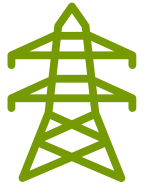


CORPORATE CLIMATE STOCKTAKE: POWER SECTOR





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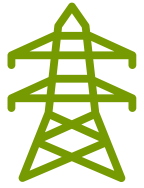
The **Transition Frontier** narrative explores the state of transition of the power sector in developed economies such as the US and EU

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The **Legacy Thermal** narrative explores the state of transition of the power sector in developing economies such as China, India and Southeast Asia

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The **Clean Generation** narrative explores the state of transition of the power sector in emerging economies such as Latin America and Africa



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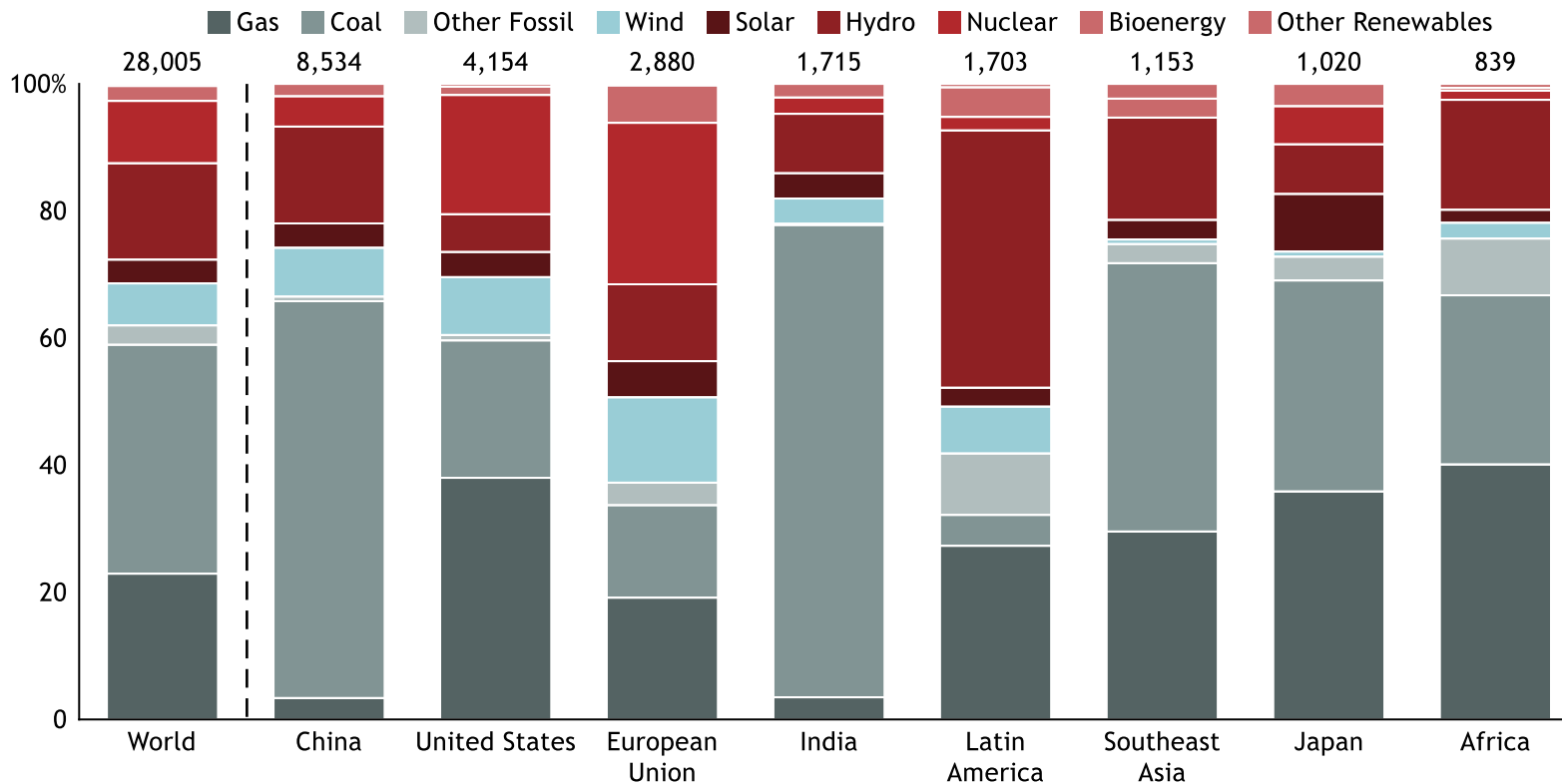
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The **Clean Generation** narrative explores the state of transition of the power sector in emerging economies such as Latin America and Africa

~61% of global power generation occurs in four major economies - China, the US, EU and India - though generation mix varies significantly by geography

~27% of world power generation comes from renewable sources (solar, hydro, wind)

Annual power generation by source (TWh, 2021)



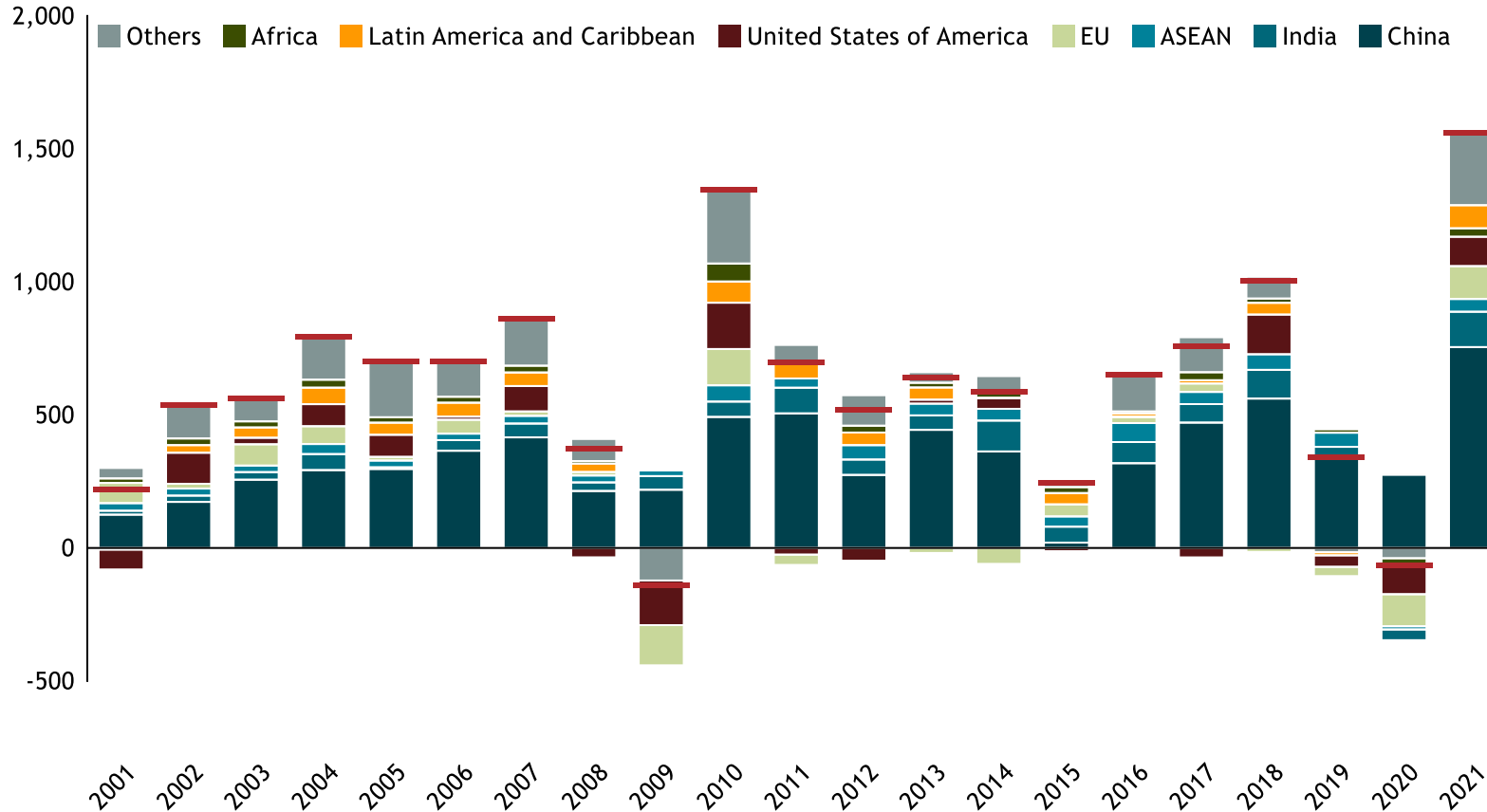
Commentary

- **China and India predominantly rely on coal** for their power generation, primarily due to its cost-effectiveness. Together they account for **65% of global coal-based power production**
- The EU and US have a **larger portion of nuclear** in their power mix than other regions
- **China's nuclear capabilities are young and growing**; despite the low portion of nuclear power (~5%), they generated the third largest amount of nuclear power in 2022
- African countries primarily rely on fossil fuels (76% of generation), with **per capita consumption set to rise** - in 2022, 43% of Africa's population lacked electricity access
- **EU and LATAM generate over half their power from clean sources**
 - LATAM historically generates most of their power from hydro while the EU is reliant on nuclear power sources

Note: Latin America includes Mexico, Central America, South America, and the Caribbean; Southeast Asia includes Philippines, Indonesia, Vietnam, Malaysia, Thailand, Myanmar, Laos, Cambodia, Singapore, Brunei
 Source: Ember, Lit. search

Since 2001, there have only been two years when net electricity demand decreased

Year-on-year change in electricity demand by regions (TWh)



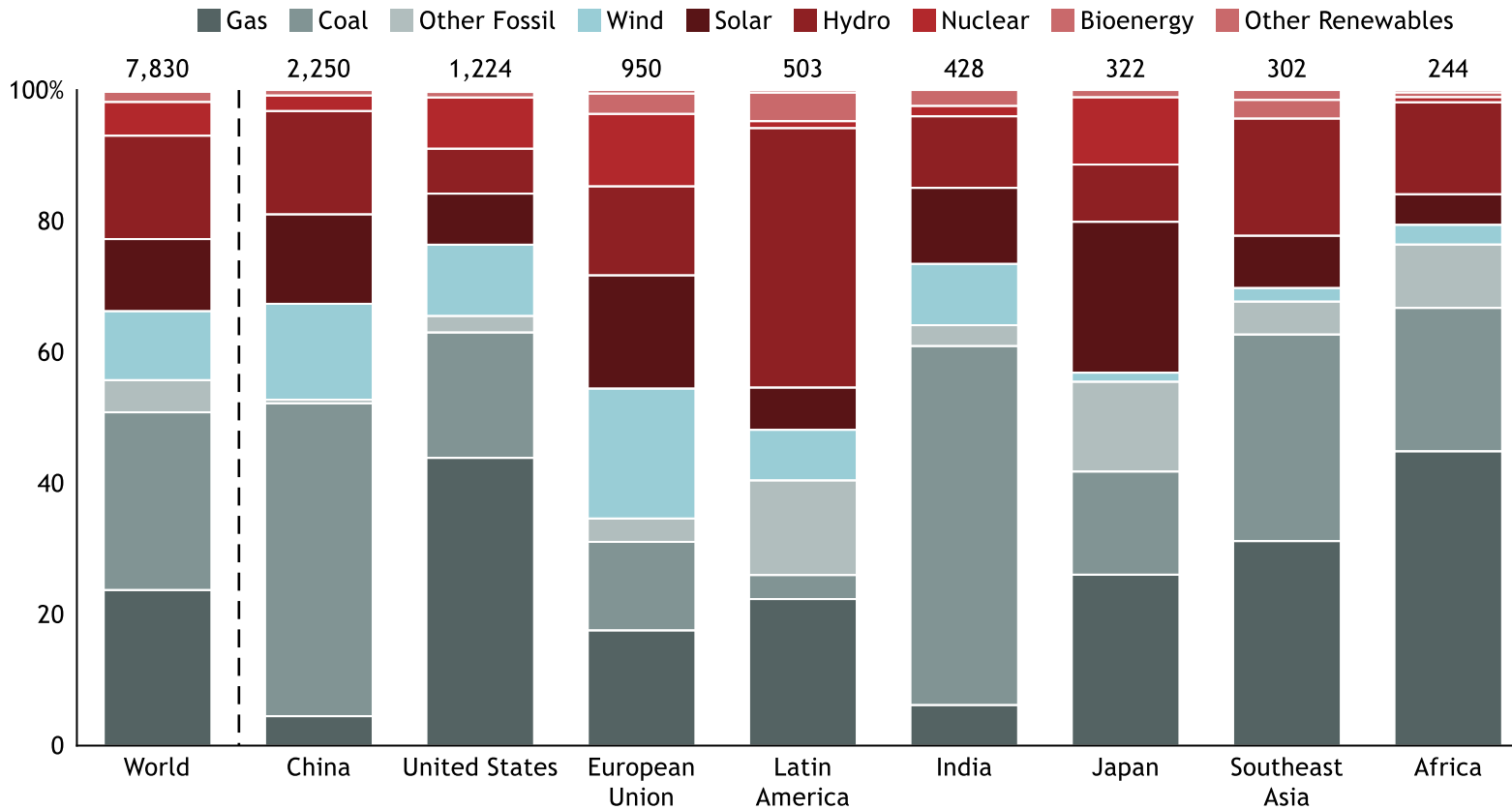
Commentary

- Since 2001, the only time there has been a net decrease in electricity demand was in the years following the **Global Financial Crisis and Covid-19 pandemic**
- **China has continued to have the largest year-on-year increase** in electricity demand for the last two decades
- Aside from these two global crises, the **U.S. and EU have contributed to the largest year-on-year decreases** in demand
- **Industrial demand, access to electricity, and electrification of sectors such as the automobile industry** will lead to increases in future demand which emphasizes the importance of decarbonizing the power sector

Clean electricity capacity represents ~45% of global capacity and ~27% of global generation

Clean power capacity sources contribute to ~45% of global power capacity

Annual power capacity by source (GW, 2021)



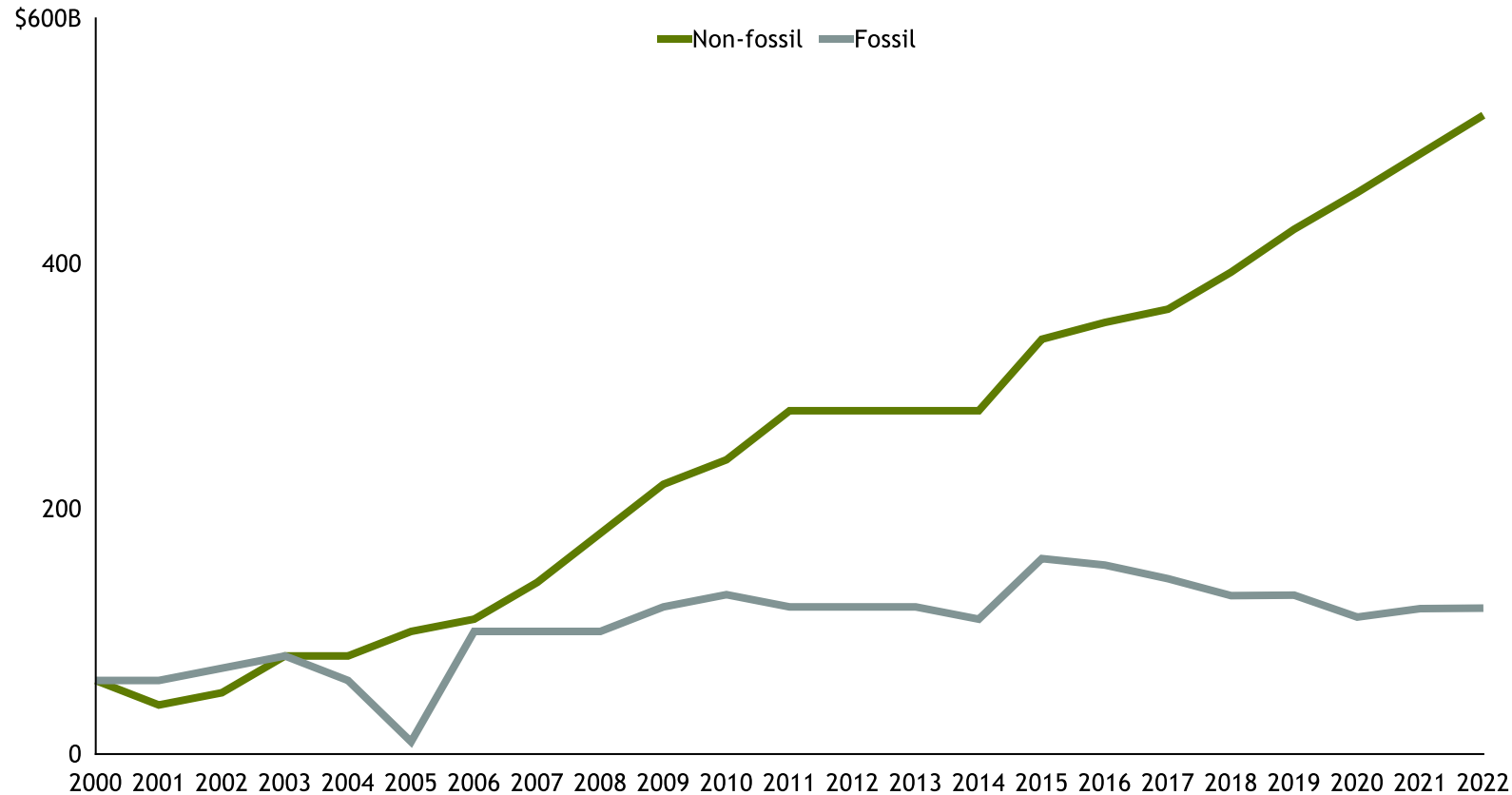
Note: Latin America includes Mexico, Central America, South America, and the Caribbean; Southeast Asia includes Philippines, Indonesia, Vietnam, Malaysia, Thailand, Myanmar, Laos, Cambodia, Singapore, Brunei
 Source: Ember, Lit. search

Commentary

- **Capacity** refers to the **theoretical maximum** amount of electricity a source can produce based on its design and physical constraints
 - **Power generation** reflects the **real amount of electricity** that was produced and used over a period
- **Solar and wind** make up a **larger percentage of power capacity** than generation for most regions
 - The need for T&D infrastructure development and the intermittency - the inability to generate power due to external factors - of renewable power sources drive this gap
- **Gas** contributes to ~25% of global power capacity while only contributing to ~23% of generation, indicating the use of **gas power as a peaking strategy** in some regions
 - The US is generating additional gas power during peak times to meet demand, rather than always using that capacity
 - Countries like the US and China use power sources like gas and coal to fill in excess demand because they are more reliable than renewable sources due to intermittency

Global capital investment in non-fossil dependent power generation has been outpacing fossil investment since 2004, reaching \$520 billion in 2022

Capital expenditure on electricity generation (\$B)



Commentary

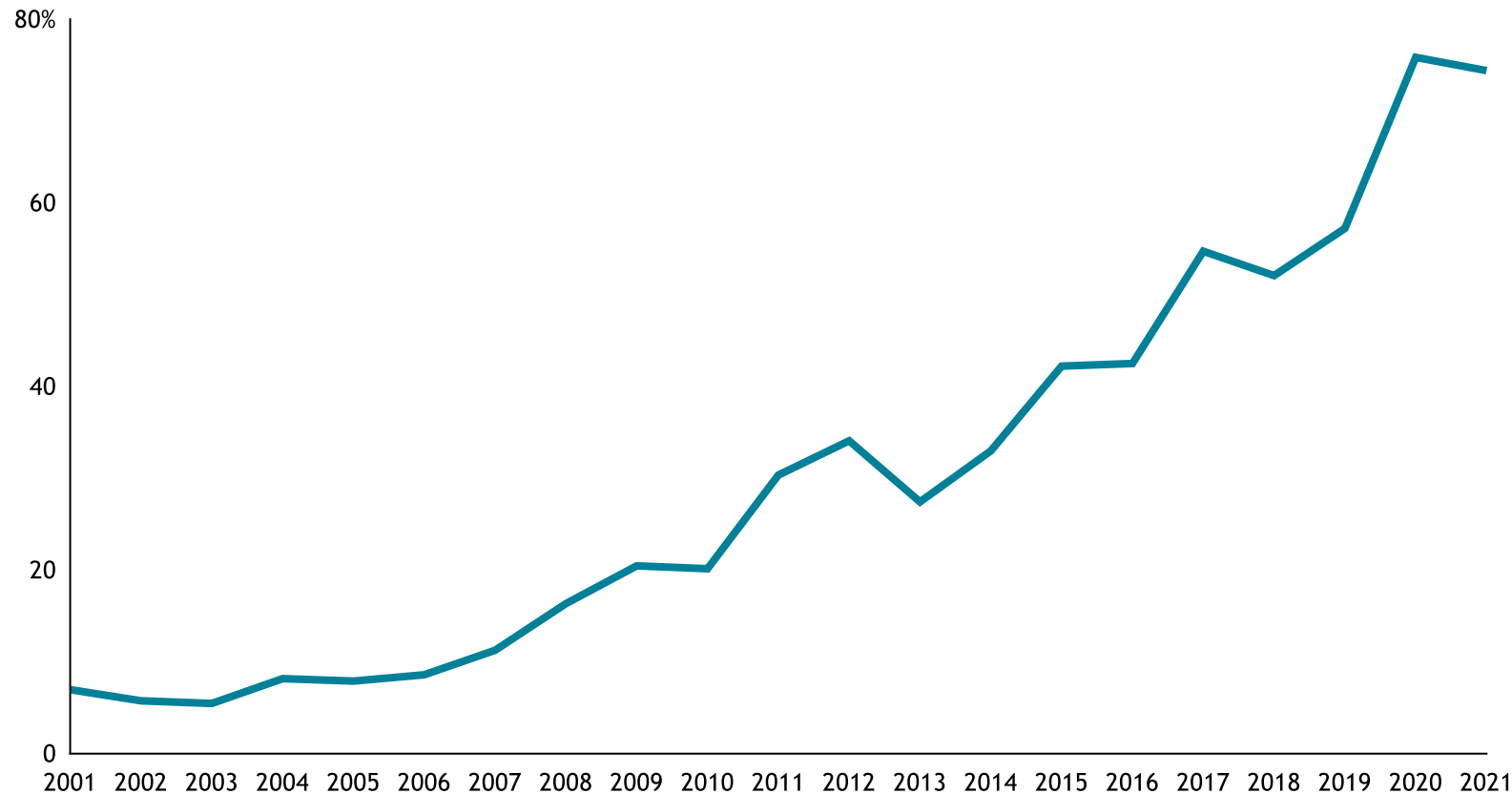
- **Renewable generation CapEx in 2022 was \$520 billion, 10 times larger than 20 years ago**
- **In 2022, over 80% of all new electricity generation capital was being invested into renewables**
 - This is true for developed markets (88%), China (89%), and the Global South (63%)
- **CapEx on fossil fuel generation peaked in 2015 and has dropped to below 20% of total**
- **Fossil fuel CapEx is used mostly to maintain existing assets, not expand their capacity**

The power sector has accelerated its transition as wind and solar contributed to nearly 75% of global net new capacity in 2021

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Global share of solar and wind in net new generation capacity (%)



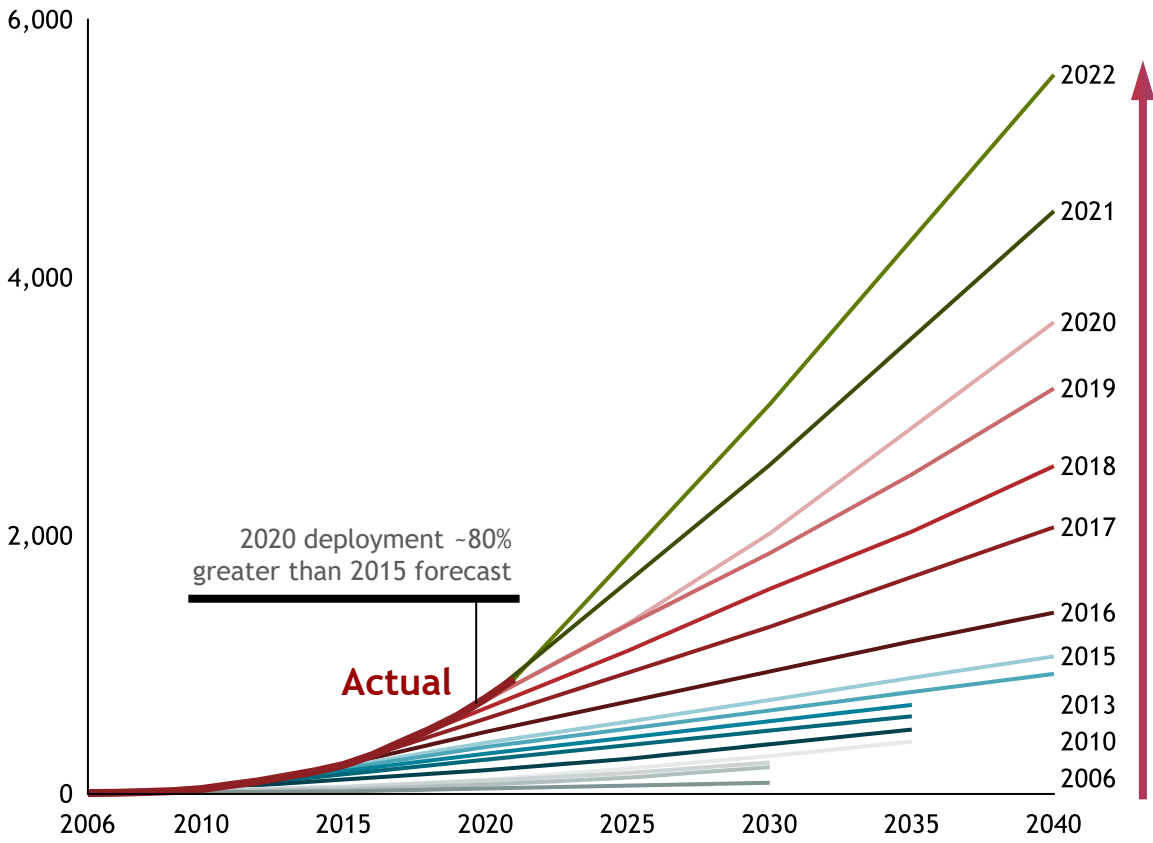
Commentary

- In 2006, solar and wind capacity additions only contributed to ~9% of global annual additions
 - To put this into context, electric vehicle sales in 2021 only made up 9% of global car sales
- In 2021, solar and wind combined to contribute to nearly 75% of global net new additions
- This is a classic S-curve of deployment, taking 15 years to move from the tipping point to global dominance

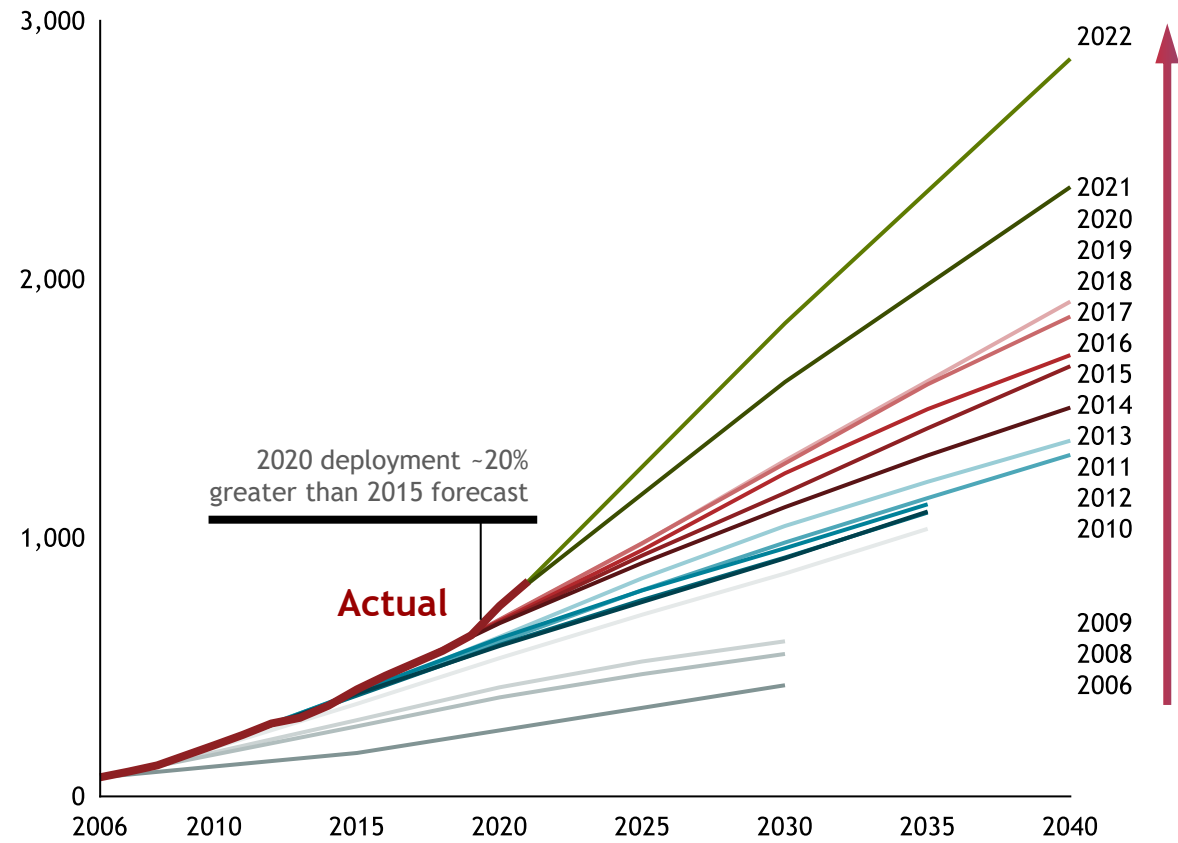
Source: RMI, IEA

Deployment of renewable capacity is expected to continue to grow faster than historical forecasts have anticipated

Solar electricity generation capacity (GW)



Wind electricity generation capacity (GW)



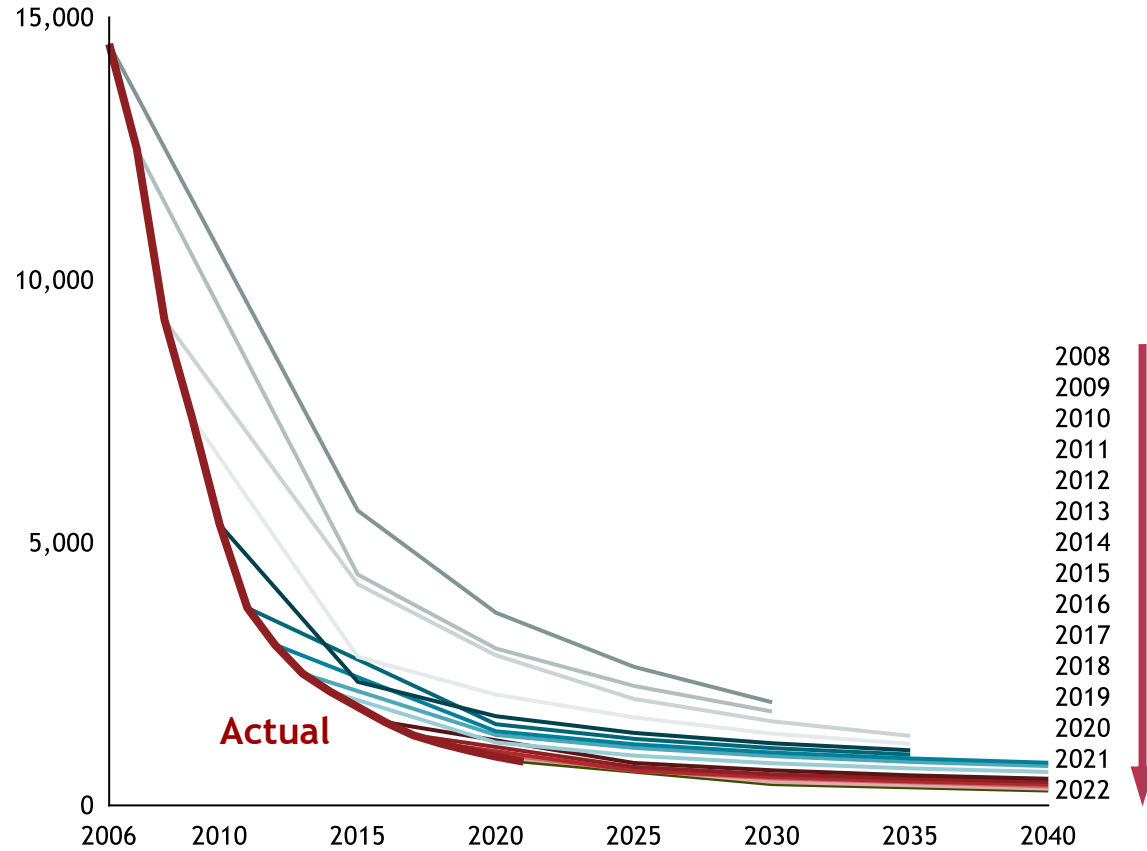
Note: 2010-18 new policies scenario; 2019-2022 stated policies scenario
 Source: IEA World Energy Outlook 2006-22

Costs are also falling faster than historical forecasts had projected

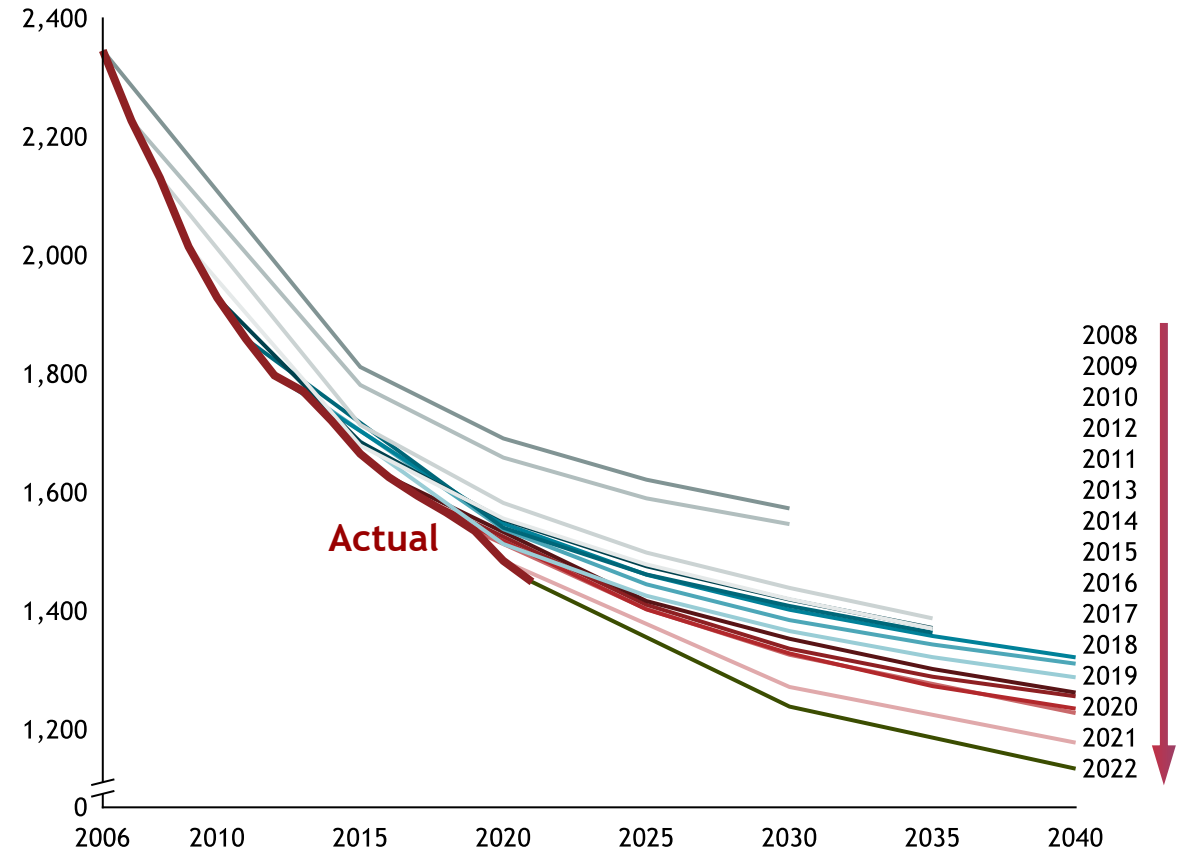
01 SECTOR OVERVIEW

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Solar capital costs (\$/kW)



Wind capital costs (\$/kW)

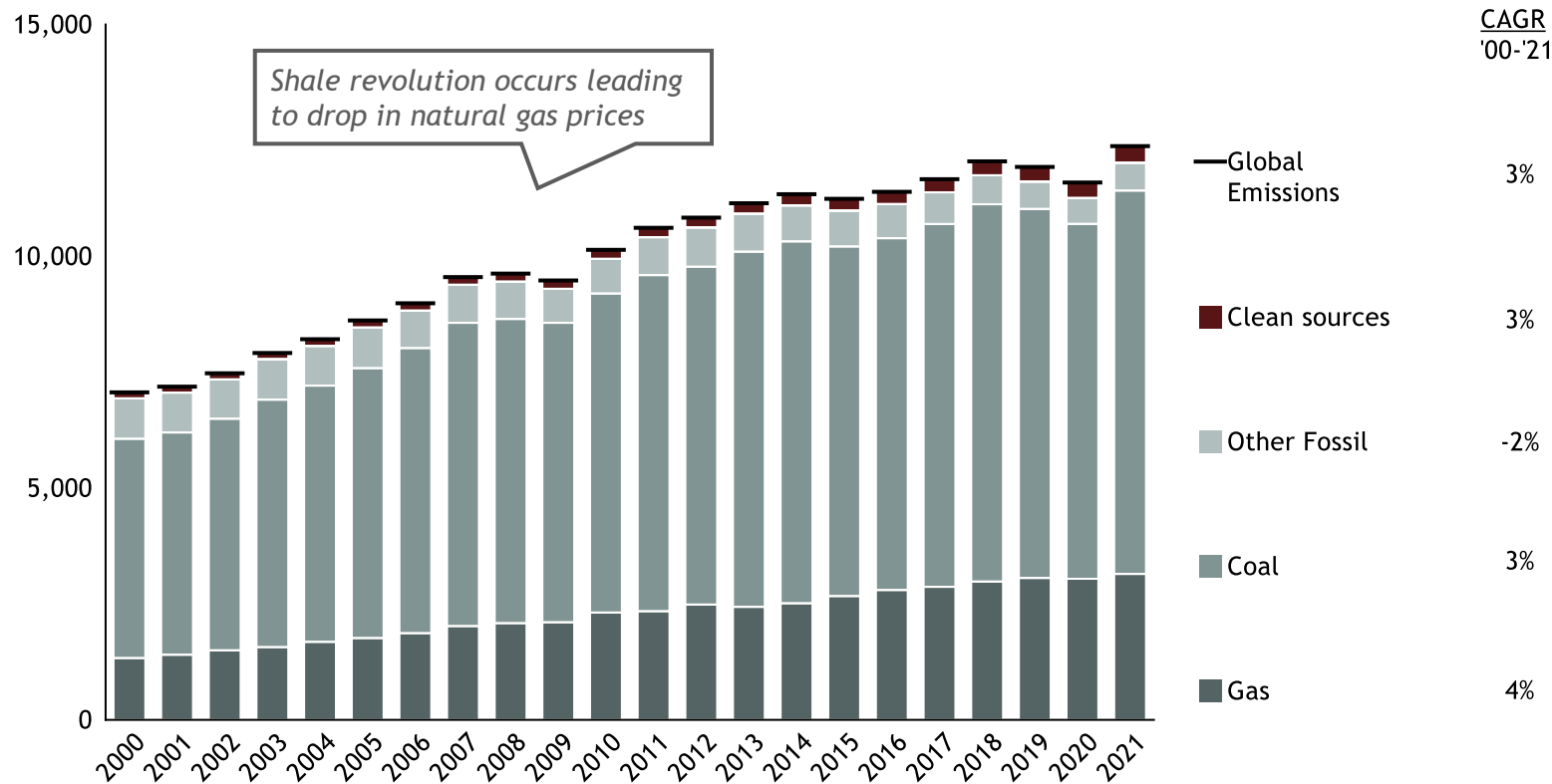


Note: Capital costs calculated using experience curve from IEA and IRENA dataset
 Source: IEA World Energy Outlook 2006-22; IRENA 2019

Coal contributed 67% of global power sector emissions in 2021 despite generating only 36% of global electricity

Coal and gas contribute to the greatest share of emissions and have grown since 2000

Annual carbon emissions by source (M tonnes CO₂e)

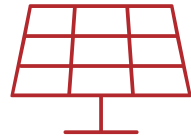


Commentary

- **Coal capacity has twice the emissions intensity** (tons of CO₂ per MWh) when compared to natural gas
- **Share of gas emissions grew from 19% in 2000 to 25% in 2021** due to increased usage
 - Increase in gas emissions share is due to the **reduction in natural gas prices** post-shale revolution
 - Coal to gas switching occurred regionally, primarily in the EU and US, and has not occurred widely throughout large parts of Asia such as China and India
- Due to recent expansion of renewable generation capacity, emissions from renewable sources appears to be growing but **contribute to less than 3%** of total emissions in 2021
 - Renewable and clean sources produce emissions in their manufacturing and supply-chain

Note: Ember uses statistics from the IPCC which estimate full lifecycle emissions (upstream methane, supply-chain and manufacturing, and include all gases converted into CO₂ over a 100-year timescale)
 Source: Ember, EIA, Lit. search

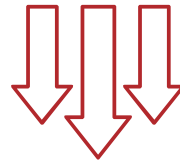
At COP 26, major governments set a series of “Breakthrough Goals” for the power sector



Clean generation

Renewables rise to 61-65% of total generation*

In 2021, renewables contributed to ~27% of global electricity generation



Emissions reduction

7% annual reduction in emissions

Emissions from the power sector grew ~6% from 2020-2021



Emissions intensity

Emissions intensity of 25-138 gCO₂ / kWh

Global emissions intensity was roughly ~464 gCO₂e/kWh in 2021



Electrification

26-30% share of electricity in final energy consumption

Electricity contributed to 20% of final energy consumption in 2022

Breakthrough Agenda Targets 2030

Progress

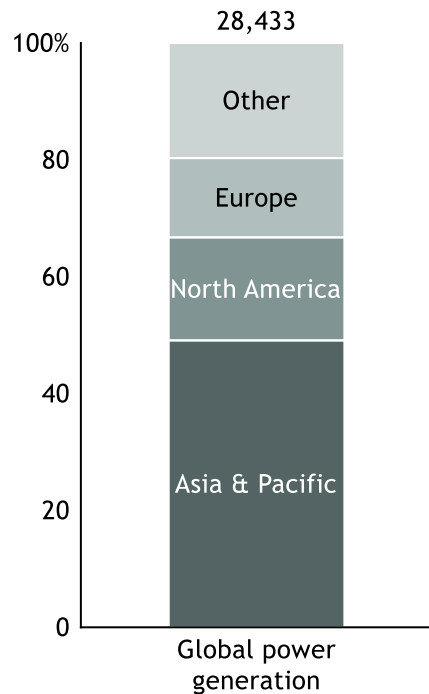
Sources: *Also the 2030 IEA Race to Zero milestone target

Over 100 power sector companies have set short or long-term targets; a significant portion (40%+) are on track to surpass their ambitions

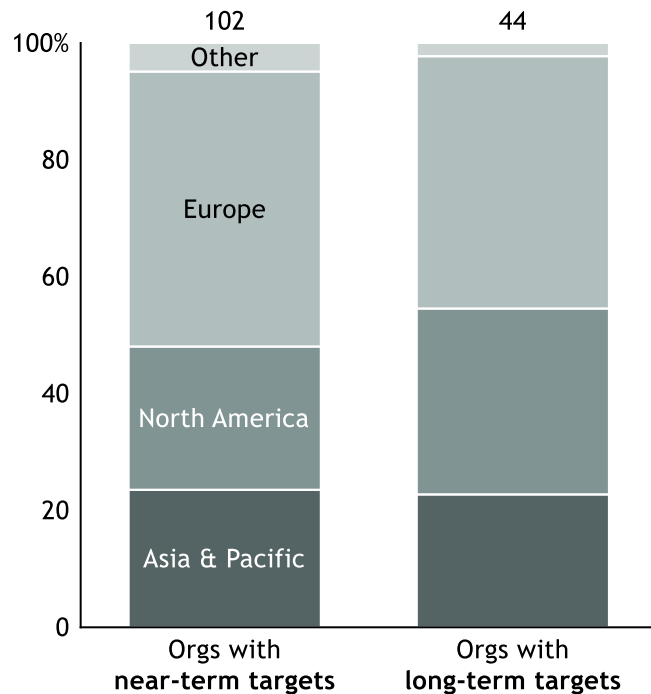
Legend: Company performance vs. Breakthrough ■ Missed target (<80%) ■ Near miss (80-100%) ■ Hit target (+100%)

Europe leads the way on disclosures and targets

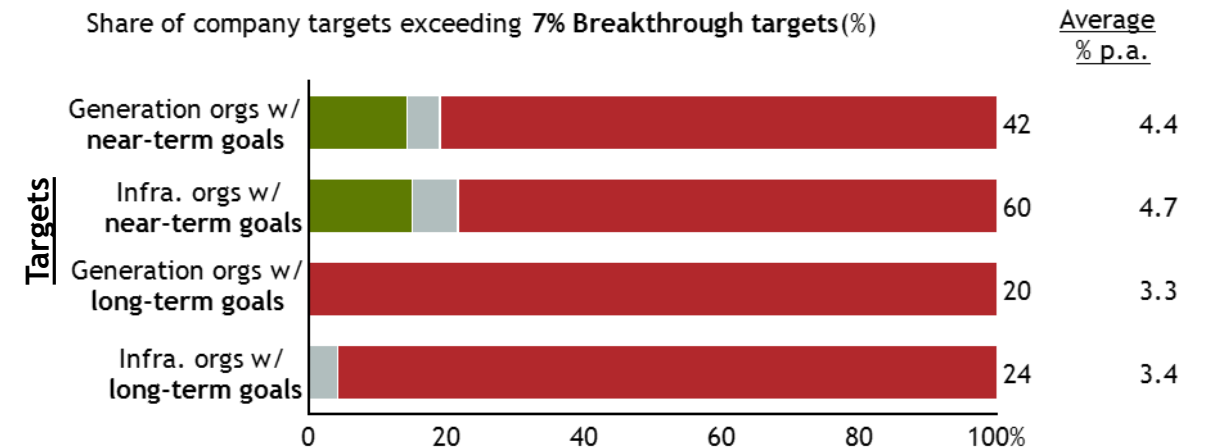
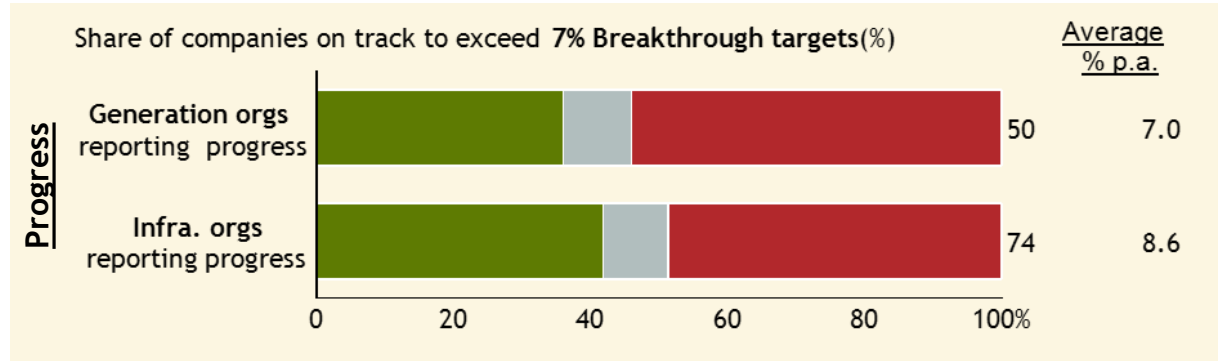
Global mix of 2021 power generation (Twh)



Mix of companies reporting ambitions to CDP



~60% of orgs are below Breakthrough Agenda targets



Note: Annual reduction ambition shows the % reduction a company will need per year in order to reach their target from the base year (includes underway, new, or revised targets); near-term defined as target year before 2030; Priority countries selected based upon highest emission countries from 2022 Global Carbon Project Data; % reduction refers to an annual percentage and does not take into account compounding; Breakthrough Agenda goals account for Scopes 1+2 only; Average %p.a. in the chart indicated %p.a. required to achieve the target

Source: 2022 CDP Climate Questionnaire Data; 2022 Global Carbon Project; The Global Economy

Executive summary: the state of the transition in power



Dimension of sector

Developing the transition frontier

Future decarbonization scenario

In regions like US and EU, infrastructure expands, and market design evolves to accommodate increases in renewable generation

Barriers to accelerating decarbonization

Levels of renewable **generation capacity** are rising **exponentially - and faster than existing grid infrastructure** and regulatory processes (i.e., permitting) can keep up

Utilities require **support in planning and workforce development** for grid infrastructure development (i.e., regional integrations, additional capacity)

Investment into **dispatchable generation** (e.g., storage) and **grid flexibility** (e.g., demand response) must be made more attractive to **enable balancing** of power supply and demand

Moving beyond legacy thermal

Regions like China and SEA accelerate fossil retirement as renewable generation scales

Renewables are also growing strongly in many emerging markets with significant existing thermal capacity, but economic incentives and long-term contracts make **early retirement of legacy thermal plants** financially difficult

The current **cost of capital and investment climate** is dampening levels of **investment in renewable generation** needed to meet demand

Expansions of grid infrastructure and international grid integration are necessary to balance supply and demand across Southeast Asia

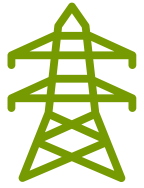
Prioritizing clean generation

Regions like Latin America and Africa with less legacy thermal meet rising electricity demand with renewables

Rapid growth in demand for energy **creates risk of adoption of new fossil electricity** in absence of economically attractive renewable sources

In many parts of the world, and particularly Latin America, growing electricity **demand is being met largely by renewables**

But many developing or emerging markets are **simply not attractive enough for renewable developers** to invest when set against other markets



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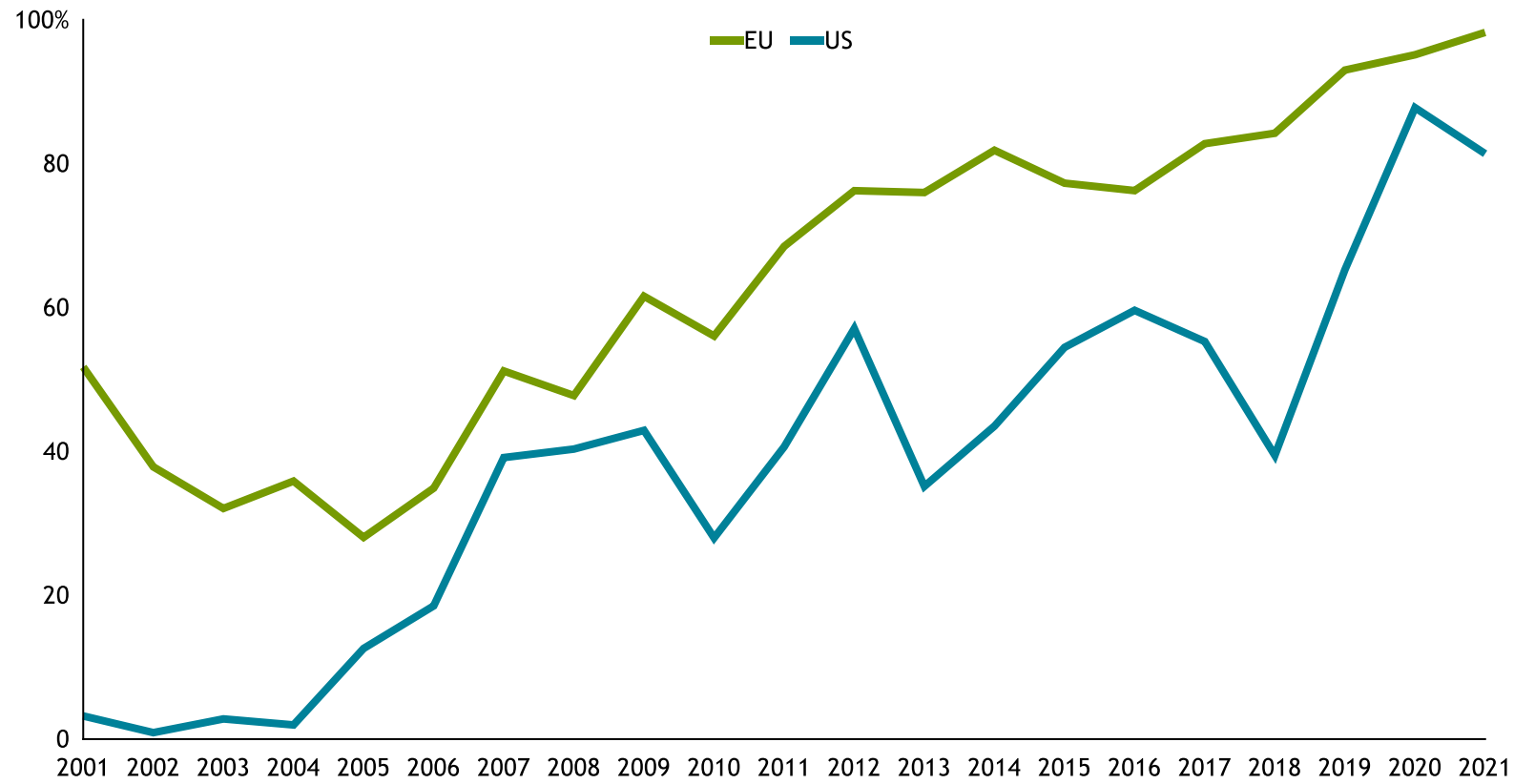
The **Legacy Thermal** narrative explores the state of transition of the power sector in developing economies such as China, India and Southeast Asia

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The **Clean Generation** narrative explores the state of transition of the power sector in emerging economies such as Latin America and Africa

“We see a lot of renewables projects coming down the track, the acceleration is promising, but we have to deliver”

Share of solar and wind in net new generation capacity (U.S. and EU, %)



Commentary

- In 2021, the share of solar and wind generation capacity for the US and EU was 81% and 98% respectively
- The EU has consistently outpaced the US in terms of share of solar and wind additions, but the pace in the U.S. has accelerated significantly between 2018-2020
- While new additions across both regions are almost completely renewable, retiring existing thermal capacity will be necessary to reducing overall emissions

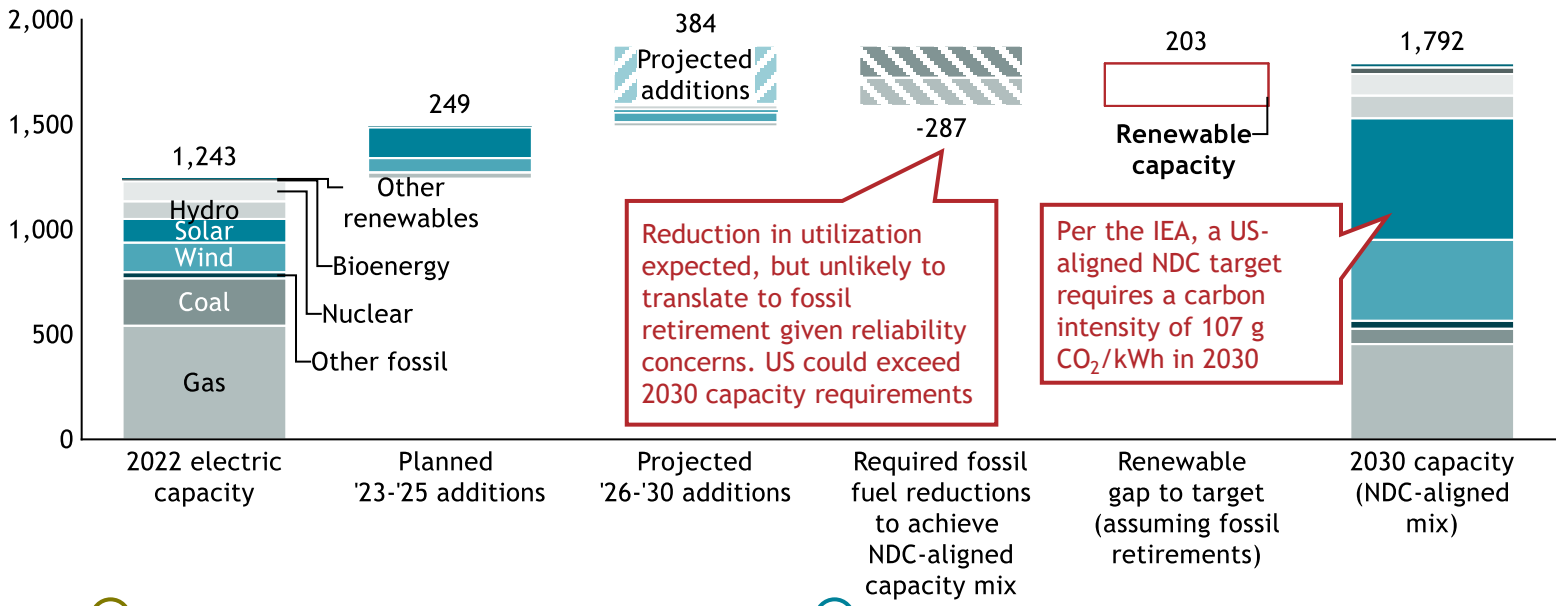
Note: Title quote from Manager of Sustainability, Renewable power producer #3
Source: Ember

In the US, projections suggest planned clean capacity additions are nearing 2030 targets



Projected planned capacity in wind and solar is nearing 2030 NDC-aligned targets

Electric capacity by source (GW, U.S.)



① *US renewable energy capacity pipeline through 2030 will exceed the incremental generation requirements to meet future demand*

② *To achieve capacity mix anticipated by NDC, fossil fuels would need to further shift towards renewables, with concerns of intermittency simultaneously addressed*

Commentary

- ① Projected renewable capacity additions through 2030 set to exceed incremental demand growth
 - ~1250 GW of additional potential low-carbon capacity sits in US interconnection queues
 - From 2020 to 2022, ~60 GW of wind and solar energy capacity were added
 - Historically, completion of these projects has been limited (10-15%)
- ② Fossil fuel capacity reductions will be constrained by reliability concerns, but utilization set to decline, reducing the share of generation
 - NDC-aligned capacity mix reduces dispatchable power from 985 GW in 2022 to an untenable 807 GW in 2030
 - Companies re-weighting from coal to natural gas given lower costs at low-capacity factors and higher reliability
 - Fossil fuel capacity will persist to ensure adequate dispatchable power (supplemented by increases in battery storage up to 147GW)
 - Nuclear plants, pumped hydro storage, and Hydrogen-powered turbines are a potential path to meet clean dispatchable energy demand

Note: 2030 capacity targets are according to the GEC APS model which projects that all commitments and policy that countries have proposed will be met in full; Fossil fuel CCUS capacity included within 'Other fossil' segment; Planned additions include projects in the 'announced, permitted, financed, or under construction' phases of development as defined by Global Data; 2030 capacity splits reflect increases in demand while maintaining typical utilization rates
 Source: Ember - Yearly Electricity Data (Capacity data aggregated from Global Energy Monitor, Global Data - Upcoming Power Plants; IEA - Global Energy and Climate (GEC) APS Model; UN Intergovernmental Panel on Climate Change - Average Life-cycle CO2 equivalent emissions; EIA - Carbon Intensity of Natural gas, Berkeley Lab Electricity Markets & Policy - Interconnection queue capacity

“Top-down regulation is playing a key role: RPS targets have been a factor in deciding where to focus renewable investment in the US”

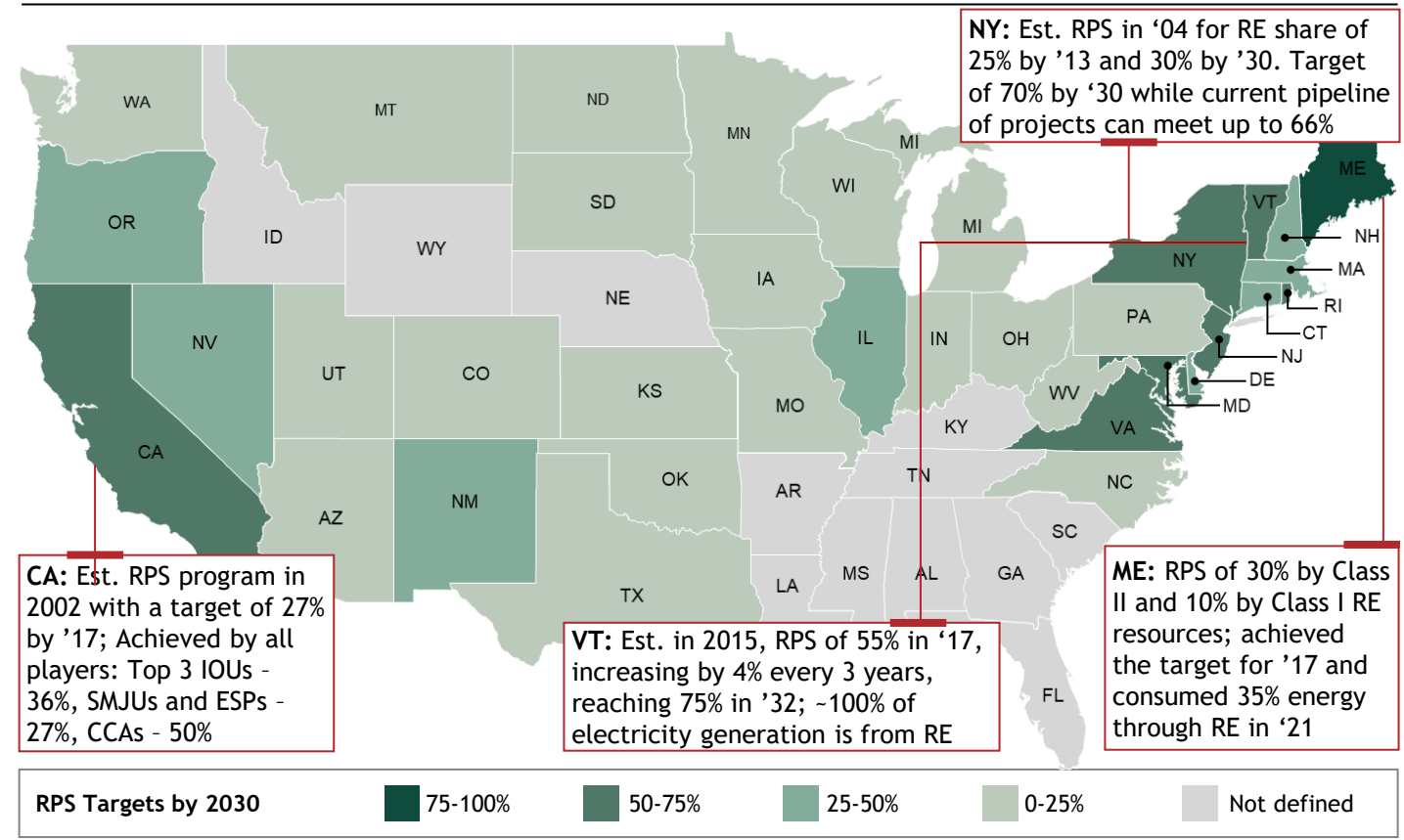


Majority of U.S. states have set a RE requirement

- Renewable Portfolio Standards (RPS) mandate that utilities provide a **minimum percentage of renewable electricity** to meet demand
 - As of 2019, **37 US states and District of Columbia** have adopted RPS requirements as they are an **efficient, cost-effective, and market-based approach** to achieving RE policy objectives
- Most jurisdictions with have set targets of at least 40%**
- 10 states, Washington D.C., Puerto Rico, and Guam** have set **100% clean or RPS requirements** with deadlines from 2030 - 2050
- 3 states, plus the U.S. Virgin Islands, have goals of >50%**

“It is quite astonishing how quickly some of the states anticipate RPS enabling the switch to renewables”
 - VP & Chief of Sustainability Officer, Utility company #1

Only 7 states have adopted standards to reach >50% renewables by 2030



Notes: 1) IOU - Investor-Owned Utility, 2) SMJU - Small and Multi-Jurisdictional Utilities, 3) CCA - Community Choice Aggregation, 4) IN, KS, MT, ND, SD, UT have RPS targets defined till 2020 (or earlier) and have not defined RPS targets for the upcoming years yet
 Title quote from Manager of Sustainability, Renewable power producer #3
 Sources: 1) [State Renewable Portfolio Standards and Goals, National Conference of State Legislatures](#); 2) [Energy and Environment Guide to Action - Chapter 5](#); 3) RPS and CES Percentage Targets, Berkely National Laboratory

“The IRA is also helping pull the cost down of the clean energy transition”



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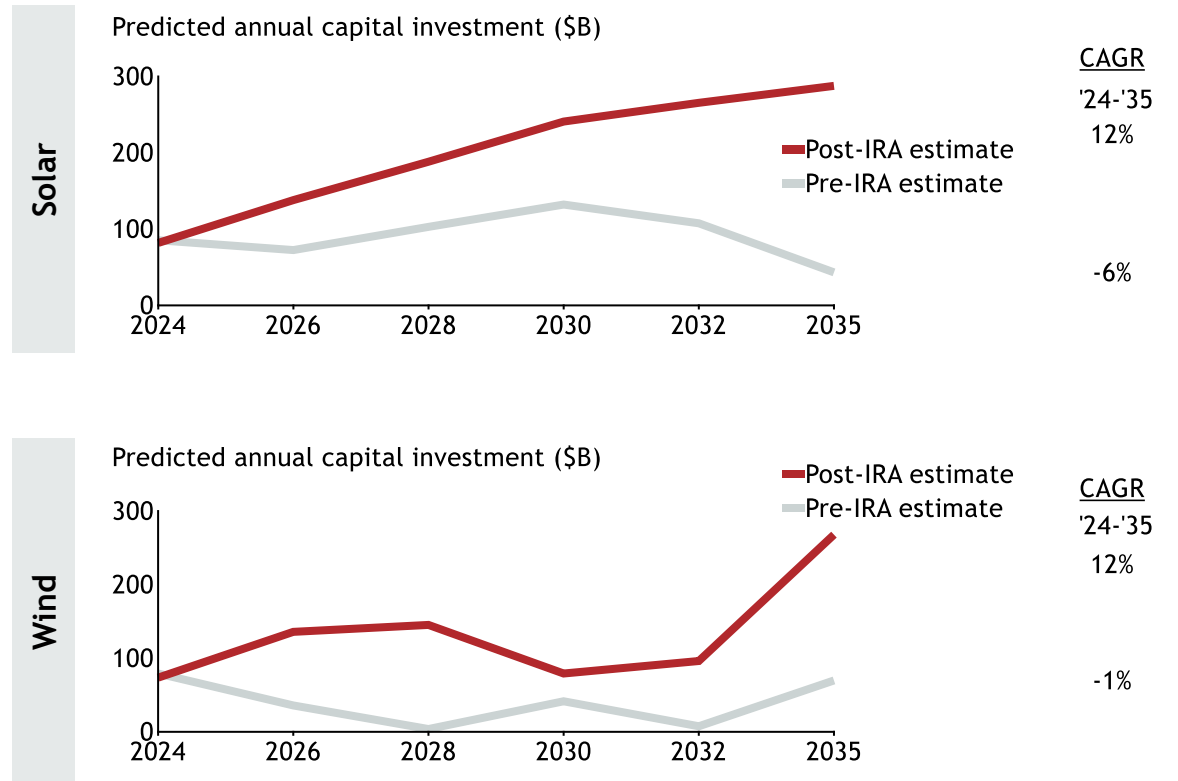
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IRA increases subsidies for clean generation...

- IRA expands **investment (ITC) and production (PTC) tax credits for clean energy** (\$150B+) to more technologies (incl. wind, solar, and stand-alone energy storage) and extends credits through 2032
 - Credits require projects meet fair wage and apprenticeship requirements and offer bonuses for **projects in energy communities** or that meet domestic manufacturing requirements
 - Expansion of investment tax credit to include **stand-alone energy storage** is expected to accelerate investments into storage technologies needed to support expansions of variable renewable energy generation
- IRA also increases tax credits for **carbon capture** and introduces a new credit for existing power produced after 2024 by **nuclear** plants and new nuclear power after 2025
 - Credits for existing nuclear will help improve economics of existing plants and avoid retirements, while credits for new power will support deployment of new reactor technologies (e.g., small modular reactors, Gen IV technologies, etc.)
- Policy also includes ~\$37B in tax credits to **support domestic manufacturing capabilities for clean energy industries**, including a new production tax credit and extending the Advanced Energy Project Credit
 - At least \$4B must be for facilities built in energy communities
- IRA also allocates ~\$3B in **financing to support transmission** buildout, though this is not likely to be sufficient to close gaps in transmission capacity



... driving expected increases in investment



Note: Energy communities refer to brownfield sites, statistical areas that have disproportionately relied on the fossil fuel economy, or census tracts in which coal mines have closed after 1999 or coal fired electric generation units have closed after 2009;

Title quote from VP & Chief of Sustainability Officer, Utility company #1; EOR - Enhanced Oil Recovery

Source: Joint Committee on Taxation, Congressional Budget Office Estimated Budgetary Effects of H.R. 5376, the Inflation Reduction Act of 2022 (revised August 2, 2022), Tax Foundation ([link](#)), Congressional Research Service ([link](#)), REPEAT Project preliminary analysis of the Inflation Reduction Act of 2022, Bain analysis

In the EU, “targets are challenging, but achievable with the right framework to get there”



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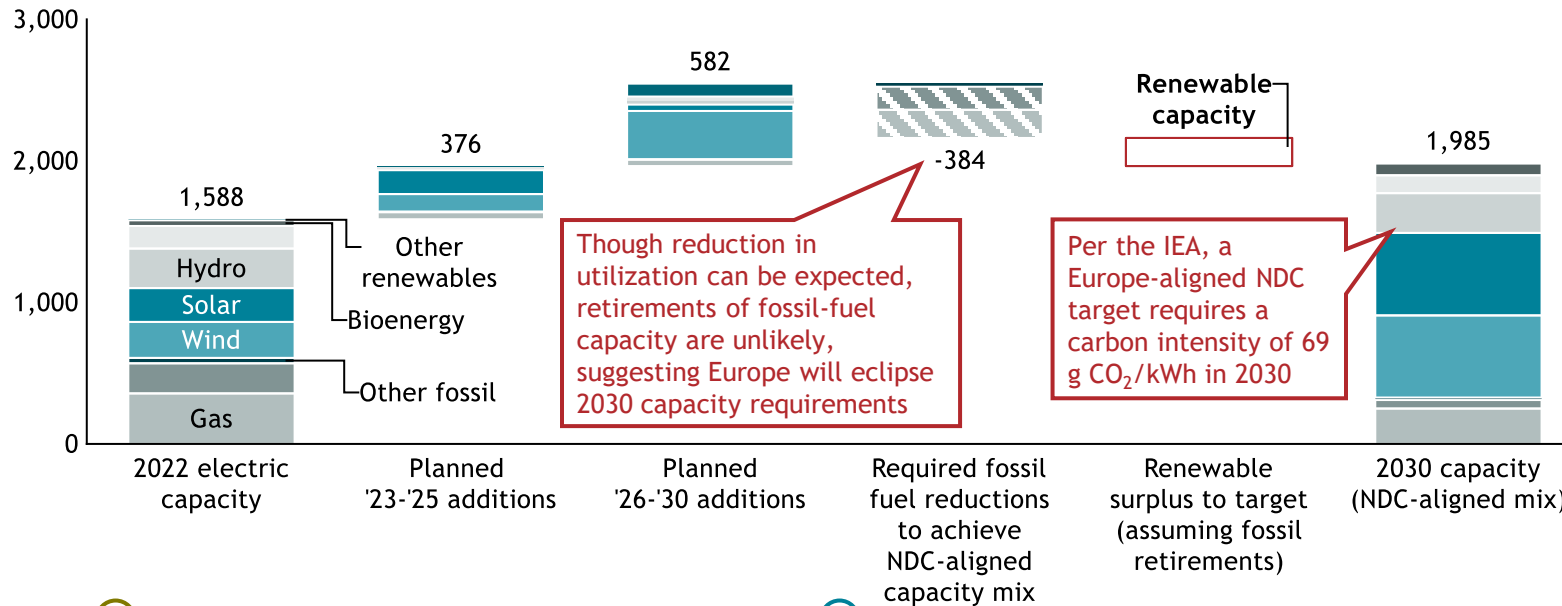
03

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Projected planned capacity is nearing 2030 NDC-aligned targets, driven by off-shore wind

Commentary

Electric capacity by source (GW, Europe)



① Europe renewable energy capacity pipeline through 2030 will heavily rely on wind capacity to meet future demand

② To achieve capacity mix anticipated by NDC, fossil fuels would need to further shift towards renewables, with concerns of intermittency simultaneously addressed

Note: 2030 capacity targets are according to the GEC APS model which projects that all commitments and policy that countries have proposed will be met in full; Fossil fuel CCUS capacity included within 'Other fossil' segment; Planned additions include projects in the 'announced, permitted, financed, or under construction' phases of development as defined by Global Data; 2030 capacity splits reflect increases in demand while maintaining typical utilization rates; Title quote from Head of Climate Change, Utility company #4

Source: Ember - Yearly Electricity Data (Capacity data aggregated from Global Energy Monitor, Global Data - Upcoming Power Plants; IEA - Global Energy and Climate (GEC) APS Model; UN Intergovernmental Panel on Climate Change - Average Life-cycle CO2 equivalent emissions; EIA - Carbon Intensity of Natural gas

① Wind capacity represent the majority of Europe's planned additions, with solar additions deployed in the near-term

- ~70% of planned wind capacity is scheduled to come online between '26-'30, mostly located offshore
- ~79% of planned solar capacity is scheduled to come online before the end of 2025
- European contracts for difference enable the expansion of RE capacity by ensuring a long-term and stable revenue stream for renewable energy projects

② Fossil fuel capacity reductions are unlikely due to concerns with reliability, but utilization will go down to reduce share of generation

- NDC-aligned capacity mix reduces dispatchable power from 1,087 GW in 2022 to 818 GW in 2030
- Barring additional battery storage, pumped hydro storage or nuclear plants, fossil fuel capacity will persist to ensure adequate dispatchable power
- Companies re-weighting from coal to natural gas given lower costs at low-capacity factors and higher reliability

European companies are generally positive about their capacity to deliver their pipeline of projects



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*“**European targets are challenging** and there are a lot of issues to overcome in terms of the grid and customers. But we **remain confident**”*

- Head of Group Sustainability, Utility company #2

*“We are optimistic that **renewable energy targets in Europe will be achieved**, provided that the new regulations and streamlining of project approvals are properly implemented within the next months, in all the member states. We consider the **energy crisis as an accelerator**. As we plan projects out for the 2030 horizon or even 2050, we are assuming that the targets will be met”*

-Gonzalo Sáenz de Miera, Global Director of Climate Change and Alliances, Iberdrola

Source: Corporate interviews

But across both markets, business leaders believe that regulatory procedures and capacity of T&D infrastructure are the biggest barriers to full decarbonization

01

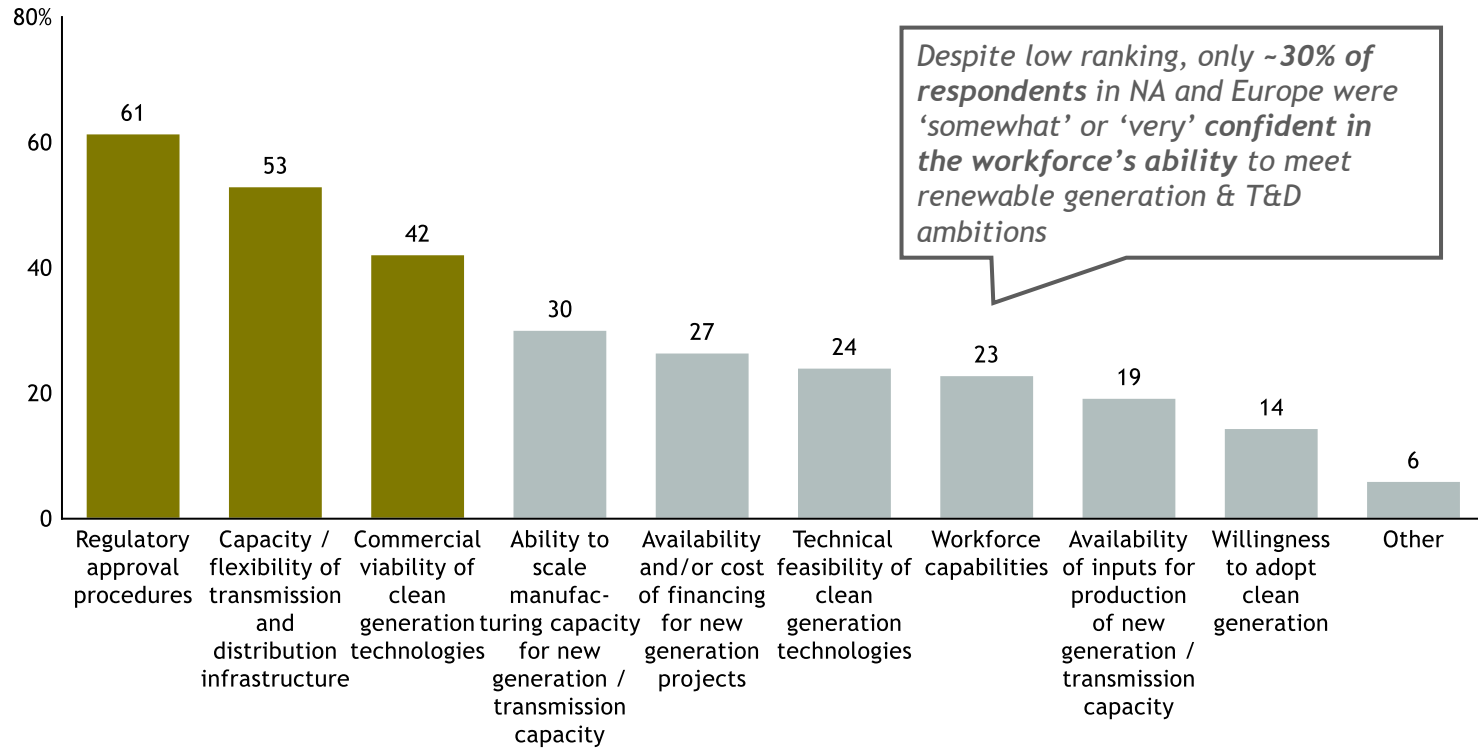
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Which of the following do you view as the power sector's largest barriers towards accelerating decarbonization? Please select the top 3 most impactful barriers.

Share of survey respondents selecting barrier in the top 3 (%)



Note: Chart reflects share of respondents with expertise in the U.S. (N = 41), the EU (N = 30), other Europe (N = 5) and other North America (N = 7)
Source: Bain / WMBC Global Stocktake Survey (N = 215)

① **Regulatory approval procedures**

"[Permitting] takes too long, it's tricky, it's complicated, it involves a lot of uncertainty, there are loops back and forth where even if you get a permit, there's still risk of litigation and delaying or even moving back in the process"

-Magnus Gottlieb, External Affairs Manager, Ørsted

② **Capacity/ flexibility of T&D infra**

"Grid infrastructure will become a bottleneck if we don't take action quickly. At present, the planning frameworks are designed for a different era - they've become obsolete given the transformation we are aiming to achieve and requiring anticipated investments. The same is true of remuneration schemes which are not connected or aligned with these goals"

- Gonzalo Sáenz de Miera, Global Director of Climate Change and Alliances, Iberdrola

③ **Commercial viability of clean gen technology**

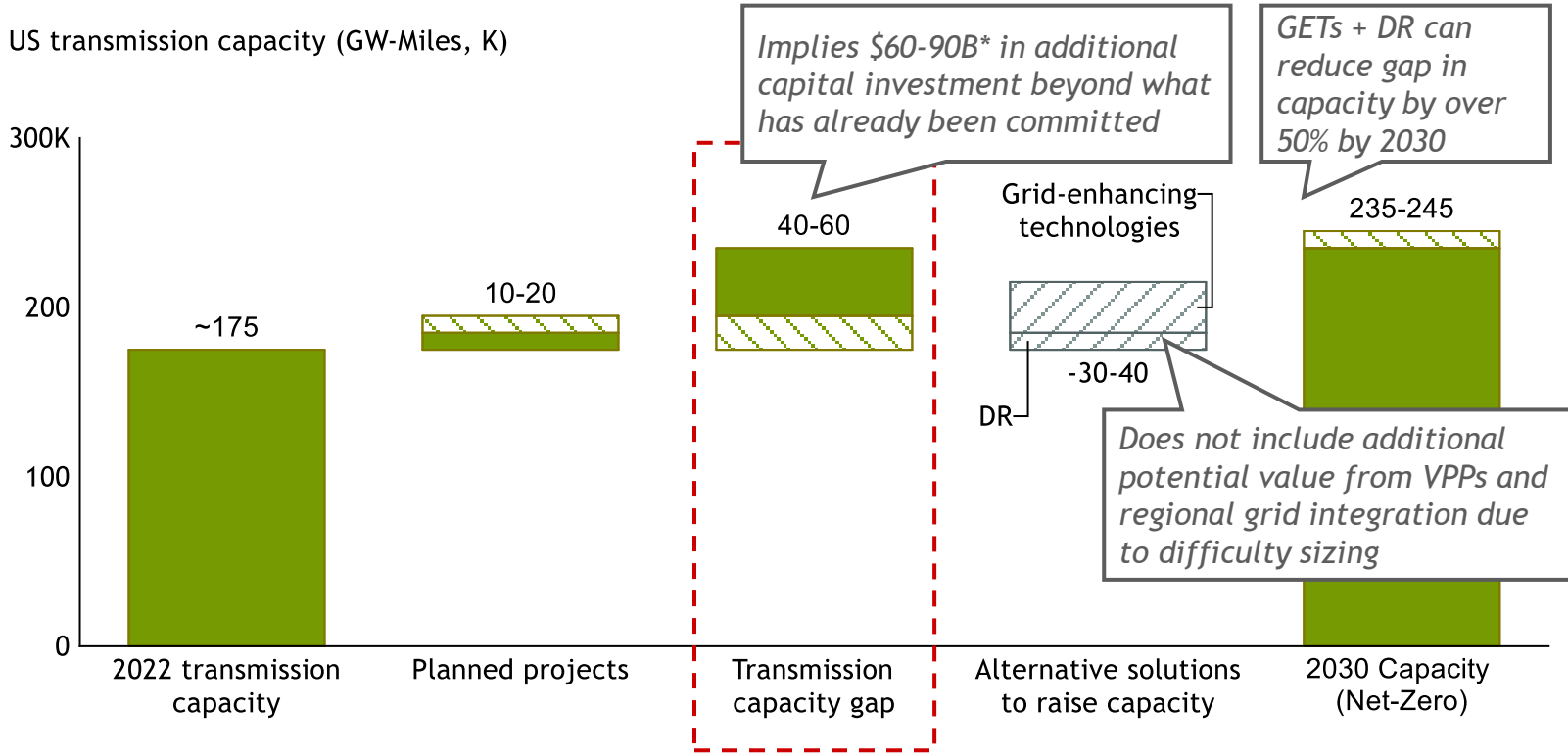
"The EU needs to ease rules for long-term contracting, promoting CFDs for auctions, and removing barriers to PPAs"

- Head of Climate Change, Utility company #4

In the US, “a lot more transmission is needed: around 85% of investment is going to modernize the grid over the next decade”



Planned projects only cover ~20% of needed additions to align with a net-zero pathway



Commentary

- There is currently a **significant gap in planned transmission capacity** to support anticipated levels of power generation in 2030
- Given **~7-10 year timelines** from planning to project completion for typical transmission expansions, utilities have limited time to plan additional lines
 - Even with planning and investment, **workforce gaps** (i.e., insufficient linemen with required training) could slow project execution

“It takes us a decade to build a transmission line. it's 2023 now and that will be 2033. So, a lot of the ambition is running right into the reality of what it actually takes to get this stuff built”

- VP & Chief of Sustainability Officer, Utility company #1

Note: Planned projects defined as all under construction, planned, and theoretical projects between 2023 and 2030 per NERC’s 2022 Long-Term Reliability Assessment; 2030 capacity assumes net-zero aligned levels of renewable generation with significant lels of end-use electrification (e.g., transport) per Princeton’s Net Zero America Report and DOE’s 2023 Draft National Transmission Needs Study; *Assumes -\$1500 / MW-Mile of transmission per DeSantis et al. (2021)

Title quote from VP & Chief of Sustainability Officer, Utility company #1

Source: 2022 Transmission Capacity - DOE, RMI, Brattle Group, Princeton University Net-Zero America Report; Planned projects - NERC 2022 Long-Term Reliability Assessment, Americans for a Clean Energy Grid; 2030 Capacity Target - Princeton University Net-Zero America Report, DOE 2023 Draft National Transmission Needs Study; Transmission Capital Cost - “Cost of long-distance energy transmission...” DeSantis et al. (2021), Impact of alternative solutions - RMI, Brattle Group

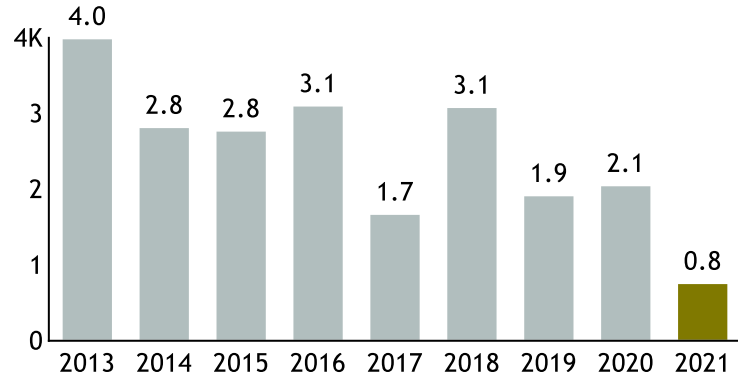
“Occasionally, the process stretches so long that the interconnection agreement takes more time than the project design, installation and operations”



Annual transmission additions in 2021 were 80% lower than 2013

- **Progress on T&D buildout** in the US has slowed since 2013 due to several factors:
 - Complex, time-consuming permitting process
 - Challenges in coordination between RTOs
 - Long lead times for components
- Transmission line growth in 2021 was **~70% lower than average growth from 2013-2020**

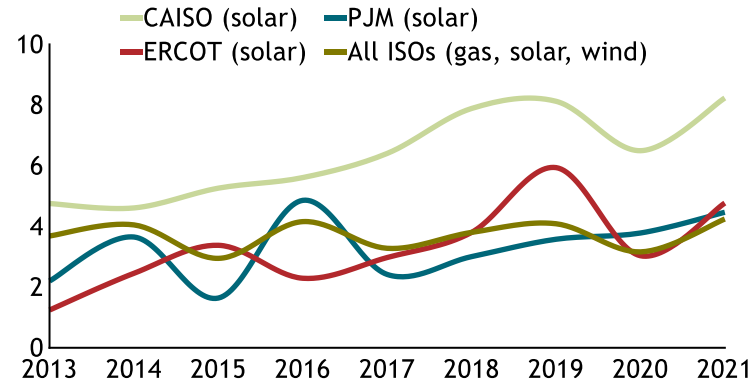
Annual US transmission line additions (miles)



Decline in grid buildout has resulted in longer lead times for projects

- Average time generation spent in interconnection queues¹ increased by **~6 months** from 2013-2021
- **~90% of capacity in queues** is zero-carbon in '22, with solar & battery storage growing fastest
- By 2021, **solar projects** in CAISO and ERCOT waited in the queue **~3.5 years longer** vs. 2013

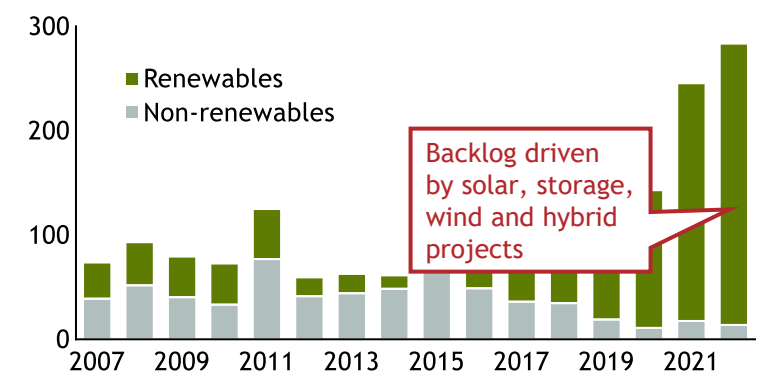
Median project time in interconnection queue (years)



Interconnection queues have grown rapidly since 2019 as a result

- Critical renewables projects waiting to be deployed are **overwhelming the ability of grid managers** to integrate them due to lengthy studies required
- Average backlogs for major grid operators have **increased 1.8x since 2019**
 - The backlog for PJM (largest grid operator in the US), has grown **2.4x since 2019**

PJM interconnection queue (GW)



“Queueing is really difficult- you have to wait for years and years. A lot of projects are fed into the pipeline but then drop out because of high transmission costs, or another project that gets approved ahead of you throws your project out - the system is totally broken” -VP & Chief of Sustainability Officer, Utility company #1

Note: Transmission lines >100 kV; All ISOs includes CAISO, ERCOT, PJM and NYISO; ISO = Independent System Operator; RTO = regional transmission organization
 Title quote from Shane Menefee, Director, EHS, Legrand North and Central America
 Source: JP Morgan (2023); Berkeley Lab Electricity Markets & Policy

Underlying issues around grid build out and permitting are complex political and social barriers



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*“People are going to **see the transition in our backyard** in a way that we haven't experienced in living history. Coupled with affordability, this just makes it really, really hard. Also appreciated is the **amount of land** required, especially where we are displacing farmland and interrupting people's lives. These are **questions of environmental justice**”*

-VP & Chief of Sustainability Officer, Utility company #1

Source: Corporate interviews

“In the US, the disparity between regulated and deregulated energy markets significantly impacts the financial viability of renewable projects”



Types of power markets

Independent System Operator / Regional Transmission Organization

Includes some deregulated states; in regulated states, the ISO/RTO manages the wholesale market only

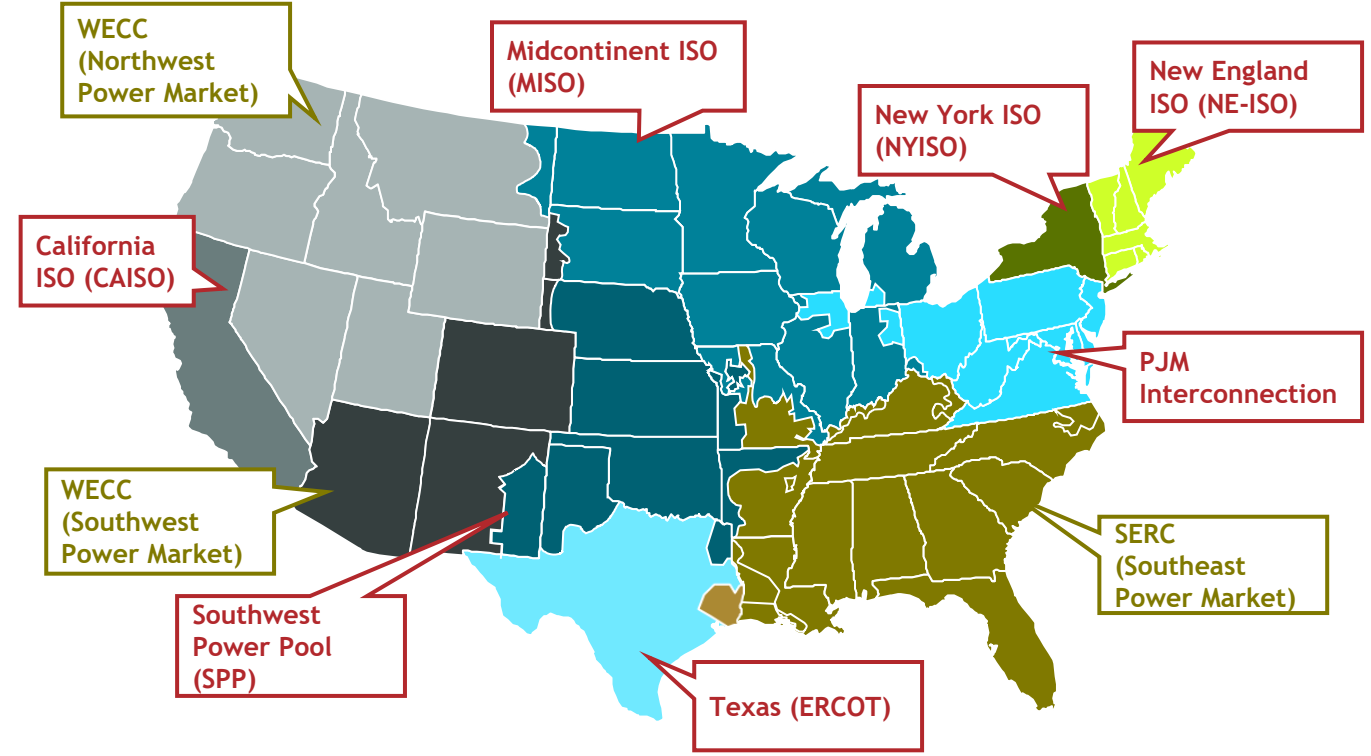
- ISO / RTOs are independent organizations facilitating a centralized wholesale electricity market
- In ISO-operated regions, participants buy and sell electricity based on competitive market mechanisms
- There are 7 ISO / RTO areas across the U.S.

Bilateral bulk power markets

All states contained in these markets are vertically integrated

- In bilateral bulk power markets, the participants negotiate and privately agree on the terms, price, and quantity of electricity traded
- The terms of bilateral contracts may not be subject to the same level of transparency or market mechanisms as those in ISO-operated markets

The US has 3 bilateral bulk power markets and 7 independent system operators



“We aim to establish PV systems wherever possible. However, the regulatory and commercial environments vary significantly across regions, there's no one-size-fits-all solution and that slows down our progress” - Shane Menefee, Director, EHS, Legrand North and Central America

Note: There are in total six regional entities in the US having delegated responsibility from NERC for bulk power system reliability. These include WECC and SERC, and 4 areas fully overlapping with ISOs: MRO, TRE, RFC, NPCC (not shown on the map)
 Title quote from Shane Menefee, Director, EHS, Legrand North and Central America

The US electric grid is limited in its ability to coordinate transmission planning across regions with various standards



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US electric grid is fragmented

- US electric grid is **highly fragmented** with 3 interconnections (Eastern, Western, and EROT) and 12 separate transmission planning regions
- Only 6 of 12 regions are regional transmission organizations (RTOs) with **authority to conduct transmission planning** for the region
- 5 of 12 regions lack an RTO, and instead are comprised of dozens of **vertically integrated utilities** that plan transmission for their individual territories

This lack of market integration leads to multiple interoperability challenges



Inconsistent transmission

- **Multiple operators with competing interests** complicates building **regional interconnections** and **long-distance power lines** needed to transport newly deployed renewable generation to demand centers
 - Majority of solar and wind power plants are **far from cities and the existing grid**, requiring thousands of miles of new high-voltage transmission lines
 - Individual operators spend **~\$25B per year** on transmission, but funding is **mainly focused on intra-jurisdiction spending** for local upgrades



Incompatible permitting processes

- Inter-regional planning also **amplifies risks associated with permitting**, with approvals required from multiple regional authorities that may disagree over whether lines are needed or who should pay for them

“For transmission, we’re working with so many stakeholders - 3-5 different government jurisdictions, utilities, local governments. Approval also requires working with the state and the federal regulators [...] it is a slow process and it’s regionalized”

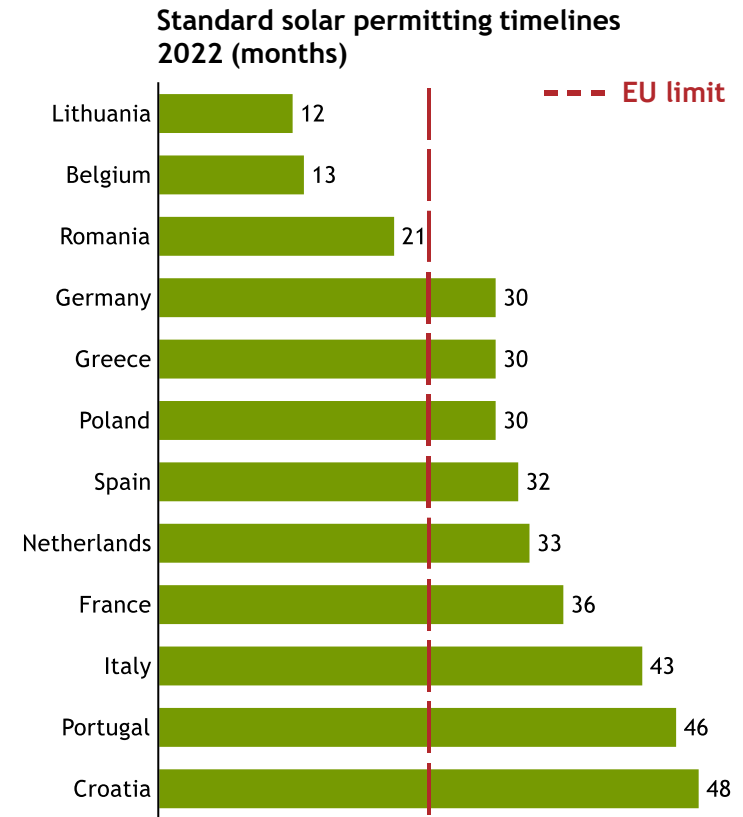
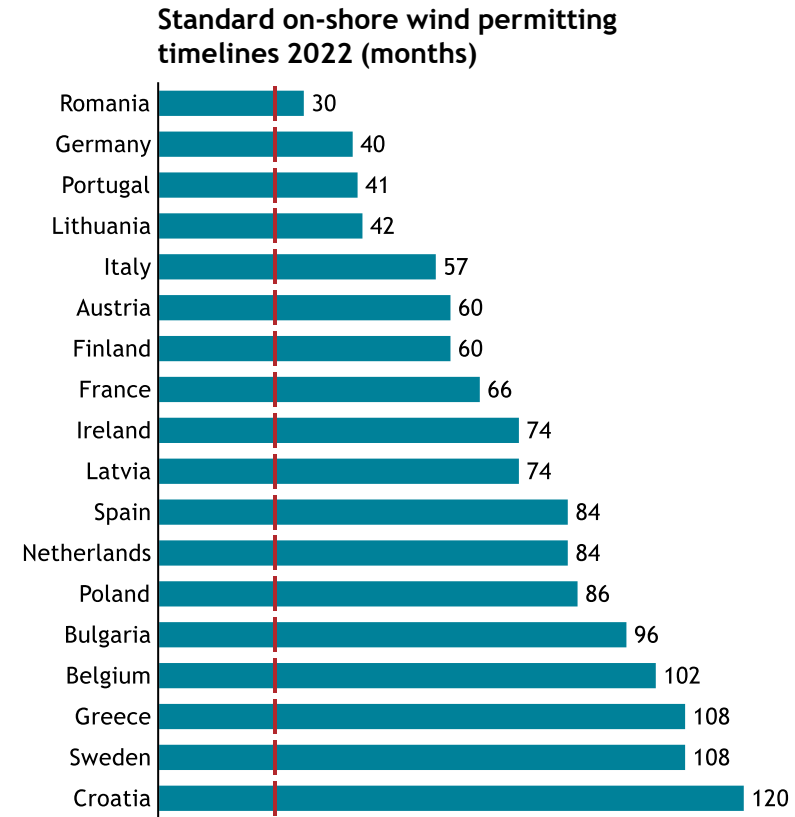
- Head of Climate, Sustainability, and Environmental Policy, Fleet operator #4

Source: [RMI](#), [NYT](#), [Canary Media](#)

In the EU, “the biggest barrier is administrative - it’s permitting and bureaucracy. The process lasts for years for some installations”



Average permitting time exceeds the EU delay limit in most RE projects



Commentary

- EU business leaders cite **permitting delays** as **top barrier** to grid expansion
 - Delays are driven by **limited resource capacity**, **inefficiencies in licensing** and **coordination issues**
- **4x more wind capacity** and **8x more solar capacity** in the ‘**permitting**’ stage than **under construction**
- **Permitting delays more common for on-shore wind** compared to solar
 - For on-shore wind, some permitting timelines have exceeded the 2-year limit by up to 5 times

“A big barrier is the bureaucracy in terms of permitting. We have to reduce the timelines and complexity. It’s absolutely impossible to spend 2 - 3 years obtaining permissions to build a new plant”

-Head of Sustainability Planning and Performance Management, Utility company #7

Notes: EU Renewable energy directive set a two-year maximum limit for permitting new projects and one year for repowering projects; For permitting timelines, Ember analyzed 18 countries for on-shore wind projects and 12 countries for solar projects. “Permitting” is defined by GlobalData as when a power plant has moved beyond the point of simply being “announced”, and is in the process of obtaining “some or all of the necessary government clearances and approvals”; Title quote from Gonzalo Sáenz de Miera, Global Director of Climate Change and Alliances, Iberdrola
Source: Ember, GlobalData

“The most important element of market design is a stable framework - this is critical for investors given the long lifetime of assets”



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Market design reform is critical to prevent cannibalization

- **High growth of renewables** with low running costs runs the risk of **price cannibalization** in the electricity market
 - In Germany, growing penetration of solar and wind energy projects coincided with lower capture prices between 2015- 2021, indicating presence of price cannibalization
 - California experienced both absolute and relative cannibalization, evidenced by the decline in wholesale prices from 2013 to 2017
- **Market design reform** is required to ensure that **investment in renewables is still economical**
 - Subsidies need to be complemented with other mechanisms such as carbon pricing to prevent continued downward pressure on prices
 - Increasing flexibility of the grid (e.g., using smart grids) can further decrease the speed of the prices decline

*“Marginal pricing is not working for utilities like us. We see fossils making a lot of profit, whereas utilities are not. [...] It’s important to have a **stable regulatory framework**. Efficiency of deployment depends on **predictability and visibility over the investment context**. We have the technology. We just need to be sure that projects are profitable”*

- Head of Sustainability Planning and Performance Management, Utility company #7

*“The markets that already have a lot of capacity and an **established regulatory frameworks** are the most interesting to us”*

- Head of Global Positioning, Renewable power producer #1

Note: Title quote from Head of Climate Change, Utility Company #4
Source: Lit search

“[Across US and EU], governments must reaffirm commitment to offshore wind buildout, even if prices have gone up”



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Offshore wind is at the cusp of scaling

- The industry has **matured and scaled quickly** through learning, innovation, and scale
 - Costs decreased by ~2/3rd from 2012 to 2021
- This has led to **increased expectations for buildout**
 - Targets increased to 200GW by 2030 in EU/US
 - Projects pipelines grew, as developers scrambled to secure GW scale projects
- This growth is **expected to continue** till 2030
 - Projected 10x increase in annual non-Chinese additions by 2030

But macroeconomic conditions and market uncertainty are affecting the supply chain in the short-term

- **Macroeconomic shifts and supply chain disruptions** have led to **25-40% rise in LCOE**
 - Driven by 3-4x increase in key input prices (steel, copper) and recent hikes in interest rates
- Many **approved projects** are stuck **before the final investment decision stage**
 - In US, developers were awarded non-indexed PPAs with prices prior to recent inflation shock
 - In UK, developers secure sites before off-take contracts, leading developers to renegotiate contracts, take impairments, or even cancel/ postpone projects
- Supply chains further squeezed by **market uncertainty and tough competition**
 - Off-shore wind project lead times are longer, and the market is driven by fewer, larger projects and facilities - e.g., heavy lift vessels capable of installing modern turbines are in the low double-digits and ~50% of installations EU have passed through only one single port
 - Western turbine OEMs are currently challenged on fundamentals and new competition is emerging from China
- Finally, while **ever-larger turbines** have **long-term benefits** with respect to efficiency and cost, they require **investments in new equipment and infrastructure**, which will also add pressure to the supply chain

Policy needs to reflect new market conditions

- Industry is calling for governments to respond to changes in market fundamentals in order **move projects to FID**
 - E.g., by renegotiating or indexing offtake agreements
- To maintain investment levels in offshore wind, leading industry players would also like to see future tenders **move from upfront concession payments** (risk to developers) **to revenue-sharing** (sharing risk and reward with developer and public)
- **Tendering out larger volumes faster** would also fill order books and unlock investment

“Value proposition of the industry is still fundamentally strong. What we’re seeing is growing pains, not an indication of a flawed technology. [...] Policymakers should be concerned because 1) if unaddressed, these challenges put policy targets, decarbonisation and energy diversification in jeopardy, and 2) the ability to attract and maintain a strategic industry” - Magnus Gottlieb, External Affairs Manager, Ørsted

Note: Title quote from Magnus Gottlieb, External Affairs Manager, Ørsted

Source: WoodMackenzie “Cross currents - Charting a sustainable course for offshore wind”, IRENA “Renewable Power Generation Costs in 2022”, Ørsted “Targets today, Turbines tomorrow”

Companies welcome government efforts to overcome permitting issues but are cautious about the results

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*“Politically, we see a strong shift towards a higher appetite for large scale renewables projects. It’s this ‘we need to figure this out’ attitude that has changed the zeitgeist [...] **Political will translates into regulatory learning and innovation, and working across the table to find new ways of addressing stakeholder concerns and speeding up processes**”*

-Magnus Gottlieb, External Affairs Manager, Ørsted

*“Having **pre-qualified areas** and **digitalization** would speed things up. We need to reduce bureaucracy across governments entities - a **one-stop shop to take care of all licensing processes** would be a clear pathway”*

-Head of Climate Change, Utility company #4

Source: Corporate interviews

The EU is pushing for grid improvements using interconnection targets and supporting policies



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Given the EU's need for interconnection infrastructure...

- Regional grid interconnection would allow **surplus electricity produced in one country to be used in another country** where demand for electricity is higher
 - This eases the burden of demand-supply balancing as countries can burden-share to support each other through peak load periods
- Interconnection could support **integration of more renewables** by limiting required levels of dispatchable power within a given market
- Sharing power across member states can improve grid reliability, **lowering the risk of electricity blackouts**
- To date, **interconnection capacity has not increased at the same rate as generation deployment**, suggesting policy may be needed to support action

...the EU has set interconnection development targets ...

- The EU has set an interconnection target of **at least 15% by 2030**
 - Target requires each country to have transmission capacity capable of sharing at least 15% of the electricity produced in its territory with neighboring countries
- Achieving interconnection targets **requires significant investment** in additional grid infrastructure
 - 2015 analysis from the European Parliament suggested member states would need to **invest €150B** to support interconnection of national grids¹
- In 2021, **16 countries** reported reaching or being on track to reach the 15% target by 2030
- Agency for the Cooperation of Energy Regulators (ACER) estimates that **cross-border trade of electricity delivered a yearly benefit of €34B² to consumers in 2021**

...which are supported directly by policy

- **Connecting Europe Facility (CEF)³** is an EU funding instrument that supports development of infrastructure in the energy sector
 - CEF Energy has a budget of **€5.84B** for 2021-2027 to support energy sector, smart grids, and CO₂ networks
 - EU has invested **€602M** in **cross-border projects** under the **Connecting Europe Facility (CEF)** for Trans-European Networks for Energy⁴
- **European Fund for Strategic Investments** aims to mobilize private investment for projects within areas of energy efficiency, renewable energy, power grids and interconnectors
 - Joint initiative between the European Investment Bank (EIB) group and Commission which **helps finance energy projects by providing companies with loans** and other financial instruments to de-risk investments
- **Interoperability Network for the Energy Transition (€500M)** establishes cross-domain community for developing, testing & deploying **interoperable energy services⁶**

Sources: 1. [Communication on achieving a 15 % electricity interconnection target](#), 2. [Council regulation on emergency intervention](#) 3. [CEF Energy Budget](#), 4. [Connecting Europe Facility](#), 5. [Projects of Common Interest](#) 6. [EU-funded IntNET project](#)

“There are positive signs that the EU permitting is being streamlined, but measures need to be transposed in EU member states, and government and local capacities can still be a bottleneck”

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Spotlight: Germany

For example, in Germany, permitting barriers have slowed renewable deployment...

- Germany has set a **target to have 80% share of renewables in their power mix by 2030** (vs 47% in 2020)
- Goal to expand renewables was accelerated due to **energy crisis arising out of Russia’s invasion of Ukraine**, as Germany was highly dependent on Russian gas
- In support of achieving ambitious targets, the EU approved a **€28B** German renewable energy scheme to expand use of wind and solar power plants
 - The scheme would pay a premium on top of the market price to renewable energy producers to incentivize deployment of generation
- However, **red tape associated with permitting requirements** has hampered Germany’s efforts to reach the **80% renewable target by 2030**
 - German Economy and Climate Ministry analysis showed a **sizeable backlog** in emission reduction efforts, suggesting Germany was on track to **miss their 2030 target by 15%**

... but recent measures provide a model for expediting deployment going forward

- In January 2023, **Germany adopted EU’s Emergency Regulation¹** to expand renewable energy and electricity grids by **fast tracking wind & solar permitting**, enforcing deadlines on approving authorities to clarify environmental and grid permits
 - The regulation is applicable to all licensing procedures for **onshore and offshore wind turbines & grids with nominal voltage of 110kV or higher** that begin before July of 2024
- As part of the emergency regulation, **production of renewable energy is classified as overriding public interest²**, resulting in prioritization over other concerns (e.g., species protection)
- Reforms set defined timelines for permitting process across various technologies:
 - **Repowering of renewable energy plants:** Maximum deadline of 6 months for permitting process including all relevant Environmental Impact Assessments (EIA)
 - > Permitting deadline shortened to 3 months for capacity increases of less than 15%
 - **Solar installations:** Maximum deadline of 3 months for permitting process.
 - > PV installations that are built on existing artificial structures no longer require an EIA
 - > Installations below 50 kW (including production of solar energy for own consumption) to receive tacit agreement after one month, provided there are no issues of grid safety, stability or reliability
 - **Heat pump installations:** Deadline of 1 month for licensing procedures for installation of heat pumps with an output of <50 MW and 3 months for geothermal heat pumps

Sources: 1. [German cabinet approves EU emergency measures to push renewables expansion](#), 2. EU to speed up permitting process for renewable energy projects

Notes: Title quote from Gonzalo Sáenz de Miera, Global Director of Climate Change and Alliances, Iberdrola

In the US, recent legislative announcements by FERC also aim to streamline permitting process, but additional reforms are needed



Permitting reform through regulatory authorities in the US is underway

- Federal Energy Regulatory Commission (FERC) announced new rules to encourage grid operators to conduct **comprehensive long-term planning** and to **strengthen ties between regions**
 - FERC announced requirements for **20-year transmission planning** and **interregional transfer capability** (including cost allocation) in April of 2022
 - New plans must also consider a broader set of potential benefits than current analyses, **improving likelihood that projects are deemed cost-effective** enough to proceed
- FERC is also considering **reforms to speed-up approval** of interstate transmission infrastructure
 - Leveraging **FERC's legal authority to override objections** from state regulators for power lines deemed to be in the national interest
- Additional proposed rules from FERC aim to **reduce length of time projects spend in interconnection queues**
 - Requirements for grid operators to **streamline studies that determine whether projects can connect to the grid** are viewed as promising by clean energy developers

But implementation hurdles remain

- However, recent rules still **leave most existing permitting challenges intact**, suggesting additional reforms are needed
- The Biden administration has **pushed for additional legislative permitting reforms** but **prospects for passage are unclear**
 - The reforms would **consolidate agencies** with permitting authority limit duration when projects can be legally challenged,

Aside from building more transmission, system integration of renewables can be improved through a range of other solutions

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	Description	Potential implications
Higher Anticipated Impact	<p>Improving incentives for dispatchable power when and where its most needed</p> <ul style="list-style-type: none"> • Market design reform focused on long term price signals include ensuring visibility and guarantees over electricity costs • Dispatchable power availability helps ensure power is generated when and where it is needed <ul style="list-style-type: none"> - Innovative solutions such as hybrid projects and low-cost storage solutions are examples of improvements to existing grid 	<ul style="list-style-type: none"> • Long-term price signals incentivize the most efficient technology choices to be installed at locations which provide maximum value • Flexibility and storage in the grid facilitates burden-sharing and reducing required transmission <ul style="list-style-type: none"> - E.g., EU has successfully created a trade system for exchanging power across country borders
Anticipated Impact	<ul style="list-style-type: none"> • Virtual power plants (VPPs) are aggregations of distributed energy resources that can be remotely charged / discharged to meet grid needs • Demand response (DR) capabilities enable shifting of consumption by customers to match supply of power <ul style="list-style-type: none"> - VPPs are an example of demand response capabilities 	<ul style="list-style-type: none"> • VPPs and demand response capabilities enable peak load management and resulting deferral of investment in T&D infrastructure • Modeling suggests significant potential benefits: <ul style="list-style-type: none"> - ~\$2B of T&D investment could be avoided by 2030 - 200 GW system-wide reduction of peak demand by 2050
Lower	<p>Grid-enhancing technologies</p> <ul style="list-style-type: none"> • Technologies that increase the functional capacity of existing transmission and distribution infrastructure <ul style="list-style-type: none"> - Dynamic line rating (DLR) - real-time thermal rating in response to weather conditions to maximize load - Flexible AC transmission systems (FACTS) - static devices used to increase power transfer capability of transmission lines - Phase shifting transformers (PSTs) - specialized transformers that enable active redirection of power flows to relieve network stress 	<ul style="list-style-type: none"> • GETs enable increased utilization of existing transmission, reducing congestion while improving resiliency • Case studies demonstrate degree of potential impact: <ul style="list-style-type: none"> - SPP: Addition of GETs doubled the amount of renewables integrated - NYISO: GETs could reduce curtailment by 23-43%

Note: SPP refers to Southwest Power Pool, NYISO refers to New York Independent System Operator, SCOE refers to System Cost of Electricity
 Source: US Department of Energy, The Brattle Group, Rocky Mountain Institute, National Resource Defense Council, "The Value of Inter-Regional Coordination and Transmission..." Brown & Botterud (2021)

Companies largely welcome EU efforts to improve long term price signals



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EU is limiting price volatility using 3 main policies

Power Purchase Agreements (PPA)

- Between a customer and a generator, where the generator commits to **supplying power directly to the customer at a predetermined price**
 - It is unclear how demand will scale based on customer willingness to agree to long-term pricing

Forward contracts

- Between a customer and a generator to **buy / sell a certain amount of electricity at a specific price usually over a shorter period**
 - Reform is needed to encourage standardized products across Member States and remove barriers to trade in forward markets

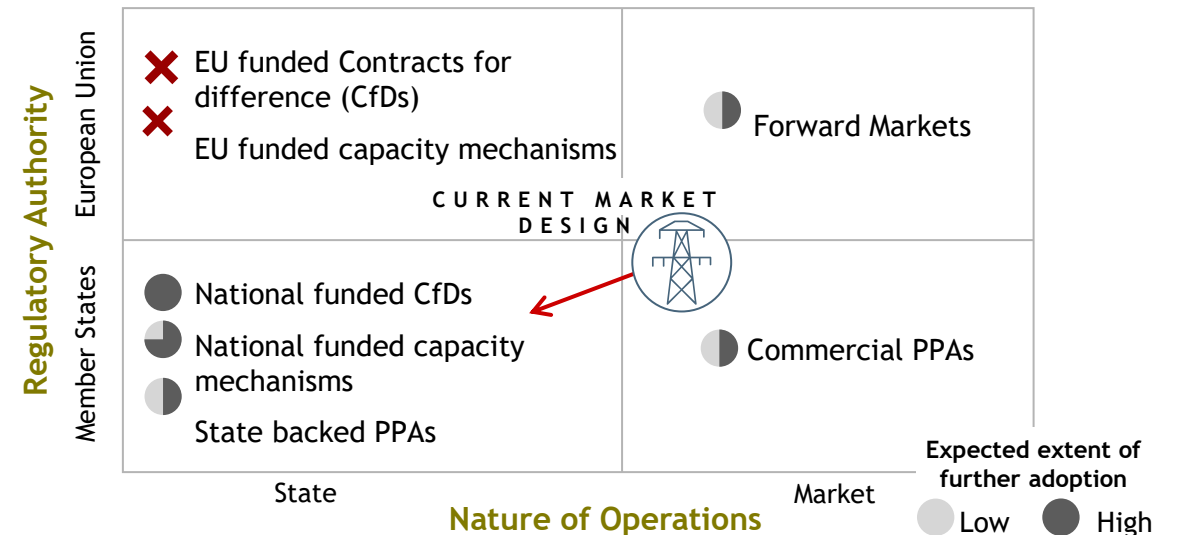
Contracts for Differences (CfD)

- Between an **electricity generator and a public entity** which sets a **strike price** (i.e., predetermined price). If market prices fall below the strike price, the **state is required to compensate** the generator. Revenues remain stable for the generators, irrespective of market
 - It can distort incentives for generators and create fiscal pressure for the state. Hence, states are recommended to provide subsidies to RE generators and adopt CfDs with an upward limitation

Source: Official website of European Union, Lit. search, Bain analysis

Reform is aimed at establishing long-term pricing signals

- Under proposed reforms, **government backed CfDs expected to play major role in overcoming system challenges alongside capacity markets**



“We see PPAs as an important part of the business case for building new generation capacity. And a liberalized market, where private parties can enter into PPA agreements is an effective way to unlock additional renewable energy, driven by corporate demand” - Magnus Gottlieb, External Affairs Manager, Ørsted

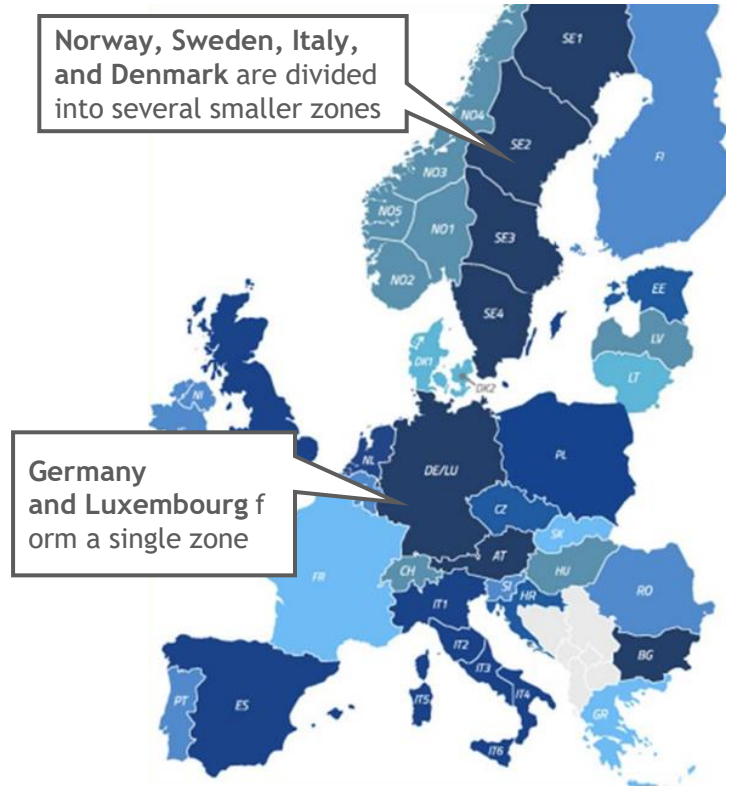
How price zones are configured can also help incentivize generation capacity where it is most needed



The size of bidding zones should ideally be configured to balance the need for liquidity whilst also reflecting the physical constraints of transmission

- The EU energy market has several major price zones which largely follow national borders; though some MS have several bidding zones
- Bidding zones are areas with no transmission constraints influencing price formation - i.e., there is one price within a bidding zone
- When bidding zones don't reflect major bottle necks in the grid, it can incentivize investment in new generation where it's not most efficient for the system - potentially also exacerbating the bottleneck
- However, bidding zone configuration needs to be balanced with forward market liquidity - too small bidding zones can reduce liquidity in the forward market, increasing costs of hedging price exposure

European bidding zones are divided by country, with a couple of exceptions



Shades of blue used to emphasize the borders of EU bidding zones

Source: ACER; Lit. search

Companies are not waiting for grid capacity constraints to be resolved and are increasing focusing on hybrid projects and other innovative solutions

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*“We need to make **better use of existing transmission capacity** so we can connect as much projects as possible – that means **hybrid project development of wind and solar so that we are using grid capacity more efficiently**”*

- Head of Group Sustainability, Utility company #2

*“We need to **invest more in hybridization** and repowering to **maximize the use of the existing grid**. We’ve invested in a **pioneer project - PV plants on a hydro dam** - where we combine wind and solar assets [..] Governments in Europe are also **incentivizing more storage**. E.g., in Portugal, we could **bid for hybrid assets** with both storage and solar”*

- Head of Climate Change, Utility company #4



Source: Corporate interviews; image from Belectric

More, lower-cost storage solutions are coming on stream to help address intermittency of renewable energy sources

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Case study: Form Energy

Overview

- **Description:** Energy storage technology manufacturing company developing low-cost, multi-day energy storage systems
- **Founded:** 2017
- **Headquarters:** Somerville, Massachusetts
- **Ownership:** Private
- **Funding:** Total funding of \$923M with a series E funding round worth \$450M

“We need to incentivize the network of distributed batteries. Activating distributed battery storage requires bi-directional charging infrastructure, and the right pricing mechanism. We are developing our own battery factory and charging points” -CEO Carbon Technologies, Utility company #5

Technology overview

- **Iron-air battery**
- Multi-day, low-cost battery storage that costs 1/10 of lithium-ion battery technology
- 100+ hour duration required to make wind, water, and solar reliable year-round
- Modular and scalable design, 1-3MW per acre

Activities

Flagship production facility



Upcoming Orders



- Form Factory 1 will be Form Energy’s first **high-volume battery manufacturing facility** in West Virginia, United states, at full capacity it’ll have an annual **production capacity of 500MW of batteries**
 - Form Energy broke ground in 2023 and will **begin production in mid-late 2024** with expansion plans for 2025
- Batteries use **“reversible rusting”** - the process of rusting and unrusting iron electrochemically enabling low-cost battery storage
 - Developing battery technology that utilizes abundant and cheap components such as low-cost iron, water, and air
 - Plans to have its batteries cost <\$20 per kilowatt-hour due to these low-cost materials
- **Georgia Power** ordered a **15 MW/1500 MWh** iron-air battery, Form Energy’s largest sold system to date
 - This battery could be operational by 2026 and would have more storage than every installed energy storage project in the U.S. in 2019
- Utility company Xcel Energy ordered **two 10 MW/1000 MWh** battery systems for projects in **Minnesota and Colorado**
 - Each project will place the systems at retiring coal power plants
 - Minnesota expected to be operating by 2025; will have up to 710MW of solar power
- **Minnesota** utility company, Great River Energy, purchased a **1 MW/150 MWh** pilot system that will supply 100 hours of continuously rated power and be active at the end of 2023
 - Current utility-scale lithium-ion batteries provide a 4-hour usage period

Source: Form Energy, Lit. Search

Innovative business models are emerging to capture value from curtailed renewable energy, but access to wholesale markets is critical

Overview

- **Description:** Energy storage company developing a thermal battery to store excess energy from renewables into heat to be used in industrial processes
- **Founded:** 2017
- **Headquarters:** Sunnyvale, United States
- **Ownership:** Private
- **Funding:** Raised \$50 Million in series A

“Policies that streamline access to the wholesale power market empower companies to capitalize on lower prices of renewable power. Enhanced access to the wholesale market, especially in major U.S. states, would facilitate our expansion” - VP, Public Policy, Antora

Technology overview

- Thermal battery**
- Thermal battery to store 50h of energy
 - Energy output as heat or electricity
 - Modular and scalable design based on graphite cells

Activities

Heat storage for industrial applications



- Antora Energy’s thermal batteries use electricity to heat up graphite blocks to more than 3,200°F inside an insulated container. **Stored heat can be released for 50 hours** through a window in the side of the container
- The heat can either be used as heat directly or converted to electricity with thermophotovoltaic cells
- The **system is modular** with factory made graphite cells that can be added to scale up the battery capacity
- The startup’s solution addresses the need for consistent energy supply in industries which require a significant industrial heat, like **paper, chemicals, concrete or steel production**, which traditionally depend on fossil fuels
- Antora Energy started operating a commercial scale pilot project in Fresno, California
- Antora Energy is building out a battery manufacturing facility in the Bay Area that it expects to be completed by 2024

Source: Antora Energy, Lit. Search

Business leaders are also investing in VPPs and demand response initiatives to enable peak management

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*“High electricity prices led **many people** to start investing in **generating electricity at home**. We now have mechanisms for individual households to directly **invest in remote solar parks**”*

-Head of Group Sustainability, Utility company #2

*“We’re looking at the ability to **control the thermostat** and prevent building 10 more capacity units [...] We’re **shifting relationships with our customers** to use them as **mini power plants**. it’s 6 kWh and not 16 gigawatts - it’s incremental. But if you’re able to aggregate this, it becomes interesting”*

-VP & Chief of Sustainability Officer, Utility company #1

*“The system is changing from centralized production and consumption – smart grids are critical for **load flexibility and managing supply and demand**. On the consumer side, we need **clearer incentives for people to participate**. We also need the infrastructure to evolve to get the **volumes necessary to balance the grid**. But we see a lot of potential”*

-Head of Climate Change, Utility company #4

Source: Corporate interviews

Government policy is instrumental for enabling greater consumer participation and demand side response

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Spotlight: Australia

Subsidy programs are supporting broad deployment of DERs and battery storage...

Federal government



- National government's **Small-scale Renewable Energy Scheme (SRES)** provides customers who install solar panel systems (<100 kW) **small-scale technology certificates (STCs)** that **reduces upfront cost** of the system by ~30%¹
 - STCs are sold in an open market which is susceptible to price fluctuations or regulator-set fixed prices of \$40 (ex GST)
 - Energy council recommended the addition of home battery systems and EVs in SRES in 2020²

Local government



- Subnational governments have **added incremental subsidies** to further accelerate deployment of distributed solar and residential battery storage
 - Victoria: **\$1.3B Solar Homes Package program** started in 2018 to subsidize the cost of installing solar panels or batteries over a 10-year period
 - South Australia: **Home Battery Scheme** including ~\$100M in subsidies and ~\$100M in loans to help ~40k homes install homes batteries ended in June 2022
 - Northern Territory: **Home and Business Battery Scheme** provides grant of \$400 per kW hour of useable battery capacity, with a maximum grant up to \$5000⁴
 - Australian Capital Territory (ACT): **Generation Energy Storage Program** provided a rebate of \$3500 or 50% of the battery price, reaching its target of subsidizing 5000 batteries
 - New South Wales: **The Empowering Homes Solar Battery Loan** was valid through 2022, in which the government offered an interest free loan up to \$14k towards a solar PV and battery system

... enabling development of VPPs

- Victoria's government has announced a **VPP pilot program** with incentives to join one of six approved VPPs in the region
 - Up to 2000 participants can receive a **~20% higher solar battery rebate** if they choose to participate in an approved VPP⁵
- South Australia's government is leveraging broad solar and battery deployment to support development of the **country's largest VPP in partnership with Tesla** and Energy Locals (an Australian energy retailer)
 - **Tesla Housing Scheme**³ works like a Power Purchase Agreement (PPA) where Tesla installs solar and battery systems in tenant's premises and eventually sells the electricity to power markets or to the homeowner
 - Homeowners do not own the systems, so they do not receive free energy, but they receive competitive prices and blackout protection

Sources: 1. [Home Solar Battery System Rebates and Subsidies in Australia](#) 2. [Unleashing Renewable Energy Storage With Home Battery Subsidies](#) 3. [South Australia's Virtual Power Plant Schemes](#) 4. [Home and Business Battery Scheme](#) 5. [IEEFA](#)

Finally, companies working on grid technology solutions are bringing down costs and making renewables more accessible

Overview

- **Description:** Electron is an energy technology company, combining blockchain and energy expertise to design and build digital trading platforms that will support the transition to cheaper, cleaner, and more resilient power systems for the energy industry
- **Founded:** 2015
- **Headquarters:** London, United Kingdom
- **Ownership:** Private

Technology overview

- Electron Connect**
- Multi-market digital energy trading platform
 - Supports local energy markets by **increasing resiliency and reducing curtailment** through data collection and demand response
 - Built to connect **grid operators with distributed energy resources** to facilitate the generation of electricity at the right time, in the right place, for the right price

Activities

Distributing data through shared models



Designing energy markets

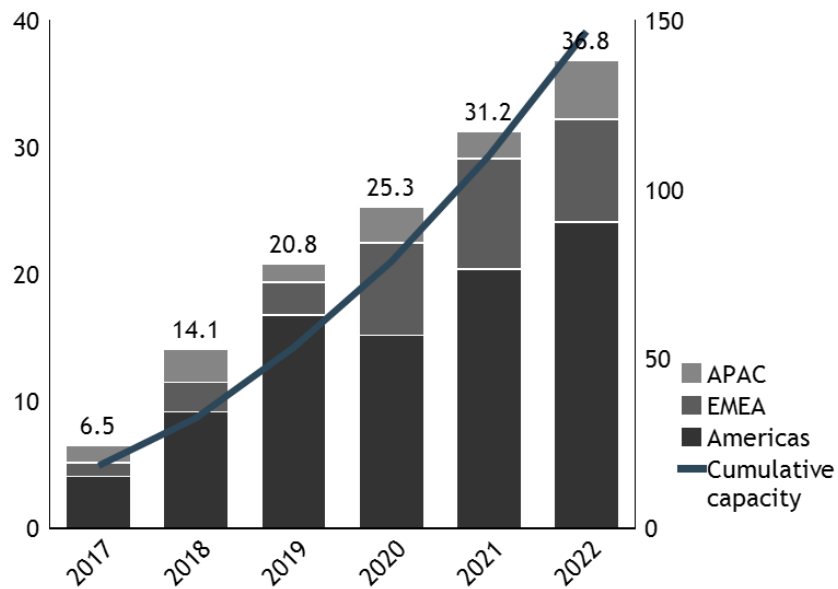


- Project RecordER located in the UK is the first shared asset database of generation and storage connected to T&D networks, **improving visibility for operators across the grid**
 - Availability of asset data will enable new systems that facilitate decarbonization and a reduction of overall operating costs
 - Will create a coherent view of assets connected to the energy network by integrating existing datasets in the industry to improve forecasting, modelling, and coordinating across diverse flexibility markets
 - Future phases of work will incorporate contractual visibility of assets and functionality for mapping into market procurement processes
- Project ResponDER is a partnership between Electron and Silicon Valley Clean Energy (SVCE) to design a new market to **incentivize regional grid resiliency**
 - Completed in 2021, the pilot program designed a prototype of a new local market where SVCE can procure clean energy services
 - The local market leverages owners of flexible technologies like EVs and batteries to generate additional revenue and decrease the cost of resiliency for customers
 - Value from minimization of wholesale market exposure and reduction in Resource Adequacy payments is estimated at \$37M based on a 10yr NPV
 - Potential reduction of hourly carbon emissions estimated at 250k tonnes CO₂ / yr saved

Source: Electron, Lit. Search

PPAs have been an important and growing source of long-term investment in renewable energy

Global Corporate PPA volume, by region (GW)



Growth in corporate PPAs is led by Americas and EMEA

- Firms have invested ~150 GW of clean power since 2008 (more than total capacity in France), driven by big tech to meet rising electricity demand
- Americas and EMEA are leading this growth in PPA volumes
 - Contracts rose 18% in the Americas to a record 24.1GW in 2022
 - EMEA volumes expected to bounce back in 2023 driven by lower natural gas prices and the proposed power market reforms¹
- In the US, the corporate PPA market has been dominated by big tech players and with virtual PPAs comprising a growing share
 - In US, ~50% of demand was driven by 3 big tech players - Amazon, Meta and Google - with Amazon making up ~1/3rd of the demand
 - VPPAs are easier to sign and enable firms to hedge risks against price hikes. However, it still depends on whether the production and revenue is correlated with the wholesale power price at the point of consumption

“Corporate PPAs can play an important role in driving investment in renewable energy, particularly at lower levels of renewable penetration” - Devon Swezey, Senior Manager, Global Energy and Climate, Google

Notes: 1 Reforms to several energy related legislation in the EU, including Electricity Regulation, the Electricity Directive, and the REMIT Regulation; in the chart, onsite PPAs are excluded, APAC values are estimates, pre-reform PPAs in Mexico and sleeved PPAs in Australia are not included, capacity is in GW DC

Source: Bloomberg New Energy Finance, Clean Energy Buyers Alliance (CEBA)

At higher levels of renewable penetration, time-matched PPAs are needed to ensure demand signals are driving investment when and where it's most needed

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Spotlight: 24/7 UN CFE

Granular clean energy procurement requires location and hourly matching

- Requires **every KW-h of electricity** consumed to be met with **carbon-free electricity sources** at every hour, every day, everywhere
- As **renewable penetration increases**, location and hourly matched procurement will be key to **sending strong long-term demand signals**
- Proponents cite many **benefits** to this approach vs traditional annual matching
 - Accelerates decarbonization of electricity systems
 - Maximizes system impact by addressing the dirtiest generation hours
 - Enables **efficient hedging** for energy buyers by providing **predictable electricity costs**
 - Unlocks **24/7 carbon accounting and reporting**
- Hourly matching also key to **limiting emissions from electrolytic hydrogen production**
 - As noted in EU Delegated Act and soon-to-be-published US 45V hydrogen tax credit rules

Leading businesses are increasing taking this systems perspective

- Started in Sept 2021, **UN 24/7 Carbon-free Energy Compact** now has **140+ signatories**
 - Includes a host of stakeholders - energy buyers, suppliers, NGOs, advisors, financial institutions etc.
- **Corporate PPAs** will play an important role everywhere **firms have direct access** to purchase clean electricity
 - Firms like Google and Microsoft have set 2030 targets
 - Companies are implementing pilots using orgs like 24/7 CFE Hub, coordinated by Eurelectric



*"We're working to **fully decarbonize our electricity consumption by matching it with clean energy around the clock on the same grids where we operate. We're also working to build the tools and advance the technologies and policies that can enable all consumers to do the same. Together, we can accelerate the decarbonization of the world's electricity systems in these critical decades of the energy transition**" - Devon Swezey, Senior Manager, Global Energy and Climate, Google*

Upcoming regulation will further enable systems-wide change

- **Regulation** will enable energy consumers to advance toward location and hourly matching
 - European Commission's Delegated Act for renewable hydrogen will need **electrolyzers to match their electricity consumption** with renewables in 2030
 - Renewable Energy Directive enables issuance of **time-stamped Granular Guarantees of Origin (GOs)**
- Governments are also implementing **national rules** that will further incentivize the transition
 - E.g., UK 24/7 Low Carbon hydrogen standards cites **real-time tracking of generation and consumption**

Sources: [UN 24/7 CFE Compact](#), [Eurelectric 24/7 Hub](#), Energy Tag, EU commission Delegated Act, Red III

Market participants in developed economies like the US and EU lack infrastructure to match planned levels of renewable generation



Capacity deployment

- Announced renewable capacity additions are growing and are nearly sufficient to meet 2030 NDC targets.
- The bottleneck to deployment of new generation capacity is the **speed and complexity of the permitting process**. Both the **length of time** to secure approvals and **number of jurisdictions** requiring approvals for a single project has become a major drag on transition
- In the short-term, **inflation, interest rates and supply chain bottlenecks** are also causing delays, especially for off-shore wind deployment

“EU targets are challenging and there are a lot of issues to overcome in terms of the grid and customers. But we remain confident”

Head of Group Sustainability,
Utility company #2



Infrastructure capacity

- Gaps in transmission and distribution (T&D) contribute to **delays in grid interconnection queues**, extending timelines to add generation; as well as limiting system flexibility.
- In some cases, **greater regional planning and coordination of new T&D infrastructure** may be needed; in others more rapid execution of existing plans is required
- **Expansion of additional grid capacity is also slowed by workforce limitations**, with a small and aging population of linemen with the knowledge required to install and maintain T&D infrastructure

“A lot of projects are fed into the pipeline but then drop out because of high transmission costs, or another project that gets approved ahead of you throws your project out - the system is totally broken”

VP & Chief of Sustainability
Officer, Utility company #1



Flexibility

- **Supply/demand mismatches** from continued electrification and transition of baseload generation capacity toward intermittent sources (e.g., wind, solar instead of fossil) **require increased dispatchable generation (e.g., battery storage, pumped hydro)**
- **Increased storage must be coupled with incentives for improved demand response** capabilities to limit the scale of peak loads and draw power into the grid from non-traditional sources, as needed

“People have tended to focus on the generation of renewables as being the biggest barrier. But increasingly people are thinking about infrastructure, grid flexibility, and interoperability”

Climate VP,
Environmental services
company #1

Government regulations and subsidies will drive investment towards streamlining new build out and improving existing grid to meet targets



Streamline permitting to enable new grid build out

- Streamlining permitting is already top of the policy agenda - operational improvements like **pre-qualification**, **digitization**, and creating a **'one-stop-shop'** for licensing by compressing redundant steps are the big asks. Many firms have also pointed to the importance of addressing the underlying issue of government capacity constraints
- Measures to **ensure communities directly benefit** from new renewable investment - whether that's through **lower utility bills**, or **revenue sharing** - can also increase the underlying societal support for new infrastructure
- But leading governments will need to exercise **"Covid pandemic levels"** of ambition in the way they work together if they are to fully unlock supply chain bottle necks, and accelerate cross-national infrastructure investment



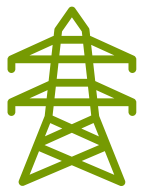
Improve coordination to solve T&D gaps and increase interoperability

- Much **greater political ambition** will also be needed to **build out the scale of grid capacity** that is required through the transition - again Covid levels of focus are required alongside cross jurisdictional coordination
- Greater **integration of electricity markets** can be game-changing in terms of system balancing as the EU's progress in establishing a single electricity market has demonstrated. In the US, enhanced cross-border exchange of electricity would require **greater consensus across public and private stakeholders** on all market design aspects including trading rules, inter-connection standards, system operation and monitoring, dispute resolution, and data reporting



Create incentives to enhance storage and flexibility in existing grid capacity

- **Long term price signals** are critical for supporting investments in low-carbon and enhanced flexibility. More liquid forward markets and the increased availability of **bilateral contracts** - such as **multiyear PPAs** - are essential for enabling long-term financing in some markets
- But as renewables capacity grows, governments will need to ensure that **new investment is targeted** towards projects that deliver **actual decarbonisation at scale** (as opposed to generation that is curtailed or subject to network congestion), and that keep price affordable for end consumers. In this context, **capacity-oriented (vs production-oriented schemes) subsidy schemes** are more likely to prioritise the most efficient projects
- **At the same time, increased government intervention will likely be needed to drive more flexibility on the demand-side.** This might include greater financial incentives, such as dynamic pricing, measures to increase investment in enabling infrastructure such as two-way grid interconnections, as well as more innovative policy measures to engage consumers - such as default opt in programmes for energy efficiency



Power: Table of Contents

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The **Sector Overview** section provides context on the state of power generation, capacity deployment, investments pathway, and global power sector targets

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The **Transition Frontier** narrative explores the state of transition of the power sector in developed economies such as the US and EU

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The **Legacy Thermal** narrative explores the state of transition of the power sector in developing economies such as China, India and Southeast Asia

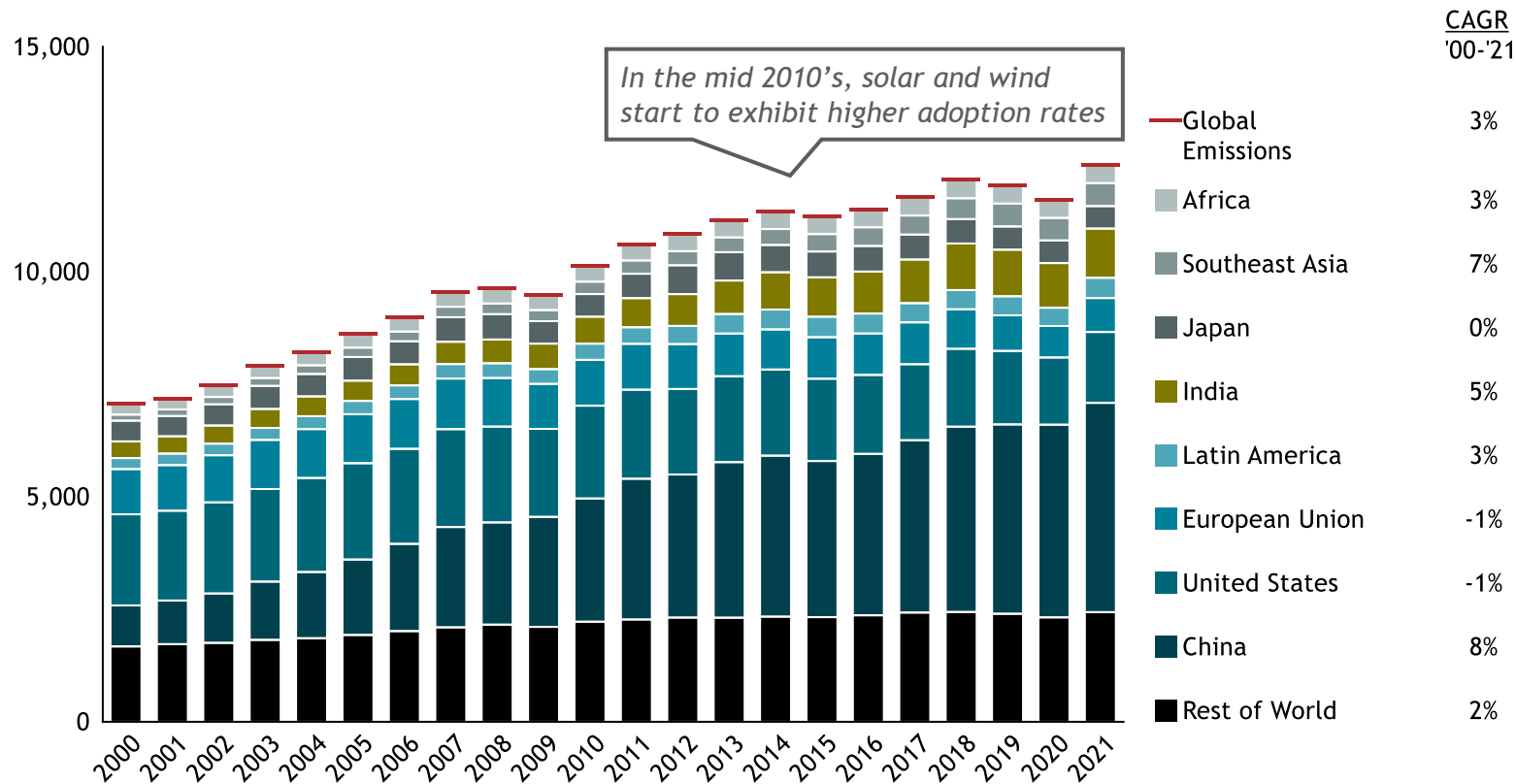
04

The **Clean Generation** narrative explores the state of transition of the power sector in emerging economies such as Latin America and Africa

Global power sector emissions are growing at a rate of ~3%, with regions like China, India, and Southeast Asia outpacing the global average

Emissions declined in transition frontier countries and accelerated rapidly elsewhere

Annual carbon emissions by region (M tonnes CO₂e)



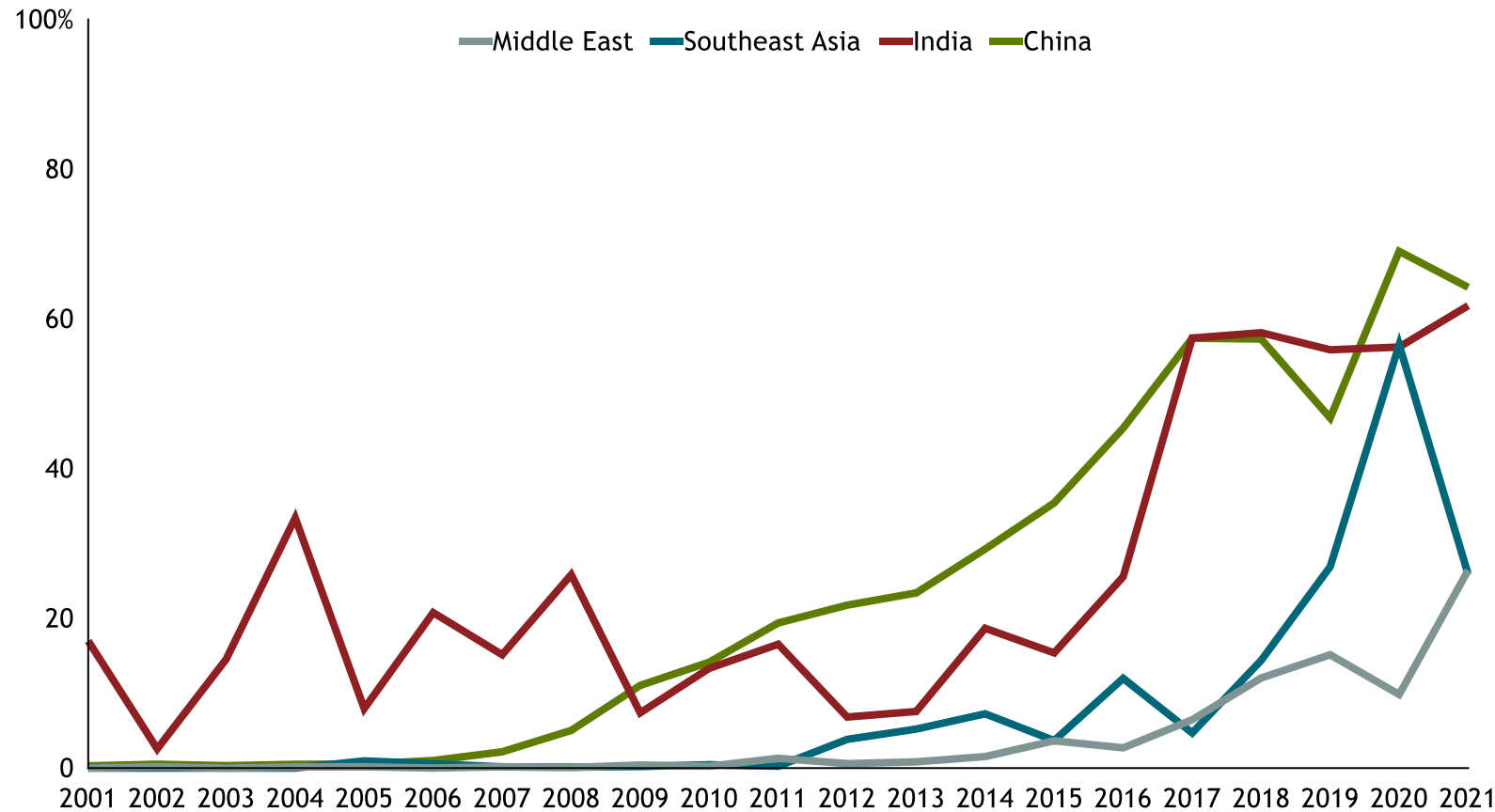
Commentary

- **Global power sector emissions grew by 75% from 2000-2021**
 - Rate of global emissions slowed from ~4% between 2000 and 2010 to ~2% between 2011-2021
- **The US and EU decreased their emissions by 2-3% p.a. from 2011-2021**
 - Decreased emissions are due to increased use of renewable and nuclear power sources and reduced use of coal in favor of natural gas
- **China, India, and Southeast Asia are significantly outpacing the global average emission rate**
 - Rapid economic development and a reliance on fossil fuels led to higher emissions in China, India, and Southeast Asia
 - Despite contributing to the majority of power sector emissions, Chinese emissions per capita were ~31% lower than US emissions per capita

Note: Latin America includes Mexico, Central America, South America, and the Caribbean; Southeast Asia includes Philippines, Indonesia, Vietnam, Malaysia, Thailand, Myanmar, Laos, Cambodia, Singapore, Brunei
 Source: Ember, IEA, Lit. search

India and China's solar and wind power generation capacity contributed 62% and 64% of net new capacity additions in 2021 respectively

Share of solar and wind in net new generation capacity (Middle East, Southeast Asia, India, and China, %)



Commentary

- China has accelerated its share of renewable capacity additions since 2008, but continues to add a significant portion of fossil-dependent generation to their grid every year
- Adoption of solar and wind capacity remains low in the Middle East and Southeast Asia where the share of additions equaled only 26% in 2021
- India's share of renewable additions appears high in the early 2000s due to lower overall additions volumes, but has accelerated again since 2015

Source: Ember

But while renewable capacity additions are growing in China and SEA, most coal retirements are expected to occur outside this region

Globally, less than 15% of coal plant capacity is expected to be retired before 2040

Share of installed coal plant capacity planned for retirement (GW)



Source: Global Coal Plant Tracker, Global Energy Monitor, January 2023 release

Commentary

• China:

- China has retired ~6 GW of coal annually since 2012
- Although they have only announced ~5 GW of coal retirements before 2040, the Chinese government may continue to retire relatively small portions of coal annually without prior public announcement

• Southeast Asia:

- Excluding Thailand and Indonesia, no Southeast Asian countries have made commitments to retire coal plant capacity

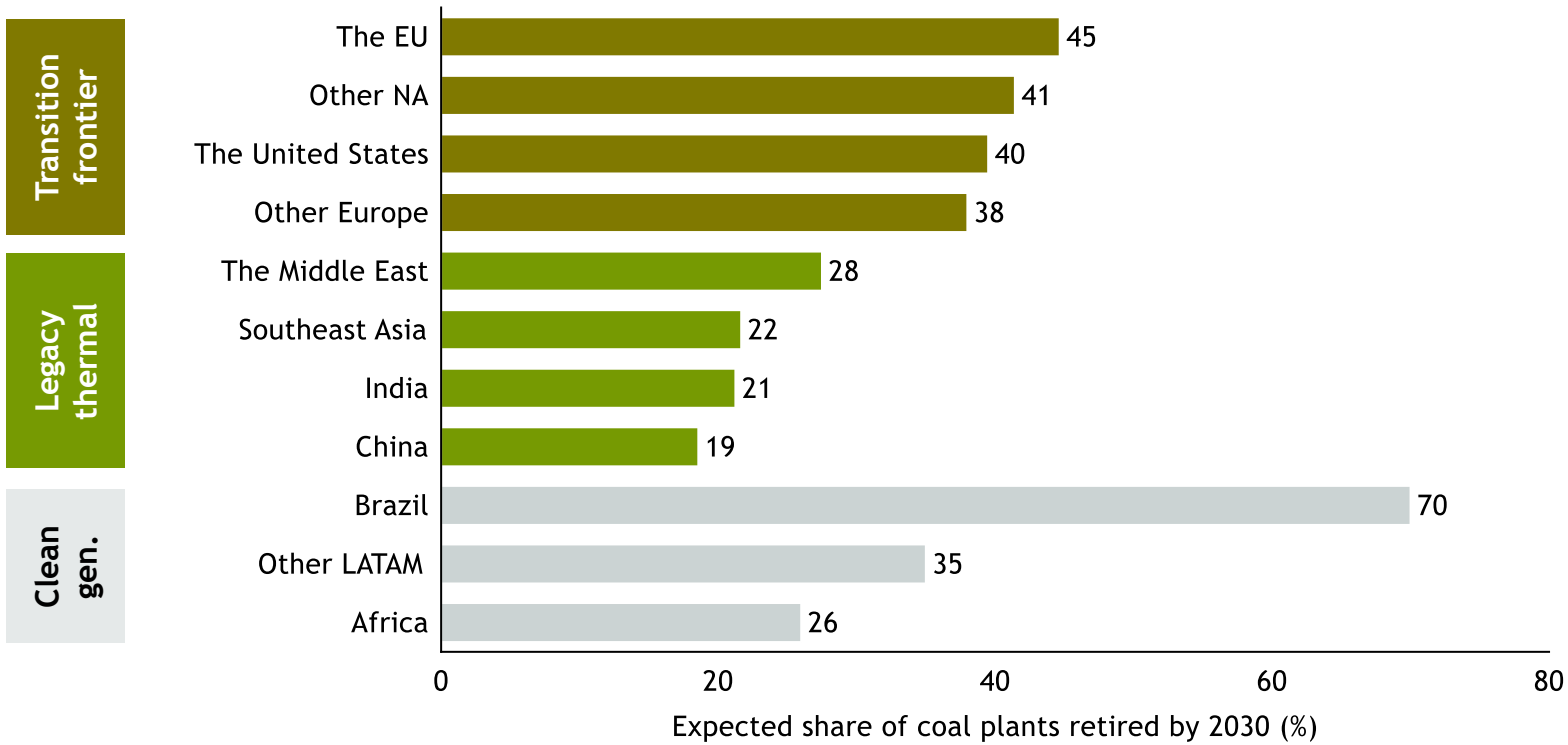
• Other large operators:

- India has made no future retirement commitments despite operating the second highest volume of coal plant capacity
- The U.S. plans to retire the highest volume of coal plant capacity before 2030
- Japan has only committed to retiring roughly 3% of existing coal plant capacity
- Australia plans to retire more than 80% of their existing coal plant capacity by 2040

Business leaders across the power sector also see significant variation in expected coal retirements across geographies

North America, Europe, and Latin America lead on expected coal retirements

What share of existing coal power production capacity in [region] do you expect will be retired by 2030?



Note: Expected share retired calculated as average of respondents within each geography
 Source: Global Corporate Stocktake Survey (N = 215)

Commentary

- Leading geographies on anticipated coal retirements (e.g., North America, Europe, Latin America) are **starting from a point of less coal** in their generation mixes
 - US and Europe have already executed significant amounts of coal retirements over last two decades
- Geographies with the lowest share of anticipated retirements (e.g., China, India, Southeast Asia) are **starting with higher amounts of coal** in their generation mix
 - These regions also tend to have **younger coal plants** relative to those in regions with higher shares of expected retirements

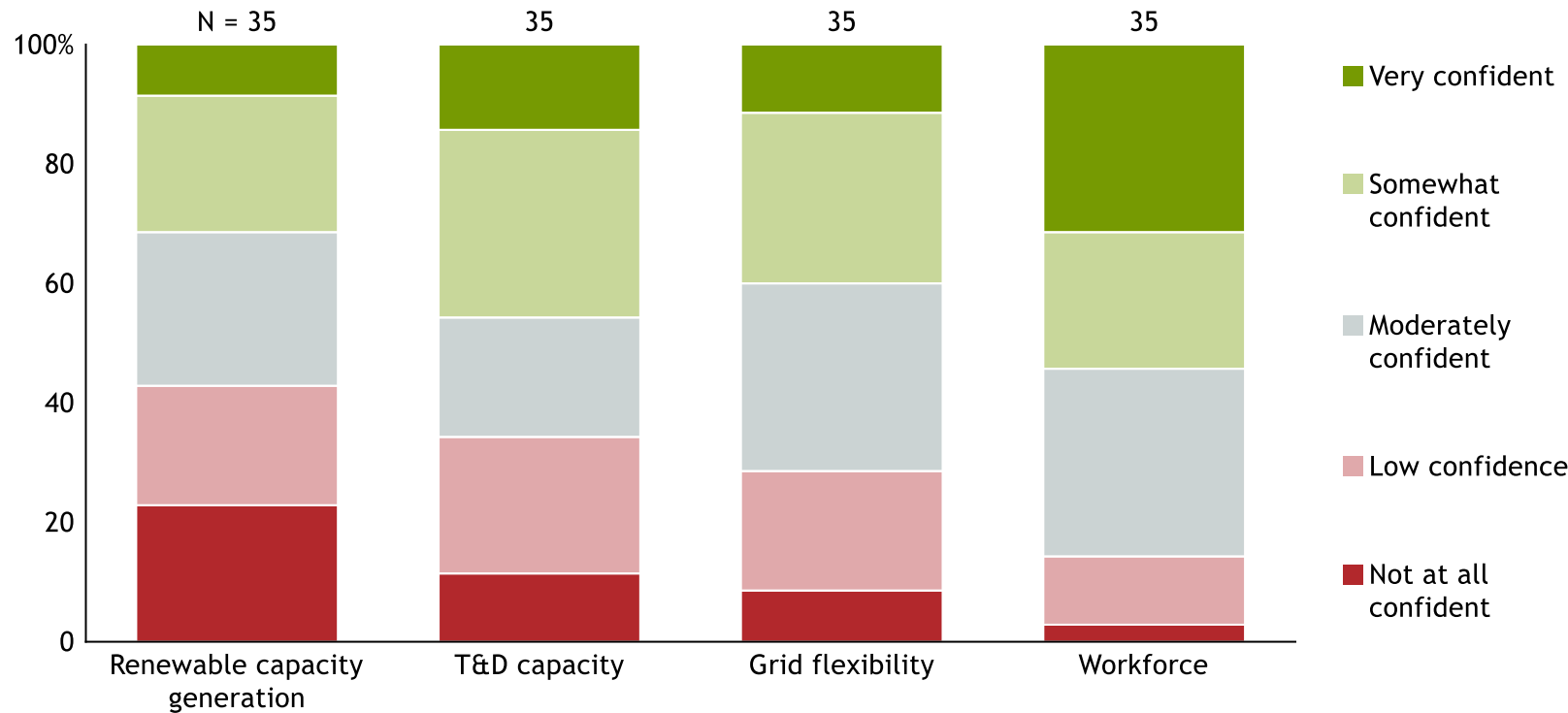
“There is no renewable technology today that will replace all of the coal that we need to retire. - certainly not cost effectively and with reliability”
 VP & Chief Sustainability Officer, Utility Company #1

“We have now accelerated the coal exit from 2038 to 2030. But with the clear message that with this decision, we also expect the government to accelerate processes”
 -Manager of Sustainability, Renewable Power Producer #3

Most business leaders in these geographies also lack confidence in ability to meet both generation and transmission capacity, likely driven by high costs

On a scale from 1 to 5 - where 1 is not confident at all and 5 is very confident - how confident are you that ____ will match the ambition necessary to achieve Breakthrough Agenda targets?

Share of survey respondents (%)



Commentary

- Lower levels of confidence in ability to achieve renewable generation ambitions relative to ‘transition frontier’ geographies likely driven by differences in project financing costs
 - 62% of leaders in ‘legacy thermal’ geographies view access to low-cost financing as a top barrier compared to 26% in ‘transition frontier’ geographies

“We probably won’t be able to make it without thermal generation for the foreseeable future. Therefore, it should be as efficient as possible - use renewable fuels and have some sort of capture and an IFS storage or utilization” - Head of Global Positioning, Renewable power producer #1

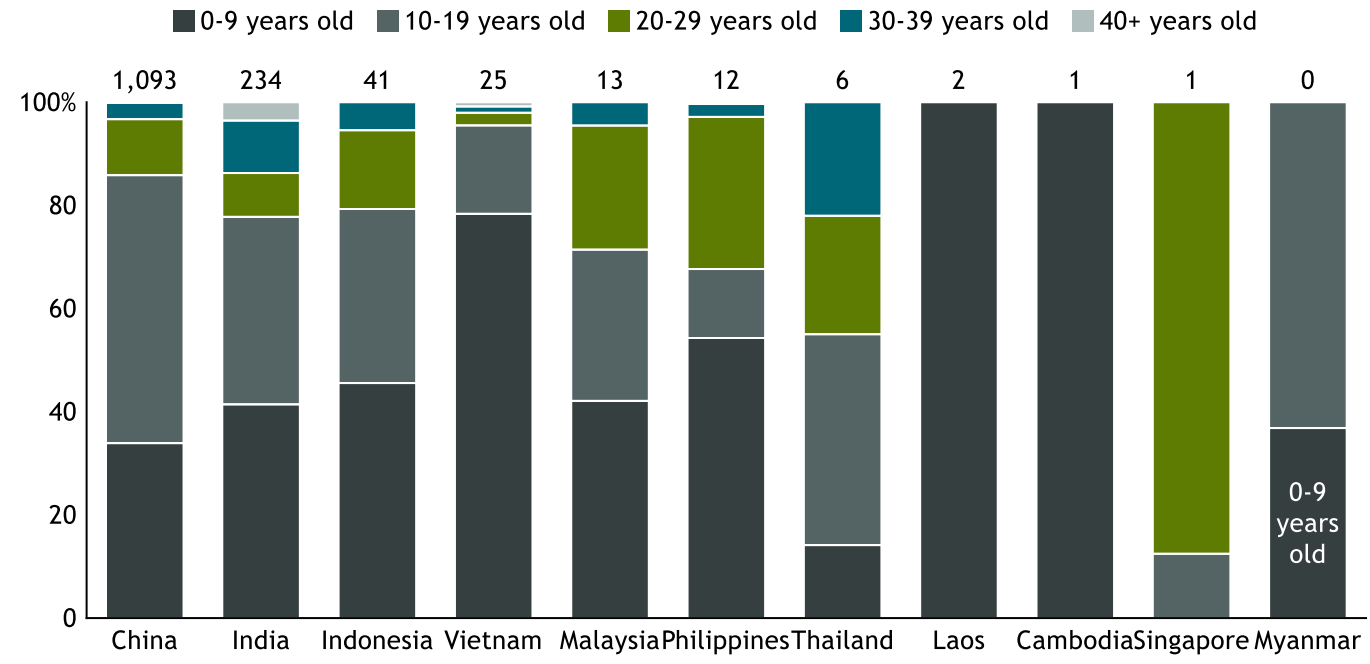
“And maybe the problem...is not necessarily getting enough [generation] capacity, but rather getting [generation] capacity where it’s actually needed, and getting it connected” - Magnus Gottlieb, External Affairs Manager, Ørsted

Note: Chart reflects share of respondents with expertise in China (N = 7), India (N = 16), and Southeast Asia (N = 12)
Source: Bain / WMBC Global Stocktake Survey (N = 215)

Also, in many Asian economies, coal retirement will be harder because the capacity is less than halfway through its expected useful life

~37% of Chinese, Indian, and Southeast Asian coal capacity is less than 10 years old

Coal power plant capacity (GW)



% <10 years old	34%	41%	46%	78%	42%	54%	14%	100%	100%	0%	37%
Proposed additions (GW)	187	1	15	19	0	7	1	5	1	0	1

Note: Capacity limited to plants categorized as 'active' or 'partially active' (excludes 'decommissioned', 'dormant', 'suspended', 'temporarily shutdown', etc.); Proposed additions include projects categorized as 'announced', 'permitting', and 'under construction'; percent of capacity less than 10 years old calculation excludes capacity where age is unknown
 Source: Global Coal Plant Tracker, Global Energy Monitor, January 2023 release, International Energy Agency, Ember

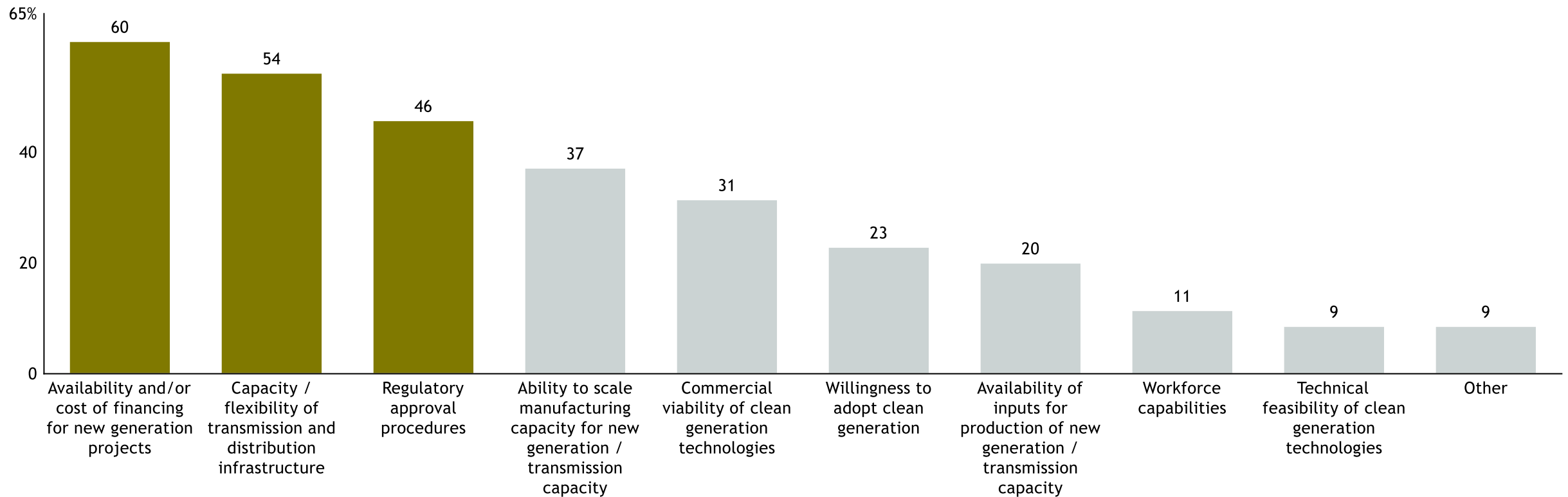
Commentary

- Anticipated **useful life** of coal plants typically ranges from **30-40 years**
 - Retrofits can enable further extensions of useful life
 - Capacity can be added to a plant over time meaning a single coal plant's capacity can have a range of "ages"
- Chinese and Southeast Asian coal plants are **significantly younger** than those seen in other regions, making retirements uniquely difficult
 - **China / SEA:** ~14 years
 - **US:** ~44 years
 - **Europe:** ~41 years
- Achieving retirement goals becomes even more difficult if **additional ~240 GW of proposed coal plant capacity additions** come online
- Proposed additions include projects categorized as 'announced', 'permitting', and 'under construction'

For meeting decarbonization goals - leaders in China, India, and Southeast Asia, believe financing, regulatory procedures, and T&D infrastructure are top barriers

Which of the following do you view as the power sector's largest barriers towards accelerating decarbonization? Please select the top 3 most impactful barriers.

Share of survey respondents selecting barrier in the top 3 (%)



Note: Chart reflects share of respondents with expertise in China (N = 7), India (N = 16), and Southeast Asia (N = 12)
 Source: Bain / WMBC Global Stocktake Survey (N = 215)

These markets share similar barriers to US and EU concerning infrastructure capacity and complex permitting processes

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*“The constraints are similar in many of the places where we operate- including the **framework for permitting and administrative issues**, challenges with **communities’ consent**, and **grid connection**”*

Gonzalo Sáenz de Miera, Global Director of Climate Change and Alliances, Iberdrola

Source: Corporate interviews

But high levels of regulation and low financial incentives can make these markets even tougher to navigate

 **Regulatory environment**

“Renewables have grown in many markets, initially driven by CFDs and other subsidy schemes. But now the prices are their lowest mostly. Penetration is tough in markets that are most regulated. Investments by new entrants is often restricted. IPPs need to be legally permitted with access to transmission networks “

- Senior Sustainability Advisor, Financial services provider #2

 **Local content requirements**

“Local content requirement is an issue. In some places, you can build solar plants but only if some proportion of the manufacturing is done domestically. That’s challenging given the geography of solar manufacturing”

- Senior Sustainability Advisor, Financial services provider #2

 **Role of state utility**

“State utilities have driven investment, but in many cases, can also lead to barriers - whether that’s the obligation to provide cheap stable power, vested interests, or workforce barriers”

- Senior Sustainability Advisor, Financial services provider #2

 **Financial incentives**

“There are lots of active markets with good profitability currently - venturing beyond these safe havens would require stronger incentives”

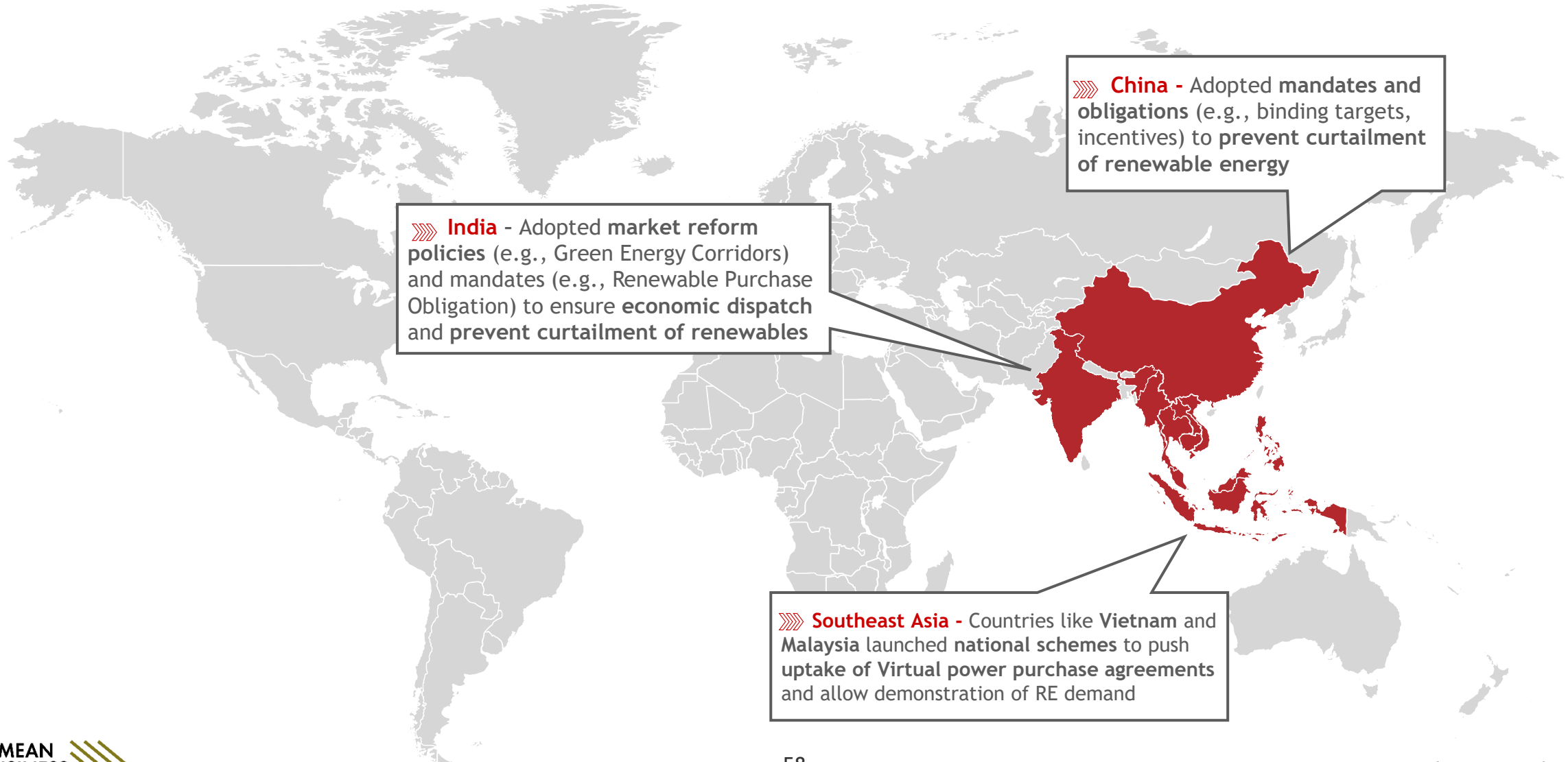
- Global Sustainability Lead, Utility company #5

 **Project bankability**

We are constantly looking for opportunities to fund the transition, but the financing costs are so high. High interest rates have made it worse. Everything looks expensive - high capital costs and stress testing requirements”

- Managing director, Sustainable Finance Group, Financial services provider #1

Given these constraints, government interventions and policies play an important role in driving renewables expansion

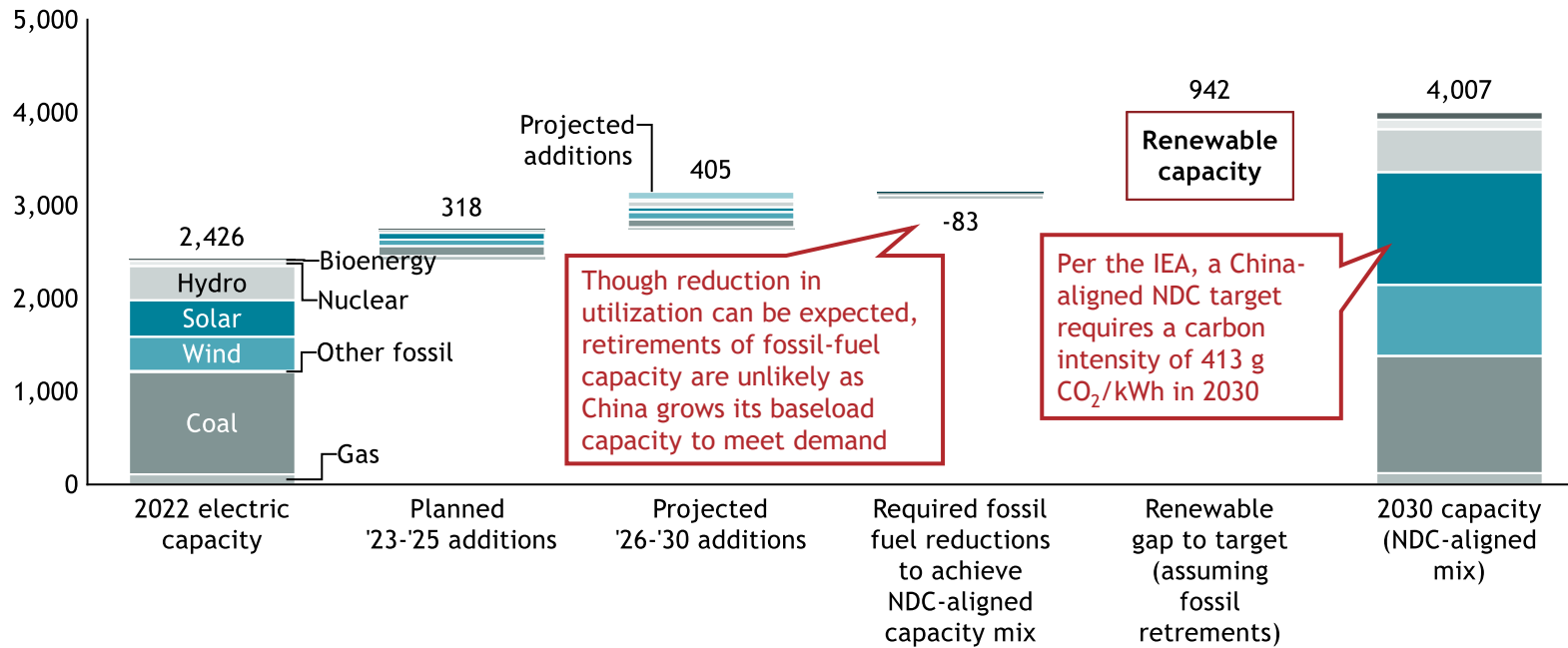


In China, roughly 350 GW of renewable capacity has been brought online since 2021 which has positioned China as a global leader in renewable deployment



Although China lacks public capacity announcements, if they continue to deploy renewable capacity at historic rates, they will achieve NDC-aligned 2030 targets

Electric capacity by source (GW, China)



① China has a relatively significant amount of planned fossil fuel capacity additions in the pipeline before 2030

② Continued deployment of renewable capacity will need to be added to meet rapidly growing demand in China

Note: 2030 capacity targets are according to the GEC APS model which projects that all commitments and policy that countries have proposed will be met in full; Planned additions include projects in the 'announced, permitted, financed, or under construction' phases of development as defined by Global Data; Data includes capacity volumes from China and Hong Kong; 2030 capacity splits reflect increases in demand while maintaining typical utilization rates

Source: Ember - Yearly Electricity Data (Capacity data aggregated from Global Energy Monitor, Global Data - Upcoming Power Plants; IEA - Global Energy and Climate (GEC) APS Model

Commentary

- ① China's 14th five-year plan has outlined targets that exceed 1,100 GW of wind and solar capacity by 2025
 - Roughly 350 GW of wind and solar has been added since 2021 suggesting this target will be surpassed
 - The IEA's APS model implies an additional 800 GW of wind and solar will be needed between '25-'30
- China has outlined plans to develop massive-scale 'clean energy bases' concentrated in rural areas such as the Gobi Desert
 - These plans will take advantage of underutilized land, but transmitting power to urban demand centers will present infrastructure challenges
- ② China will continue to rely on coal to ensure reliable access to electricity amid intermittency concerns associated with wind and solar generation
 - NDC-aligned capacity mix increases dispatchable power from 1,666 GW in 2022 to 2,031 GW in 2030
 - 'Baseload' coal plants can transition to lower utilization rates as clean capacity comes online

China is building clean energy mega bases to double wind and solar power installed capacity by 2030



Overview

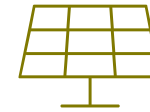
- **Description:** China's 14th five-year plan aims to develop 570GW of wind and solar power between 2021-2025, largely through the development of clean energy mega bases
- **Power sources:** Wind and solar
- **Developers:** State-owned enterprises
- **Regions:** Primarily located in desert areas in western provinces such as the Gobi Desert, Inner Mongolia, and Xinjiang

Targets

- 2023** • 97 GW of solar and wind bases in northwestern regions
- 2025** • 200 GW of additional capacity at larger bases
- 2030** • 1,200GW of solar and wind power
 - 25% of energy consumption powered by non-fossil fuels
 - Peak carbon emissions before 2030
- 2060** • Carbon-neutral power sector before 2060

Activities

Wind and solar mega bases



Progress



- Gigawatt-scale solar and wind parks connected to demand centers with long-distance transmission lines
- Mega bases require large amounts of land, allowing China to unlock a **new use for sparsely populated deserts and arid regions** while also meeting land needs of mega bases
 - To meet the 1,200GW of solar and wind capacity goal, China needs 7,028sq km of land, the equivalent to 0.07% of their total land area
 - China can reduce the costs of land, construction, operation, and maintenance by locating bases in deserts, barren lands, and wastelands from coal mining
 - Largest planned mega bases will be in the deserts of Inner Mongolia and Gasu
- Current state of development of mega bases has set China up to meet its 2030 goal of developing **1,200GW of solar and wind capacity by 2025**
- China has released two lists detailing development of 555GW of mega bases that will host **~50% of its wind and solar capacity to be connected to the grid by 2025**
 - The first list is across 19 provinces and will comprise 97GW of capacity with 43GW in the Gobi and other north/northwest deserts
 - The second list details 300GW of mega bases to be constructed by 2025 with an additional 255GW to be added in the future

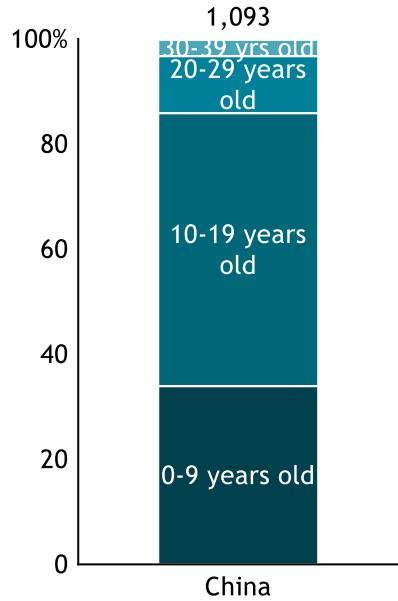
Source: Carbon Brief, S&P Global, Lit. Search

Despite China's high growth in renewables, additional coal capacity has been announced



China's coal plant capacity is young...

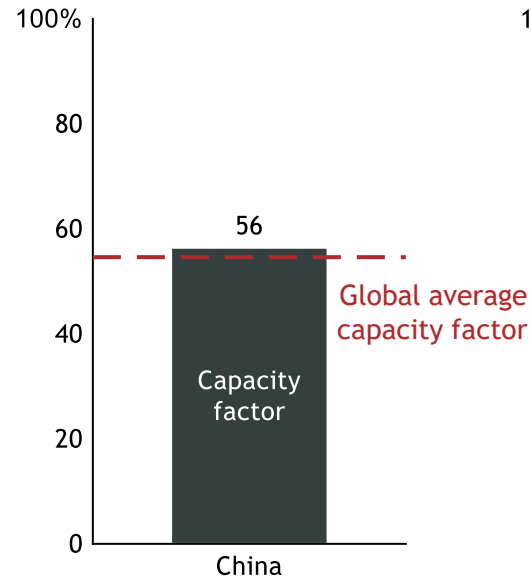
Coal power plant capacity (GW)



Proposed additions (GW) 187

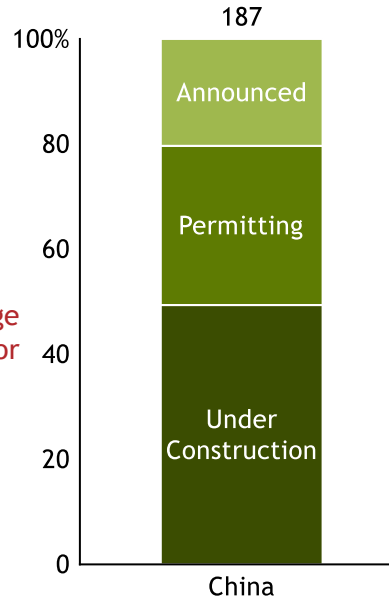
...with a high utilization rate...

Coal power plant capacity factor by region (2022, %)



...and a lot more is under construction...

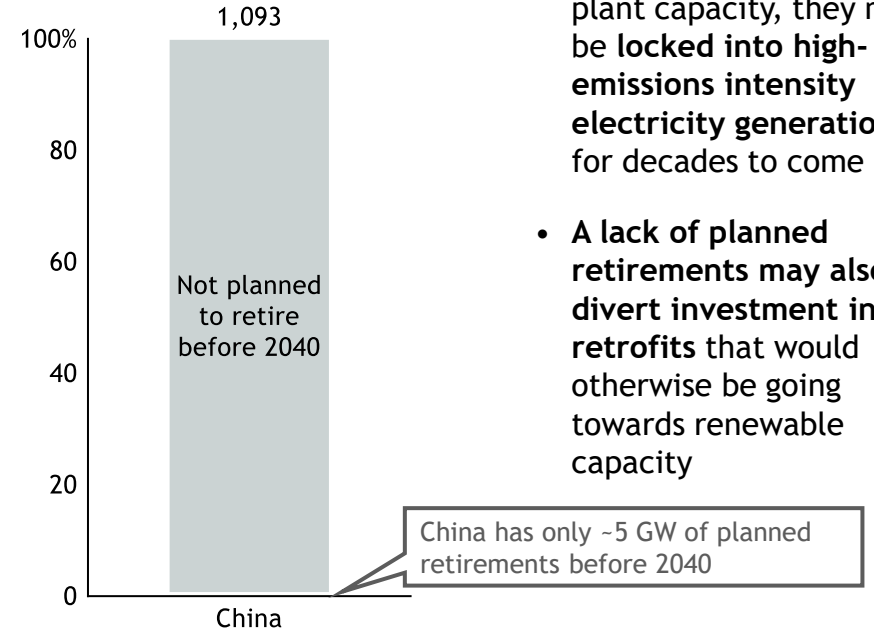
Coal power plant capacity in the pipeline (2023-2035, GW)



Share of capacity coming 99% online by 2025

...with no plans of future retirement...

Share of coal plant capacity planned for retirement (GW)



China has only ~5 GW of planned retirements before 2040

Commentary

- If China completes planned coal power plant capacity, they may be locked into high-emissions intensity electricity generation for decades to come
- A lack of planned retirements may also divert investment into retrofits that would otherwise be going towards renewable capacity

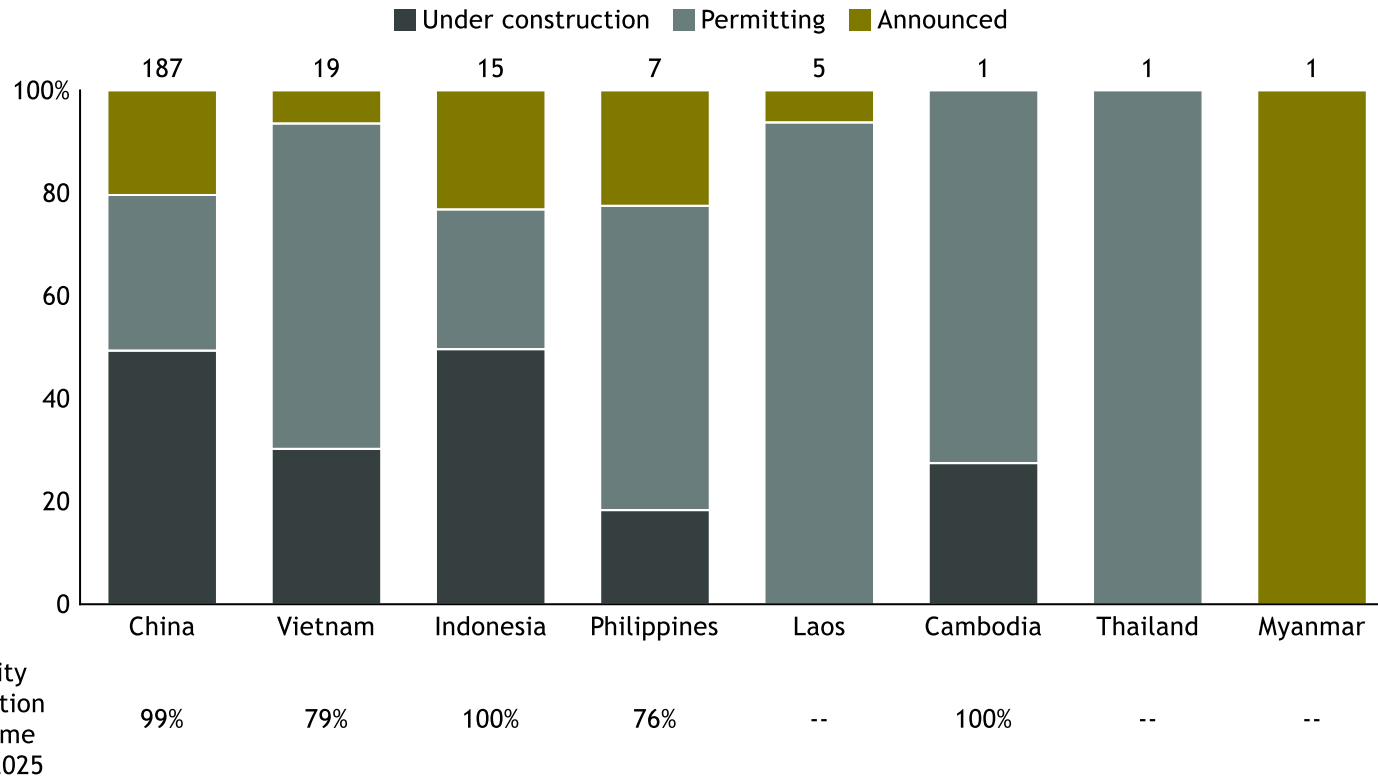
Note: Capacity limited to plants categorized as 'active' or 'partially active' (excludes 'decommissioned', 'dormant', 'suspended', 'temporarily shutdown', etc.); Proposed additions include projects categorized as 'announced', 'permitting', and 'under construction'; percent of capacity less than 10 years old calculation excludes capacity where age is unknown

Source: GlobalData Thermal Plants Database, International Energy Agency, Ember, Global Energy Monitor - Planned Coal-fired Power Capacity Retirements by Country

The pipeline of planned additions of coal capacity is sizeable, with nearly half of capacity additions in China and Southeast Asia already under construction

~45% of coal plant capacity in the pipeline is already under construction

Coal power plant capacity in the pipeline (2023-2035, GW)



Share of capacity under construction expected to come online before 2025

Commentary

- The majority of coal plant capacity under construction will be completed by 2025 if development plans are successfully achieved
- Larger coal producers have the highest share of capacity in the construction phase of development
- Chinese coal plants currently operate at a 56% utilization rate, but could significantly decrease if planned capacity comes online
 - Global average utilization rate: ~55%

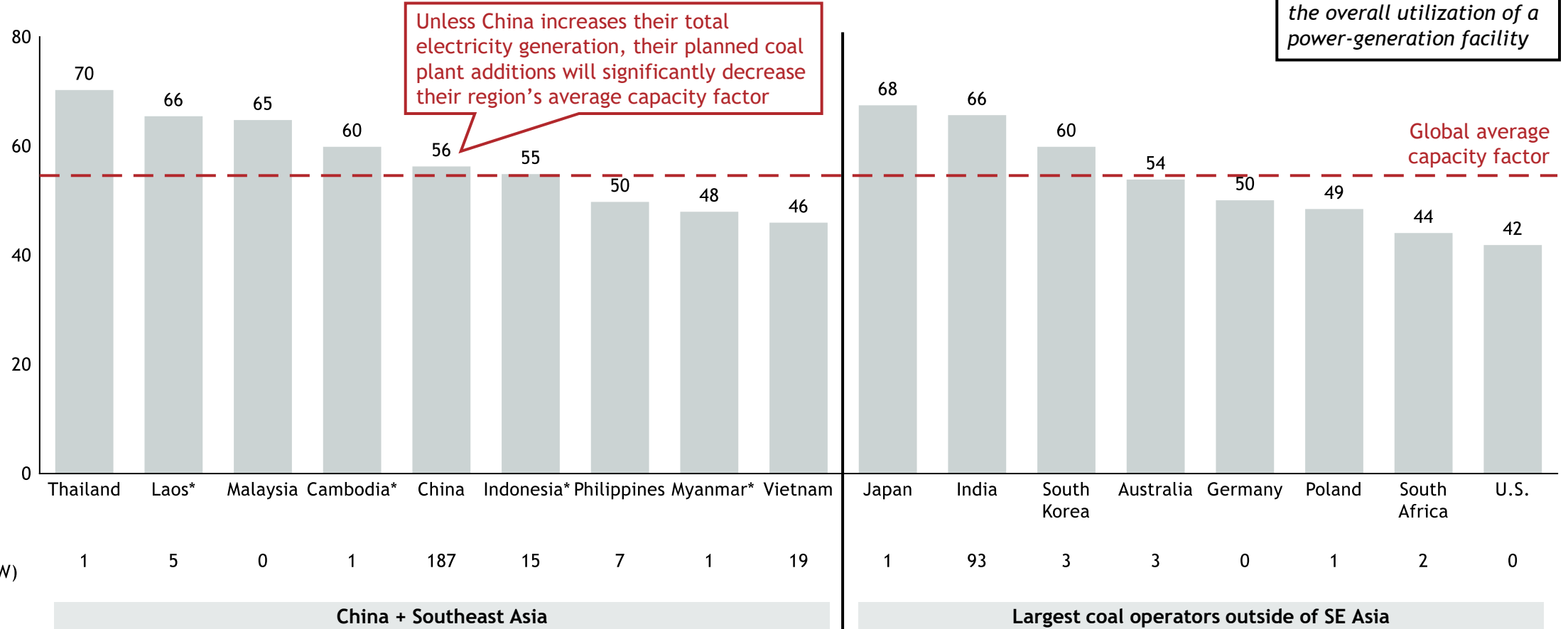
*“For the **Chinese commercial banks**, they aren’t going to stop financing fossil infrastructure if the government wants to make sure that the power system doesn’t fall off a cliff. So, the **government has a big say in these markets**”*

-Managing Director, Sustainable Finance Group, Financial services provider #1

Note: Capacity limited to plants categorized as ‘active’ or ‘partially active’ (excludes ‘decommissioned’, ‘dormant’, ‘suspended’, ‘temporarily shutdown’, etc.); Proposed additions include projects categorized as ‘announced’, ‘permitting’, and ‘under construction’; Average year that capacity under construction will come online was calculated as a weighted average of total capacity under construction over time per region
 Source: GlobalData Thermal Plants Database, International Energy Agency, Ember

China's average utilization rate of coal power plants is also slightly above the global average, indicating that they are actively using installed coal power plant capacity

Coal power plant capacity factor by region (2022, %)



Unless China increases their total electricity generation, their planned coal plant additions will significantly decrease their region's average capacity factor

Note: * Indicates countries with data from 2021; Capacity factor calculated as (Total Generation GWh / 8760 hrs) / (Total Capacity) for each region; Proposed additions include capacity from 2023-2035; Source: Global Data Thermal Plants Database; Ember

The government in China has adopted mandates and renewable obligations at provincial level, which has helped prevent curtailment of renewable energy



Policy measures preventing the curtailment of renewable energy

Guaranteed consumption of renewable energy

- China's RE Law **guarantees full purchase of RE**, but in practice **dispatch did not prioritize RE**
- In 2016, the government reiterated the requirement for full purchase of RE and issued **minimum dispatch quotas for provincial grid companies**
- Guaranteed purchase amounts are set based on **provincial capacity factors** (depending on local RE resources)
 - The renewable obligation was adopted in 2018 which specifies consumption targets for three years - these range from 4% to 25%

Binding targets for reducing curtailment

- In 2018, national energy authorities established a rule that provinces should **resolve curtailment by 2020** and were compelled to develop plans to **reduce curtailment to below 5% by that year**

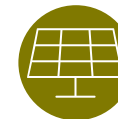
Economic incentives for reducing curtailments

- The initial Renewable Energy Law was unclear as to whether wind and solar would receive compensation for total energy produced or only for the energy accepted by the local grid - in practice, **curtailed electricity production was not compensated**
- In 2016, China issued a rule, **mandating compensation for curtailed energy**
- In late 2019, NDRC clarified that **grid companies would bear the cost of curtailment** - which led to introduction of **real, systematic economic incentives to reduce curtailment**

Impact on renewable generation



Wind energy curtailment rates decreased from 17% in 2016 to 4% in 2019 as generation doubled



Solar energy curtailment rates decreased from 11% in 2015 to 2% in 2019 as generation quintupled

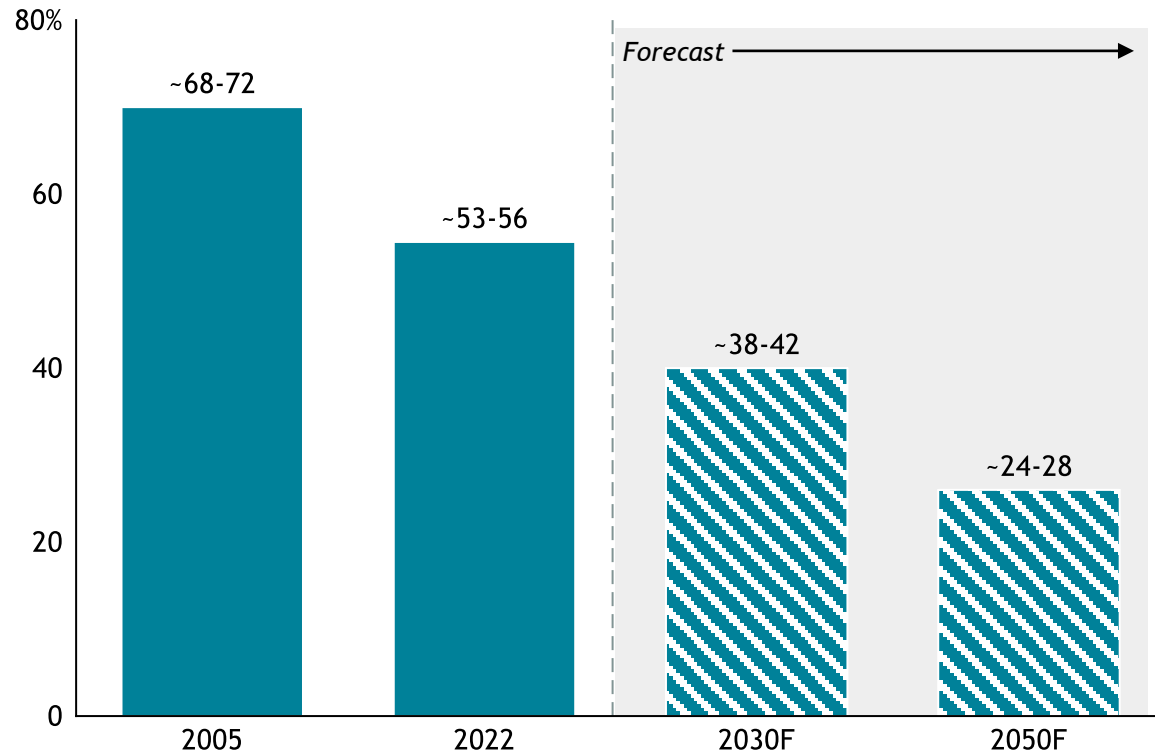
Sources: 1) China Energy Policy, Columbia Edu;

Although coal capacity is increasing, utilization is expected to decline in support of meeting peak demand as renewables come online rapidly



Coal power plant utilization is expected to continue declining...

Chinese coal-fired power utilization rate (%)



Note: Utilization rates are ranged to reflect slight disparities across sources in historic and forecasted estimates of utilization
Source: S&P Global, TransitionZero, Ember, "Reducing coal overcapacity in China..." (Zhang et al., 2022)

...implying additions are driven more by policy than economics

Political economy

- Base utilization threshold for profitable operation of coal plants is typically ~70%, suggesting most existing plants and future additions will operate in the red
- Announced reforms to shift to economic dispatch would further reduce utilization and limit curtailment of renewables
- Reforms are meeting political resistance given relationship between local coal power generation revenue and political prospects of provincial governors
 - Construction jobs associated with building new coal plants also support provincial governors' promotion prospects, providing rationale for construction of new thermal additions

Flexible generation

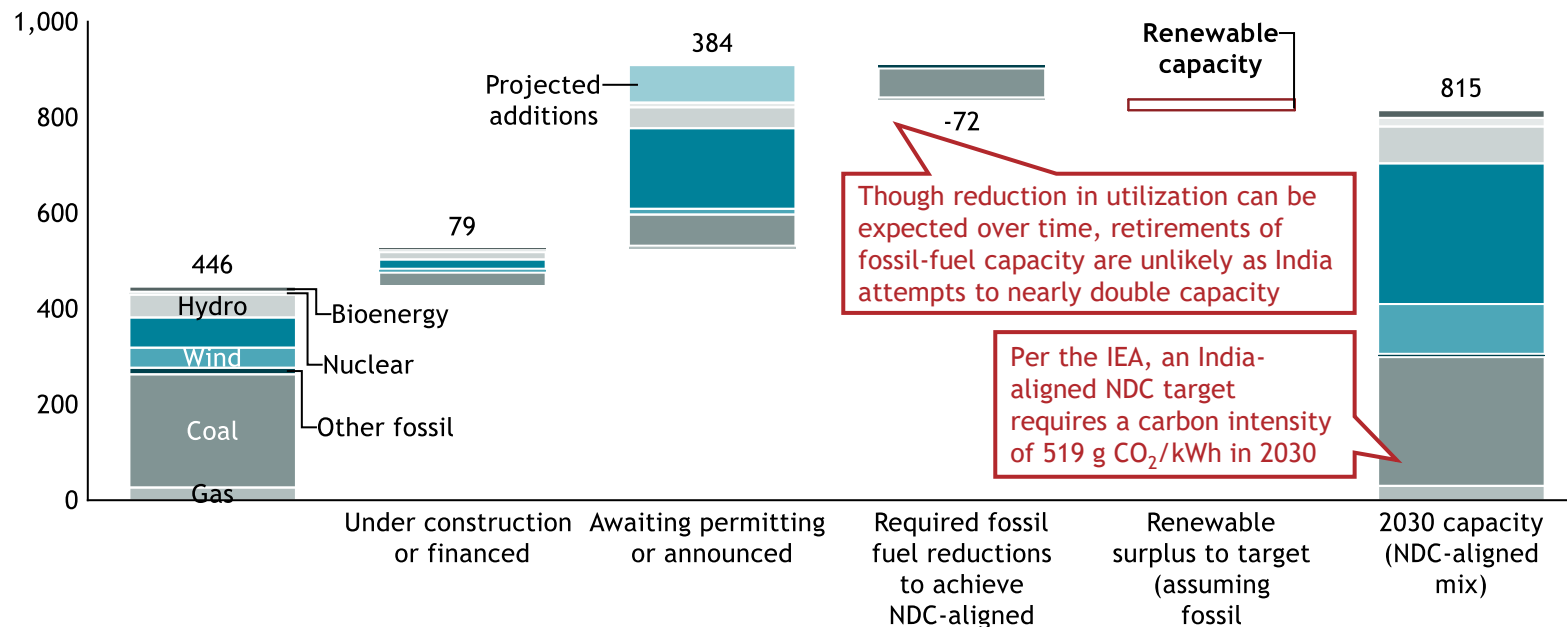
- Continued unprofitable operation of legacy thermal plants also results from plans to utilize coal as a primary source of dispatchable generation to manage peak loads
 - Limited domestic supplies of natural gas and high cost of LNG imports have constrained financial viability of coal-to-gas switching seen in other countries (e.g., US)
- Rapid growth in renewables within China creates significant risk associated with intermittency of generation
 - Chinese officials are taking a conservative approach to intermittency management with a desire for significant reserves of dispatchable generation to minimize risk to reliability
 - Reductions in generation from hydropower after limited rainfall and extreme temperatures limits potential of alternative baseload sources

In India, more than 80% of projects in the pipeline remain in the earliest stages of development, but can allow India to meet generation mix targets if completed



India is scaling deployment of solar capacity to achieve NDC-aligned 2030 targets

Electric capacity by source (GW, India)



① India has a large amount of clean capacity additions in the pipeline, but most appear to be in early development stages

② A significant amount of fossil-dependent capacity will be kept online in 2030 to meet India's growing energy demand

Though reduction in utilization can be expected over time, retirements of fossil-fuel capacity are unlikely as India attempts to nearly double capacity

Per the IEA, an India-aligned NDC target requires a carbon intensity of 519 g CO₂/kWh in 2030

Commentary

- ① India's Prime Minister has committed to installing 500 GW of total renewable capacity by 2030, implying ~350 GW of incremental clean capacity compared to today
 - Roughly 80% of proposed capacity remains in the earliest stages of the development pipeline
- India has provided electricity access to 50M citizens / year over the last decade
 - Energy consumption per household remains low at one tenth of U.S. rates, but is expected to increase as infrastructure is developed and electric vehicles penetrate the transportation sector
 - India's National Grid ensures that all generated electricity can be transmitted to meet demand in any part of the country
- ② Relatively high cost of natural gas in India has promoted the historical development of coal power plants
 - Coal plants can transition to operating as 'Peaker Plants' as more renewable capacity comes online

Note: 2030 capacity targets are according to the GEC APS model which projects that all commitments and policy that countries have proposed will be met in full; Planned additions include projects in the 'announced, permitted, financed, or under construction' phases of development as defined by Global Data; Data includes capacity volumes from China and Hong Kong; 2030 capacity splits reflect increases in demand while maintaining typical utilization rates
 Source: Ember - Yearly Electricity Data (Capacity data aggregated from Global Energy Monitor, Global Data - Upcoming Power Plants; IEA - Global Energy and Climate (GEC) APS Model

India's existing power market faces multiple technical, policy, and regulatory challenges for integrating renewable energy into the grid



Technical challenges

Transmission challenges

- Large-scale RE is often deployed on barren land that is far from demand centers, causing curtailments due to a lack of transmission infrastructure
 - Limited interstate transmission lines create further bottlenecks across states

Inconsistent data tracking

- Many states lack the ability to track solar and wind generation data in real-time
 - Where tracking is possible, it is inaccurate as regulations often allow for forecast errors of +/-15%
- Lack of visibility of existing and future installations of distributed energy resources (e.g., rooftop solar panels)

Demand variability

- Peak demand is increasing primarily driven by new demand sources such as air conditioners and EVs
- Flexibility requirements are increasing for coal plants where there is a lack of ramping capabilities and SOPs

Lack of coordination

- Lack of co-ordination among state-level transmission planners and central planning agencies
- Unified planning model across the country is absent

Policy, market, and regulatory challenges

Lack of support for flexibility

- Solar and wind curtailments limit financial returns, which can affect investor confidence
- Priority for coal power plants (at technical minimums) reduces the grid operators' ability to balance the system with lower-carbon sources in some states
 - No remuneration for coal power plants if investment in increased flexibility is required by the state

- Lack of regulatory frameworks for demand response and storage technologies

Financial stress on DISCOMS

- Long-term contracts for coal power plants create an economic burden due to requirement for capacity payments (fixed) and energy payments (variable)
- Increasing investment into transmission infrastructure can translate into higher electricity costs
- DISCOMS need to pay fixed charges for coal plants bound by long-term PPAs, while also being bound by national renewable purchase obligations
 - The gap between average cost of supply and average revenue increased from ₹0.54 in '13 to ₹0.72 / kWh in '19 with AT&C loss at 22% at a national level (as high as 55% in some states)
 - High dependence on subsidies (~20% tariff subsidy as a share of revenue) prevents DISCOMS from making structural changes

Notes: AT&C - Aggregate technical and commercial losses; DISCOM - distribution company

Source: 1) [Renewables Integration in India, IEA](#); 2) [Renewables Integration in India, NITI Aayog](#); 3) Turning around the power distribution sector, RMI, NITI Aayog

India has multiple market reform policies and mandates in place to ensure economic dispatch and prevent curtailment of renewable energy



Types of policy

MBED provides country-wide ranked bidding

Renewable Purchase and Energy Storage Obligations mandates the use of RE sources

VPPAs allow direct purchase of renewable electricity

Green Energy Corridors support transmission development

Must-run status for renewable energy limits curtailment

Impact on India's renewable energy dispatch and curtailment

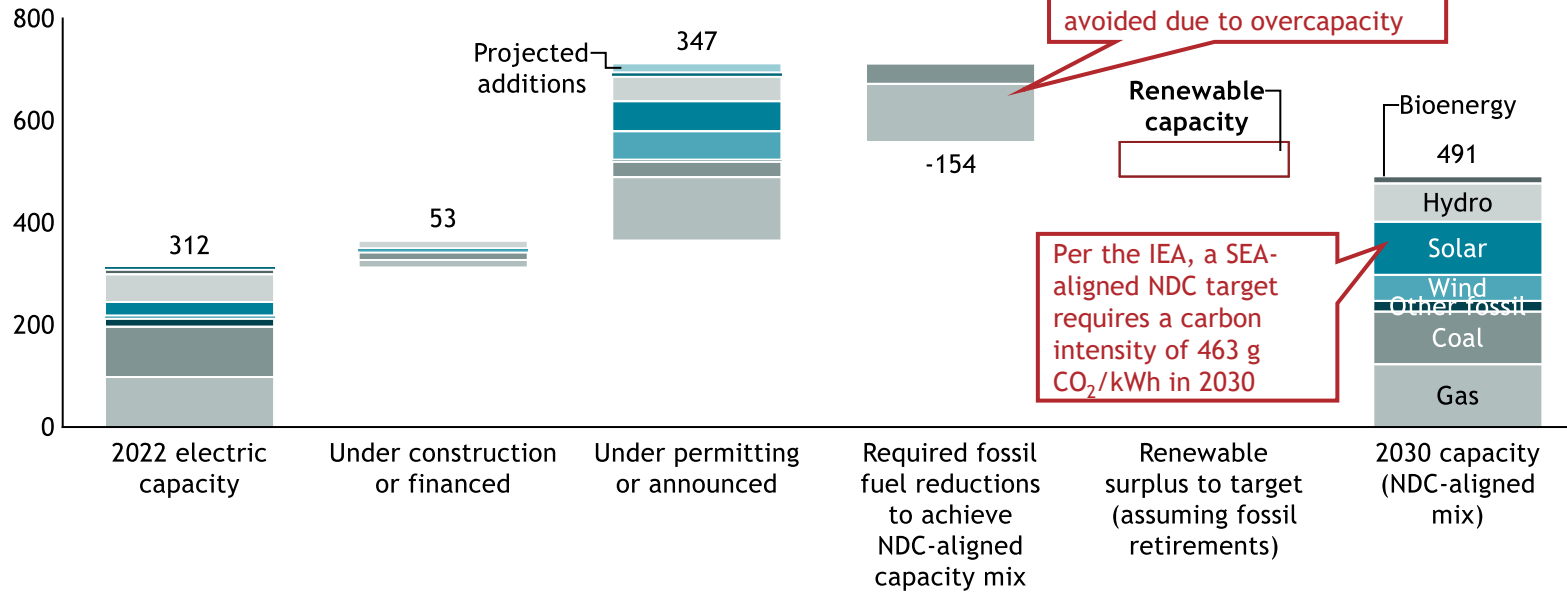
- Ministry of Power proposed market-based economic dispatch (MBED) where distribution companies (DISCOMs) and generators submit bids to national market operator that will rank the bids on a country-wide basis based on price and provide a day-ahead dispatch schedule¹
 - Govt. estimates that this would reduce power procurement costs by \$1.6B³ annually, improving the financial position of DISCOMs and adding protection to RE PPAs
- **Renewable Purchase Obligation (RPO)** mandates that all electricity distribution licensees purchase or produce ~25% of their requirements from RE Sources, increasing to ~43% by 2030⁴
 - New thermal plants must set up RE capacity equivalent to at least 40% of the thermal plant's capacity or by procuring from other RE generators⁵
- **Energy Storage Obligation (ESO)** for DISCOMs requires that 1% of total energy consumed through solar and / or wind should occur through storage in 2023-2024, rising to 4% by 2029-2030
- Supreme Court ruling in 2021 allowed shift from physical PPAs to direct corporate purchase of renewable electricity through virtual PPAs⁸
 - New policy helps demonstrate demand and supports industrial consumers with plants across locations to fulfill green credit requirements under a single contract
 - 8.1 GW of cumulative capacity has already been contracted through this mechanism, with expectations of continued growth⁹
- Corridors policy supports integration of renewable energy into the grid by developing dedicated transmission corridors⁶
 - Phase 1 sanctioned in '15-16 to install ~9700km of transmission lines and substations with a capacity of ~20 GW of large-scale RE power and improvement of the grid in 8 implementing states with a cost of ~\$1.25B (40% Gol Grant, 20% state equity, and 40% loan from KfW, Germany)
 - Phase 2 facilitates grid integration and power evacuation of ~20 GW of RE power projects in 7 states by creation of transmission systems over a period of 5 years until 2025 at a total project cost of ~\$1.5B (Central Finance Assistance will contribute 33%)
- Ministry of New and Renewable Energy has granted **must run status to all RE Generation Stations** in India
 - This requires that power from renewable generation should not be curtailed for factors other than grid, equipment, or personnel safety

Sources: 1) RMI: Wholesale electricity market reforms for India; 2) PIB, Gol: Renewable Energy in India; 3) IEEFA India: Proposed power market reforms could reduce RE costs; 4) Ministry of Power, RPO and ESO Obligation, July 2022; 5) Business Standard: Mandate for Thermal Plants; 6) MNRE notification April 2020; 7) Ministry of New and Renewable Energy, Green Energy Corridors 8) Mercom India: VPPA Trajectory; 9) WoodMac: Power of VPPA

In Southeast Asia, more than 50% of planned capacity is fossil fuel dependent, although the majority remains in early development

Southeast Asia has a relatively high share of fossil dependent capacity planned for 2030

Electric capacity by source (GW, Southeast Asia)



While retirements of fossil-fuel capacity are unlikely, it is possible that announced fossil additions could be avoided due to overcapacity

Per the IEA, a SEA-aligned NDC target requires a carbon intensity of 463 g CO₂/kWh in 2030

① SEA has a large amount of clean capacity additions in the pipeline, but most appear to be in early development stages

② Significant fossil fuel retirements or avoided additions would be required to meet NDC-aligned mix in 2030

Commentary

- Southeast Asia is seeking to transition from a primarily fossil (i.e., coal and gas) based power sector to one more based on renewables

 - Historic renewable electricity has primarily come from hydropower; new additions will have to scale wind and solar in the region
- While Southeast Asia would reach targets if all projects are completed, ~80% of projects are still in high-risk early stages (pre-financing)

 - Risky investment climate has increased cost of capital and dampened availability of financing for renewable projects in the region
- Meeting carbon intensity targets implies limited room for additions of fossil-based capacity

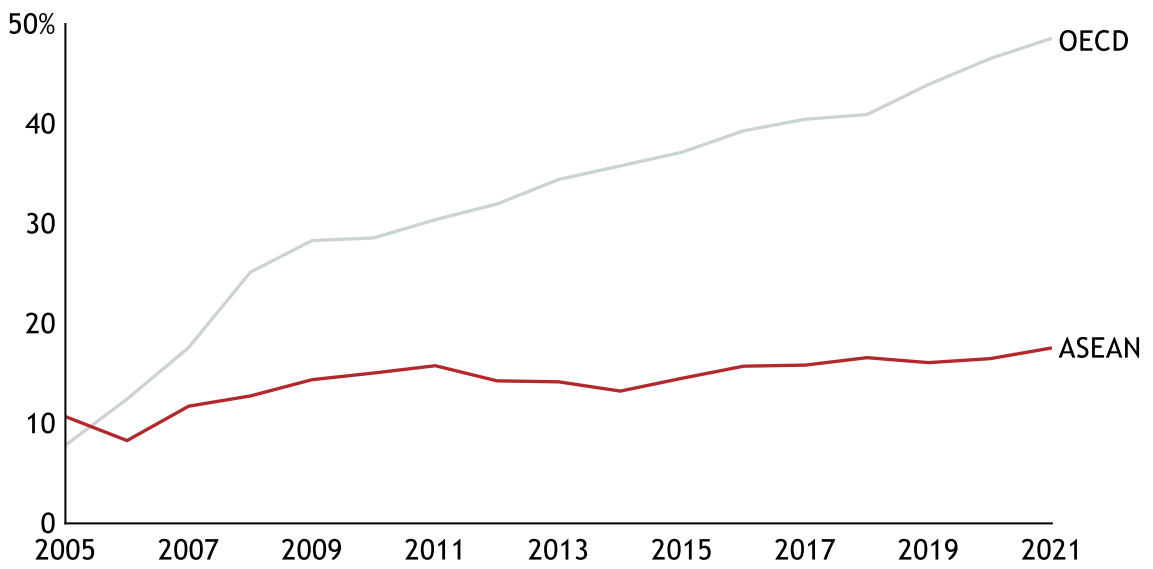
 - Current plans suggest up to 180 GW of additional fossil production in the pipeline
 - Actualizing these additions would significantly increase the amount of older fossil capacity that would need to be retired

Note: 2030 capacity targets are according to the GEC APS model which projects that all commitments and policy that countries have proposed will be met in full; Planned additions include projects in the 'announced, permitted, financed, or under construction' phases of development as defined by Global Data; Countries included: Philippines, Indonesia, Vietnam, Malaysia, Thailand, Myanmar, Laos, Cambodia, Singapore, Brunei; 2022 electric capacity figures for Brunei, Cambodia, Indonesia, Laos, and Myanmar reflect 2021 capacity figures due to a gap in Ember dataset; 2030 capacity splits reflect increases in demand while maintaining typical utilization rates
 Source: Ember - Yearly Electricity Data (Capacity data aggregated from Global Energy Monitor, Global Data - Upcoming Power Plants; IEA - Global Energy and Climate (GEC) APS Model

“Green transition in these markets requires international financing, but the commercial lending market needs stable revenue streams and a track record”

Renewables FDI flows in the region have underperformed relative to OECD countries ...

Renewable energy as % of cumulative energy FDI flows



“From 2016 - 2020, for every dollar invested in RE power capacity in SEA, another dollar was invested in unabated fossil fuels, compared with US\$0.5 in Sub-Saharan Africa, US\$0.3 in China and US\$0.2 in Latin America.”
 Southeast Asia Energy Outlook 2022, IEA¹

Note: *FiT refers to feed-in-tariff; Title quote from CEO, Financial services provider #3
 Source: 1) IEA 2022 Energy Outlook; 2) [ASEAN Renewables: Opportunities and Challenges \(IEA\)](#)

... driven in large part by market and regulatory conditions as well as costs of capital



Higher offtake risk
 In many SEA countries, RE electricity power is heavily regulated and requires a **state-owned utility enterprise to be the sole off-taker²**



Lack of policy continuity
 Supportive policy incentives in SEA countries like Vietnam have spurred a significant solar and wind buildout, especially over the past 5 years, but the **process has been characterized by constant changes to deployment and grid regulations²**



Higher costs of capital
 The cost of capital for RE investments remains relatively high in many SEA countries, and the **financial value proposition for private sector investment in renewables remains unclear** vs. advanced economies



Higher perceived risks lower project bankability
 Private capital has accounted for only 60% of renewable power investment in Southeast Asia, compared to about 90% in advanced economies due to **ongoing perceived currency fluctuation and regulatory risks**

To de-risk these economies, firms believe governments need to push for easing regulations and a stronger presence of both regional and international financing

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Easing regulations

"We've seen how quickly progress can be made through deregulation in some cases. But there are trade-offs. E.g., after South Africa removed barriers on customers to generate their own power, big players added ~30% of system capacity in just a year. This was a massive transformation. But this can undermine the financial position of the utility"

-Senior Sustainability Advisor, Financial services provider #2

"We need to strike a balance in terms of end-user price controls. Utilities are currently forced to buy high and sell low. We need to continue what happened in Thailand. The state utilities there started passing costs to the consumers and made profits. While it is difficult politically, end-user tariffs need to rise"

-CEO, Financial services provider #3



Stronger presence of regional players

Regional financial institutions can play a much bigger role if governments adopt a carrot (labelling, verification, frameworks) and stick (better taxonomy and disclosure rules) approach to green lending [...] need incentives to taking on more costs and risks - rating agency don't do this yet"

-Managing Director, Sustainable Finance Group, Financial services provider #1

"Banks operating in these economies, including regional banks, understand local markets. They need to drive investment. We can obviate risks with guarantees, but this can crowd in bad projects"

-Senior Sustainability Advisor, Financial services provider #2



Stronger incentives for international finance institutions

"In SEA, green transition needs international financing. While the equity market still has regional financial players and infra funds, debt market requires liquidity. E.g. In Vietnam, the 2030 power development plan requires 135B capex investment. The local market can't support that"

-CEO, Financial services provider #3

"Large financial institutions - MDBs, Japanese, Chinese banks - lowering their lending into brown energy areas [...] would make a big difference"

-Managing Director, Sustainable Finance Group, Financial services provider #1

"We need metrics to show transition lending is the right thing to do. Financial regulation is misaligned with govt. policy objectives. If we take on a coal asset, the emissions accounting will show a rise in our emissions. Where is the motivation or enabling environment?"

-Managing Director, Sustainable Finance Group, Financial services provider #1

Sources: 1) [Vietnam VPPA](#), 2) [Vietnam's Direct PPA Scheme](#), 3) [Vietnam's energy transition](#), 4) [Orrick: SA next frontiers for VPPAs](#); 5) [Insight Plus: Malaysia Corporate PPAs](#)

Also, “we see PPAs as a quite strong venue for offtake, in some APAC markets, it's just the name of the game”

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Virtual power purchase agreements allow demonstration of RE demand

- Under **Virtual Power Purchase Agreements**, the generator and consumer enter a bilateral contract outside the power market without a physical transaction of power taking place between them
- The generator continues to sell power in the power exchange but **transfers the green attributes** to the consumer
- The consumer (buyer) is **free to source its power requirement** in the best possible manner - through a DISCOM, power exchange, bilateral, or captive mode
- Since the consumer under VPPA continues to procure physical power from DISCOM, the **distribution companies do not lose their consumers** and source of revenue

Vietnam



- Ministry of Industry and Trade (MIOT) aims to open up electricity market to bilateral PPAs through a pilot scheme
- Since 2020, until as recently as **May 2022**, Vietnam has passed legislation around several proposals for a **pilot Direct PPA (DPPA) scheme**¹
- The pilot scheme will enable RE generators to **directly sell electricity to private off takers under VPPAs**
 - No sale of physical electricity from a generator to a corporate is permitted
- Pilot is expected to run from 2022-2024, expected to be **introduced on a permanent basis from 2025 onwards**²
- Vietnam is poised for massive energy transition which offers opportunities for its virtual PPA schemes
 - Solar, wind and gas-fired power plants expected to make up **47% share of the power system in 2030**, 60% in 2040³

Malaysia



- **Direct PPAs** between consumers and solar power producers have been **permitted since 2016** under the **Net Energy Metering Scheme**⁴
- Government announced a **Corporate Green Power Programme** in 2022 allowing corporate customers to enter VPPAs with power producers for green electric supply (**initial quota of 600MW**)⁵
- With over **80% electricity generation from coal and gas**, VPPAs would bring potential investors which would **attract more solar power producers** and facilitate new projects
- However, electricity prices in Malaysia are **fixed by the government** under an **Incentive-Based Regulation** to reduce volatility, rendering VPPAs **less effective** for the purpose of **hedging RE power prices**

Note: Title quote from Magnus Gottlieb, External Affairs Manager, Ørsted

Sources: 1) [Vietnam VPPA](#), 2) [Vietnam's Direct PPA Scheme](#), 3) [Vietnam's energy transition](#), 4) [Orriick: SA next frontiers for VPPAs](#); 5) [Insight Plus: Malaysia Corporate PPAs](#)

Regions like India, China and SEA face challenges meeting new demand with renewables while legacy fossil generation is retired



Economic rationale to retire

- Renewable capacity additions are also growing exponentially across regions like China and SEA, but this is not leading to significant thermal retirement
- There are limited incentives for fully amortised thermal plants to stop servicing long-term contracts; while early retirement of newer thermal plants can create significant stranded costs for investors
- Energy security concerns also support the maintenance of coal as a source of reliable baseload generation

“There’s a bit of uncertainty on the timeline [of coal retirements] because these timelines have been shifting a lot.”

Chief Sustainability Officer, Utility company #1



Supply / demand mismatches

- The general increase in electricity demand serves to focus political attention on new capacity additions rather than the retirement of high-emitting generation assets
- A higher cost of capital and investment risks in many countries have resulted in under-investment in additional renewable generation
- An inability to execute PPAs directly with independent power producers constrains corporate investment

“There are lots of active markets with good profitability currently - venturing beyond these safe havens would require stronger incentives”

Global Sustainability Lead, Utility company #5



Infrastructure capacity

- Gaps in available T&D infrastructure risk limiting integration of new renewable generation assets
- Insufficient regional planning and integration of T&D infrastructure results in international mismatches in renewable supply and electricity demand

~55% of business leaders consider infrastructure to be a top barrier to the decarbonization of the power sector

Ramping up legacy thermal retirement and encouraging financing through policy reform will enable the green transition



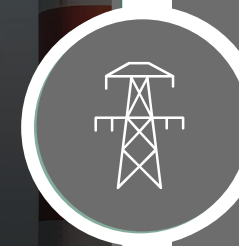
Transforming power markets

- The rapid transition to a predominantly renewables system is not inevitable, even if it may ultimately be cheaper
- **Significant political will** is needed to **accelerate the exit of coal** from many markets. In most cases, the transition will require **significant power market reform** to enable investment and the **retraining of a workforce** comfortable with centralized generation and dispatch. It will likely require **tackling vested interests** and **addressing politically sensitive issues** such as subsidized retail pricing regimes and under resourced utilities
- **Increasing cross border market integration** will be important, but will again depend less on technical constraints and more on overcoming political barriers



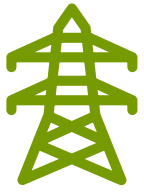
Increase the availability of transition finance

- Country platforms under the **Just Energy Transition Partnership (JETP)** model have enabled a step change in **coordination and implementation of technical assistance** in several countries, including through bringing together of international policy expertise and finance - this is critical for improving the bankability of projects, particularly for lenders
- **International public finance institutions** need **greater latitude to invest** across both transition finance and green finance, recognizing that the route to deploying green finance is through managing the phase out of legacy assets
- **More sophisticated climate frameworks** are also needed to recognize the positive contribution of international banks in taking on and transitioning brown assets. At the same time, **governments could encourage domestic and regional banks** to play a bigger role through increased disclosure requirements and green lending criteria



Just transition

- Managing the **financial and social implication of retiring coal assets** is extremely challenging
- Much **stronger international government and business collaboration** is needed to support broader sustainable economic development and ensure countries in transition are attracting investment in the buildout of new, low carbon energy and industrial supply chains



Power: Table of Contents

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The **Sector Overview** section provides context on the state of power generation, capacity deployment, investments pathway, and global power sector targets

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The **Transition Frontier** narrative explores the state of transition of the power sector in developed economies such as the US and EU

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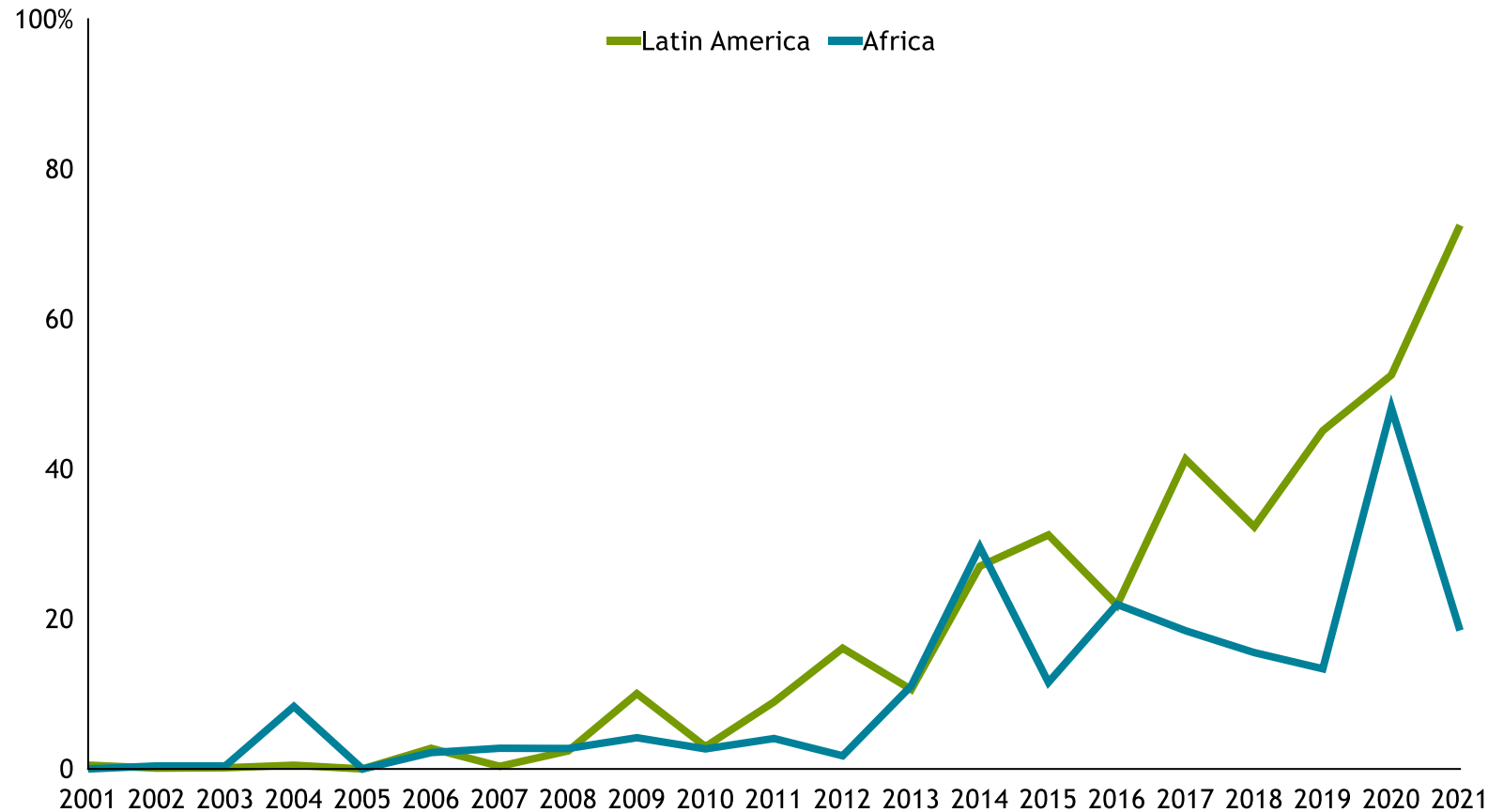
The **Legacy Thermal** narrative explores the state of transition of the power sector in developing economies such as China, India and Southeast Asia

04

The **Clean Generation** narrative explores the state of transition of the power sector in emerging economies such as Latin America and Africa

In Africa and Latin America, solar and wind power generation capacity contributed to nearly 18% and 73% of net new capacity additions in 2021 respectively

Share of solar and wind in net new generation capacity (Africa and Latin America, %)



Commentary

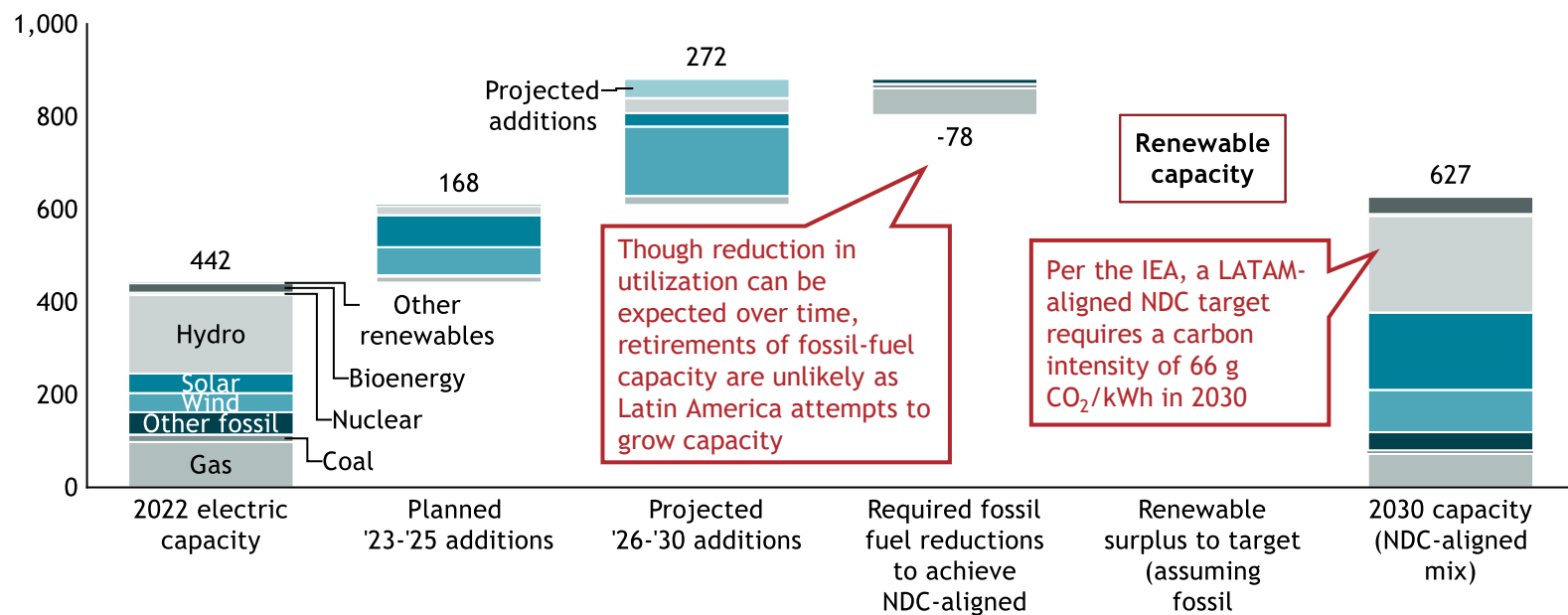
- Latin America has successfully accelerated the share of **wind and solar capacity additions to ~73% in 2021**
 - The relatively high share of **hydropower capacity** in the region implies that a lower share of non-solar and wind additions were fossil-dependent
- Africa has been slow to accelerate their share of solar and wind capacity additions, but **peaked at 48% in 2020, before falling back to 18% in 2021**

Source: Ember

Regions like Latin America have avoided significant fossil power generation through hydro resource access, modest demand growth, and a growing wind and solar base

Latin America is scaling deployment of renewables to achieve NDC-aligned 2030 targets

Electric capacity by source (GW, Latin America)



① Latin America has plans to meet growing energy demand with wind capacity, but may deploy solar in the near-term

② A small amount of fossil-dependent capacity will be kept online in 2030 to meet LATAM's growing energy demand

Commentary

- Latin America is the only region in the world that increased capacity fast enough to both meet growing demand and reduce fossil generation in 2022
 - Electricity consumption per capita has remained below the global average despite a 3.6% increase in demand in 2022
 - Latin America: 2.7 MWh per capita
 - Global: 3.6 MWh per capita
 - Significant financial support from national governments has continued to rapidly accelerate the expansion of wind and solar capacity in Latin American countries
- Some Latin American countries like Chile and Brazil are retiring old fossil fuel capacity, but recent fossil additions will remain to address intermittency concerns
 - NDC-aligned capacity mix increases dispatchable power from 356 GW in 2022 to 369 GW in 2030

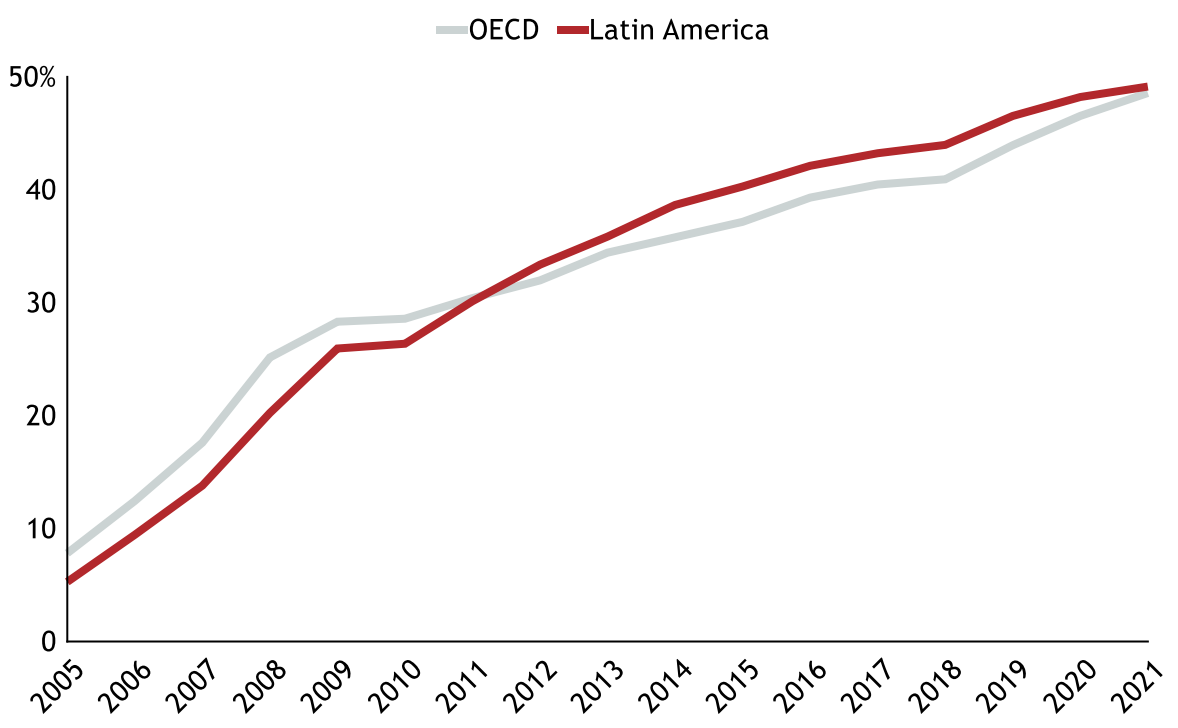
Note: 2030 capacity targets are according to the GEC APS model which projects that all commitments and policy that countries have proposed will be met in full; Coal and gas figures for 2030 target capacity include CCUS retrofits; Planned additions include projects in the 'announced, permitted, financed, or under construction' phases of development as defined by Global Data; Latin America includes: Mexico, Central America, South America, and the Caribbean; 2030 capacity splits reflect increases in demand while maintaining typical utilization rates

Source: Ember - Yearly Electricity Data (Capacity data aggregated from Global Energy Monitor, Global Data - Upcoming Power Plants; IEA - Global Energy and Climate (GEC) APS Model

Also, “concessional finance really sweetens the deal for investors, especially in regions where projects aren’t perceived as bankable”

Renewable FDI as a share of total energy FDI has matched OECD counterparts

Renewable energy as % of cumulative energy FDI flows



This growth of renewable FDI has been driven by concessional finance that have eased investor concerns

- Historically, most energy-focused FDI in LatAm was focused on **development of fossil fuels** due to significant oil reserves
- Over the last decade, LatAm has **surpassed other OECD nations** in securing renewable energy-focused FDI, **despite perceptions of a relatively high-risk investment climate**
- Latin America has been particularly effective at **securing concessional finance** for renewable energy (43% of total low-cost debt) to help ease investor concerns and mobilize additional private capital

*“In some countries in Latin America, the **growth in renewables has been so fast, transmission lines are not keeping pace. You cannot develop renewables without infrastructure**”*
-CEO Carbon Technologies, Utility company #5

Note: Concessional finance refers to grants and low-cost project debt ; Title quote from Senior Sustainability Advisor, Financial services provider #2
Source: UN ECLAC, OECD, IRENA, Climate Policy Initiative

Auctions and public tenders have driven the growth in renewables capacity in regions such as Latin America and the Caribbean

Auctions foster low-cost RE generation

- Power auctions involve energy providers bidding against each other for contracts to generate energy for buyers who select the provider offering energy at the lowest price
 - Power auctions for renewable energy are competitive processes, typically organized by governments to promote procurement of RE
- Public tenders and auctions have driven **80% of current RE capacity** in Latin America and the Caribbean¹



Uruguay



- Auctions in Uruguay are supporting progress against targets to achieve **100% RE generation by 2030**
- Uruguay instituted an auction mechanism in 2006 to create **stable demand and prices for RE**
 - Contracts span up to 20 years with ability to trade surplus power
 - Auctions are administered by the **state-owned utility, UTE¹, Ministry of Industry, Energy, and Mining**
 - Players are **exempt from grid charges** for PPA duration³
 - > E.g., no connection or grid upgrade costs are incurred
 - **Auctions are technology-specific** for wind, biomass, small hydropower and solar PV, and in some cases, are **conducted simultaneously**²
- RE investment **exceeded \$8B** between 2010-20, driven in part by the auction mechanism⁴
- Experts note three factors that have made the auction mechanism successful
 - **Gradual implementation** has allowed for the auction design to be adapted as barriers have been encountered
 - **Contracting power without offering base load** demonstrated mutual trust between project developers and financial institutions
 - **Setting prices in USD** limits the risks of currency and exchange rate fluctuation
- Challenges related to **local energy mix requirements** and **lack of certified resource measurement** remain

Chile



- Auctions in Chile are supporting progress against target to achieve **70% RE generation by 2030**
- Chile instituted an auction mechanism in 2005 to create **stable demand and prices for RE⁷**
 - Auctions are conducted by the **National Energy Commission and Ministry of Energy** and include **incentives for energy storage contracts up to 20 years⁵**
 - **Auctions are technology-neutral**, allowing RE and non-RE to participate (specific auctions for RE can occur if progress towards target is not made)⁶
- Small RE generators (<9MW) are **exempted from transmission toll** (to be borne by consumer), allowing them to choose resource rich areas for RE generation
 - Ministry of national assets launched a tender process to offer **~10.8K hectares of public land for RE development**
- Cumulative **PV installations increased to 4.6GW** by March of 2021, driven in part by the auction mechanism

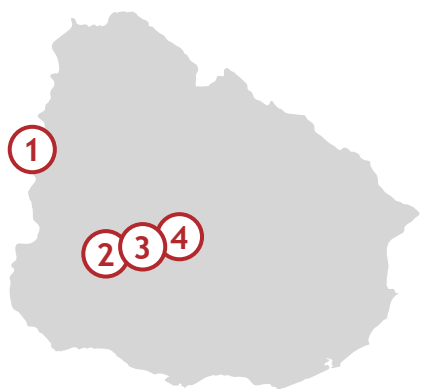
Notes: 1) UTE - Administración Nacional de Usinas y Trasmisiones Eléctricas

Sources: 1) [RE News: PPAs drive Latin America's RE](#); 2) [GEF: RE Auction in LA and Caribbean](#); 3) [IRENA: RE Policy Brief, Uruguay](#); 4) [Uruguay XXI](#); 5) [Solarpaces: Chile's 2023 Auction Rules](#); 6) [IEA: Chile's energy auctions](#) 7) [IAEE](#)

This rapid growth, especially in hydropower, has even led to surplus capacity in some regions, prompting a shift of focus to grid upgrades and energy exports

Uruguay has access to extensive sources of hydropower, a dispatchable source of electricity

- Dispatchable sources of electricity can be turned on or off, meaning they can adjust their power output supplied to the electrical grid on demand
 - Most conventional sources of electricity like coal and nuclear are dispatchable
 - Hydropower, in contrast to other RE sources like wind and solar power, is also a dispatchable source of electricity
- Uruguay has access to 1.54GW of dispatchable hydropower across 4 major plants



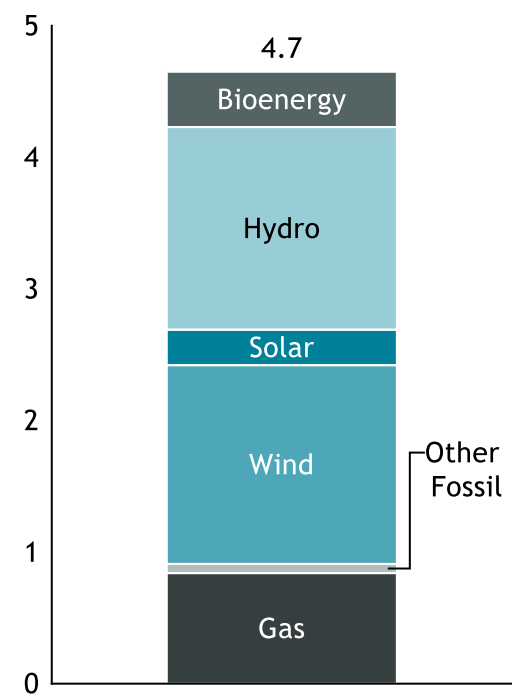
- ① Salto Grande
- ② Constitucion (El Palmar)
- ③ Gabriel Terra (Rincon del Bonete)
- ④ Baygorria

Source: IRENA, EMBER, International Trade Administration (ITA)



They have stopped investing in capacity and moved to deploy excess capacity elsewhere, investing in grid upgrades instead

2022 electricity capacity by source (Uruguay, GW)



- Uruguay generates a surplus of electricity due to an excess of wind and hydro capacity
 - Uruguay is seeking additional domestic uses for excess electricity
 - The country is increasing electricity exports to Argentina and Brazil
- Moving forward, instead of increasing generation capacity, Uruguay wants to upgrade the national grid through
 - Expanded transmission
 - Smart grid development
 - Battery storage expansions
- Additionally, the country is pushing to deploy excess electricity toward green hydrogen production and EV charging

But “100 countries account for less than 10% of the renewable electricity production”

Electricity access in Africa is low

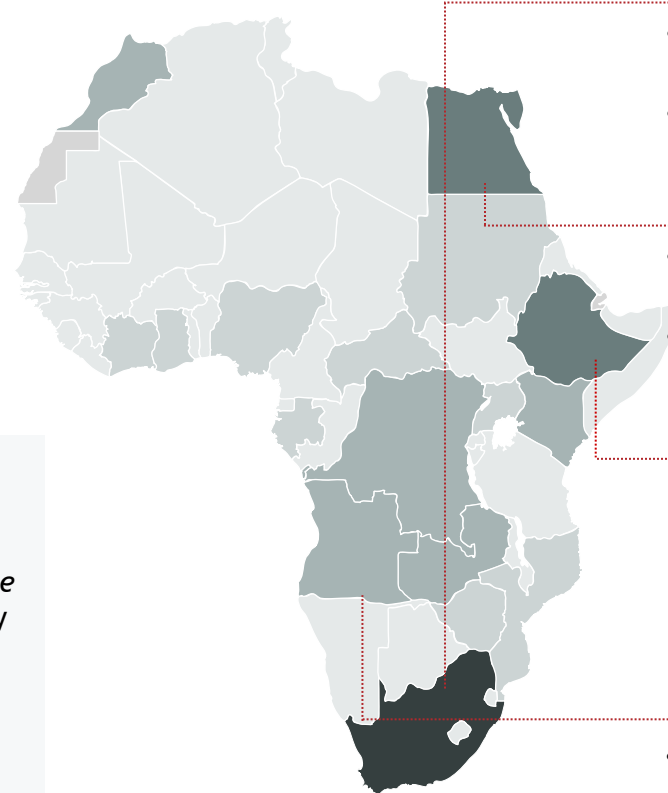
- As of 2023, 600M people, or 43% of the total population, lack access to electricity, most of them in sub-Saharan Africa¹
- Currently natural gas (42%) and coal (30%) are the primary sources of generation, followed by Hydro (18%)²
 - Installed renewables capacity was ~50GW in 2020 (Hydro - 34GW, Solar - 10.5GW, Wind - 6.5GW)
- Total solar potential is ~7,900 GW, hydropower - ~1,750 GW and wind - ~460 GW

“We have exponential growth of renewables, but this is highly concentrated geographically: 80 percent of renewable growth is serving 50% of the population, and 100 countries account for less than 10% of the renewable production” - CEO Carbon Technologies, Utility company #5

“This issue is not just scale, it’s speed - we need companies to go beyond BAU [...] things are not moving fast enough” - Managing Director, Sustainable Finance Group, Financial services provider #1

Notes: Title quote from CEO Carbon Technologies, Utility company #5
Sources: 1) [Africa Energy Outlook, IEA](#); 2) [Electricity generation in Africa as of 2020 by source](#); 3) [Africa Energy Market, 2022 - IRENA](#);

Most African countries have <1 GW of installed RE capacity



South Africa - 10.5 GW



- Integrated Resource Plan 2011 set an ambitious target of 17.8GW of renewable energy to be achieved by 2030
- Multiple tax incentives including a 125% deduction in 1st year for RE projects and up to 25% tax rebate for solar PV panels

Egypt - 6.3 GW



- Targets for 20% of power generation to be based on renewables by 2022, and 42% by 2035
- The government invested around \$1.5B in the distribution grid between 2017 and 2020 to integrate RE

Ethiopia - 5.6 GW



- Economy-wide RE target - 32% by '30, Power - 32% by '30, and 10% biofuel blending mandate in Transport by '30
- Scaling-Up Renewable Energy Program for Ethiopia (in collaborating with WB, ADB) provides grants of \$50M

Angola - 4.1 GW



- Aims that RE will constitute 70% of country’s installed capacity (plans to install 100 MW solar capacity by '25, 30 MW is off-grid)
- In 2023, Angola raised funding of \$1.29B to deploy 48 solar projects and storage mini grids

Firms believe that regulatory risks and project bankability are key barriers for capital flow from the commercial lending market in these regions

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Regulatory risks

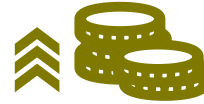
- Investor confidence is limited because **regulatory environment is often not fully developed**, especially in nascent markets

“We have been refocusing our efforts on markets that we know well and potentially opting out of some of the less mature markets with larger regulatory risks”

-Head of Global Positioning, Renewable power producer #1

“Financial institutions don’t like the look of the offtake contracts in some markets. This is one of the debates that happens over time - because these offtake contracts vary across countries. Financial institutions need to get comfortable with that. Equity is comfortable with that, but debt is not there. You need different type of risk appetite from the debt side”

-CEO, Financial services provider #3



Weak project bankability

- **Cost of capital** for energy projects in African countries is at least **2-3x higher than in advanced economies and China**
 - Perceived risks also increase cost of capital, making projects ‘unbankable’

“At the moment there are very good incentives in IRA - so it makes the case for investing in emerging and developing markets more difficult. There is a competition for capital”

-CEO Carbon Technologies, Utility company #5

“We are operating in these countries anyway. And so, the country risk is the same. Although, it’s probably accentuated in a capex heavy sector like renewables. The bigger issue for us is the bankability of the offtake”

-Senior Sustainability Advisor, Financial services provider #2

Country risks are also a key deterrent, especially for international finance institutions



*“For many international banks– the reality is **country risk** and **exchange rate risk** are much more important. The **incentives for investing in a solar park in a largely decarbonized European power market are simply much greater than projects where the carbon impact is going to be greatest**”*

-Senior Sustainability Advisor, Financial services provider #2

*“**International players are worried about country risk** before even talking about project bankability. Only those closer to the project level are more worried about bankability”*

-CEO, Financial services provider #3

Source: Corporate interviews

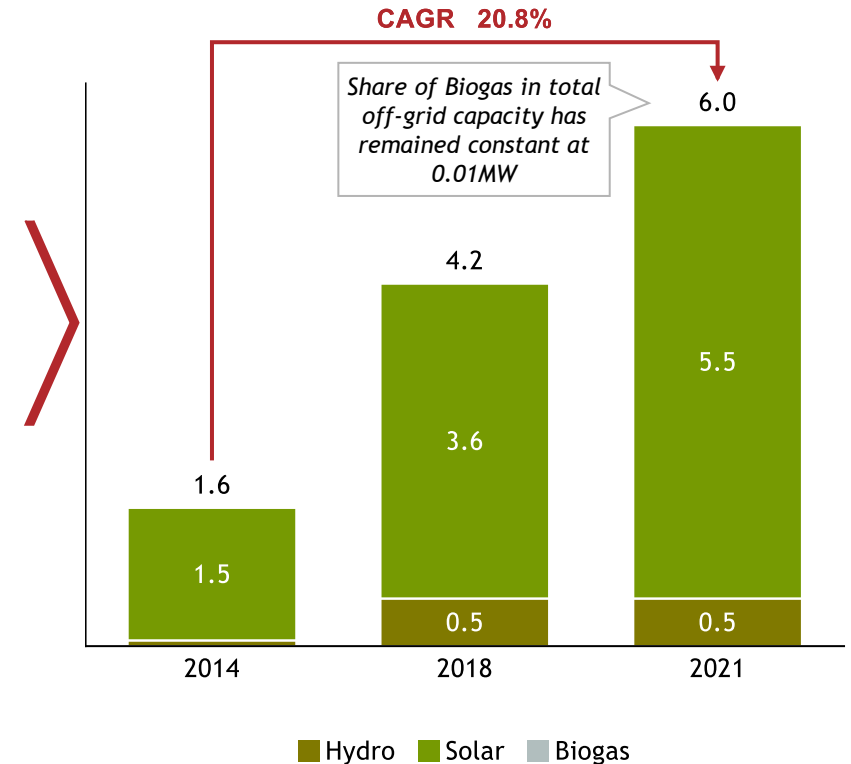
Where countries have made progress, it's often policy intervention that has catalysed investment

For example, Mozambique has incentivized the deployment of DERs and mini-grids

- The government of Mozambique is targeting **universal electricity access by 2030, 70% through grid connected systems and 30% off-grid**²
 - With only **40% households having access** to electricity as of 2020, reaching universal access is likely to be challenging in the near-term
 - Only **8% of rural areas** currently have access to electricity compared to 72% in urban areas, suggesting a need for policy to support generation in traditionally 'hard-to-reach' regions²
- In September 2021, the government approved new policy regulating **energy generation through off-grid solutions**³ to help support access in rural areas
 - The regulation facilitates investment into services providing energy via **mini-grids** through a dedicated policy for **smaller installations**
 - Additionally, the policy opened **end-customer energy provisions** to the private sector and allows **diversion from standard national tariffs**
 - The result has been an improved regime for **solar home systems** & standalone solutions
- The government has also solicited **international support** to assist in the transition process
 - The EU's **ElectriFI Country Window** is a **€15M package** to invest in early-stage RE companies⁴
 - The UK's **BRILHO Programme** is supporting energy access through funding solar home systems and green mini-grids benefiting **1.5M households** and **15,000 small businesses** until 2024⁵

Off-grid capacity has thus quadrupled since 2014 driven by growth in solar⁶

Total off-grid installed capacity in Mozambique (in MW)



Sources: 1) [ESI Africa - Off Grid RE](#); 2) [Diagnostic of Electricity Sector - Mozambique](#); 3) [Energylopedia - Mozambique](#); 4) [ElectriFI funding from EU](#); 5) [ESI Africa: Off-grid energy access in Mozambique](#); 6) [IRENA: Off-grid RE statistics 2022](#)

To decrease country risks and unlock capital, the industry is pushing for tools such as concessional finance successfully used in Latin America



*“The problem in many countries is de-risking, so we need **more work on de-risking** to ensure the **incentives** are there for a **second wave** of large-scale investment”*

-Global Sustainability Lead, Utility company #5

*“We need to solve these issues using **blended finance**, and we need **local players to channel concessional capital** to abate the risk. **Concessional finance is the interim solution** until commercial market gets more comfortable and accept the risk. **The “unbankable” project need to develop a bit of a track record**”*

-CEO, Financial services provider #3

Source: Corporate interviews

Corporates can also be an important source of capital for building new power generation in developing and middle-income economies



“In some countries, it’s just **not that easy to sign PPAs**”

-Environment Manager, Auto manufacturer #2

“We’ve **already signed renewables PPAs to cover 100% of our forecasted demand.** But given the integrity issues around purchasing contracts and certificates, we see **a trend toward building behind the meter generation.** Not solving these issues could result in lower market efficiencies [..] It’s a net loss for decarbonization of the grid”

-Manager of Sustainability, Resource provider #1

“We took commitments, and **we want to produce as much as we consume within five years.** It will be fascinating to see the power system development. Although small for now, **if lots of big players start putting power behind the meter - this could be a problem for grid operators**”

-Climate VP, Environmental services company #1

Source: Corporate interviews

Regions like Latin America and Africa face challenges ensuring rising electricity demand is met with renewables



Deploying generation at scale

- In many parts of the world, electricity demand is growing rapidly. In Latin America, this growth has been largely met through renewable generation, particularly hydro
- Limited hydropower potential, coupled with risks to hydropower resources from climate change (i.e., droughts, declines in snowpack) means the next wave of global electricity growth will need to come from solar and wind technologies
- In many emerging markets, there is a lack of visibility over the long-term project pipeline. Moreover, project tendering and underpinning PPAs don't meet international standards, making many potentially attractive investment much less bankable

“And maybe the problem is not necessarily getting enough capacity, but rather getting capacity where it's actually needed.”

Head of Global Positioning,
Renewable power producer #1



Ensuring supporting infrastructure

- Absent significant investment, increases in electricity demand and additions to generation capacity will create a gap to lagging T&D infrastructure
- Corresponding investments and changes to regional market structures must be made to ensure the grid not only has capacity, but is also sufficiently flexible (i.e., demand response technologies, dispatchable generation) to take on intermittent generation sources

“What we see, at least in our foreign markets...is that we need more of these, what we call transmission motorways, to transport renewable energy from the places where it is produced to the places where it is needed.”

Mngr. of Sustainability,
Renewable power producer #3

Increased capital flow by de-risking these economies and plugging infrastructure gaps will help meet rising energy demand



Increase capital flow by decreasing perceived risks for investors



Tackle permitting and intermittency challenges

- **Effective and stable regulatory frameworks** are the foundation to driving renewable investment at scale. Renewables generation has scaled under different market designs - the key in all cases is to ensure an **attractive, predictable investment environment** for independent power producers
- **Credible and transparent power sector planning**, coupled with the adoption of international best practice around project tendering - including issues such as arbitration, social and environmental safeguards, and local content requirements - all play a major role in attracting international developers and finance
- In this respect, **greater international attention** could be directed at supporting the development of the **power sector in nascent markets**, alongside the focus on transitioning legacy coal systems through the JETP
- **Concessional finance** can play an important role, particularly if it is directed at countries which are **not yet investment grade, but where projects are bankable** and just lack the track record to attract commercial lending

- In regions with rapid renewables growth, the issues are similar to developed markets - with the need to break down the barriers to **T&D infrastructure build out** through fast-tracking permitting and coordinated planning, as well as incentivizing greater flexibility

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