product=Total>

International Energy Agency Analysis and Forecast to 2026

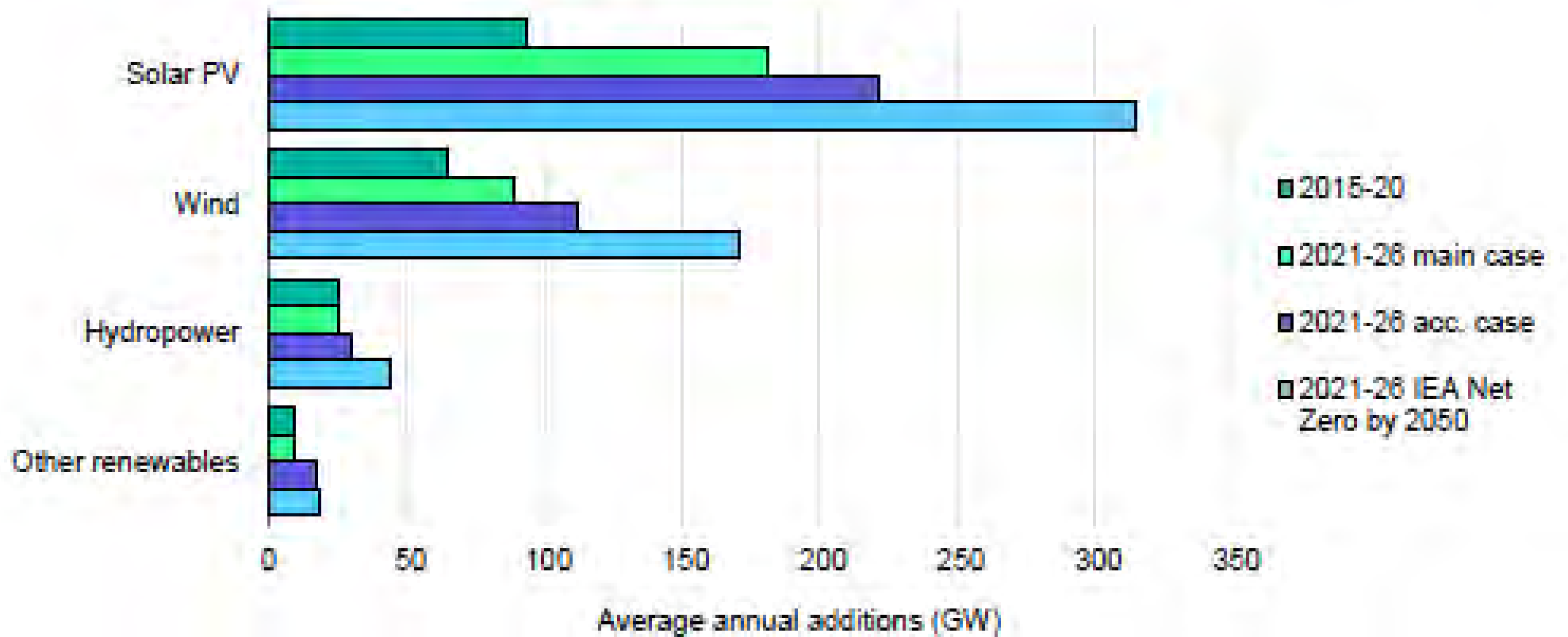
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IEA Renewables Forecast to 2026

Figure 1.12 Average annual capacity additions by technology, actual, forecasts and IEA Net Zero Scenario, 2015-2026



Large additions
of Solar
and
Wind

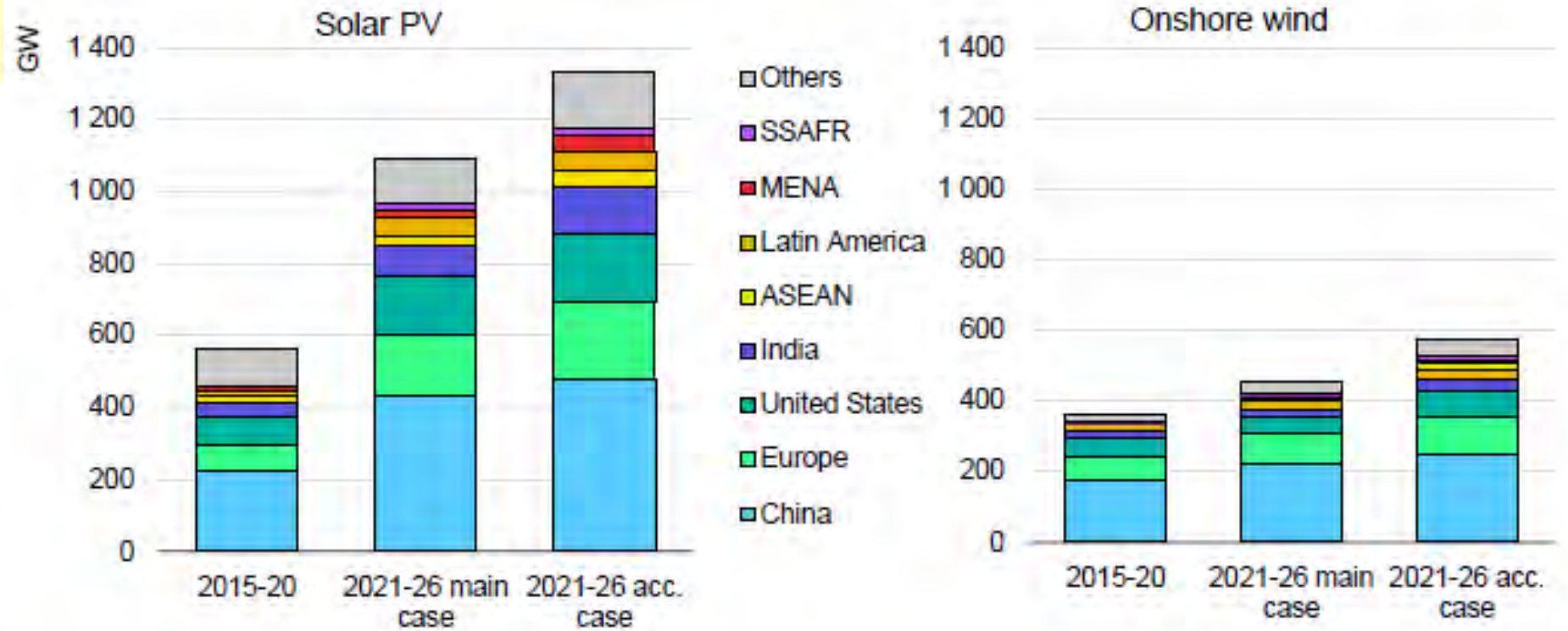
Hydro is very
important but
is maxed out
already

IEA 2021 Forecast to 2026 – enormous renewable growth, but significantly short of Net Zero by 2025

IEA Renewables Forecast to 2026

Solar is much larger wind

Figure 1.7 Solar PV and onshore wind capacity additions, actual and forecast by country/region, 2015-2026



IEA, All rights reserved.

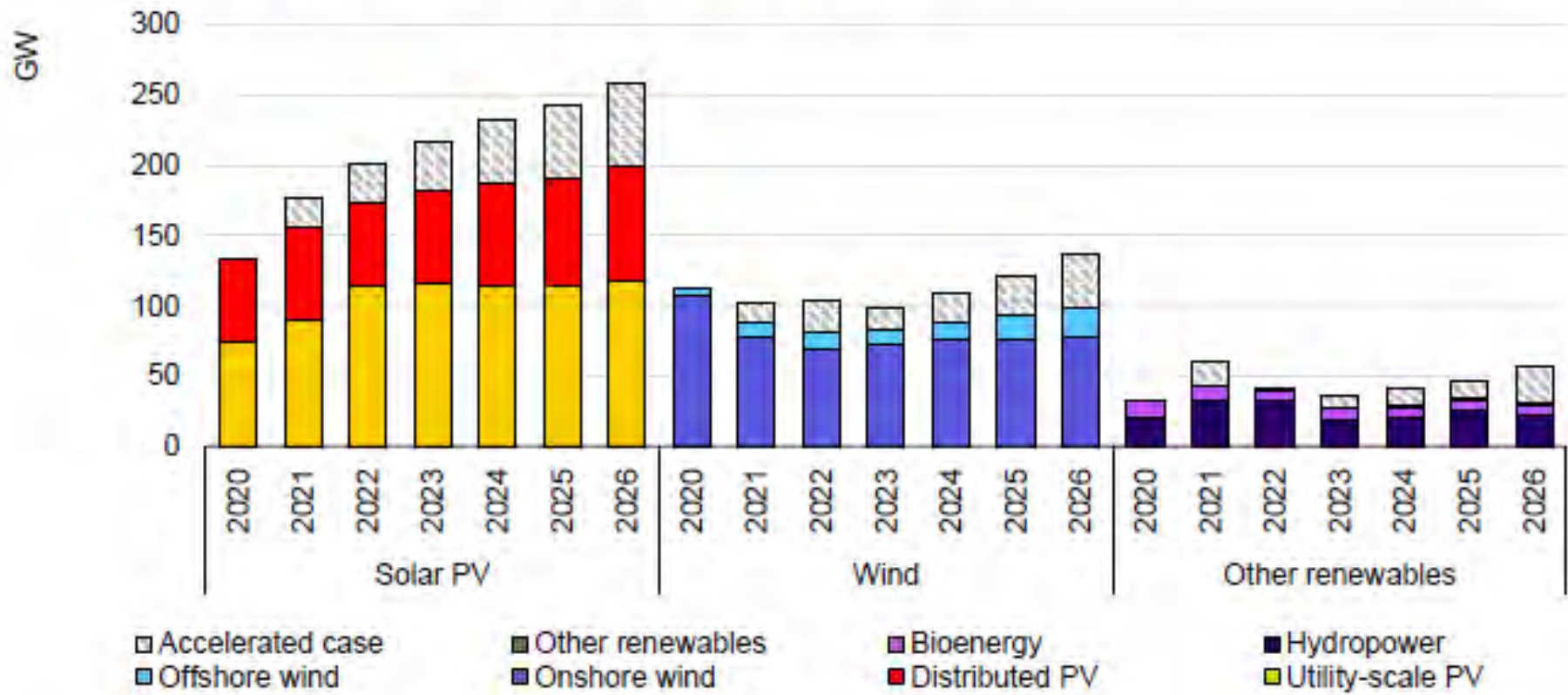
Note: acc. case = accelerated case; ASEAN = Association of Southeast Asian Nations; MENA = Middle East and North Africa; SSAFR = sub-Saharan Africa.



IEA 2021 Forecast to 2026 – enormous renewable growth, but significantly short of Net Zero by 2025
 IEA Renewables
 Forecast to 2026

Greatest opportunity for Distributed PhotoVoltaics

Figure 1.6 Annual capacity additions of solar PV, wind and other renewables, main and accelerated cases, 2020-2026



IEA. All rights reserved.

Disruptive Factor: Stunning drop in Renewables Prices;
 Explosion of investment in renewables. We are following a new path

Cost vs. Installed Capacity

Miracle of astonishing drop in renewable prices

Learning curve – price drops with installed capacity

<https://ourworldindata.org/cheap-renewables-growth>

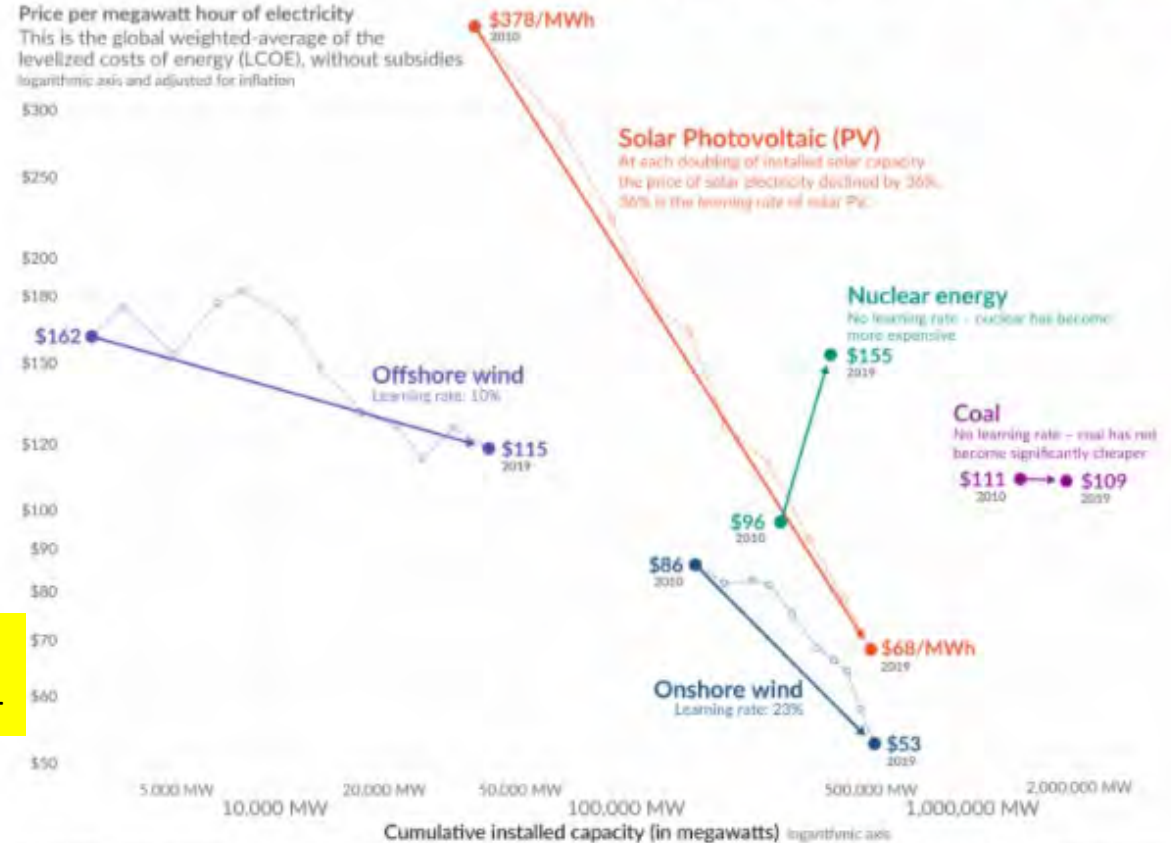
Dec. 2020 **Max Roser**

Very clear and important article – I suggest that you read, especially if you want a more positive outlook!

PRICE
\$378-----

Electricity from renewables became cheaper as we increased capacity – electricity from nuclear and coal did not

Our World in Data



PRICE
\$68-----

-----CUMULATIVE INSTALLED CAPACITY-----log scale-----
 |5000MW |1000000 MW



Alternate perspective of hope - Longtermism

“Longtermism” – smarter people than me (ccp) think we’ll get through current crises like Climate Change, and humanity is at the start of a vast productive & positive period!

<https://ourworldindata.org/longtermism> **Max Roser** 15Mar2022 fascinating article and links

Our potential future is *vast*

Our World
in Data

Every triangle in this chart (▼) corresponds to 7.95 billion people, the number of people alive today.

Humanity's past



All the people who have died, 109 billion.
These are 14 triangles – the dead outnumber the living by a ratio of 14 to 1.

Humanity's present



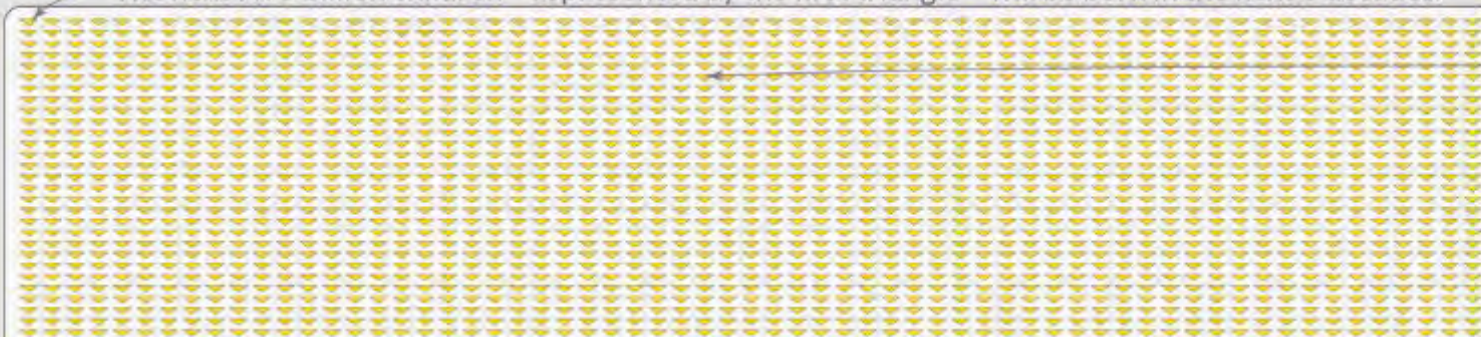
All people who are alive today, 7.95 billion. Those of us who are alive now are about 6.8% of all people who ever lived.

Humanity's future?

The 12,572 triangles below represent all people who might be born in the future – from 2022 onwards.

This is a scenario in which humanity survives for another 800,000 years, in which the population stabilizes at 11 billion people and in which global life expectancy rises to 88 years.

The next 7.95 billion children – represented by the first triangle – will be born in the next 6 decades.



Each row represents the lives of half a trillion people

Children born here are about 1,000 generations away from our generation today.

← 50,000 years from now: The Niagara Falls will have eroded its river bed and will cease to exist.

← This is when the ten trillionth child after today will be born.

← 100,000 years from today



Alternate perspective of hope – “Longtermism”

<https://ourworldindata.org/longtermism> **Max Roser** 15Mar2022

<https://www.whatweowethefuture.com/> book coming out late 2022 by William MacAskil Max Roser:

MacAskil’s manuscript very much inspired this post and I very much recommend his book. It has changed how I think about my time on Earth. https://en.wikipedia.org/wiki/What_We_Owe_the_Future

Our opportunities are vast too Perspective by Max Roser March 2022

So far I’ve only spoken about the risks that we face. But our large future means that there are large opportunities too.

Problems are solvable. This is for me the most important insight that I learned from writing Our World in Data over the last decade.

Compared to the vast future ahead, the two centuries shown in this chart here are only a brief episode of human history. But even in such a short period we have made substantial progress against many large problems.

Given enough time we can end the horrors of today. Poverty is not inevitable; we can achieve a future where people are not suffering from scarcity. Diseases that are incurable today might be curable in just a few generations; we already have an amazing track record in improving people’s health. And we can achieve a world in which we stop damaging the environment and achieve a future in which the world’s wildlife flourishes.

Our children and grandchildren can continue the progress we are making, and they may create art and build a society more beautiful than we can even imagine.



The Astonishing Drop in Cost of Renewables: Can Economics Save the Climate?

CLS Marist GS4 & SS4 Sept. 28, 2022 Poughkeepsie NY Lect4: can Economics save climate?

- World 3C likely Future – 40C heat waves ramping till Net Zero CO2 achieved
 - Spectacularly Small Response over 40 years <0.3% of Gross Domestic Product (US & others)
- Disruptive Miracle: Wind, Solar, Battery costs fall exponentially
 - **Renewables are rushing in Breaking the bleak backdrop of the past 40 years**
- Renewables: 20% yearly increases, 755B\$ approaching 1% of World GDP
 - Major 2022 Reports: BloombergNEF Ember McKinsey IEA Renewables
 - Driven by China – Solar, Wind, Batteries, Control of Rare Earths, Congo Cobalt, Nickel, Copper
 - US just starting to follow: Surprise August 2022 passage of historic IRA emphasizing renewables
- **Perspective:**
 - Explosive growth of renewables – world going from budgetary rounding error amount 0.3% of GDP investment to almost 1% of GDP.
 - >7% of GDP needed to stabilize climate at whatever CO2 level the world arrives at, per McKinsey 2022 report

Renewables major progress! Short in magnitude by 7X But train has moved out of the station!

