Finanzierung der Klima- und Energiewende

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THE WALL STREET JOURNAL.

LATEST IN ENERGY AND OIL

Saudi Aramco to Return $31 Billion to Shareholders, Government After Profit Beat

Aramco said its second-quarter net profit beat market estimates, and that it planned to pay $31 billion in dividends to the Saudi government and its shareholders.

Saudi Arabia's national oil company on Tuesday posted a quarterly net profit of $29.07 billion, down from the $30.83 billion it reported for the same period last year.

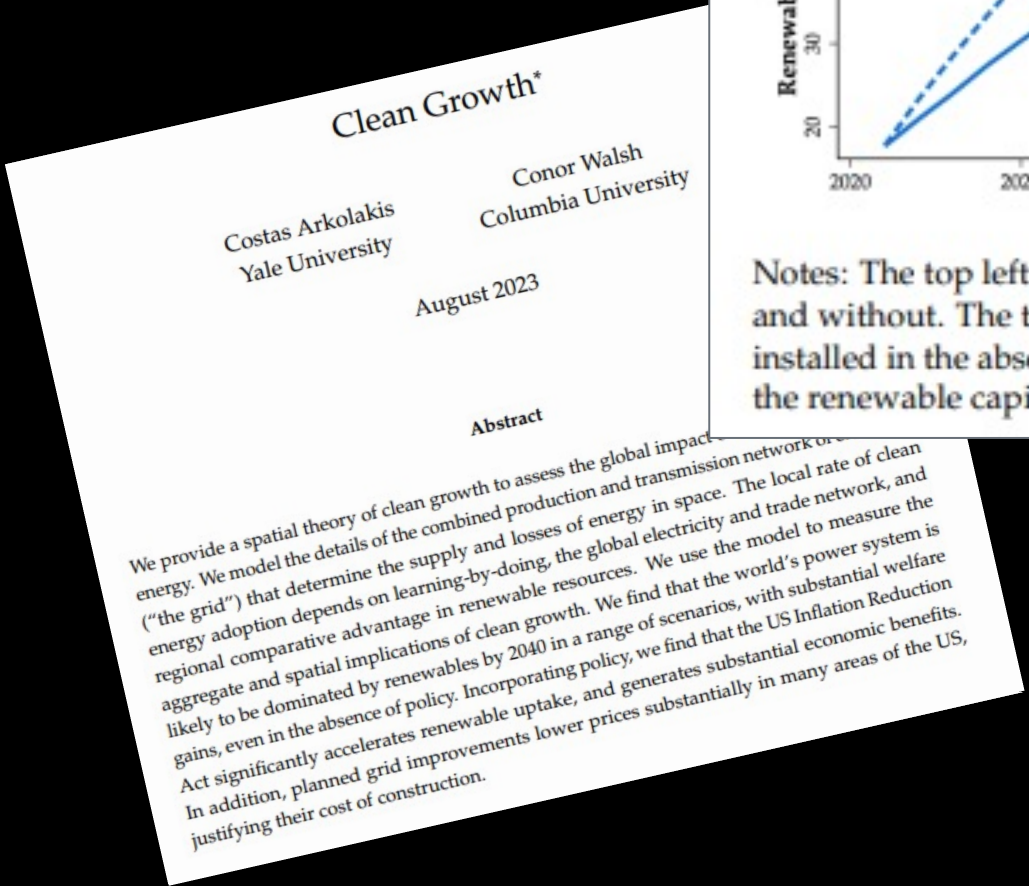
The result was higher than the $27.7 billion the market had forecast, according to a median estimate provided by the company. Earnings were driven by robust crude-oil prices, offsetting lower crude oil volumes sold and weaker refining margins on year.

Source: *WSJ* (6 August 2024)

Can This Country Show Europe How to Compete Again?

Sweden outperforms in tech, has a roster of $1 billion-plus start-ups and could be a model as the European Union refigures its growth policies.

Source: *NYT* (13 August 2024)



Clean Growth*

Costas Arkolakis
Yale University

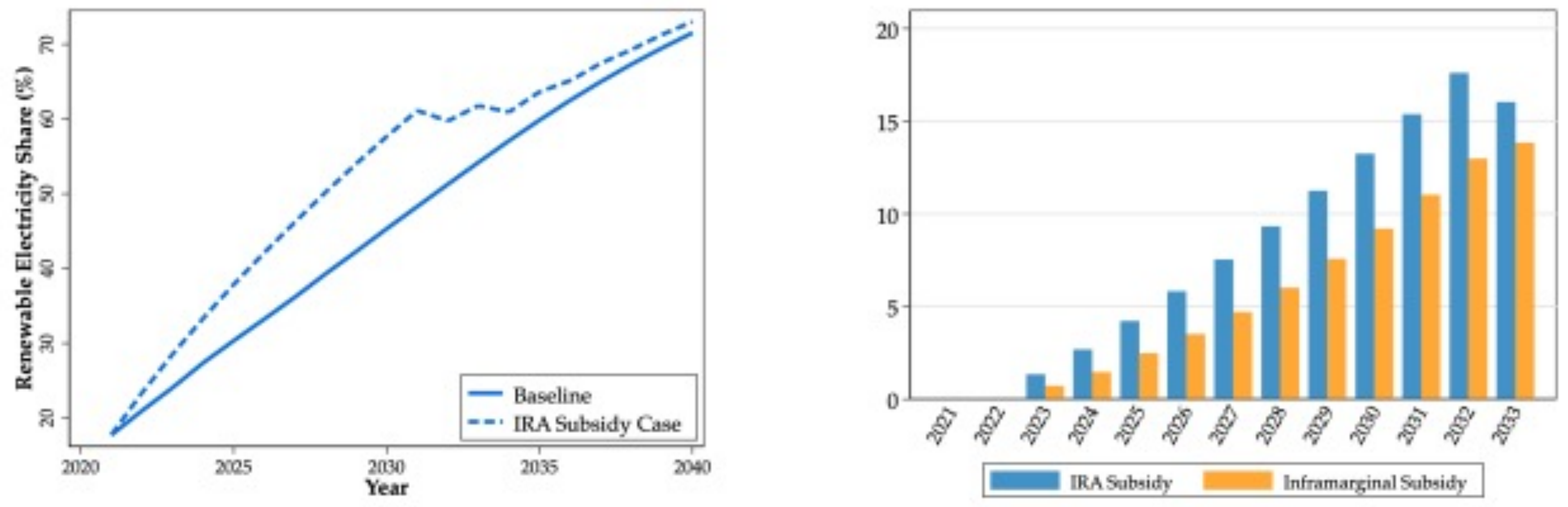
Conor Walsh
Columbia University

August 2023

Abstract

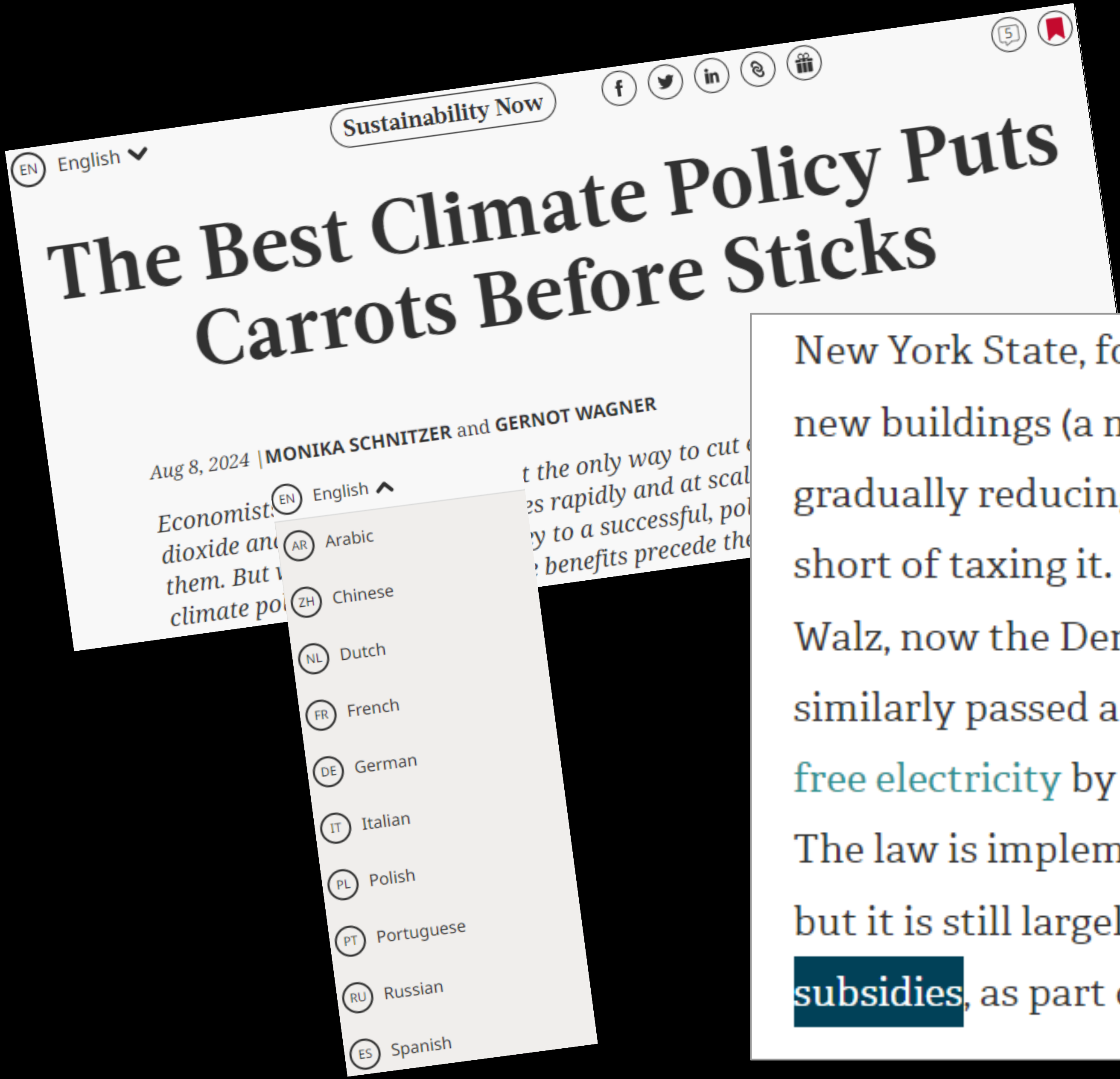
We provide a spatial theory of clean growth to assess the global impact[...] energy. We model the details of the combined production and transmission network [...] ("the grid") that determine the supply and losses of energy in space. The local rate of clean energy adoption depends on learning-by-doing, the global electricity and trade network, and regional comparative advantage in renewable resources. We use the model to measure the aggregate and spatial implications of clean growth. We find that the world's power system is likely to be dominated by renewables by 2040 in a range of scenarios, with substantial welfare gains, even in the absence of policy. Incorporating policy, we find that the US Inflation Reduction Act significantly accelerates renewable uptake, and generates substantial economic benefits. In addition, planned grid improvements lower prices substantially in many areas of the US, justifying their cost of construction.

Figure 11: The Impact of the Inflation Reduction Act



Notes: The top left panel shows the model's projection for renewable power share under the IRA production tax credit, and without. The top right panel shows the total cost of the bill (in blue), and subsidies going to capital that would be installed in the absence of the subsidy. The bottom left shows GDP growth in both scenarios, and the bottom right shows the renewable capital price.

Source: conor-walsh.com/s/CleanGrowth.pdf

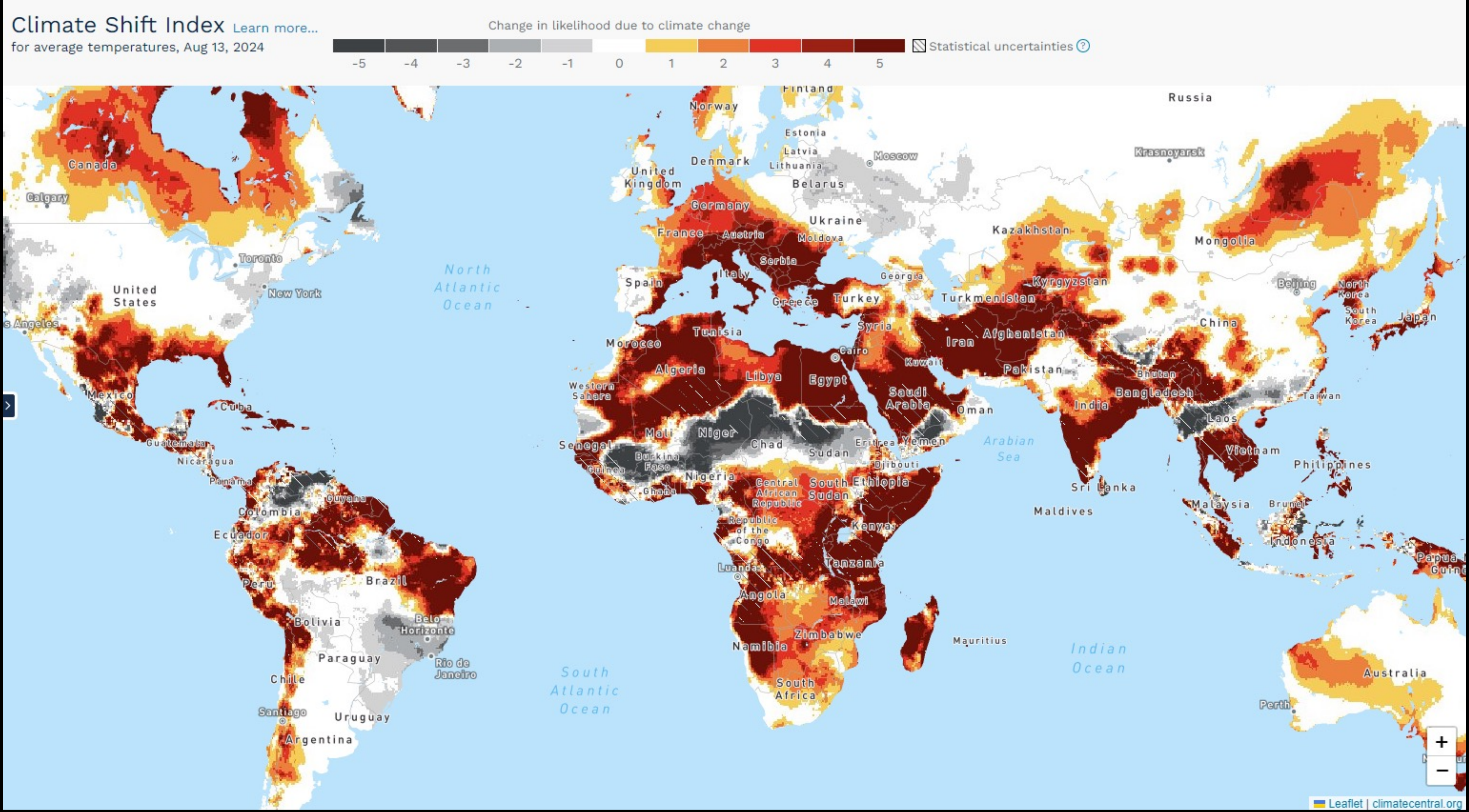


New York State, for example, has banned gas connections to most new buildings (a measure that Germany has yet to pass), thus gradually reducing its reliance on a fossil-fuel source while stopping short of taxing it. Minnesota, under the leadership of Governor Tim Walz, now the Democratic candidate for the vice presidency, has similarly passed a law requiring utilities to achieve 60-80% carbon-free electricity by 2030, and 100% by 2040, up from around 50% today. The law is implemented with a flexible renewable portfolio standard, but it is still largely a stick. The carrot: $2 billion in clean-energy subsidies, as part of the state's comprehensive action plan.

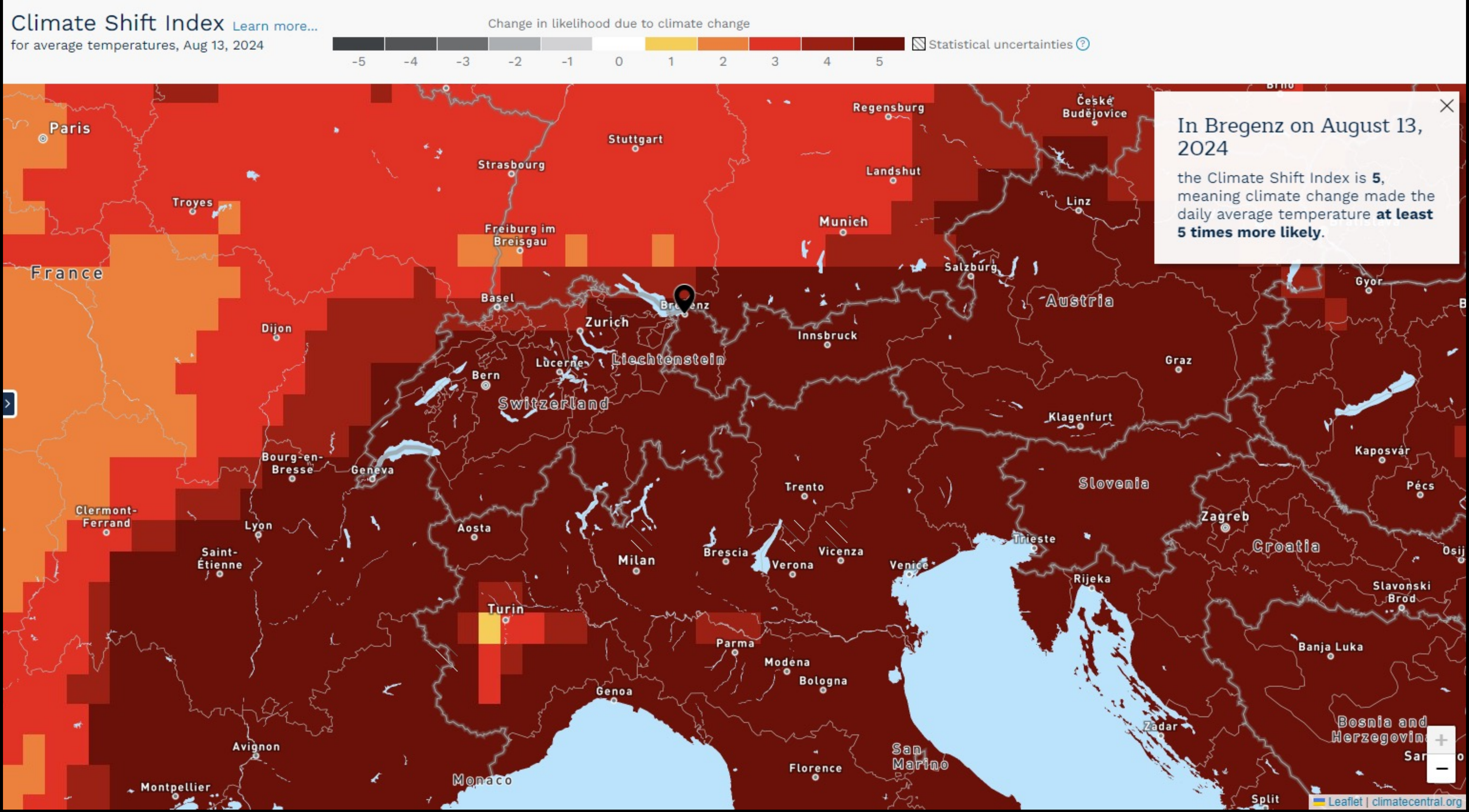
Source: Schnitzer & Wagner, "Die beste Klimapolitik arbeitet mit Zuckerbrot vor der Peitsche"
(*Project Syndicate*, 8 August 2024)

1. Climate risk ≻ known knowns
2. Climate policy = opportunity
3. Pricing carbon “+”

1 Climate risk ≻ known knowns

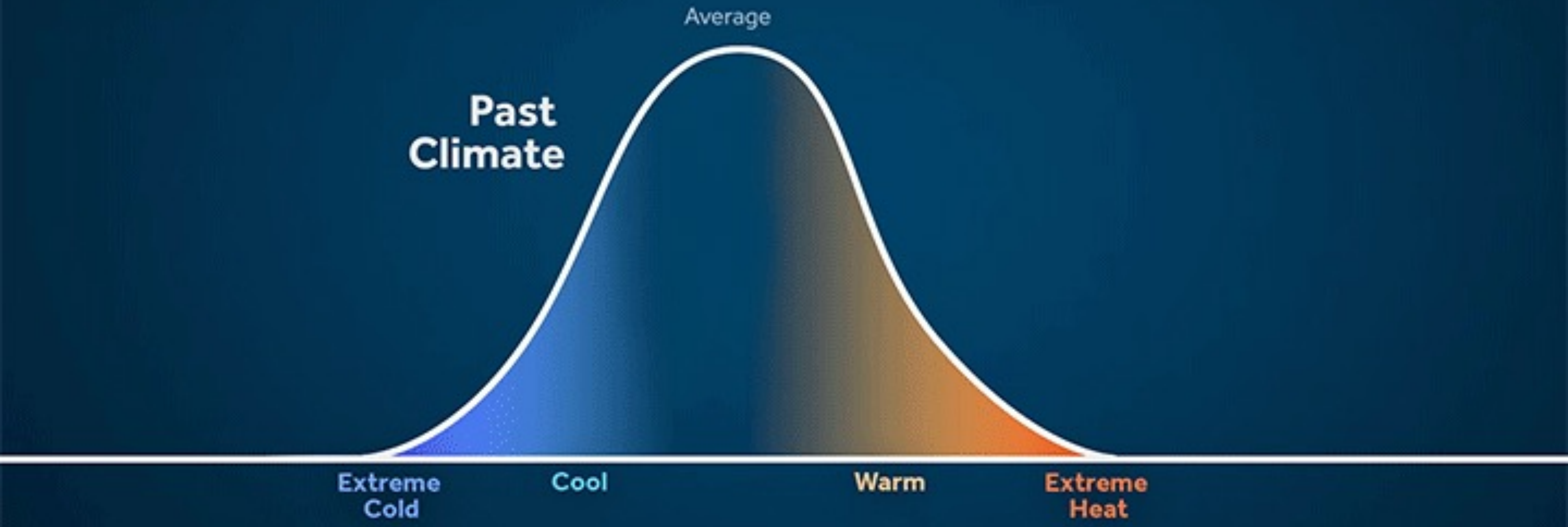


Source: climatecentral.org/climate-shift-index

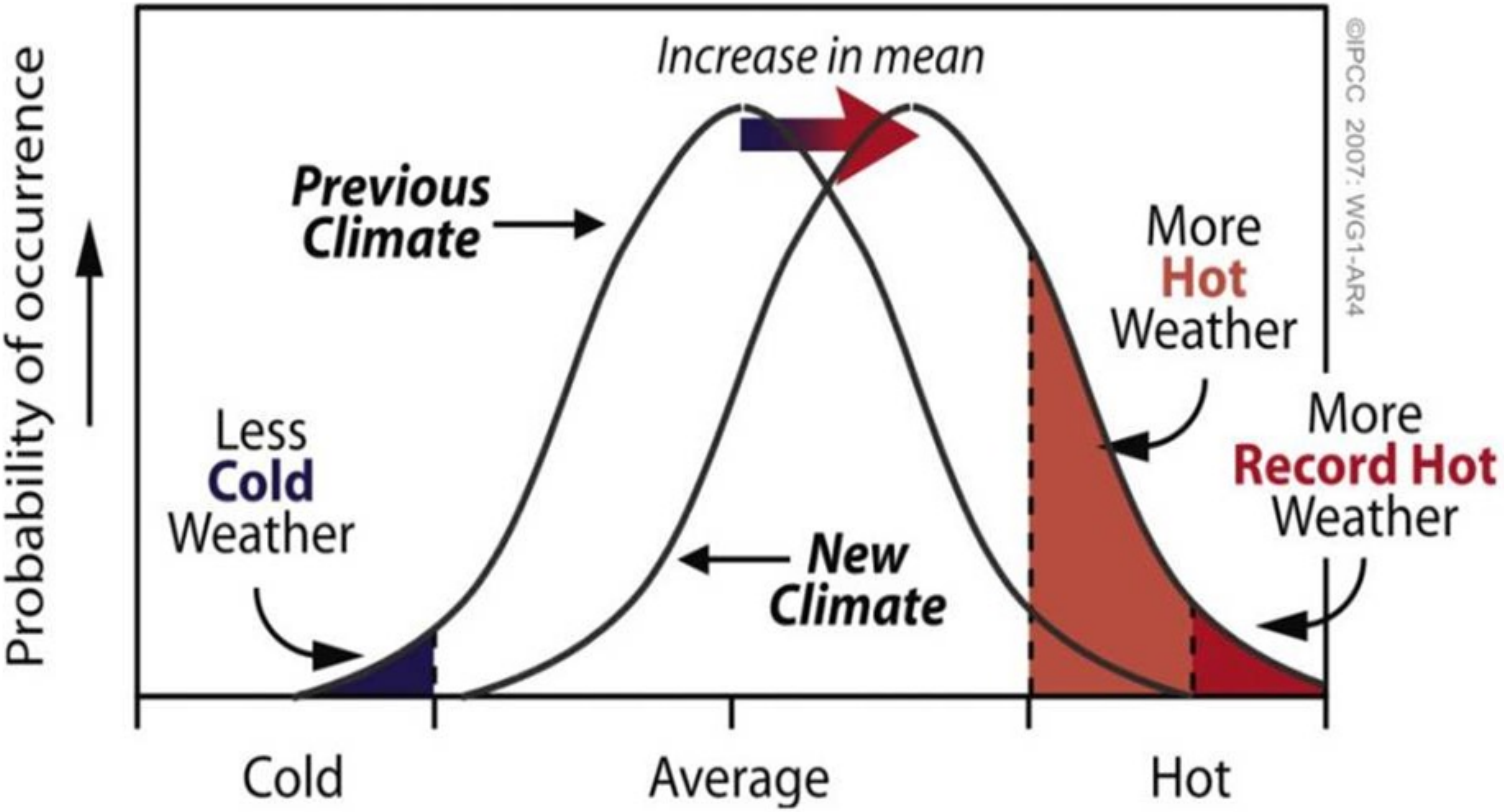


Source: climatecentral.org/climate-shift-index

SMALL CHANGE IN AVERAGE
BIG CHANGE IN EXTREMES



CLIMATE CENTRAL


Probability of occurrence
Increase in mean
Previous Climate
New Climate
Less Cold Weather
More Hot Weather
More Record Hot Weather
Cold
Average
Hot
©IPCC 2007: WG1-AR4

~$200 / tCO_2

~€200 / tCO_2

~$200(!?) Social Cost of CO_2

Based on 2% discount rate, subject to external review

Table ES.1: Estimates of the Social Cost of Greenhouse Gases (SC-GHG), 2020-2080 (2020 dollars)

	SC-GHG and Near-term Ramsey Discount Rate								
	SC-CO_2 (*2020 dollars per metric ton of CO_2*)			SC-CH_4 (*2020 dollars per metric ton of CH_4*)			SC-N_2O (*2020 dollars per metric ton of N_2O*)		
Emission Year	2.5%	2.0%	1.5%	2.5%	2.0%	1.5%	2.5%	2.0%	1.5%
2020	120	190	340	1,300	1,600	2,300	35,000	54,000	87,000
2030	140	230	380	1,900	2,400	3,200	45,000	66,000	100,000
2040	170	270	430	2,700	3,300	4,200	55,000	79,000	120,000
2050	200	310	480	3,500	4,200	5,300	66,000	93,000	140,000
2060	230	350	530	4,300	5,100	6,300	76,000	110,000	150,000
2070	260	380	570	5,000	5,900	7,200	85,000	120,000	170,000
2080	280	410	600	5,800	6,800	8,200	95,000	130,000	180,000

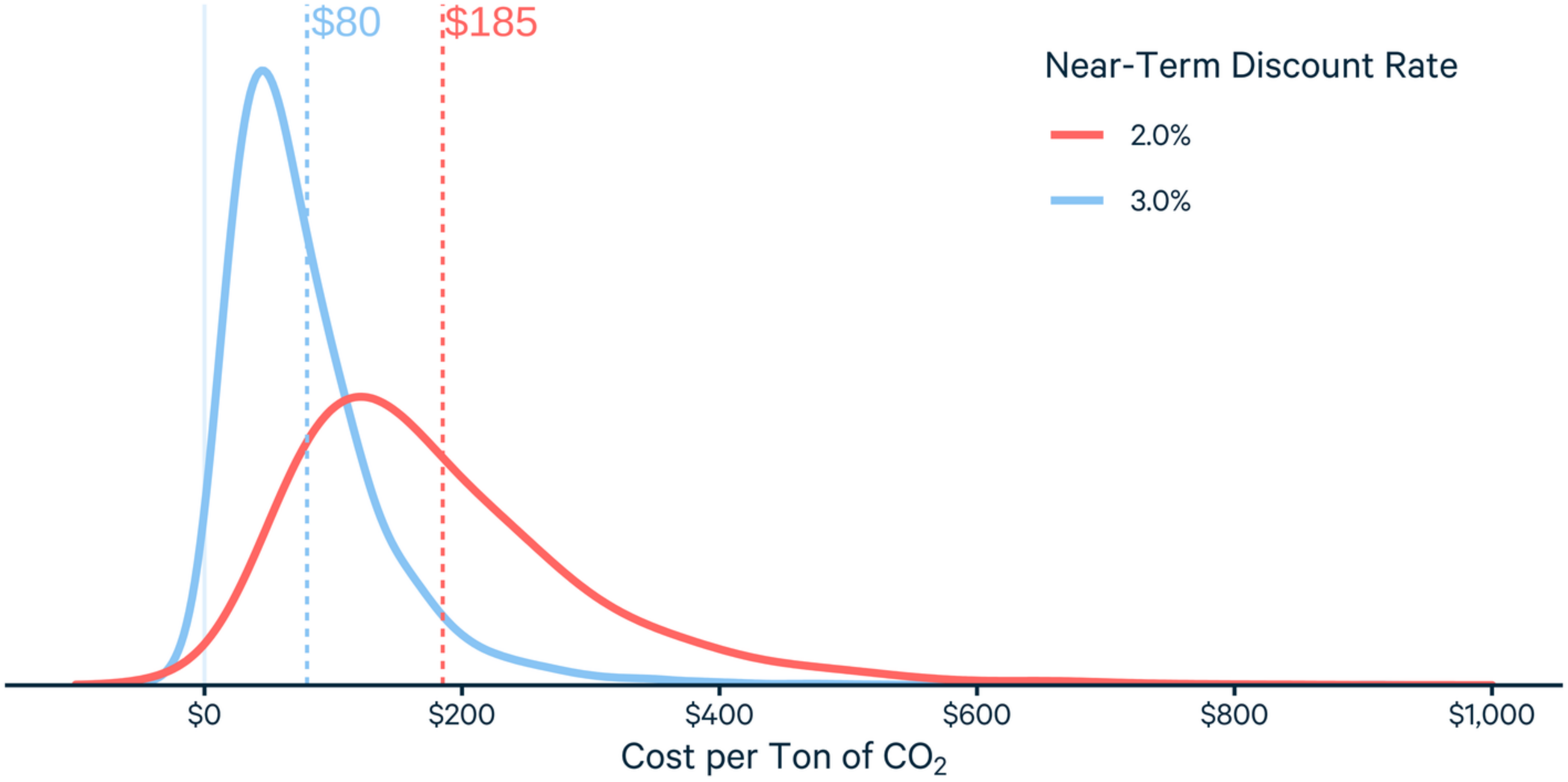
Values of SC-CO_2, SC-CH_4, and SC-N_2O are rounded to two significant figures. The annual unrounded estimates are available in Appendix A.4 and at: www.epa.gov/environmental-economics/scghg.

~$200 U.S. EPA SC-$CO_2$, subject to external peer review

Source: EPA External Review Draft of Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances (September 2022)

~$185 Social Cost of CO_2

Based on 2% constant discount rate, with most of the increase due to discounting

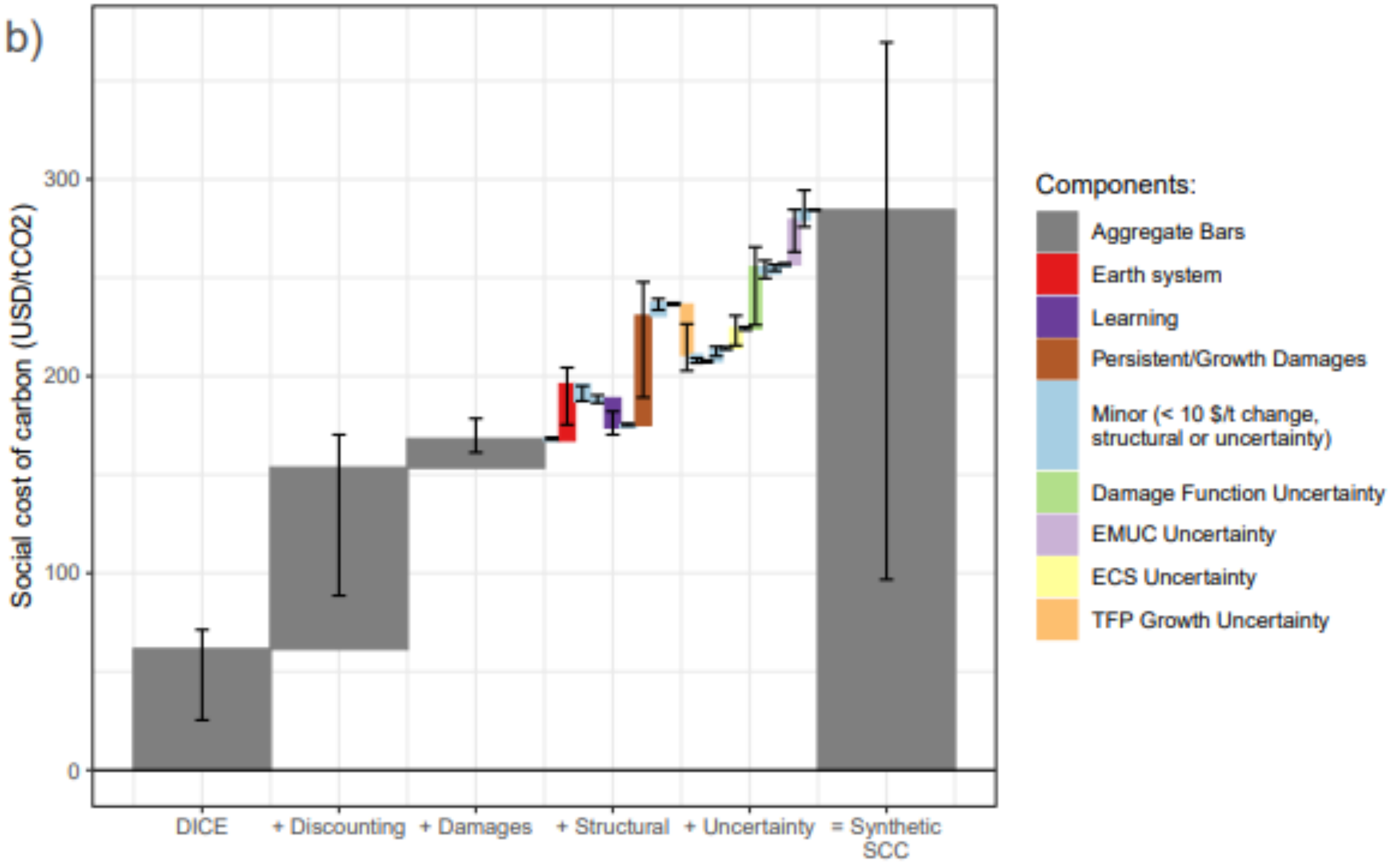


~$50 to ~$80 from updated damages,
~$80 to ~$185 from discounting

Source: Rennert *et al* "Comprehensive Evidence Implies a Higher Social Cost of CO_2" (*Nature*, September 2022).

“Synthetic” Social Cost of Carbon with median = $185 and mean = $284

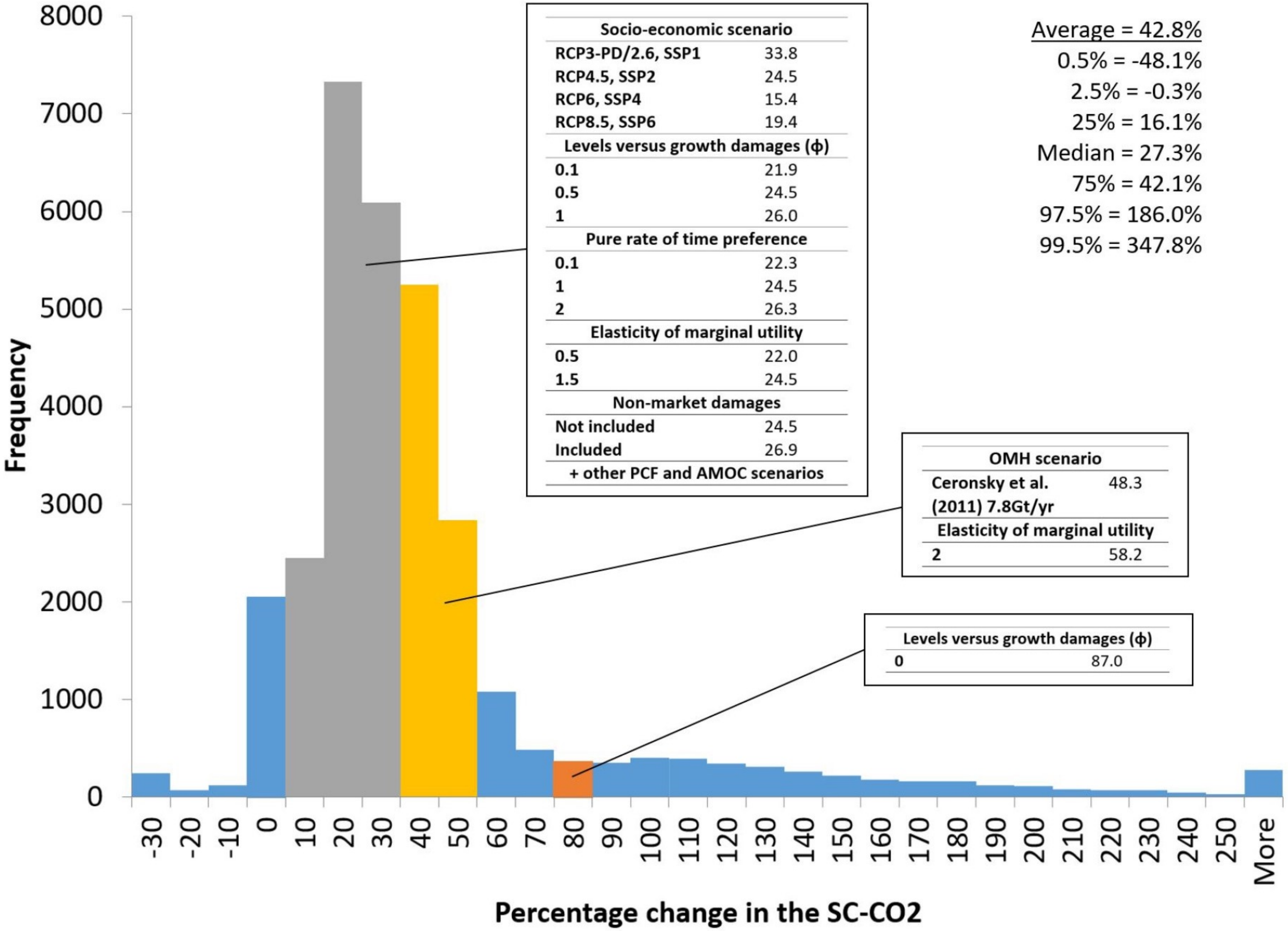
For 1 tonne of CO_2 emitted in 2020, in $2020, with 5%–95% range of $32–$874(!)



Source: Moore, Drupp, Rising, Dietz, Rudik & Wagner (*2024*), gwagner.com/synthesis-scc

Economic impacts of tipping points in the climate system

Tipping points increase SCC by between ~27-43%, with large, right-skewed distribution



Source: Dietz, Rising, Stoerk & Wagner (*PNAS* 2021), gwagner.com/tipping-economics

>€200 / tCO_2

~ \$200 / tCO_2

=

~8-10% of

global GDP

~ $1,000 / tCO_2

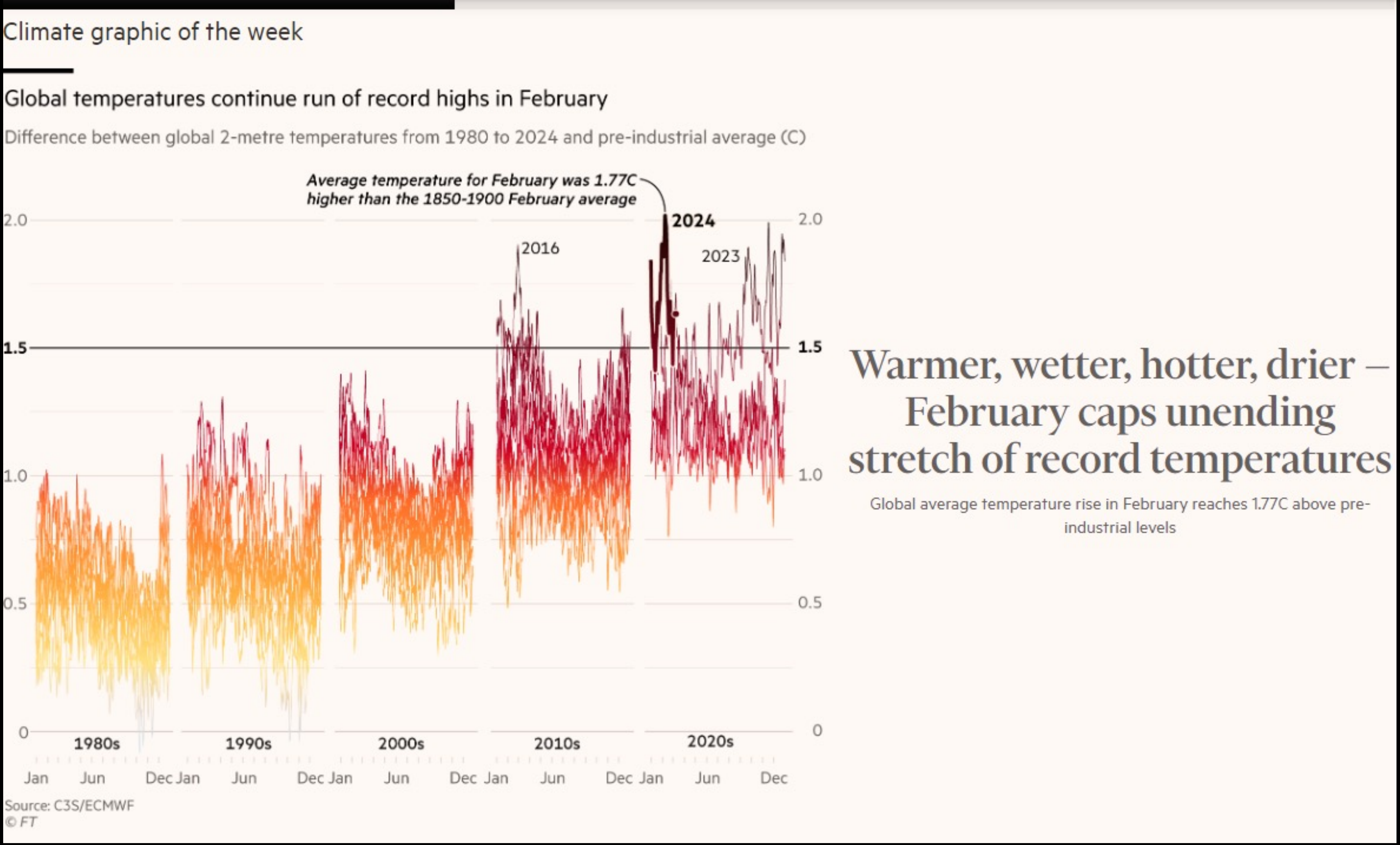
=

~50%(!!) of *global* GDP

Source: Bilal & Känzig (NBER, 13 May 2024), nber.org/papers/w32450

> $150 /
car entering NYC*

* Manhattan below 60^{th} Street



Source: *Financial Times* (10 March 2023)

Leaders | A $25trn hit

Global warming is coming for your home

Who will pay for the damage?

The potential costs stem from policies designed to reduce the emissions of houses as well as from climate-related damage. They are enormous. By one estimate, climate change and the fight against it could wipe out 9% of the value of the world's housing by 2050—which amounts to $25trn, not much less than America's annual GDP. It is a huge bill hanging over people's lives and the global financial system. And it looks destined to trigger an almighty fight over who should pay up.

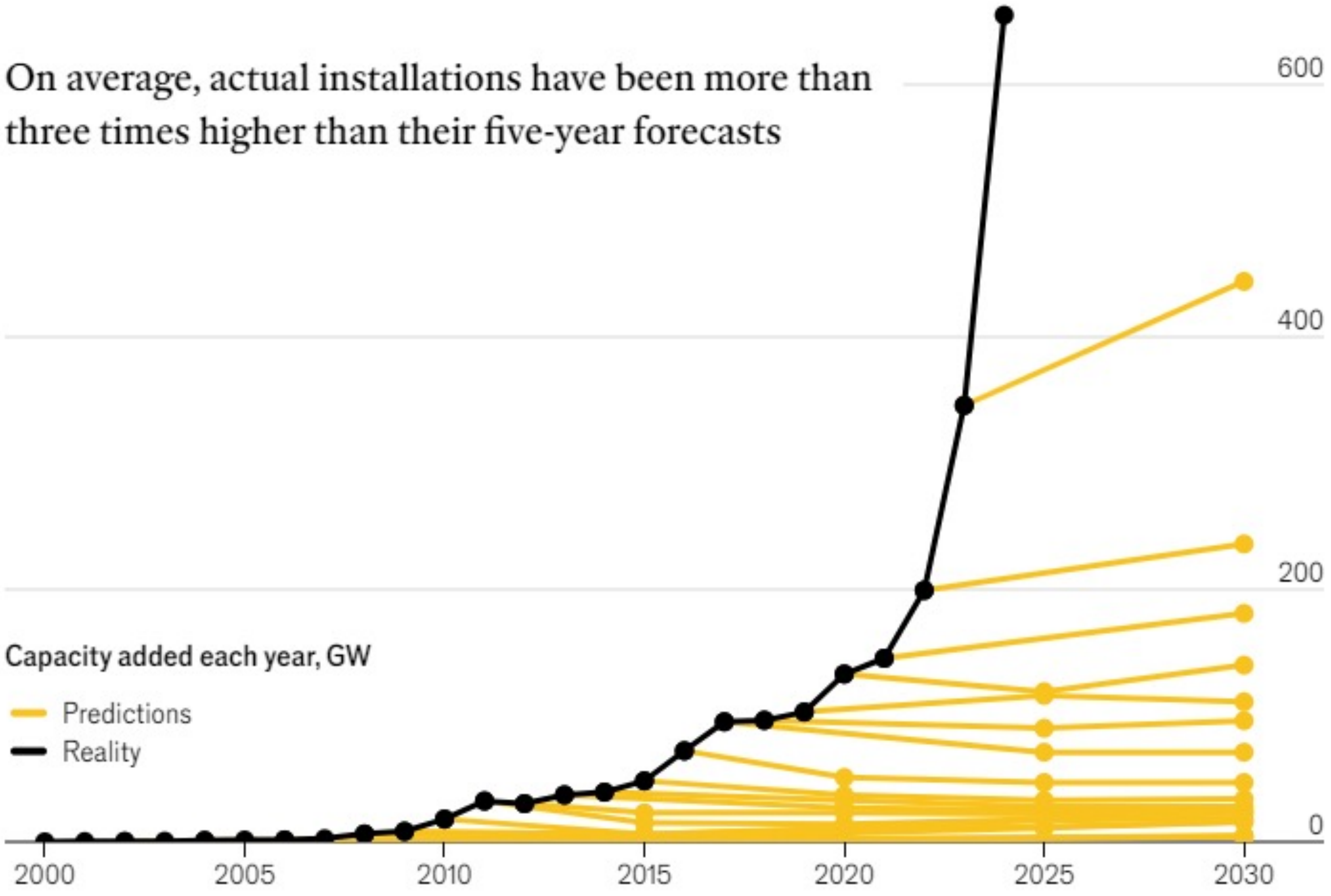
1 Climate risk ≻ known knowns

Climate policy = insurance

1 Climate risk ≻ known knowns

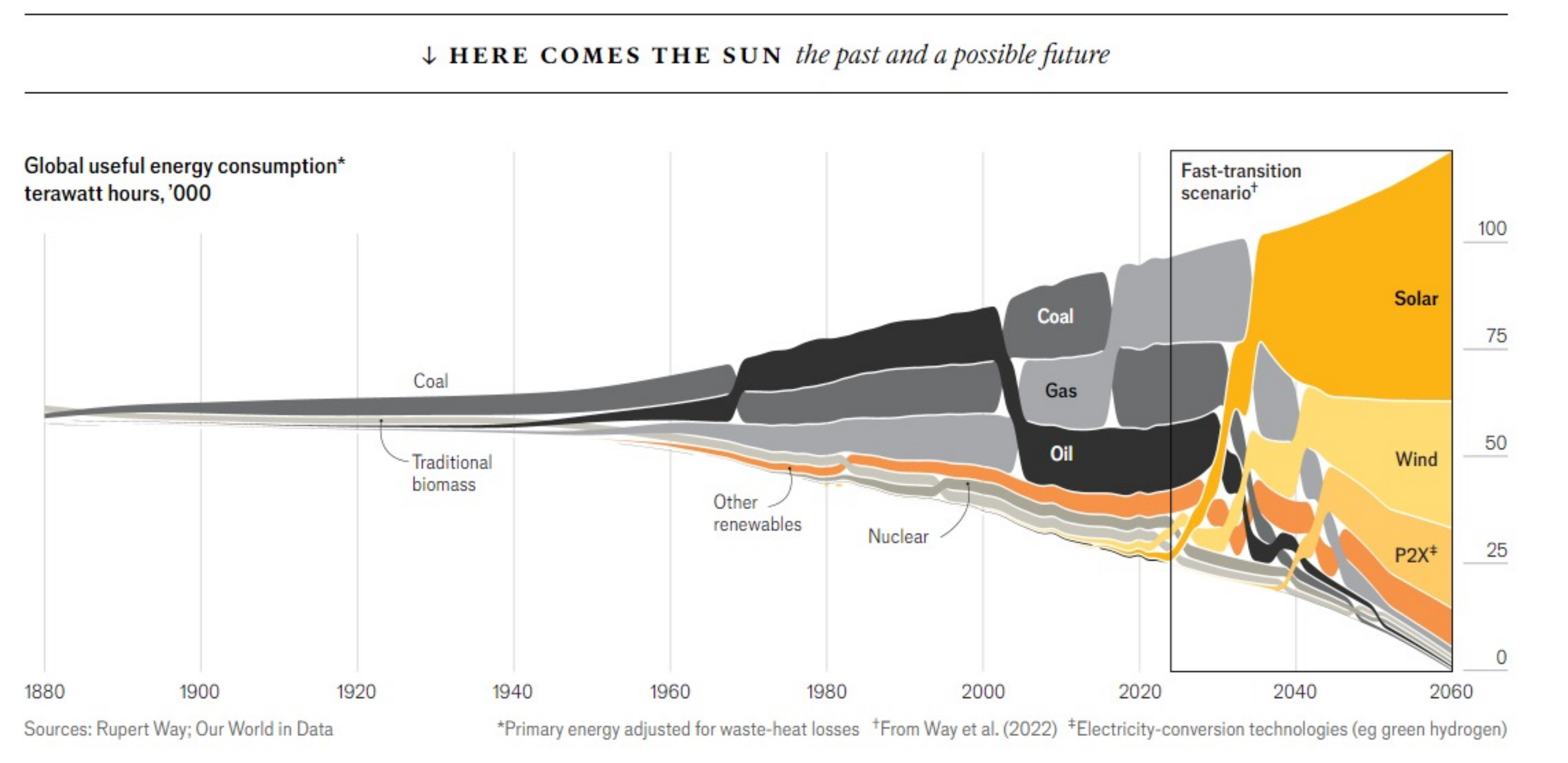
2 Climate policy = opportunity

↓ **EASY PV** *how solar outgrew expectations*



Installations for 2024 are an estimate from BloombergNEF for direct current solar capacity

Sources: IEA; Energy Institute; BloombergNEF



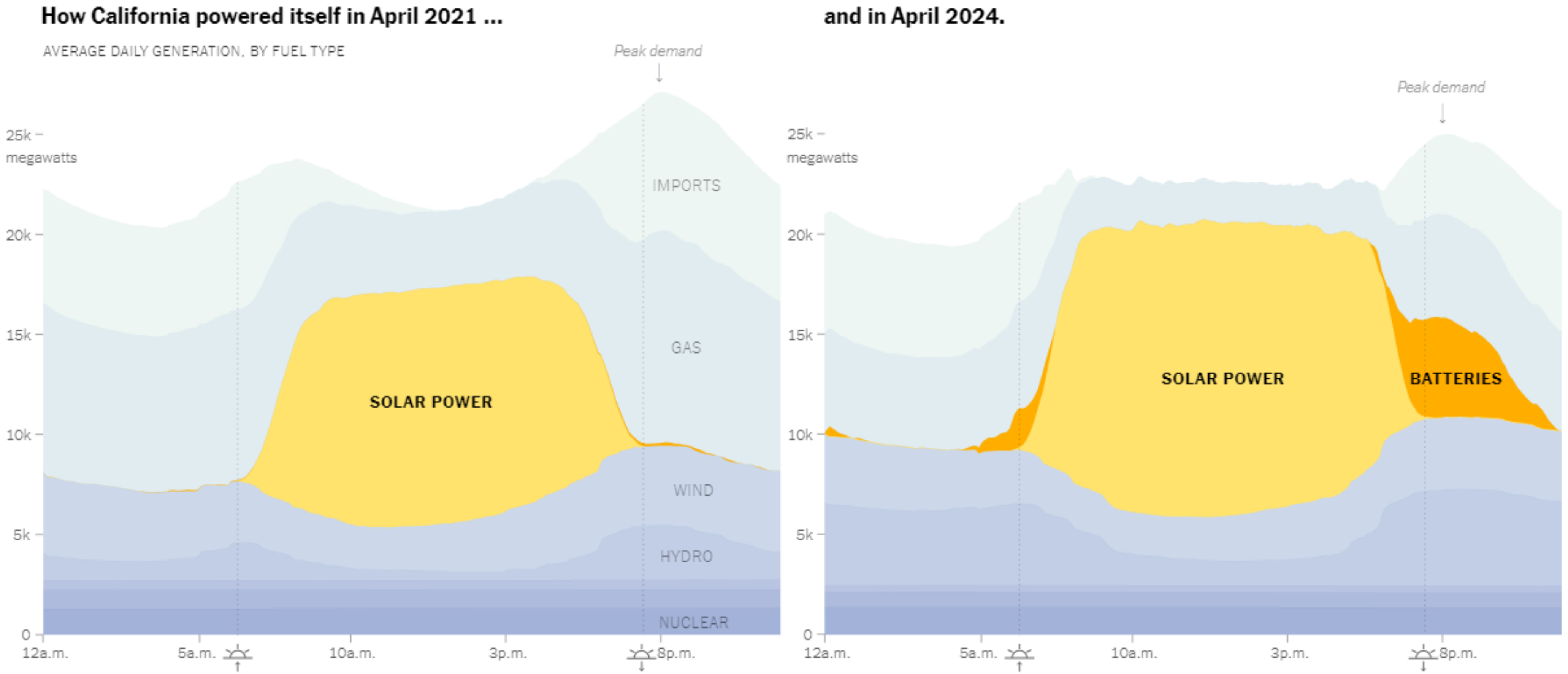
Source: *Economist* "Sun Machines" (20 June 2024)

The New York Times

Giant Batteries Are Transforming the Way the U.S. Uses Electricity

They're delivering solar power after dark in California and helping to stabilize grids in other states. And the technology is expanding rapidly.

By Brad Plumer and Nadja Popovich May 7, 2024



Technology

China's Longi says it will lay off about 5% of employees

By **Reuters**

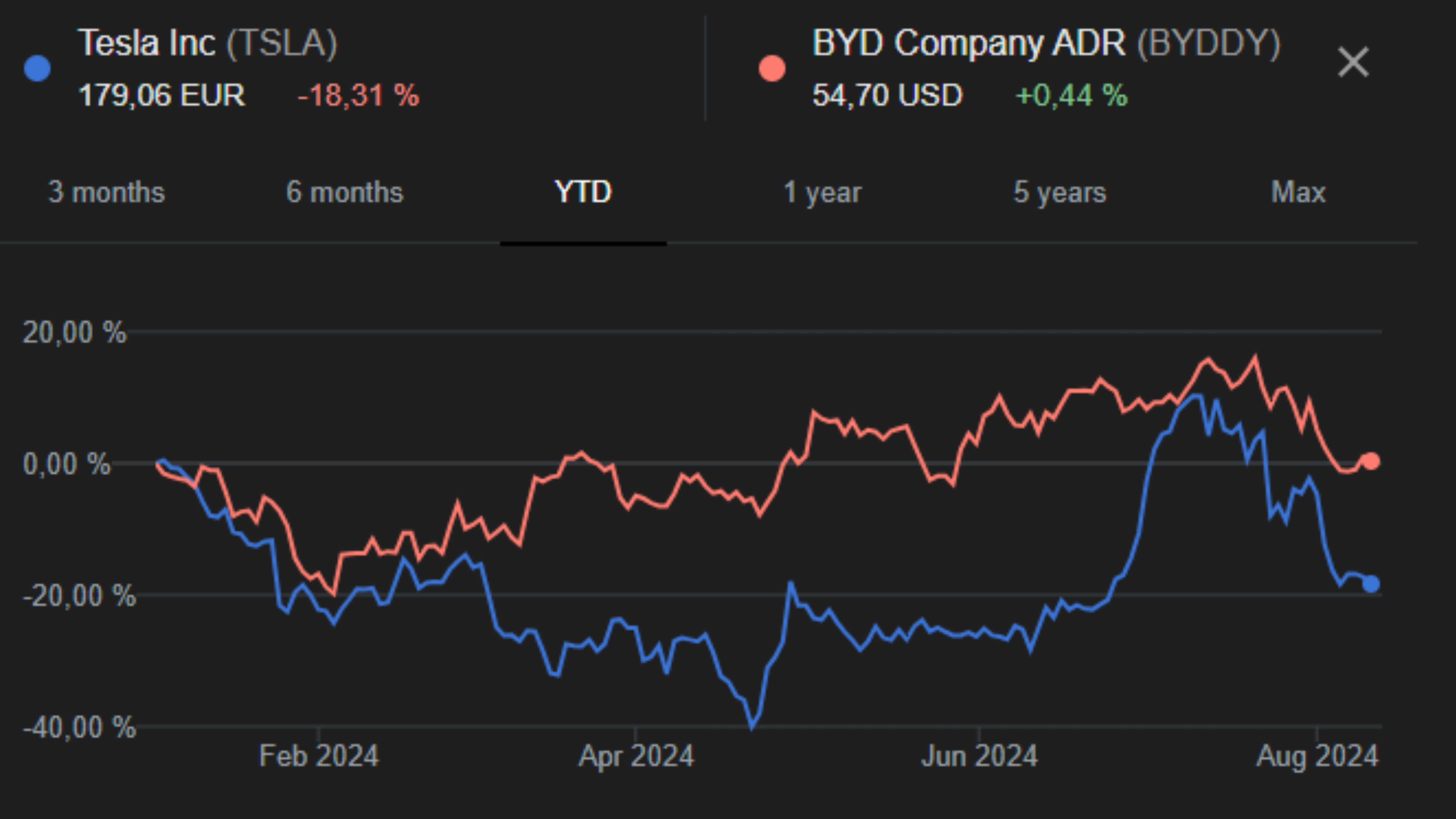
March 18, 2024 10:34 PM EDT · Updated 4 months ago

Bloomberg

Green

Longi Layoffs Speed Move in Solar Production Away From China

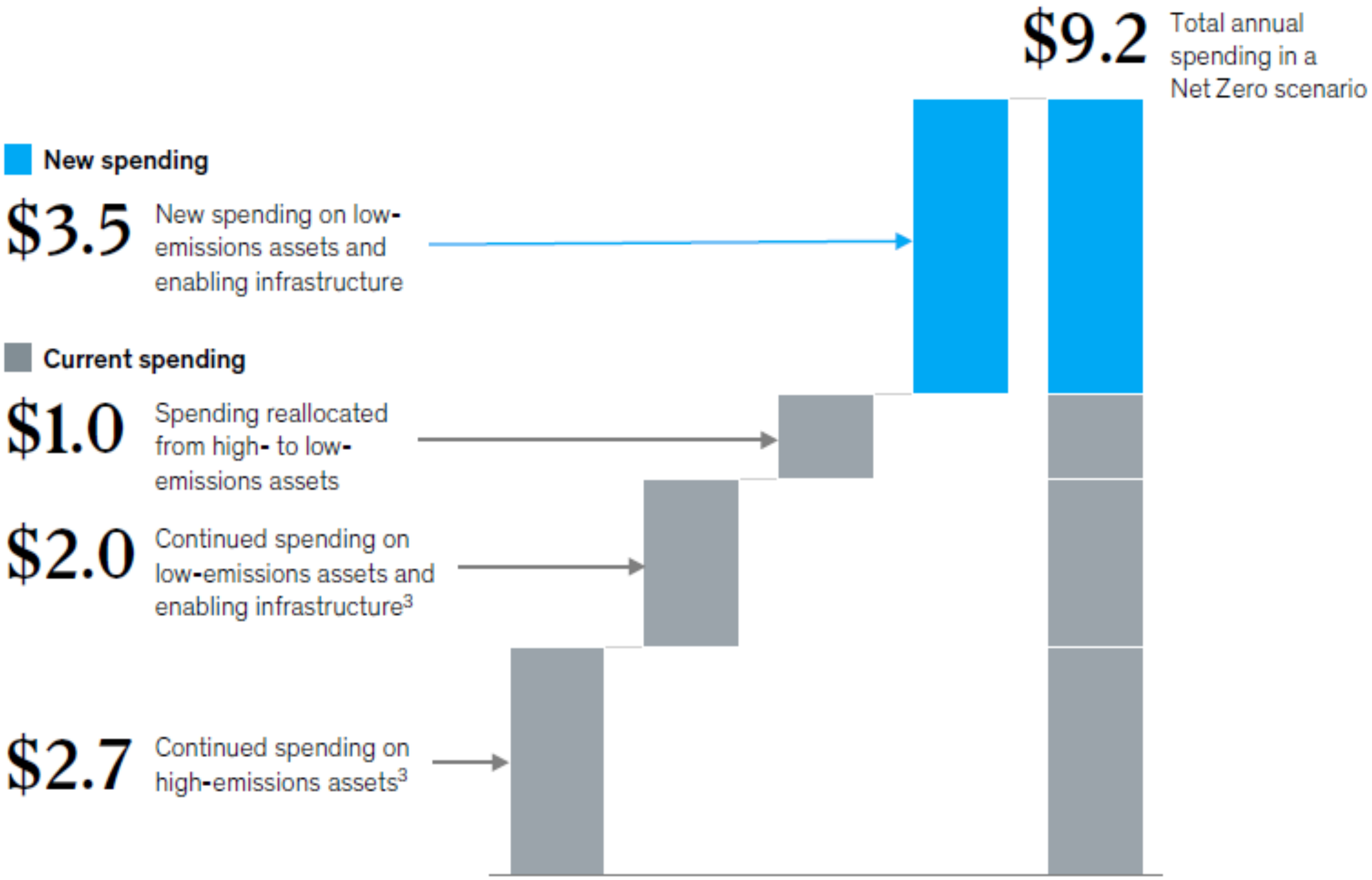
- Most of the job cuts will likely be in China, says Daiwa's Ip
- Chinese firms increasingly looking to move capacity offshore



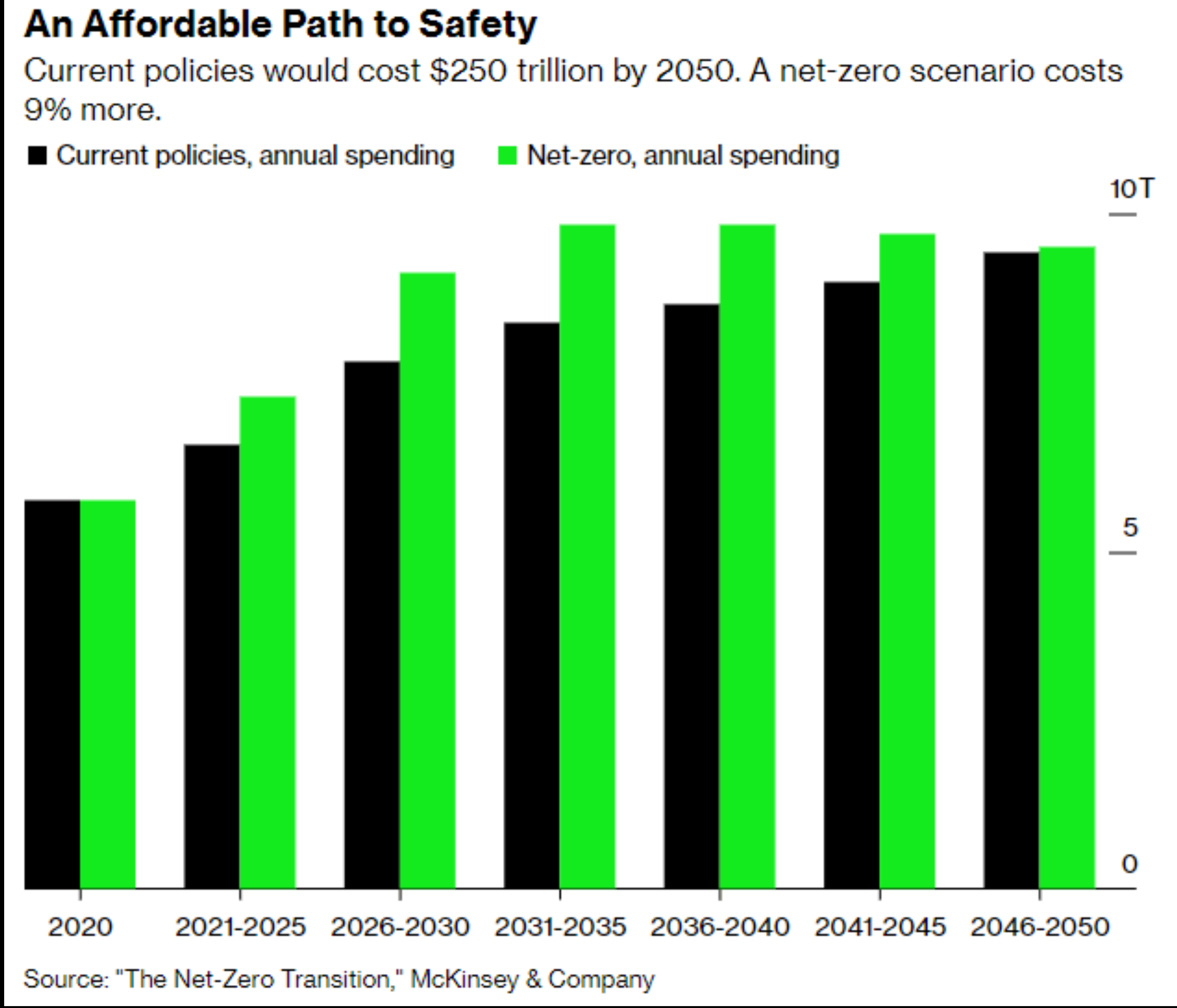
Tesla Inc (TSLA)
179,06 EUR -18,31 %
BYD Company ADR (BYDDY)
54,70 USD +0,44 %
3 months
6 months
YTD
1 year
5 years
Max
20,00 %
0,00 %
-20,00 %
-40,00 %
Feb 2024
Apr 2024
Jun 2024
Aug 2024

Spending on physical assets for energy and land-use systems in the NGFS Net Zero 2050 scenario would rise to about $9.2 trillion annually, or about $3.5 trillion more than today.

Annual spending on physical assets for energy and land-use systems[1] in a Net Zero 2050 scenario,[2] average 2021–50, $ trillion



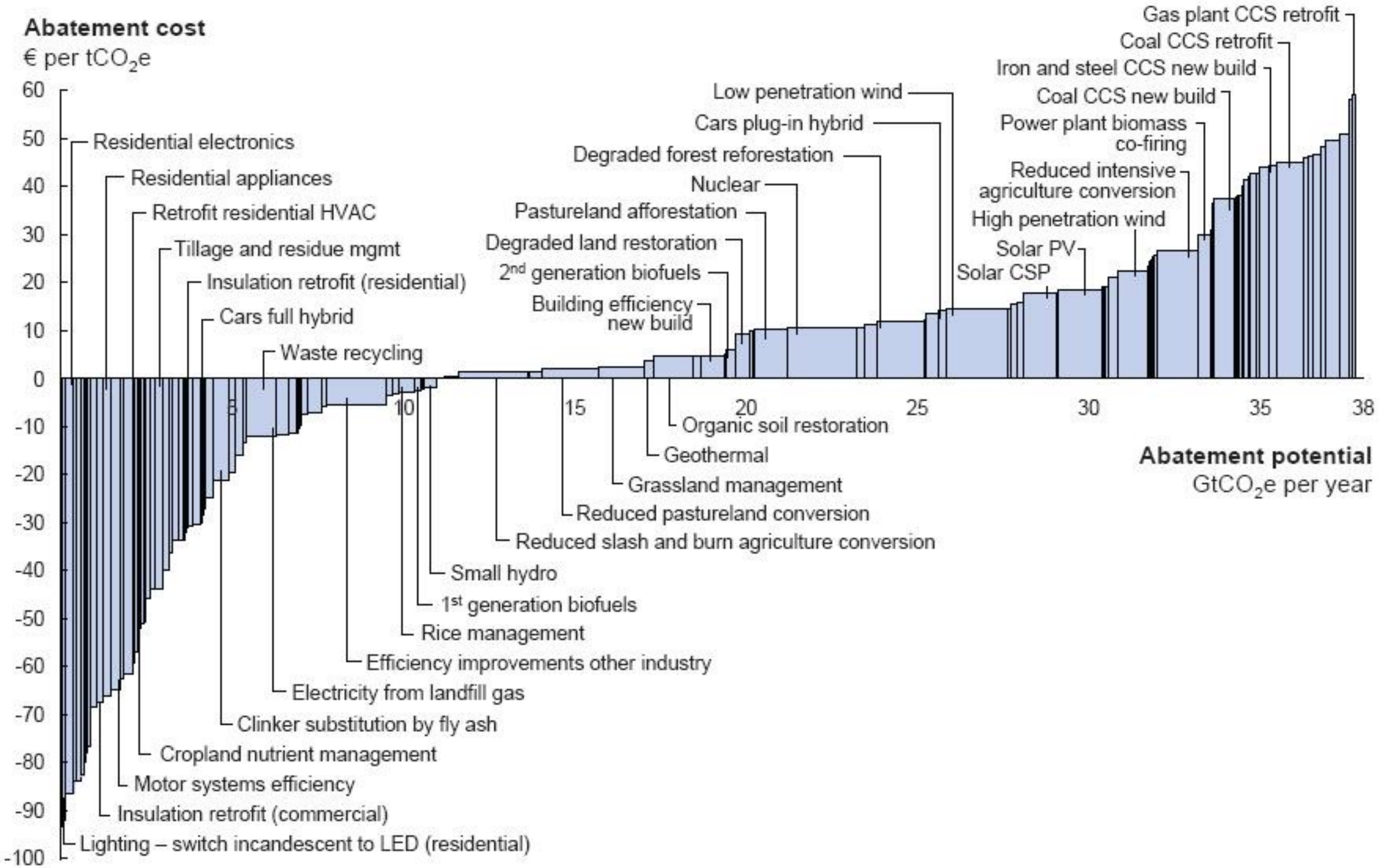
McKinsey's 2022 *The Net-Zero Transition* report



Wagner, "The Cost to Reach Net Zero By 2050 Is Actually a Bargain," *Bloomberg Green* Risky Climate (28 January 2022)

Large abatement opportunities available at low or no cost

McKinsey Global v2.0 effort in 2009 identified 38 $GtCO_2e$ abatement potential in 2030



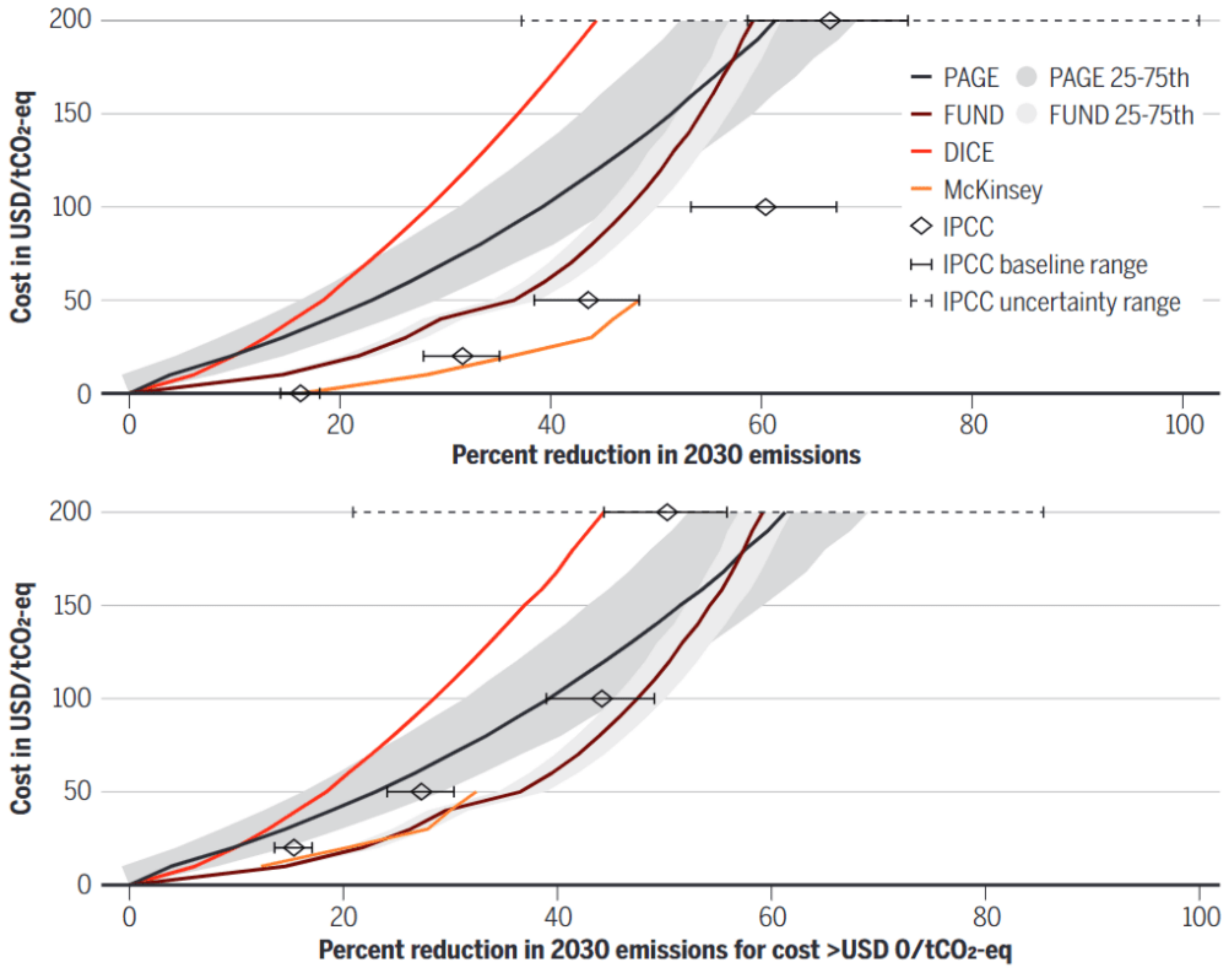
Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €60 per tCO_2e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.

Source: Global GHG Abatement Cost Curve v2.0

How costly, or costless, is climate emissions mitigation? p. 1001

Comparison of global mitigation potentials at different costs

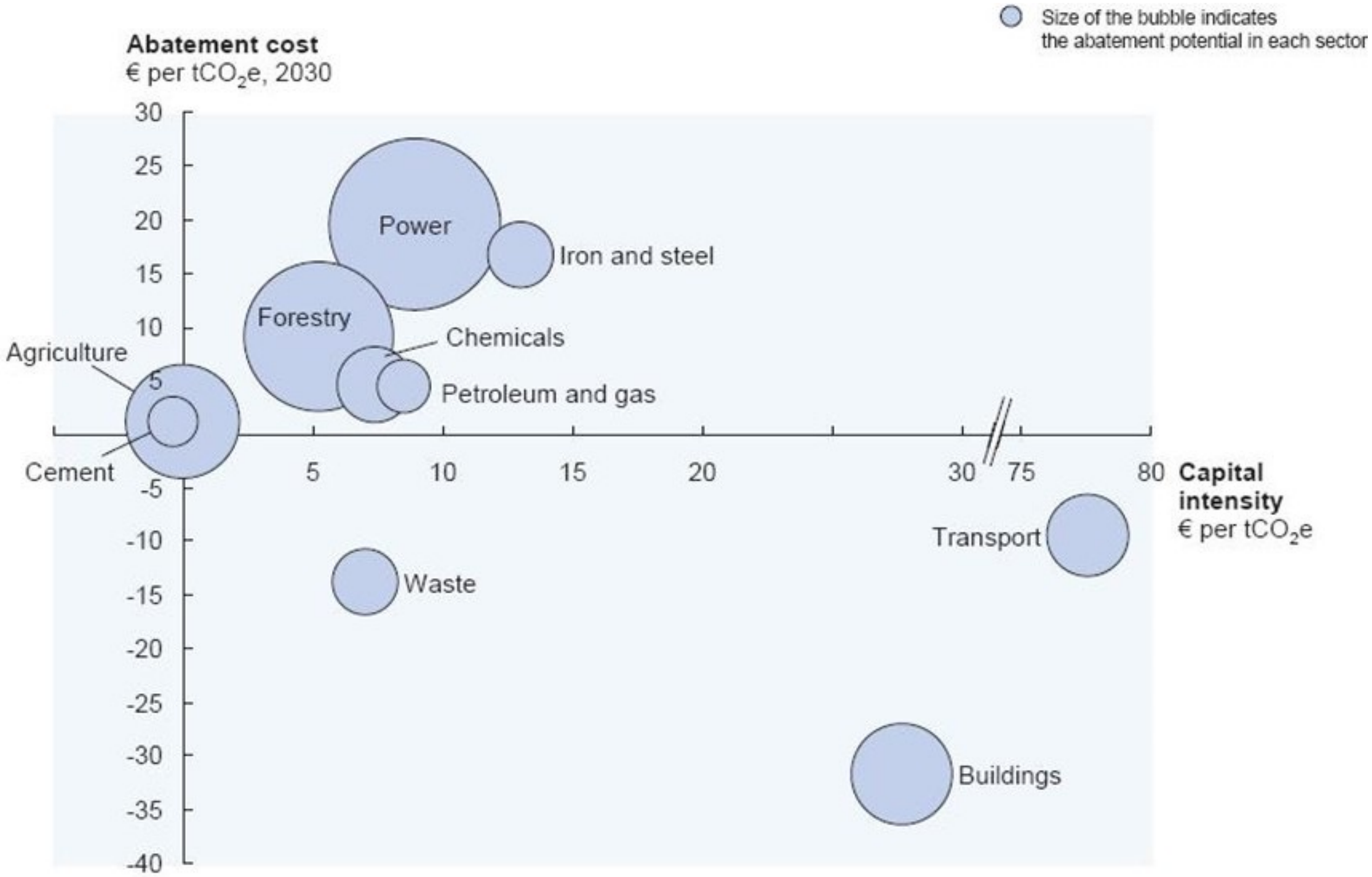
The IPCC results use different baseline emissions to calculate the range of mitigation potentials. The top panel reports the full set of results, and the bottom panel reports only the mitigation potentials with costs >$0 per tonne of CO_2 equivalent (tCO_2-eq). USD reported in 2020 dollars. See supplementary materials.



Source: Kotchen, Rising & Wagner. "The costs of "costless" climate mitigation." *Science* (30 November 2023).

Capital intensity varies widely across sectors

Transport and buildings with largest up-front capital expenditure requirements

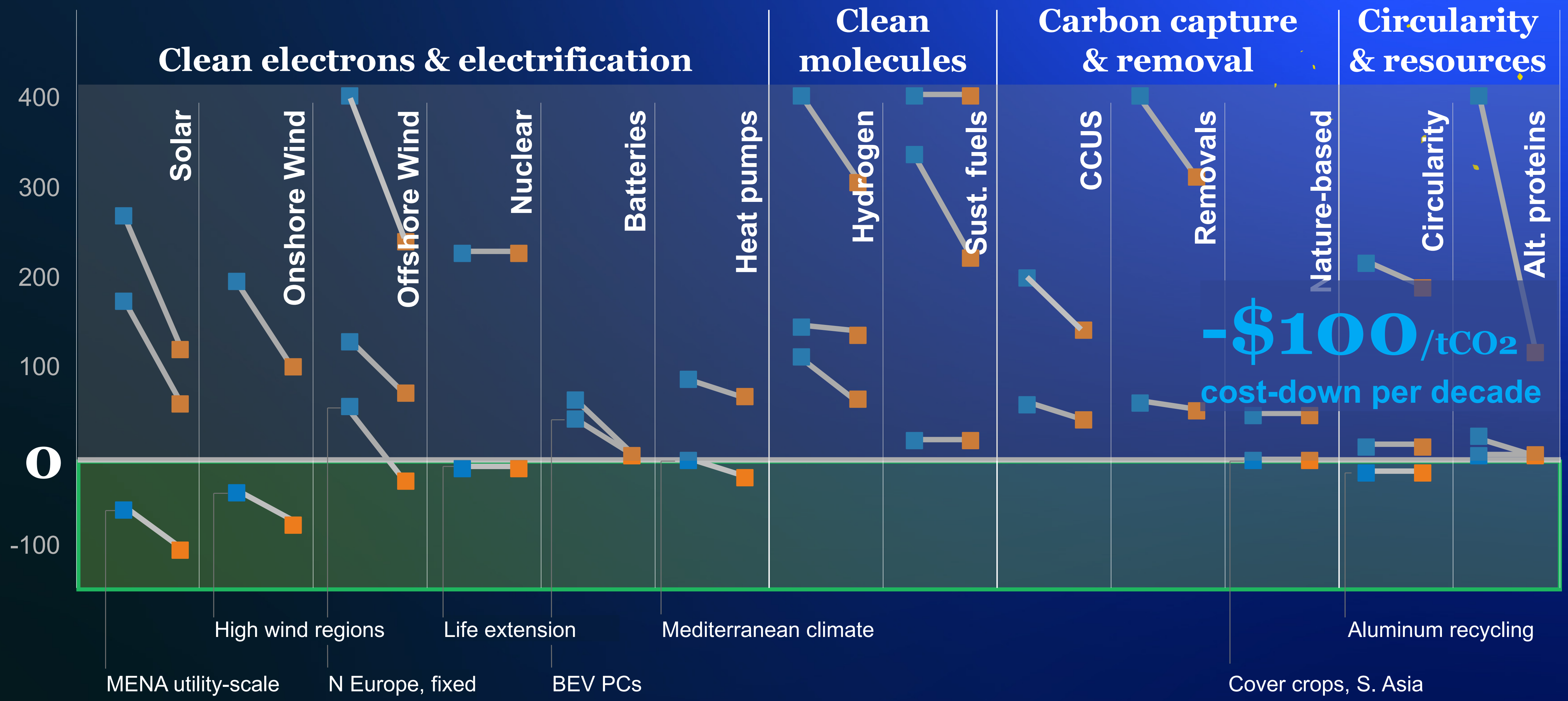


Source: Global GHG Abatement Cost Curve v2.0

Bernd Heid, Senior Partner, McKinsey, at Columbia Business School, 2024

10 % of techs in the money today – steep cost-down to 2030

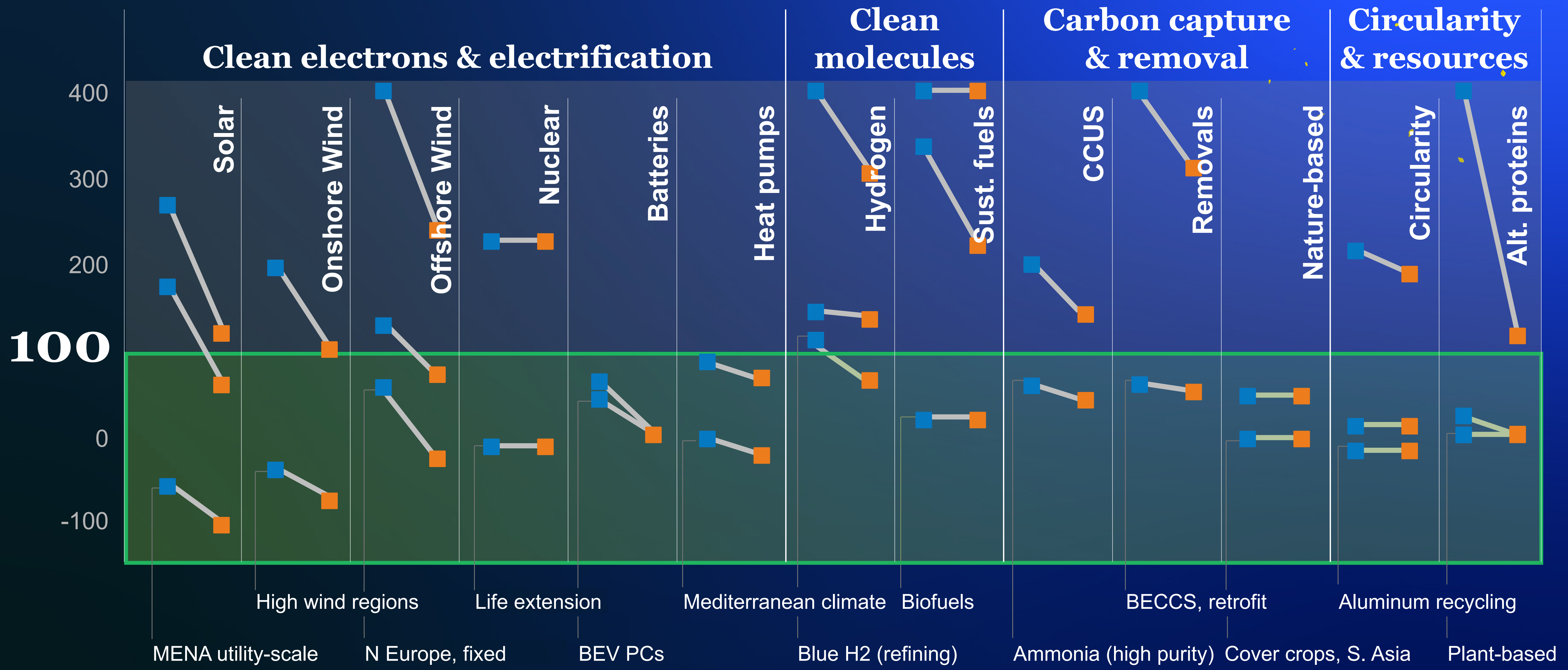
Estimated abatement costs, USD/tCO_2e



Source: McKinsey Global MACC with regional/product estimations

100$/$tCO_2$ carbon tax would make most techs competitive

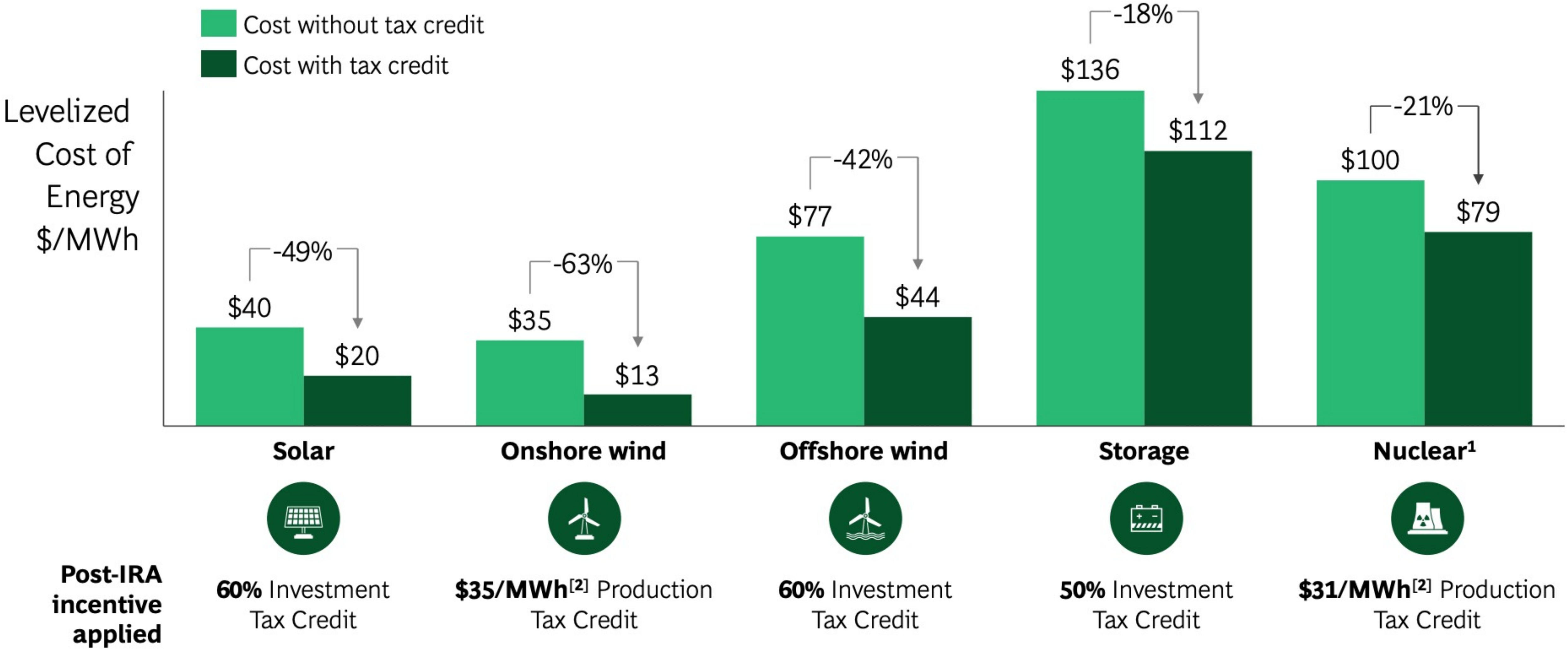
Estimated abatement costs, USD/tCO_2e



Source: McKinsey Global MACC with regional/product estimations

Rich Lesser, Global Chair, Boston Consulting Group, at Columbia Business School, 2022

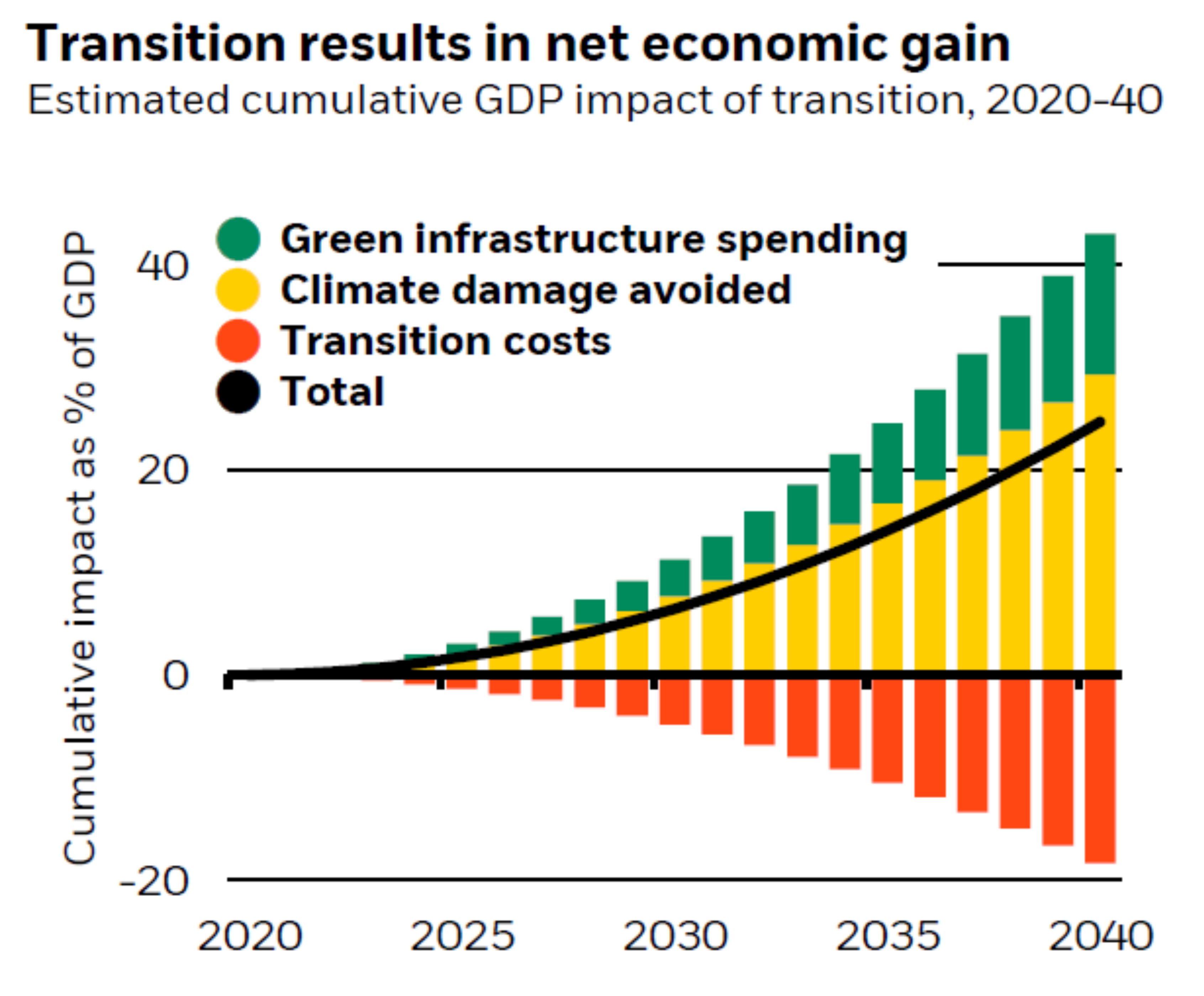
Impact of IIJA + IRA on Climate Solutions



1. New small-modular reactor; 2.Assumes $15/MWh incentive, inflation adjusted and with bonuses; Note: all technologies assume base + prevailing wage bonus + domestic production bonus + energy community bonus, and wind and solar also include low-income bonus Source: Lazard, BCG analysis

Source: BCG

Managing the net-zero transition



Transition results in net economic gain
Estimated cumulative GDP impact of transition, 2020-40
Green infrastructure spending
Climate damage avoided
Transition costs
Total
Cumulative impact as % of GDP
40
20
0
-20
2020
2025
2030
2035
2040

BlackRock

Transition costs additional
<$1T / yr, shifting ~$8T / yr

U.S. IRA alone ~$1.2T / 10 yr,
leveraging ~$3T in private capital

Negative climatic tipping points, meet the positive socio-economic ones the IRA is jumpstarting

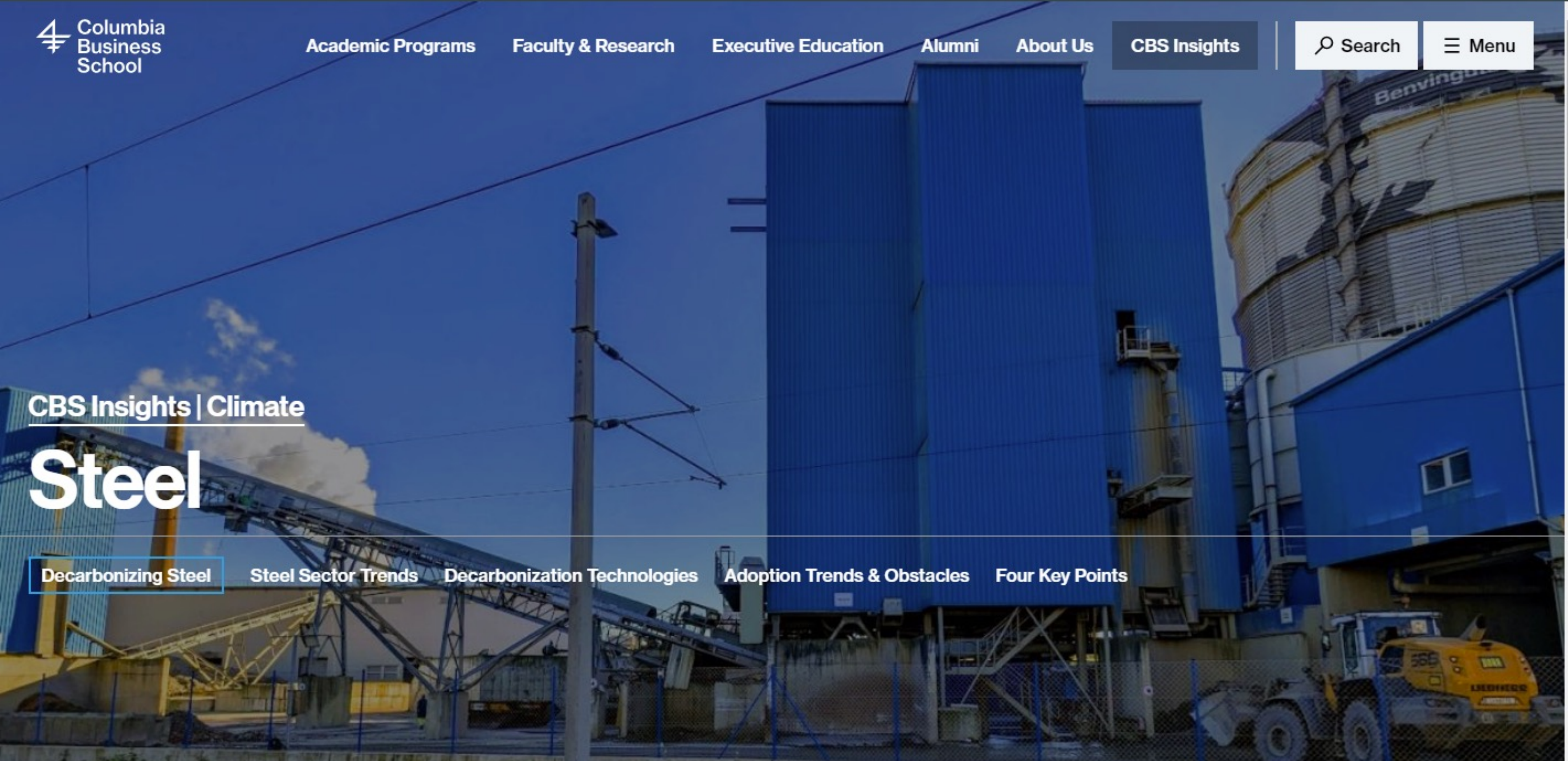
- The challenge: Addressing ‘fossilflation’ while keeping ‘greenflation’ in check
- Direct effects are important
  - e.g. get $8k rebate for your heat pump, $2.5k to improve electric wiring, … $250b in DOE loans
  - adding up to $1.2 trillion in federal spending over first decade, spurring $2.9 trillion in total spending over first decade, >$10 trillion by 2050, per Goldman Sachs Research,

  But:
- It’s the external effects, norm changes, positive socio-economic tipping points that will make the real difference

1 Climate risk ≻ known knowns

2 Climate policy = opportunity

3 Pricing carbon “+”



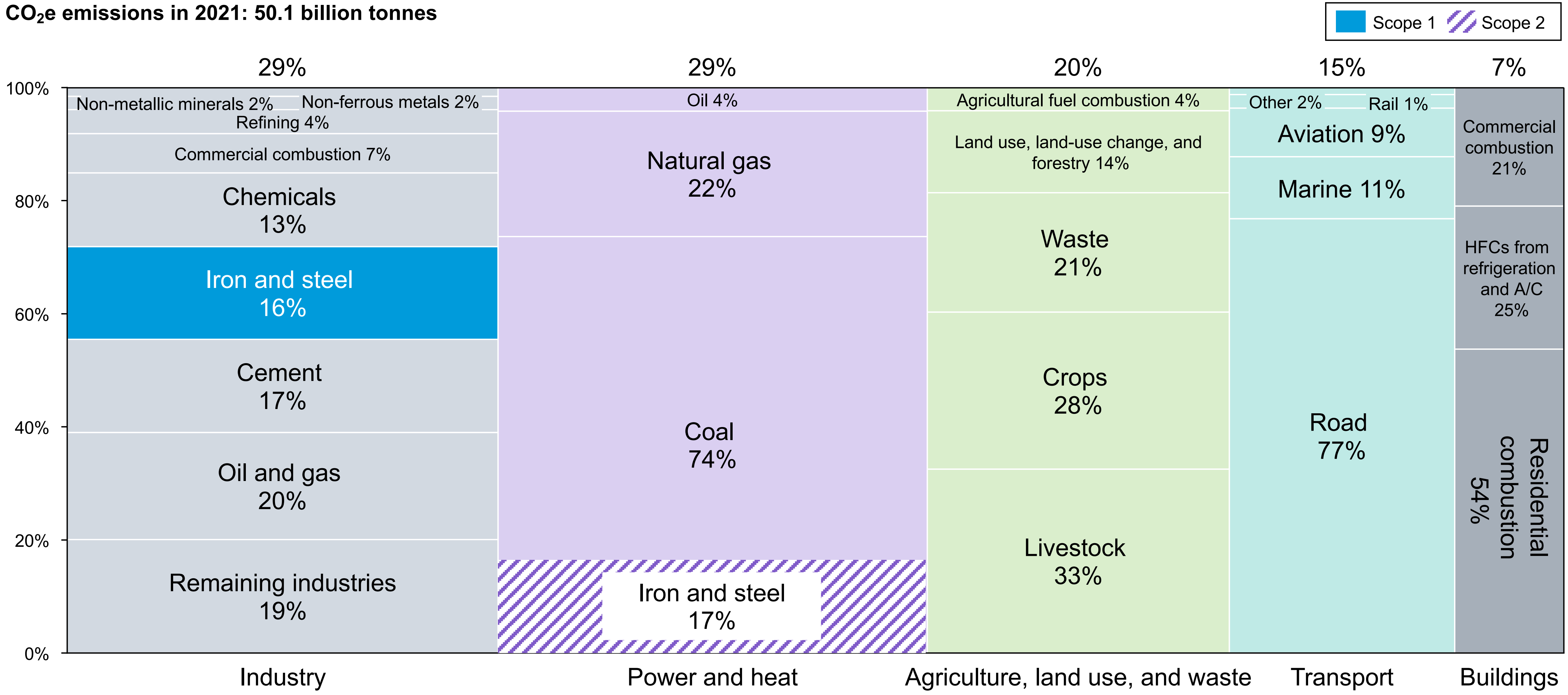
CBS Insights | Climate

Steel

Decarbonizing Steel | Steel Sector Trends | Decarbonization Technologies | Adoption Trends & Obstacles | Four Key Points

Steel sector scope 1 and 2 emissions are ~10% of global emissions

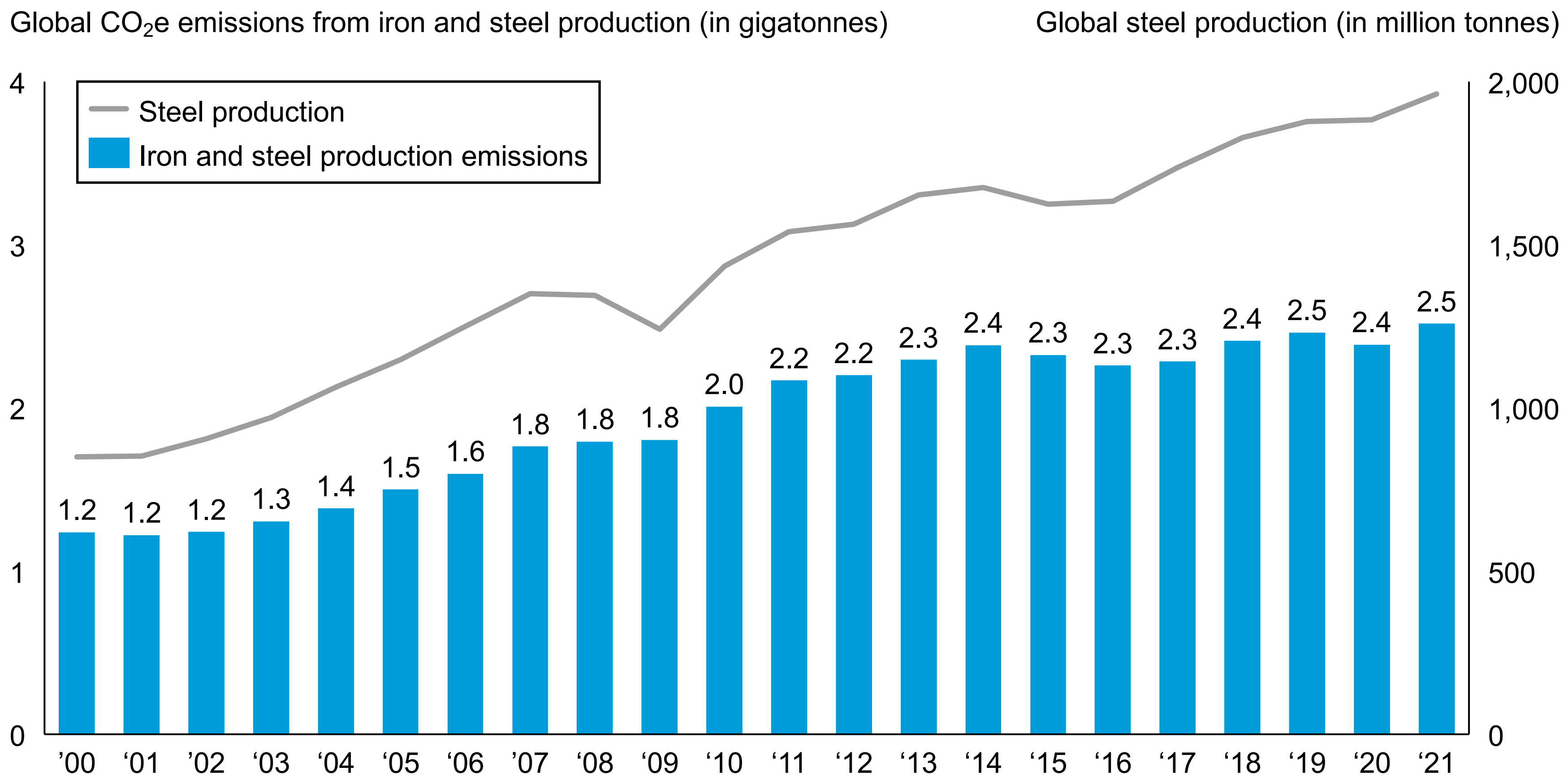
CO_2e emissions in 2021: 50.1 billion tonnes



Sources: Scope 1 emissions from Rhodium Group ClimateDeck (September 2023); Scope 2 iron and steel estimate from IEA (2023).
Credit: Mimi Khawsam-ang, Max de Boer, Grace Frascati, and Gernot Wagner (22 February 2024); share/adapt with attribution. Contact: gwagner@columbia.edu

Global steel emissions have more than doubled since 2000, with emission growth decoupled from production growth after 2016

Global CO_2e emissions decoupled from steel production post-2016



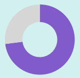
Note: The majority of the world's iron is used to make steel. Sources: Rhodium Group ClimateDeck (September 2023); World Steel Association; McKinsey, Decarbonization Challenge for Steel; IEA, CO_2 Emissions in 2022, Reuters, China 2021 Crude Steel Output. Credit: Mimi Khawsam-ang, Max de Boer, Grace Frascati, and Gernot Wagner (22 February 2024); share/adapt with attribution.
Contact: gwagner@columbia.edu

Observations

- In recent years, the steel industry has made efforts to **reduce its carbon footprint** with **more energy-efficient processes and technologies**
  - Though not enough by itself, recycling rates **have improved** (sitting around 80%-90% globally)
  - **Better manufacturing yields** have made supply chains more efficient
  - **Enhanced control processes** and **predictive maintenance strategies** have led improvements in **operational efficiency**
- **China**, the largest steel producer in the world, saw a **3% decline in steel output** in 2021 and a similar decline in the years since

Columbia Business School

At present, crude steel is produced through three main methods that all emit CO_2: BF-BOF, scrap EAF, and NG DRI-EAF

	1 Blast Furnace-Basic Oxygen Furnace (BF-BOF)	2 Scrap Electric Arc Furnace (Scrap EAF)	3 Natural Gas-Based Direct Reduced Iron – Electric Arc Furnace (NG DRI-EAF)
Description	**Iron ore, coke, and limestone** produce pure iron in a **blast furnace**, which **is turned into steel in an oxygen furnace**	**Scrap metal** is **melted in an EAF** using **electrical energy**	**Iron ore** is turned **into iron** using **natural gas**, which is then **melted in an EAF** to **produce steel**
Main inputs	**Iron ore, cooking coal**	**Scrap steel, electricity**	**Iron ore, natural gas**
% of global steel production	 72%	 21%	7%
CO2 per tonne of crude steel	**2.3 tonnes**	**0.7 tonnes**	**1.4 tonnes**
Energy intensity per ton of crude steel	**~24 GJ**	**~10 GJ**	**~22 GJ**
Average cost per tonne of crude steel	**~$390**	**~$415**	**~$455**

Sources: World Steel Association; IEEFA (2022); IEA, Iron and Steel Technology Roadmap (2020); Steel Technology, Basic Oxygen Furnace Steelmaking; Recycling Today, Growth of EAF Steelmaking; Wildsight, Do We Really Need Coal to Make Steel. Credit: Mimi Khawsam-ang, Max de Boer, Grace Frascati, and Gernot Wagner (22 February 2024); share/adapt with attribution. Contact: gwagner@columbia.edu

Columbia Business School
AT THE VERY CENTER OF BUSINESS

Steel Decarbonization Technologies

Green H_2, electrolysis, and CCUS could reduce steelmaking CO_2 emissions by over 85% if implemented at scale

	1	2	3
	100% Green Hydrogen (H2) DRI-EAF	**Iron Ore Electrolysis**	**Carbon Capture, Utilization, and Storage (CCUS)**
Description	• **Green hydrogen** replaces **natural gas** as an iron ore reductant in DRI shaft; the rest of the process remains the same • Generates **water as a byproduct** instead of CO_2	• **Two different processes** are possible: **Molten oxide electrolysis:** High current runs through mixture of iron ore and liquid electrolyte to split ore into pure molten iron **Electrowinning-EAF:** Iron from iron ore is dissolved in acid. Iron-rich solution is then electrified to form pure solid iron	• **CCUS equipment** can be added to **existing steel-producing infrastructure** to **capture** emitted CO_2 • Captured CO_2 is then **sequestered underground** or **reused**
Real-time sector initiatives	HYBRIT 100% fossil fuel-free DRI-EAF production with green H_2 used for DRI	Electra Electrowinning to produce high-purity iron plates ready for EAF input (no DRI or MOE step)	ArcelorMittal Carbalyst® captures carbon from a blast furnace and reuses it as bio-ethanol. However, technology not proven at scale
Applicability to conventional routes	**Applicable to existing DRI-EAF route**, with minor retrofitting	**Full overhaul** of BF-BOF equipment required; **replacement** of DRI shaft in DRI-EAF	**Retrofitting** of capture technology is possible on **conventional BF-BOF and DRI-EAF**
Decarbonization potential (vs. BF-BOF)	**~90%**	**~97%**	**~90%** Hypothetical best-case scenario
Estimated production cost (excl. CapEx)	**<$800 per tonne of steel**	**~$215 per tonne of iron + cost of 'stranded' iron ore**	**~$380 – 400 per tonne**

Sources: Columbia Center on Global Energy Policy (2021); IEA, Iron and Steel Technology Roadmap (2020); McKinsey (2020); Mining Technology (2023); Tata Steel; Primetals Technologies; Edie, ArcelorMittal accused of net-zero greenwashing (2023). Credit: Mimi Khawsam-ang, Max de Boer, Grace Frascati, and Gernot Wagner (13 March 2024); share/adapt with attribution.
Contact: gwagner@columbia.edu


H2 green steel

Investors:

- Altor Equity Partners
- AMF
- Andra AP-Fonden
- Ane & Robert Maersk Uggla
- BILSTEIN GROUP
- Cristina Stenbeck
- Daniel Ek
- EIT InnoEnergy
- Exor
- FAM
- GIC
- Hitachi Energy
- Hy24
- IMAS Foundation
- Just Climate
- Kingspan
- Kinnevik
- Kobe Steel
- Marcegaglia
- Mercedes-Benz AG
- Scania
- Schaeffler
- SMS Group
- Stena Metall Finans
- Swedbank Robur Alternative Equity
- Temasek
- Vargas

Financing

Series A & B

~€2.0 billion

Debt commitment

€3.5 billion

When we launched, only 2-3mt DRI steel had been announced in Europe

DRI announced in Europe 2021, *mt liquid steel*

2025	H2 green steel	2.5mt
2026	HYBRIT FOSSIL-FREE STEEL	~1mt
2027		
2028		
2029	LKAB SSAB	2.0mt
2030	H2 green steel	2.5mt

Since our announced, more than ~40mt green steel projects have been promised by 2030

DRI announcements in Europe today, *mt liquid steel*

2025 | 2026 | 2027 | 2028 | 2029 | 2030

H2 green steel 2.5mt
ArcelorMittal 2.3mt

HYBRIT FOSSIL-FREE STEEL 1.3-2.7mt
thyssenkrupp 2.5mt
SALZGITTER AG Stahl und Technologie 1.9mt

BLASTR Green Steel 2.5mt
LIBERTY 3.0mt
GravitHy 2.0mt

ArcelorMittal 2.3mt
voestalpine ONE STEP AHEAD. 1.9mt

SHS - STAHL-HOLDING-SAAR 2.0mt

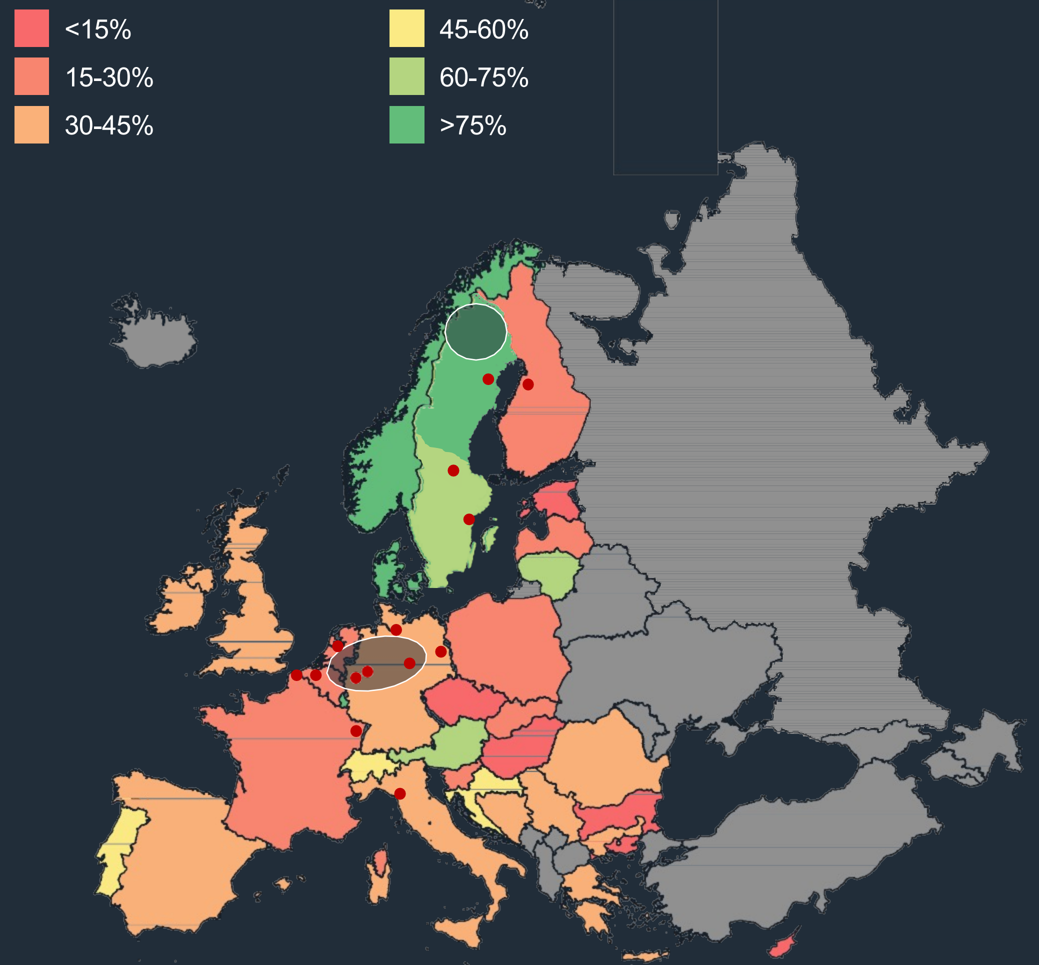
TATA STEEL 4.5mt

LKAB SSAB 5.0mt
ArcelorMittal 7.0mt

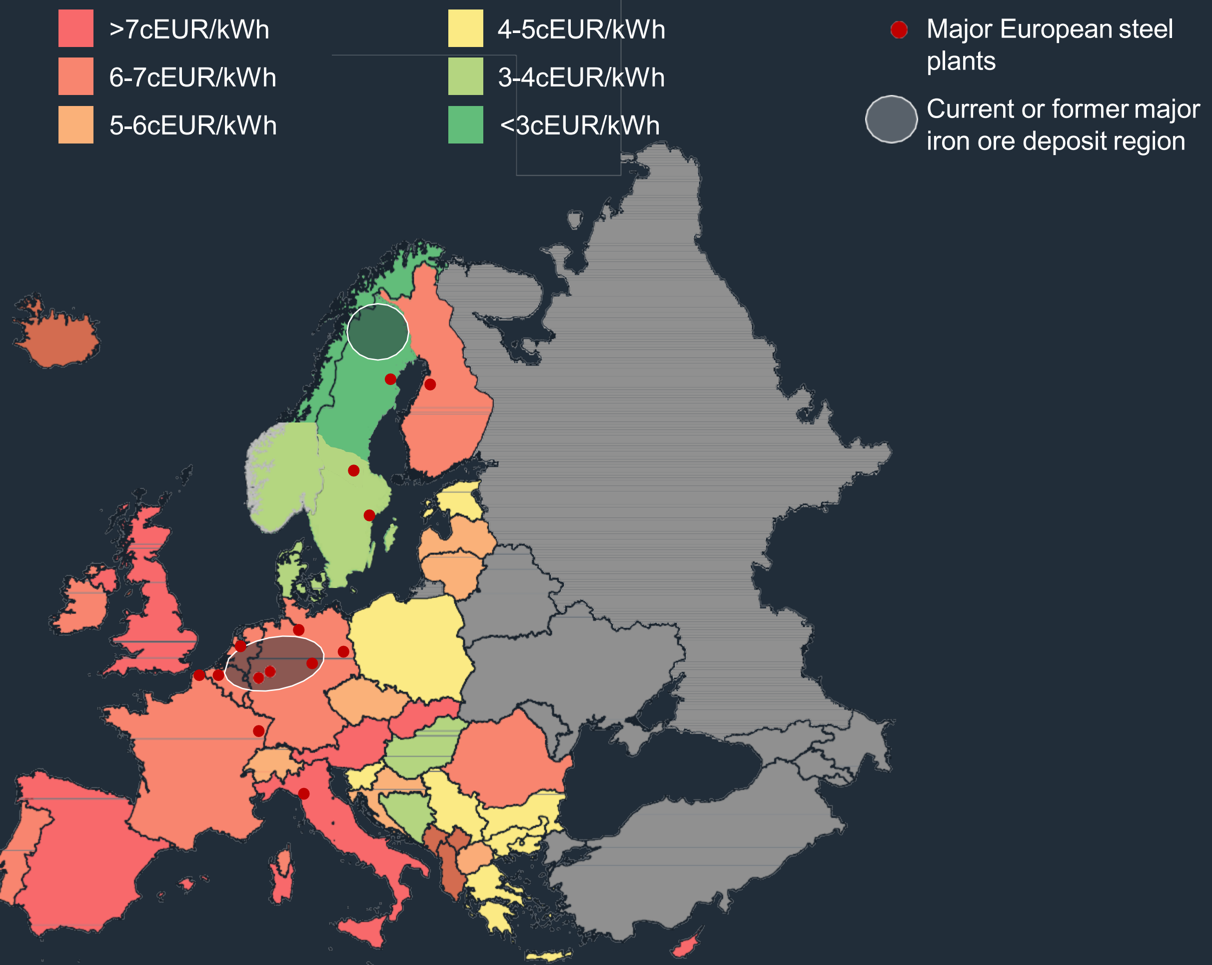
H2 green steel 2.5mt
SALZGITTER AG Stahl und Technologie 1.9mt

Northern Sweden has unique advantages from low-cost renewable electricity and iron ore deposits

Renewable share in electricity production in Europe
2019



Industrial electricity prices in Europe
2019



Source: International Energy Agency (IEA); Eurostat; ProMine

Potential projects in North America

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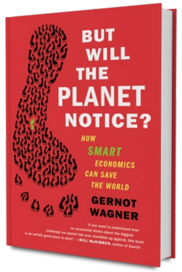

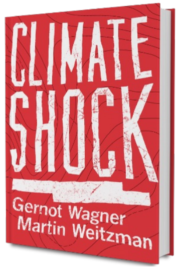

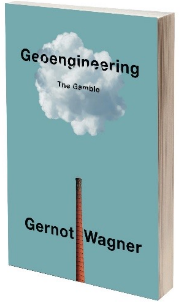

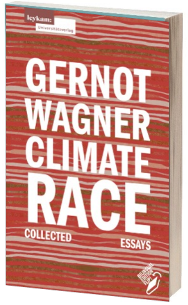

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