RMI

The Energy Transition Narrative

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Introduction

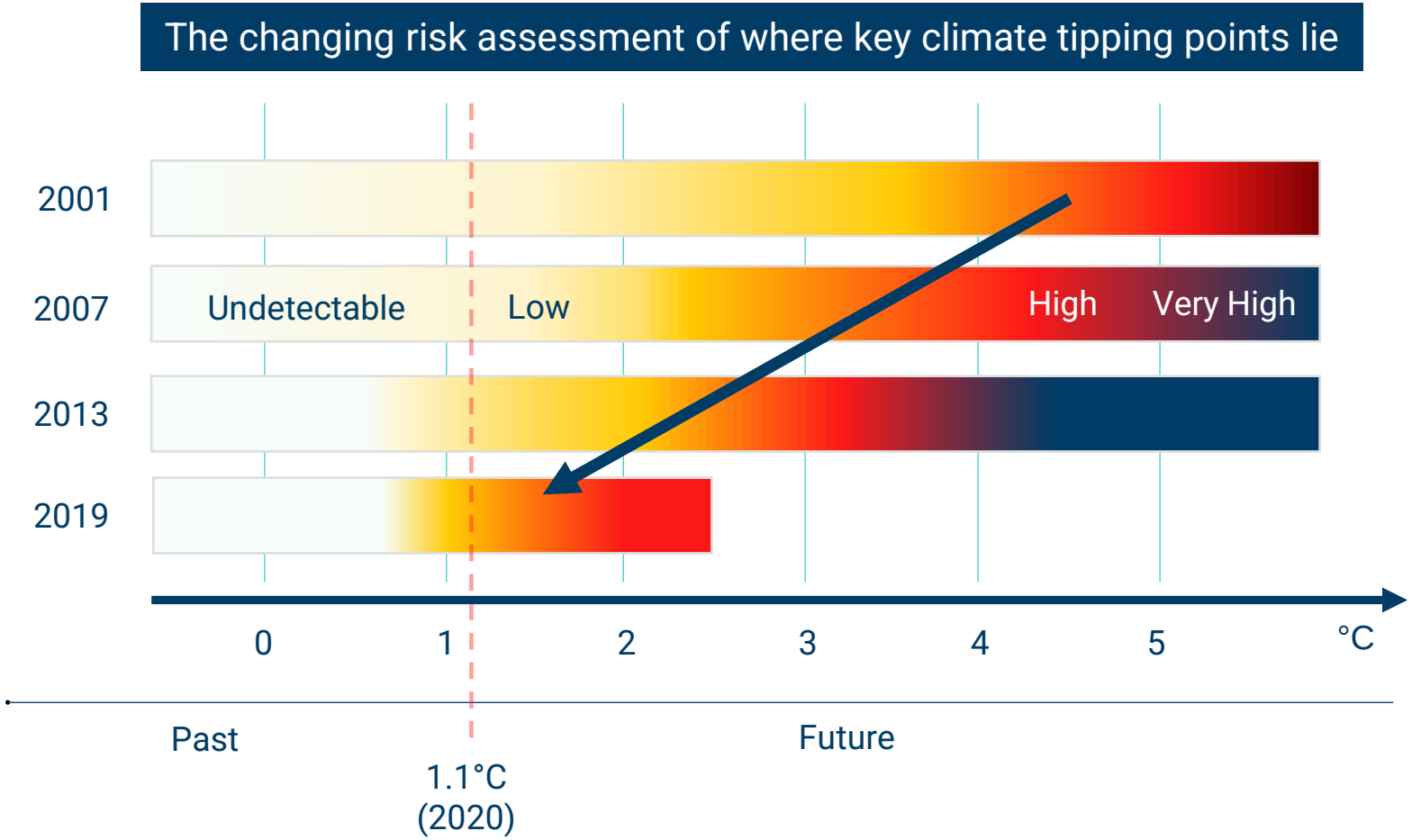
- This presentation presents an insurgent view of the energy transition.
- Rapid energy technology change is inevitable and beneficial, not forced and costly.
- The speed of change is set by challengers, not incumbents; by fossil fuel importers, not exporters; and by markets more than policymakers.
- Ever-falling costs open up new markets and opportunities.
- Financial markets, policy, and social norms are responsive, not static.
- This is a just transition, as we move from a commodity that favors the few to technology for the many.
- History shows that rapid technology shifts at the margin are the norm, not the exception.
- Peaks come early, and with peaks comes disruption.
- Change happens far faster than most incumbent experts predict.
- This decade will see enormous opportunity for those that embrace change, and catastrophic risk for those that fail to see what is going on.
- The energy transition is not primarily a debate about ideology or values. It is simply a technology shift.
- Incumbents resist change. So we need to make it happen. The renewable economy needs to be built.

Summary

The Climate Necessity to Change Is Becoming More Urgent

The climate is changing faster than scientists anticipated

IPCC Assessment Reports and Special Reports



In 2001, the IPCC thought that climate risks would be "high" at over 4°C of warming

Better modeling means that the IPCC now believes that climate risks are high at over 1.5°C

The latest paper in Science suggests that we are already at risk of crossing tipping points in several areas including the Greenland and West Antarctica ice sheets and the Northern permafrost

Source: Lenton et al 2019

Putin’s War Speeds Up Change

High fossil fuel prices and energy security bring forward change

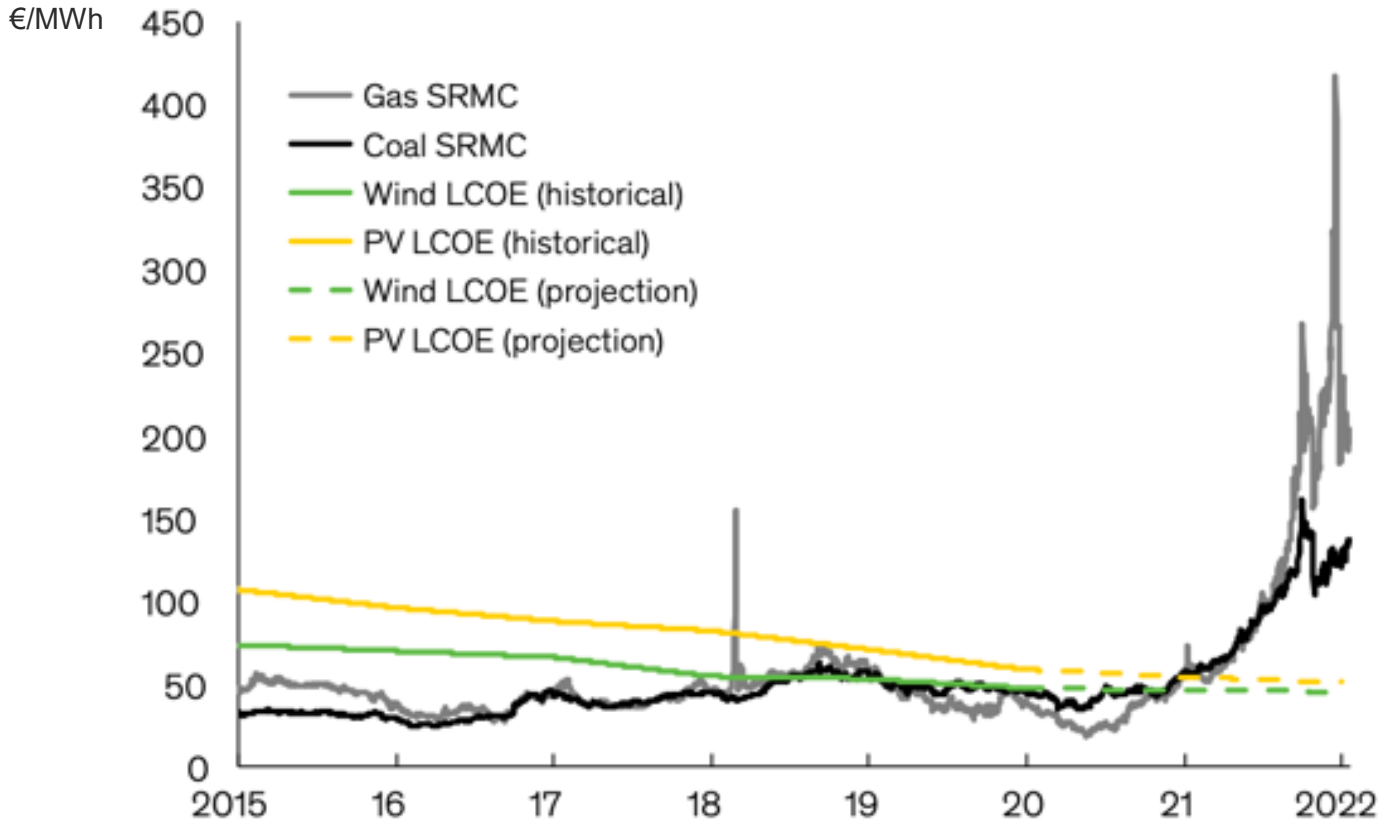
High prices of fossil fuels reduce fossil fuel demand and massively increase the **competitiveness of renewable technologies.**

Governments have an additional **energy security and economic incentive** to deploy renewables and increase efficiency. Witness the IRA in the United States, REPowerEU in Europe, and the IEA Sonderborg Action Plan on efficiency.

Renewable energy deployment **continues to grow exponentially**. We expect solar growth in 2022 of ~30% and EV sales growth of ~60%.

The removal of 5% of global fossil fuel supply from Russia inevitably means some new coal and LNG supply. But net fossil fuel demand will still fall.

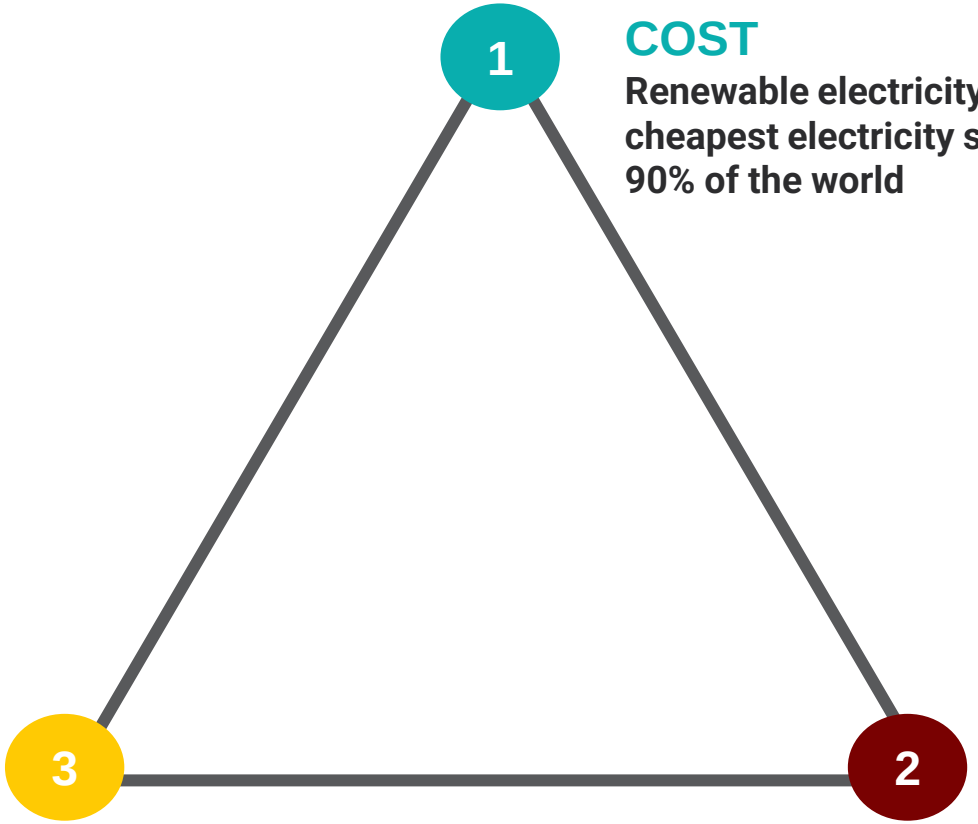
Marginal Costs of Fossil Fuels vs. Total Cost of Renewables (Germany)



Source: McKinsey

…and Solves the Energy Trilemma

Cost, security, and climate: once at odds, now fully aligned



COST

Renewable electricity is the cheapest electricity source in 90% of the world

SECURITY

90% of people live in countries with abundant renewable energy

ENVIRONMENT

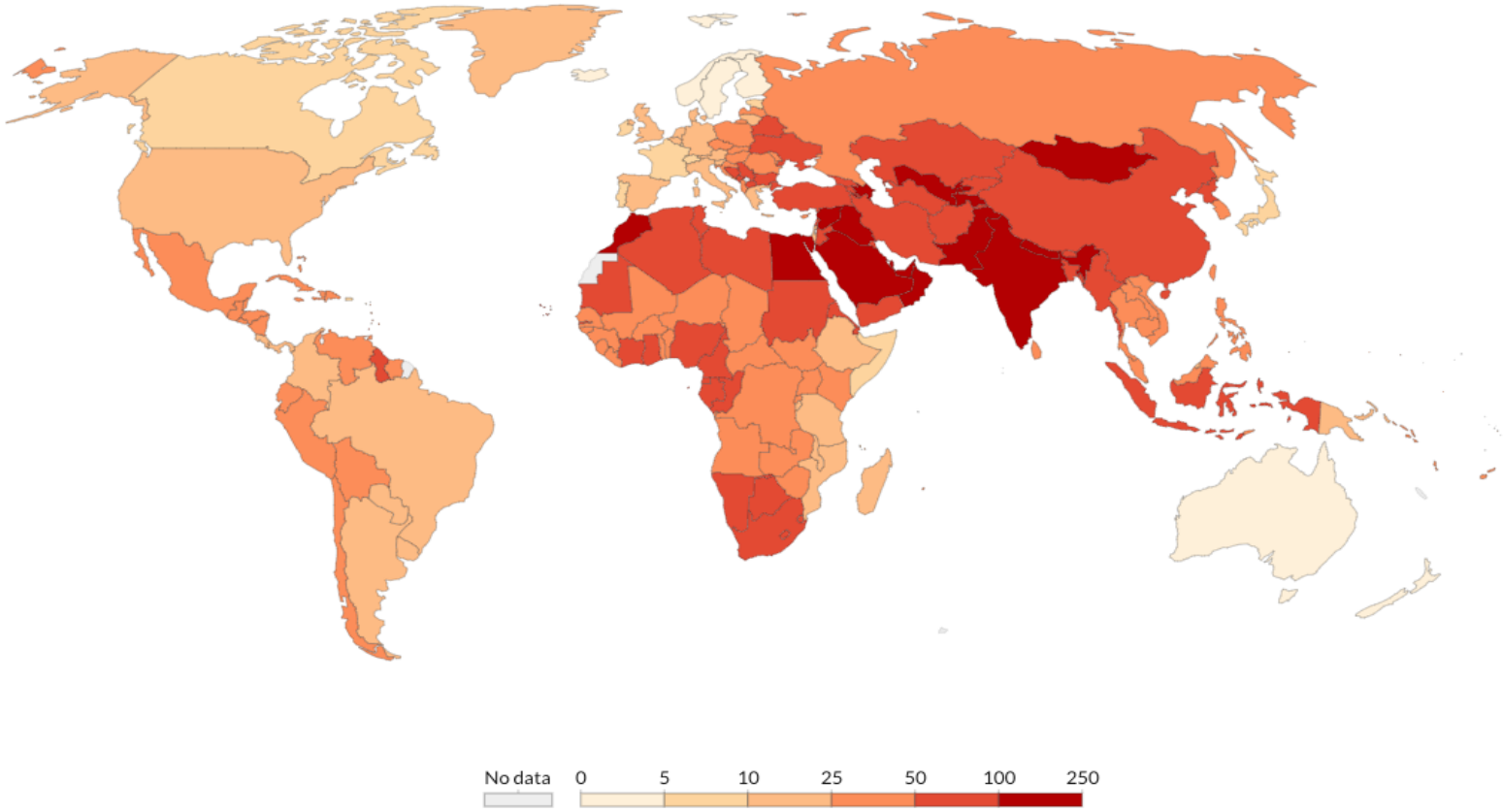
Renewables have an ecological footprint c.100 times lower than fossil fuels

Justice Demands a Change in the Energy System

Fossil Fuel Air Pollution Kills the Poor

Outdoor Pollution Death Rate, 2019

The number of deaths attributed to outdoor ozone and particulate matter pollution per 100,000



The World Health Organization estimates that outdoor air pollution kills 4.2 m people every year

More detailed analysis by Vohra suggests that 8.7 m people die as the result of burning fossil fuels

That makes fossil fuels the third largest killer, responsible for 20% of global deaths

Death rates are especially high in the Global South and in poorer communities

Source: IHME

A New Energy System Will Mean More Jobs

The impact of the energy transition on jobs

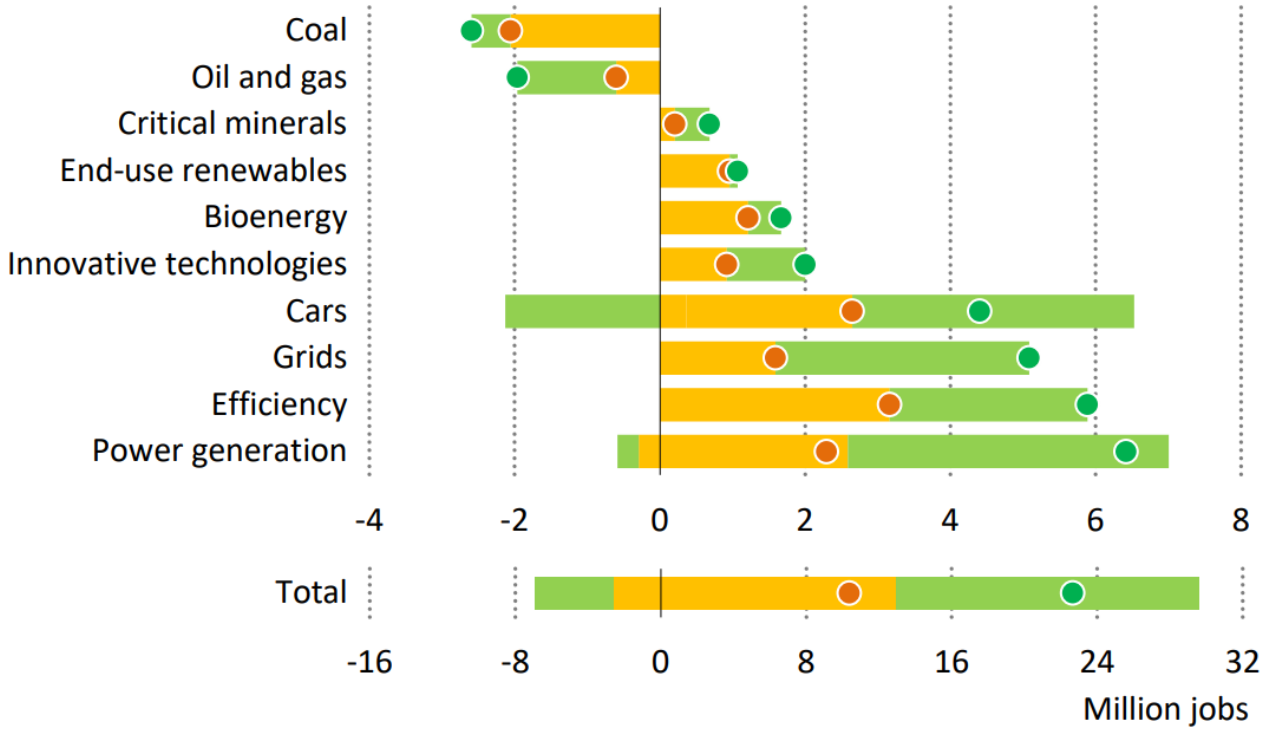
The IEA calculates that there are already more jobs in clean energy than in fossil fuels

And an energy transition would mean a net gain of 22 million jobs.

The jobs of the future are in renewable technologies

For fossil fuel importers, you exchange rent paid to petrostates for jobs paying local employees.

Employment Growth in Clean Energy and Related Areas to 2030



Source: IEA

Politics Follows the Technology Shift, Albeit Slowly

Until recently, the fossil fuel system seemed to have all the advantages.

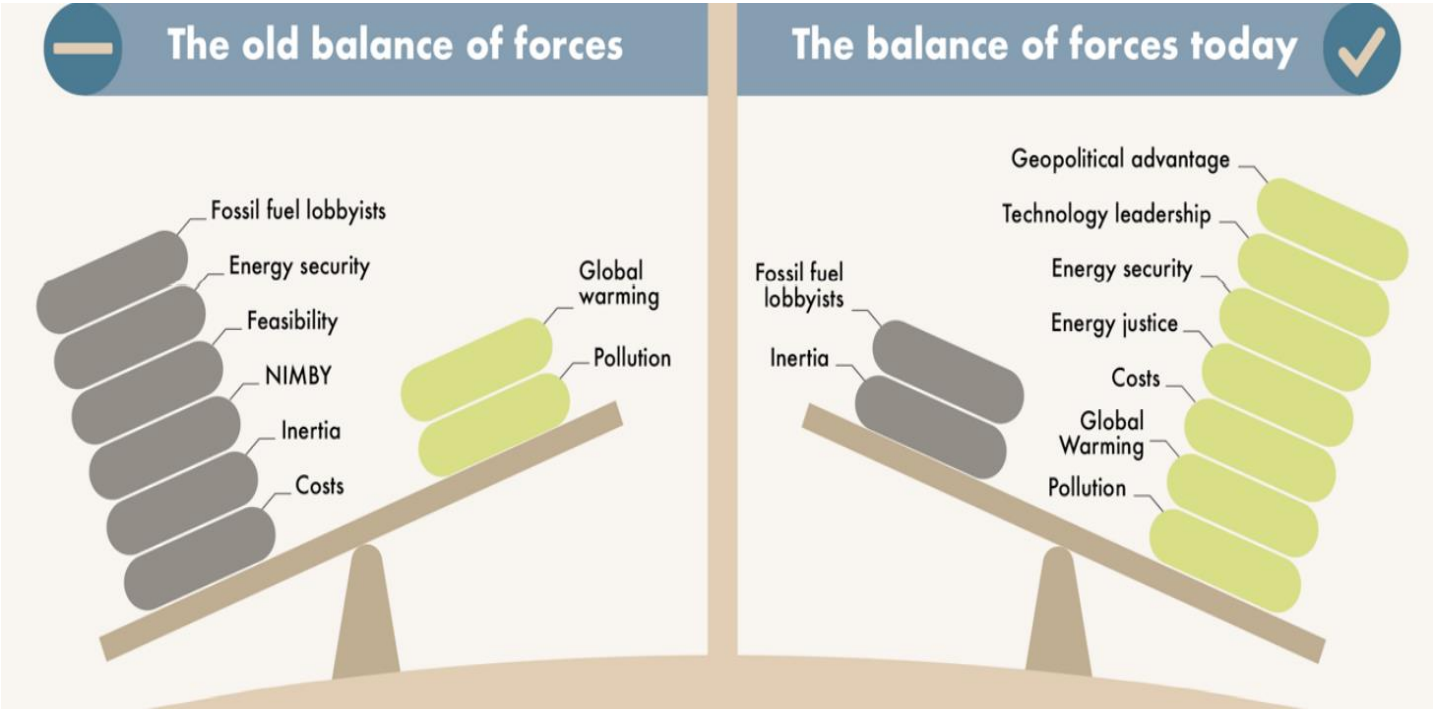
Thanks to technology solutions and lower costs, the economic, security, and technology advantage has passed to renewables.

So the seesaw has moved over toward change.

The fossil fuel system is now being propped up by political support. But that will inevitably change over time.

Petrostates will be the last to change.

The impact of the technology shift on politics



Source: Carbon Tracker

While the Drive to Change Is Greatest in Fossil Fuel Importers

80% of the world lives in fossil fuel importers

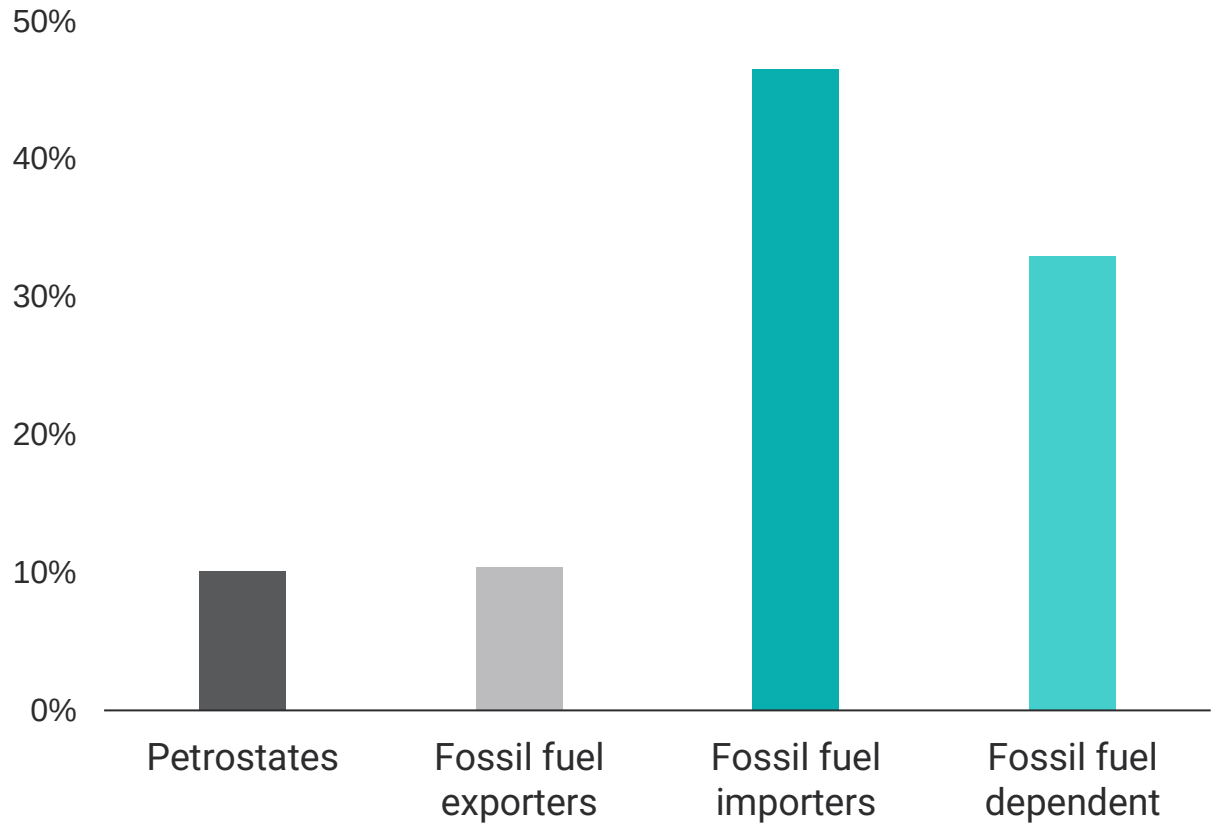
The balance of forces in favor of change is especially strong in countries that import fossil fuels.

80% of people live in fossil fuel importers. It is importers, not exporters, who determine future fossil fuel demand.

Only 10% of people live in petrostates.

Most of the sources of energy demand growth are in fossil fuel importers, notably China and India, both of which face rising dependency on oil and gas imports under BAU.

Population split by % GDP spent on fossil fuel imports/exports



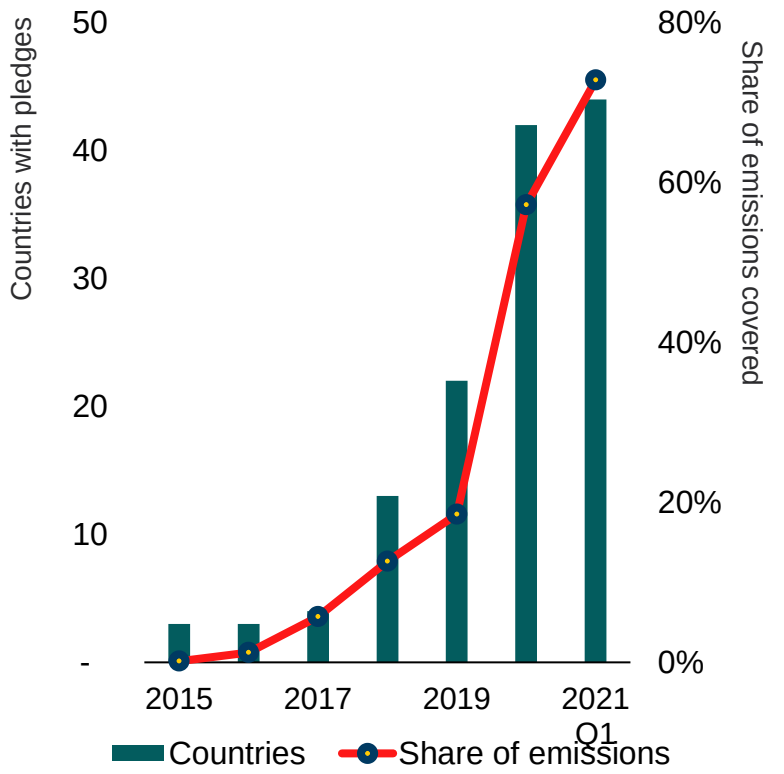
Definitions: petrostate >10% GDP in fossil fuel exports, exporter 0%–10%, importer 0%–(-5%), dependent <-5%

Source: COMTRADE 2016, RMI assumptions

There Has Been a Dramatic Policy Shift in the Past Five Years

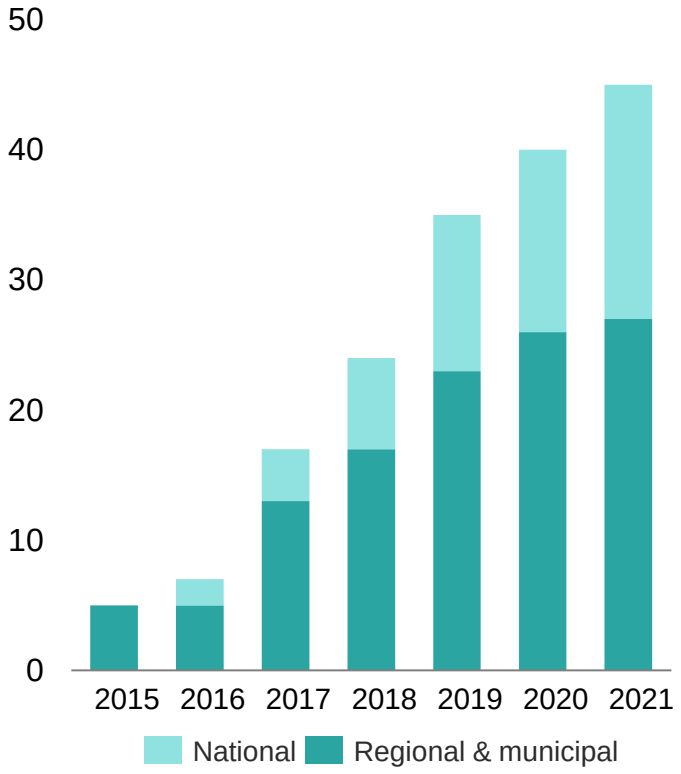
As one country sets a target, it's easier for the next to follow …

Net-Zero Targets



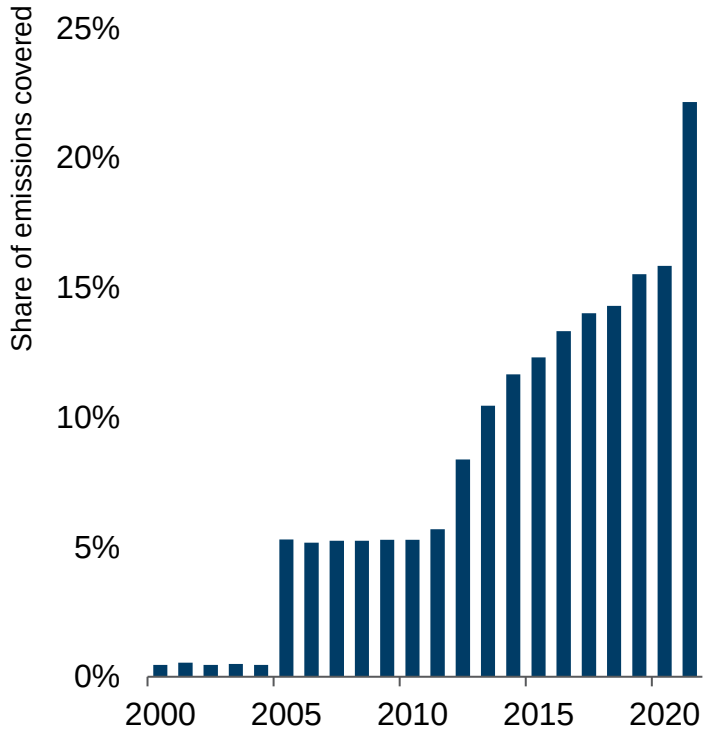
In 2022, over 90% of the world by GDP had set net-zero targets, up from 6% in 2017.

Combustion Car Bans



Fifty countries and regions are planning to ban ICE cars.

Carbon Taxes



The share of emissions covered by tax has increased fourfold in a decade to nearly a quarter.

Source: (from left to right): IEA, BNEF, World Bank

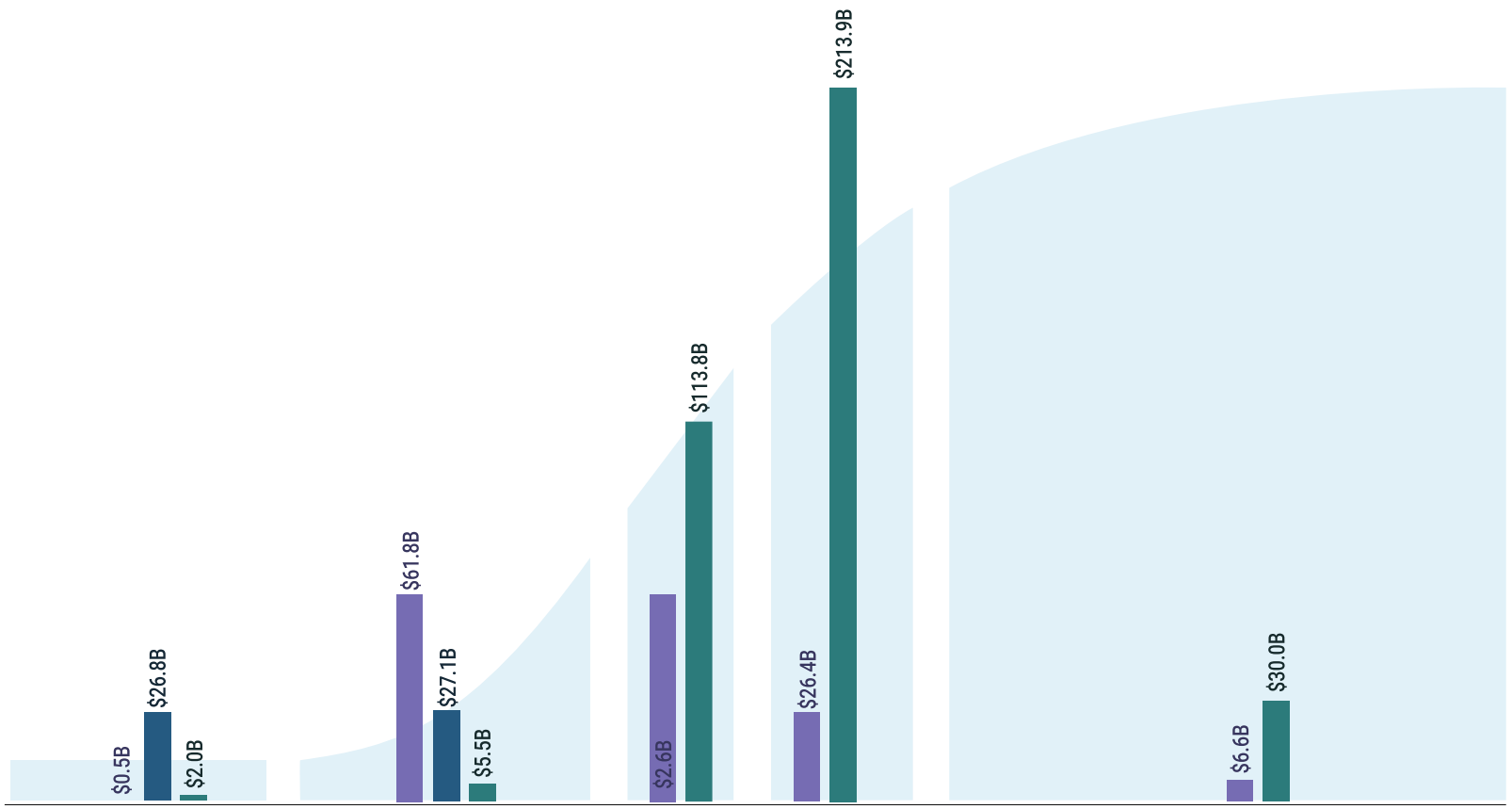
Now US Federal Action Creates a New Race to the Top

With passage of the IRA, the US triples federal spending on climate — getting in the game with China, the EU, and India

Three new bills that invest throughout the technology adoption S-curve, encourage innovation, back multiple technological solutions, and embrace risk:

- **The CHIPS and Science Act (2022)** focuses investment on the first two phases of the S-curve, supporting early/lab-stage innovations and demonstrating commercialization.
- **The Infrastructure Investment and Jobs Act (2021)** focuses mainly on the commercialization of innovations, the second phase of the S-curve.
- **The Inflation Reduction Act (2022)** invests heavily in the third and fourth phases, when innovations are taken to market, accelerating uptake of deployed technologies.

Breakdown of US climate spending (>$500B) across S-curve phases

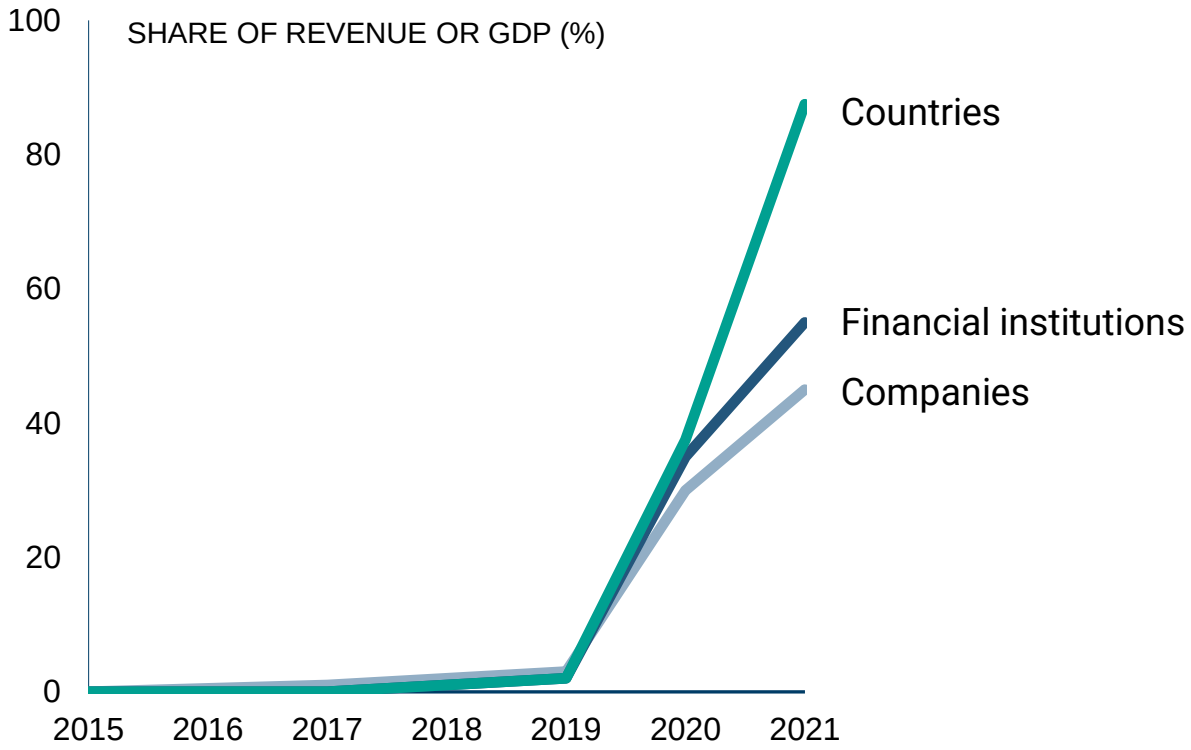


Source: RMI. The colors of the bars correspond to the colors of the program names

And the Private Sector Is Rapidly Joining In

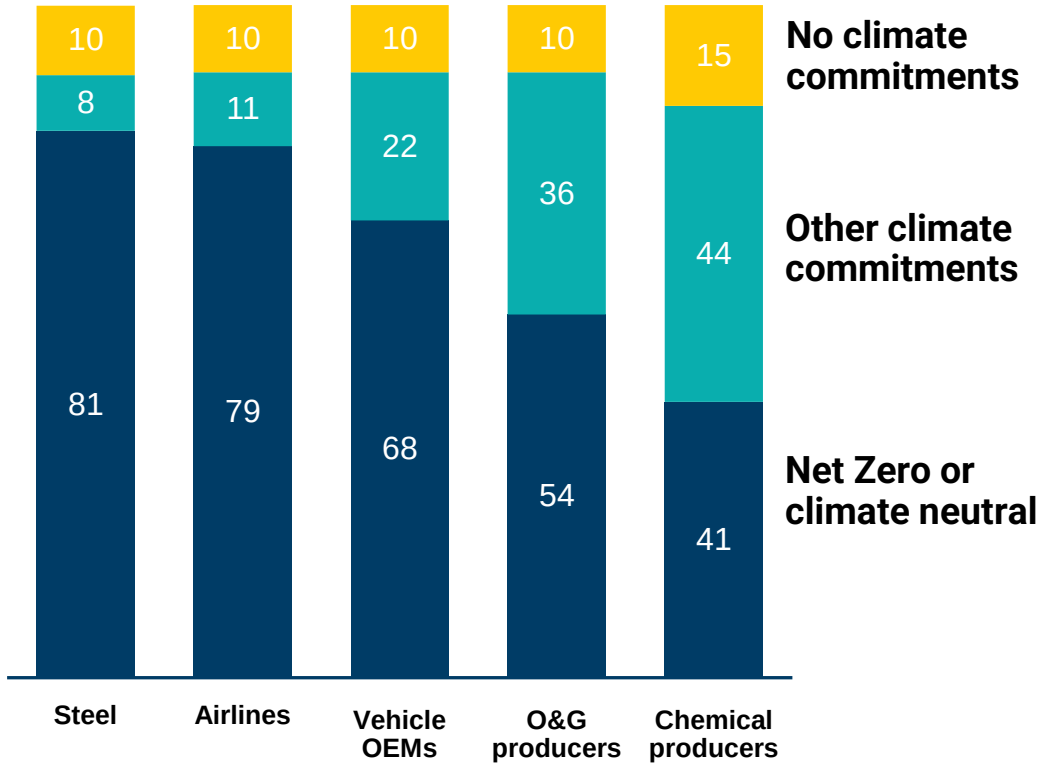
Companies and countries alike are making significant net-zero pledges, including the largest players across key industries

Share of net-zero pledges by key players, 2015–2021



Half the world's leading institutions and 40% of companies have made net-zero pledges.

Percentage of top 20 corporations, by sector



Even in heavy fossil fuel usage sectors, companies are pledging to get to net zero.

Source: BlackRock (L), McKinsey (R)

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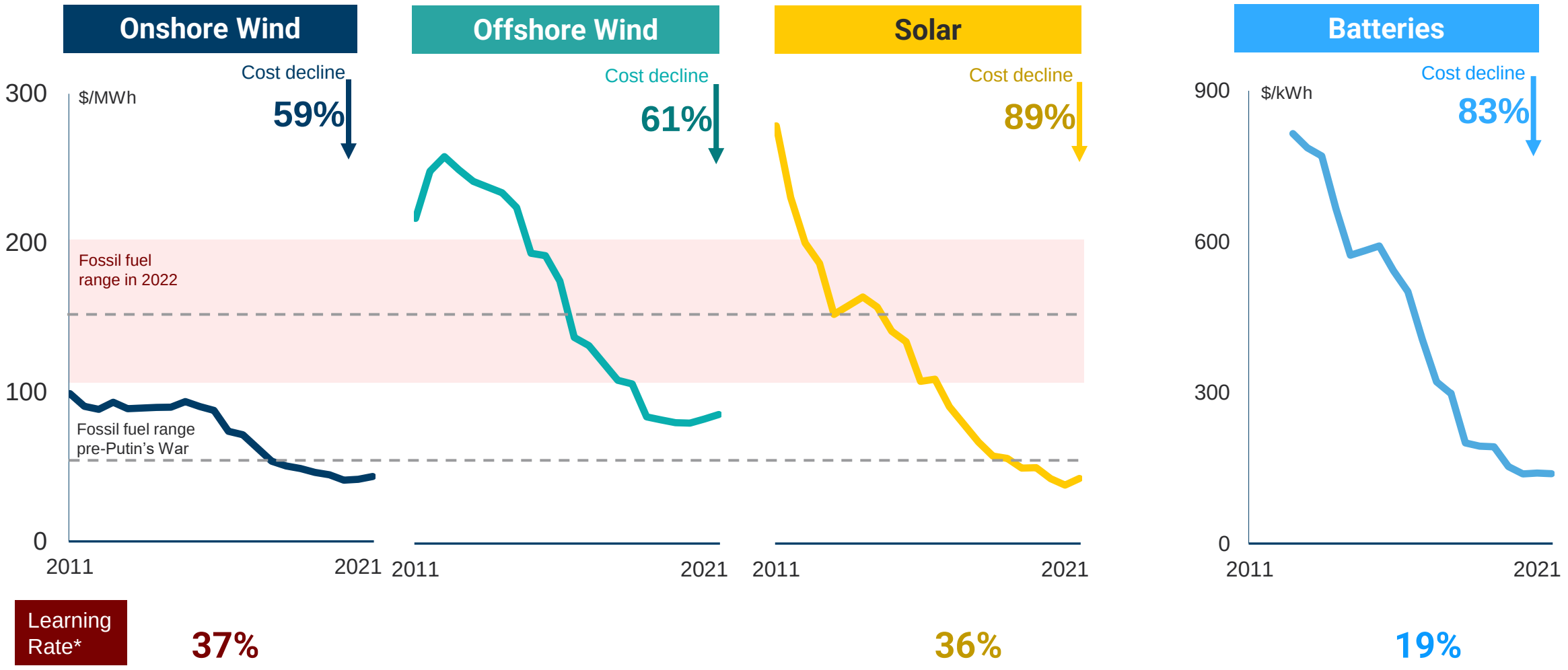
The Growth of New Energy Technologies

We Are in the Middle of an Energy Technology Cost Revolution

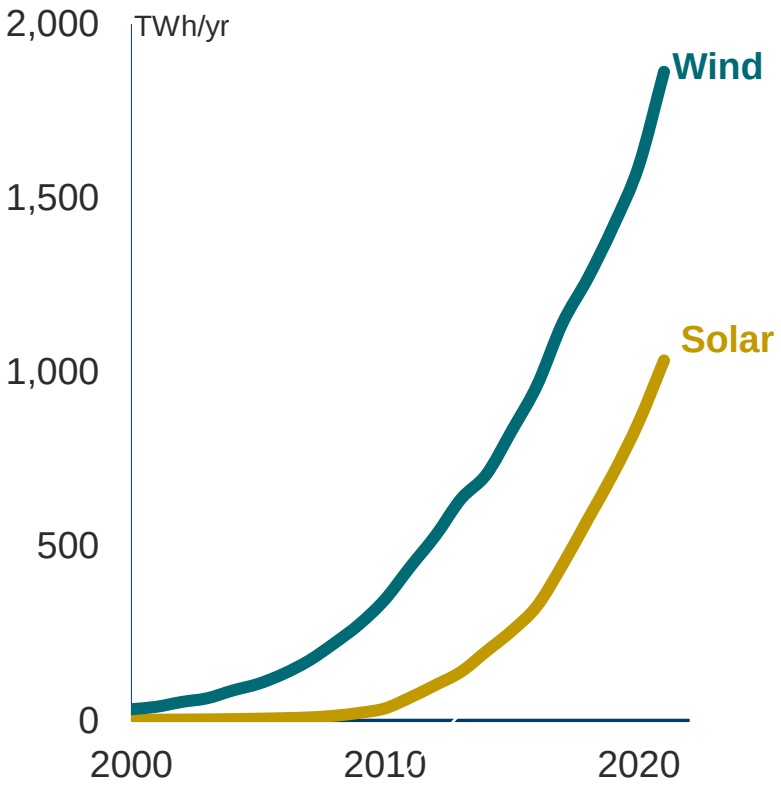
The cost of new energy technologies has fallen by 60%–90% in 10 years



Source: BNEF; Note: * in sample time period; Definition: the learning rate is the observed cost reduction for each doubling of deployment

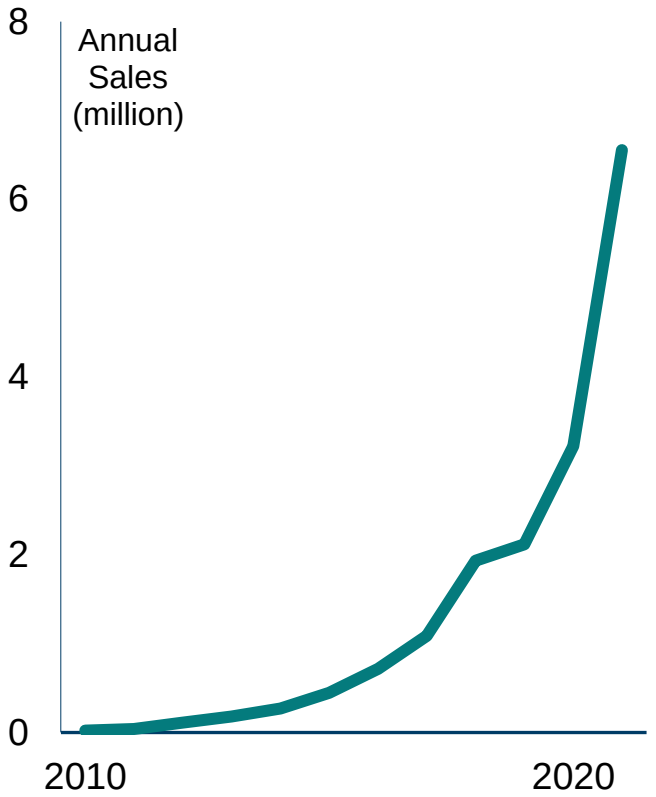
Exponential Energy Change Is All around Us

Annual solar & wind generation



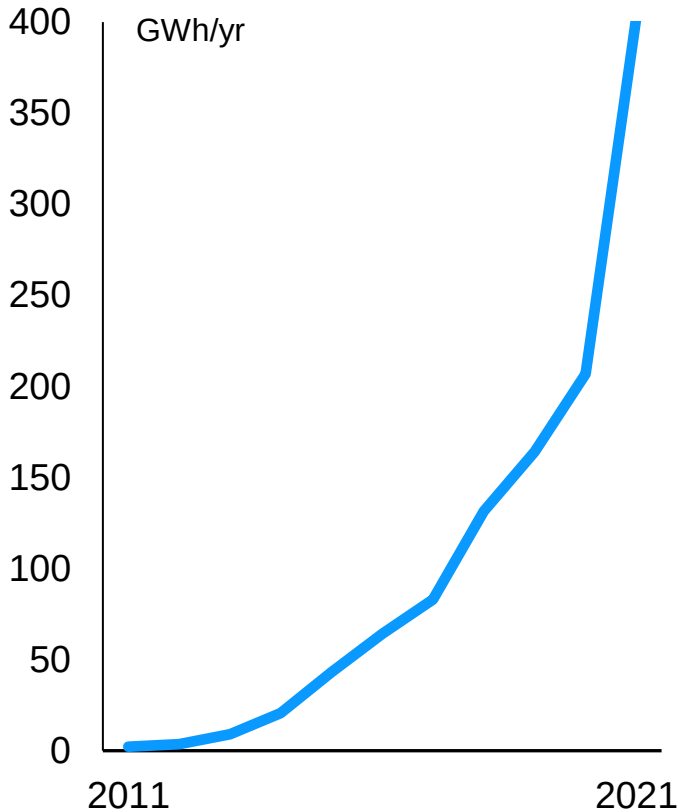
CAGR 21% 39%

Annual EV sales



68%

Annual battery sales



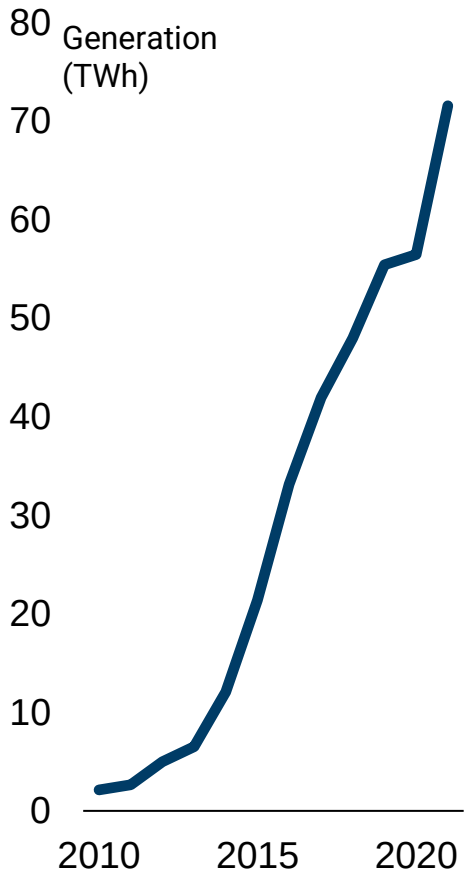
68%

Source: BNEF, BP; Note: CAGR is the compound annual growth rate over the sample time period

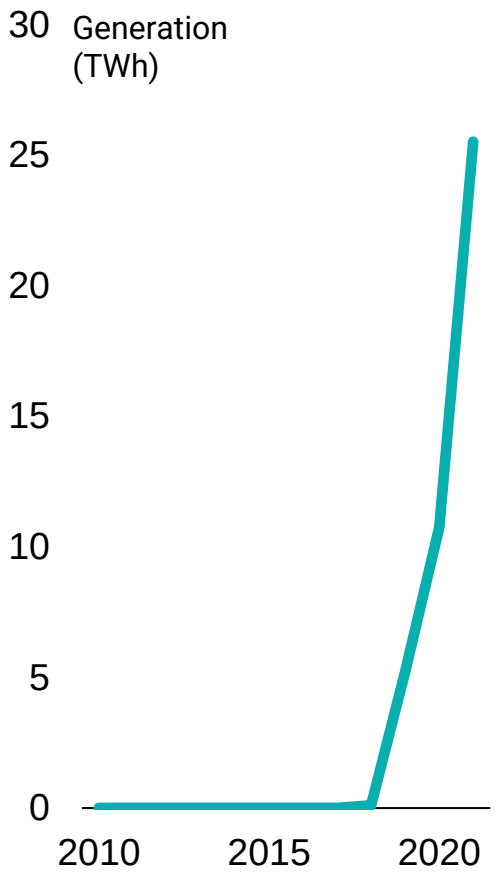
Change Is Happening across the World

Adoption of superior technology is not confined to the Global North

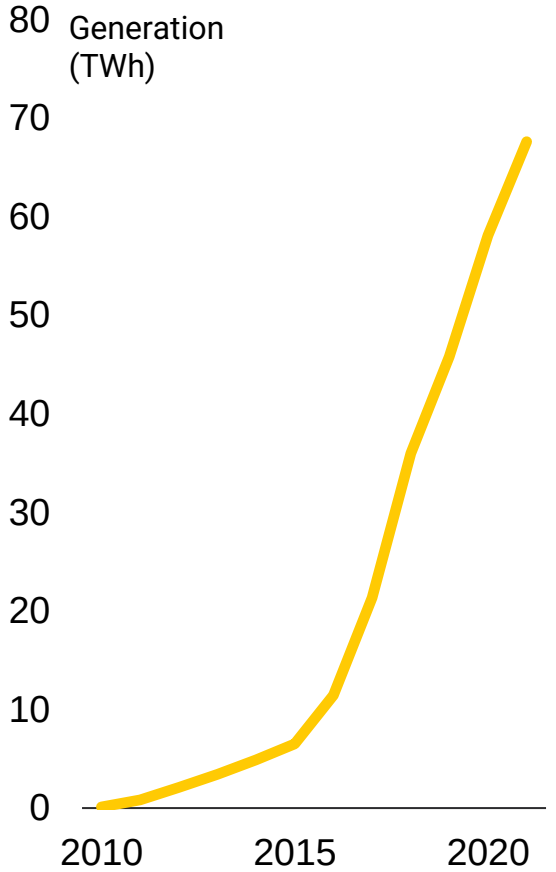
Brazil wind



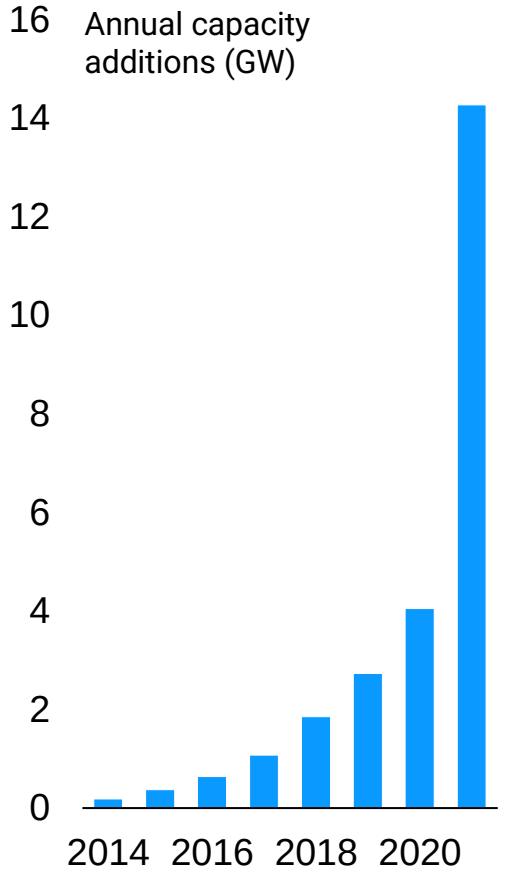
Vietnam solar



India solar



China offshore wind

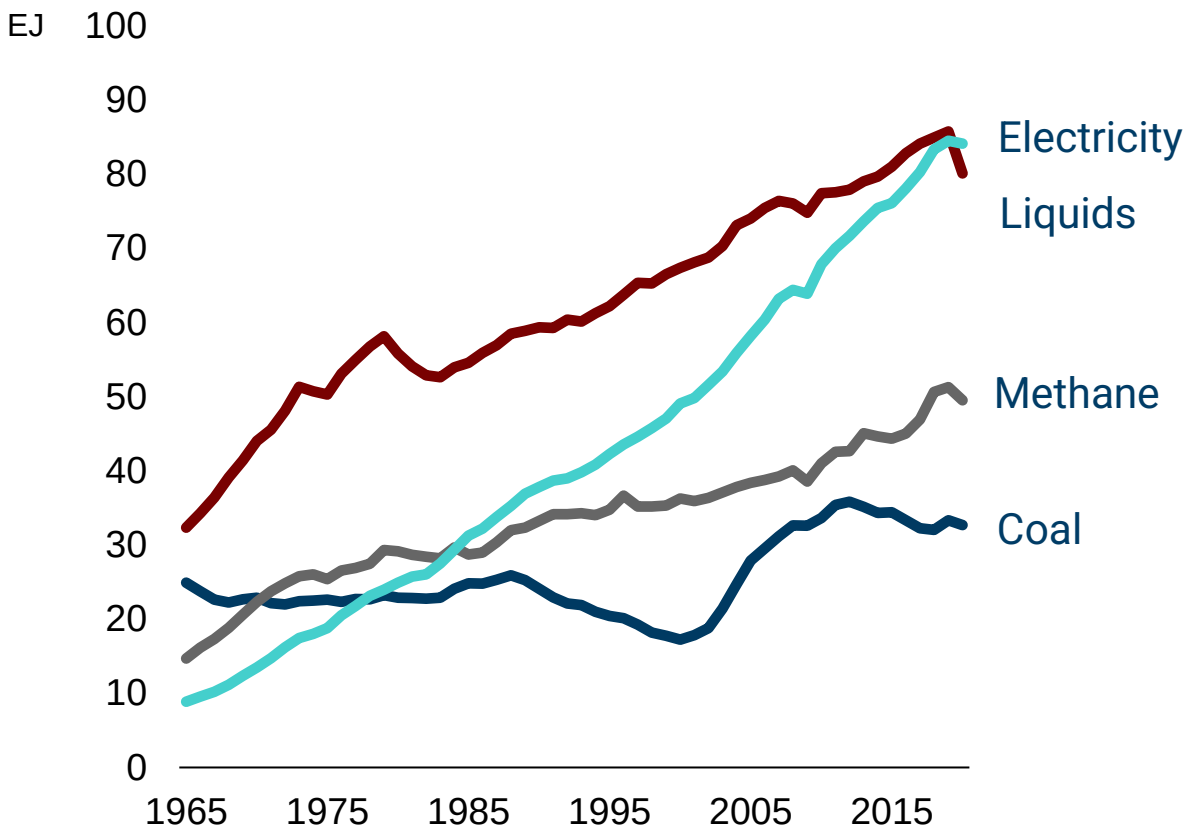


Source: BNEF, BP

Electricity Has Become the Largest Energy Carrier

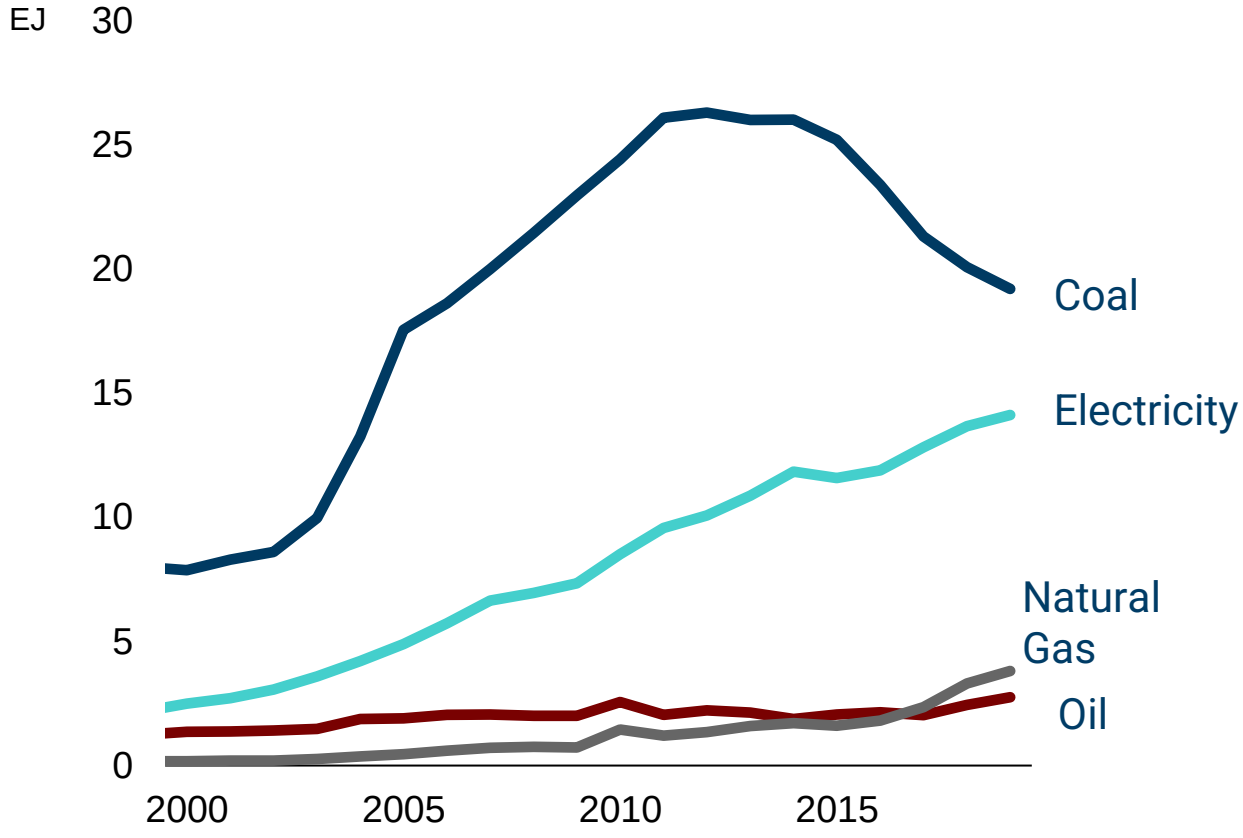
Electrification is driven by China

Useful energy by carrier, global



Electricity just overtook oil as the world's top energy carrier of useful energy, and it is rising fast.

Final energy by carrier in China's industrial sector



Electricity has been pushing coal out of the Chinese industrial sector since 2013.

Source: Rystad (L); IEA (R)

Because Superior Technology Drives Change

Renewables have fundamentally different characteristics with far-reaching consequences

The Age of Carbon	The Age of Renewables
Commodity-based system	Technology-based system
No learning curve (or decreasing returns)	Learning curve (increasing returns)
Geographically concentrated	Everywhere
Finite	Abundant
Continuous material flow required	Zero marginal cost
EROI falling	EROI rising
Heavy	Light
Fiery molecules	Obedient electrons
Low efficiency	High efficiency
Pervasive negative externalities	Much lower impact on nature
Trillions of dollars of rent for oligarchs	No superprofits
Concentrates power	Distributes power

Source: RMI

Renewable Costs Will Continue Falling on Learning Curves

Decreasing costs of solar, wind, batteries, and hydrogen — past and future

Key renewable energy technologies enjoy learning curves. Fossil fuels do not.

So the bigger renewables grow, the cheaper they get.

Learning curves are extremely persistent.

Learning curves have proven the most accurate way to forecast future costs.

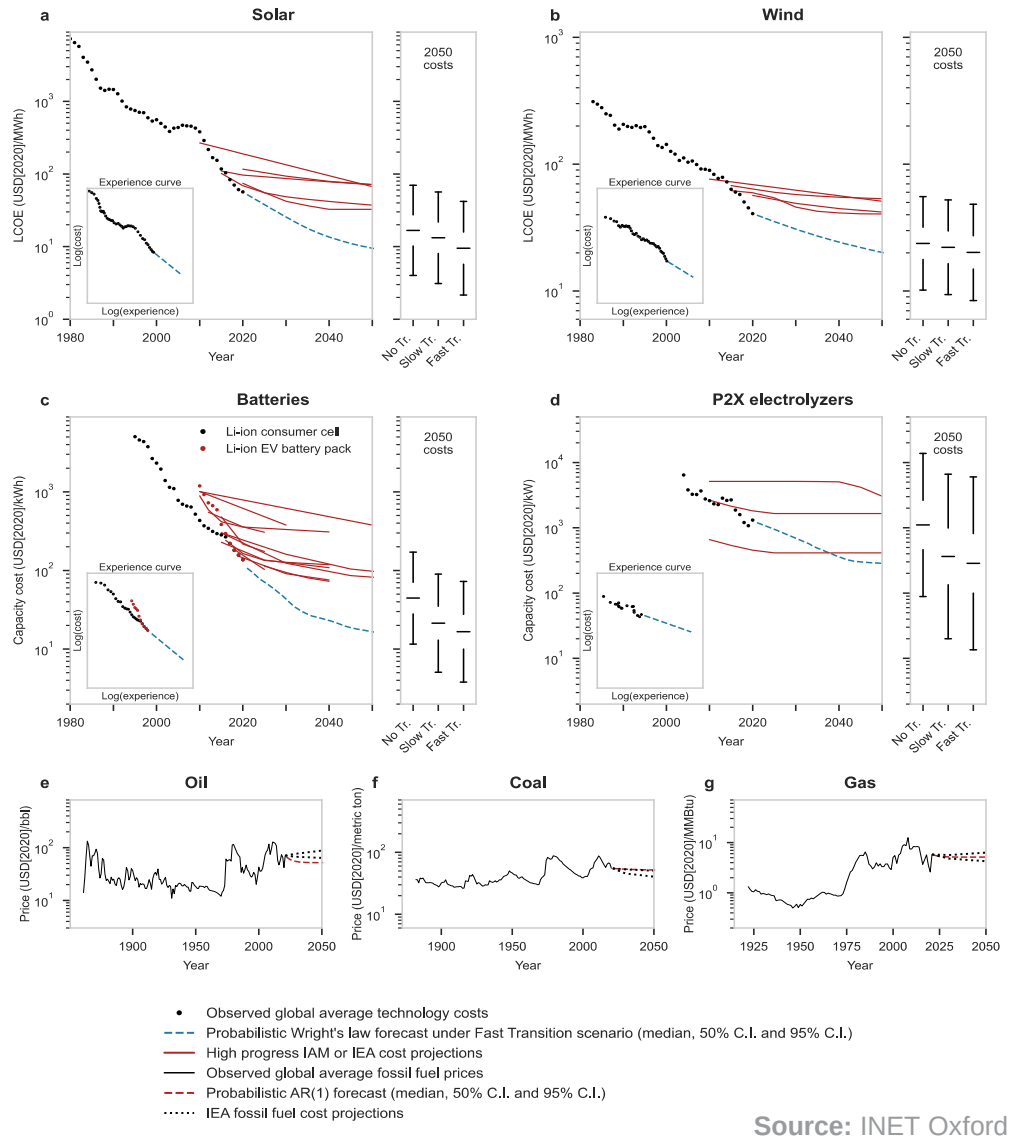
Mathematicians at Oxford University use this framing to forecast future costs.

Their central scenario implies $10 per MWh for solar LCOE by 2050.

Primary

Carrier

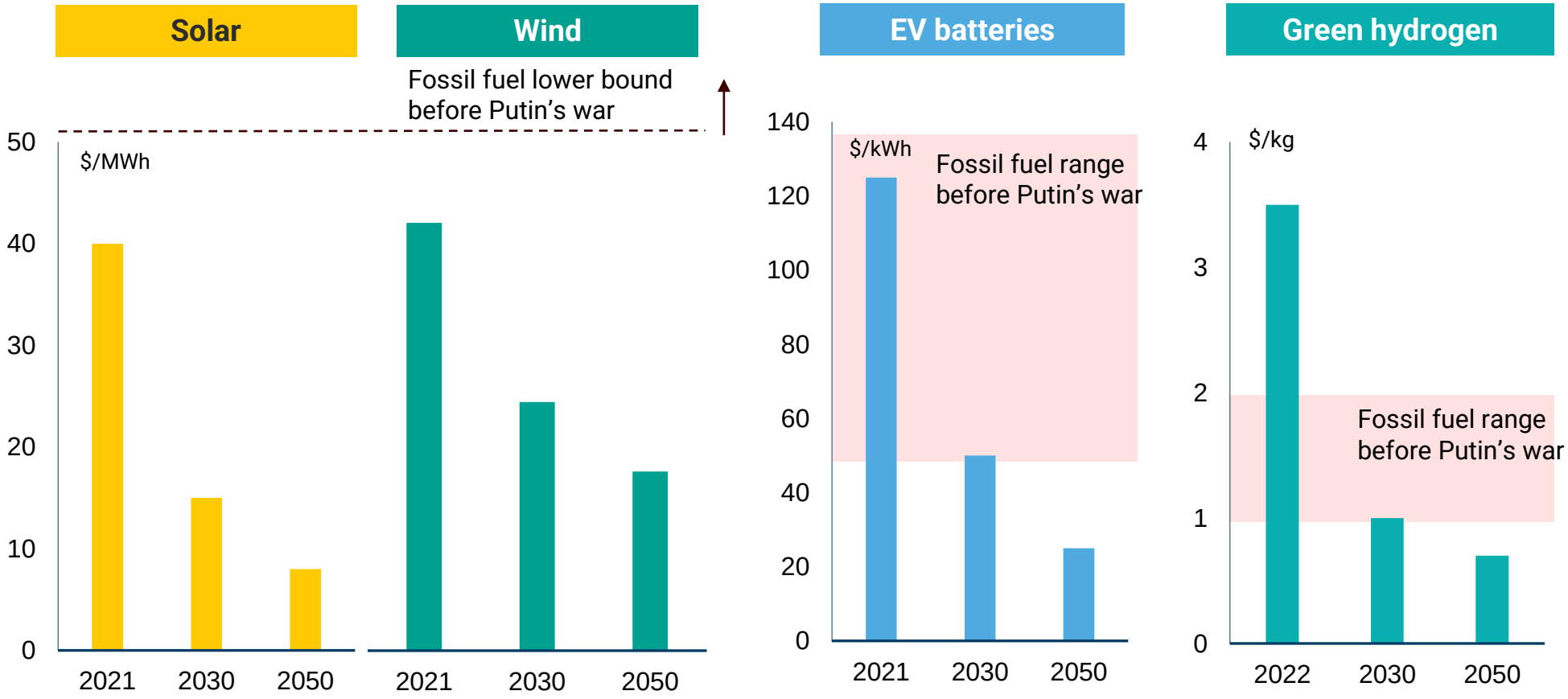
Fossil fuels



Source: INET Oxford

And Cheap Renewables Create an Entirely New Paradigm

The faster change happens, the cheaper renewables become



If we continue on existing learning and growth rates, then by 2030 the world will enjoy $15 per MWh solar, $25 per MWh wind, $50 per kWh Li-ion batteries, and $1/ kg green hydrogen.

Source: RMI; cost forecasts use Rystad's growth rates and observed learning rates. Hydrogen is competitive locations

Renewables Are 100 Times Bigger Than Fossil Fuels

Humanity has unlocked a giant new energy source

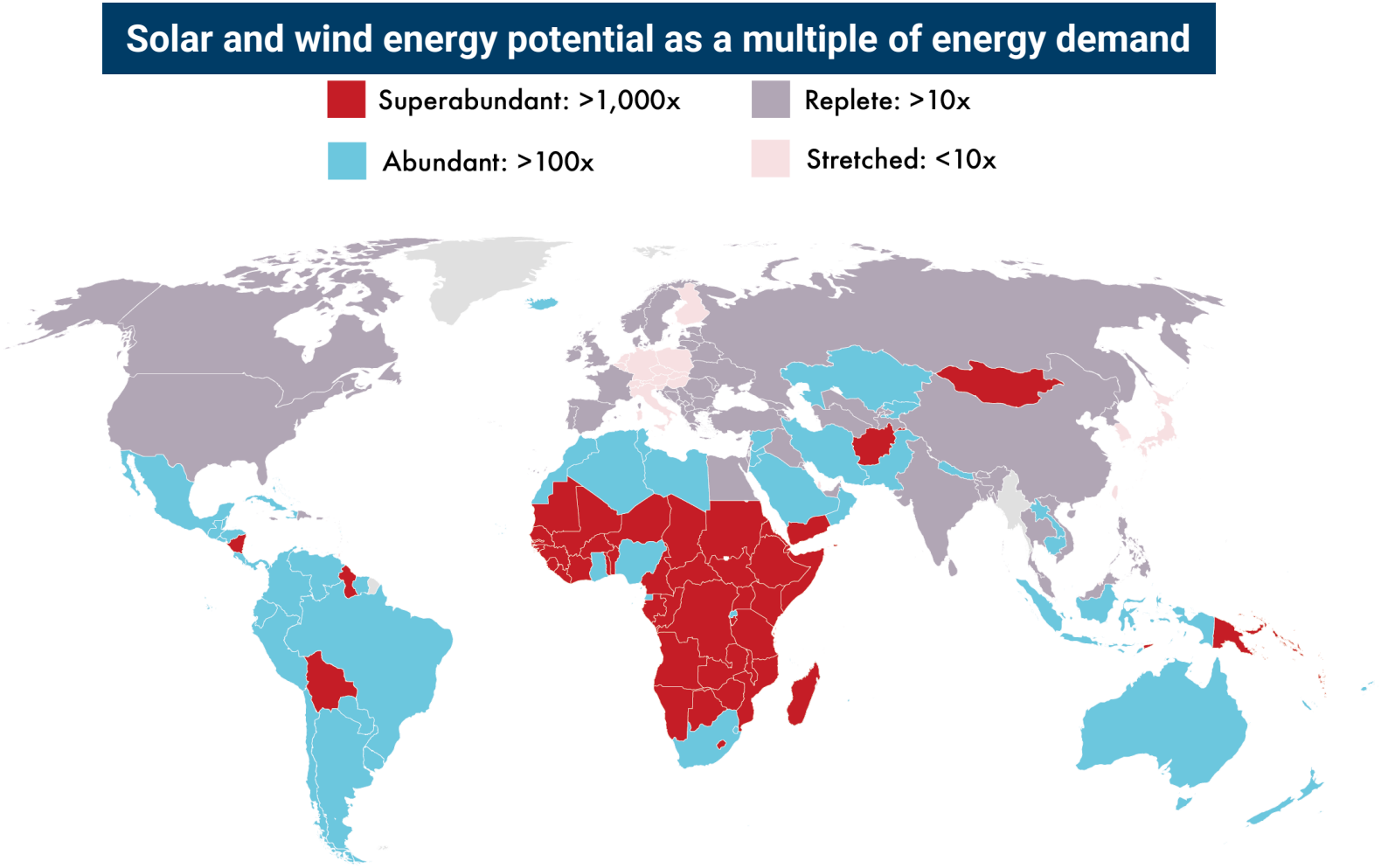
Renewables are, obviously, available everywhere.

Even if you massively constrain deployment, the world has annual renewable flows of over 100 times fossil fuel supply.

Solar rooftops alone could supply us with all our electricity needs.

The Global South is especially abundant in renewable energy resources.

Only 10% of demand comes from places like Germany or Japan that will struggle to find enough space.



Source: Carbon Tracker

We Have All the Technologies We Need

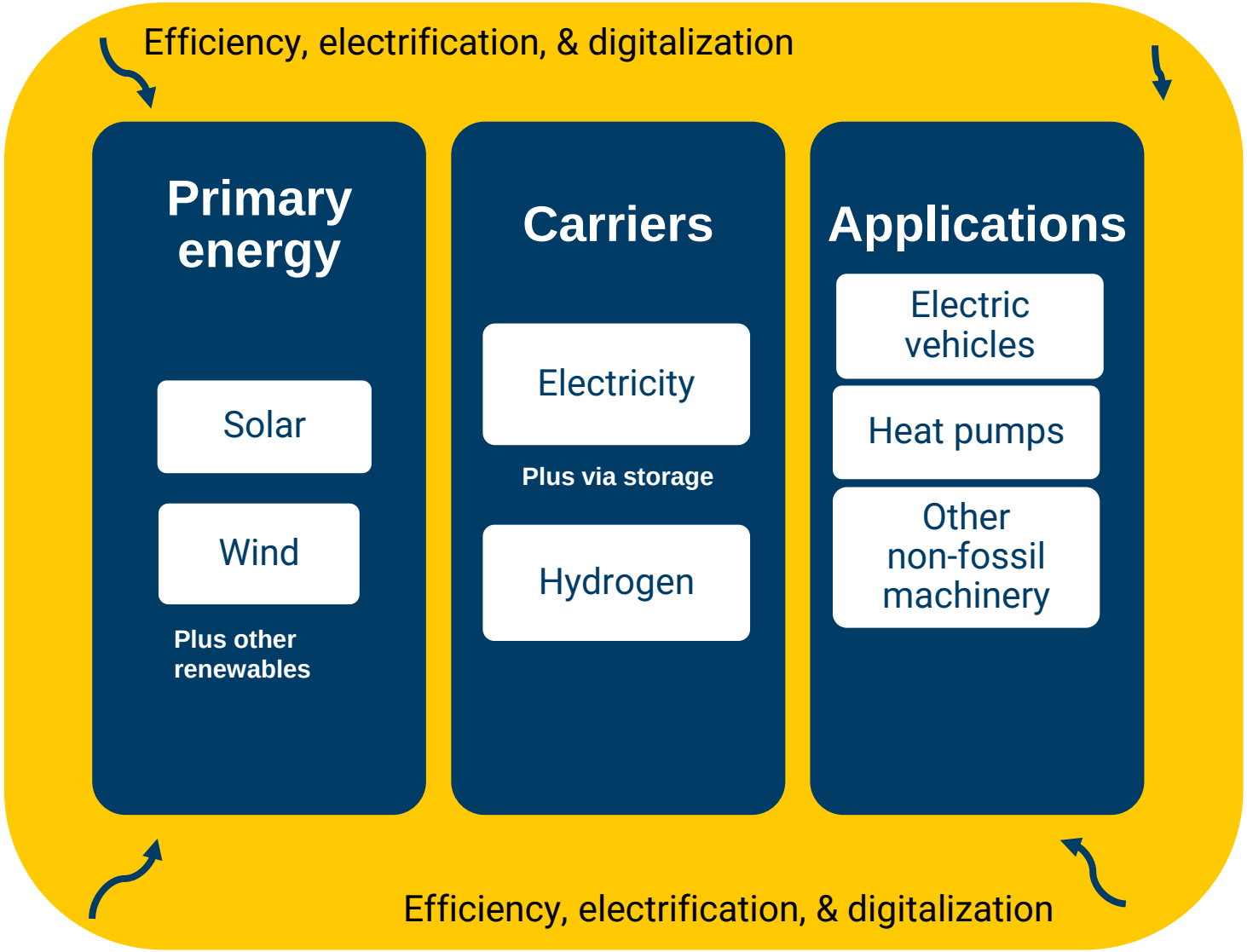
A new cluster of technologies can replace the entire fossil fuel system

Energy efficiency is improving all the time thanks to better machines, electrification and digitization

The two core primary renewable energy sources are solar and wind

The key carriers are electricity, batteries and hydrogen

The new prime movers include EV, heat pumps, ammonia powered ships and other non-fossil machinery



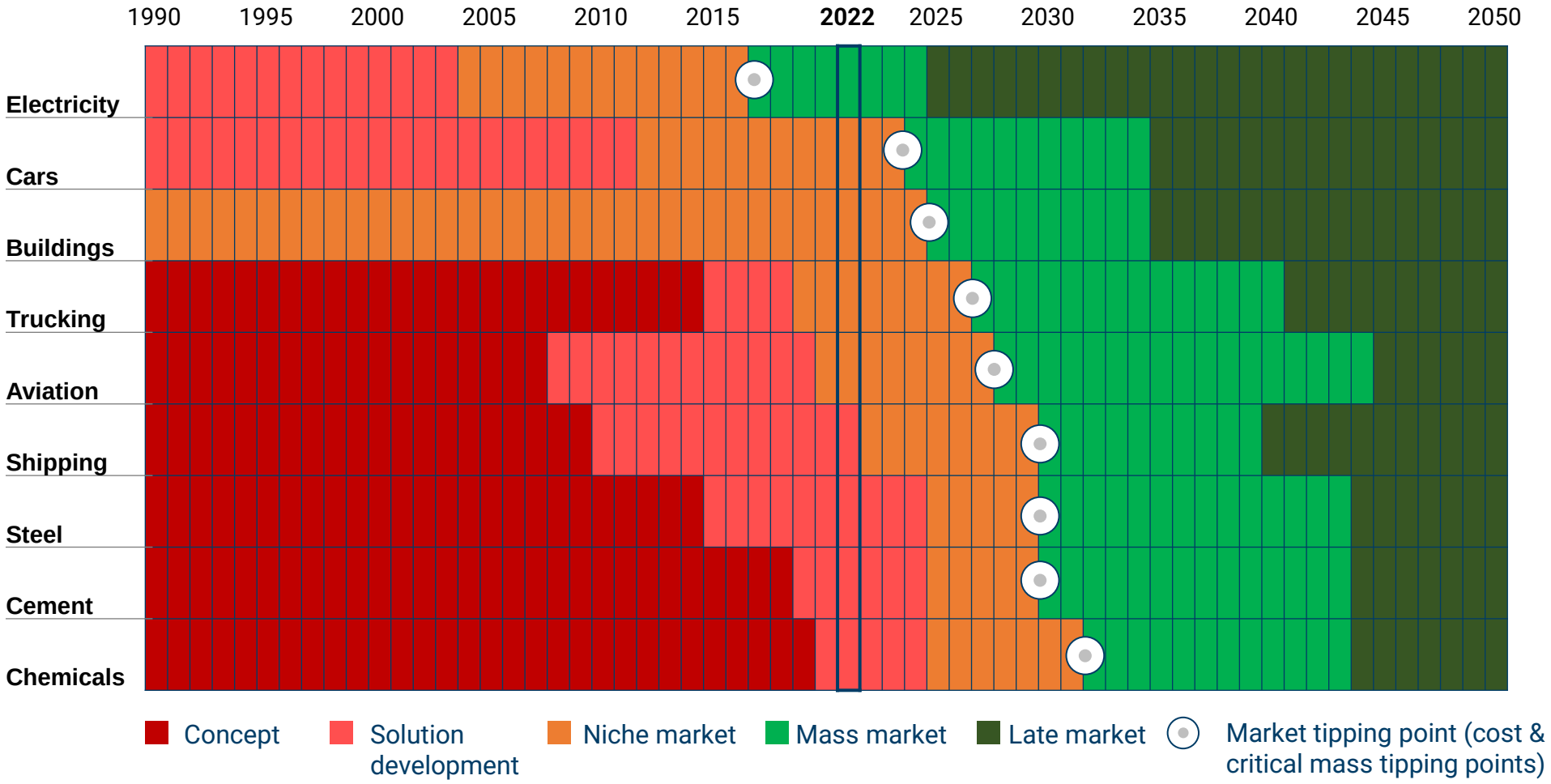
Source: RMI

We Know Roughly What to Do

What we need to do	Where we stand	What we need to do	Is this feasible?	Grounds for hope
Increase efficiency	Efficiency gains of 1.8% p.a. for the past decade	Increase efficiency to 2%–3% p.a.	Efficiency gains of 3% p.a. follow inevitably from the deployment of renewable technologies	On track
Decarbonize electricity	38% of electricity already from non-fossil sources. Renewables are cheaper than fossils in 90% of the world and growing on S-curves	Increase renewables to 100% of supply. Leaders first, then laggards	We need to maintain solar and wind growth up the S-curve	On track
Electrify whatever we can	Non-fossil energy is already the energy source for two-thirds of buildings and a third of industry. EVs are comparable in price with ICE vehicles	Electrify transport. Deploy heat pumps at scale. Electrify industry and buildings	The transport revolution has started. Industry and building electrification needs to happen faster	China is doing this
Hydrogen, biomass, or CCS for the rest	Massive ramp in green hydrogen planned	Get green hydrogen costs down to $1/kg, which is price parity	The past 12 months have seen a massive increase in hydrogen plans	Hydrogen ramp has started

Source: RMI

Key Sectors Hit Their Tipping Point This Decade



Each of the key sectors will hit a price tipping point this decade.

That moment has already come for electricity, which is 35% of fossil fuel usage.

And for light vehicles.

These tipping points are spreading to the rest of the system.

Source: SYSTEMIQ

There Are No Insoluble Barriers to Change

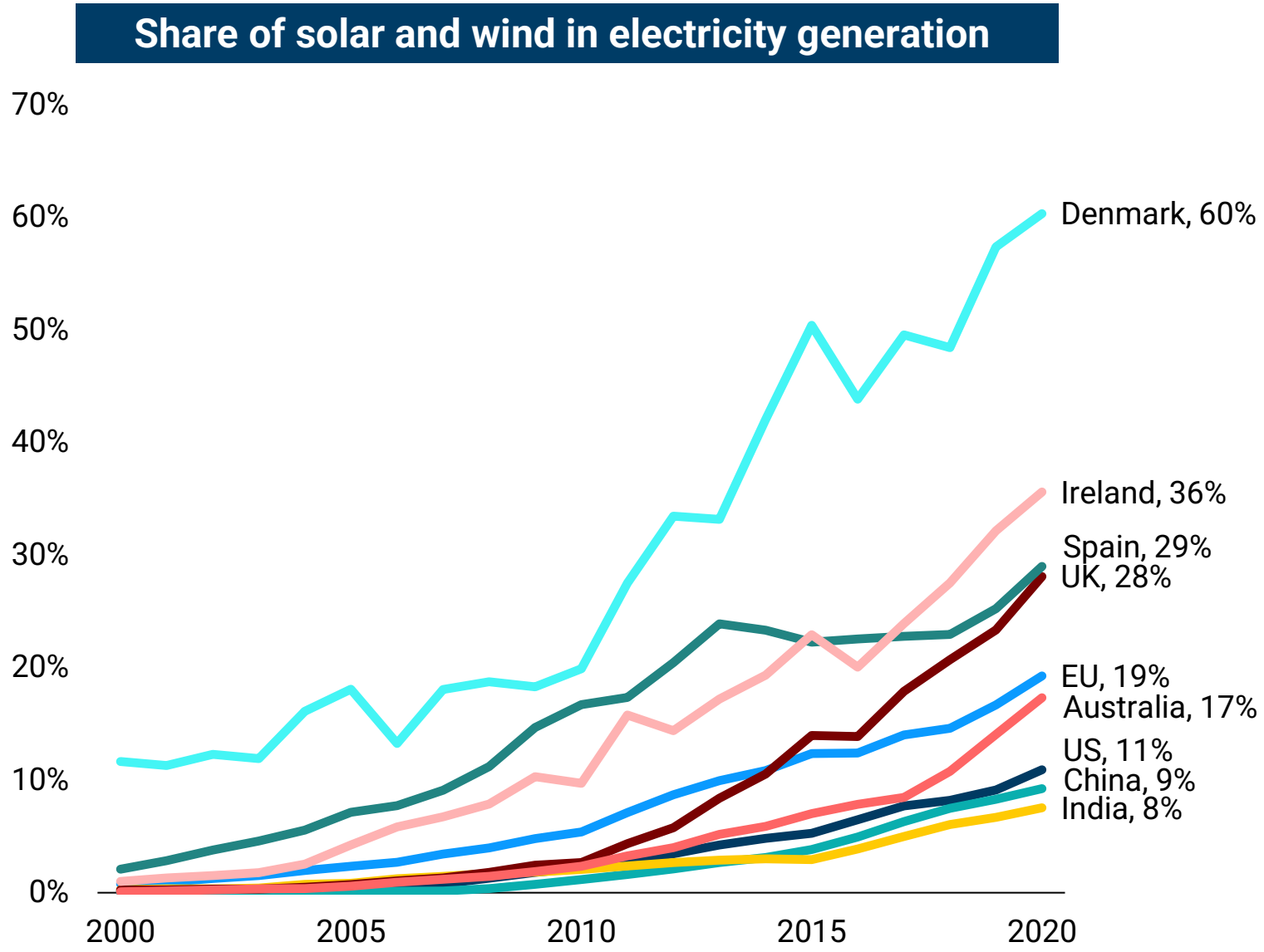
Skeptics have been hoping for years that something would stop the deployment of renewable electricity.

Grid codes, intermittency, lack of minerals, and so on were meant to act as a ceiling on growth.

But we have found solutions for all of these.

The ceiling of the possible is therefore constantly rising.

Meanwhile, most countries are far below the ceiling of the possible.

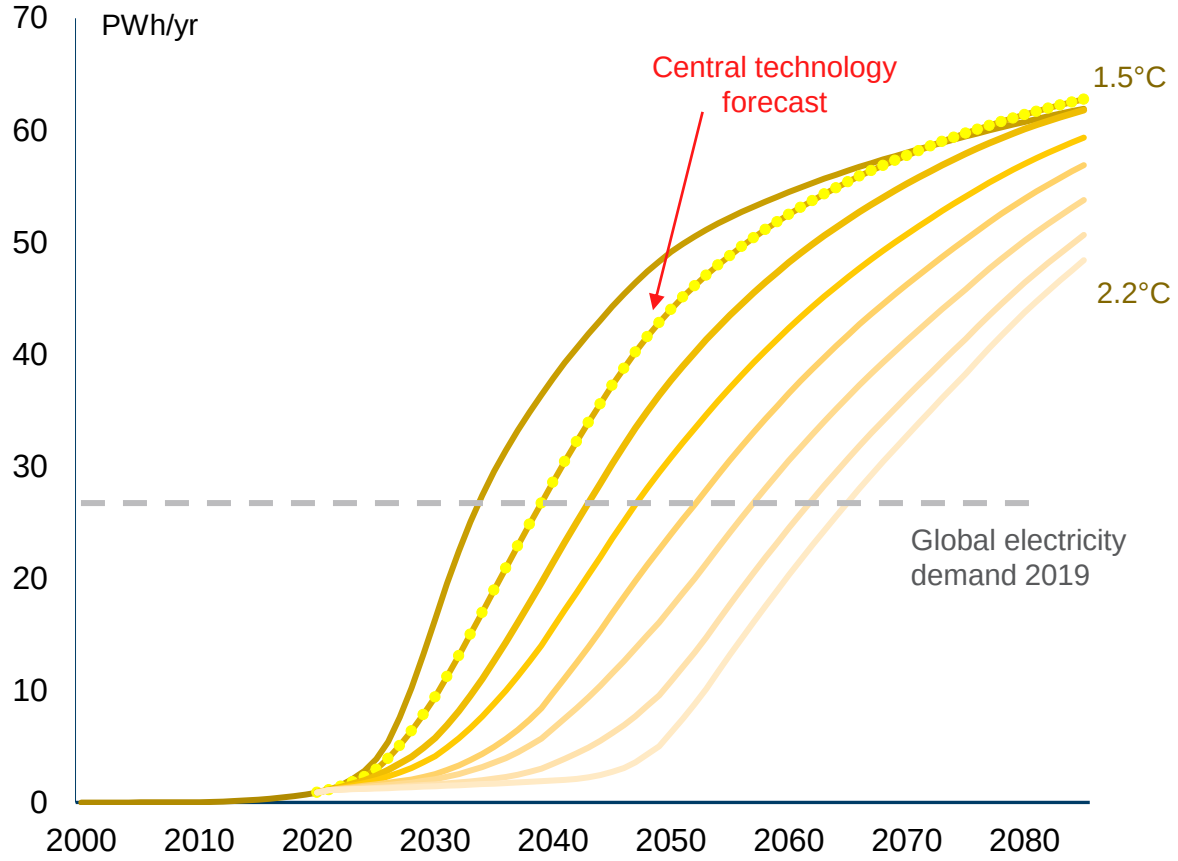


Source: BP

So Exponential Growth of Renewables Will Continue

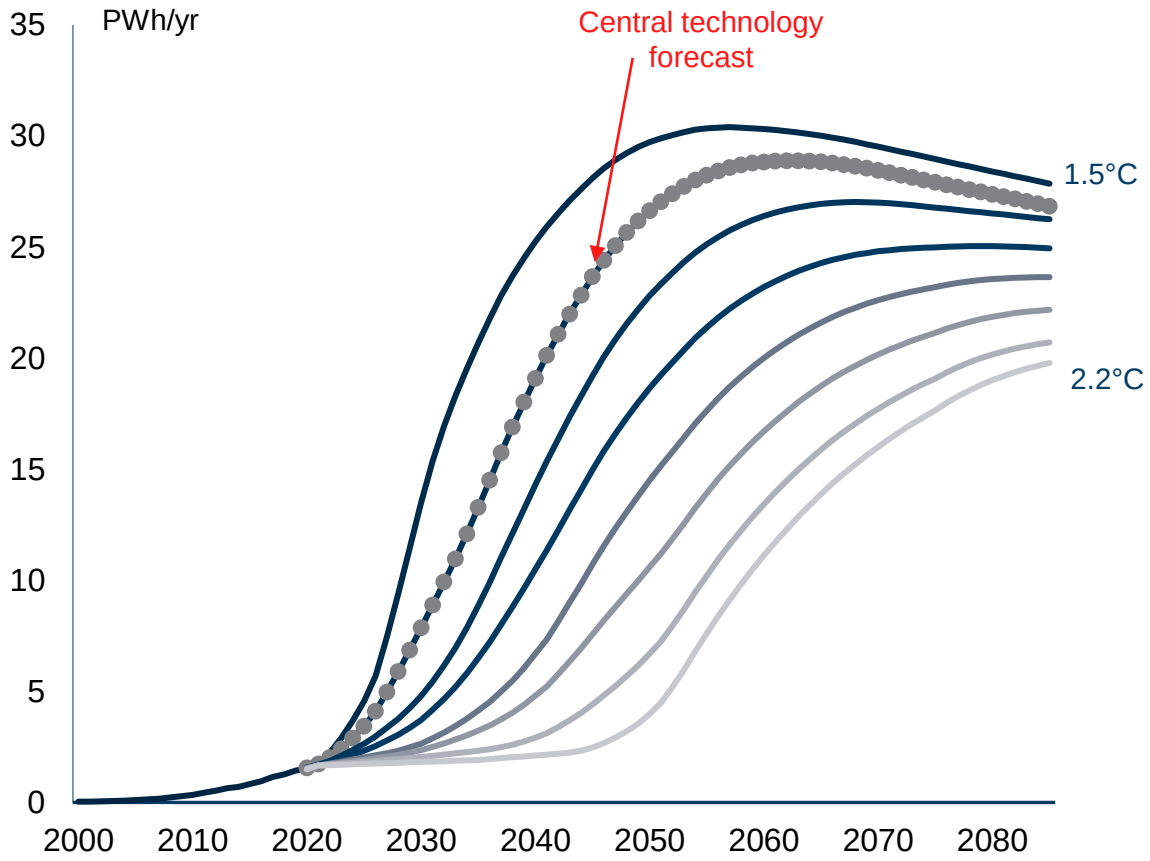
Powered by and powering falling costs

Solar generation



Solar generation will increase from over 1 PWh today to around 40 PWh in 2050, a growth rate of around 14% a year versus 25% today.

Wind generation



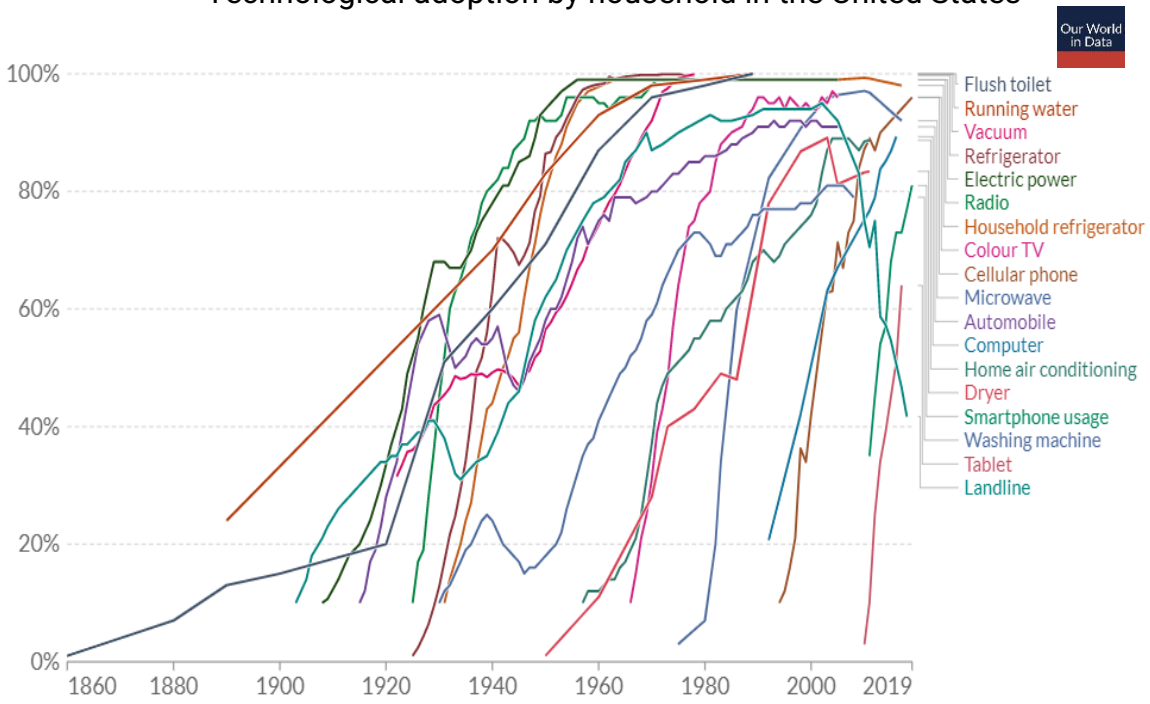
Wind generation will increase from 2 PWh today to over 20 PWh in 2050, a growth rate of 7% versus 15% today.

Source: Rystad; light to dark: 1.5°C to 2.2°C; 1.6°C (Rystad's central scenario) is based on technology change

This Pattern of Growth Has Been Seen Many Times

Individual products

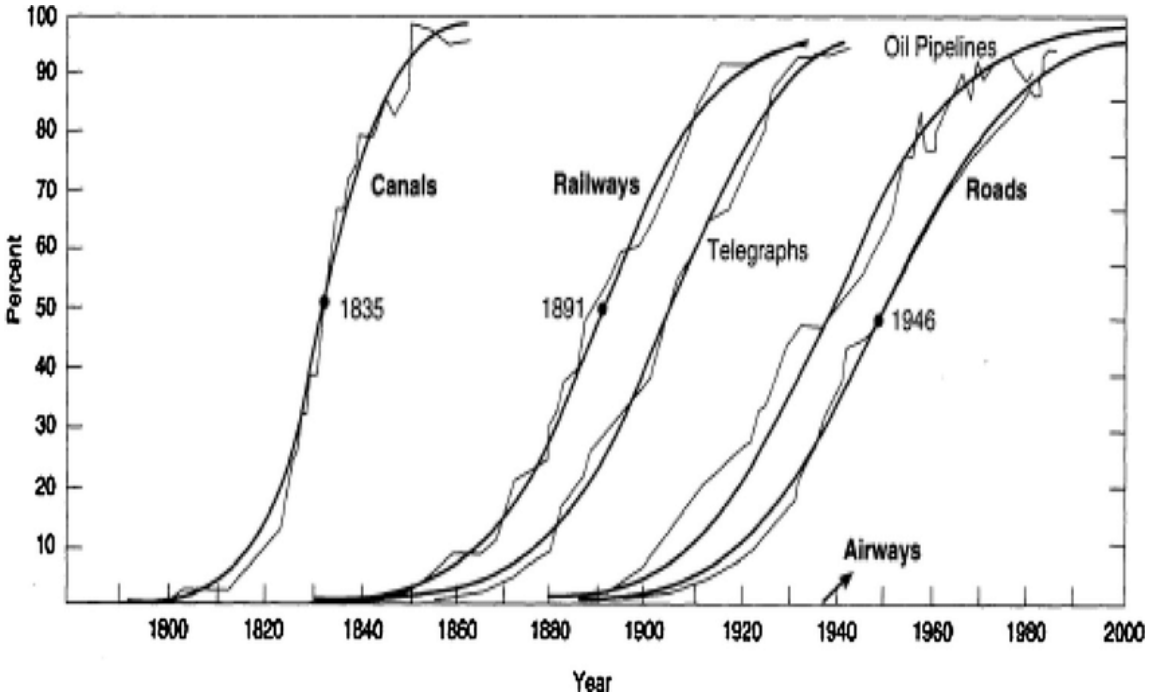
Technological adoption by household in the United States



Rapid exponential growth along S-curves is a standard characteristic of successful new technologies.

Infrastructure systems

Share of maximum size in the United States

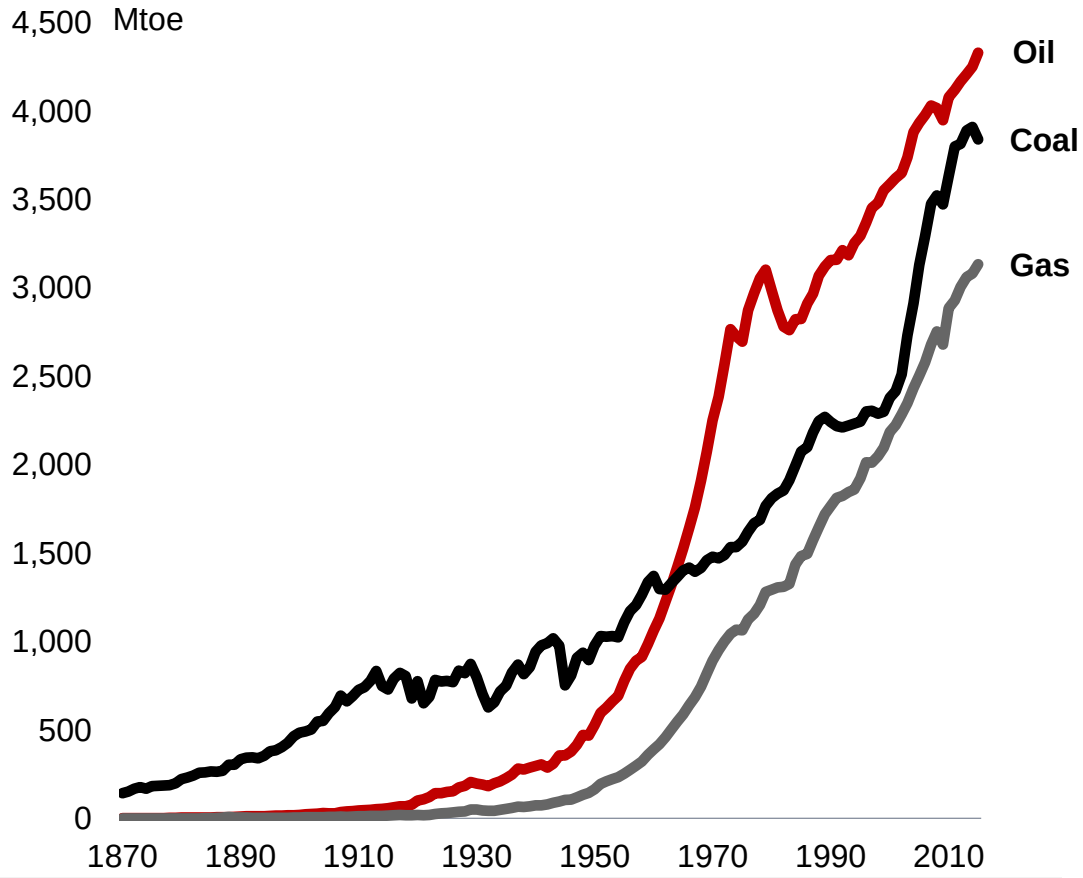


S-curve-type growth even applies to infrastructure.

Source: Comin & Hobijn via OWID (L); Grubler (R)

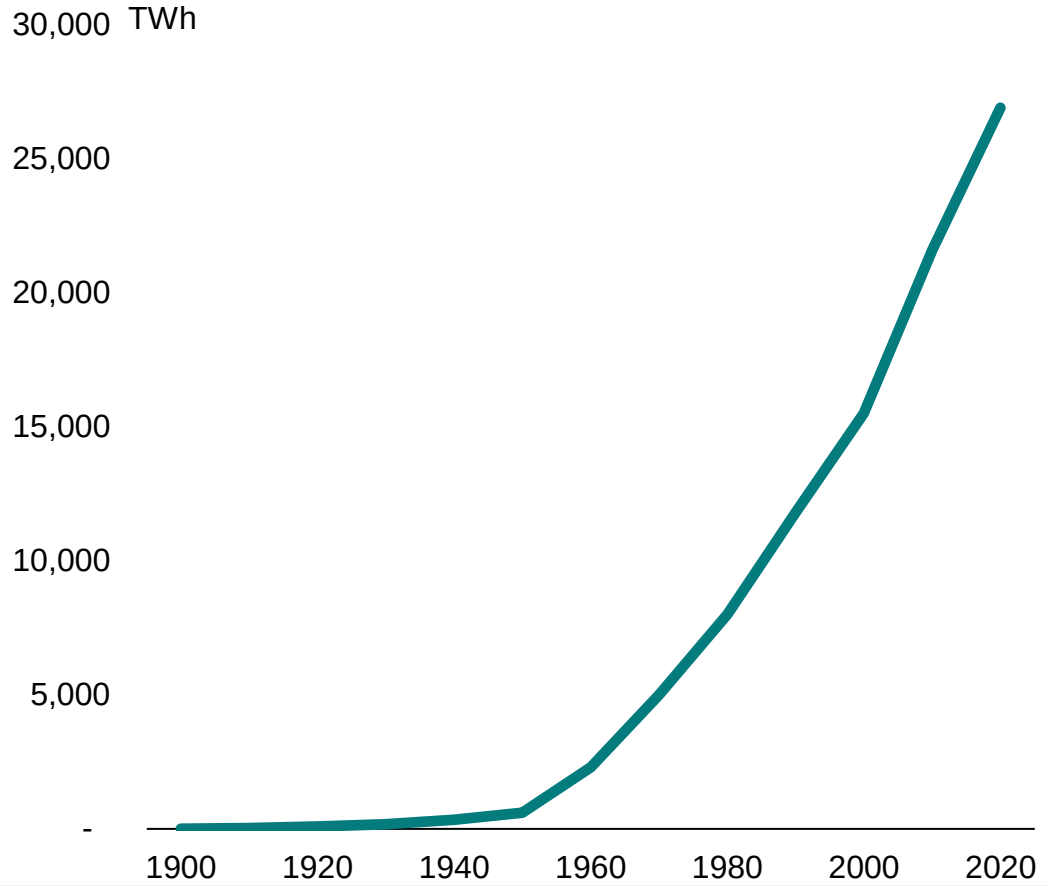
Fossil Fuels and Electricity Once Grew on S-curves

Primary energy consumption by fuel (global)



Oil and gas enjoyed spectacular S-curve growth in their era.

Electricity generation (global)



Electricity supply increased 2,000-fold in a century. Nobody sat down in 1900 and worked out the detail

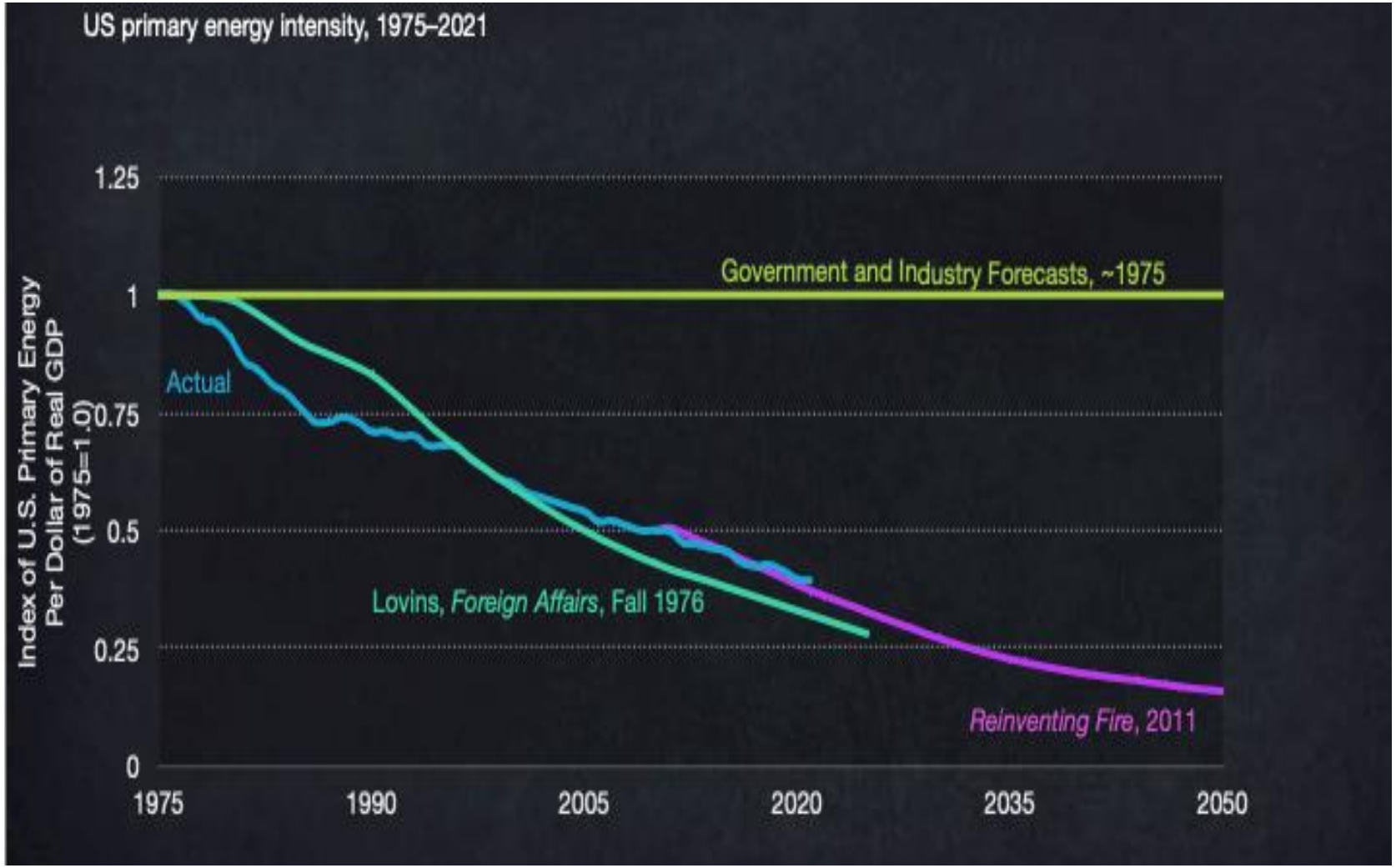
Source: Smil, BP

Meanwhile, Efficiency Has Been Reducing Energy Demand Growth for Decades

In 1976 Amory Lovins argued that efficiency gains would reduce US primary energy intensity by 2.5% a year.

Industry forecasts assumed no efficiency gains.

Lovins's predictions so far have been remarkably close to reality.



Source: RMI, Foreign Affairs

Efficiency Is Moving from Incremental to Systemic

As new energy technology penetration increases, efficiency gains will rise

Efficiency gain

Solar as a primary energy source is

250%

more efficient than coal

A heat pump is

300%

more efficient than a gas boiler

An electric vehicle is

400%

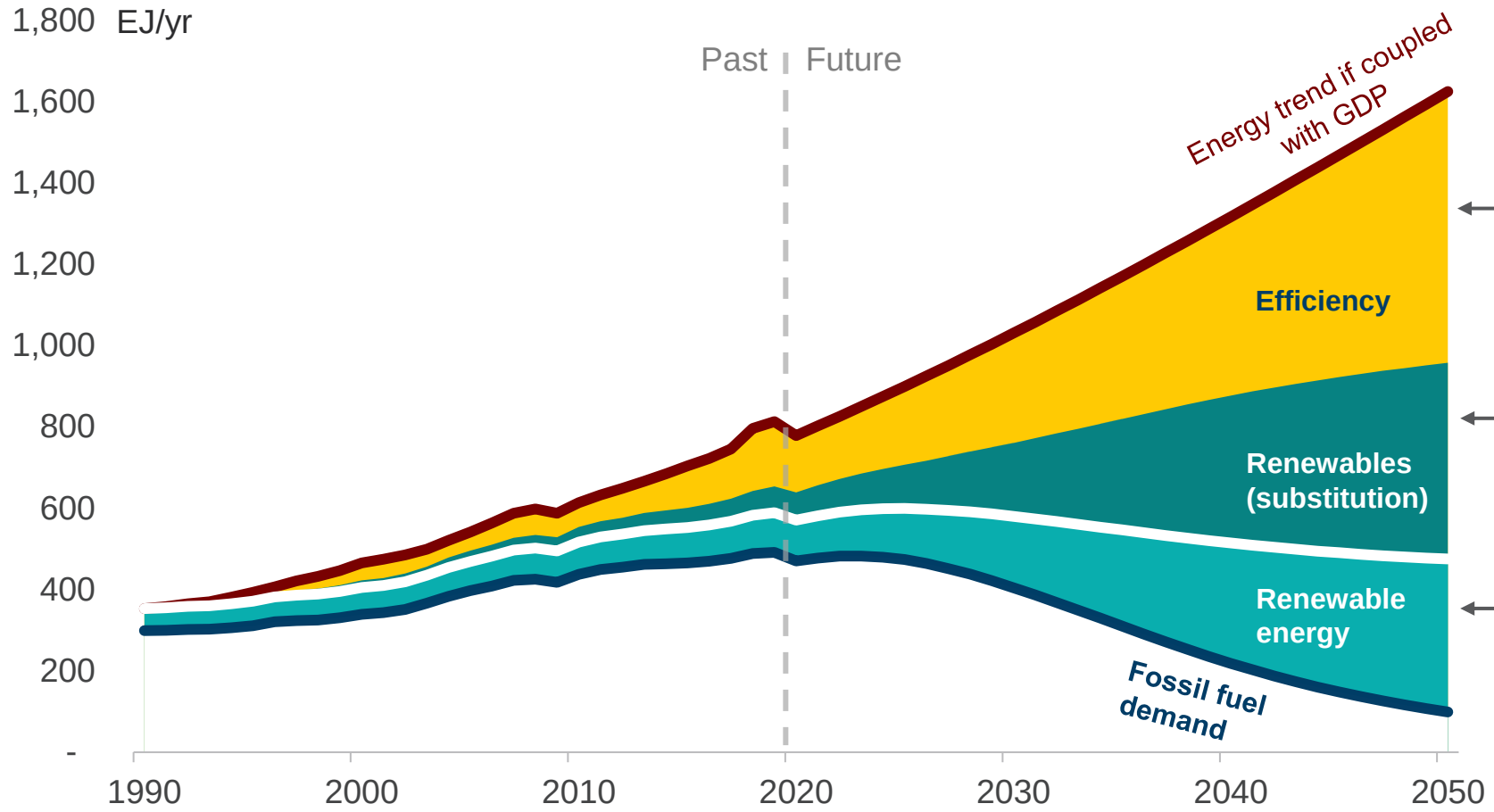
more efficient than an ICE

Source: RMI

Change Happens When You Combine Efficiency and Renewables

Efficiency slows growth; renewables push fossil fuels off the plateau

Global energy demand (EJ/year) since 1990



Description

More efficient technologies & systems

Goodbye to the huge thermal losses of fossil fuels

Renewables push out fossil fuels from the energy system

Source: Rystad central scenario (1.6°C) for energy data; IMF for GDP; RMI calculations

03

The Decline of Fossil Fuels

The Rise of the New (Renewables) Pushes Out the Old (Fossil Fuels)

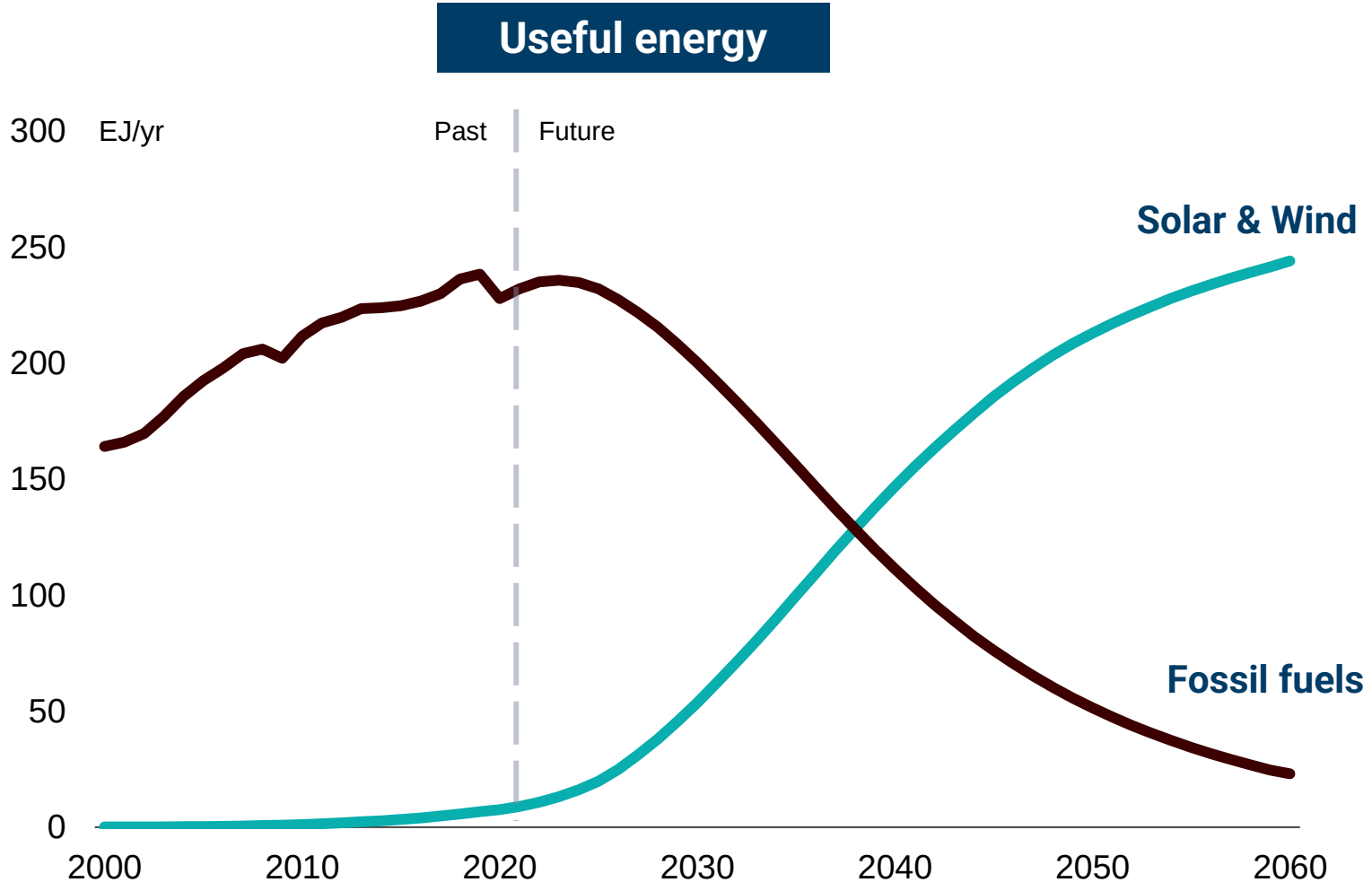
The new, not the old, sets the speed of change

The growth of renewables inevitably means a decline in demand for fossil fuels.

It is the new technology that sets the speed of change, not the old.

The very size of the fossil fuel system makes it extremely vulnerable to this type of disruptive change.

There is no debate that we will still need a lot of fossil fuels in 20 years' time. But the point is we will need much less than today.

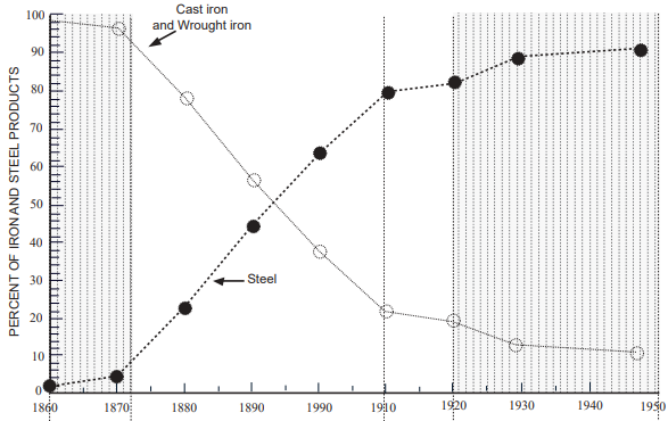


Source: Rystad Central Scenario (1.6 degrees)

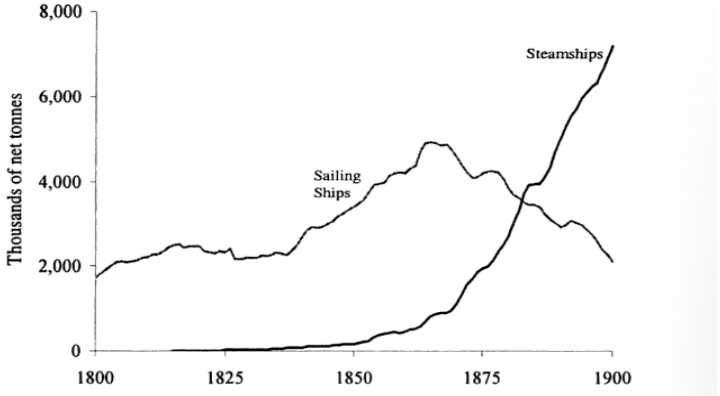
This X Pattern Is Common to Most Technology Shifts

As superior new technologies grow, demand for old technologies peaks early and falls fast

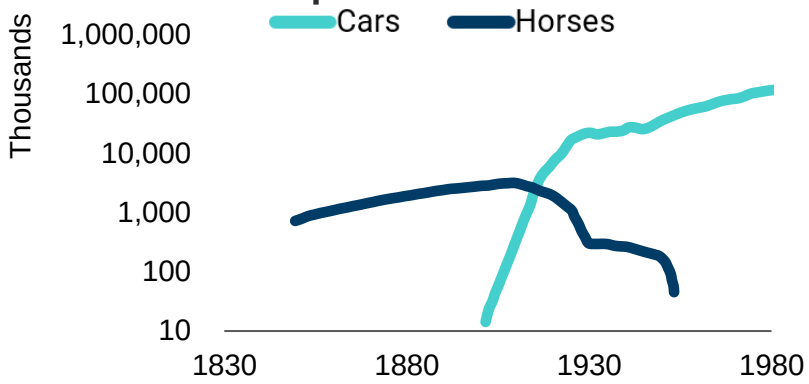
Cast iron to steel



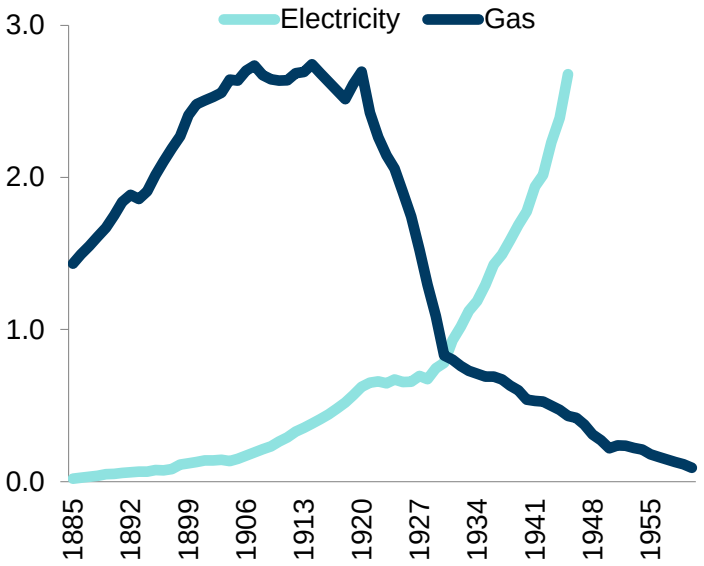
Transport: Sailing ships to steamships



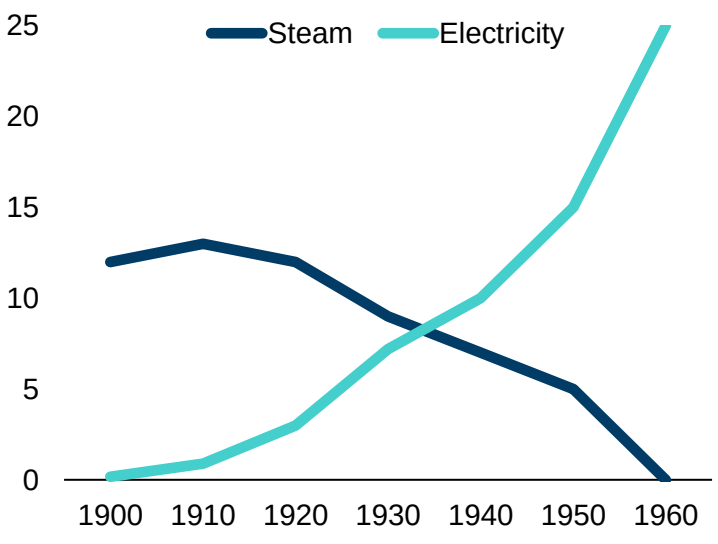
Transport: Horses to cars



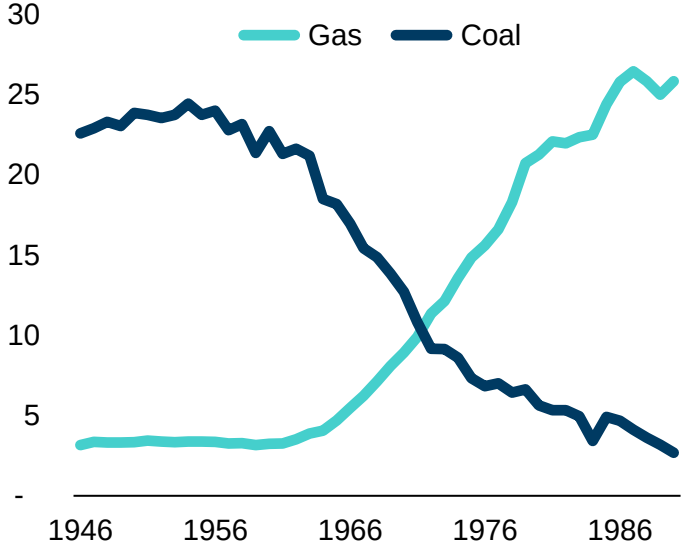
Lighting: Gas to electricity



Power: Steam to electricity



Heat: Coal to gas



Source: Perez, Fouquet, Nakicenovic, Mitchell; Note: all UK charts except horses to cars (US)

Incumbents Rarely Forecast Disruptive Change

We should not be surprised by the failure of incumbents to forecast a future without them

New area	Quote	Source
Trains	Rail travel at high speed is not possible because the passengers, unable to breathe, would die of asphyxia.	Lardner, professor of natural philosophy, UCL, c. 1830
Telephones	What use could this company make of an electrical toy?	Western Union to Bell when turning down his patents, 1876
Electricity	Edison's ideas are unworthy of the attention of practical or scientific men.	Committee of the British parliament on Edison's work, 1878
Oil	Drill for oil? You mean drill into the ground and try to find oil? You're crazy.	Prospective drillers to Drake, 1859
Cars	The horse is here to stay, but the automobile is only a novelty — a fad.	Advice to Henry Ford's lawyer, c. 1910
Computing	I think there is a market for about five computers.	Watson, Chairman of IBM, 1943
Renewables	The fundamentals of our (energy) lives will not change drastically in the coming 20-30 years	Vaclav Smil, 2022

Source: Nairn, Engines that move markets, Recharge News

The Future for Fossil Fuels Is One of Peak, Plateau, and Decline

Peak demand for incumbents is reached relatively early in all transitions.

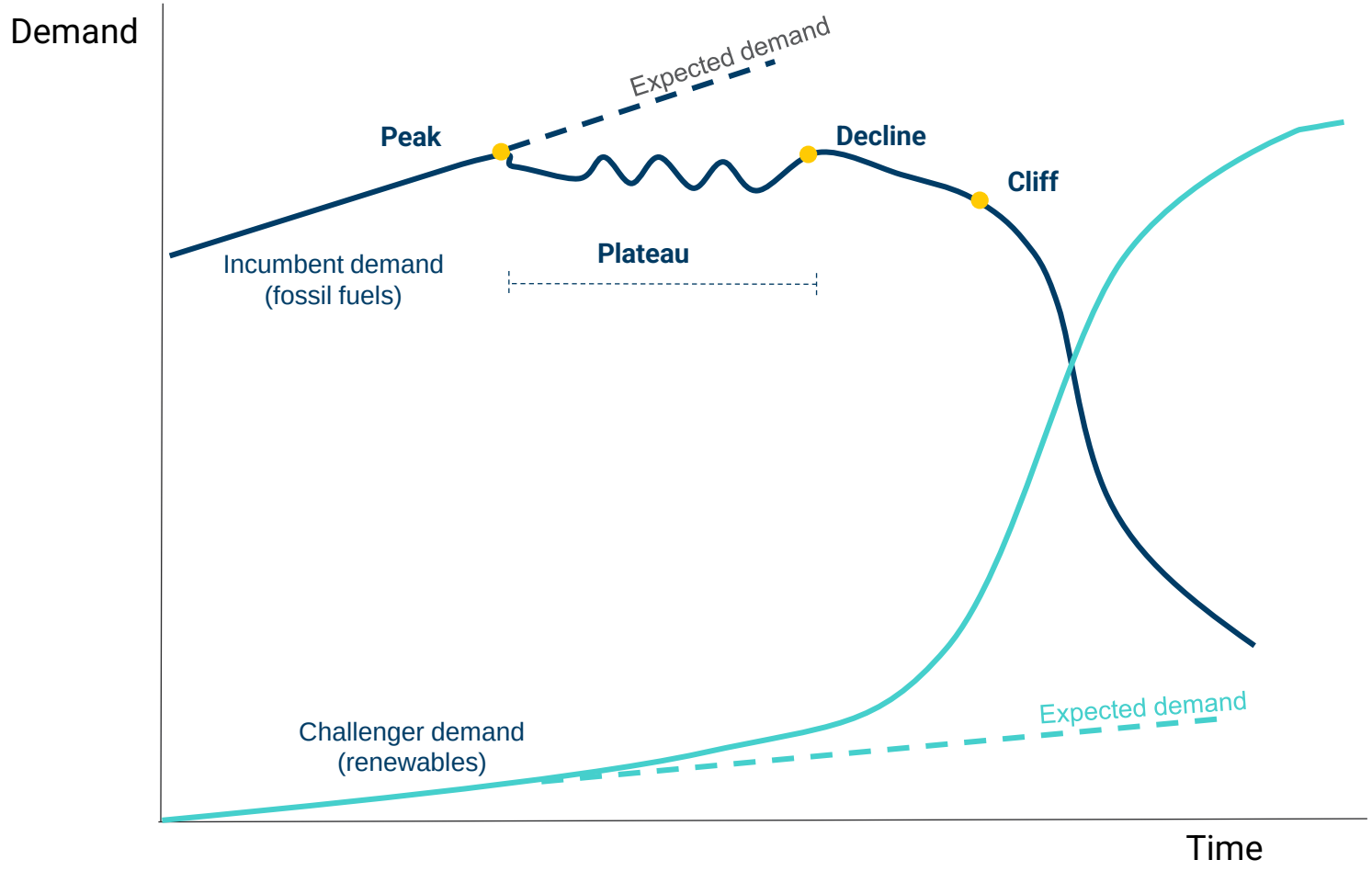
Because of inertia and large amounts of incumbent machinery, there is then a plateau.

External shocks (like COVID or Putin's war) make that plateau bumpy.

But decline sets in after 5–10 years, as new technologies move up the S-curve.

Investors should not mistake a bump on the plateau for a new mountain.

The pattern of peak, plateau and decline (illustrative)



Source: RMI

We Have Likely Reached Peak Fossil Fuel Demand

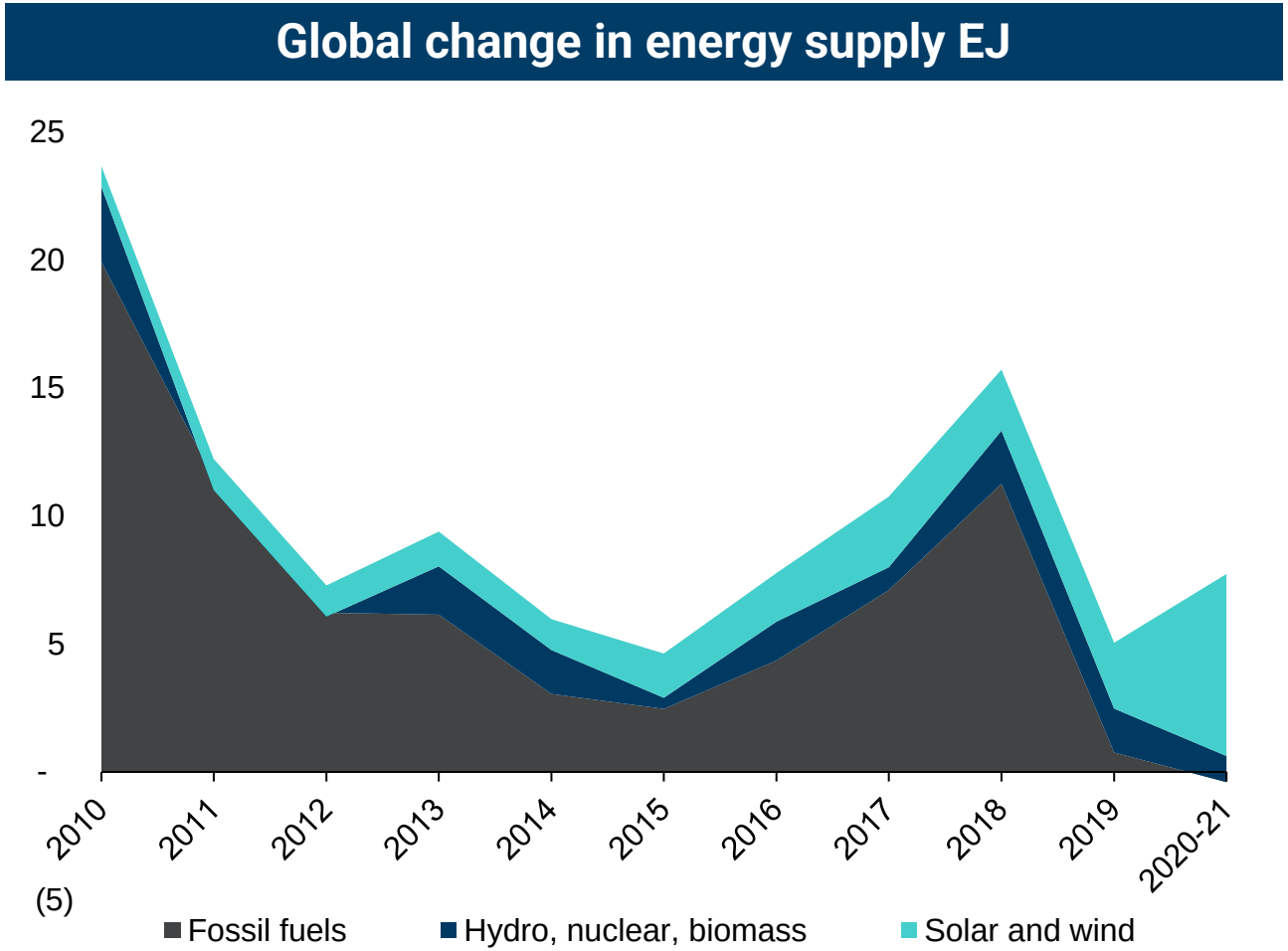
In 2019, fossil fuels were only 15% of the increase in energy supply

In the crash and recovery of 2020-21, solar and wind supply increased by 7 EJ, and other renewables by 1 EJ. Fossil fuel supply fell by 0.4 EJ.

Solar and wind are now 5% of primary energy supply and growing at around 20%.

Therefore, energy demand growth in 2022 would need to be more than 1% for fossil fuel demand to exceed its 2019 levels.

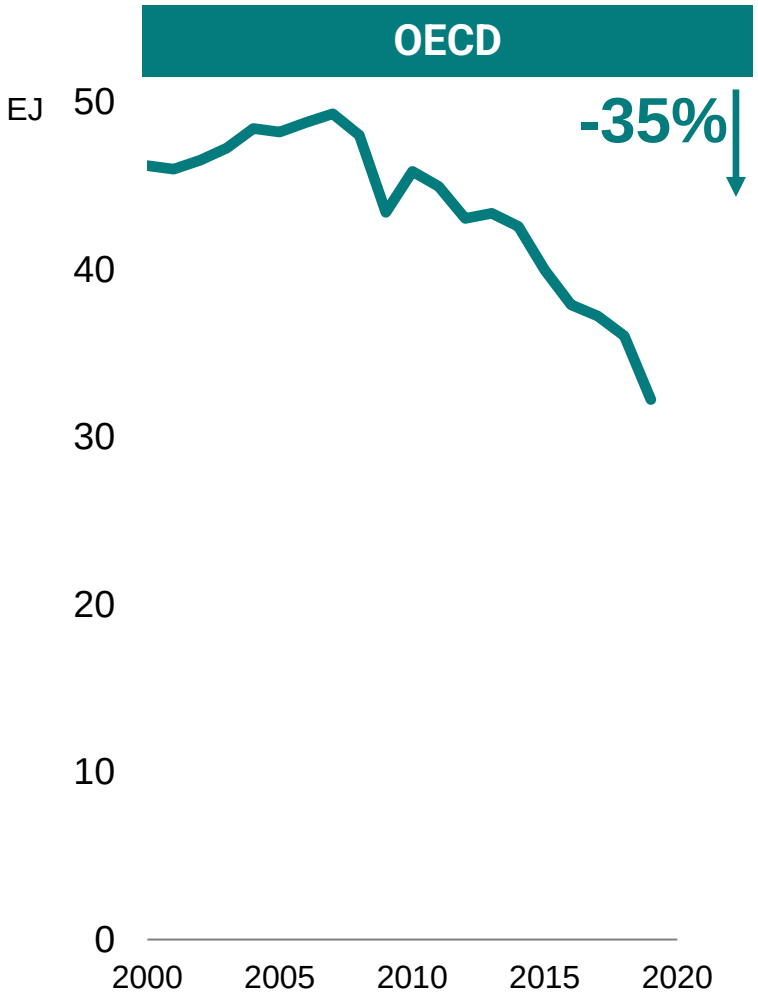
Putin's War brings forward the peak by reducing growth and supercharging renewables

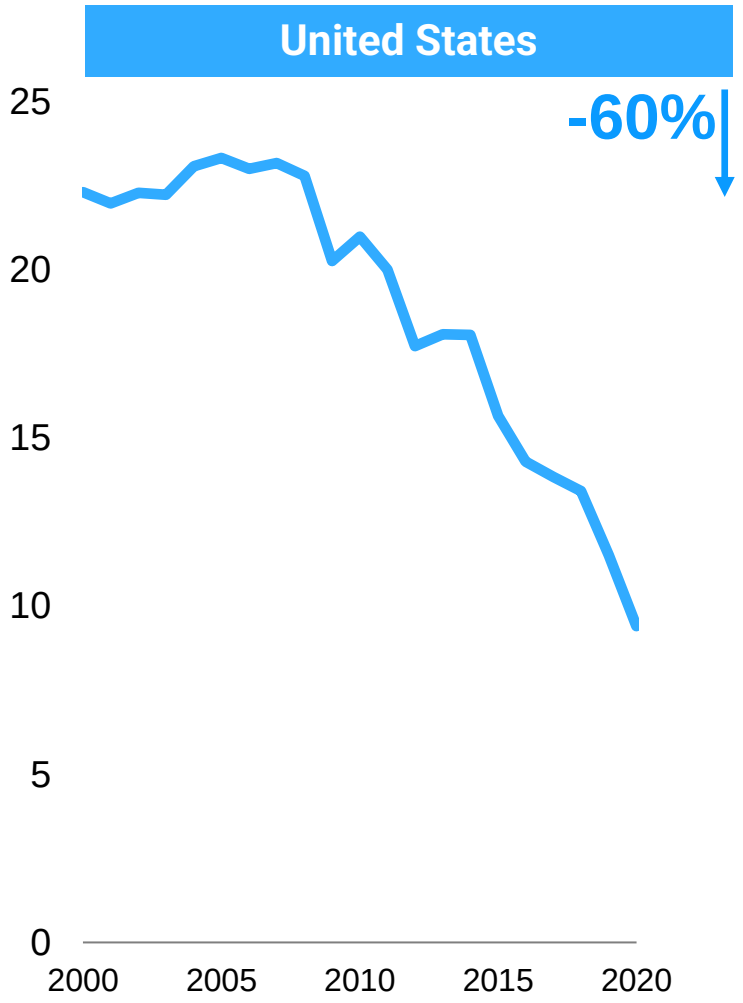


Source: BP Statistical Review

Coal is the Canary

The decline in coal demand across the OECD is the shape of things to come



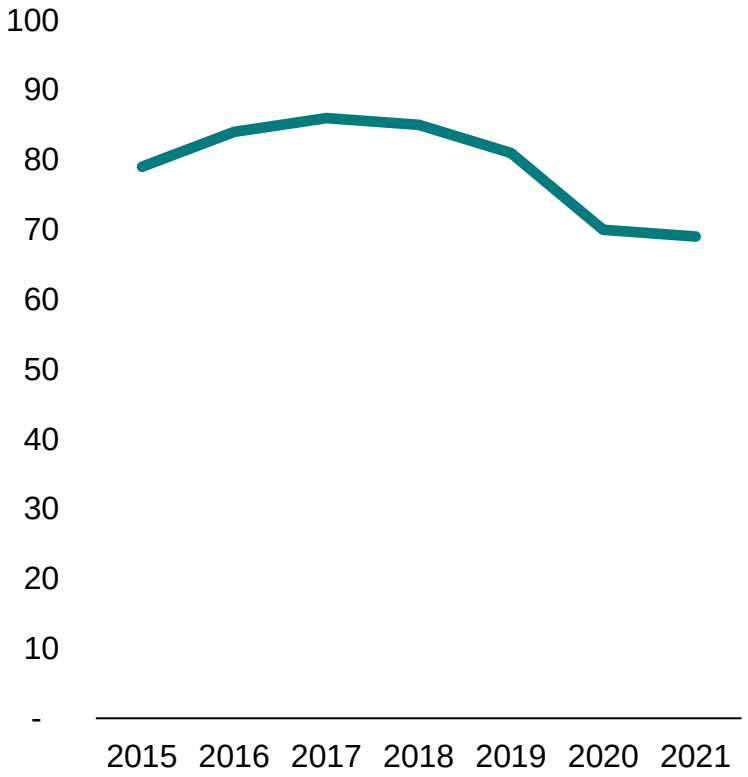


Source: IEA WEB

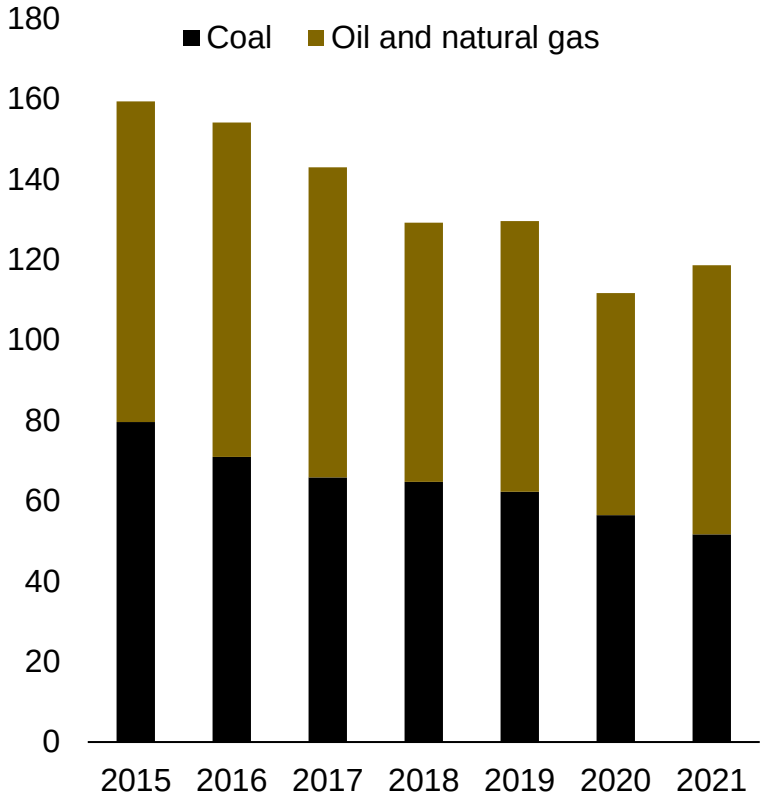
Flows of Fossil Fuel – Consuming Equipment Have Peaked

And the change in flows leads to a change in stocks and a change in fossil fuel demand

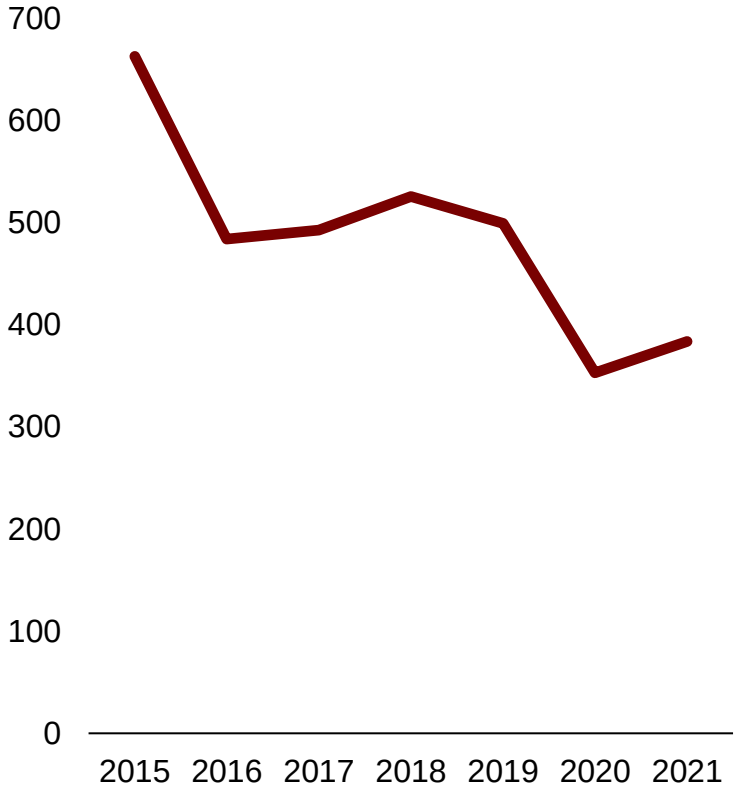
ICE sales (m)



Coal and gas power capex ($B)



Oil and gas upstream capex ($B)



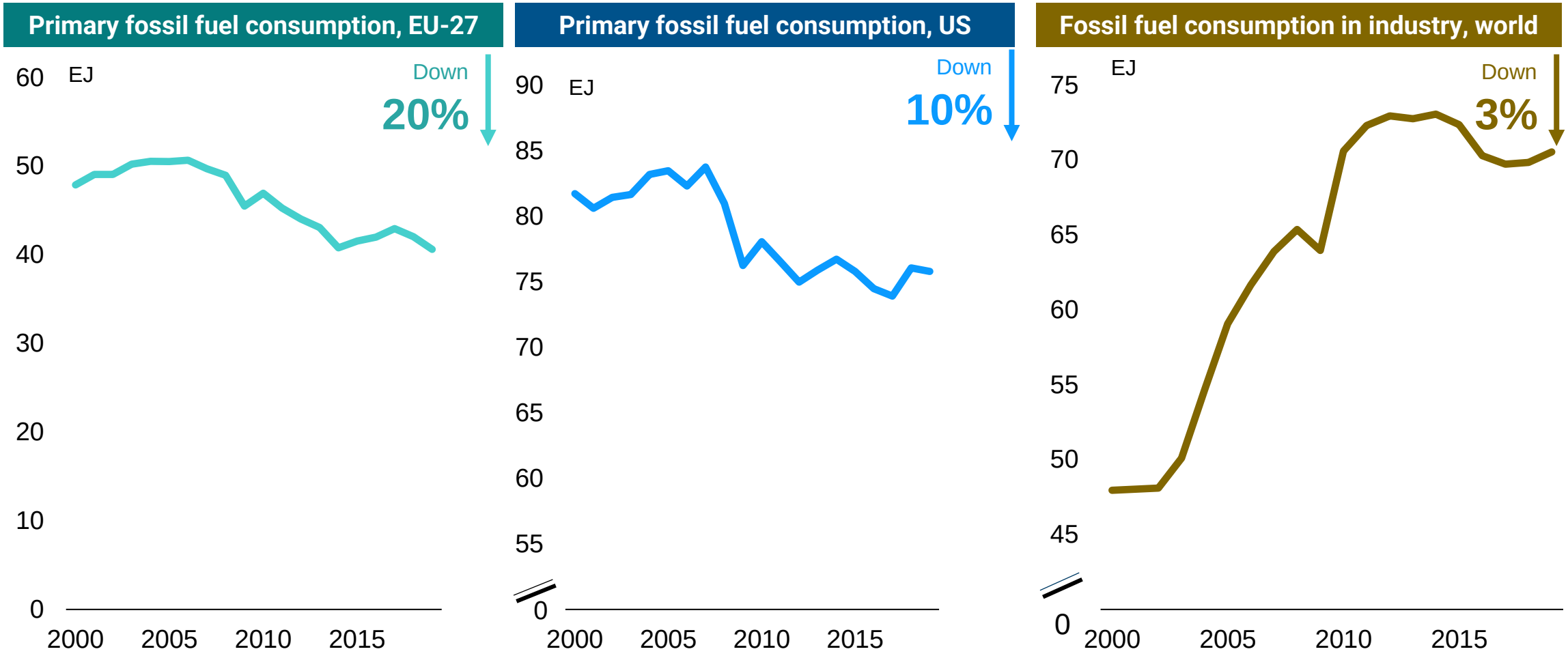
ICE sales are down by 20% since 2017.

Fossil fuel power station capex is down 26% since 2015.

Oil and gas upstream capex is down 41% since 2015.

Source: BNEF, IEA WEI

Fossil Fuel Demand Is Already Falling in Many Areas



Source: IEA WEB

60% of the World Is Past Peak Fossil Fuels

Countries that have already seen a peak and decline in fossil fuel demand

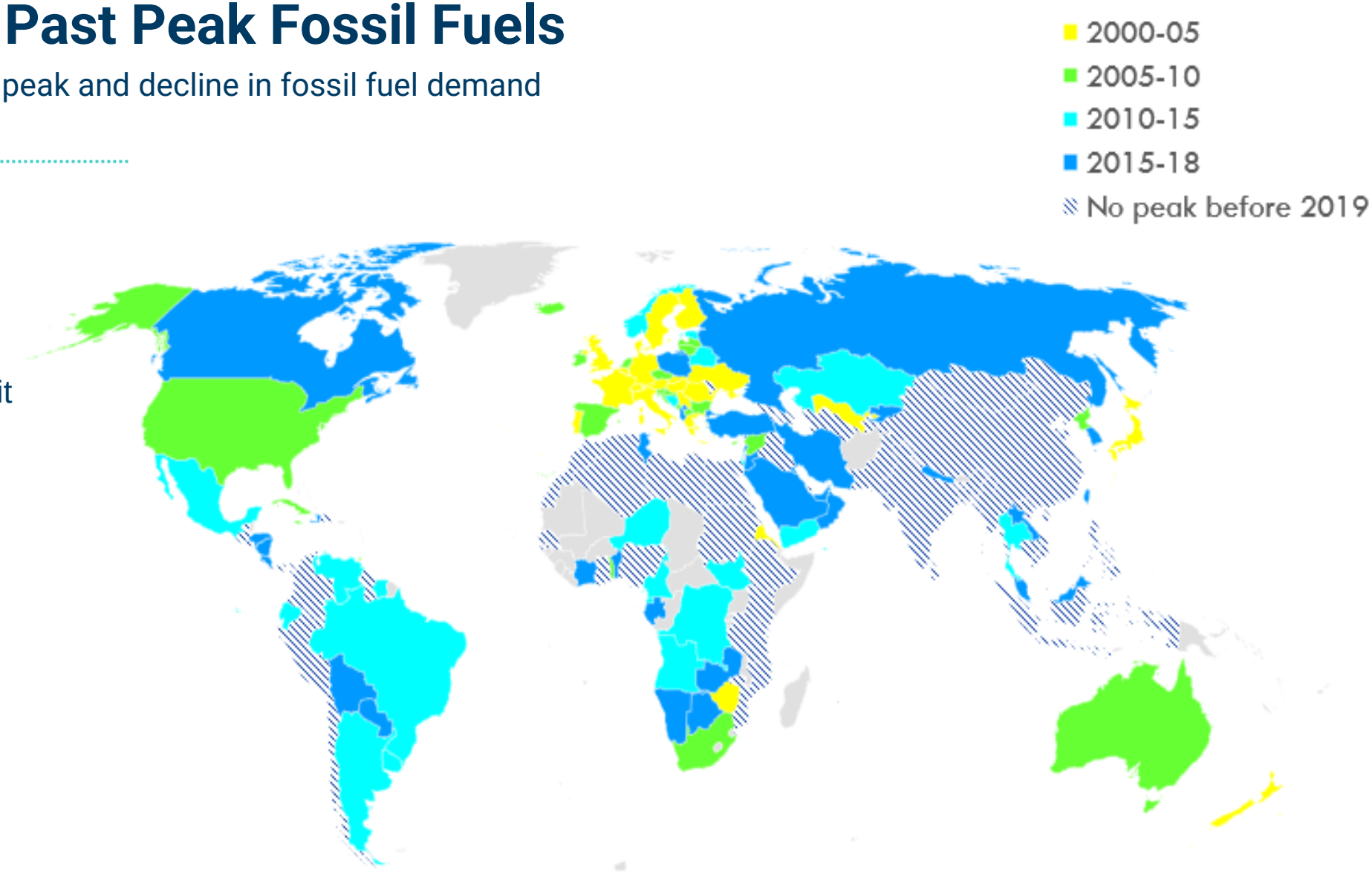
Demand for fossil fuels in most European countries peaked in 2000–2005.

In the United States and Australia, it peaked in 2005–2010.

In much of Latin America, demand for fossil fuels peaked in 2010–2015.

And in many petrostates, it peaked in 2015–2018.

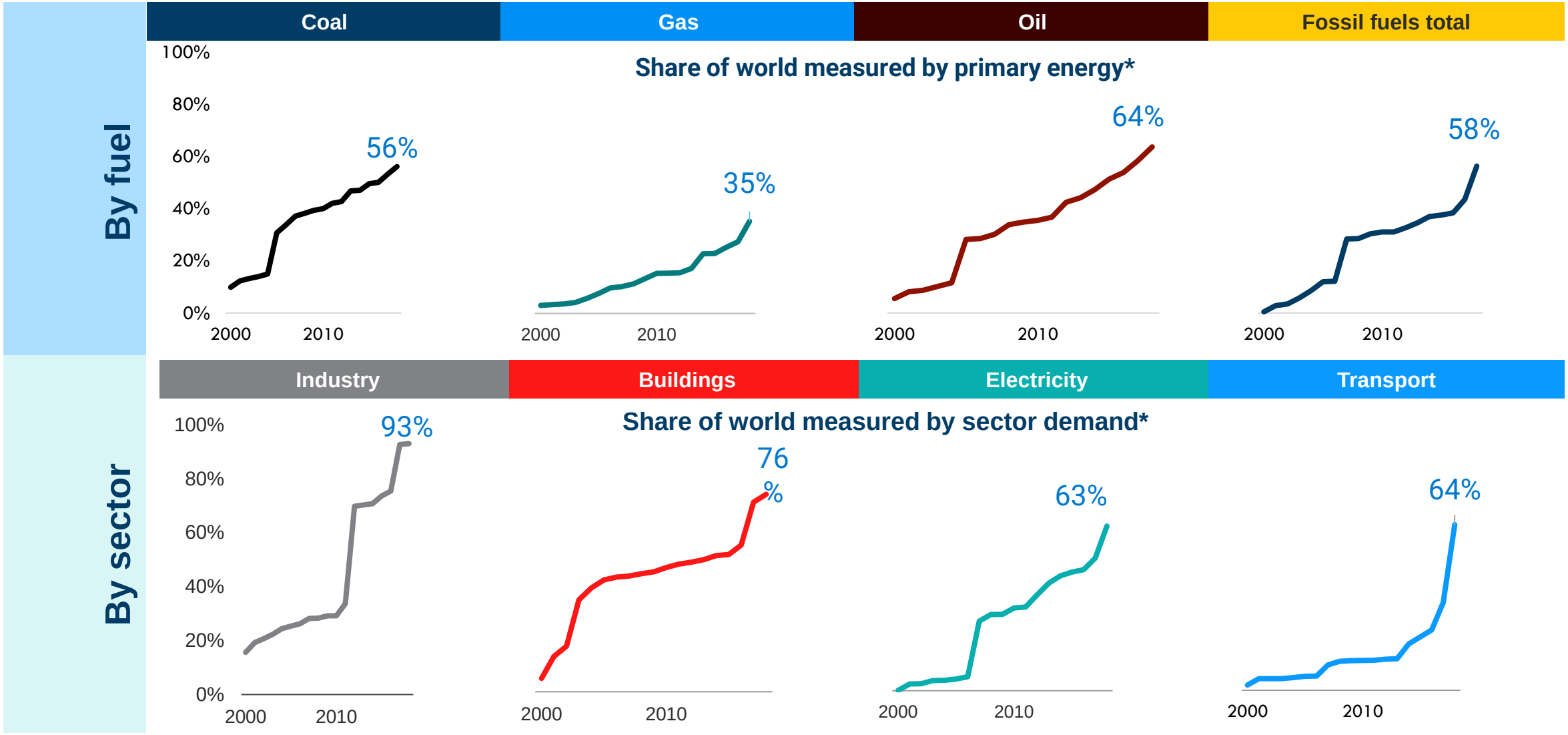
60% of the world has already seen peak demand for fossil fuels.



Source: IEA WEB with RMI assumptions and calculations; Note: 60% percent of world measured by energy demand in 2019

Share of Demand Past the Fossil Fuel Peaks by Fuel Type & Sector

Peaking demand is happening in every sector and every fuel. This shows what share of the world is past the peak



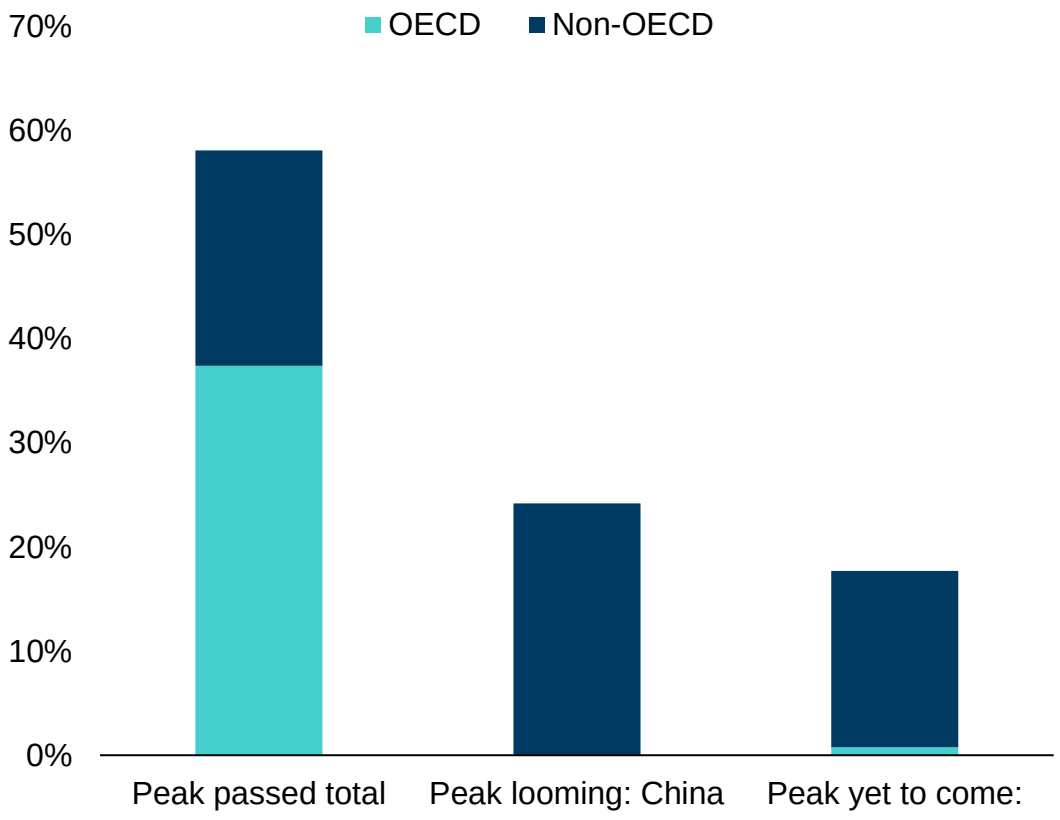
RMI – Energy. Transformed.

Source: IEA WEB; RMI. For example, countries using 56% of primary energy have seen peak coal, and countries with 76% of buildings demand have seen peak fossil fuels in buildings

China Is the Swing Factor for Fossil Fuel Demand

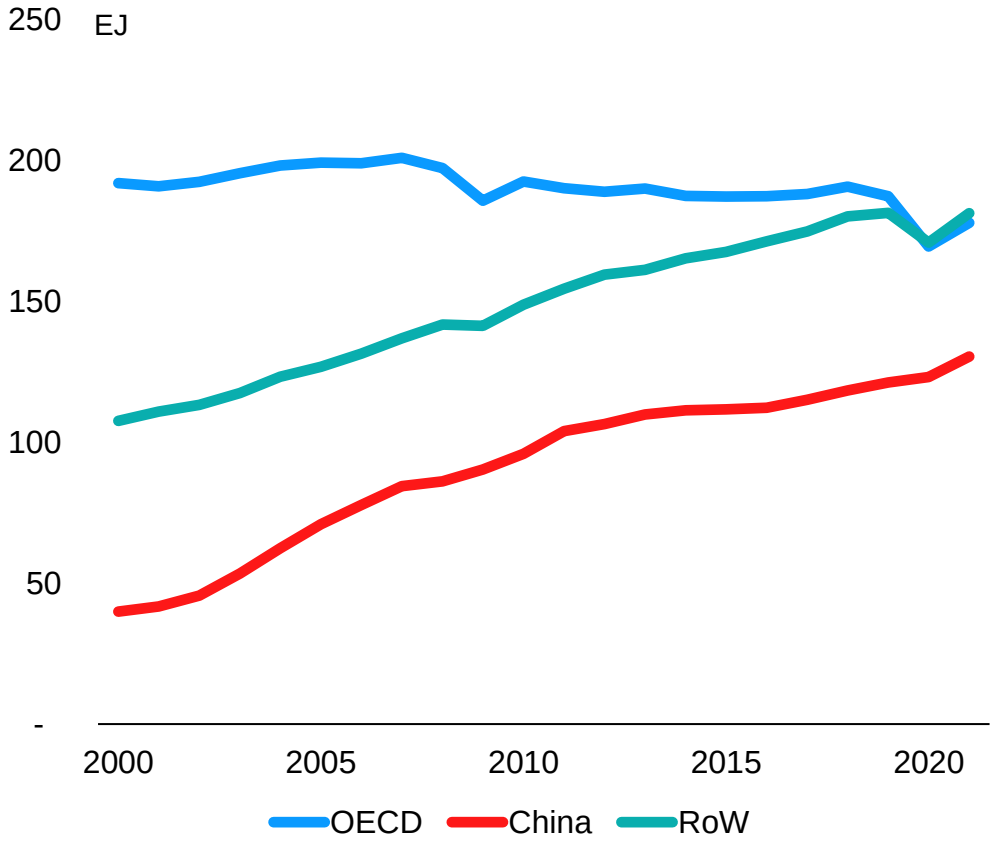
Once fossil fuel demand peaks in China, the global peak is indisputable. 80% of the world will then be in decline

Global demand and peaks



China is a quarter of fossil fuel demand.

Fossil fuel demand by region



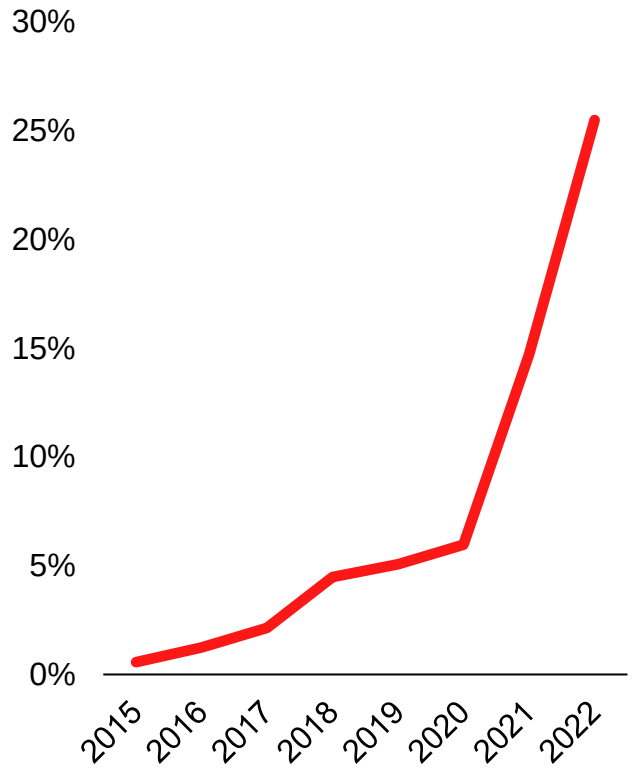
China has been the key driver of fossil fuel demand growth.

Source: IEA data, RMI (L); BP (R)

China Is Racing Up the Renewables S-curve

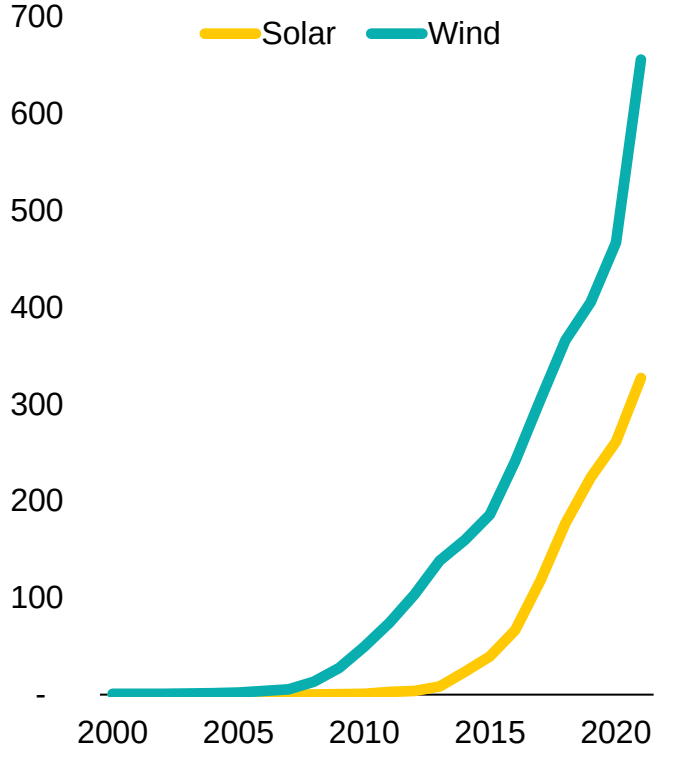
The world's largest market is setting the pace of change

EV sales share



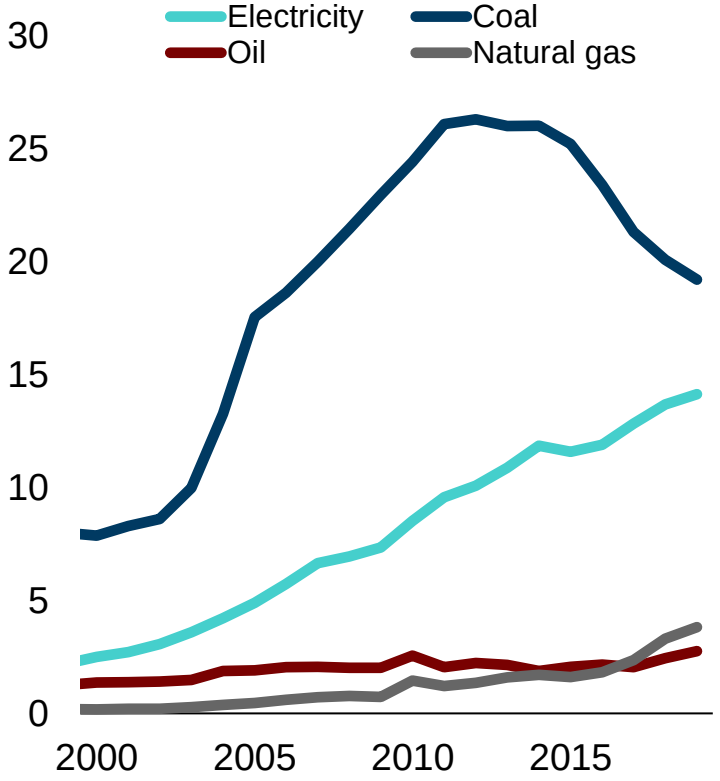
A quarter of car sales are EVs.

Solar and wind TWh



Solar and wind have been growing at 38% and 22% a year since 2016.

Final energy in industry EJ



China is leading in the electrification of industry.

Source: BNEF, BP, IEA WEB

So Chinese Fossil Fuel Demand Is Near the Peak

The Chinese government officially plans peak fossil fuel demand by 2030.

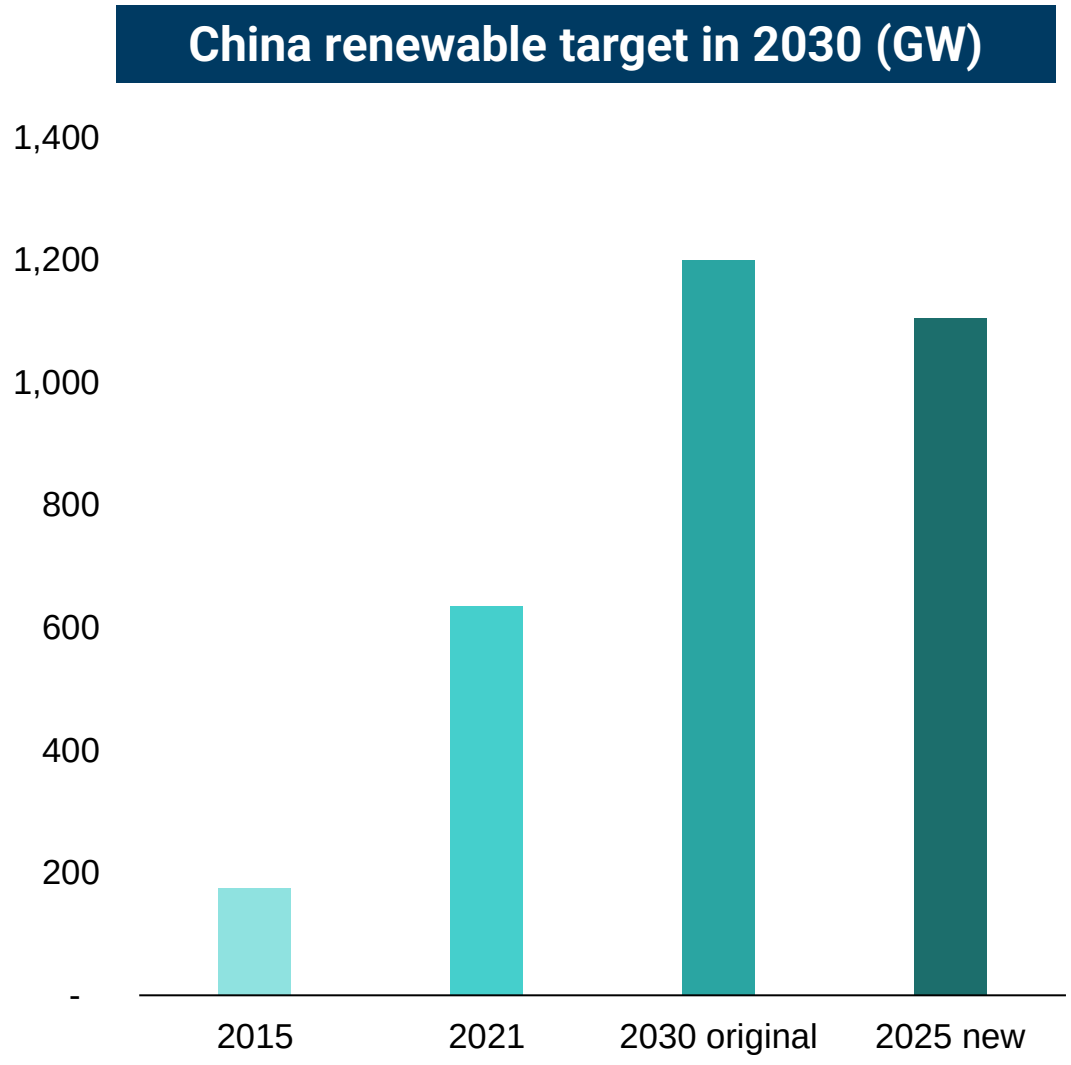
China has a very strong track record of outperforming its renewable targets.

Demand for fossil fuels in industry peaked in 2014 and in buildings in 2017.

The 2030 renewable target will now be hit by 2025, meaning that electricity demand would have to rise by more than 6% for fossil fuel demand to rise.

China is the global leader in the electrification of transport.

So China's peak fossil fuel demand is very close.



Source: Carbon Brief

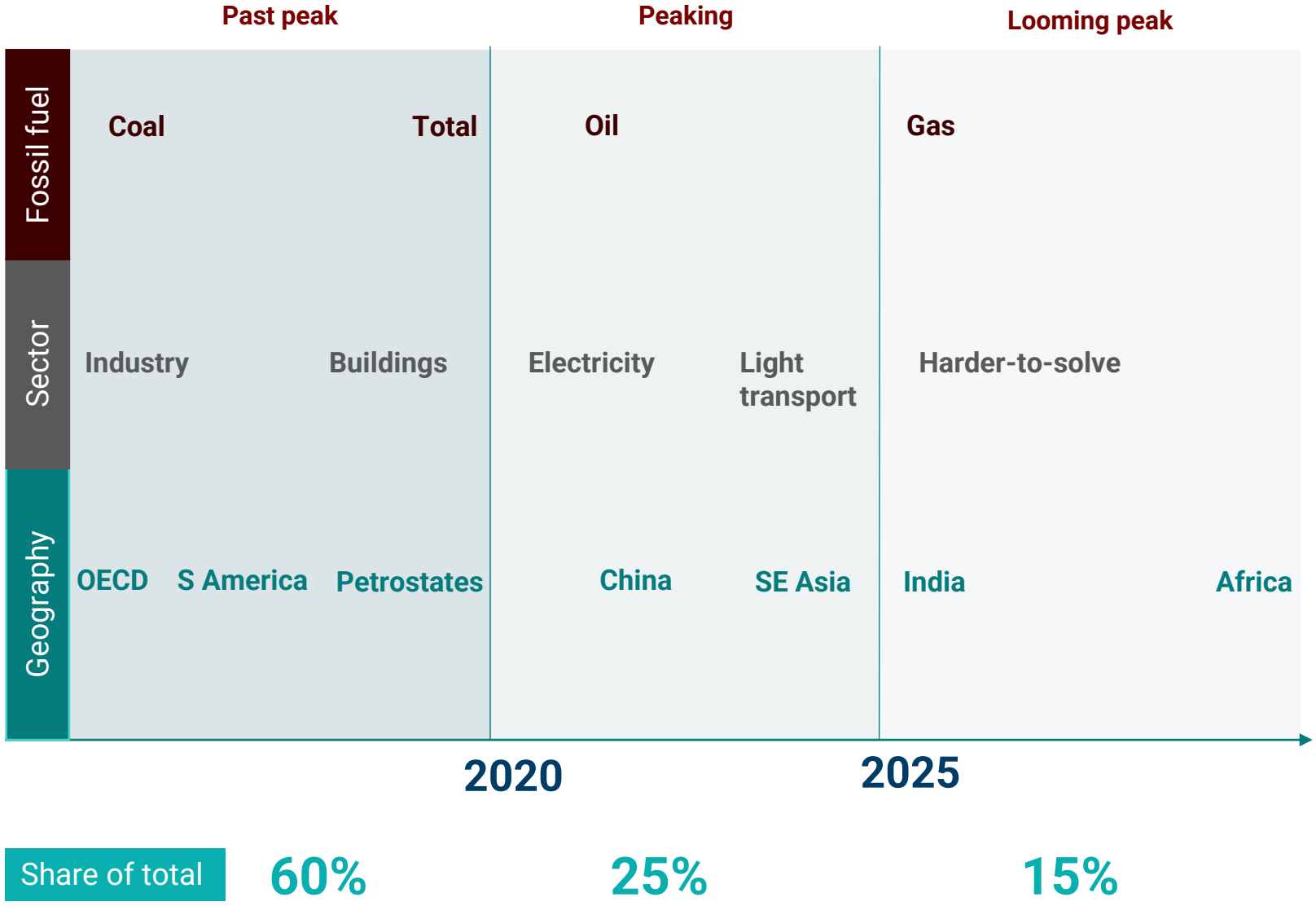
We Can Set Out the Timing of Peaks in Fossil Fuel Demand by Area

We can identify fossil fuel demand peaks by fossil fuel, sector, and region.

The past: We have seen peak demand for coal, for industry, for the OECD — and for fossil fuels as a whole.

The present: Demand is about to peak for oil, for electricity, and for China.

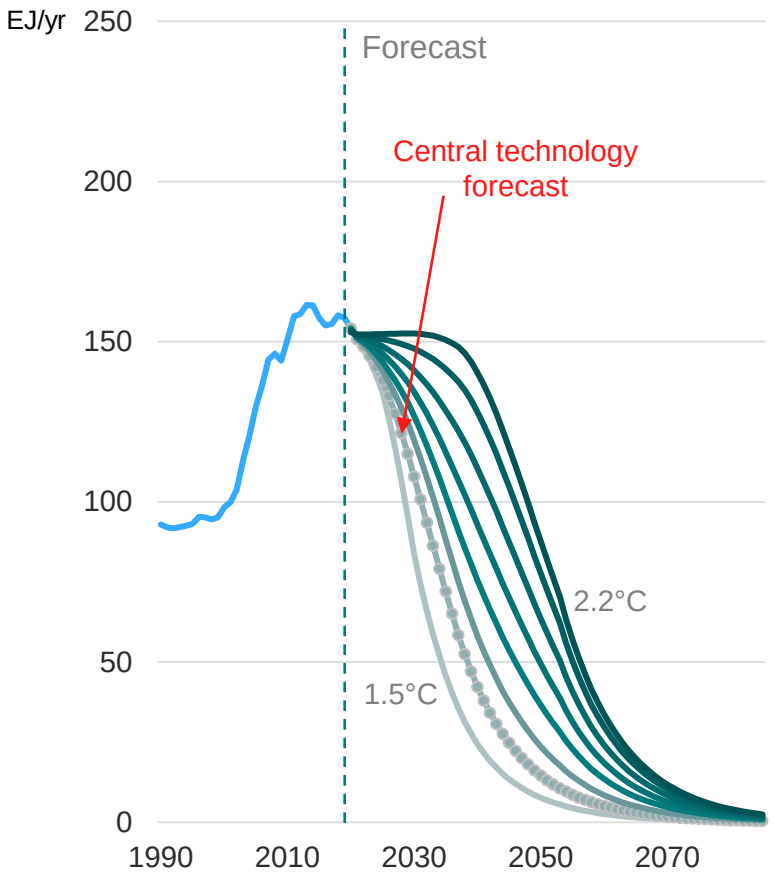
The future: Demand will peak by the end of the decade for gas, for India, and for harder-to-solve sectors.



Source: RMI

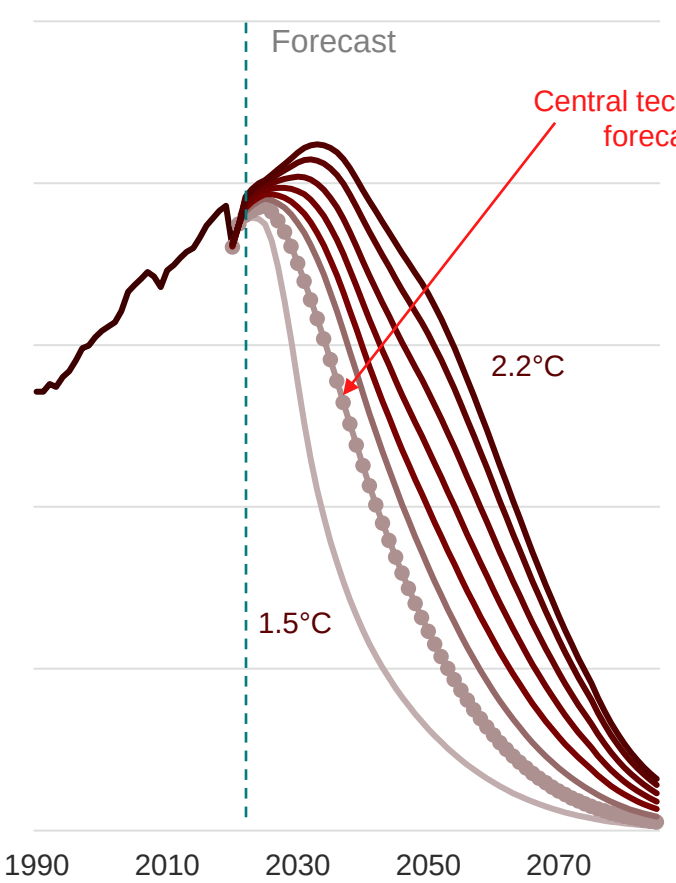
So Fossil Fuel Demand Will Shortly Collapse

Global coal demand



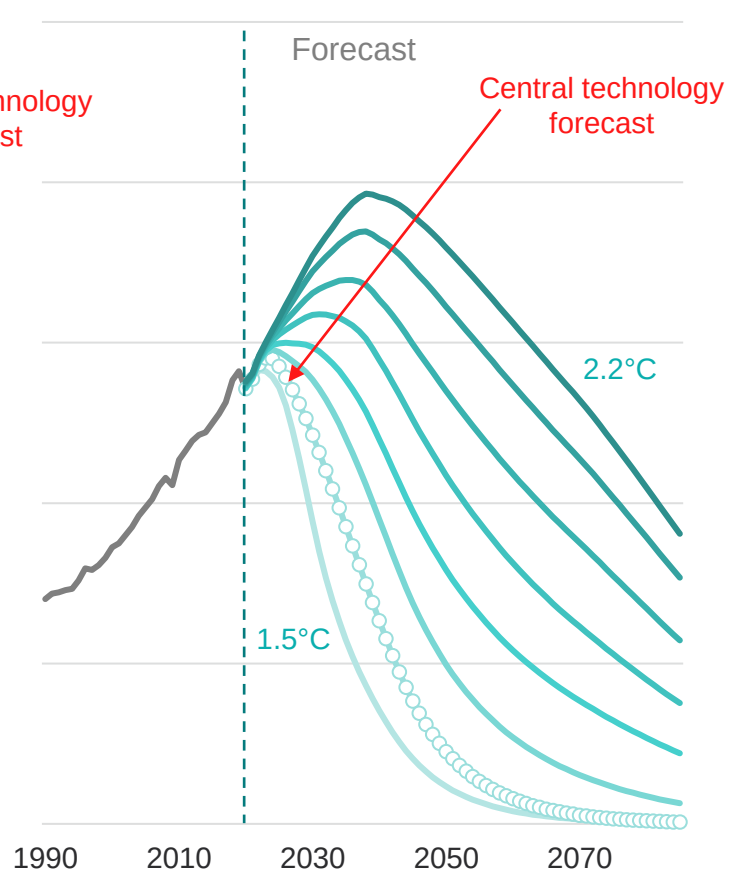
Coal demand is reaching the end of its plateau and is about to decline steeply.

Global oil demand



Oil demand reached its peak in 2019 and is bouncing along the plateau.

Global gas demand



Gas demand is still rising, but the peak is near.

Source: Rystad; Note: Light to dark: 1.5°C to 2.2°C

04

Financial Markets React Early

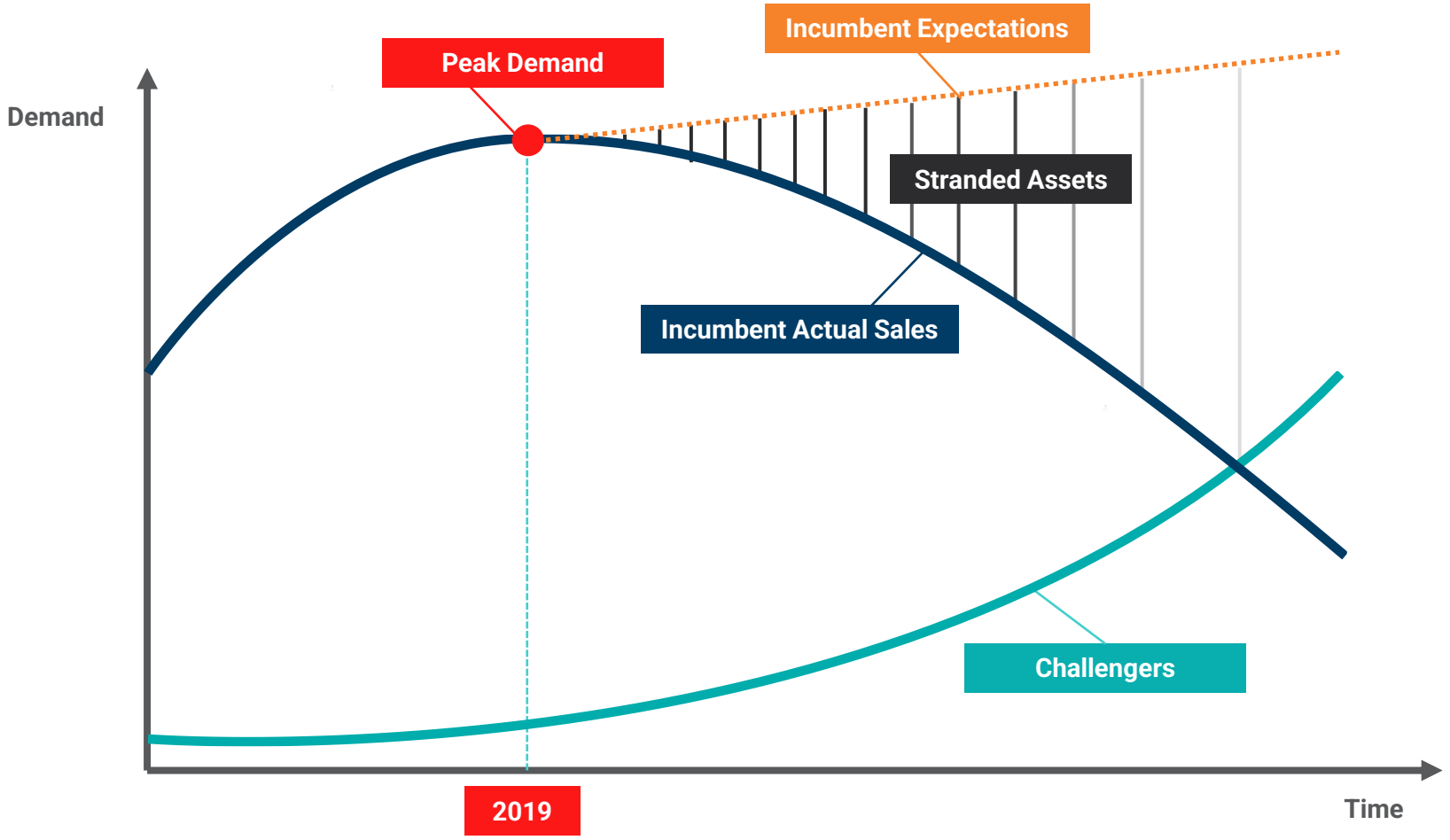
Peak Demand Means Stranded Assets

As soon as demand peaks, there are significant consequences.

Incumbents build for growth, and when there is no growth, they face stranded assets.

The rest of the industry then faces overcapacity and lower prices.

The supply shock of Putin's war is temporarily obscuring this dynamic.



Source: Carbon Tracker

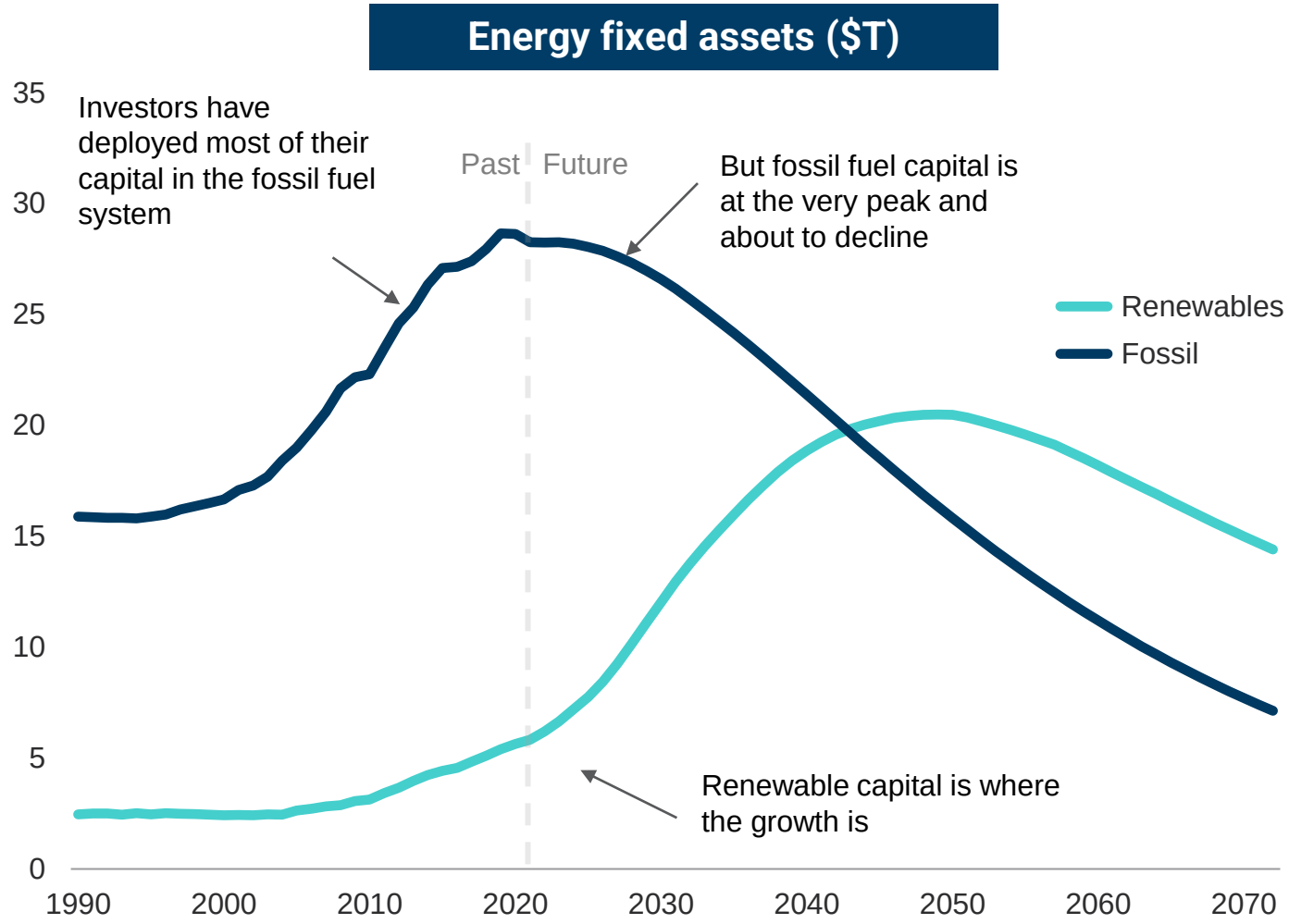
Investor Capital Is Currently Deployed in Fossil Fuels

Investors have most of their energy capital tied up in fossil fuels.

But capital assets are about to fall.

And all the growth is in renewables.

Who wants to invest at the top of the market?

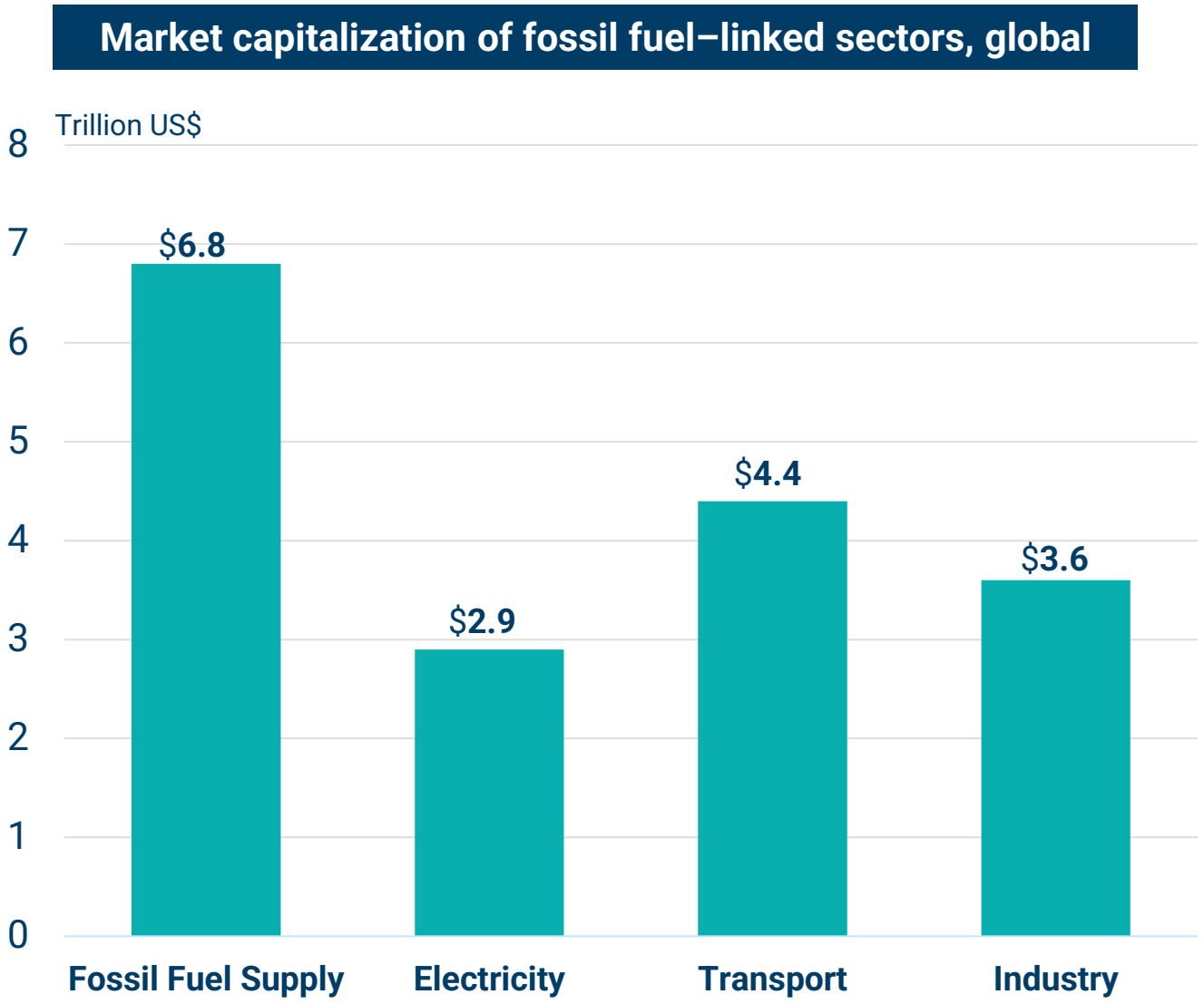


Source: Rystad 1.6 degrees

A Quarter of Equity Markets Are in Fossil Fuel Sectors

Because fossil fuel industries are highly capital intensive, investors are deeply exposed to the risk.

A quarter of the capitalization of global equity markets is in fossil fuel extraction and heavy usage sectors.

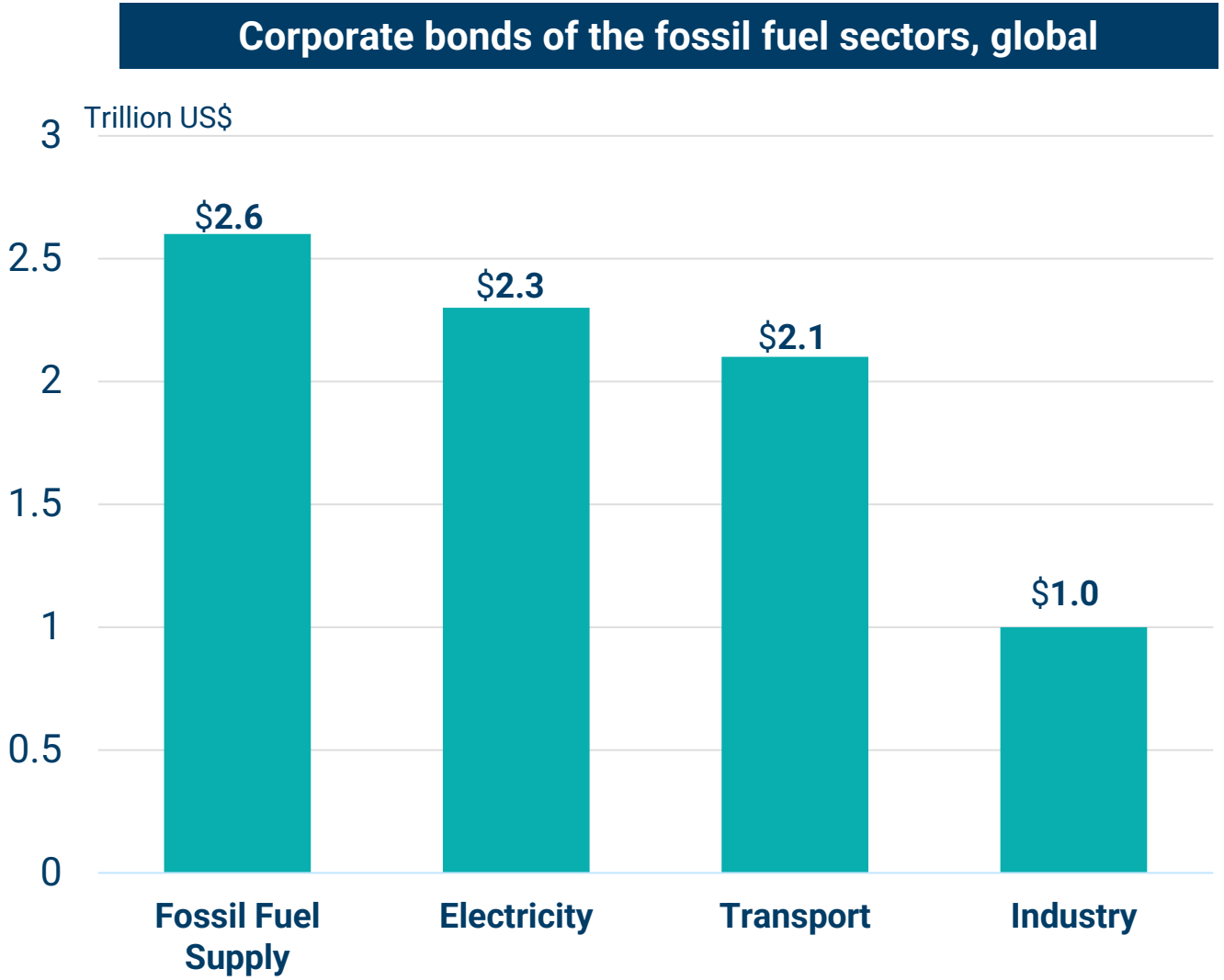


Source: Carbon Tracker for 2020

Half of Corporate Bonds Are in Fossil Fuel Sectors

Bond markets are even more vulnerable.

Half of corporate bonds are in fossil fuel extraction or heavy usage sectors.



Source: Carbon Tracker 2020

Banks Are Highly Exposed: Half of Syndicated Loans

Banks are also deeply exposed to the fossil fuel system.

Half of US syndicated loans are to fossil fuel sectors.

Banks are in denial about disruption: They use metrics built up over the past 40 years of rising fossil fuel demand in order to assess risk.

Greenwashing and ESG won't help with technology disruption.

When banks realize the degree of risk they are carrying, they will all try to sell at the same time — a classic Minsky moment like 2008.

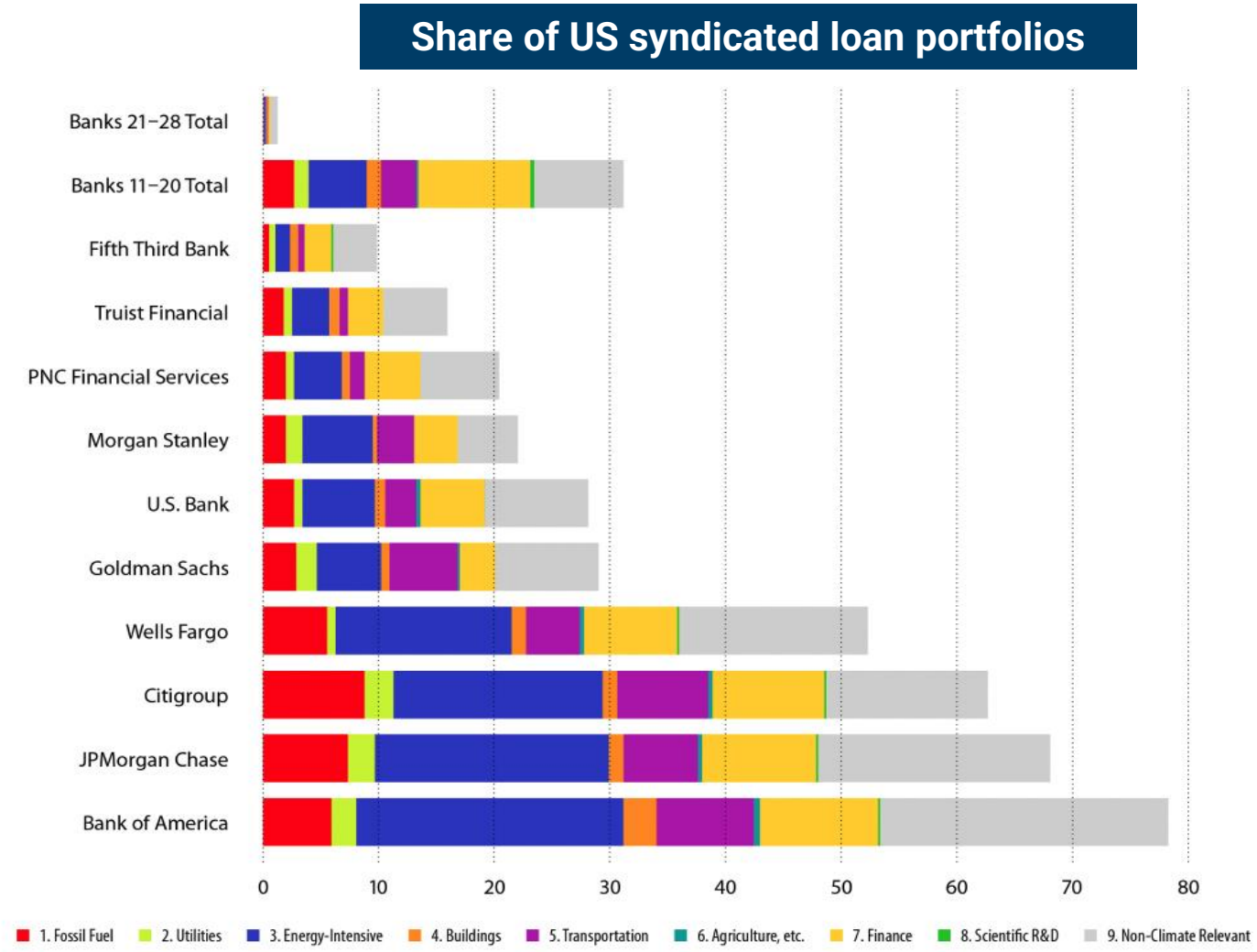


Figure 1: Climate-relevant sectors in U.S. syndicated loan portfolios ($ billions).

Source: Ceres 2020

The Threat of Peaks Drives a Higher Cost of Capital

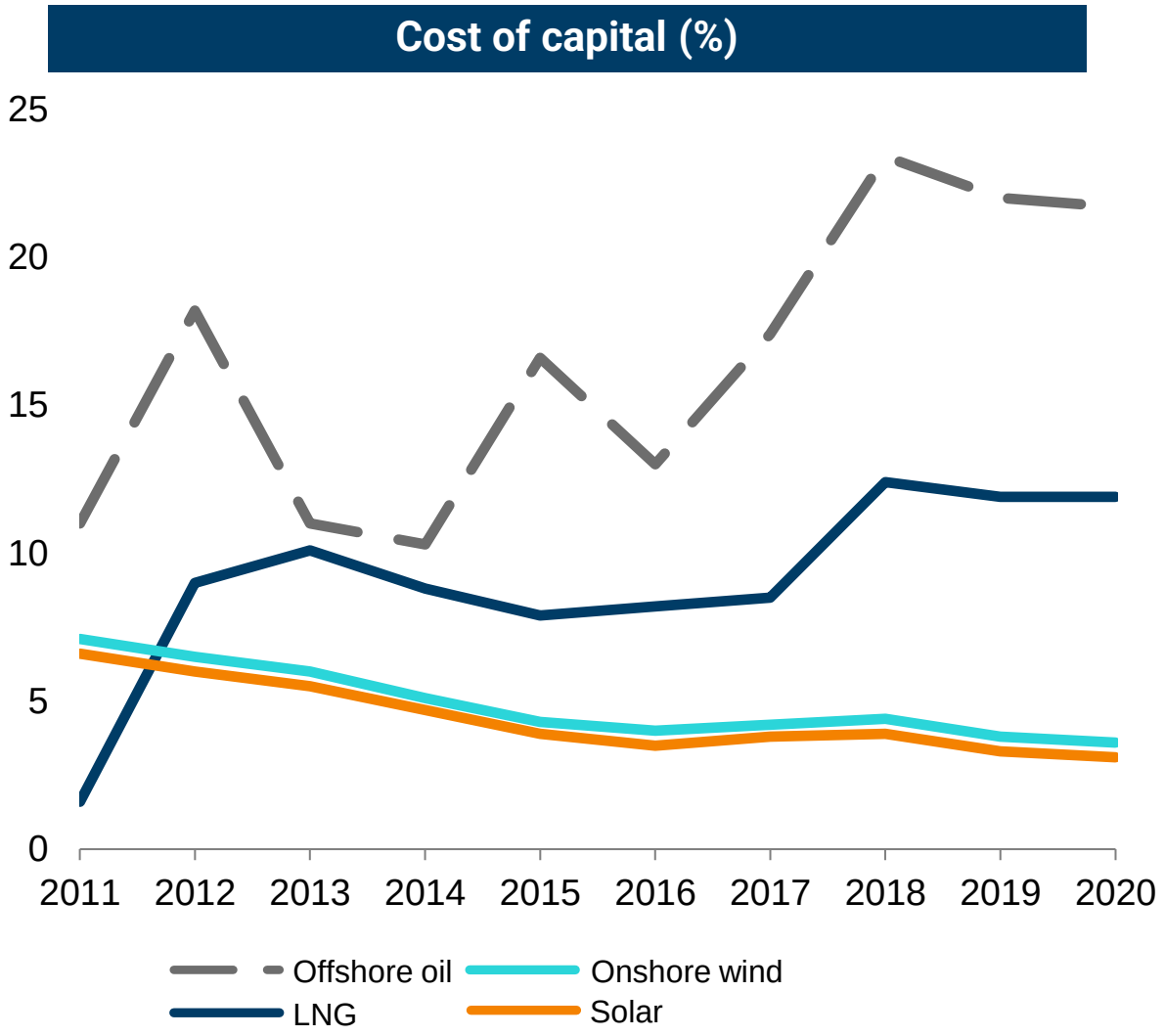
Financial markets price the future, not the past.

Investors are well aware that peaks lead to disruption and decline.

When they sniff out the risk of peaking demand, they tend to increase the cost of capital.

This is what has been happening for the fossil fuel sectors.

The cost of capital for oil and LNG has been rising, as that of solar and wind has been falling.



Source: Goldman Sachs, Bloomberg

Capital Flows Drive Change: Reflexivity

As capital is recycled out of declining industries (fossil fuels) into growth industries (renewables), it drives change.

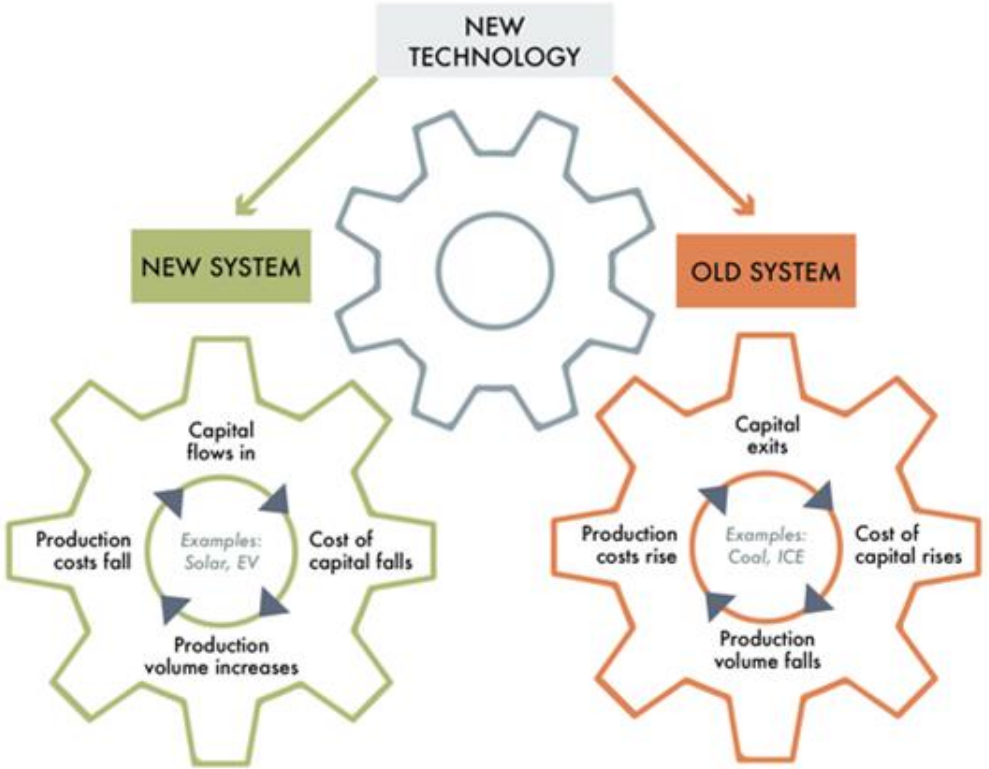
Higher cost of capital stops fossil fuel companies from expanding.

Lower cost of capital encourages money to flow into new renewables projects.

This then drives change in a feedback loop.

The process, popularized by George Soros, is known as reflexivity.

Technology & reflexivity

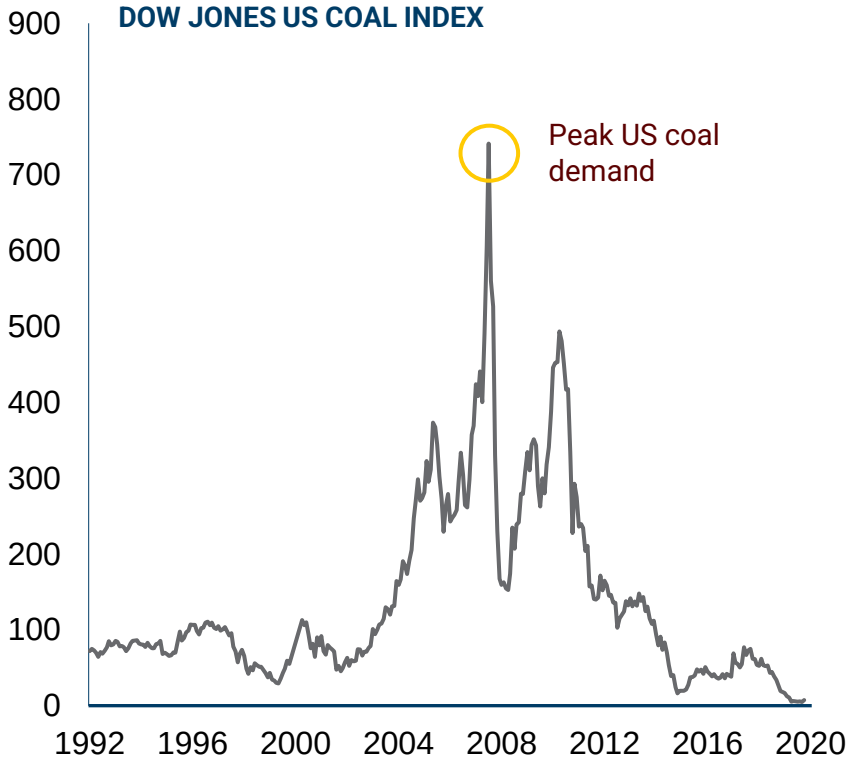


Source: Carbon Tracker, based on Soros

Investors Sell Shares in Incumbents at the Peak

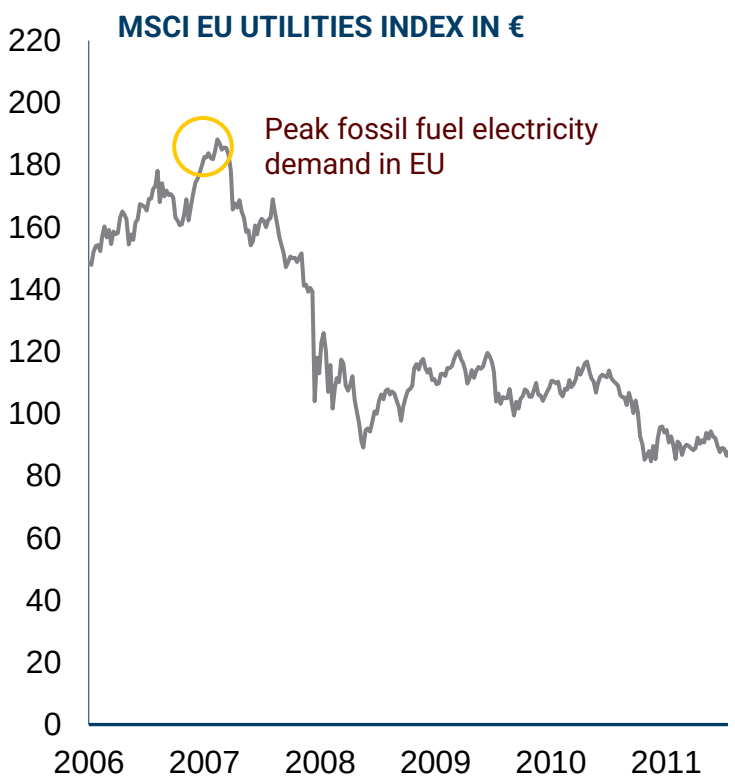
Investors hunt out peaks and sell just before

US coal



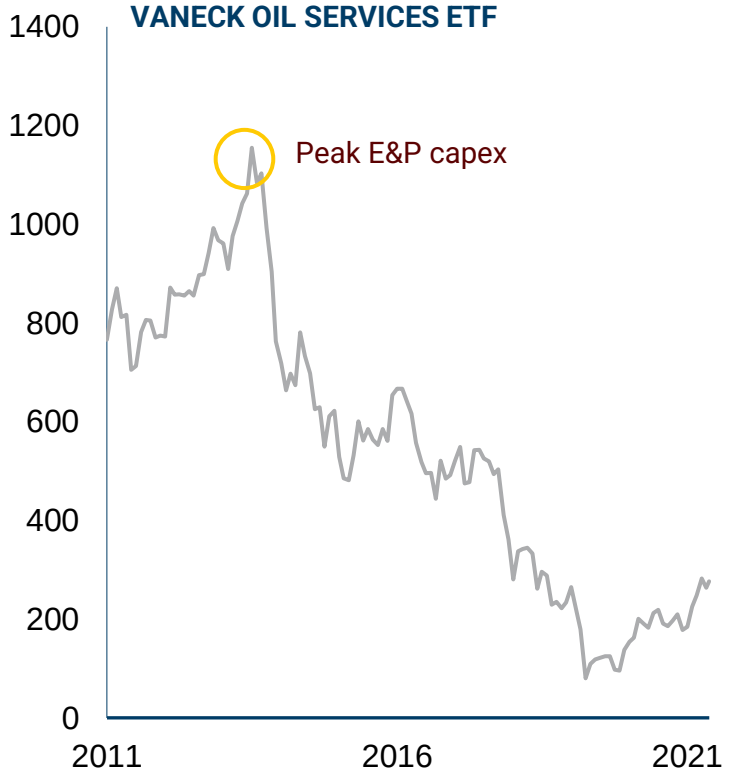
US coal stocks peaked in 2008, just as US coal demand was peaking.

EU fossil fuel electricity



EU electricity stocks peaked in 2007, just before demand for fossil fuel electricity peaked.

Oil services



The oil services index peaked in 2014, just as E&P capex peaked.

Source: Bloomberg

Investors in Fossil Fuel Assets Thus Face a Range of Risks

Area	Example
Cheaper alternatives	Gas in India
Rising taxation	Europe
Declining prices	After Putin's war
Stranded assets	European electricity
Litigation	United States
Reputation	Banks
Tipping points	Coal in UK
Cost of capital	Increased by 5% so far
Social pressure	Shift to EV
Untaxed externalities	Plastics, air travel

Source: RMI

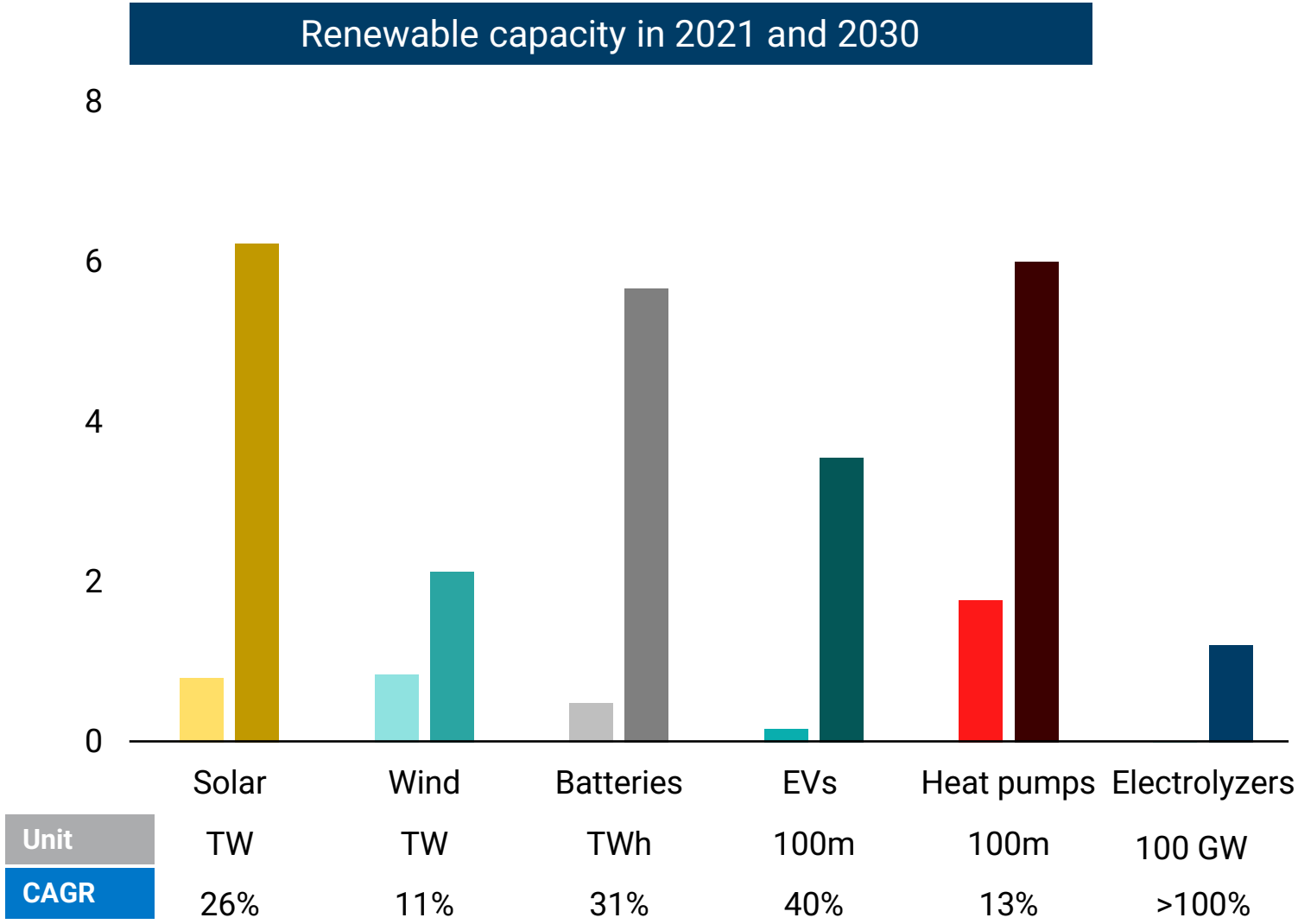
Meanwhile Renewables Have All the Growth

The exact level of renewable assets in 2030 is a matter of debate, but there is no question that there will be spectacular growth.

For example, the central scenario of Rystad assumes that solar PV capacity will increase eightfold from 0.8 TW today to 6 TW in 2030.

BNEF argues that EVs can grow 20-fold from 16M to 360M.

Forecasts of electrolyzer capacity are of up to 100 GW, up from 0.3 GW today.



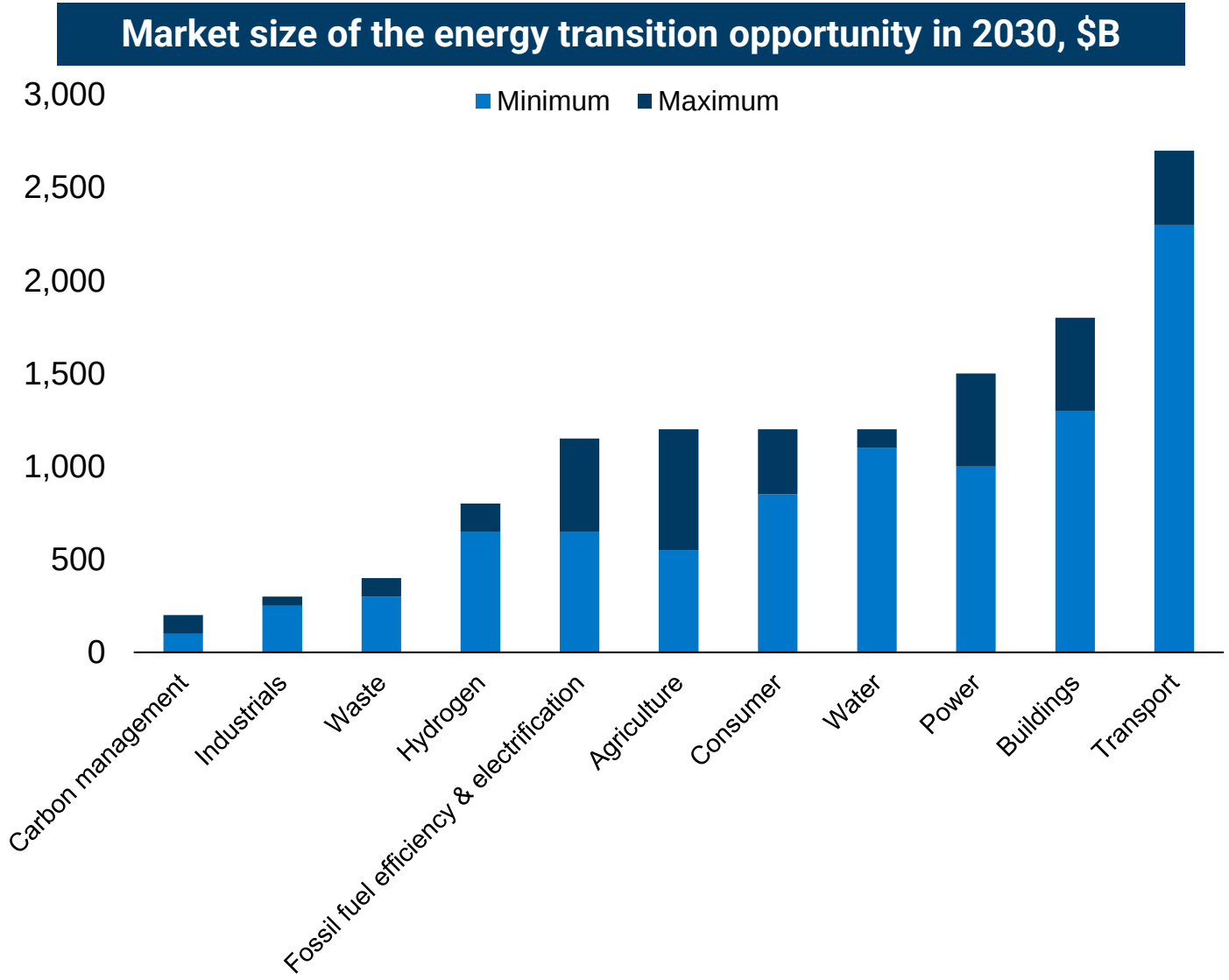
Source: Rystad 1.6°C, IEA, BNEF, RMI

The New Energy Opportunity Is Huge

Meanwhile, all of the opportunity lies in deploying capital to the winners of the energy transition.

From transport to buildings, from hydrogen to efficiency, there are multitrillion-dollar markets to be built.

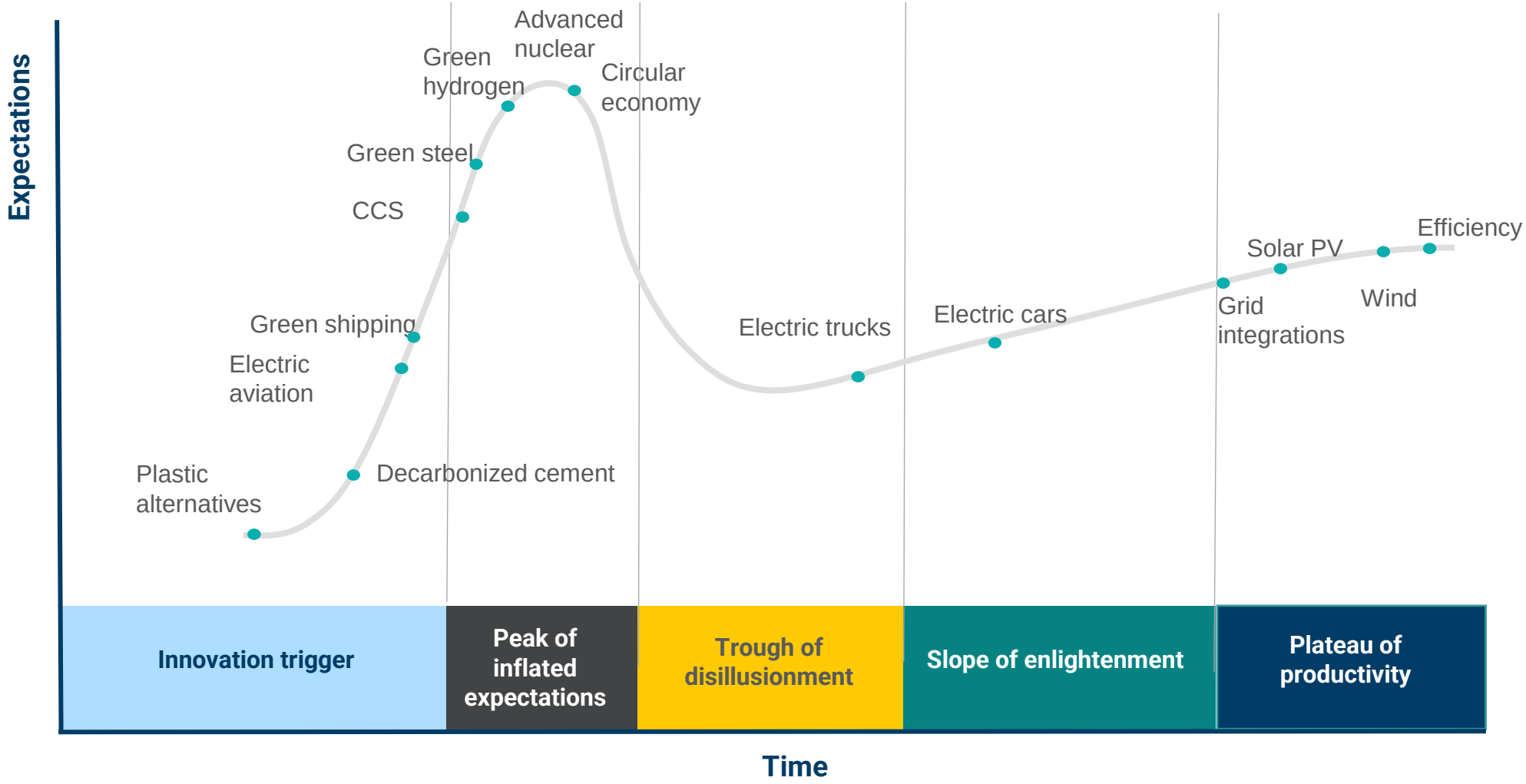
As with all technology revolutions, there will be winners and losers. Nobody said investing was easy.



Source: McKinsey

Investors Can Use the New Energy Technology Hype Cycle

The Gartner hype cycle applied to new energy technologies



Investors are very well versed in investing at times of rapid technology shifts.

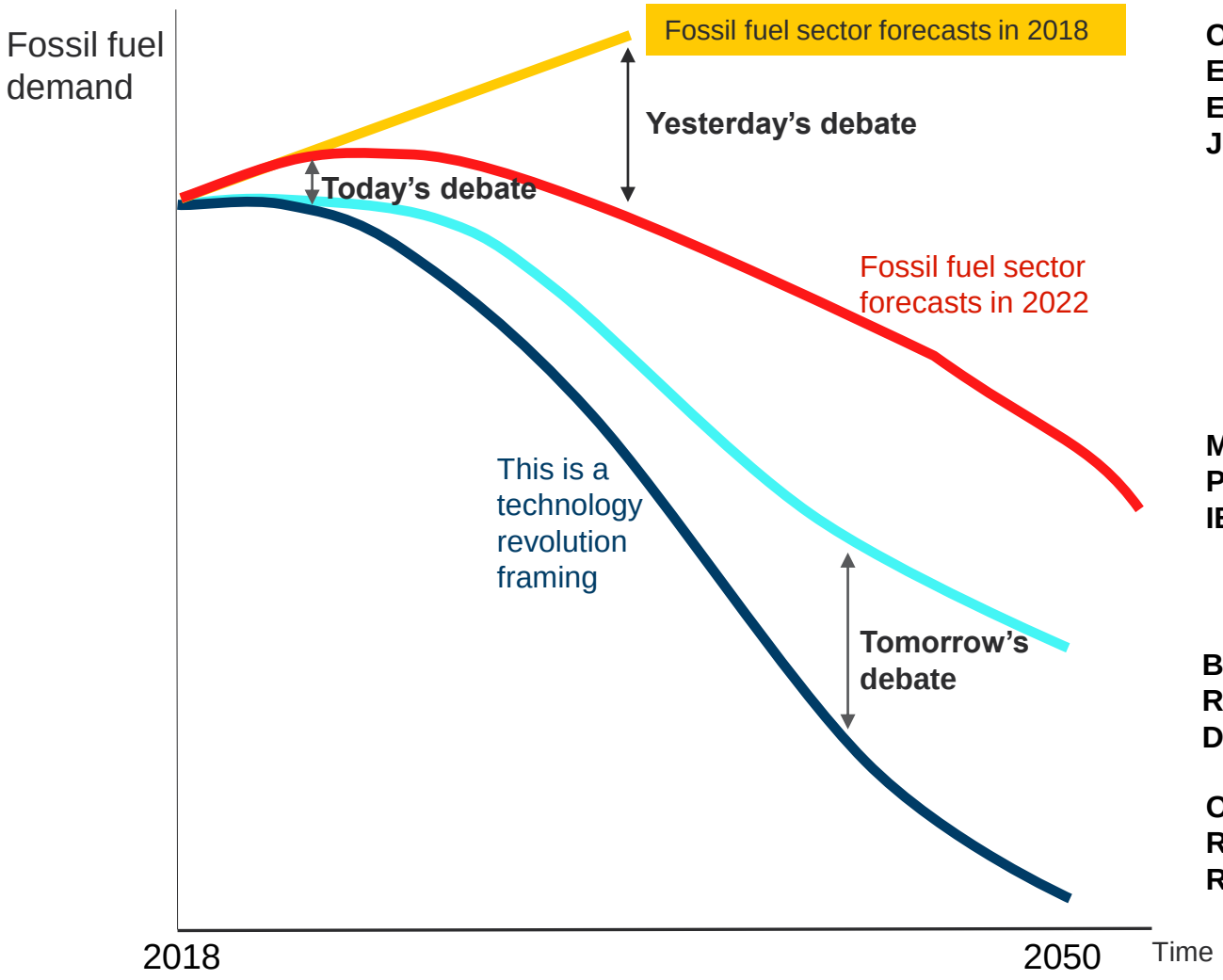
The Gartner hype cycle captures the dynamic.

Views will of course differ about the placing of each area, but that is the market.

Source: RMI using Gartner hype cycle

The Debate Has Moved a Long Way. Don't Be Behind the Curve

Fossil fuel demand concept chart



Who is where?	The group
OPEC EIA Exxon JP Morgan	Fossil fuel advocates
McKinsey Princeton Net Zero America IEA	Slow to change
BNEF Rystad DNV	Leaders
Oxford INET RMI RethinkX	Pushing the boundary

The debate on the energy system is changing fast.

Four years ago, thinking was dominated by fossil fuel incumbents.

Today the debate is between those late to the party (the IEA, Princeton) and leaders like Rystad.

As technology improves, tomorrow's debate will be between them and the visionaries.

Source: RMI

Implications for Financial Markets

1. The supply shock impact of Putin's war will eventually fade. When it does, the energy environment will be different.

2. Prepare for disruption and volatility.

3. Banks will face a climate Minsky moment when they all realize at the same time that they have too much fossil fuel exposure.

4. Reduce exposure to sectors at risk of disruption.

5. Invest in companies leading the change to a new energy system.

6. Go short greenwashers. They are the ones swimming with no trunks on as the tide goes out.

7. Lean on companies to change before it is too late.

8. Change is never easy, but good stock pickers will do well.

Leaders in Climate Will Reap the Rewards, While Laggards Are at Risk of Being Left Behind

	Government	Business	Finance
Leaders	• Govern with climate as a top priority • Create jobs of the future, lead the economies of the future, and enjoy geopolitical leadership	• Invest to decarbonize business • Gain market share, attract talent, and increase shareholder value	• Factor in climate risks in investing decisions • Decrease exposure to stranded asset risk, increase AUM
Laggards	• Minimize the impacts of climate risk in policy • Fall behind in global economy, lose geopolitical stature	• Invest in fossil fuels and infrastructure • Lose market share, lose talent, reduced free cash flow, and get decapitalized	• Invest in fossil fuels and infrastructure • Increase exposure to stranded asset risk, lose AUM

Glossary — In Simplified Terms and Tailored to the Energy Transition

LCOE
Levelized cost of electricity, a standard way to compare the generation cost of electricity.

EJ
An exajoule is a standard measurement of energy flows. For example, primary energy consumption in Hungary is 1 EJ.

Primary energy
The energy input into a system. The flow of coal, wind, or biomass. Global total in 2020: c. 600 EJ.

Final energy
The energy that reaches the machines, after losses on conversion into electricity or petrol. Global total in 2020: c. 420 EJ.

Useful energy
The energy that actually does useful work, after losses by the machines. Global total in 2020: c. 280 EJ, although estimates vary.

Energy carriers: The carrier of energy to the final user (for example: electricity, coal, or hydrogen).

Rents
Profits generated by selling fossil fuels at more than the full cost of extraction. They are $1 trillion to $2 trillion a year.

Learning rate
The percentage fall in the price of a technology for each doubling in deployment (around 25% for solar now).

Minsky moment
The moment when banks realize their fossil fuel exposure is too high and all try to sell at once.

Reflexivity
The process whereby financial markets influence activity in the real world.

Positive feedback loop
The process where self-reinforcing change happens. More begets more.

Stock
The total number of units deployed. e.g., the car fleet of 1,000 million vehicles.

Flow
Annual sales. e.g., car sales of 80 million p.a.

EROI
Energy return on energy invested — the equation at the heart of the energy transition. Renewables now beat fossils.

Energy intensity
The gap between GDP growth and primary energy demand growth.

Units
Mega is 10^6; Giga is 10^9; Tera is 10^12; Peta is 10^15; Exa is 10^18.

Joule
Roughly the amount of energy needed to lift an apple to your mouth.


Q&A
Ideas, comments, and critiques are much appreciated.