



Inside the Race to the Top

The race for cleantech among
Chinese provinces, US states,
and European countries

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Executive Summary

Cleantech has unleashed a global revolution, driven from the bottom up. Three major blocs — Europe, the United States, and China — are in a race to the top on cleantech. Yet, the real frontier of change lies within — at the country, state, and province level *inside* each bloc. The cleantech wave is coming, driven by market forces. Whether regions ride it to success or get dragged along depends on their choices.

The world is embracing cleantech. From Iowa to California, Qinghai to Zhejiang, and Norway to Greece, new cleantech leaders are rising fast.

A cornucopia of opportunity. We looked at the energy transition inside Chinese provinces, European countries, and US states: more than 110 territories in 13 regions. The largest, such as Shanxi, Texas, and Shandong, have more energy demand than Brazil or Indonesia.

There is a clear S-curve pattern in deployment. Solar and wind take 10 years to get to 5% deployment, 10 more years to get to 25%, and then 10 years to reach 50%. Electric vehicles take 6 years to get to 5% of sales and 6 more years to reach 50%.

The ceiling of the possible is far above our heads. In Northern Europe, EVs are 54% of total sales; Denmark and Iowa have solar and wind penetration of over 60%; electrification in Zhejiang and Guangdong is at 50%.

Catching up with the local leader will triple deployment. Solar and wind generation would increase by 3.5x, EV penetration by 3x, and electrification by 2x.

It's not about wealth or politics. GDP is not the key determinant of cleantech penetration, and, in the United States, four of the top six states for the deployment of solar and wind are Republican states.

Leadership from opportunity and policy. Leaders come from places with huge renewable resources (South Dakota or Qinghai) or powerful policy direction (Germany or Zhejiang).

The electricity price is key. Countries that fail to reduce their electricity price struggle to electrify. Those that succeed get over half their energy from electricity.

Europe and the United States are failing to electrify. While Chinese provinces lead and are changing fast, electrification is the key area where Europe and the United States have fallen behind, with very little change in the past decade.

Most places import fossil fuel. Of the 110-plus territories, 85% import fossil fuels and could increase their energy security by embracing cleantech.

The deployment leaders. Northern Europe (Norway, Sweden) vies with Eastern China (Zhejiang, Jiangsu) in the deployment race, and the West (California, Colorado) leads the United States.

East and Central China dominate manufacturing. They host over 80% of solar and battery manufacturing capacity.

The United States has the greatest opportunity to deploy renewables. The United States has 43 times as much renewable potential as demand. New Mexico, South Dakota, and Kansas have solar and wind potential over 400 times their energy demand.

Local benefits mean local impetus for change. Territories that move fast unlock local economic growth and jobs, lower bills for consumers, better energy security, and improved public health. These strong local benefits provide ample incentive for bottom-up action.

The regional winners will put themselves on the map. This is a technology revolution — early movers will gain a virtuous circle of market power, lower prices, and rising economic activity, which will sustain wealth for generations to come. Laggards risk obscurity and decline.

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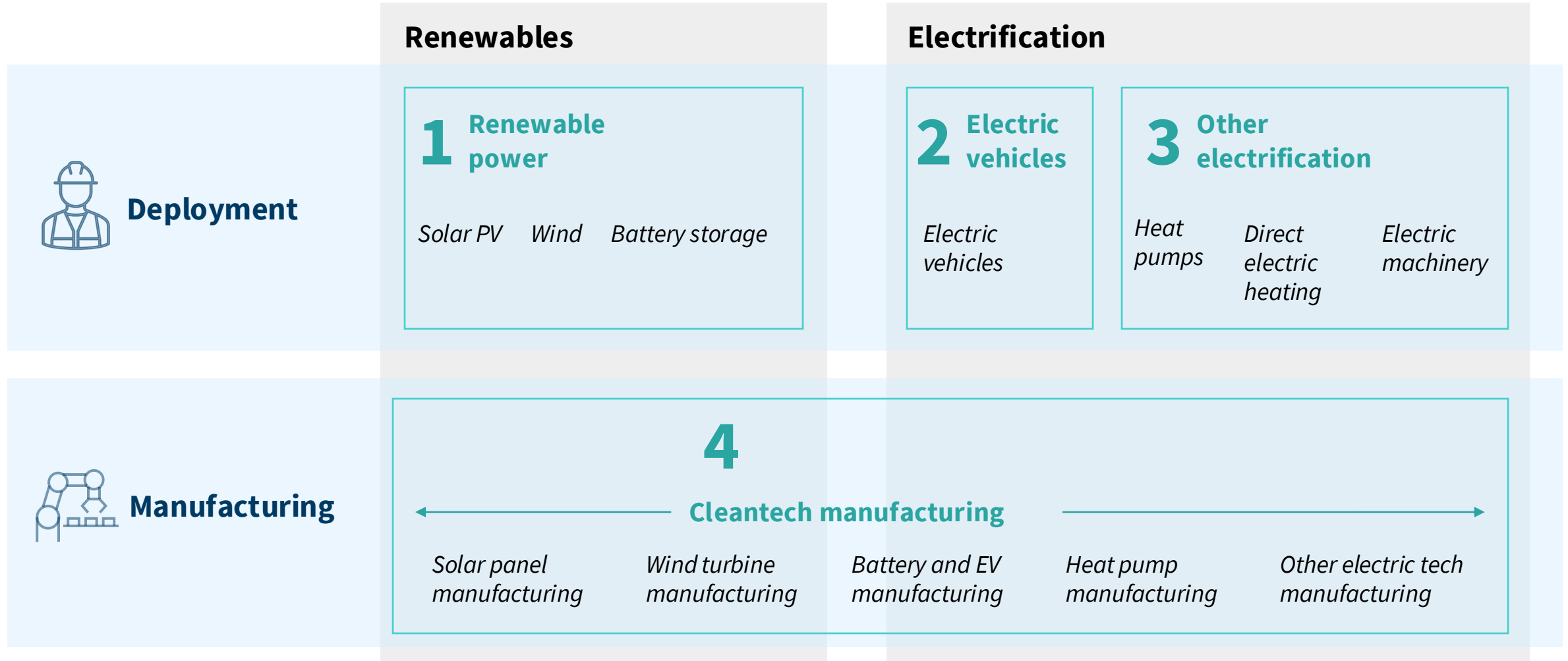


The energy transition is playing out across four key races: deploying solar and wind; EVs; other electrification tech; and manufacturing.

- **Three blocs.** Europe, China, and the United States vie for leadership and make up 80%–90% of all cleantech deployment and manufacturing.
- **Thirteen regions.** We split each of the blocs into regions: four in Europe, four in the United States, and five in China.
- **Over 110 territories.** Within each region sit US states, European countries, and Chinese provinces — over 110 territories in total.
- **Some territories are huge.** Shanxi and Texas, for example, each have energy demand of 14 EJ, which is more than the whole of Brazil (13 EJ) or Indonesia (11 EJ).
- **Cleantech uptake varies widely.** The share of solar and wind in electricity ranges from 0.5% (Kentucky) to 68% (Luxembourg). EVs as a share of sales range from 1% (North Dakota) to 93% (Norway). Electrification ranges from 3% (Alaska) to 51% (Zhejiang).
- **Past wealth does not determine leadership.** Cleantech is rising in both low- and high-GDP-per-capita territories. Some less wealthy territories are leapfrogging more wealthy ones in the deployment of clean technology.
- **S-curves are the signal in the noise.** Both wind and solar and EV uptake across territories are growing along a remarkably uniform S-curve
- **Trailblazers raise the ceiling of the possible.** A few frontrunners clear the major deployment challenges so the rest can follow rapidly.
- **The pack follows the leader.** The majority of cleantech growth in the coming decade can come from the pack copying the leader. Catching up to the local leader means 3x–4x solar and wind generation, 2x–4x EV sales, and 1.6x–2.3x electricity demand across blocs.
- **Local advantages mean local impetus for change.** Cleantech brings growth, jobs, energy affordability, energy security, and better public health — all local benefits.

Cleantech competition is playing out in four major races

Deploying renewables, EVs, and other electrification, as well as who gets to manufacture the tech

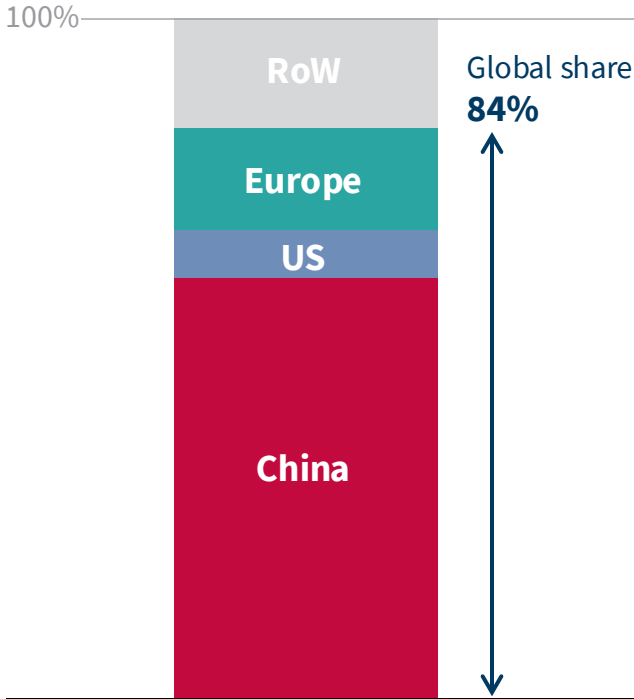


And is led by three economic blocs

China, Europe, and the United States represent about 90% of cleantech sales and manufacturing

1 Renewable power

Solar and wind installations, 2023



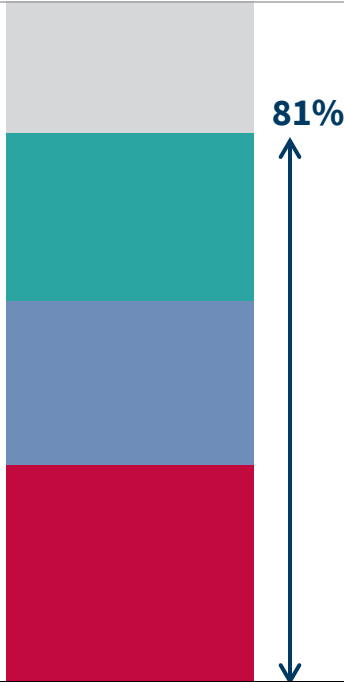
2 Electric vehicles

Electric vehicle sales, 2023



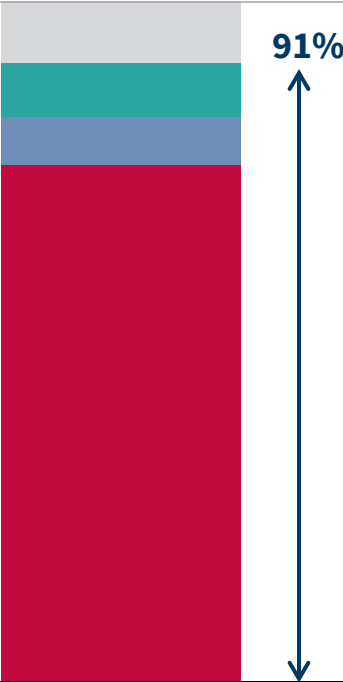
3 Other electrification

Heat pump installations, 2023



4 Cleantech manufacturing

Battery manufacturing, 2022

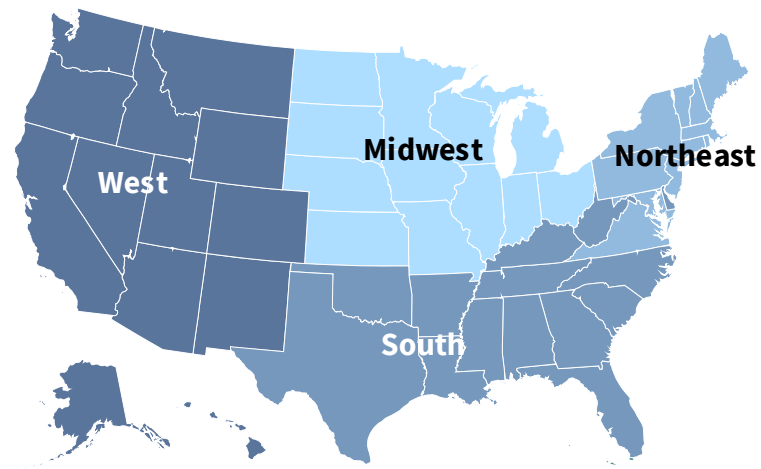


Note: Heat pump installations and battery manufacturing are EU-27 figures.
Source: IEA, RMI

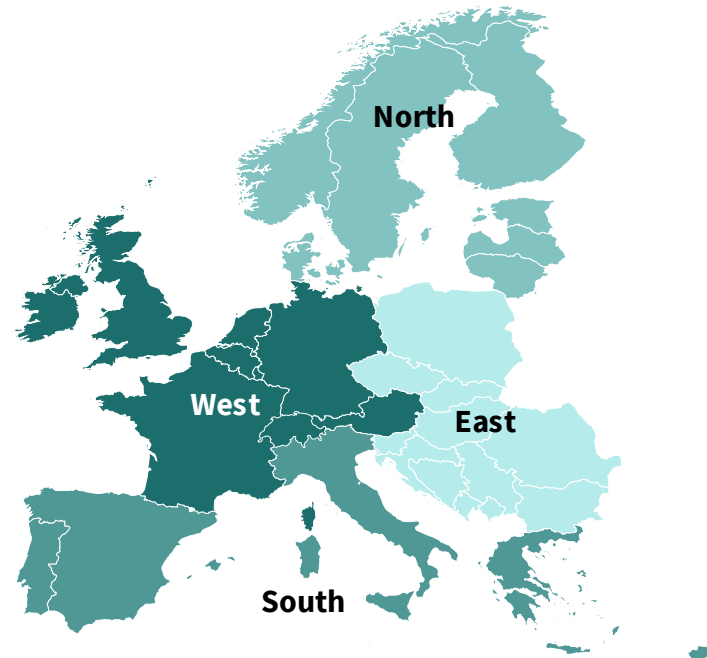
Which comprise 13 regions and over 110 territories

The territories are split across four US regions, four regions in Europe, and five regions in China

United States



Europe



China



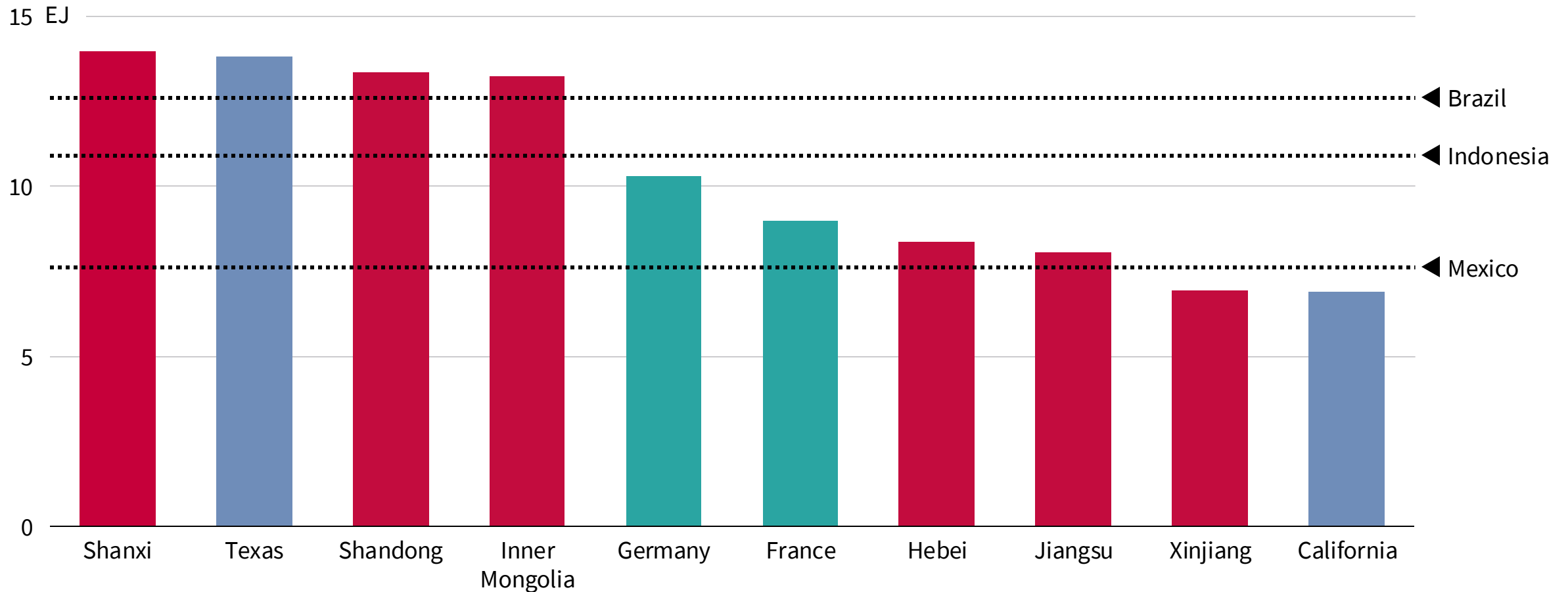
Note: These maps are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city, or area. Data availability varies — some races lack data in certain territories (e.g. the National Bureau of Statistics of China provides no data for Taiwan). Data from countries on the European periphery (e.g., Turkey) are included for some races where data is available.

Source: Eurovoc; US Census Bureau; National Bureau of Statistics of China; Wikipedia; RMI simplification in order to have comparable numbers of regions

Some of these territories are huge

Leading territories are larger than Brazil or Indonesia

Energy demand in the top 10 territories in China, Europe, and the United States

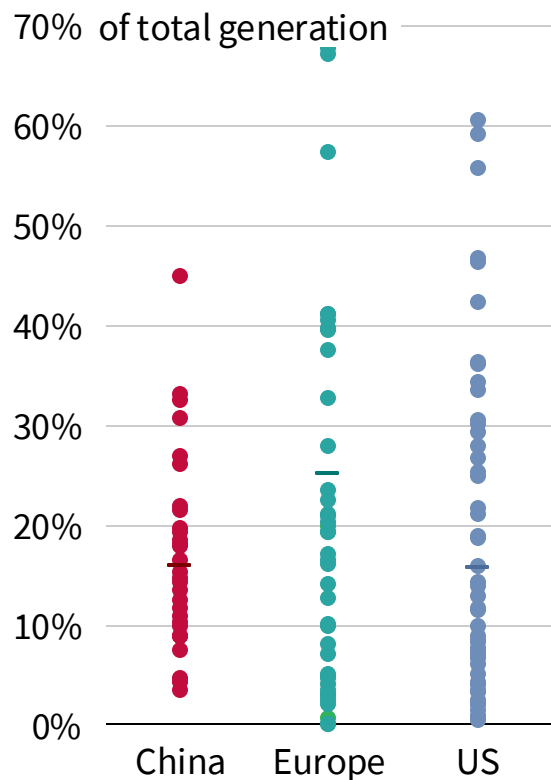


Uptake within each bloc is far from uniform

There are leaders and laggards across all four races within China, the United States, and Europe

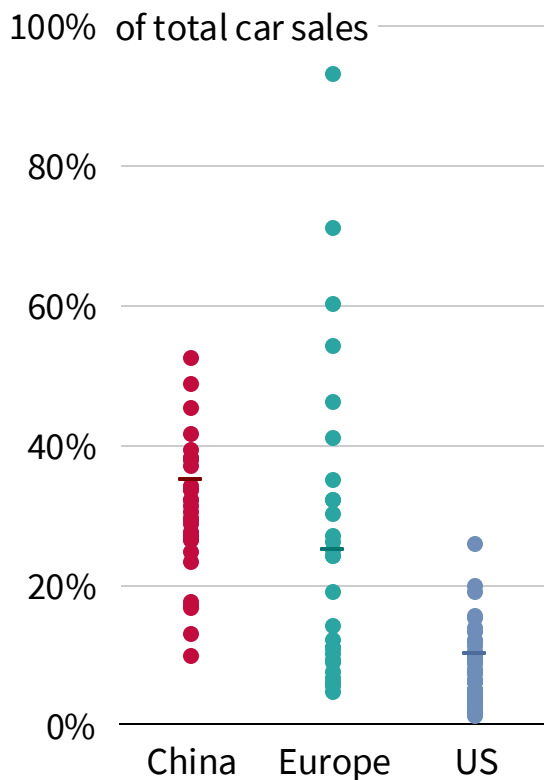
1 Renewable power

Solar and wind generation, 2023



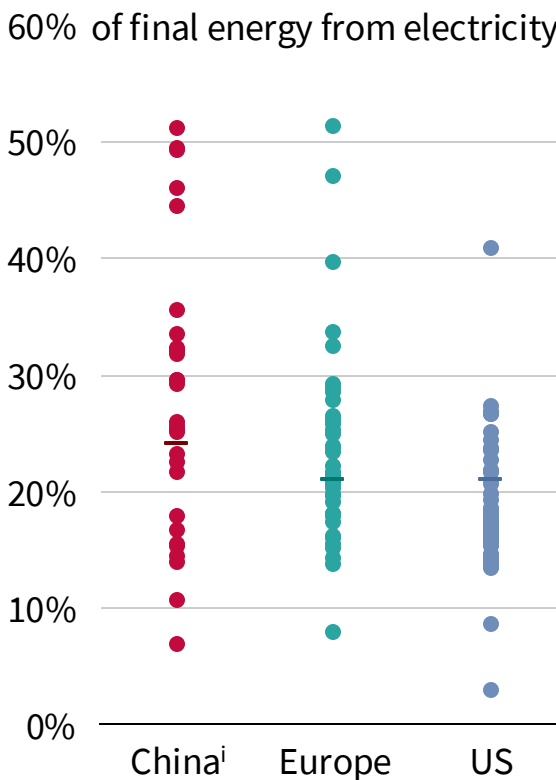
2 Electric vehicles

Electric vehicle sales, 2023



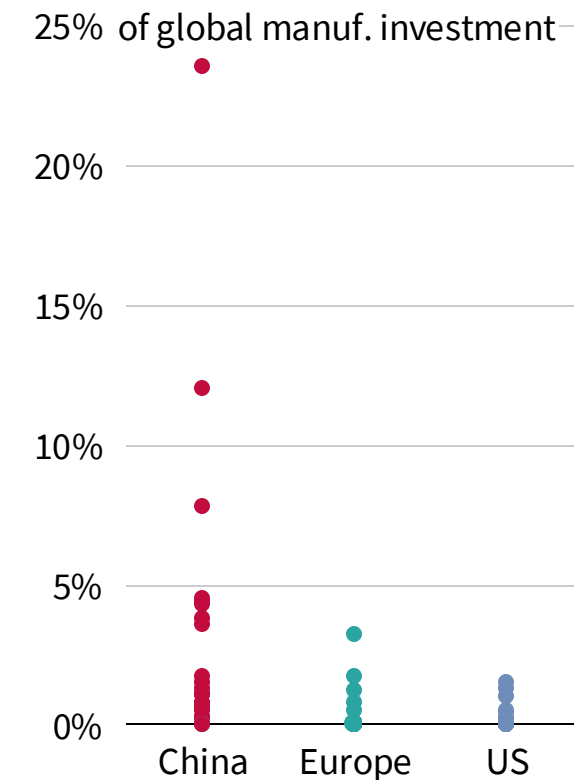
3 Other electrification

Electrification, 2022/latest



4 Cleantech manufacturing

Cleantech manufacturingⁱⁱ, 2024



ⁱ. Data from 2019, based on RMI analysis

ⁱⁱ. Proxied by the two largest factory investment segments, solar and batteries, shown as a share of total global investment in these two sectors

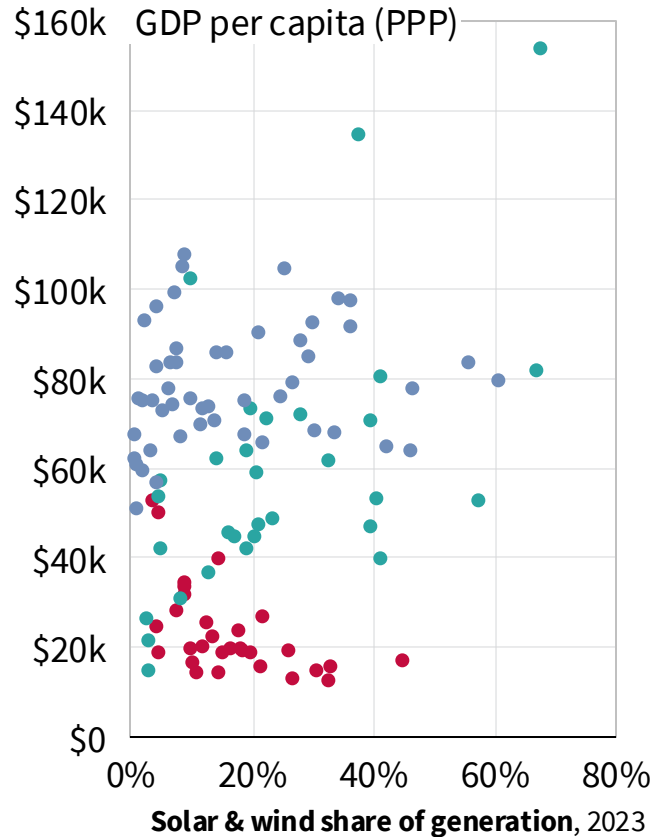
Source: IEA; EIA; 2013–2023 National Electricity Industry Statistics Bulletin; China Electricity Council; National Bureau of Statistics of China; RMI analysis

— Average ● Province/Country/State

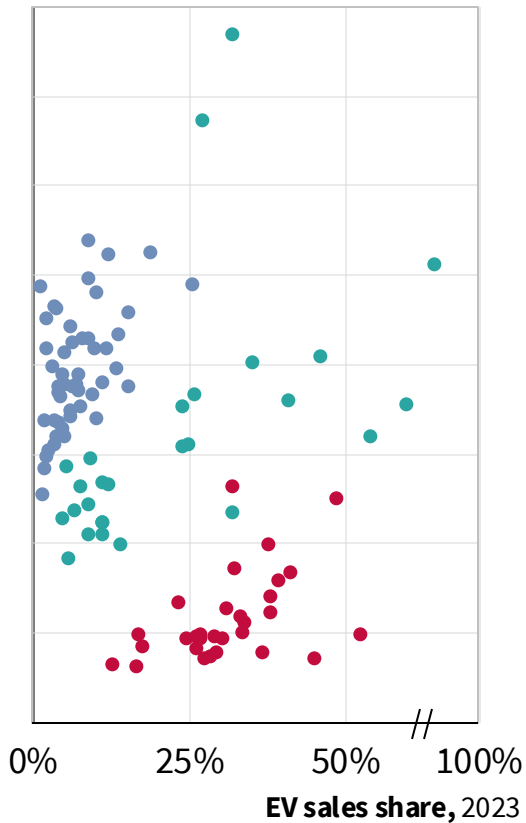
Past wealth does not determine future competitiveness

Both richer and developing territories lead the transition

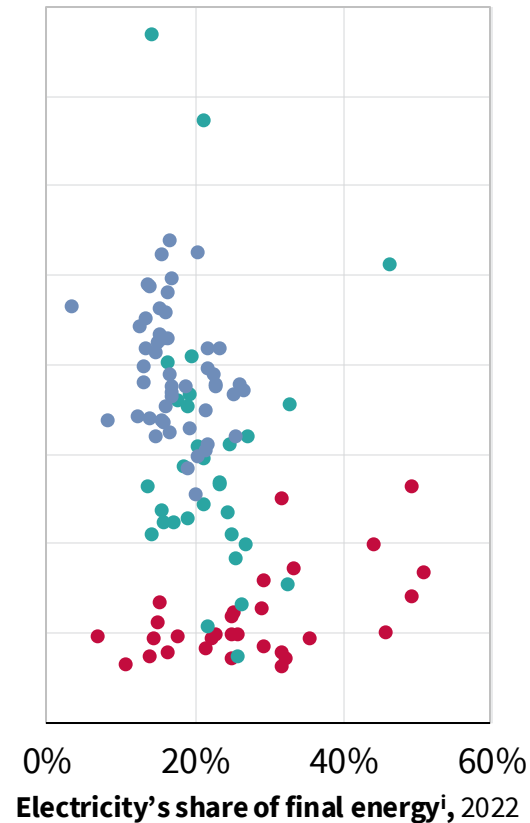
1 Renewable power



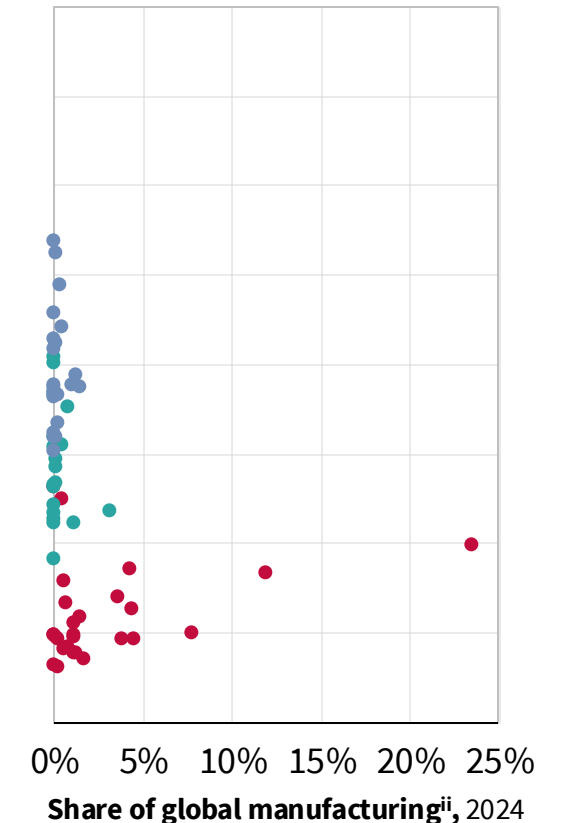
2 Electric vehicles



3 Other electrification



4 Cleantech manufacturing



● Chinese province ● European country ● US state

i. China data from 2019, based on RMI analysis

ii. Proxied by the two largest factory investment segments, solar and batteries, shown as a share of total global investment in these two sectors

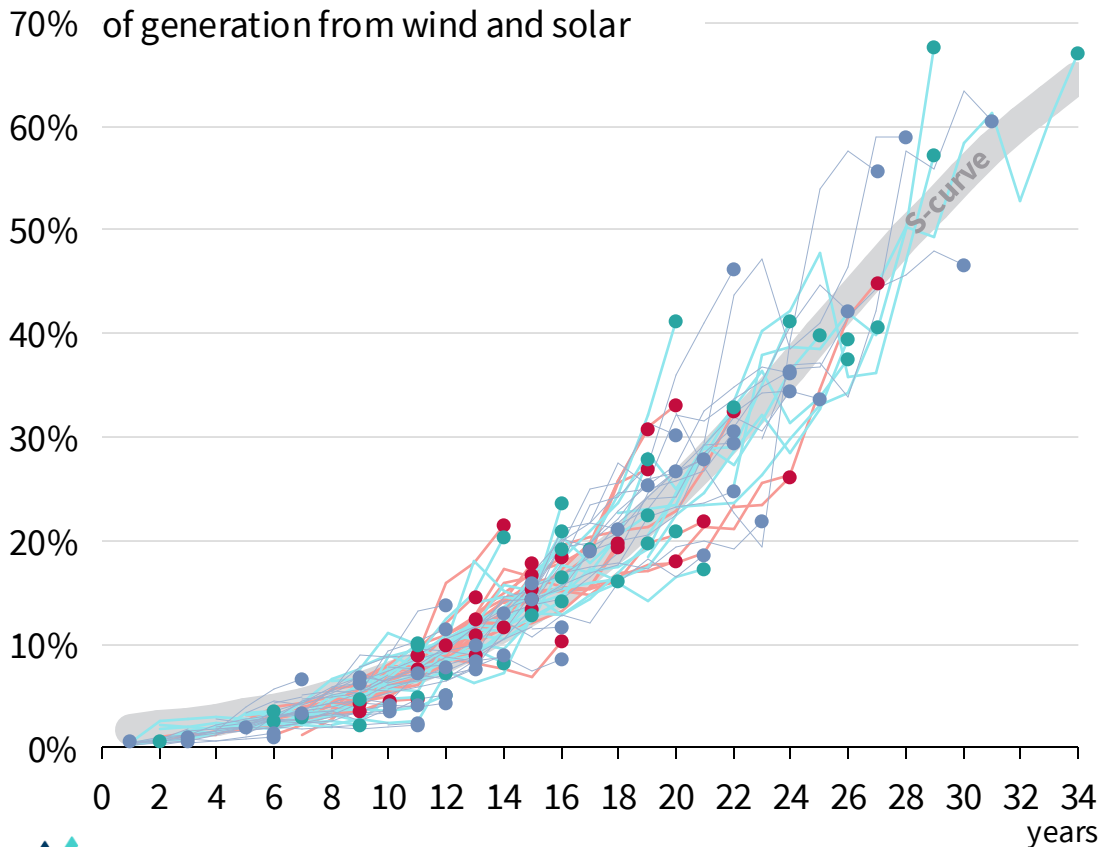
Source: IEA; EIA; 2013–2023 National Electricity Industry Statistics Bulletin; China Electricity Council; National Bureau of Statistics of China; IMF, US BEA; Wang et al. (2024); AutosInnovate; Bloomberg NEF; RMI analysis

S-curves are the signal in the noise

Solar and wind and EV uptake are growing along uniform S-curves

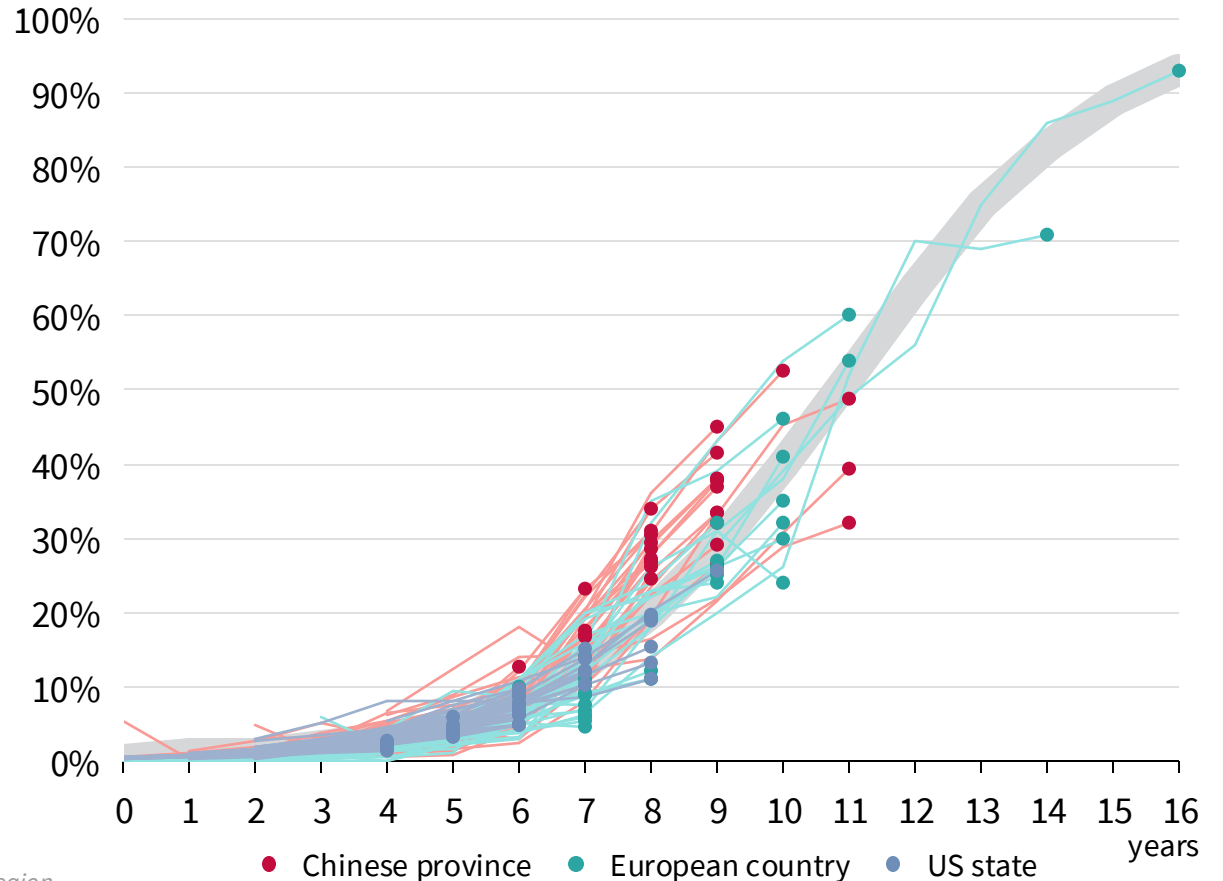
1 Renewable power

Share of electricity from wind and solar along an S-curve



2 Electric vehicles

Share of car sales from EVs along an S-curve



Note: Uptake data offset for best fit on a single S-curve — year 1 means a different year for each region.

Source: IEA; EIA; 2013–2023 National Electricity Industry Statistics Bulletin; China Electricity Council; National Bureau of Statistics of China; Wang et al. (2024); AutosInnovate; Bloomberg NEF; RMI analysis

Trailblazers raise the ceiling of the possible

A few front-runners clear the major deployment challenges so the rest can follow rapidly

1 Renewable power

Solar and wind generation, % generation, 2023

2 Electric vehicles

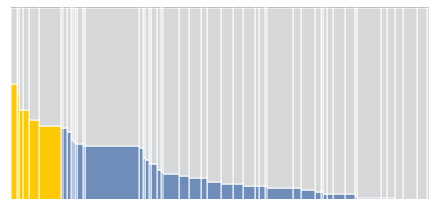
Electric vehicle sales, % sales, 2023

3 Electrificationⁱ

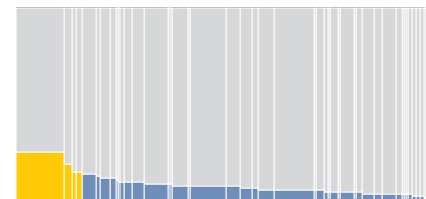
Electrification, % final energy, 2022/latest

US

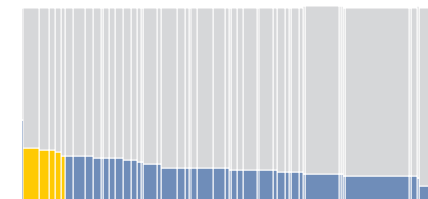
1. Iowa
2. South Dakota
3. New Mexico
4. Kansas
5. California



1. California
2. D.C.
3. Washington
4. Oregon
5. Colorado

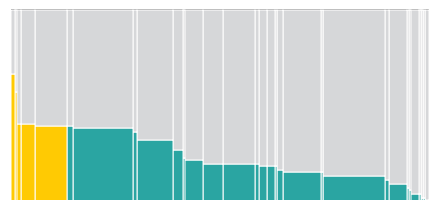


1. Florida
2. North Carolina
3. South Carolina
4. Arizona
5. Oregon

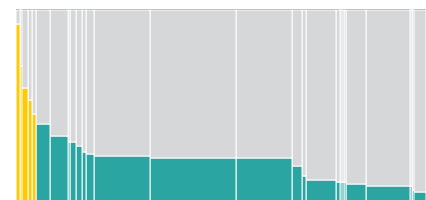


Europe

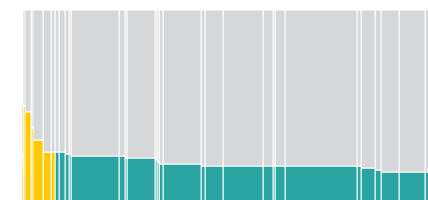
1. Denmark
2. Lithuania
3. Greece
4. Netherlands
5. Spain



1. Norway
2. Iceland
3. Sweden
4. Finland
5. Denmark

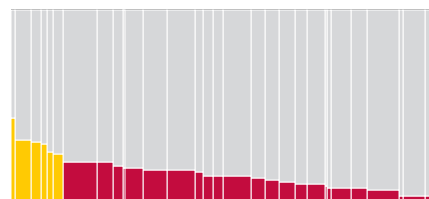


1. Iceland
2. Norway
3. Sweden
4. Finland
5. Greece

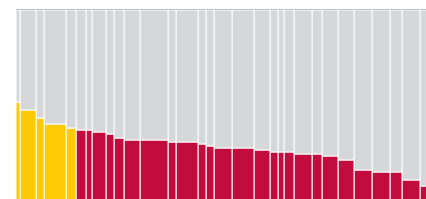


China

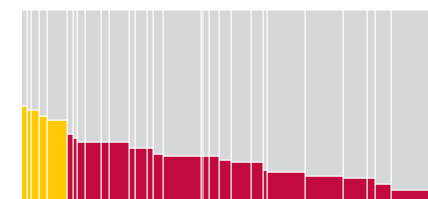
1. Qinghai
2. Hebei
3. Gansu
4. Jilin
5. Heilongjiang



1. Hainan
2. Shanghai
3. Guangxi
4. Zhejiang
5. Tianjin



1. Zhejiang
2. Beijing
3. Guangdong
4. Anhui
5. Jiangsu



share of total generation

share of total car sales

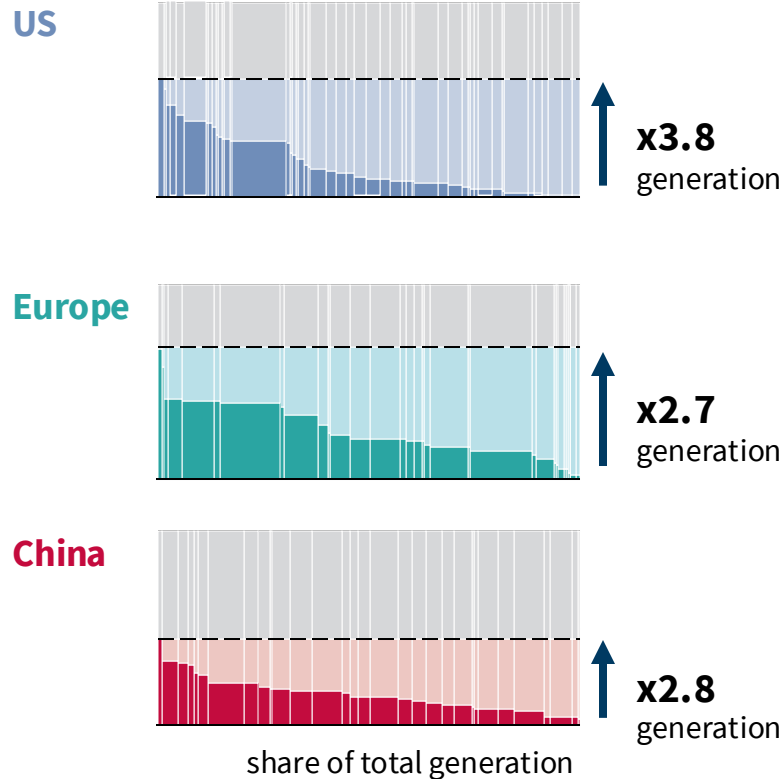
share of total final energy

The pack can follow the leader

Catching up to the local leader means 3x–4x solar & wind, 2x–4x EV sales, and 1.6x–2.3x electricity demand

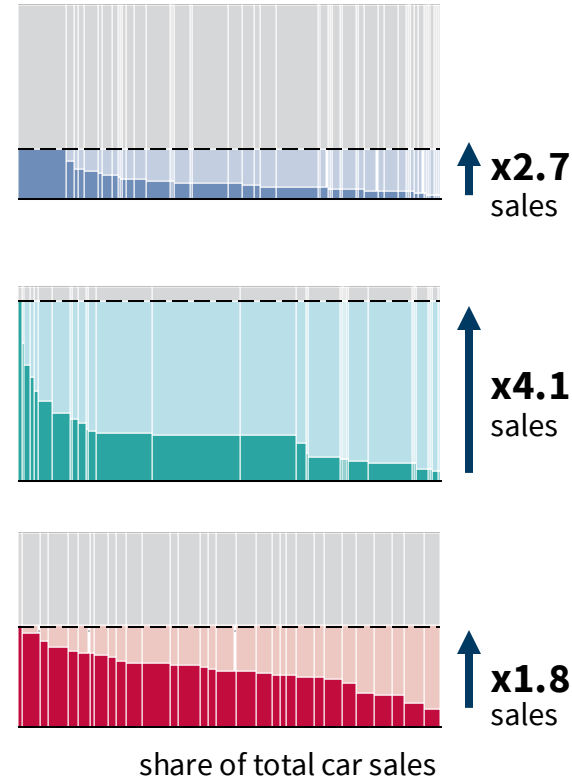
1 Renewable power

Solar and wind generation, % generation, 2023



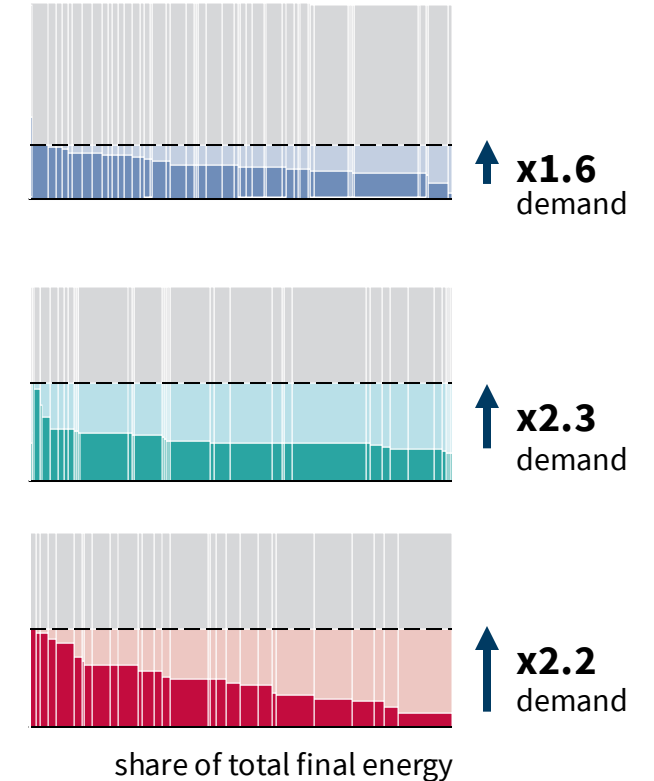
2 Electric vehicles

Electric vehicle sales, % sales, 2023



3 Electrification

Electrification, % final energy, 2022/latest



Note: Leadership on electrification today is determined as much by economic and industrial composition as by actual electrification efforts.

Source: IEA; EIA; 2013–2023 National Electricity Industry Statistics Bulletin; China Electricity Council; National Bureau of Statistics of China; Wang et al. (2024); AutosInnovate; Bloomberg NEF; RMI analysis

Local benefits mean local impetus for change

Cleantech brings ...



Economic growth and competitiveness



Affordability

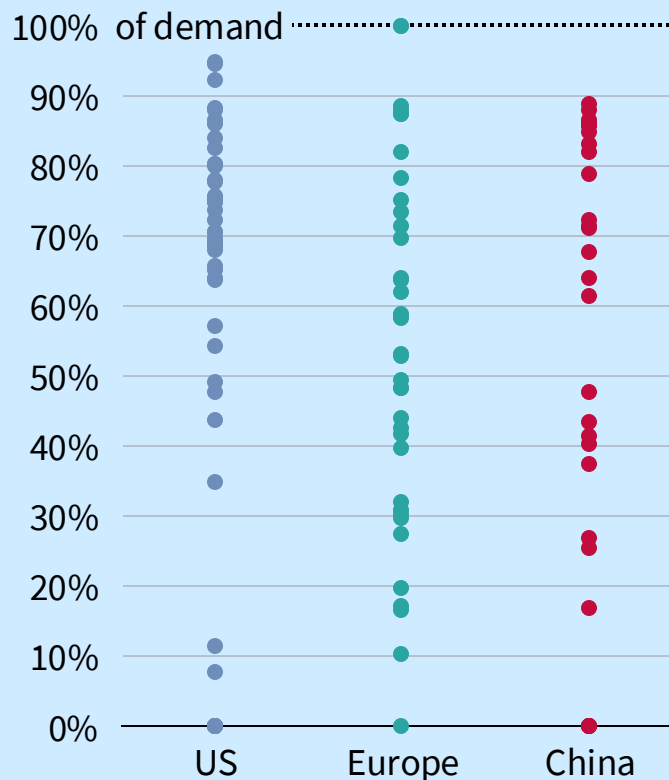


Energy security



Improved public health

Share of energy demand from imported fossil fuels today



vs

Local renewables available as multiple of energy demand



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2 The Renewables Race



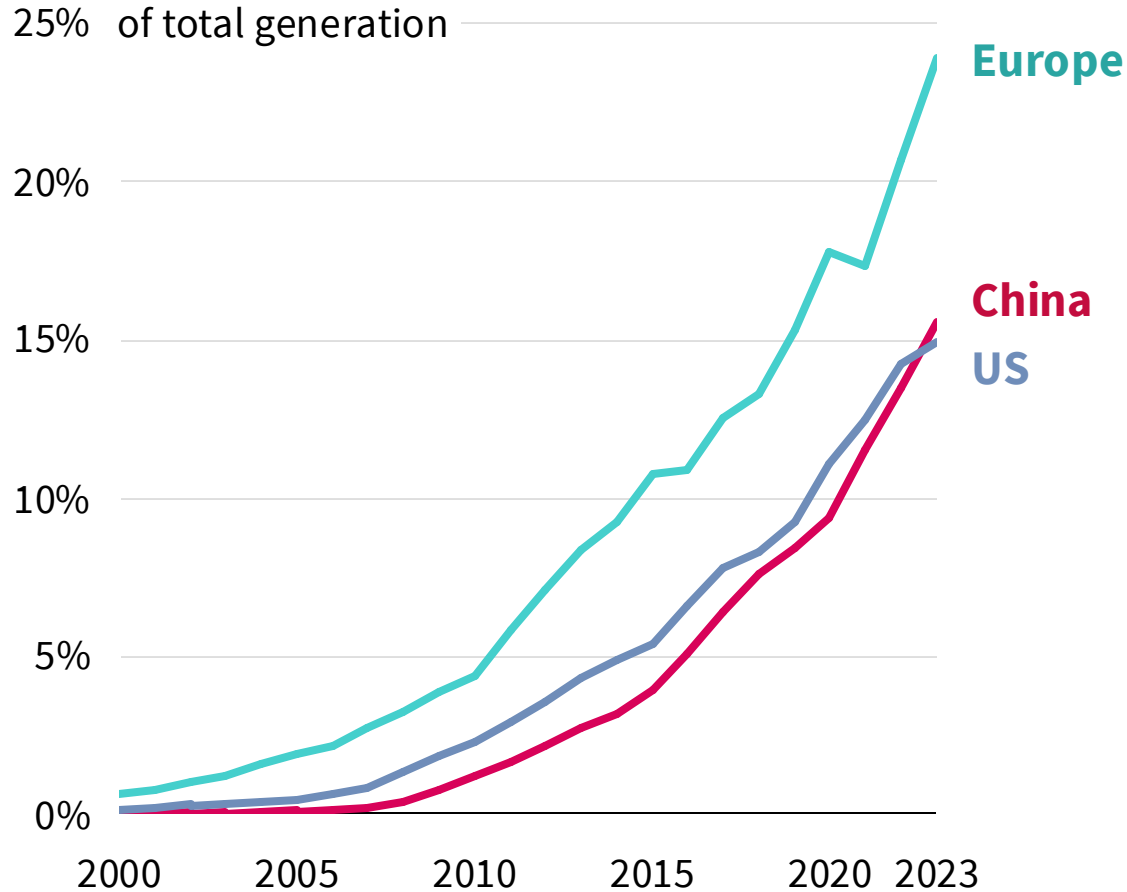
Solar and wind power are growing across the world. Europe is in the lead, followed closely by China and the United States.

- **The winner is ...** The leading region is Southern Europe with 32% solar and wind penetration in 2023. The leading territories are Demark with 67% penetration and Iowa with 61%.
- **The China story.** The leading regions are the North and Northwest at 23%, while the Southwest (rich in hydro) is at 8%. The leading province is Qinghai at 45% penetration, then Hebei at 33% and Gansu at 32%.
- **The Europe story.** The leading region is the South at 32%, and the laggard is the East at 16%. Top countries are Denmark (67%), Lithuania (57%), and Greece (41%).
- **The US story.** The leading region is the West at 24%, while the Northeast is at 7%. The leading states are Iowa at 61% and South Dakota at 56%, while Kentucky is at just 0.5%.
- **Determinants of leadership.** Neither wealth nor politics nor fossil export status are clear determinants of leadership. Rather it has been a question of political will and per capita renewable resources.
- **The ceiling of the possible is higher than you may think.** The leaders are approaching 70% of generation from solar and wind, and a quarter of countries are already over 30%.
- **Some surprising leaders.** In the United States there is little political divide on renewable deployment: four of the top six states are Republican strongholds. In China, leaders are from the inland provinces, such as Qinghai. In Europe, southern countries such as Spain and Greece are rivaling the Nordics.
- **There is an S-curve pattern in the deployment of solar and wind.** One can see a clear, surprisingly uniform S-curve pattern across all 110-plus territories. It takes 10 years to get to 5% solar and wind market share, 10 more years to get to 25%, and around 10 more years to get to 50%.
- **Where are we heading.** Following this S-curve means all three blocs will reach over 50% of power generation from solar and wind by 2035.
- **What that takes.** The vast majority of this growth can be realized simply by the pack copying the leader. If every territory catches up with the local leaders, solar and wind generation will increase by a factor of three to four.

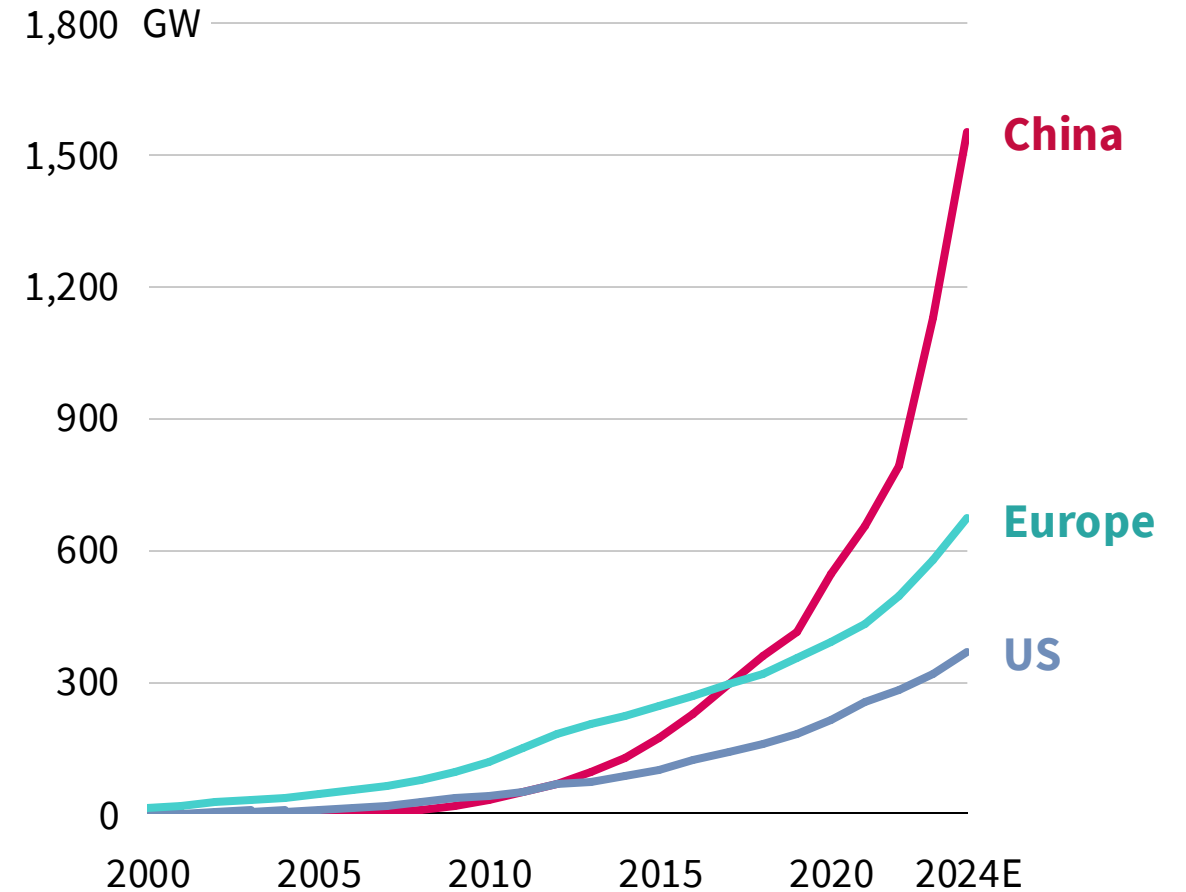
The renewables race by bloc

Europe leads by share of generation; China leads by absolute installed capacity

Solar and wind generation



Solar and wind capacity

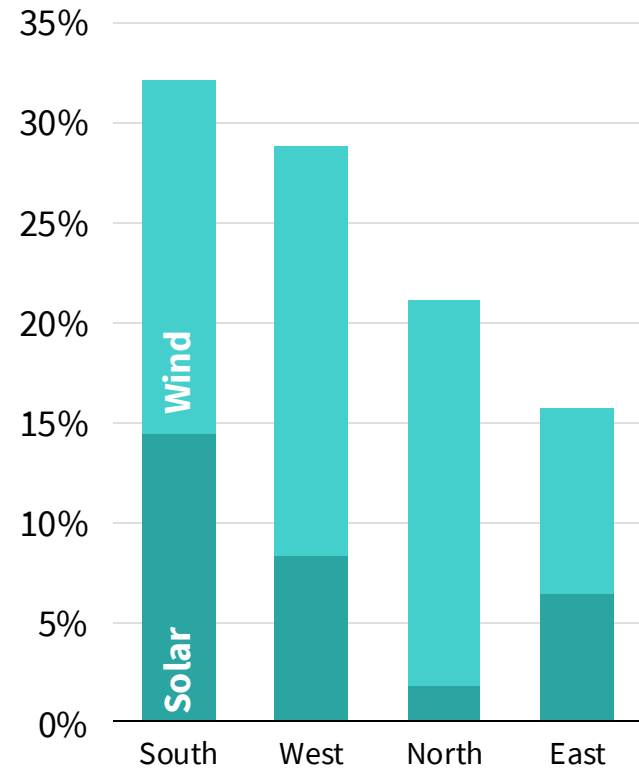


The renewables race by region

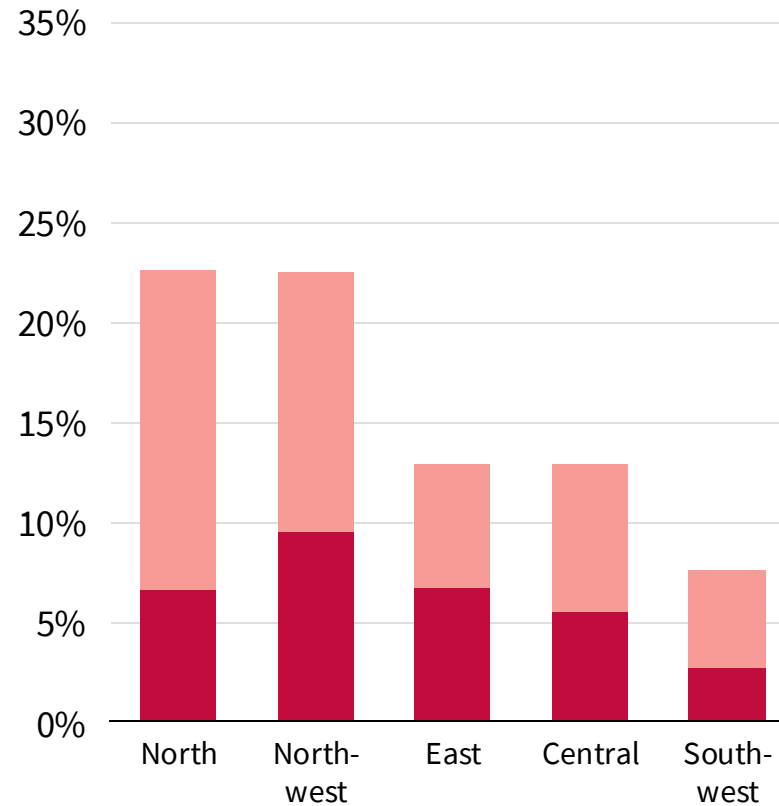
Southern and Western Europe lead, followed by Northern China and the US West

Solar and wind as a share of electricity generation, 2023

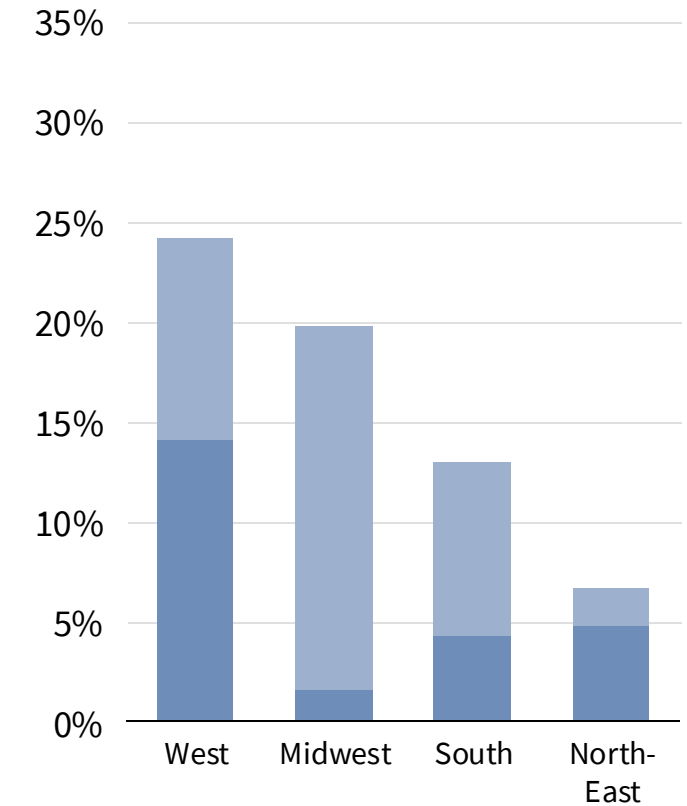
Europe



China



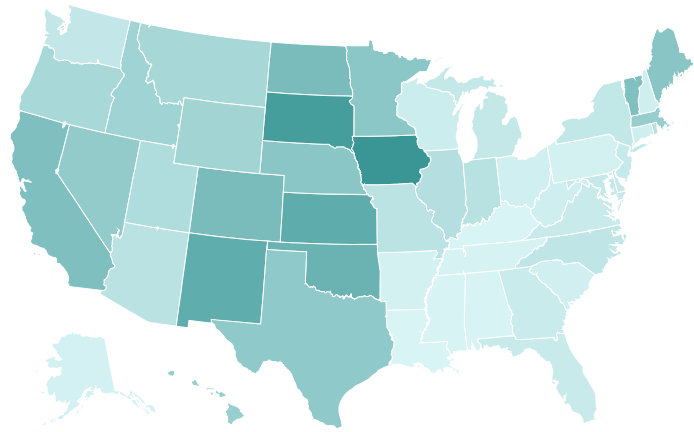
United States



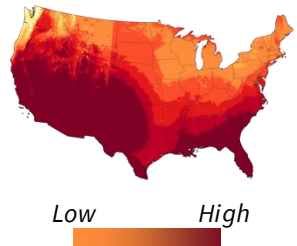
The renewables race by territory

Territories with ample wind and solar have been able to take the lead

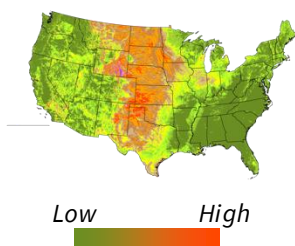
United States



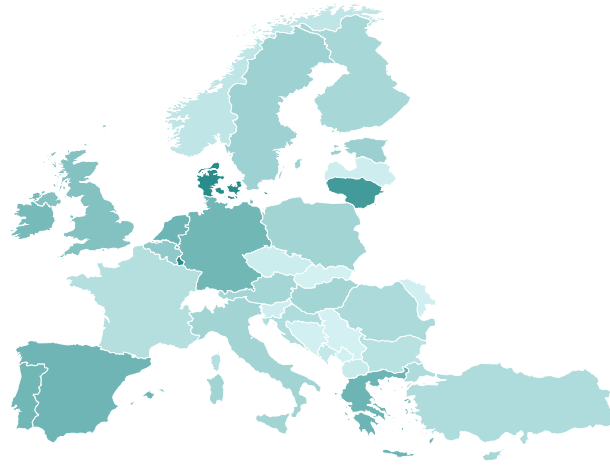
Solar irradiance map



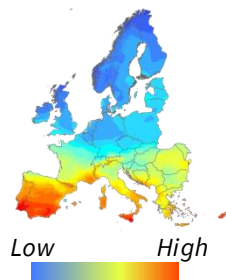
Wind speed map



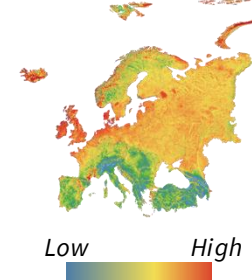
Europe



Solar irradiance map

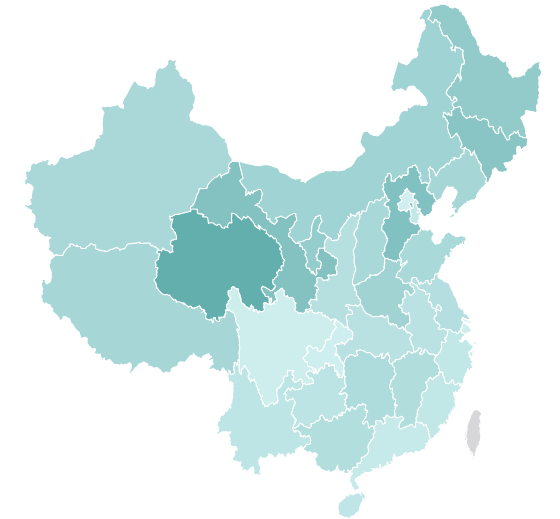


Wind speed map

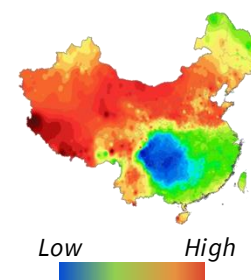


China

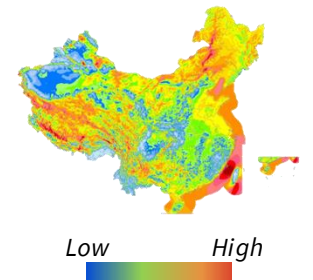
Solar and wind penetration 0% 70%



Solar irradiance map



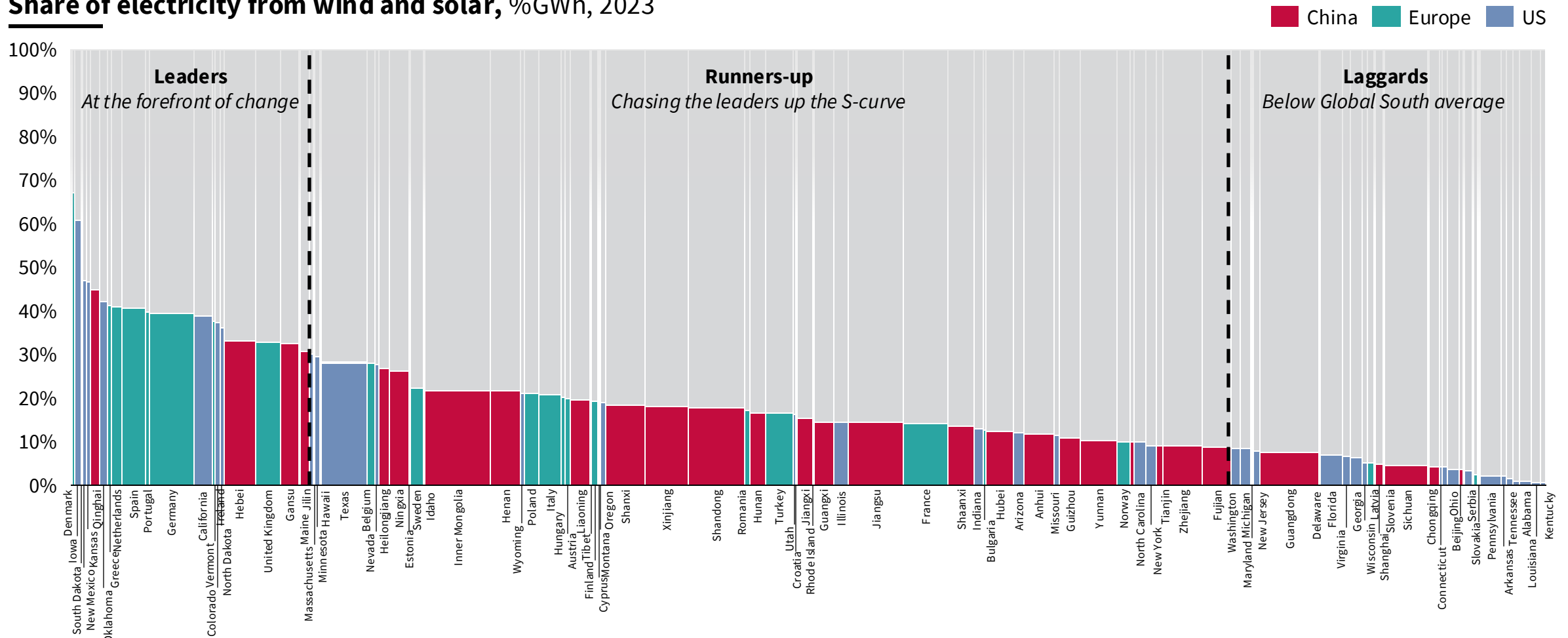
Wind speed map



Renewable leaders and laggards

A fifth of territories are lifting the ceiling of the possible, and a fifth are still behind the Global South average

Share of electricity from wind and solar, %GWh, 2023



Territory generation as share of total, %GWh, 2023

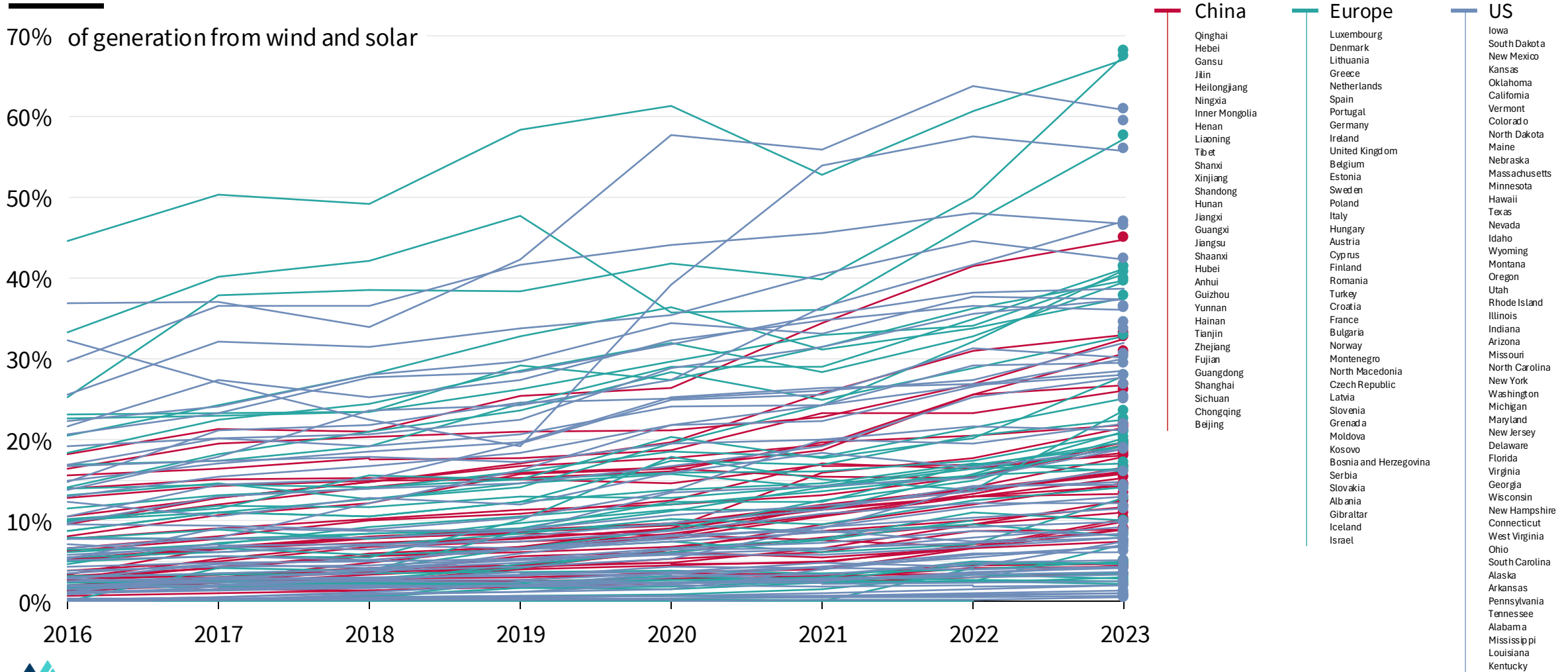


Renewables are growing everywhere

But it is hard to see a trend in the noise

Share of electricity from wind and solar

70% of generation from wind and solar



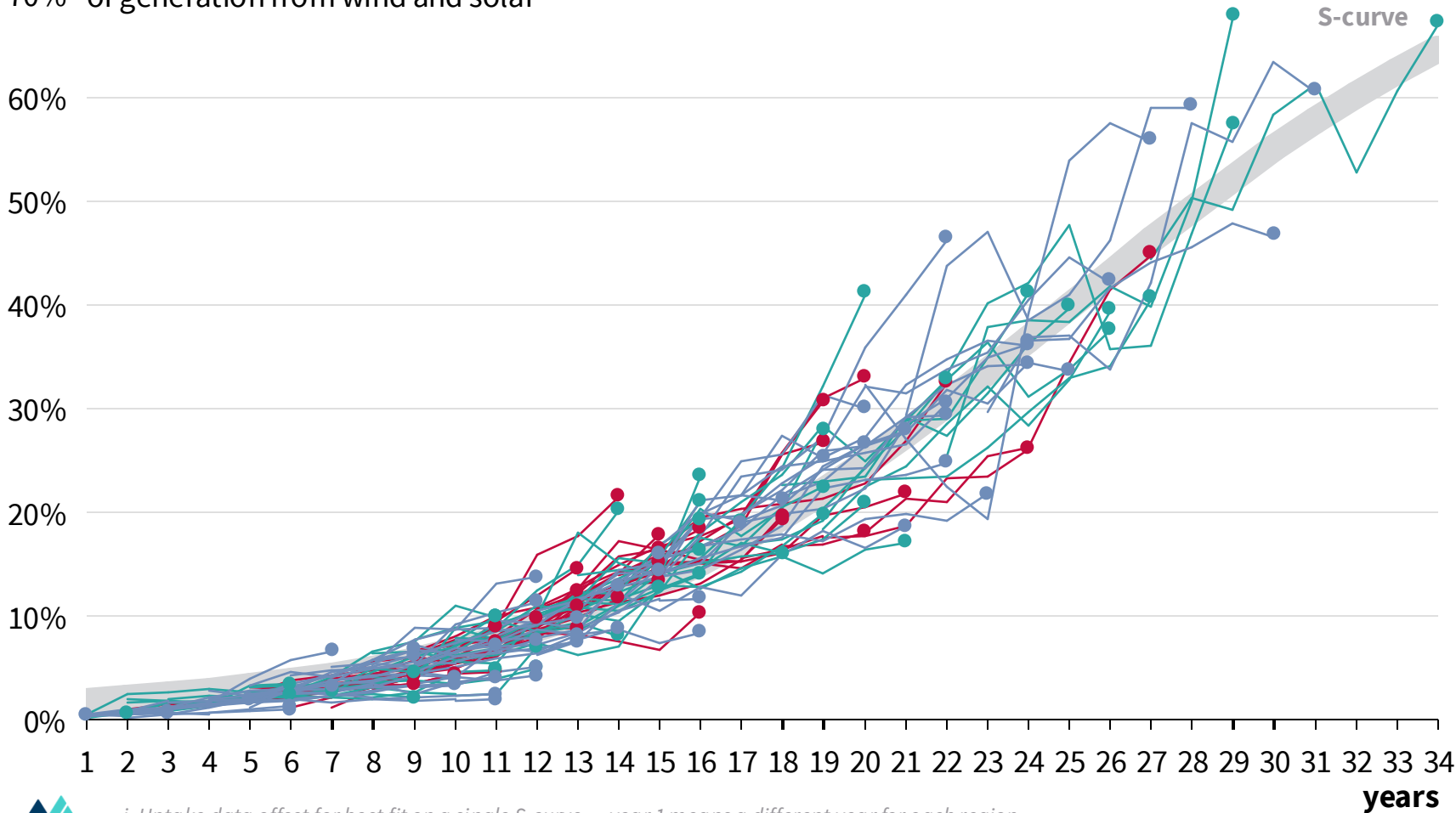
Source: 2013–2023 National Electricity Industry Statistics Bulletin; China Electricity Council; National Bureau of Statistics of China; IEA; ENSTO-E; EIA

S-curves are the signal in the noise

From Texas to Finland, Italy to Beijing, all subregions follow a very similar S-curve uptake

Share of electricity from wind and solar, offsetⁱ

70% of generation from wind and solar



- China**
 - Qinghai
 - Hebei
 - Gansu
 - Jilin
 - Heilongjiang
 - Ningxia
 - Inner Mongolia
 - Henan
 - Liaoning
 - Tibet
 - Shanxi
 - Xinjiang
 - Shandong
 - Hunan
 - Jiangxi
 - Guangxi
 - Jiangsu
 - Shaanxi
 - Hubei
 - Anhui
 - Guizhou
 - Yunnan
 - Hainan
 - Tianjin
 - Zhejiang
 - Fujian
 - Guangdong
 - Shanghai
 - Sichuan
 - Chongqing
 - Beijing
- Europe**
 - Luxembourg
 - Denmark
 - Lithuania
 - Greece
 - Netherlands
 - Spain
 - Portugal
 - Germany
 - Ireland
 - United Kingdom
 - Belgium
 - Estonia
 - Sweden
 - Poland
 - Italy
 - Hungary
 - Austria
 - Cyprus
 - Finland
 - Romania
 - Turkey
 - Croatia
 - France
 - Bulgaria
 - Norway
 - Montenegro
 - North Macedonia
 - Czech Republic
 - Latvia
 - Slovenia
 - Grenada
 - Moldova
 - Kosovo
 - Bosnia and Herzegovina
 - Serbia
 - Slovakia
 - Albania
 - Gibraltar
 - Iceland
 - Israel
- US**
 - Iowa
 - South Dakota
 - New Mexico
 - Kansas
 - Oklahoma
 - California
 - Vermont
 - Colorado
 - North Dakota
 - Maine
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 - Hawaii
 - Texas
 - Nevada
 - Idaho
 - Wyoming
 - Montana
 - Oregon
 - Utah
 - Rhode Island
 - Illinois
 - Indiana
 - Arizona
 - Missouri
 - North Carolina
 - New York
 - Washington
 - Michigan
 - Maryland
 - New Jersey
 - Delaware
 - Florida
 - Virginia
 - Georgia
 - Wisconsin
 - New Hampshire
 - Connecticut
 - West Virginia
 - Ohio
 - South Carolina
 - Alaska
 - Arkansas
 - Pennsylvania
 - Tennessee
 - Alabama
 - Mississippi
 - Louisiana
 - Kentucky



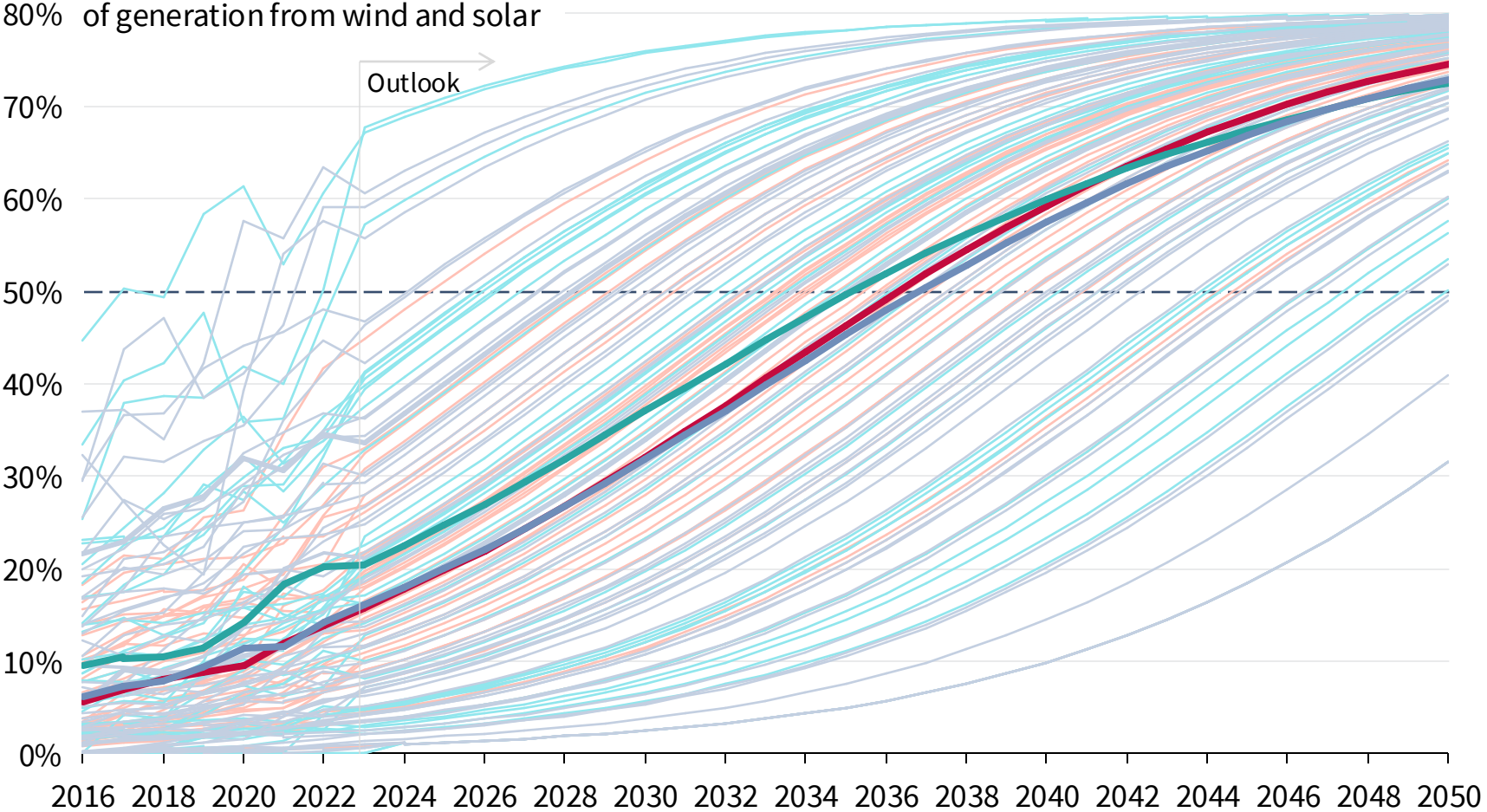
ⁱ Uptake data offset for best fit on a single S-curve — year 1 means a different year for each region.

Source: 2013–2023 National Electricity Industry Statistics Bulletin; China Electricity Council; National Bureau of Statistics of China; ENSTO-E; IEA; EIA; RMI analysis

A decade away from wind and solar dominance

Following this S-curve means all three blocs would reach ~50% wind and solar generation by 2035

Share of electricity from wind and solar



- China**
 - Qinghai
 - Hebei
 - Gansu
 - Jilin
 - Heilongjiang
 - Ningxia
 - Inner Mongolia
 - Henan
 - Liaoning
 - Tibet
 - Shanxi
 - Xinjiang
 - Shandong
 - Hunan
 - Jiangxi
 - Guangxi
 - Jiangsu
 - Shaanxi
 - Hubei
 - Anhui
 - Guizhou
 - Yunnan
 - Hainan
 - Tianjin
 - Zhejiang
 - Fujian
 - Guangdong
 - Shanghai
 - Sichuan
 - Chongqing
 - Beijing
- Europe**
 - Luxembourg
 - Denmark
 - Lithuania
 - Greece
 - Netherlands
 - Spain
 - Portugal
 - Germany
 - Ireland
 - United Kingdom
 - Belgium
 - Estonia
 - Sweden
 - Poland
 - Italy
 - Hungary
 - Austria
 - Cyprus
 - Finland
 - Romania
 - Turkey
 - Croatia
 - France
 - Bulgaria
 - Norway
 - Montenegro
 - North Macedonia
 - Czech Republic
 - Latvia
 - Slovenia
 - Grenada
 - Moldova
 - Kosovo
 - Bosnia and Herzegovina
 - Serbia
 - Slovakia
 - Albania
 - Gibraltar
 - Iceland
 - Israel
- US**
 - Iowa
 - South Dakota
 - New Mexico
 - Kansas
 - Oklahoma
 - California
 - Vermont
 - Colorado
 - North Dakota
 - Maine
 - Nebraska
 - Massachusetts
 - Minnesota
 - Hawaii
 - Texas
 - Nevada
 - Idaho
 - Wyoming
 - Montana
 - Oregon
 - Utah
 - Rhode Island
 - Illinois
 - Indiana
 - Tanjin
 - Arizona
 - Missouri
 - North Carolina
 - New York
 - Washington
 - Michigan
 - Maryland
 - New Jersey
 - Delaware
 - Florida
 - Virginia
 - Georgia
 - Wisconsin
 - New Hampshire
 - Connecticut
 - West Virginia
 - Ohio
 - South Carolina
 - Alaska
 - Arkansas
 - Pennsylvania
 - Tennessee
 - Alabama
 - Mississippi
 - Louisiana
 - Kentucky

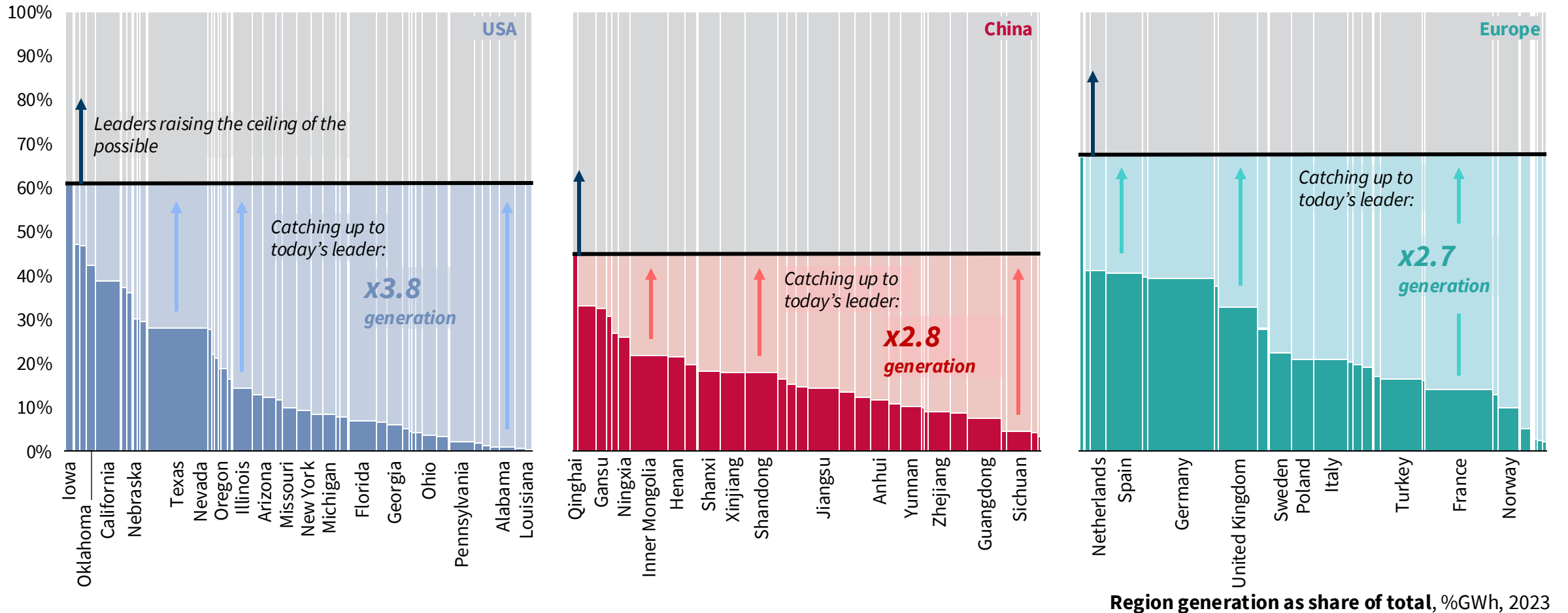


Source: 2013–2023 National Electricity Industry Statistics Bulletin; China Electricity Council; National Bureau of Statistics of China; IEA ENSTO-E; EIA; RMI analysis

Catch-up opportunity

The pack simply catching up to today's leaders would result in solar and wind energy growing 3x–4x

Share of electricity from wind and solar, %GWh, 2023



Region generation as share of total, %GWh, 2023

Contents

3 The EV Race



China leads the EV race among the three blocs, followed by Europe, with the United States a bit further behind.

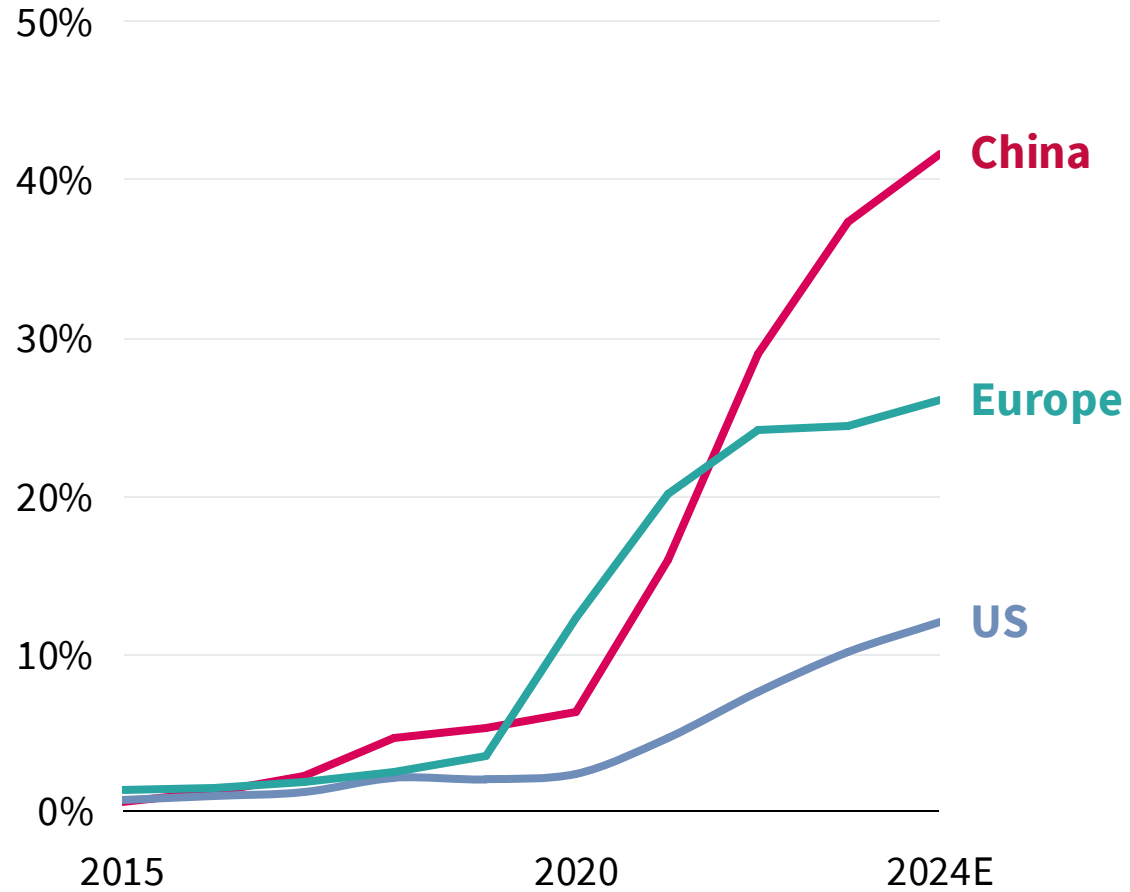
- **The winner is ...** Northern Europe is the leading region globally with EVs at 56% of car sales. Central and Eastern China are next with 37% of sales. The leading territory is Norway with 93%.
- **The China story.** Central and Eastern China lead with EVs at 37% of sales, while the Northwest is at 21%. The leading province is Hainan at 52%, followed by the City of Shanghai at 39%.
- **The Europe story.** Northern Europe at 56% is followed by Western Europe with 26% of sales. Eastern Europe is only at 7%. After Norway comes Sweden with 60% penetration.
- **The US story.** The West Coast is a clear leader, with 19% penetration, and the Midwest is a laggard with 6%. California leads with 26% penetration but is only in 36th place in our global sample.
- **Wealth does not determine deployment across blocs.** The slowest-moving territories in China are at the same level of EV penetration as the leading US states despite having nine times lower GDP per capita.

- **There is a universal S-curve pattern to EV deployment.** If we look across the 110-plus territories, EV sales take six years to get to 5%, and only another six years to get to 50%.
- **Where are we heading.** If growth continues along these S-curves, China and Europe will have over 80% EV market share by 2030; the United States will reach that level by 2035.
- **Follow the leader.** The vast majority of this growth can come from the pack copying the leaders. Sales can grow threefold if all territories in each bloc reach the penetration level of the local leaders.
- **Important implications for the Global South.** Lower-income regions are leading the EV race, implying that the Global South may well find it easier to leapfrog directly to EVs.

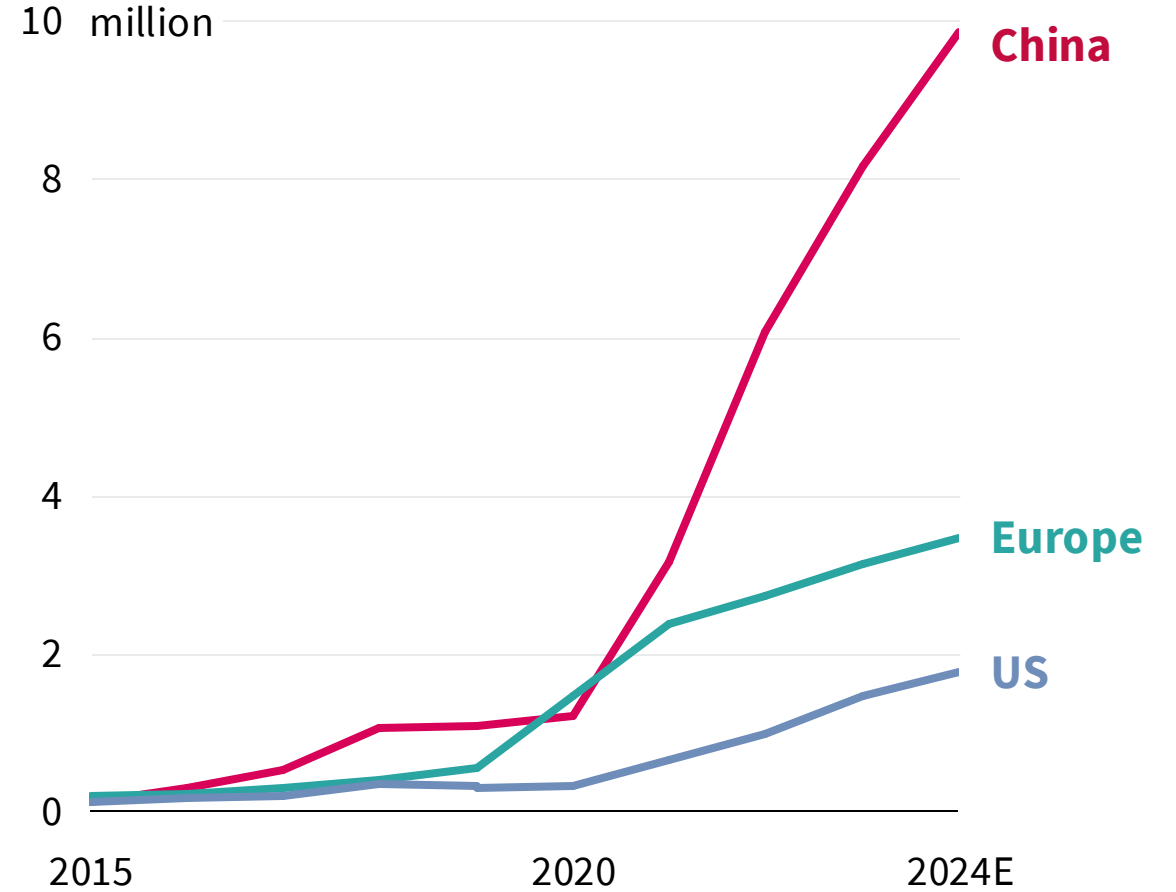
The EV race by bloc

China is racing ahead on EV deployment

EV share of total sales



EV sales

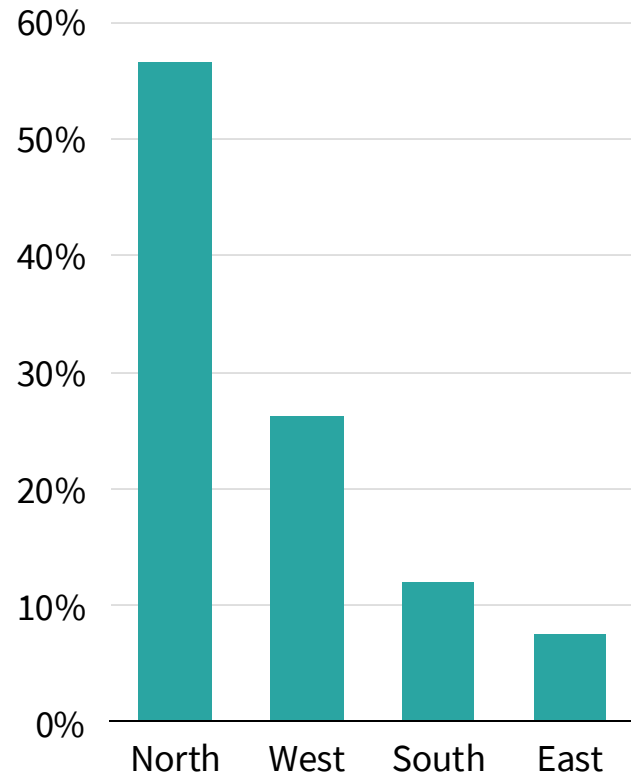


The EV race by region

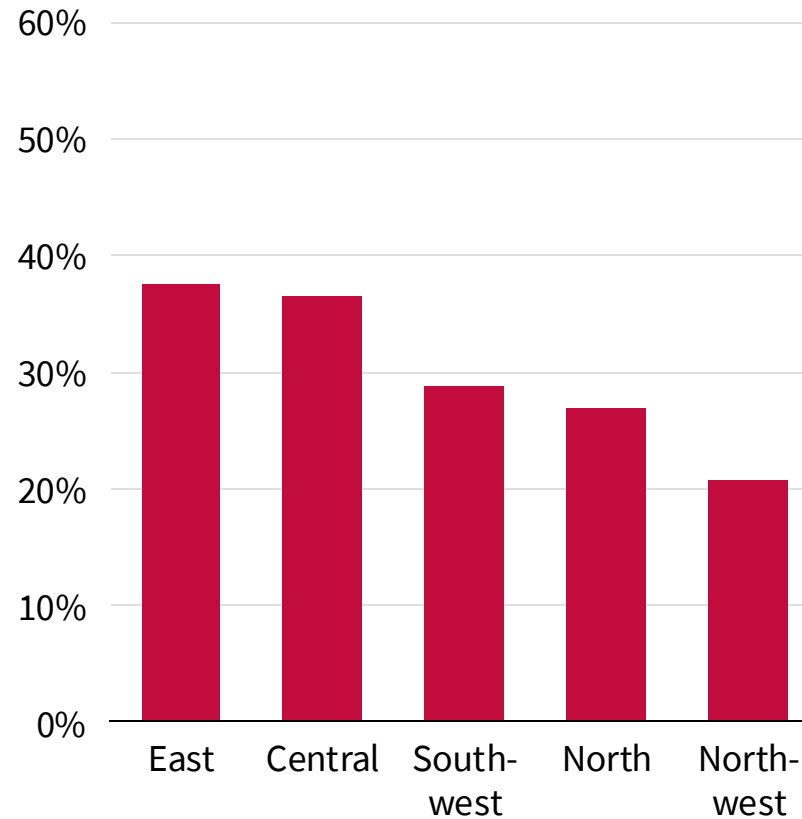
Northern Europe leads, with Central and Eastern China not far behind

EV share of sales, 2023

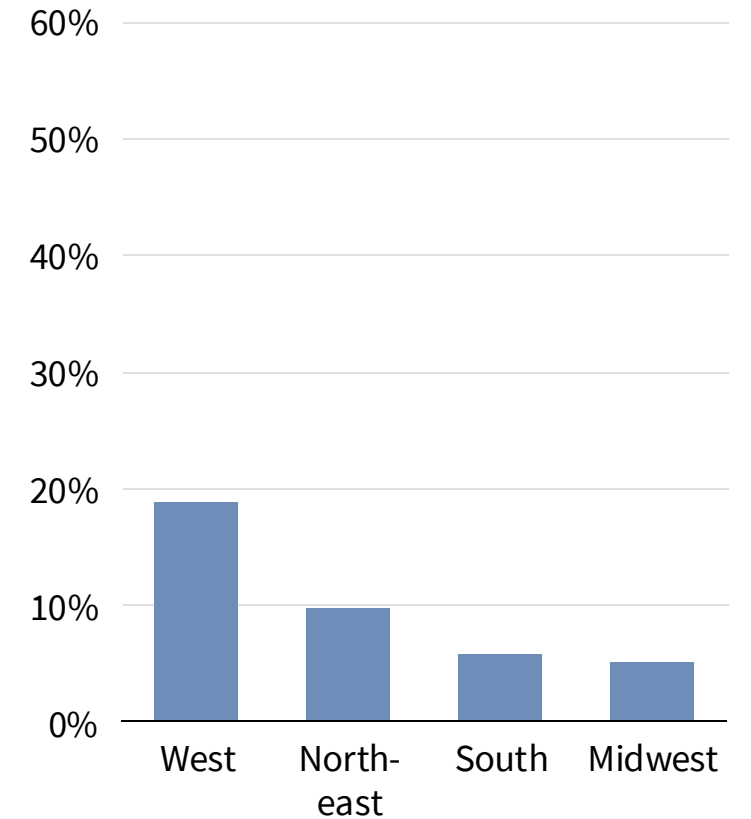
Europe



China



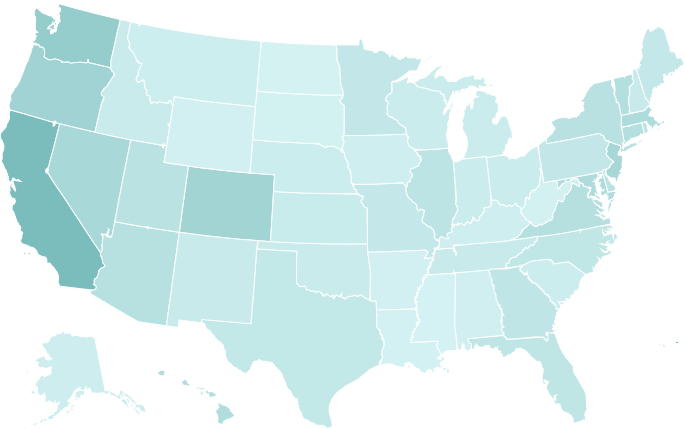
United States



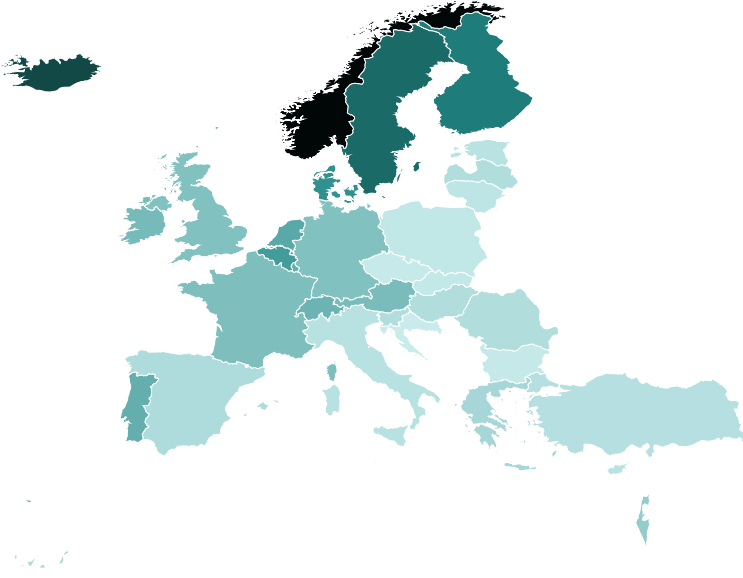
The EV race by territory

A small number of trailblazing territories are far ahead of the pack

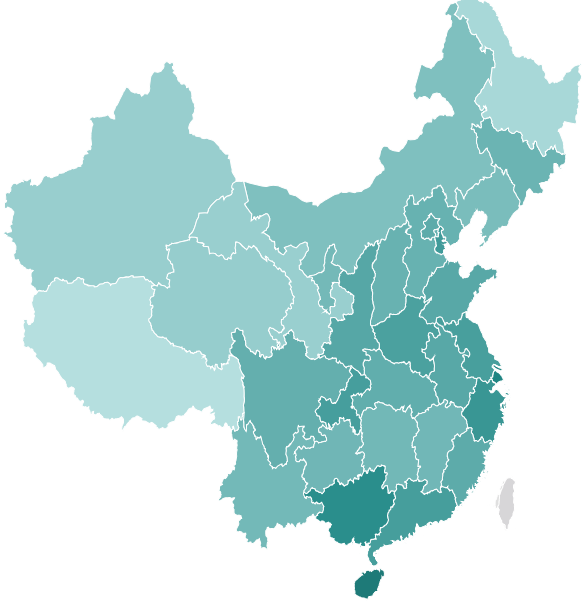
United States



Europe



China



EV sales 0%  95%

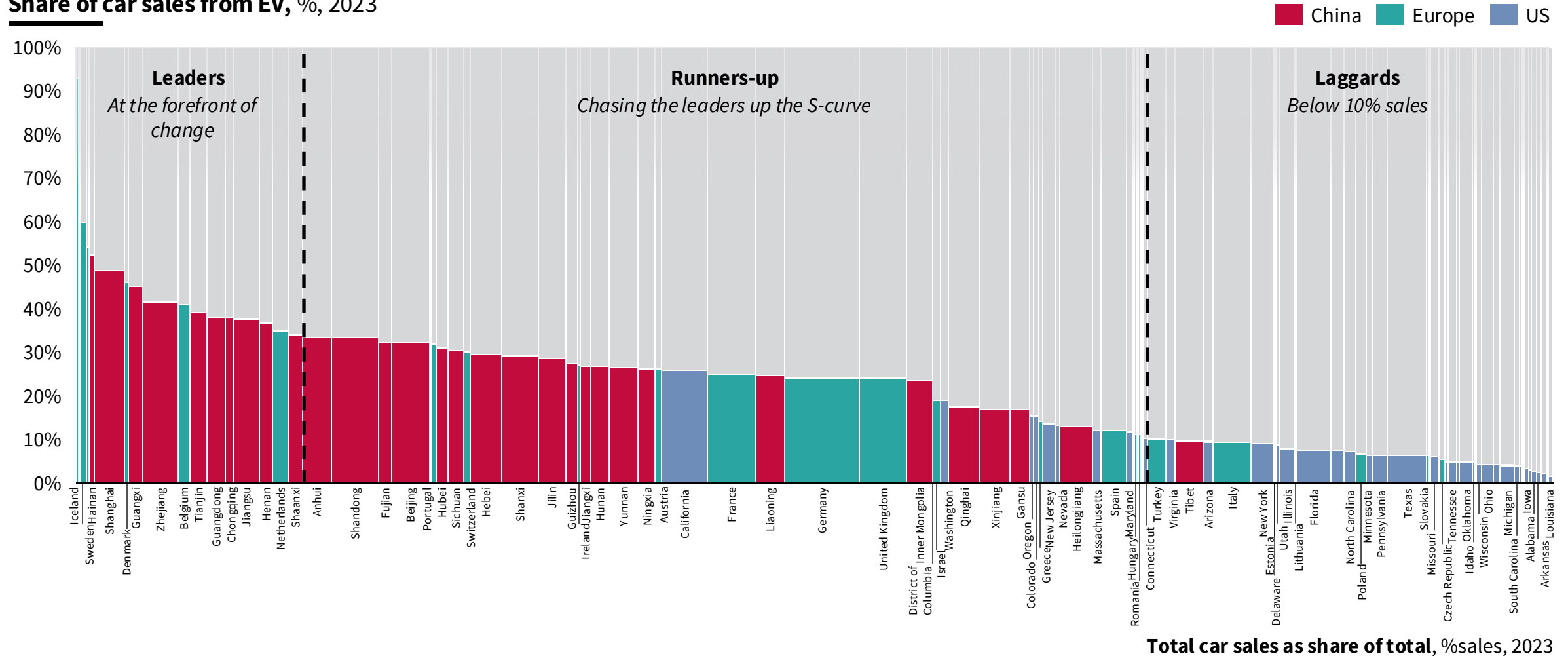


Note: These maps are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city, or area.
Source: IEA; National Bureau of Statistics of China; Wang et al. (2024); EIA; AutosInnovate; RMI estimates

The EV leaders and laggards

EVs exceeded one-third of total sales in 15% of territories — yet 30% of territories are still below 10% uptake

Share of car sales from EV, %, 2023



Total car sales as share of total, % sales, 2023

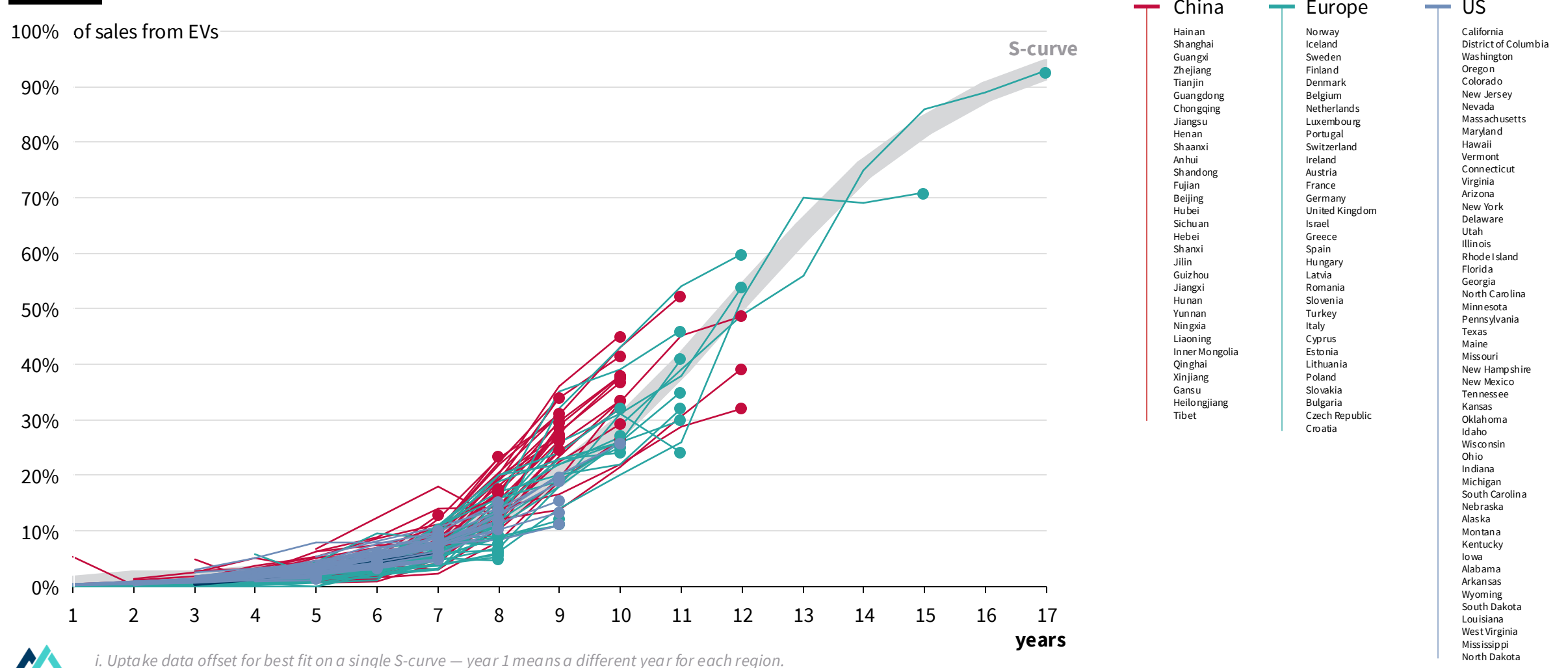


Source: IEA; National Bureau of Statistics of China; Wang et al. (2024); EIA; AutosInnovate; RMI estimates

EVs are growing along a uniform s-curve as well

Region uptake data shows a clear S-curve trend across China, Europe, and the United States

Share of car sales from EVsⁱ



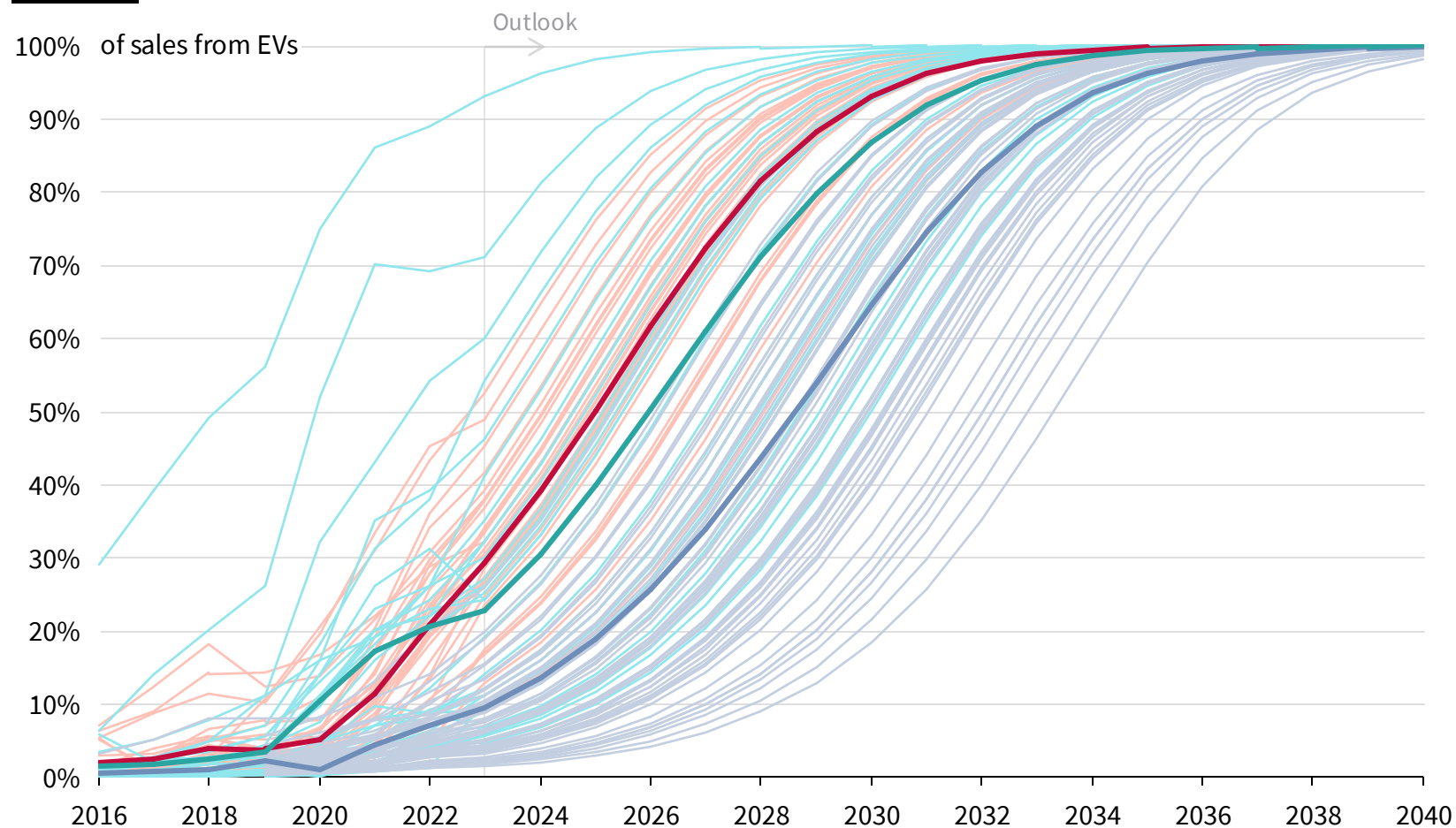
i. Uptake data offset for best fit on a single S-curve — year 1 means a different year for each region.

Source: IEA; National Bureau of Statistics of China; Wang et al. (2024); EIA; AutosInnovate; RMI estimates

EV adoption will race up the s-curve across regions

Under the current trend, Europe and China EV sales will reach 75+% by 2030 — and the US is in close pursuit

Share of car sales from EVs



- China**
 - Hainan
 - Shanghai
 - Guanxi
 - Zhejiang
 - Tianjin
 - Guangdong
 - Beijing
 - Chongqing
 - Jiangsu
 - Henan
 - Shaanxi
 - Anhui
 - Shandong
 - Fujian
 - Beijing
 - Hubei
 - Sichuan
 - Hebei
 - Shanxi
 - Jilin
 - Guizhou
 - Jiangxi
 - Hunan
 - Yunnan
 - Ningxia
 - Liaoning
 - Inner Mongolia
 - Qinghai
 - Xinjiang
 - Gansu
 - Heilongjiang
 - Tibet
- Europe**
 - Norway
 - Iceland
 - Sweden
 - Finland
 - Denmark
 - Belgium
 - Netherlands
 - Luxembourg
 - Portugal
 - Switzerland
 - Ireland
 - Austria
 - France
 - Germany
 - United Kingdom
 - Israel
 - Greece
 - Spain
 - Hungary
 - Latvia
 - Romania
 - Slovenia
 - Turkey
 - Italy
 - Cyprus
 - Estonia
 - Lithuania
 - Poland
 - Slovakia
 - Bulgaria
 - Czech Republic
 - Croatia
- US**
 - California
 - District of Columbia
 - Washington
 - Oregon
 - Colorado
 - New Jersey
 - Nevada
 - Massachusetts
 - Maryland
 - Hawaii
 - Vermont
 - Connecticut
 - Virginia
 - Arizona
 - New York
 - Delaware
 - Utah
 - Illinois
 - Rhode Island
 - Florida
 - Georgia
 - North Carolina
 - Minnesota
 - Pennsylvania
 - Texas
 - Maine
 - Missouri
 - New Hampshire
 - New Mexico
 - Tennessee
 - Kansas
 - Oklahoma
 - Idaho
 - Wisconsin
 - Ohio
 - Indiana
 - Michigan
 - South Carolina
 - Nebraska
 - Alaska
 - Montana
 - Kentucky
 - Iowa
 - Alabama
 - Arkansas
 - Wyoming
 - South Dakota
 - Louisiana
 - West Virginia
 - Mississippi
 - North Dakota



Source: IEA; National Bureau of Statistics of China; Wang et al. (2024); EIA; AutosInnovate; RMI estimates and outlook

Contents

4 The Electrification Race



China is the electrification leader. European and US electrification stagnated 15 years ago, allowing China to take global leadership.

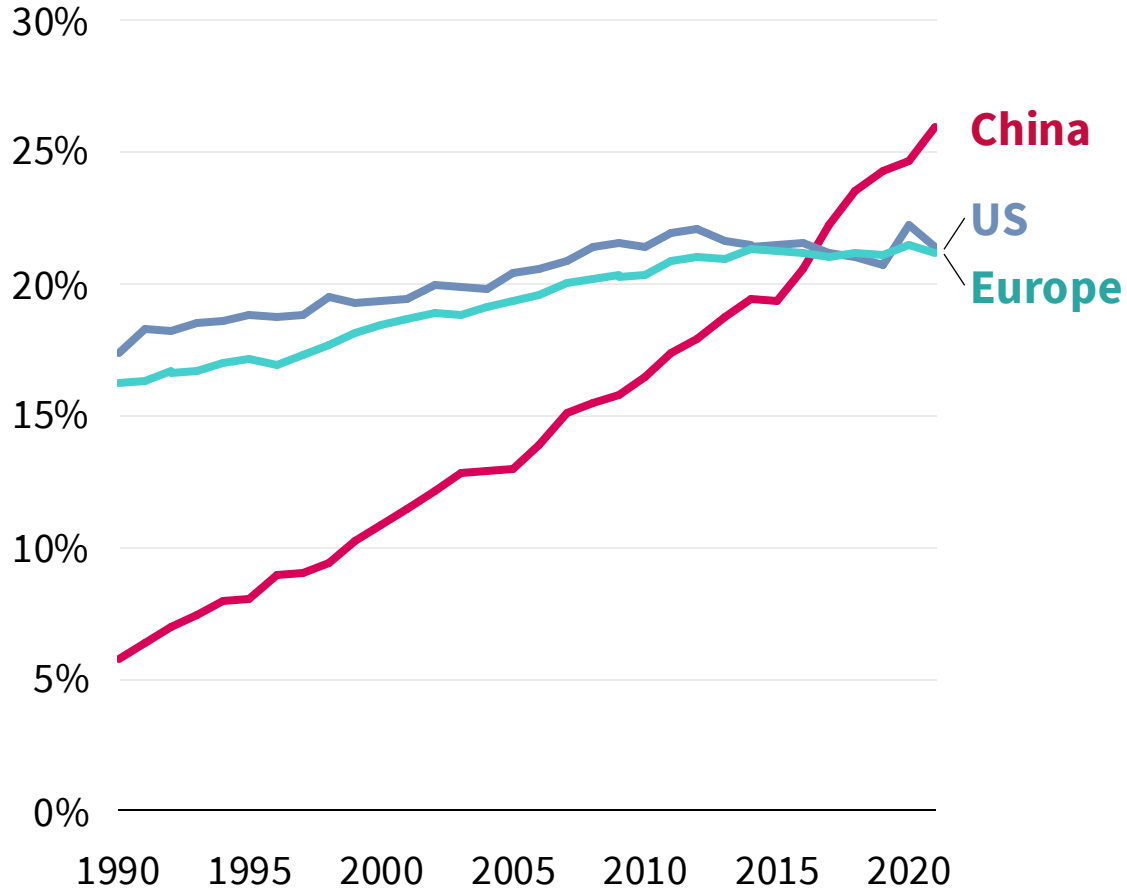
- **The winner is ...** Electrification in Eastern China is 35%, followed by Central China at 32%. The leader among territories is Zhejiang province in China at 51%, followed by Guangdong at 49%.
- **A large group of laggards.** One-fifth of the 110 territories are below 15% electrification, which is the average level in the Global South.
- **The China story.** Although the Eastern regions lead the world, the Northern region is a global laggard at only 14% electrification.
- **The Europe story.** Northern Europe is 30% electrified, and the laggard is Eastern Europe at only 18%. The country leader is Norway at 47% electrification, then Sweden at 33%.
- **The US story.** The leader is Washington, D.C., at 42%, followed by Florida at 27% and the Carolinas at 26%. Alaska is still early in its electrification journey at just 3%.
- **There is no clear S-curve pattern for electrification.** The United States and Europe have been stagnant; China has been growing on a straight line.

- **The key driver of electrification has been low electricity prices.** There are no high-electrification territories with high electricity prices.
- **Chinese electrification will continue to boom.** China is on track to reach over 35% electrification by the end of the decade. The United States and Europe will need to change to catch up.
- **Catch-up opportunity.** Simply catching up with the leaders in each region would enable electricity demand to grow by 60%–130% across blocs.

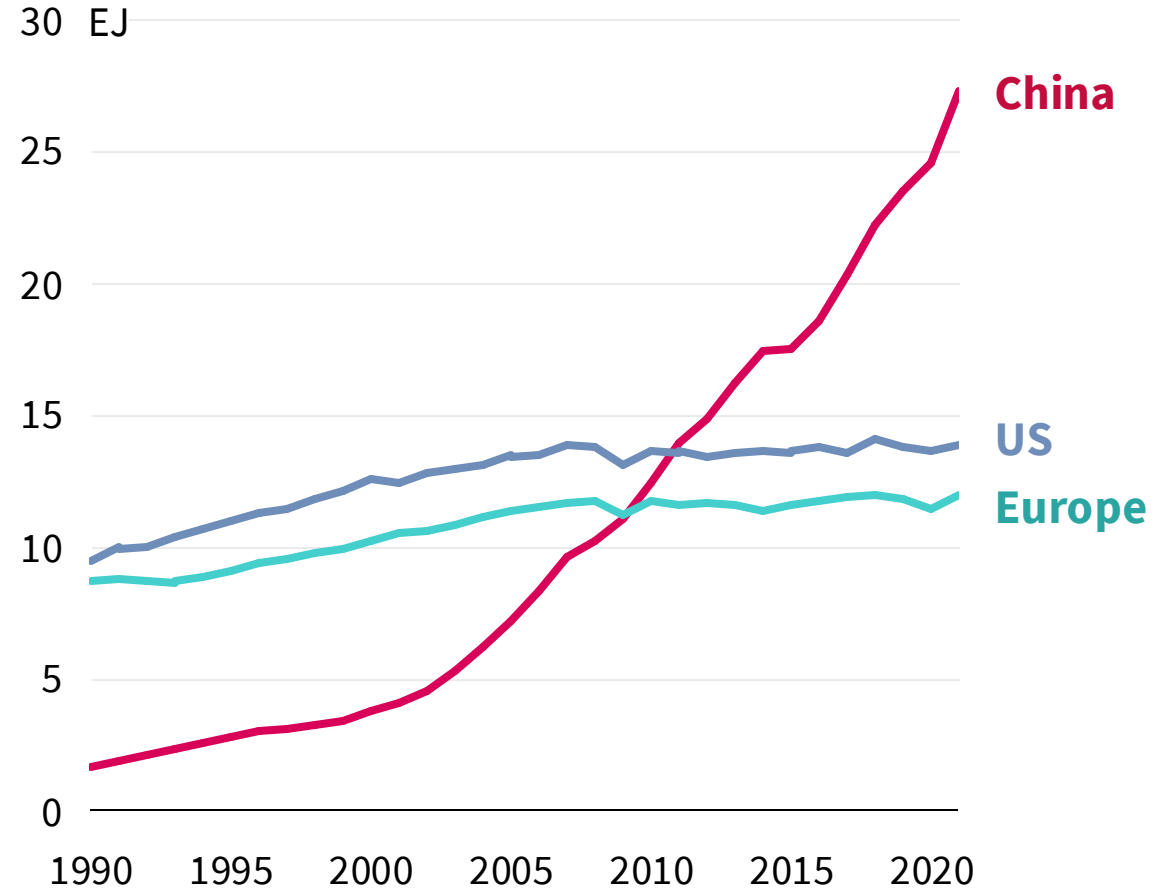
China, the first major electrostate

Electrification stagnated in the United States and Europe — while Chinese electrification keeps going

Electricity's share of total final energy consumption



Electricity demand

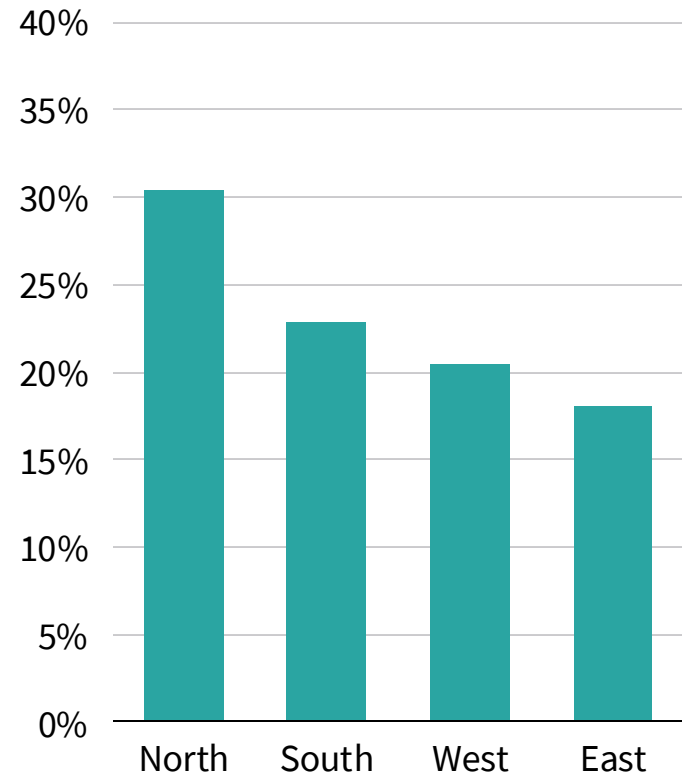


The electrification race by region

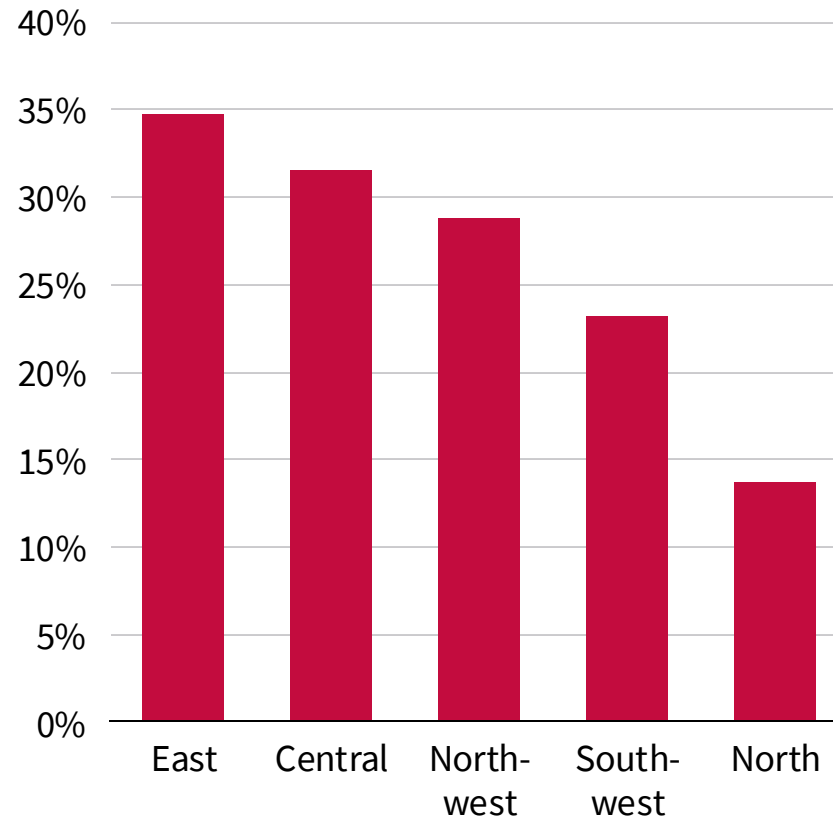
Central and Eastern China are clear leaders

Electricity as share of final energy demand

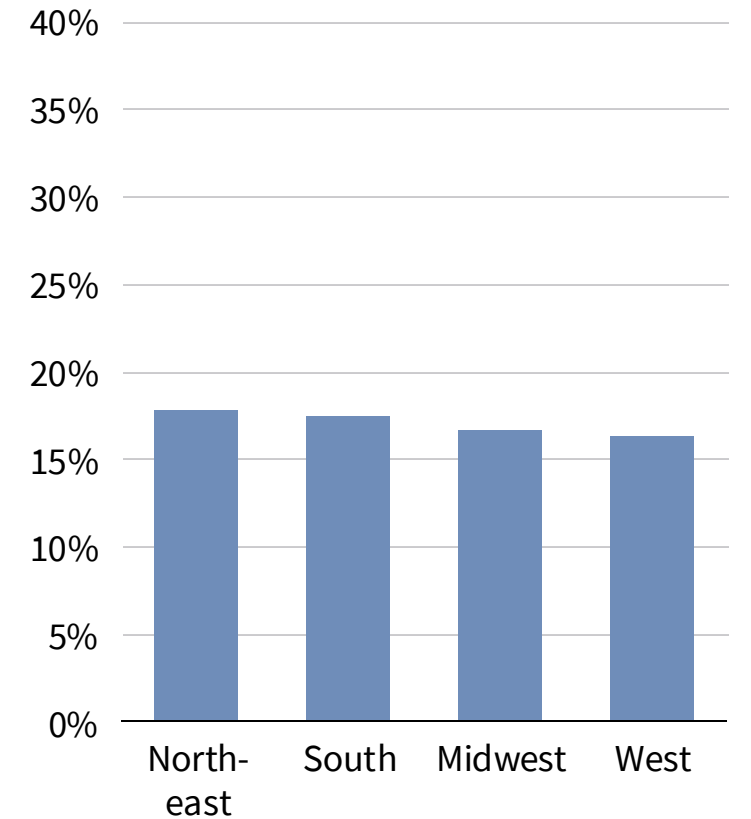
Europe



China



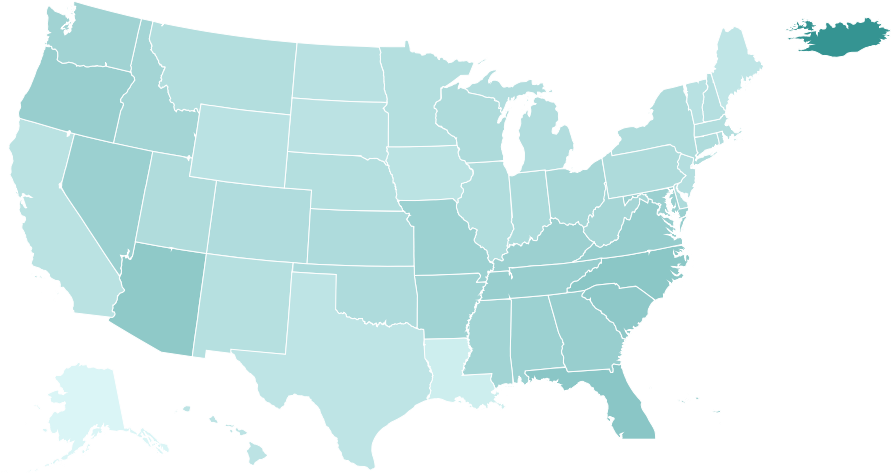
United States



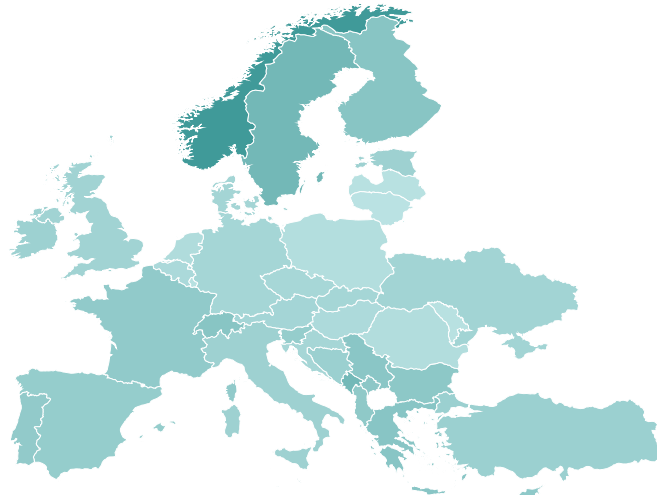
The electrification race by territory

Electrification rates show less variation across territories in the West but differ significantly in China

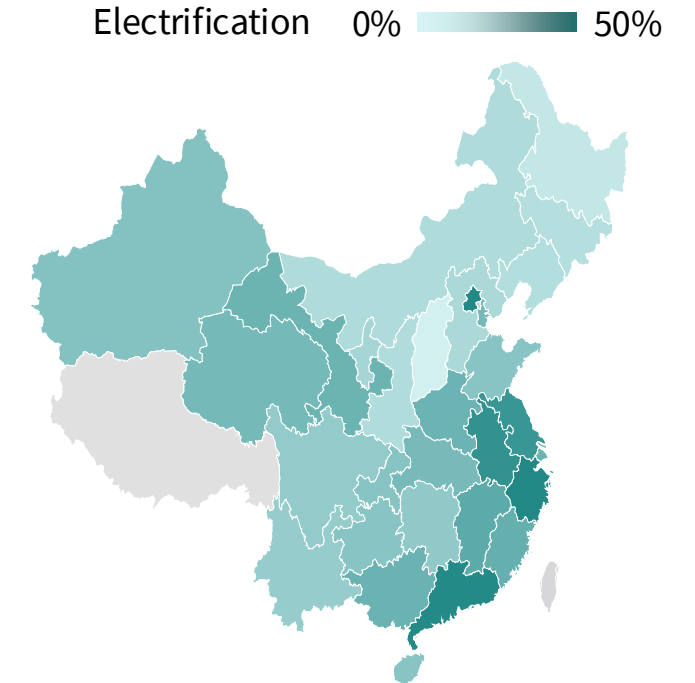
United States



Europe



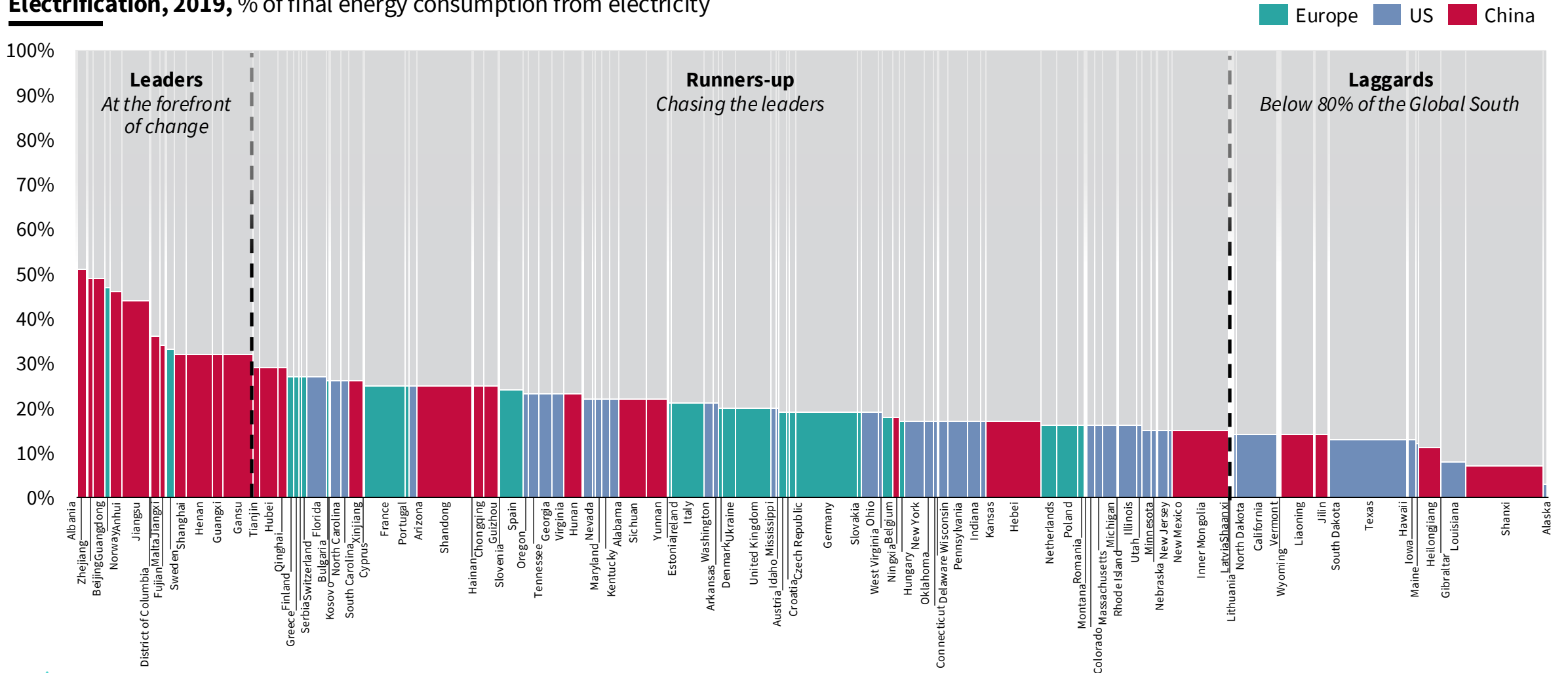
China



Chinese provinces are at the forefront of electrification

10% of territories — mainly in China — lead the charge; 20% still lag most of the Global South

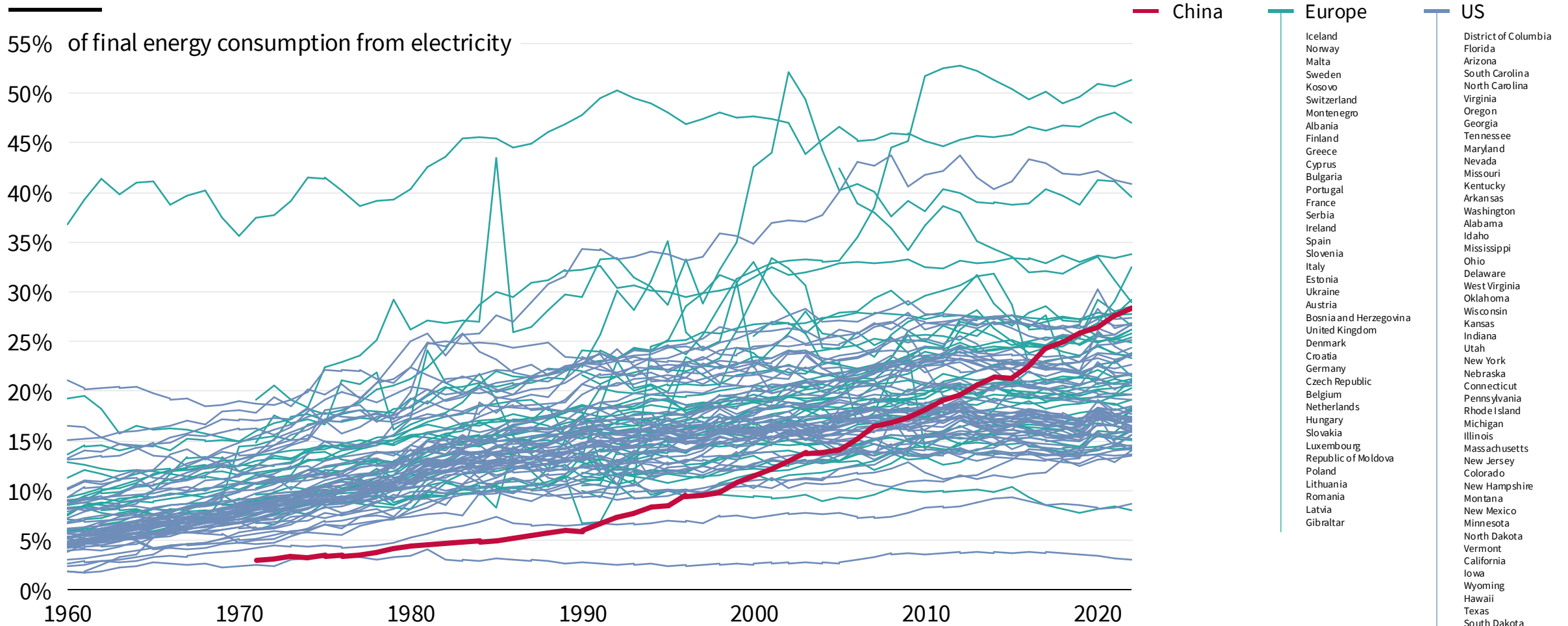
Electrification, 2019, % of final energy consumption from electricity



Electric leapfrog

China blew past the electrification levels of over 90% of Europe and the United States

Electrification

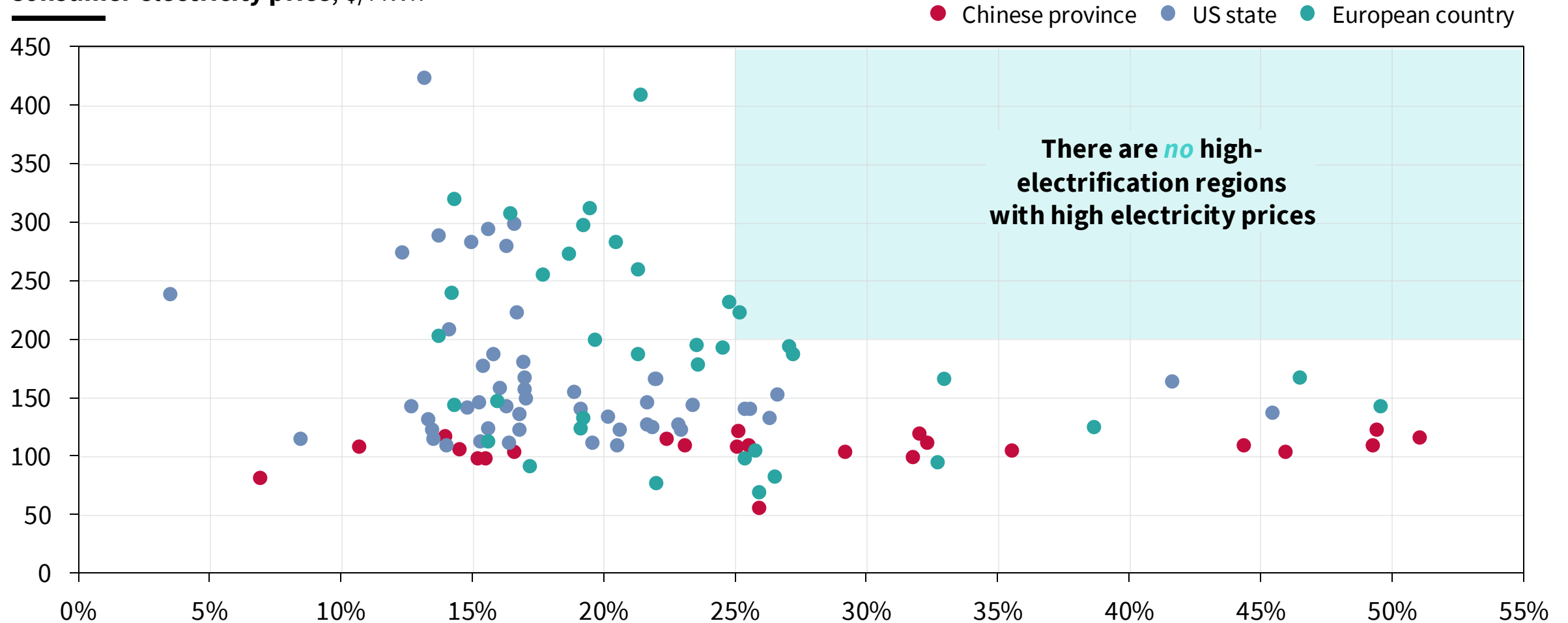


Source: China National Bureau of Statistics; ENSTO-E; IEA; EIA; RMI analysis

Electricity prices are key to success

China's low electricity prices have helped to electrify — high prices in the US and Europe inhibited growth

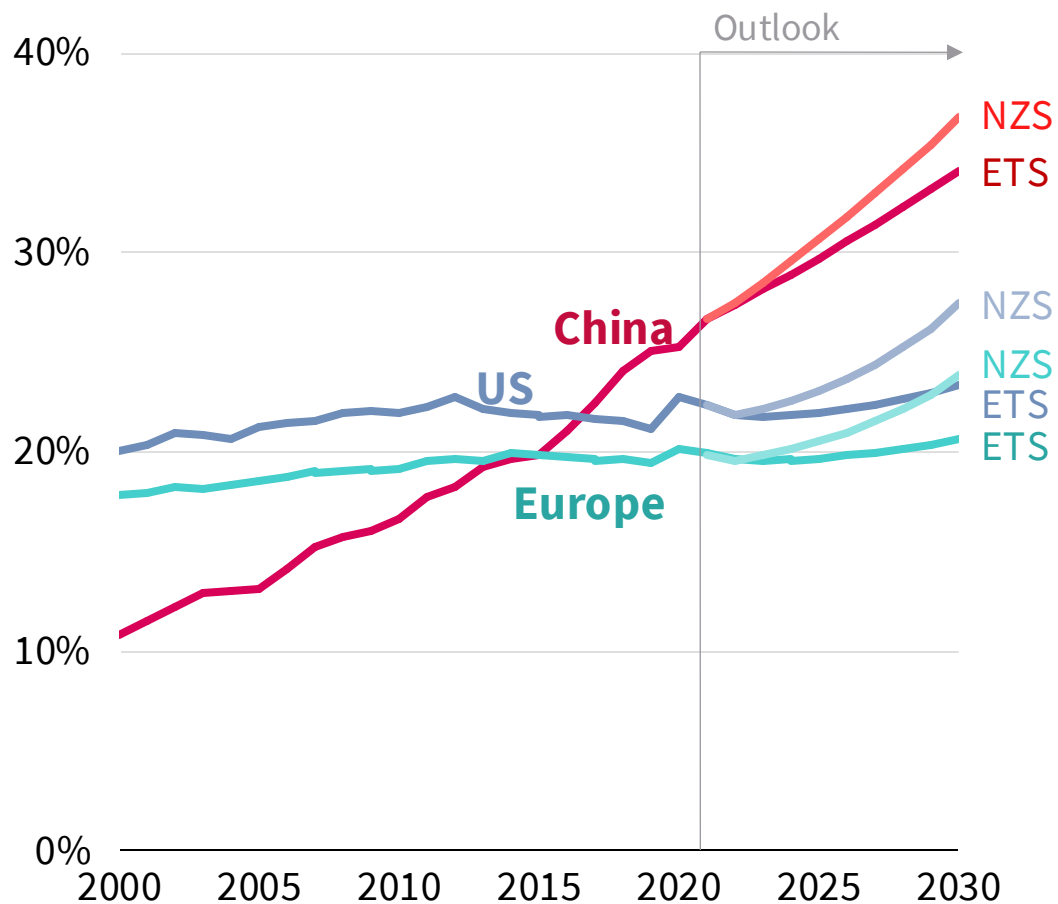
Consumer electricity price, \$/MWh



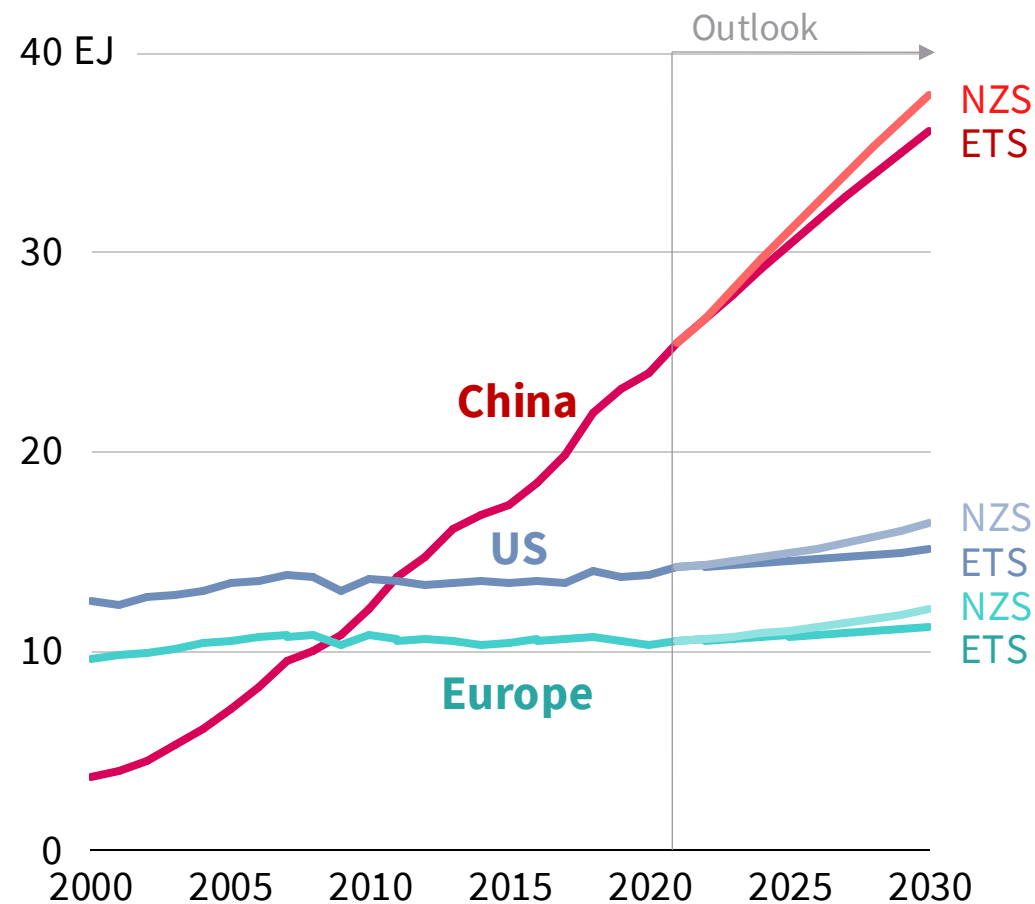
Electrification future

Under the current trend, China is set to electrify much faster than the West

Electricity's share of final energy



Electricity into final energy



Note: NZS is the Net Zero scenario; ETS is the Economic Transition scenario.
Source: BloombergNEF NEO 2022

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5 The Cleantech Manufacturing Race

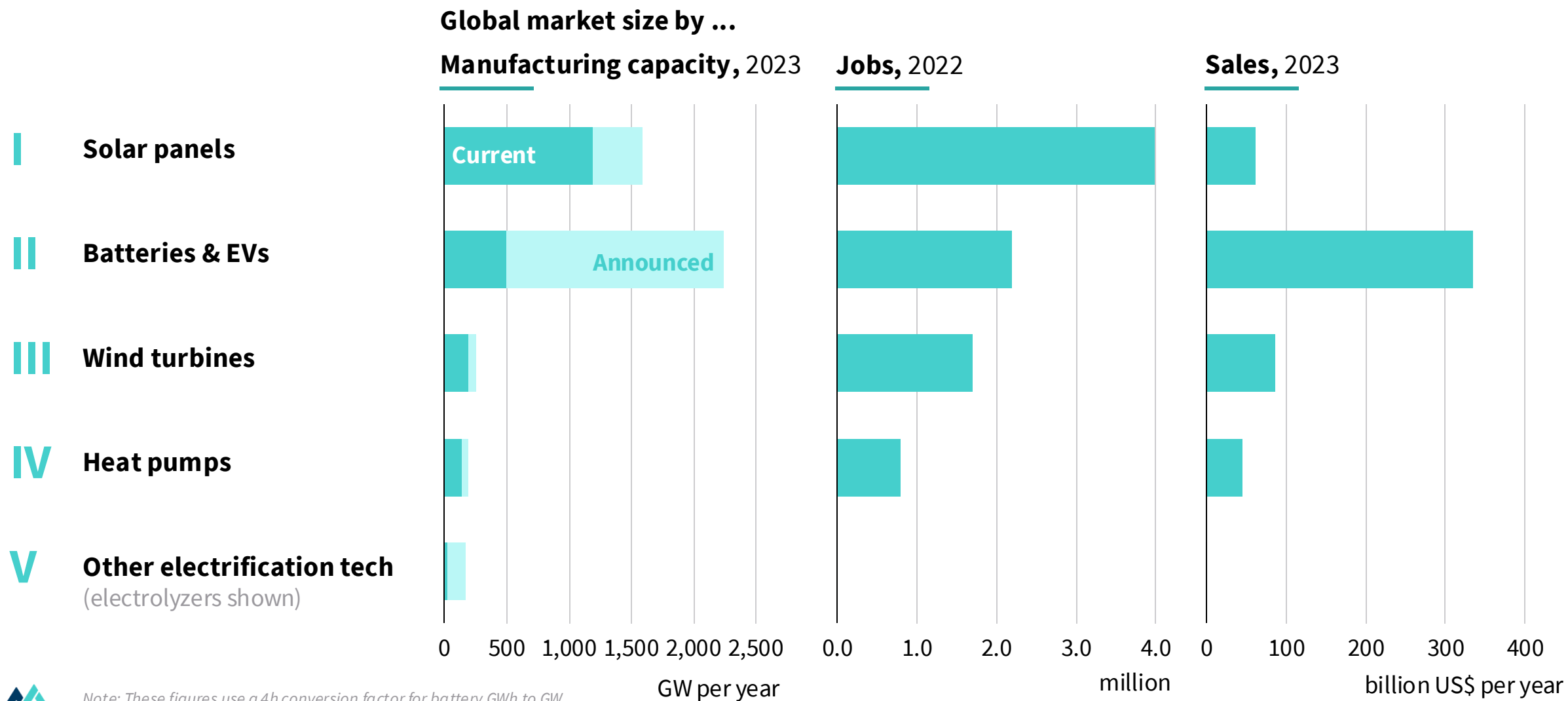


There are five key cleantech manufacturing sectors: solar panels, batteries and EVs, wind turbines, heat pumps, and other electrification technology, such as electrolyzers.

- **Solar and batteries are the largest sectors today.** Solar panels lead in terms of manufacturing capacity and jobs. EVs and batteries lead in terms of revenue.
- **China leads in both solar and batteries, with 97% and 89% of capacity, respectively, in the three blocs.** Scale and innovation drove down domestic prices — now exports are booming.
- **Eastern and Central China dominate.** Over 80% of solar and battery manufacturing is concentrated in these two regions of China. Jiangsu, Anhui, and Zhejiang host 60% of solar manufacturing; 29% of battery manufacturing capacity is in Jiangsu and Fujian.
- **The Europe story.** Poland and Hungary host 6% of global battery manufacturing capacity and are growing.
- **The US story.** US states are making a rapid manufacturing comeback. Most new capacity under construction is in the South, in states like Georgia and Tennessee.
- **Western catch-up opportunity.** There is still plenty of room to grow cleantech manufacturing outside of solar and batteries. For example, the heat pump market may well triple over the coming decade, and a clear regional manufacturing leader has yet to emerge.
- **Beyond manufacturing.** Other enabling markets for cleantech, such as software and services, are still in their early stages and hold significant potential. For instance, global energy management software revenues are projected to surpass those of solar panel manufacturing within a few years — and with much better margins.

There are five key manufacturing markets

Solar is the largest by manufacturing capacity and jobs, whereas batteries and EVs lead by sales



Note: These figures use a 4h conversion factor for battery GWh to GW.

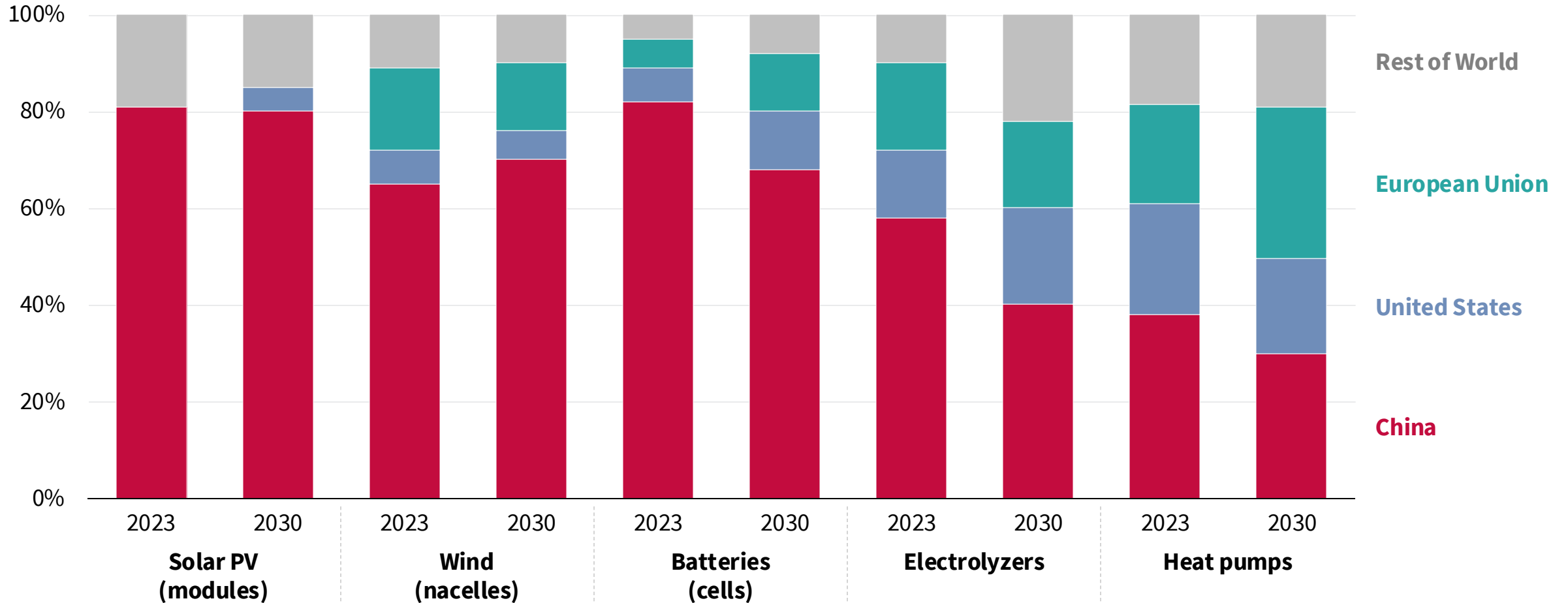
Source: IEA ETP 2024; RMI analysis



China is the manufacturing hub of the transition

China dominates manufacturing of the key energy technologies of the future

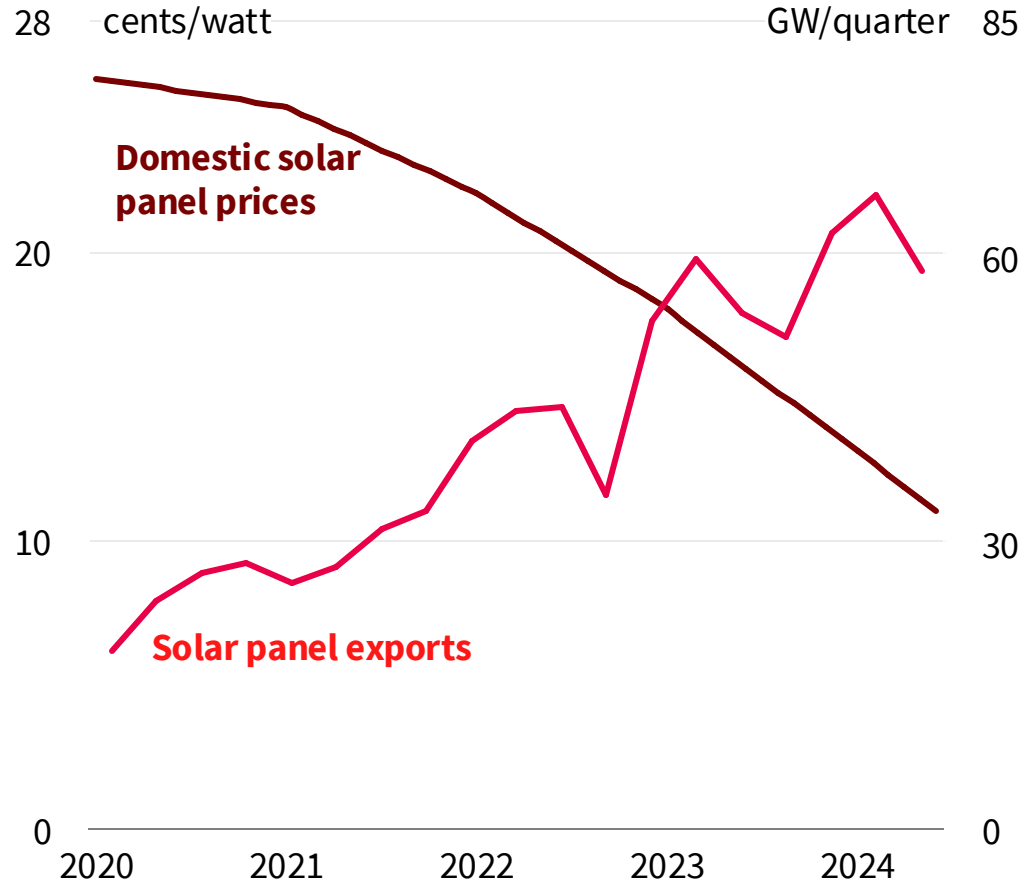
Geographical concentration of current and announced manufacturing capacity, 2023–2030



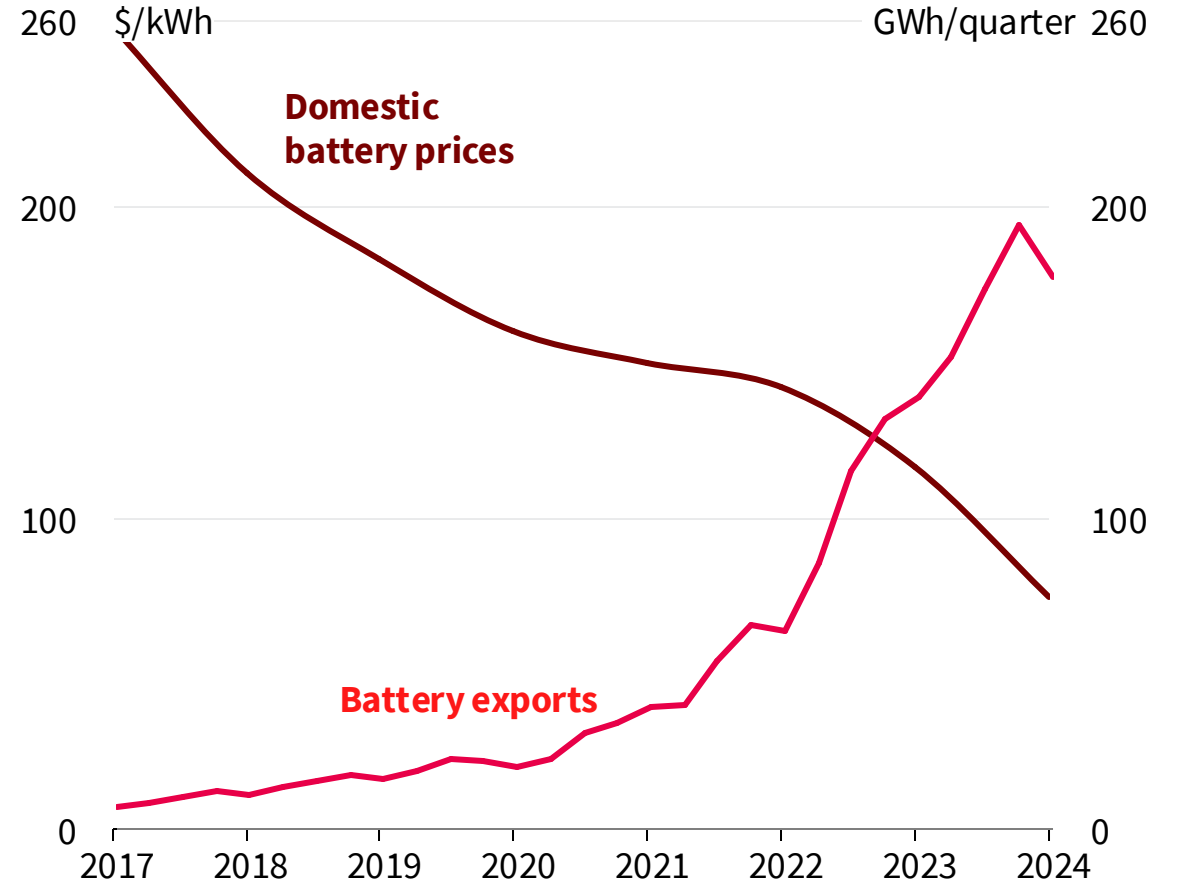
Chinese solar panels and batteries are getting very cheap

And therefore, exports are booming

Solar panel prices and exports, China



Battery pack prices and exports, China

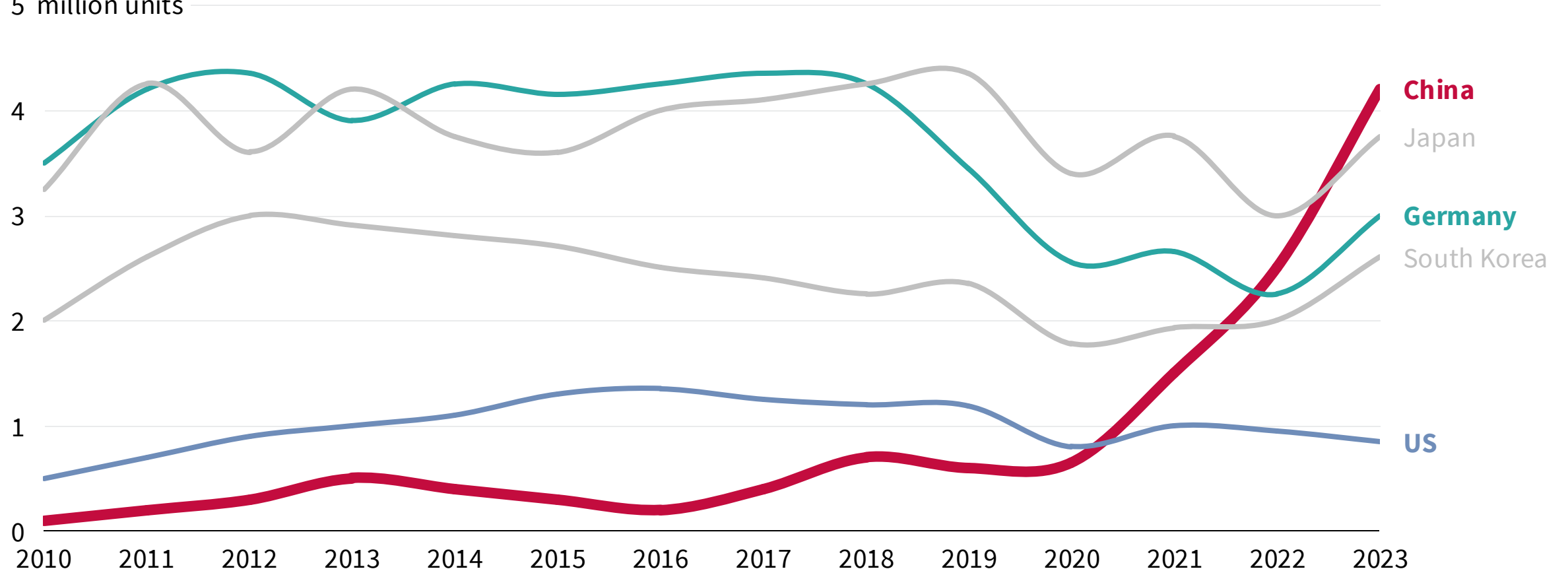


Master batteries, master the future of automotive

China leapfrogged all other major car exporters, driven by superior battery tech powering its EVs

Car exports by region, 2010–2023

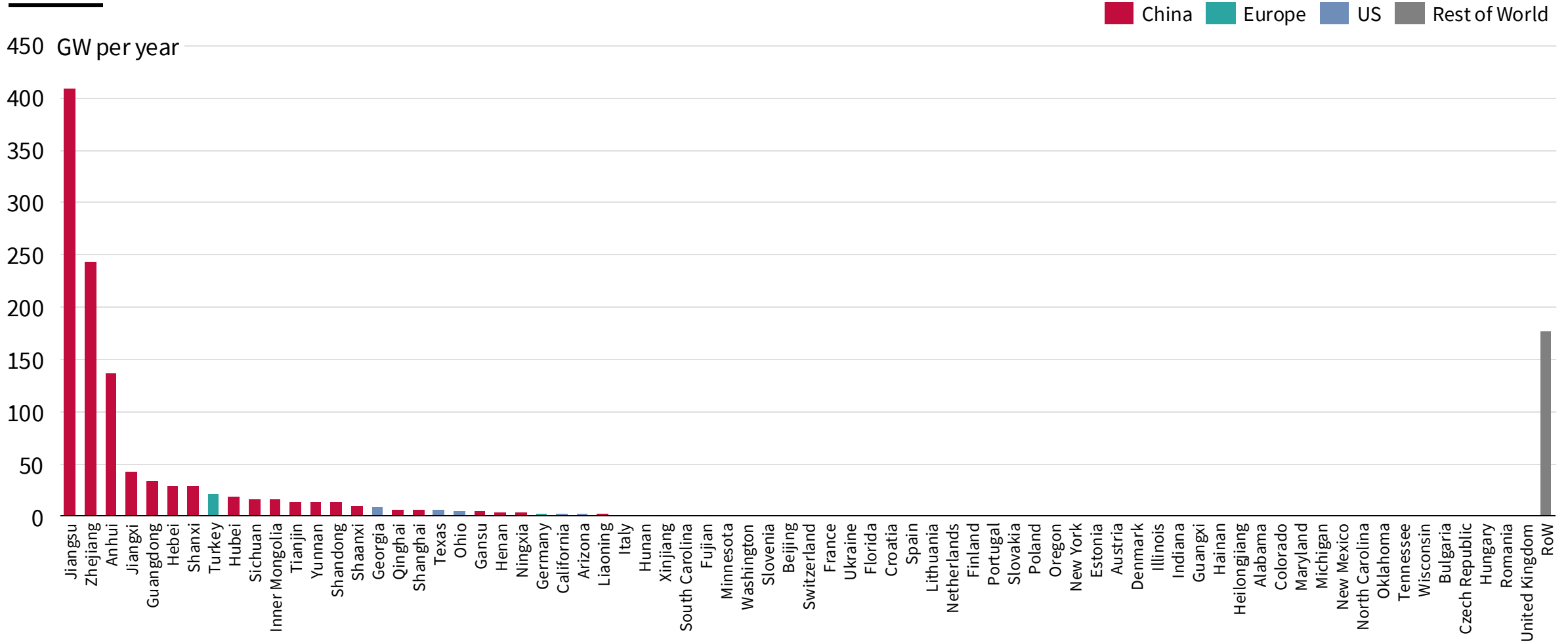
5 million units



China leads solar manufacturing

Solar panel factories are highly concentrated in just a few provinces in Eastern China

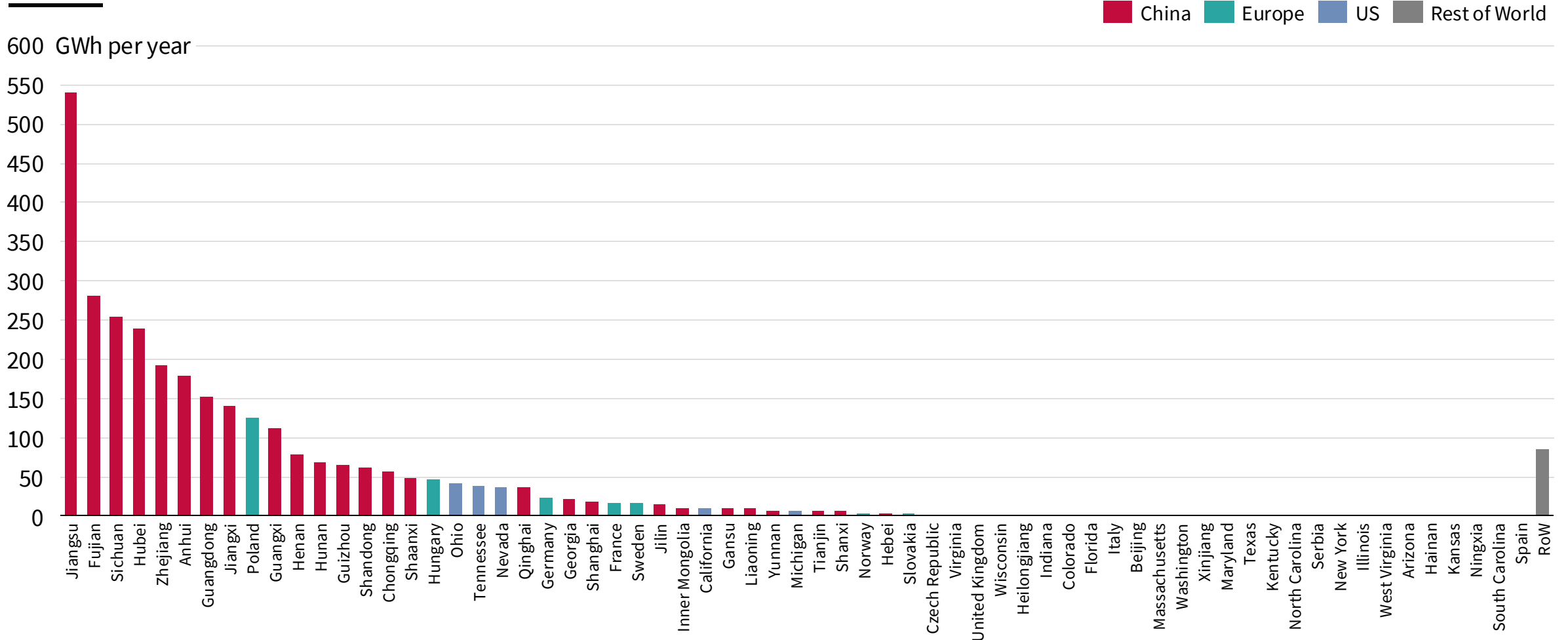
Solar manufacturing capacity, 2024



China is the backbone of global battery production

Battery manufacturing is more spread out — but still dominated by a few Chinese provinces

Battery manufacturing capacity, 2024



Made in (Eastern) China

Just a handful of regions in China manufacture the majority of the world's cleantech

Solar panel manufacturing, 2024



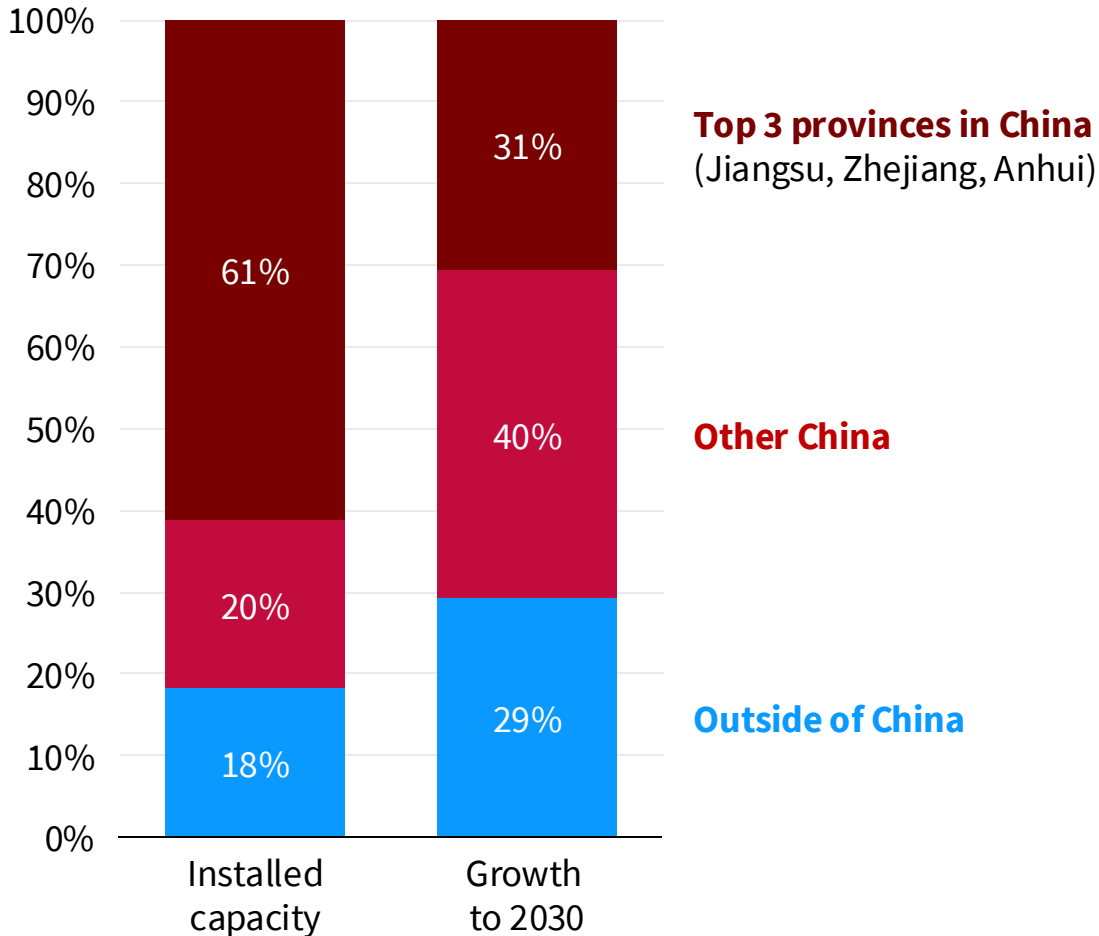
Battery manufacturing, 2024



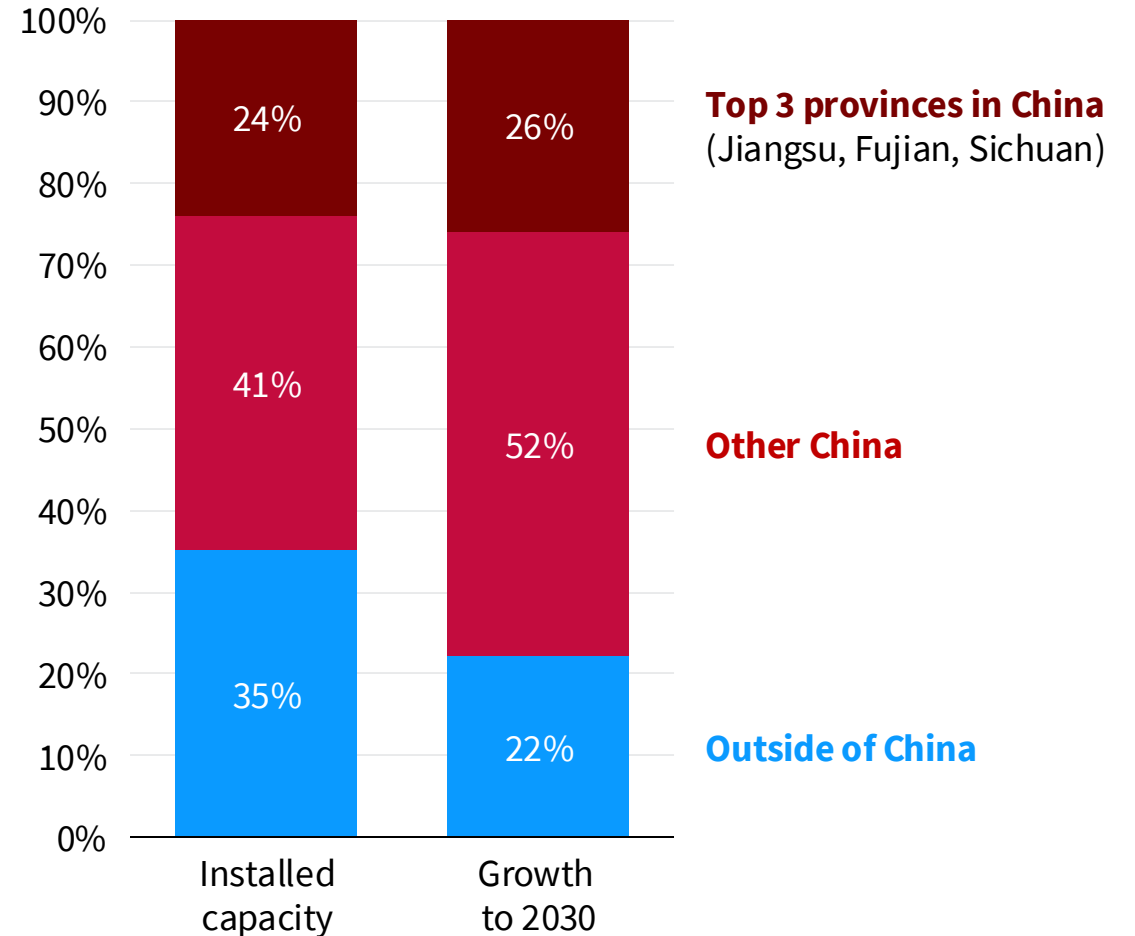
Supply chain diversification

New manufacturing is a bit more evenly spread across the world — but China still dominates

Solar manufacturing capacity outlook



Battery manufacturing capacity outlook



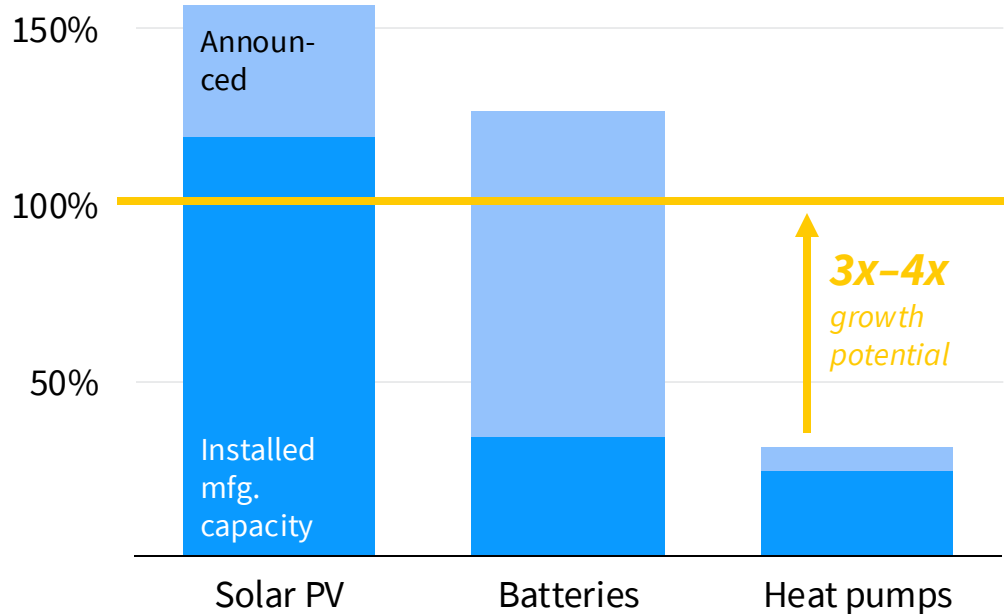
There is still plenty of room to grow into other cleantech

For example, heat pump manufacturing remains a largely open opportunity

Unlike solar panels and batteries, there is still a lot of global manufacturing growth potential for heat pumps...

Manufacturing capacity

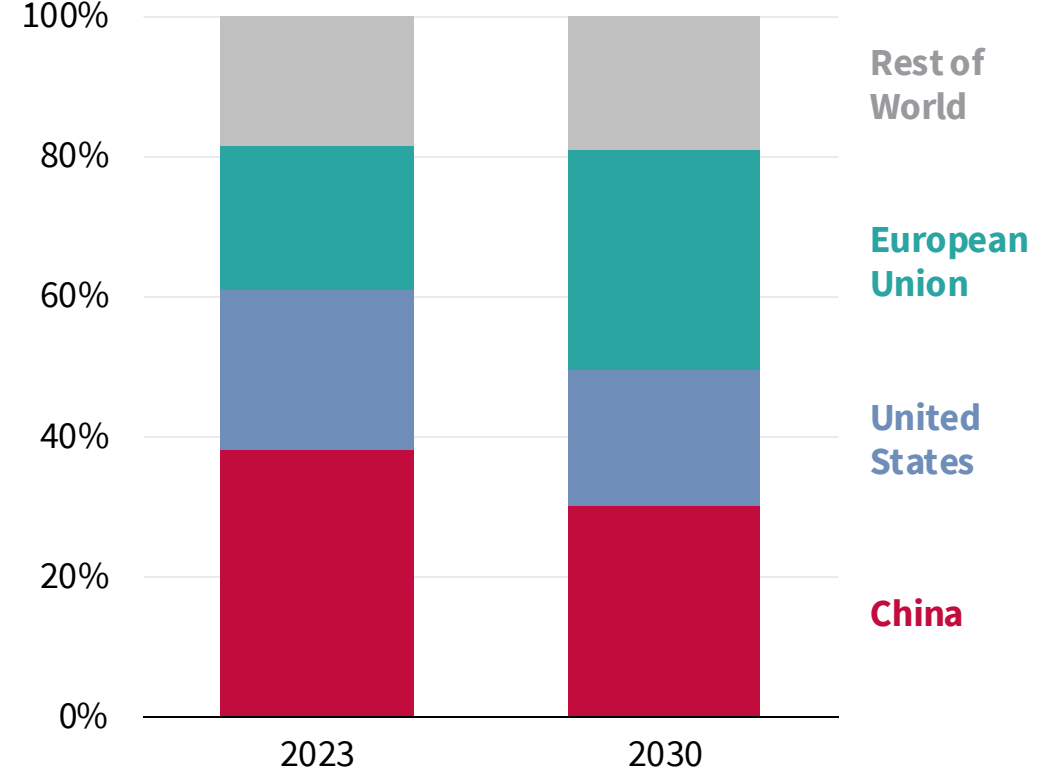
200% of 2030 market potentialⁱ



...and no single bloc has yet emerged to dominate manufacturing

Heat pump manufacturing capacity

100%

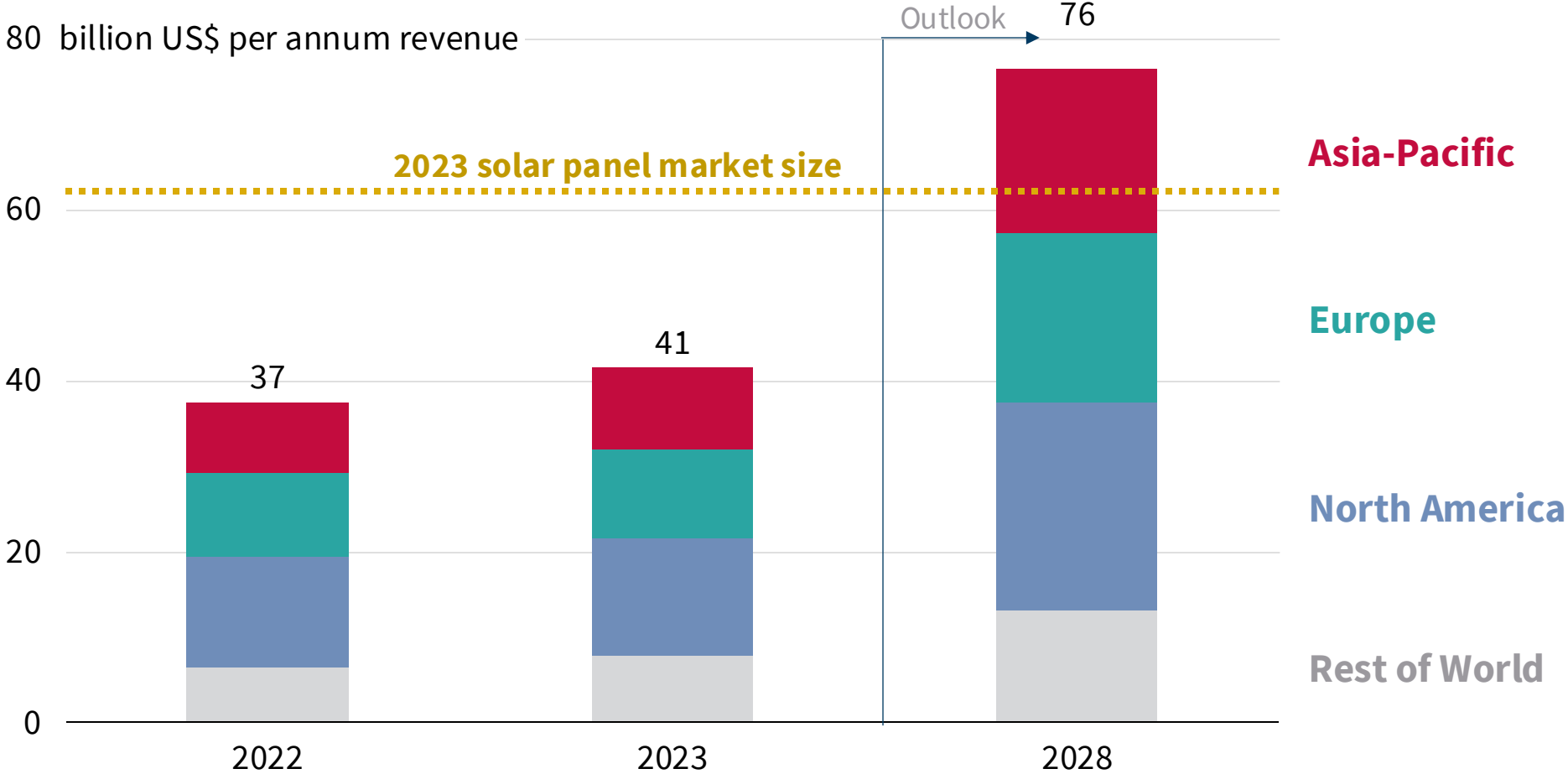


*i. Market potential based on IEA NZE market size.
Source: IEA WEO; IEA ETP 2024; RMI analysis*

As well as other markets beyond manufacturing

The transition is not just about hardware; a lot of money can be made on software as well

Energy management software market size



Note

Profit margins on software tend to be an order of magnitude larger than the ~5% margin on solar panels. Total profits on energy management software are likely far above those of solar panels today.

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6 Why Change Will Continue



The growth of cleantech comes with four key benefits: economic growth, lower energy costs, energy security, and better public health. Since these benefits are primarily local rather than global, the driving force of change should be expected to come from the local level as well.

- **Cleantech brings jobs.** Cleantech is the main driver of employment growth in the energy sector. The IEA expects over 6 million new cleantech jobs by 2030 in manufacturing alone, ready to be captured by regions that move fast.
- **Cleantech drives growth.** One quarter of Chinese growth is driven by cleantech as well as the increase in energy investment in China. One-third of European GDP growth comes from cleantech today.
- **Cleantech will reduce energy costs.** DNV estimates that rising cleantech deployment will slash energy costs for households and add hundreds of dollars per year to disposable income.
- **Cleantech reduces exposure to inflation.** Unlike fossil technologies, once cleantech is installed it keeps delivering energy at a predictable price — even if supply chains falter or fuel costs rise.
- **Some 85% of territories in the three blocs are fossil fuel importers.** There are only 16 territories out of 110 surveyed that are exporters of fossil fuels. That includes only 1 in Europe (Norway), 4 in China (all in the North and Northwest), and 11 in the United States.
- **Almost all territories *could* be energy independent.** Almost every territory has the potential to generate all its own energy with renewables — with ample room to spare.
- **The greatest opportunity.** The United States has the greatest renewable endowment of the three regions, with 456 PWh, or 43 times its own energy demand. Within the United States, the West has enough to meet its demand 86 times over.
- **Cleantech reduces pollution and saves lives.** Over the past two decades, cleantech has already saved years of life for millions, as well as billions in public health spending.

Four drivers spur change

Moving rapidly means regions can be first to realize ...



Economic growth and competitiveness

Cleantech enables regions to grow jobs and economic output, and to provide households with more disposable income.



Affordability

Cleantech reduces fuel expenses, increasing disposable income. Once deployed, it delivers energy that is largely immune to global markets and inflation.



Energy security

Cleantech allows regions to reduce imports and exposure to get rid of the dependency on fossil fuel markets — where an interruption can halt the entire economy.



Improved public health

Moving away from fossil fuels means a reduction in air pollution, which is responsible for over 7 million deaths and millions more illnesses per year.

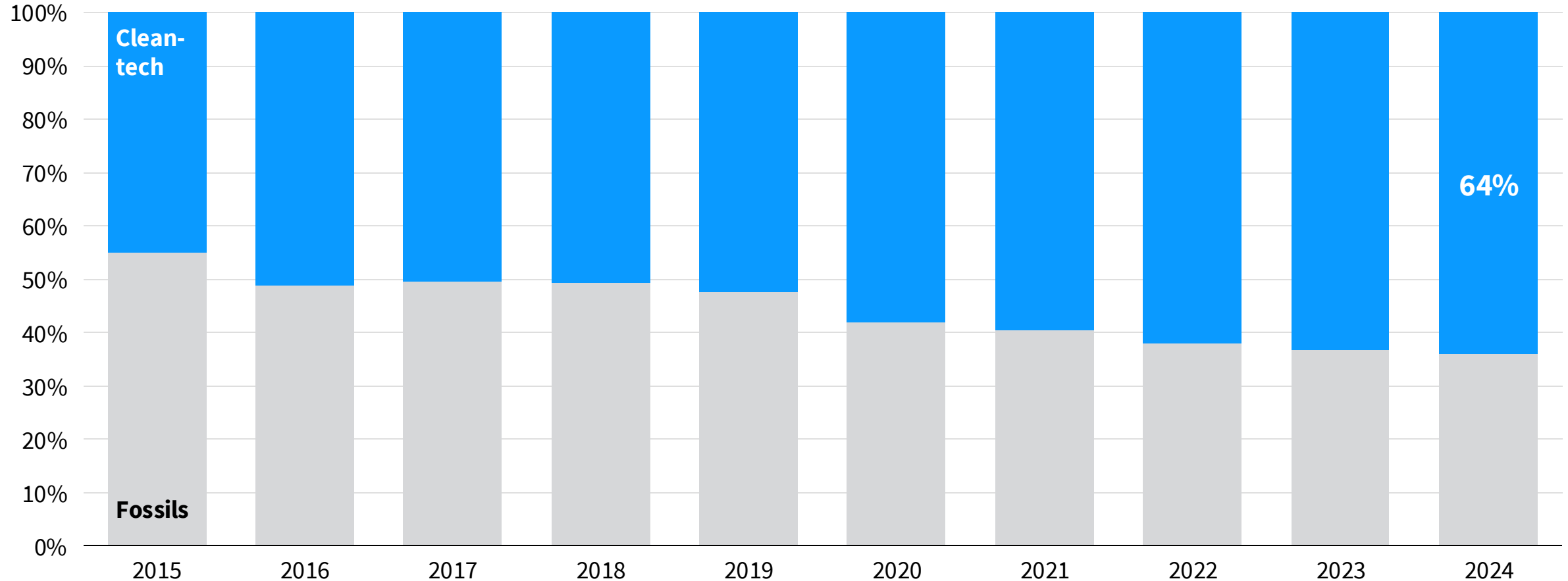


The benefits of cleantech are primarily local — hence so is the impetus for change

Capital is flowing to cleantech

Cleantech attracts almost two-thirds of global investment going into energy today

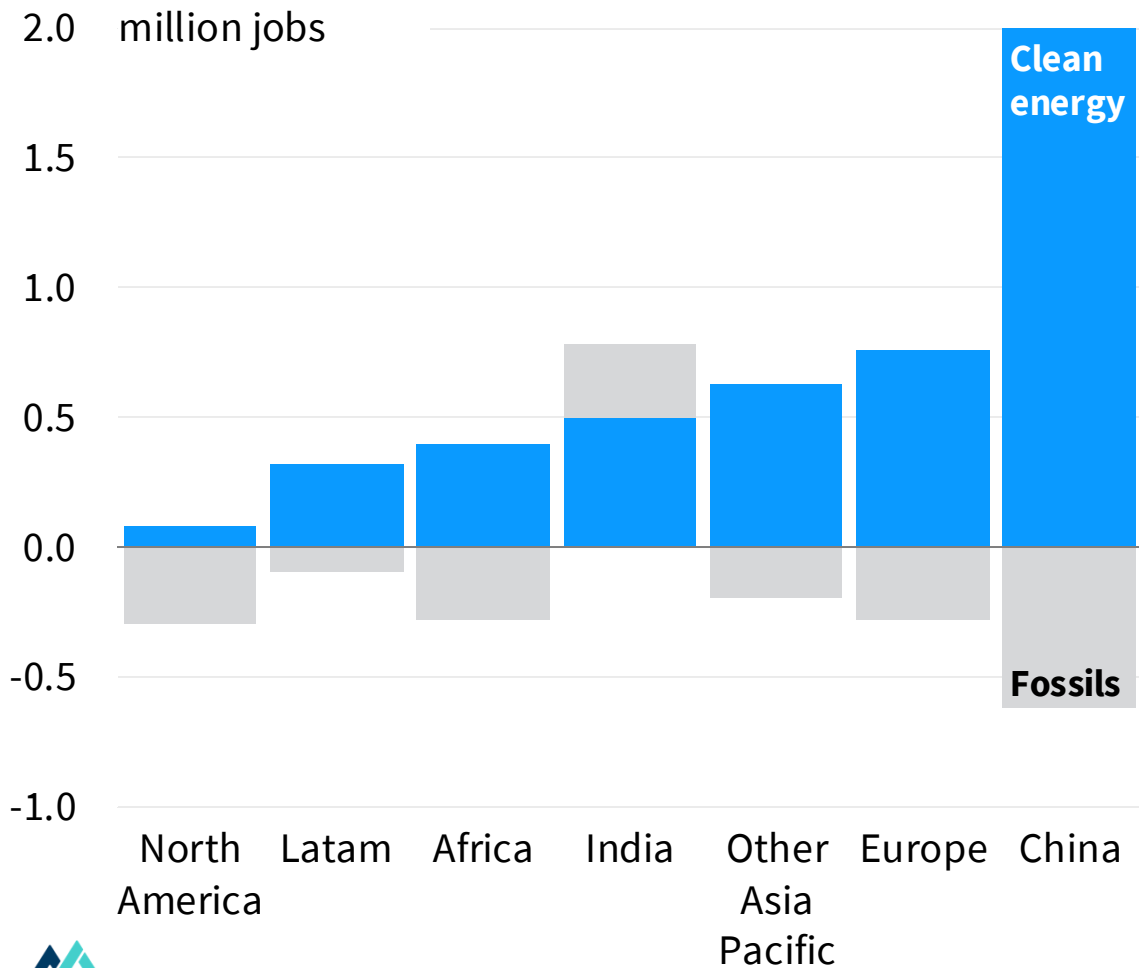
Share of global energy investment



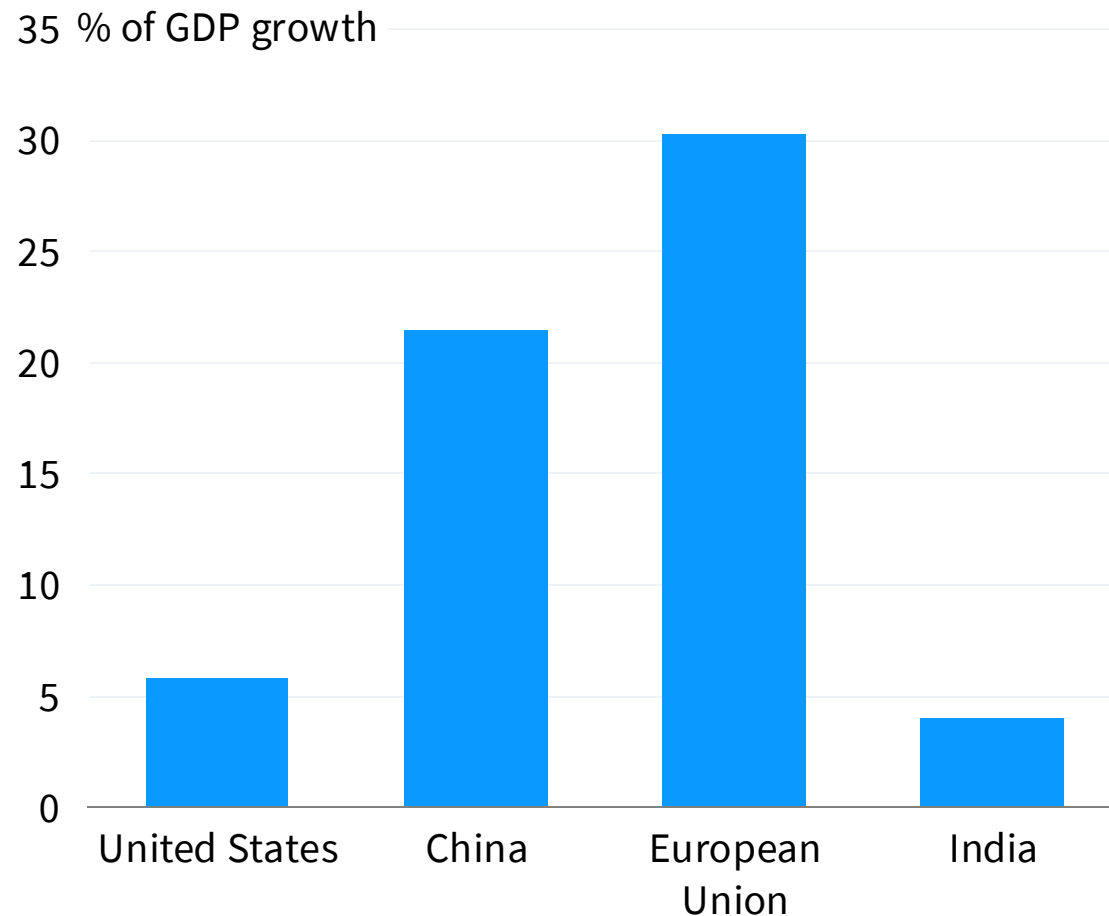
Cleantech brings prosperity

New energy technologies generate millions of jobs and boost economic growth

Change in energy employment, 2019–2022



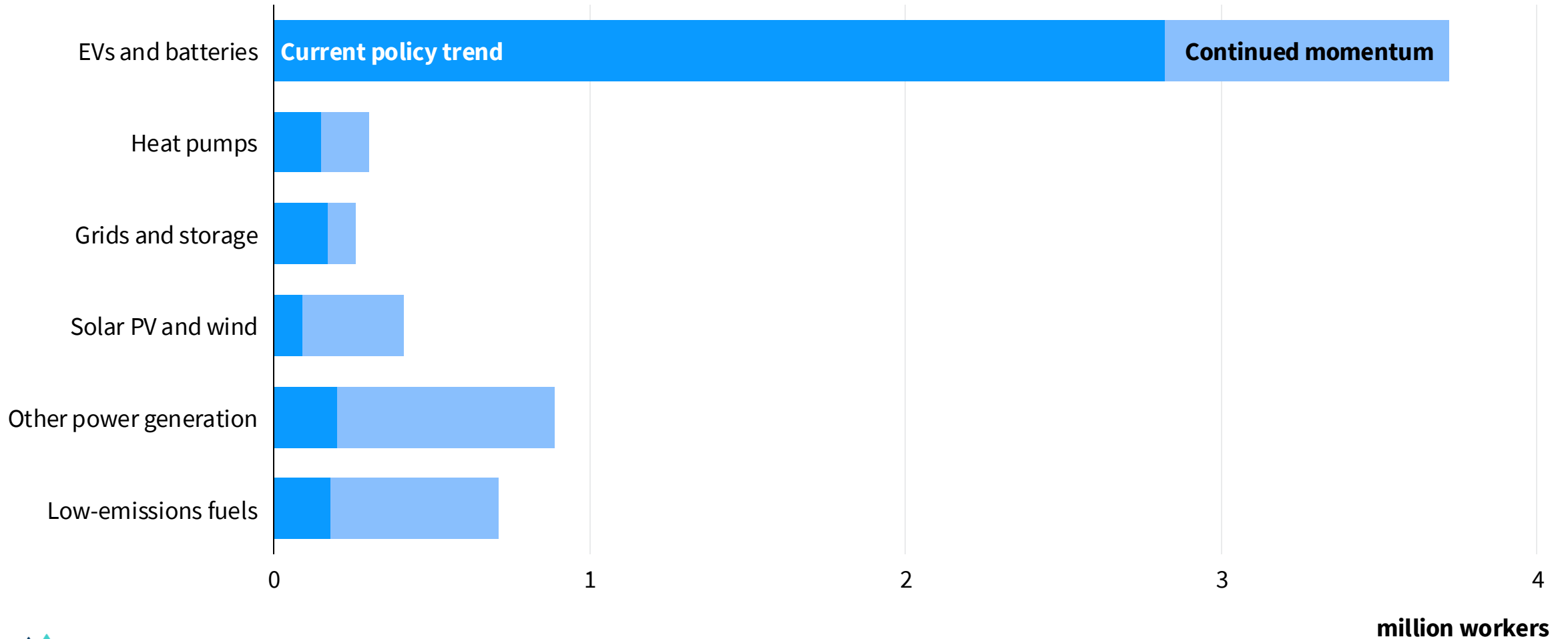
Contribution of cleantech to GDP growth, 2023



Millions more jobs are up for grabs

And fast movers will be able to bring these jobs to their districts

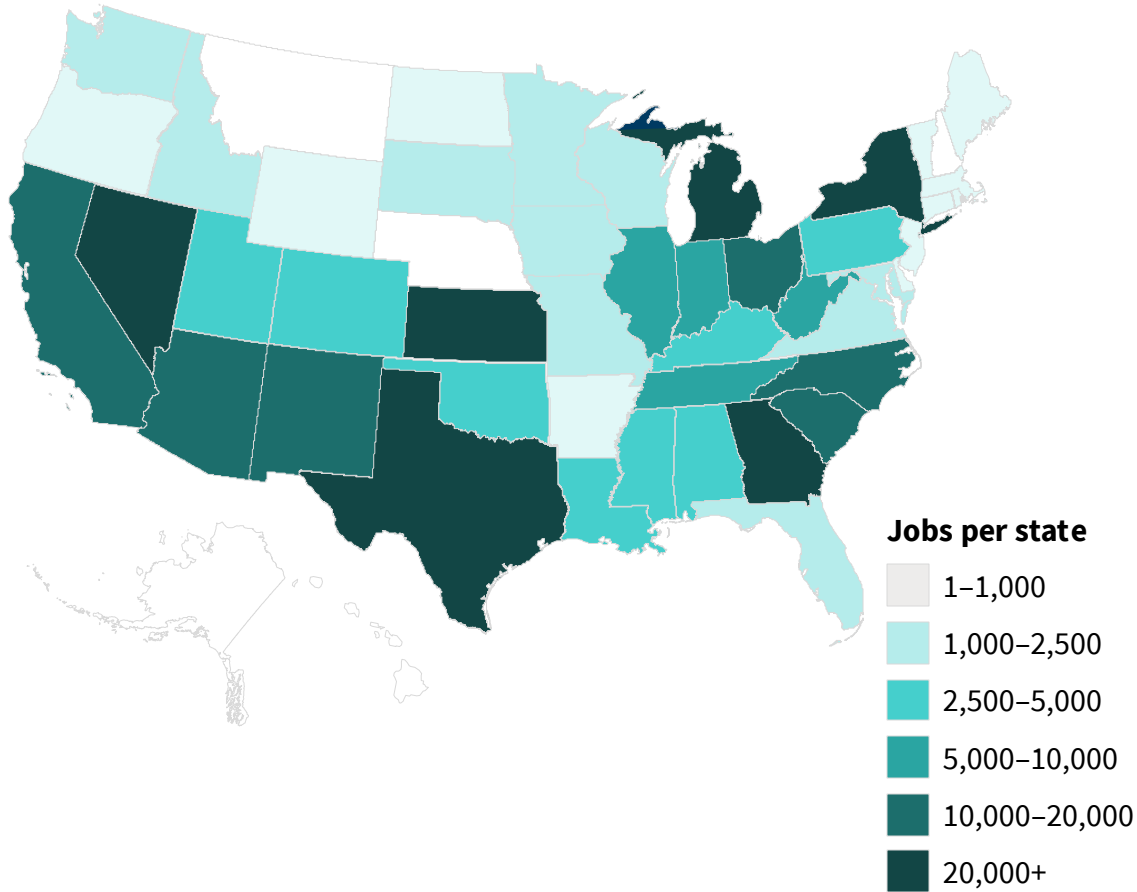
Global growth in manufacturing employment, 2022–2030



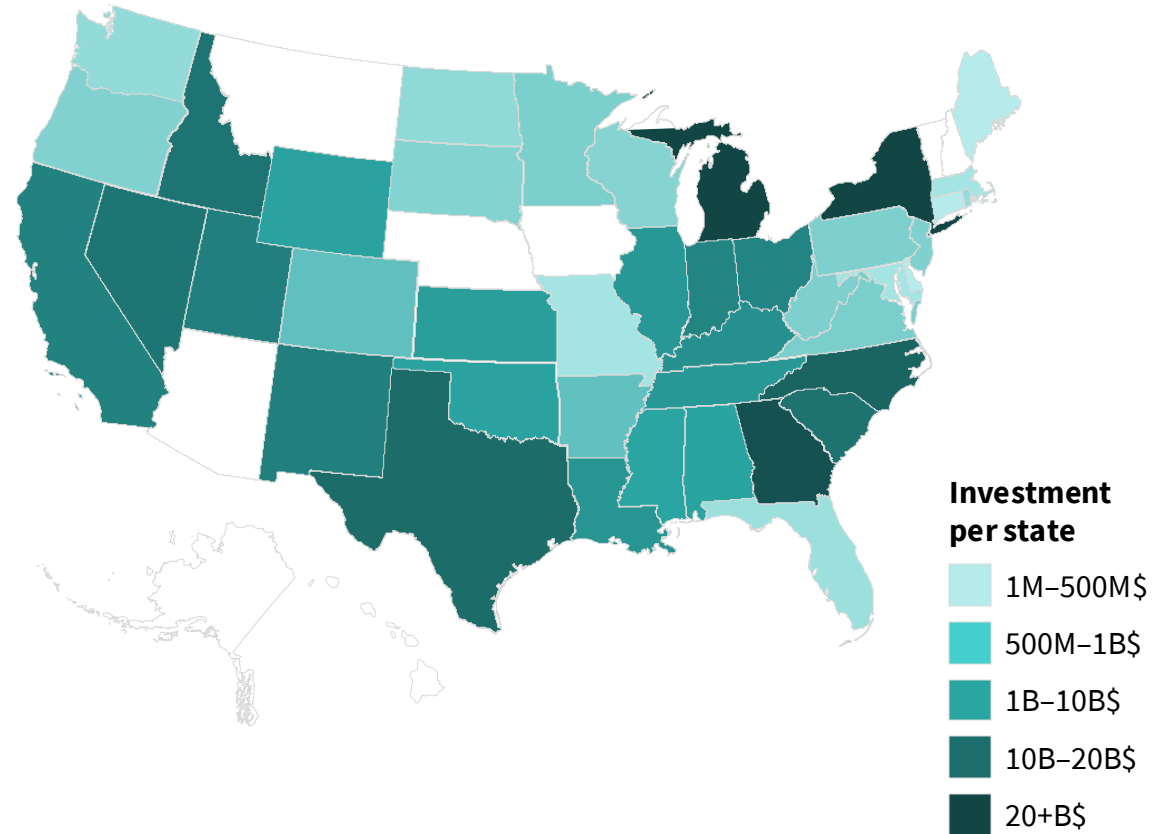
Benefits go to those regions that act fast

Most of the recent US manufacturing boom growth went to the few states that moved fast

Clean energy jobs announced per state



Clean energy investment announced per state



Cleantech boosts disposable income

More efficient technology means households spend less money on energy

Examples of cleantech efficiency gains

Fossil grid power



30%–40% efficient



Rooftop solar



100% efficient

2x–3x
as efficient

Gas boiler



85% efficient



Heat pump



300%–400% efficient

3x–4x
as efficient

ICE car



25%–40% efficient



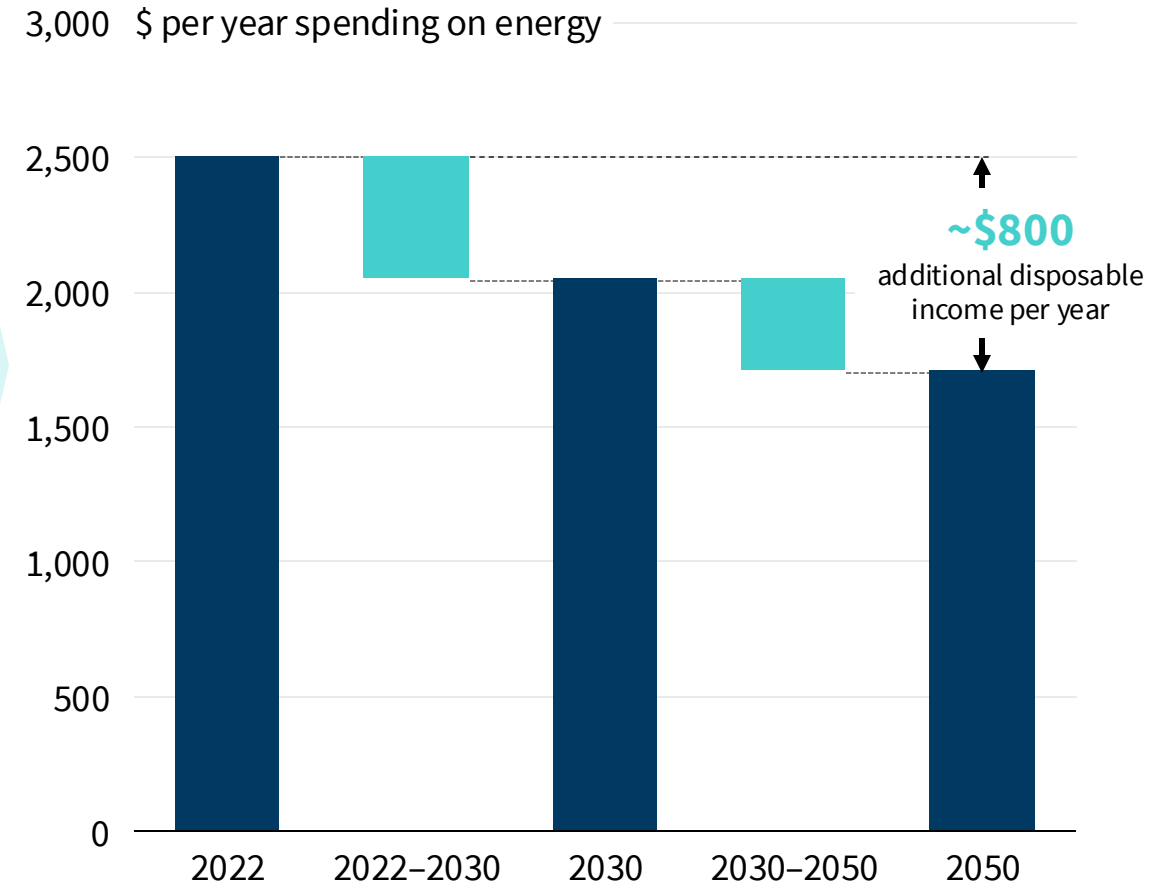
EV car



80%–90% efficient

2x–4x
as efficient

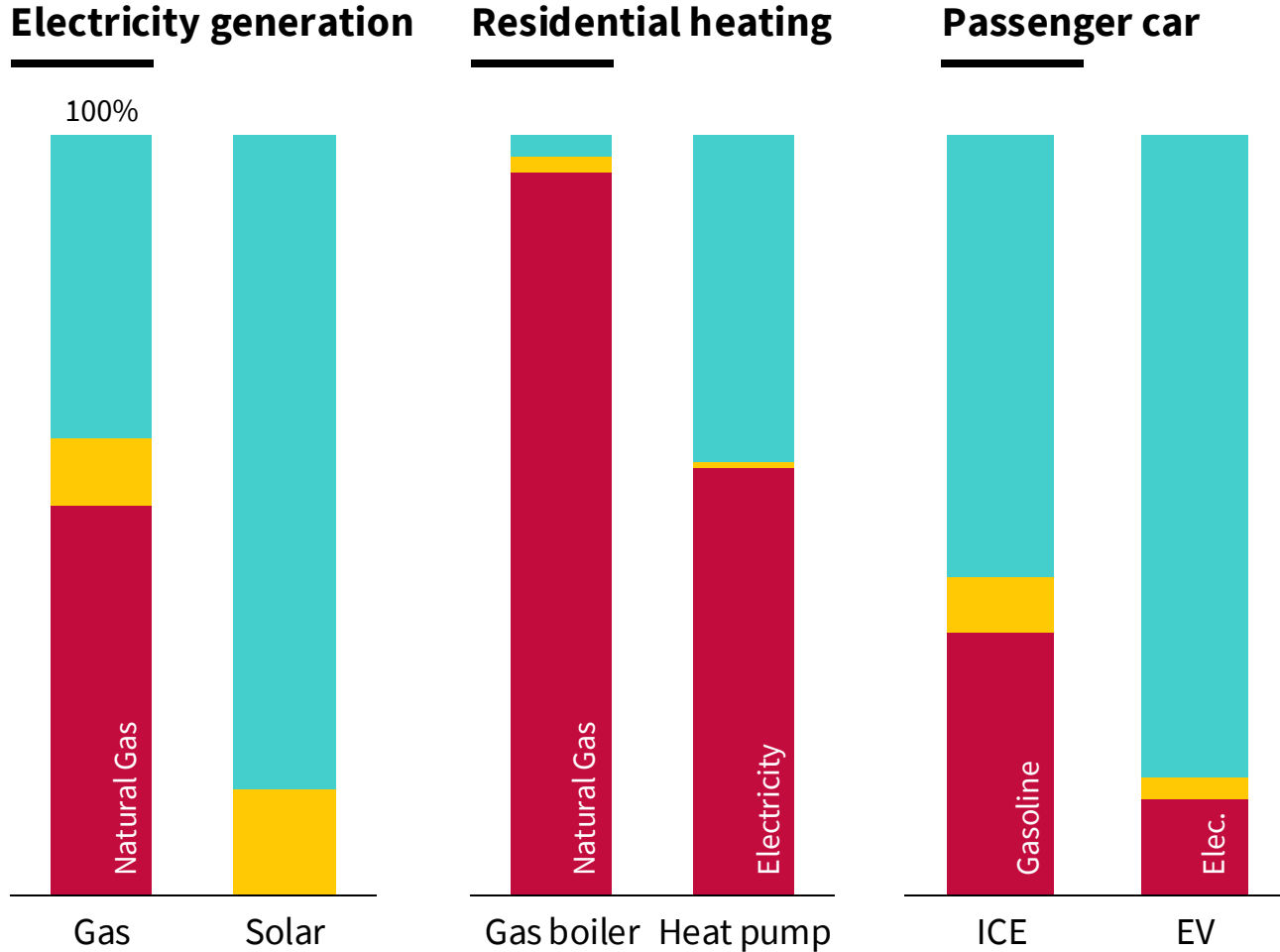
Translation into household savingsⁱ, EU, average, estimate



Cleantech lowers exposure to inflation

Once installed, cleantech costs remain stable — even if global supply chains falter or fuel costs rise

Total cost of ownership breakdown, %, US examples



Inflation risk after deployment

Fixed cost

**Low/
None**

Cost already sunk
Costs don't change with inflation, as technology is already deployed.

Maintenance cost

Mid

Labor and manufacturing inflation
Inflation in labor and replacement parts can raise maintenance costs.

Energy cost

High

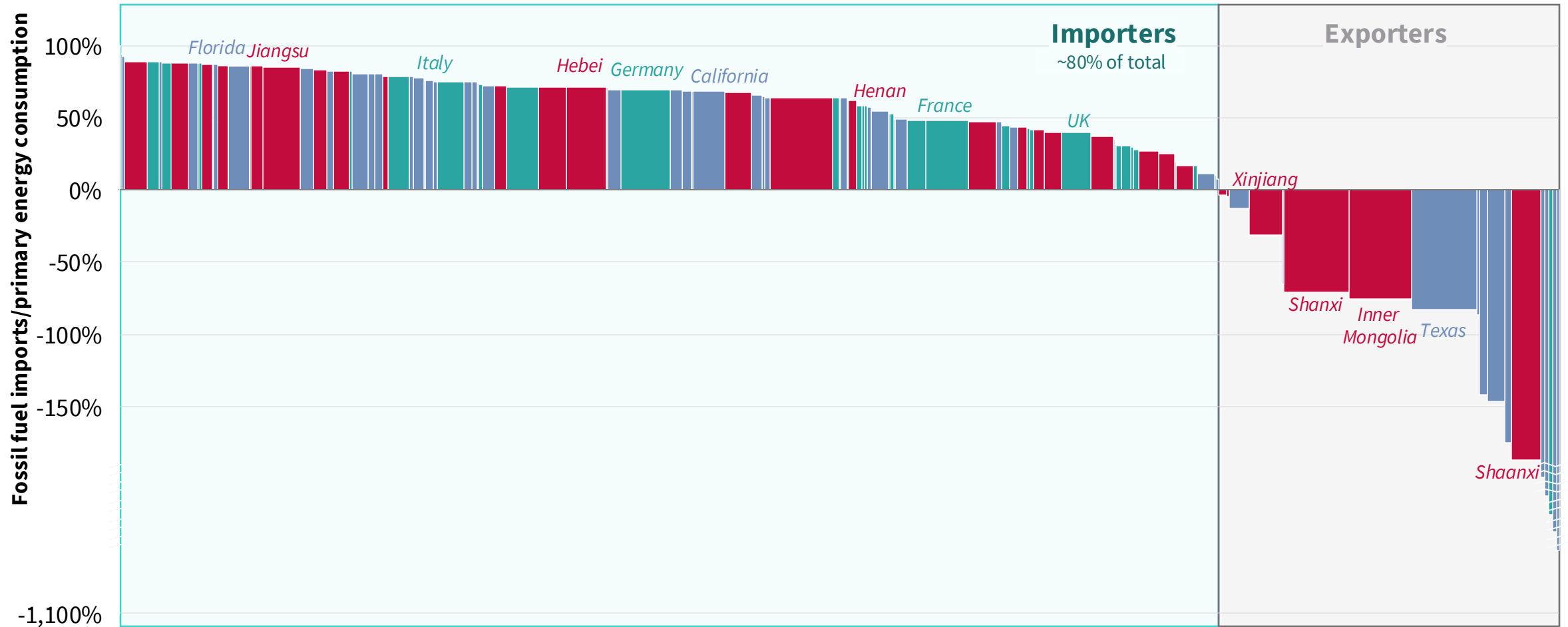
Energy inflation
Note: This applies less to cleantech, as purchased electricity can originate from renewables like solar power, which primarily involve fixed costs and therefore carry minimal inflation risk.

Some 85% of territories across the blocs are fossil importers

Even the net fossil-exporting United States consists mostly of fossil-importing states

Fossil fuel imports (exports) as share of primary energy demand

US Europe China



Share of primary energy demand



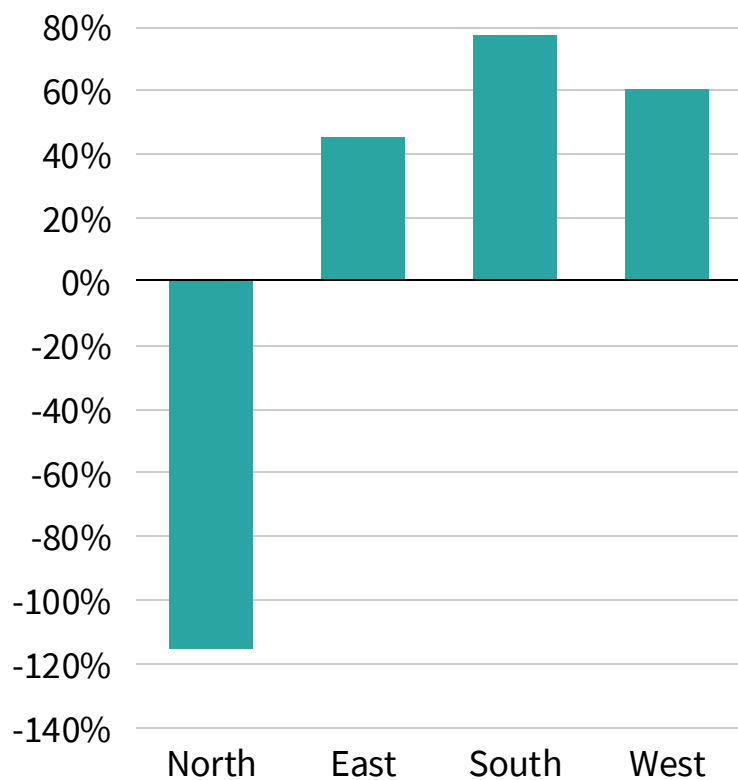
Note: China data approximated based on apparent consumption and production. Offshore oil production is not allocated to US states.
Source: EIA; IEA; National Bureau of Statistics of China; RMI analysis

The fossil fuel story by region

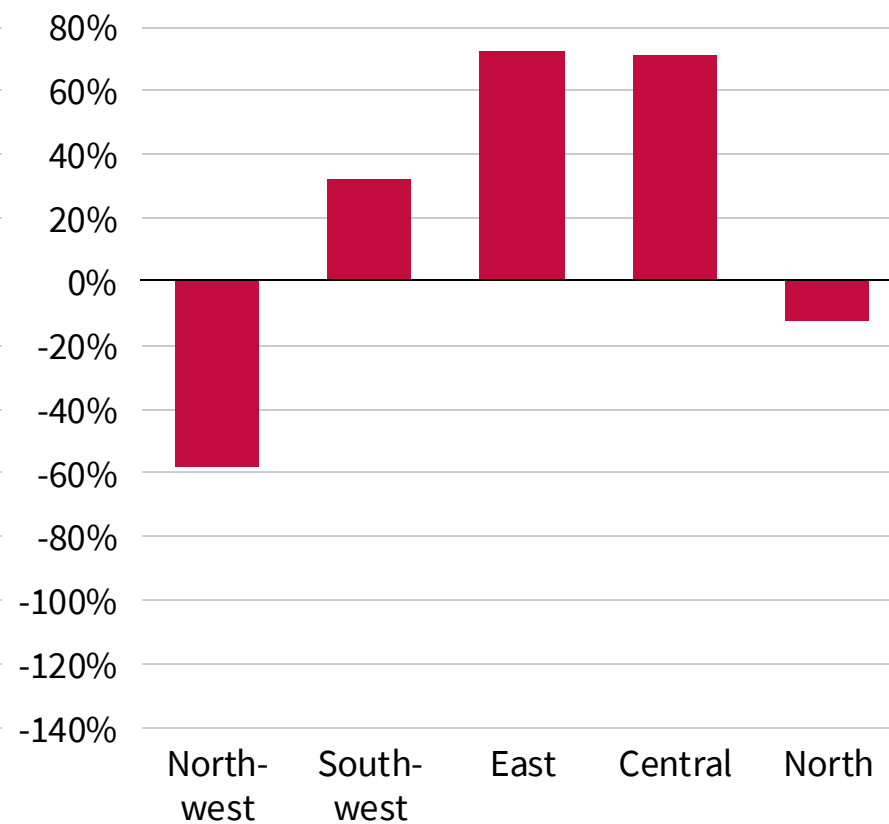
Central and Eastern China and Southern Europe are the most import-dependent

Fossil fuel imports as share of demand

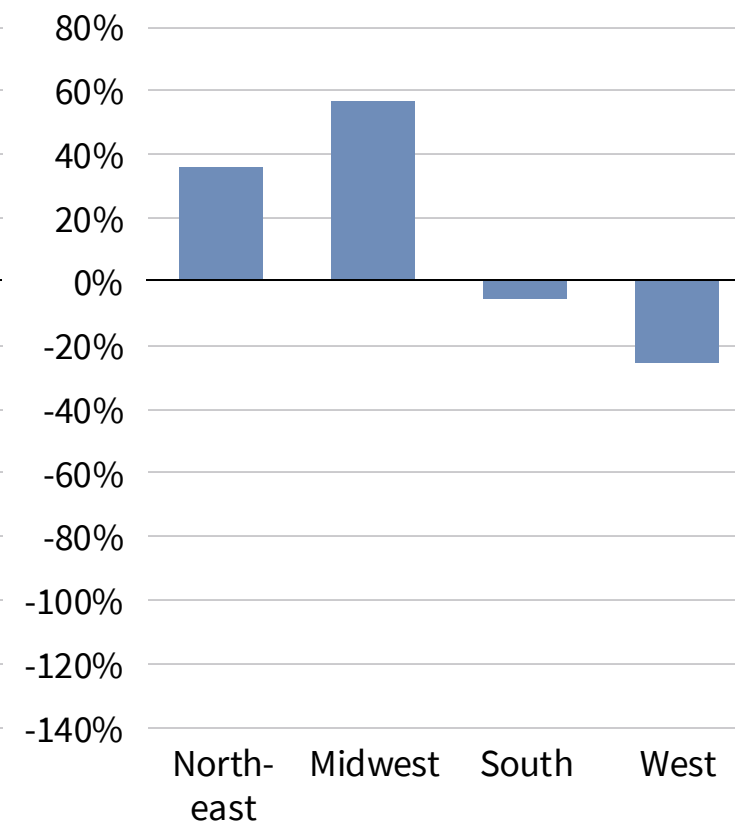
Europe



China



United States



The fossil fuel story by territory

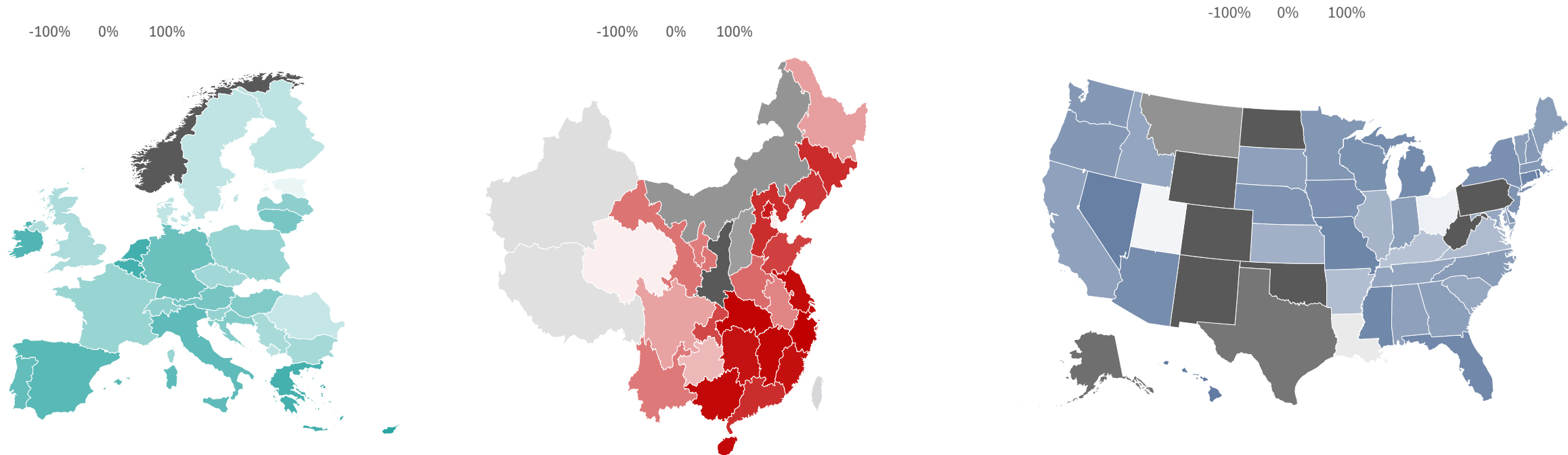
Fossil fuel exporters are highly concentrated

Fossil fuel imports (exports) as share of demand

Europe

China

United States



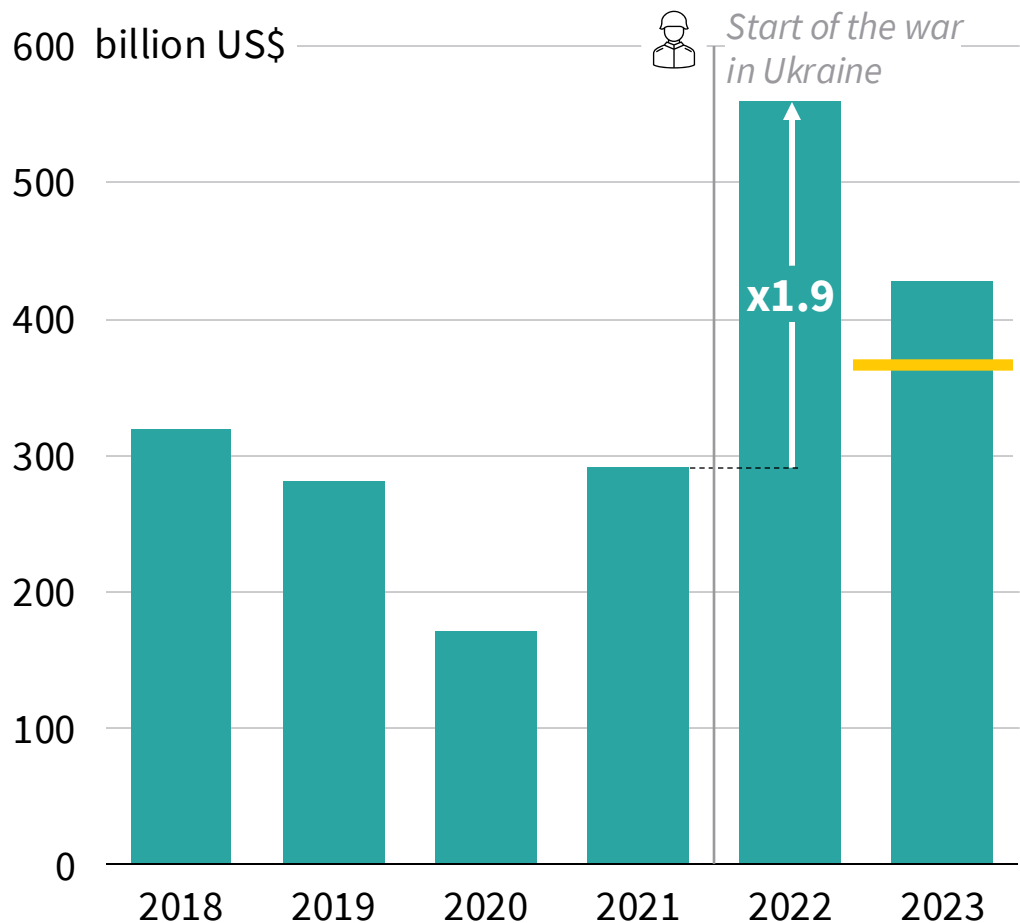
Note: Figures above 100% or below -100% have been capped at +/- 100% for visual purposes. These maps are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city, or area.

Source: EIA; IEA; National Bureau of Statistics of China; RMI analysis

Fossil import dependency is expensive – and risky

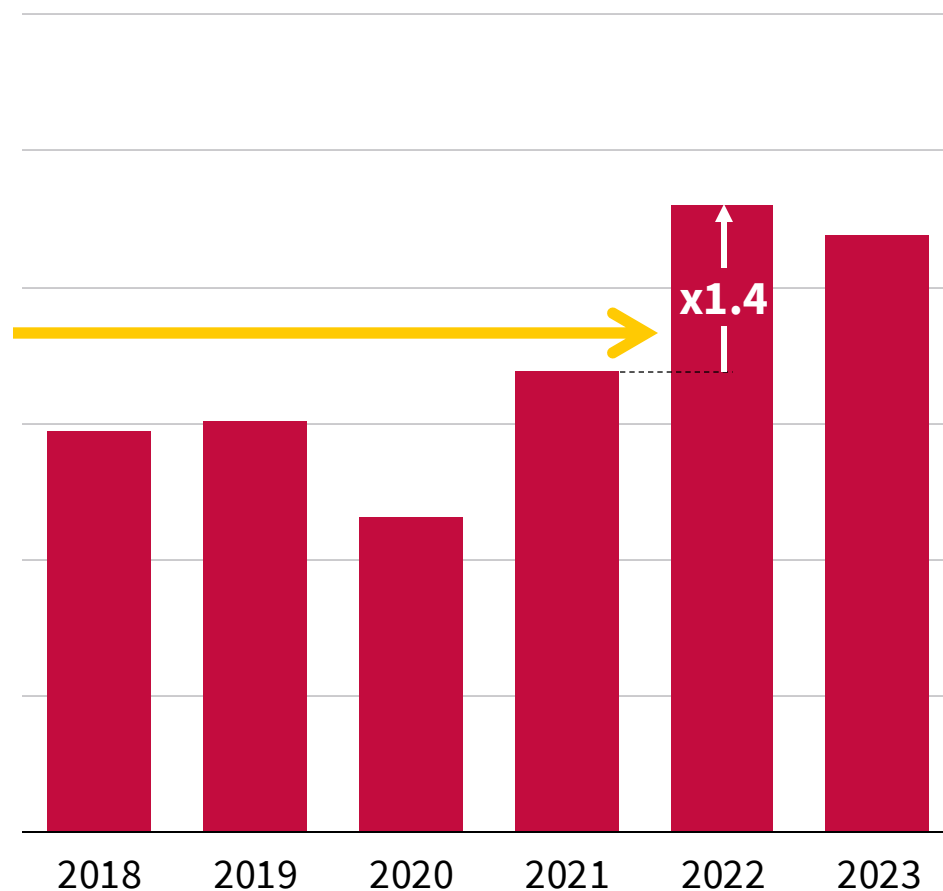
Fossil imports cost billions and are subject to sudden price surges caused by both local *and* faraway events

Europe net spending on fossil fuel imports



International fossil commodity markets directly translate European shortages to global price hikes and a higher burden of raised imports for all

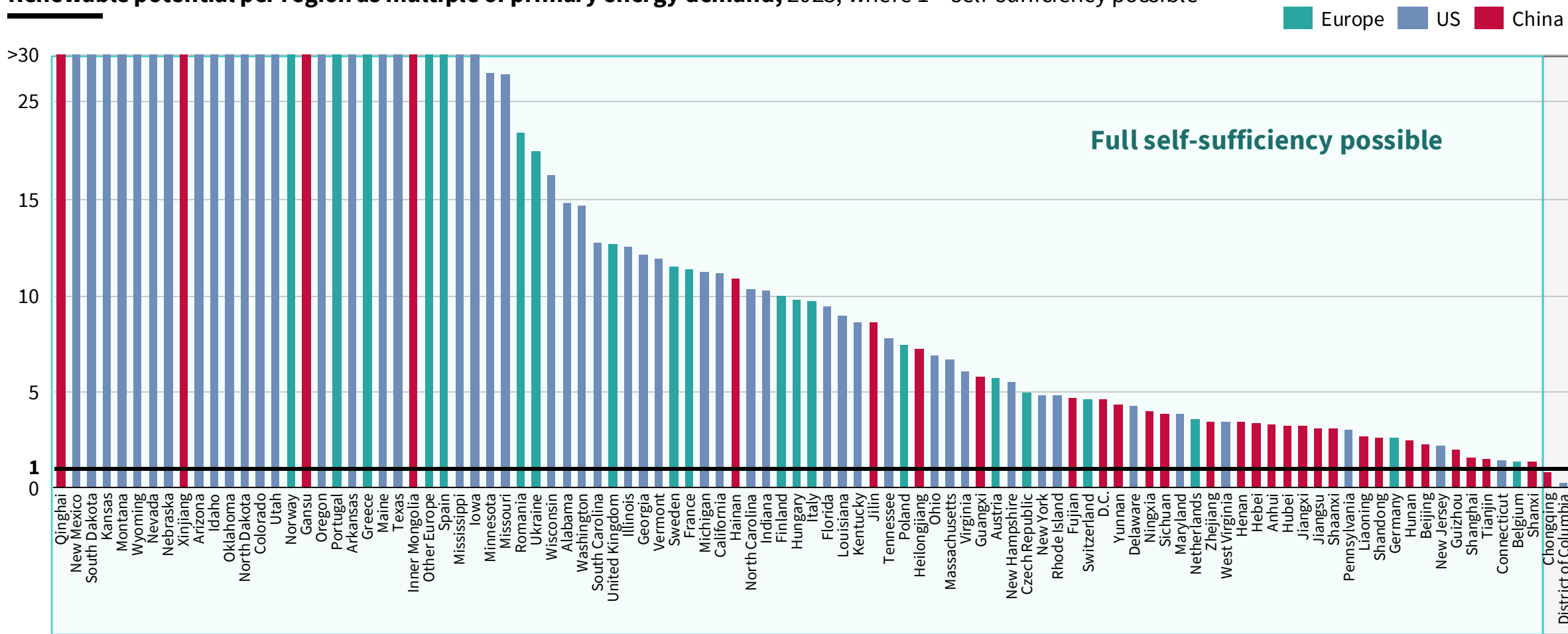
China net spending on fossil fuel imports



Renewables allow for full energy self-sufficiency

Almost every territory could generate enough renewable energy to supply all its own demand

Renewable potential per region as multiple of primary energy demand, 2023, where 1 = self-sufficiency possibleⁱ



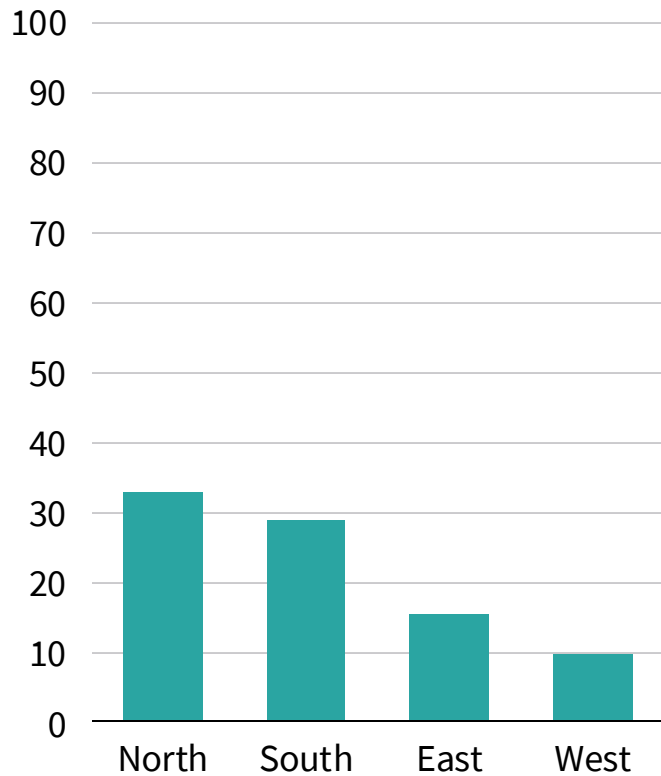
*i. This accounts for 40% efficiency gain at the primary energy level when switching from fossils to electricity.
Source: NREL; Solargis; Wang et al. (2022); Jacobson et al. (2019); RMI analysis to ensure consistency of approach*

Renewable potential by region

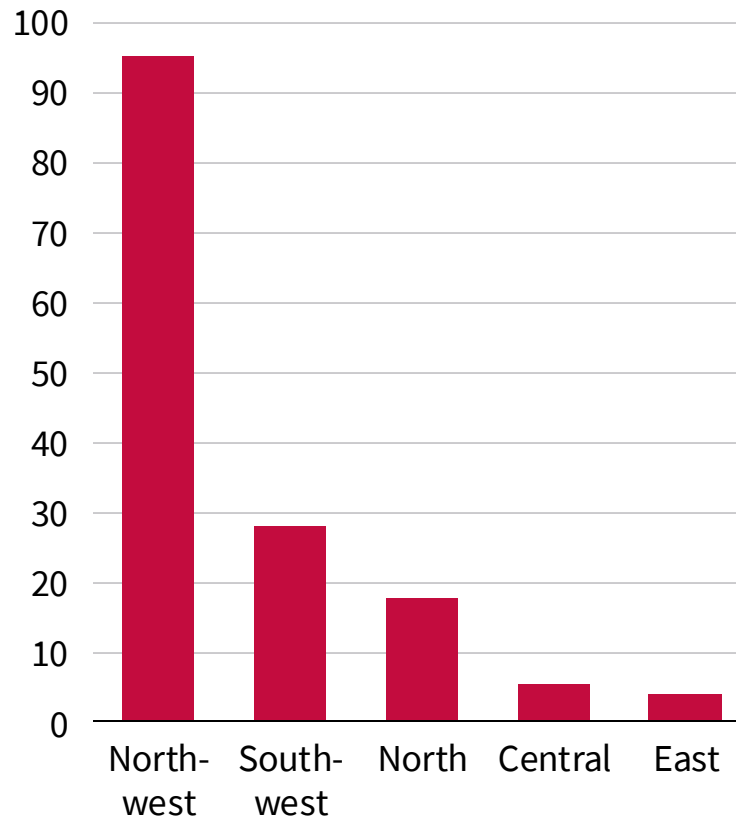
The United States has the greatest potential

Solar and wind potential as a multiple of demand

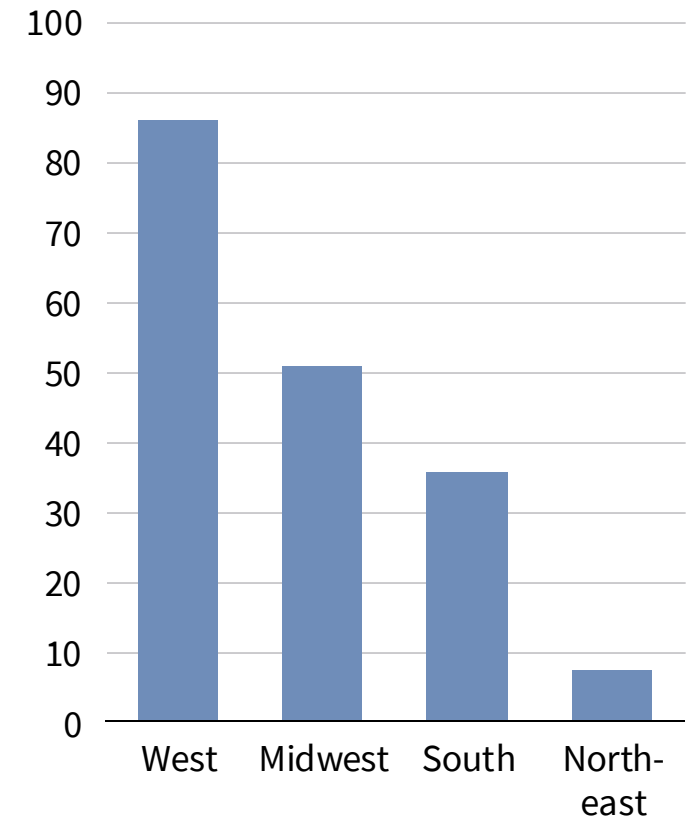
Europe



China



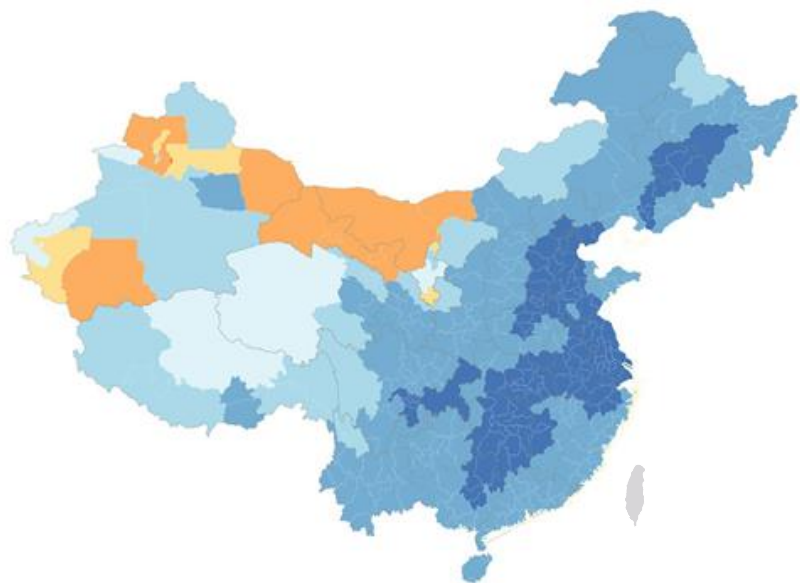
United States



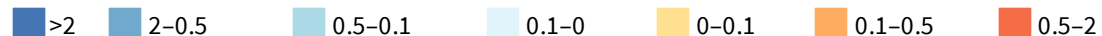
Reducing air pollution has already added years of life in China

But there are still many more years that can be added to life expectancy through cleantech

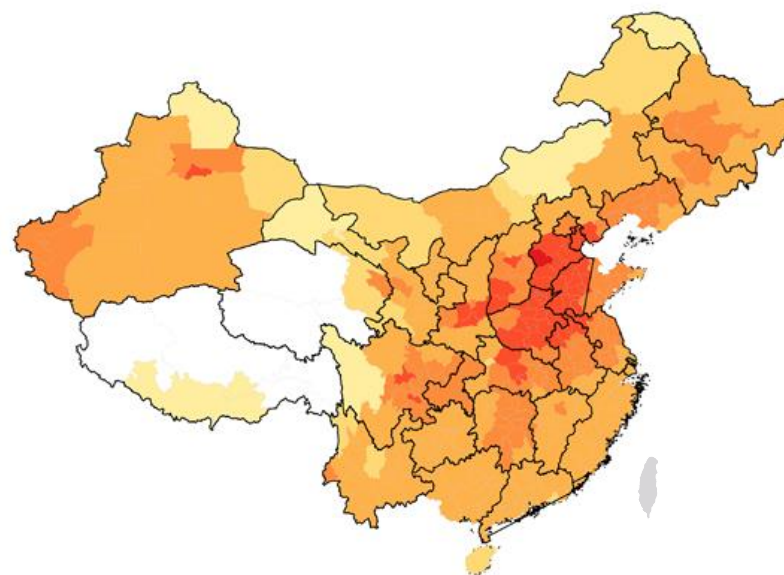
Improvements in life expectancy due to reduced pollution between 2014 and 2022



Change in life expectancy in years (blue values indicate improvement)



Potential gain in life expectancy from permanently reducing PM_{2.5} from 2022 concentration to the WHO guideline



Potential gain in life expectancy in years

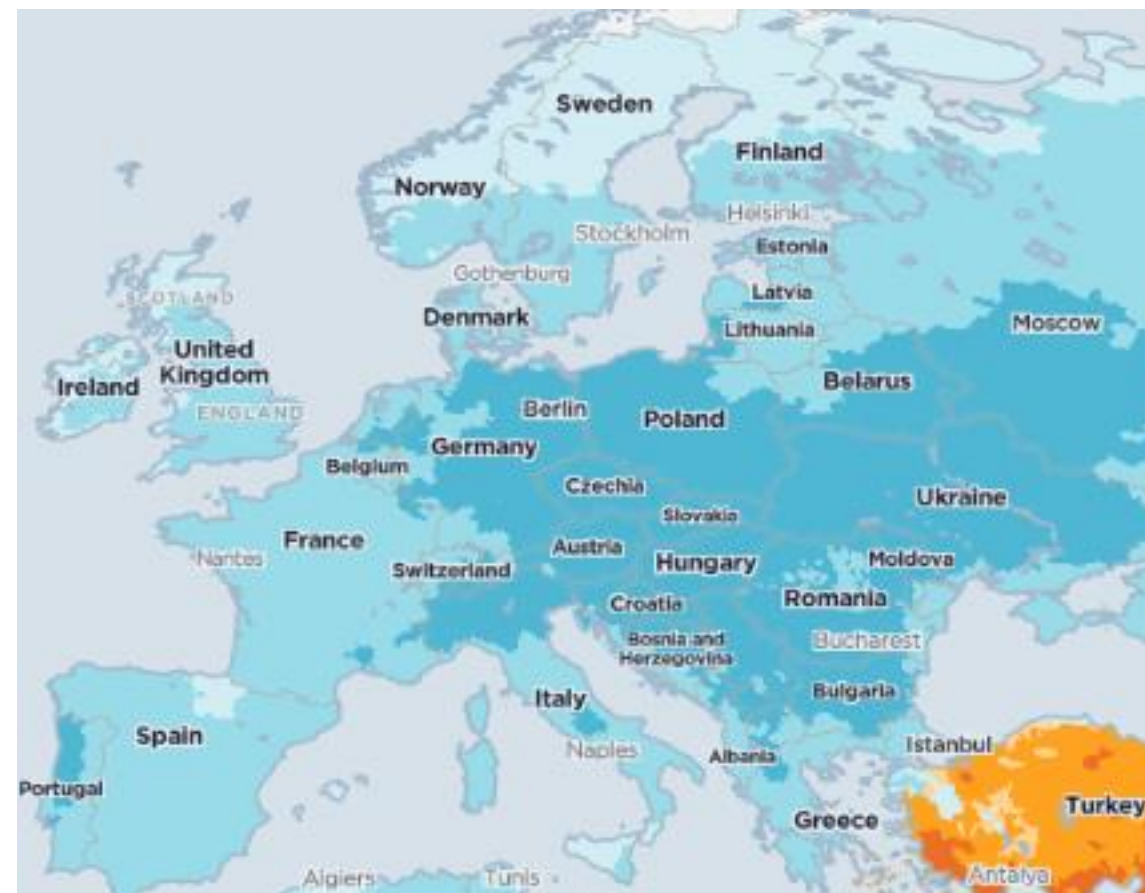
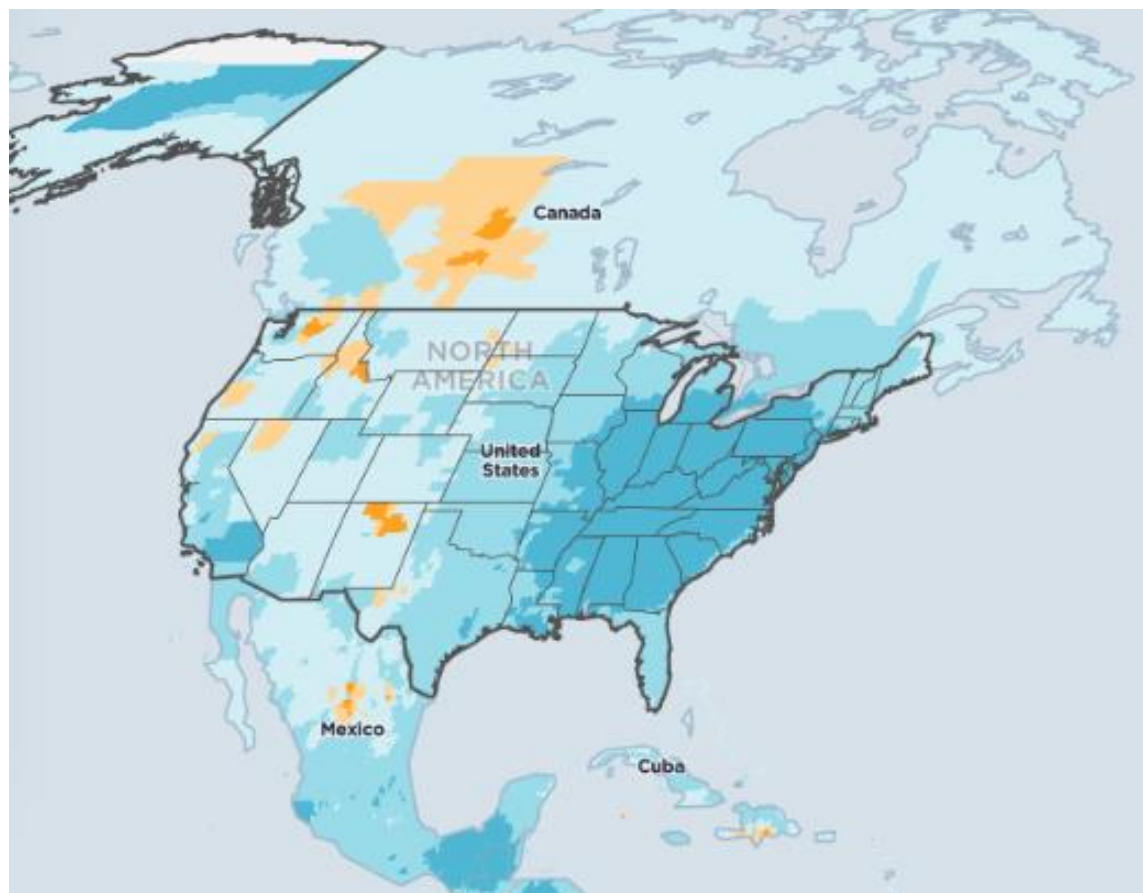
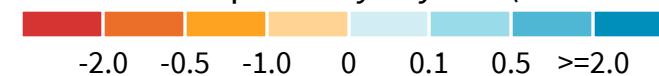


Note: These maps are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city, or area. Air pollution impacts focus on fine particulate matter (PM_{2.5}) in these data sets.

US and European health improved as well

Fossil fuels caused 80% of air pollution deaths in these regions

Gain in life expectancy in years (2005–2022)



Note: These maps are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city, or area. Air pollution impacts focus on fine particulate matter (PM_{2.5}) in these data sets.



Source: Air Quality Life Index 2024; Lelieveld et al. (2023)

About RMI

RMI is an independent non-profit founded in 1982 that transforms global energy systems through market-driven solutions to align with a 1.5°C future and secure a clean, prosperous, zero-carbon future for all. We work in the world's most critical geographies and engage businesses, policymakers, communities, and NGOs to identify and scale energy system interventions that will cut greenhouse gas emissions at least 50 percent by 2030. RMI has offices in Basalt and Boulder, Colorado; New York City; Oakland, California; Washington, D.C.; and Beijing.

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