

Energy Transition Briefing

For Tata Power Board of Directors

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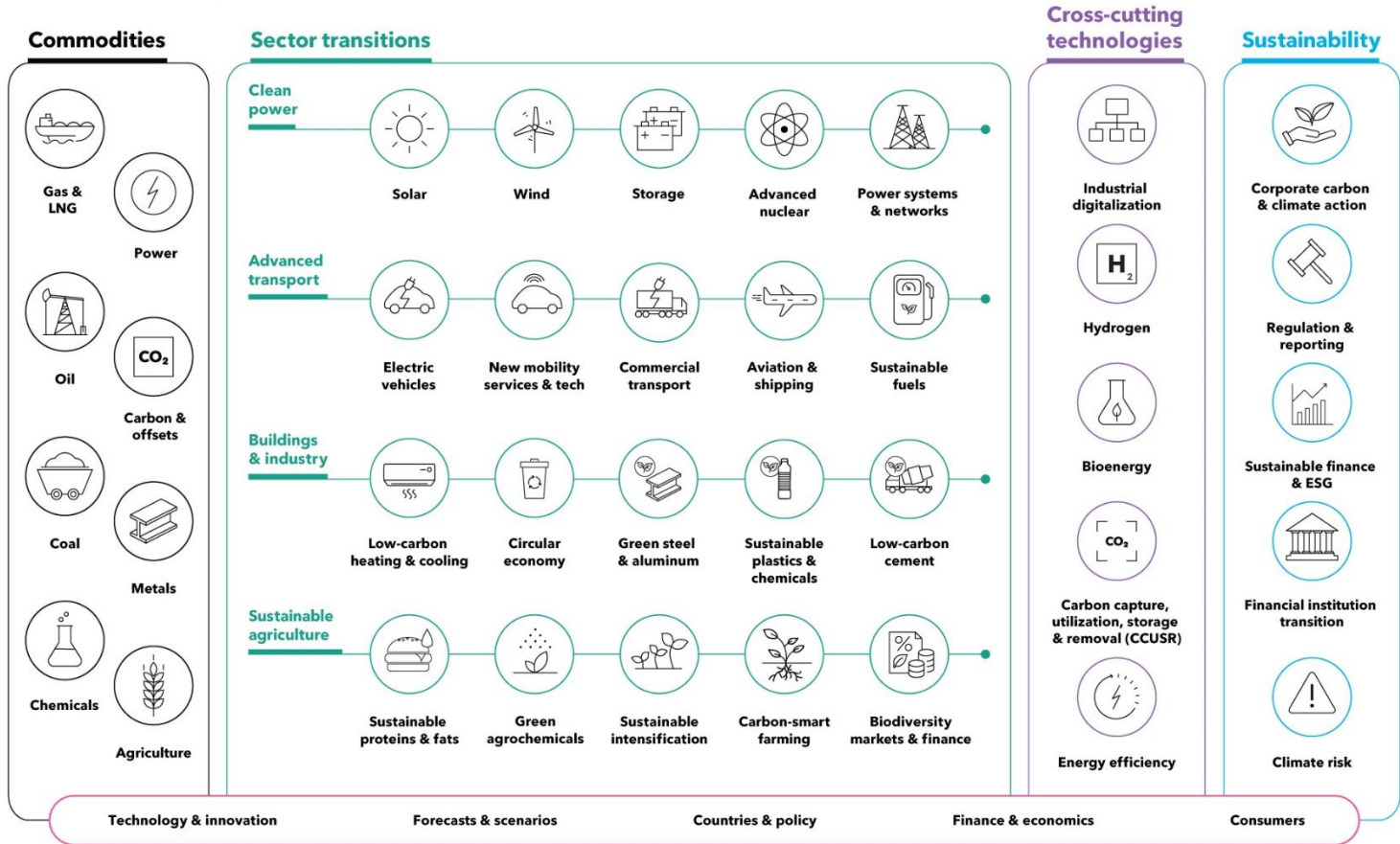
March 30, 2023



BloombergNEF

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Agenda

Where we are: Global energy transition trends

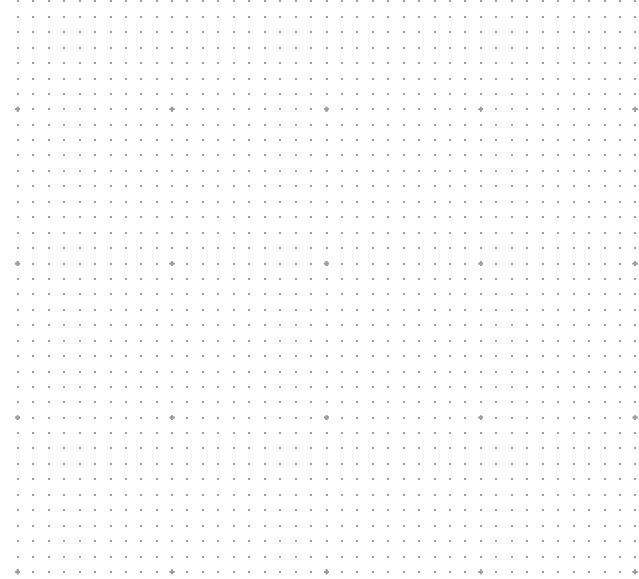
Where we're going: Transition scenarios for India and the world

Sectoral deep dives:

- Solar
 - Utility strategies
 - Other technologies (Nuclear, PV, long-duration storage, CCS)
-

Global energy transition trends

Into a new era



2022 felt like the end of an era

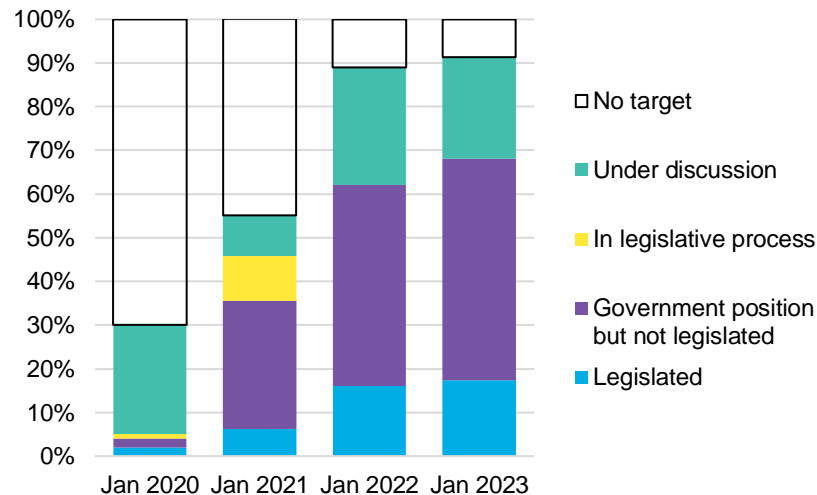
Costs of clean energy started to rise

Technology	Change in global cost benchmark in first half of 2022
Onshore wind	+6.7%
Offshore wind	-3.5%
Fixed-axis PV	+13.5%
Tracking PV	+3.7%
Battery storage	+8.4%

Source: BloombergNEF. Note: The global benchmark for PV, wind and storage is a country-weighted levelized cost average using the latest annual capacity additions. The storage LCOE is for a utility-scale Li-ion battery storage system with four-hour duration running at a daily cycle and includes charging costs.

Country ambition seemed to stall

Share of global emissions covered by EU, national and state-level net-zero targets

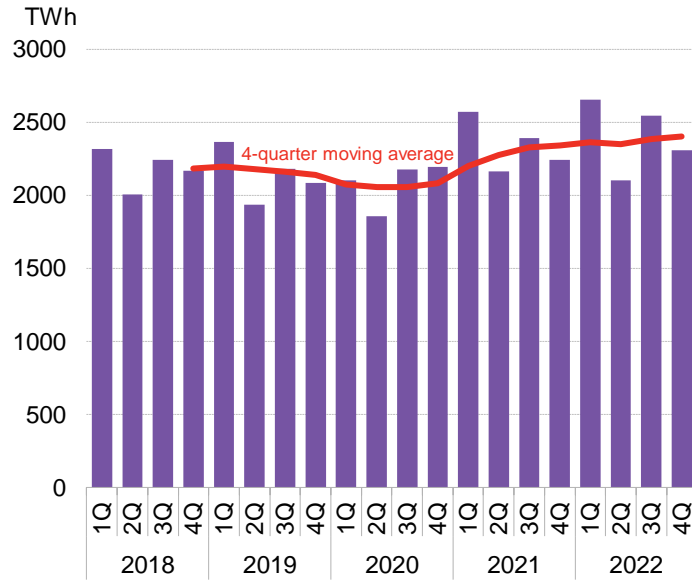


Source: WRI CAIT, governments, BloombergNEF. Note: Includes greenhouse-gas emissions including land use and forestry.

2022 felt like the end of an era (cont.)

Coal made a comeback

Global coal power generation



Source: BloombergNEF, IEA World Energy Investment reports.

Geopolitical complexity increased



THE WEEK



Why is Europe mad about Biden's IRA?



Energy prices are causing chaos in Asia. Here's why the rest of the world should worry

Africans Decry Europe's Energy Hypocrisy

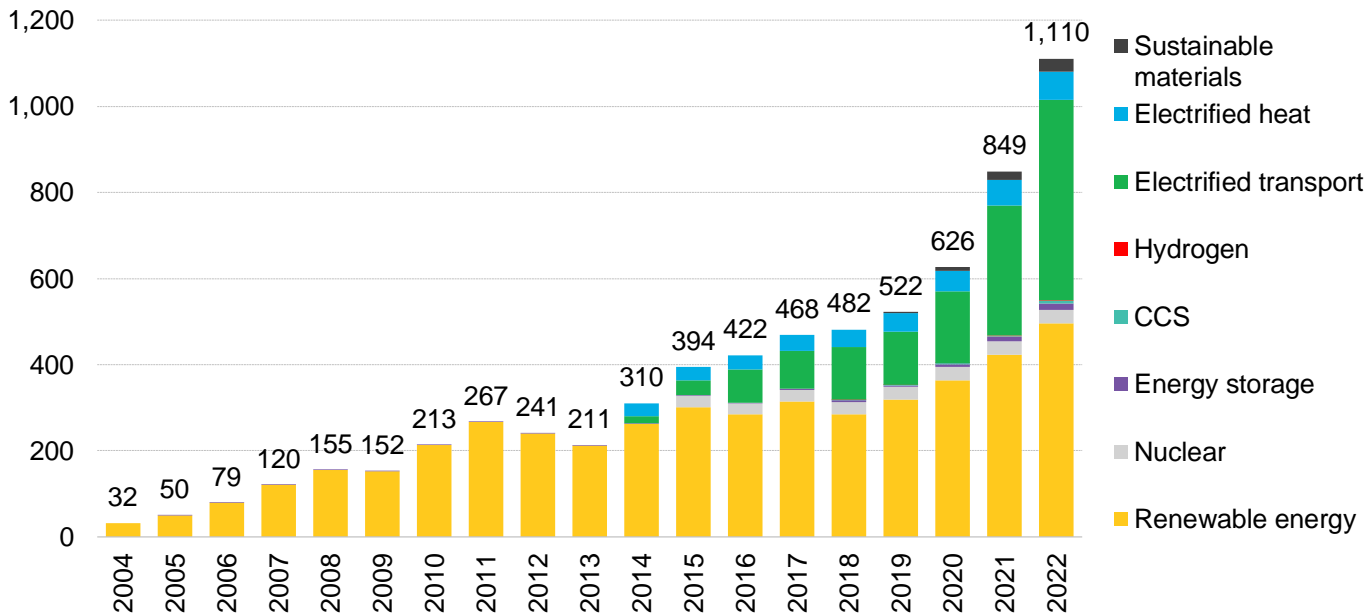
Wealthy European countries that sought to halt funding of fossil fuel projects across Africa are now scrambling to secure the continent's oil and gas.



No sign of a slowdown: energy transition investment surged past \$1 trillion

Global investment in energy transition by sector

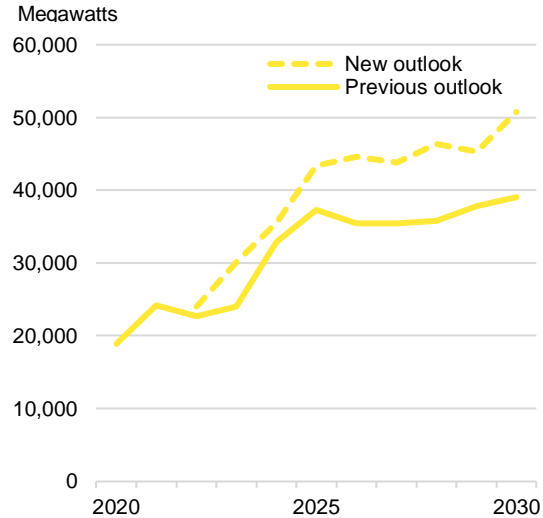
\$ billion



Source: BloombergNEF. Note: start-years differ by sector but all sectors are present from 2019 onwards; see Appendix for more detail. Nuclear figures start in 2015.

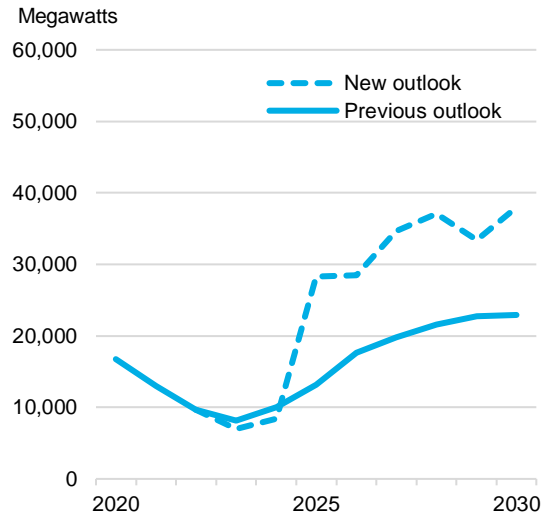
The Inflation Reduction Act will accelerate America's energy transition

US solar installations, pre- and post-IRA



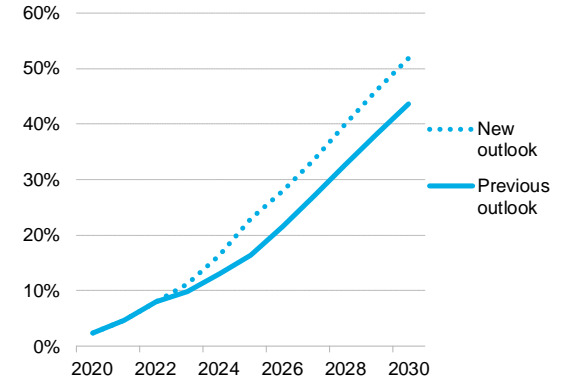
Source: BloombergNEF

US wind installations, pre- and post-IRA



Source: BloombergNEF

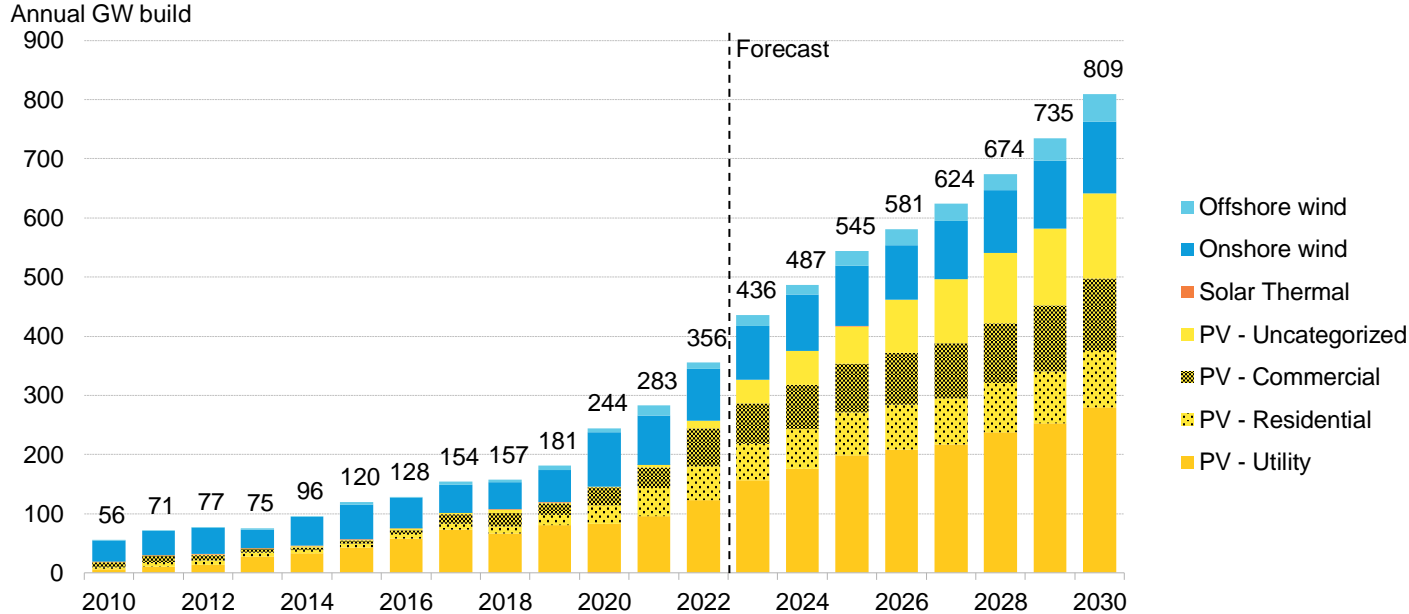
US EV share of vehicle sale, pre- and post-IRA



Source: BloombergNEF. Note: Passenger EVs only. Includes battery electrics and plug-in hybrids

The outlook for clean energy is brighter than ever

Global wind and solar build, historical and forecast (mid scenario)



Source: BloombergNEF.

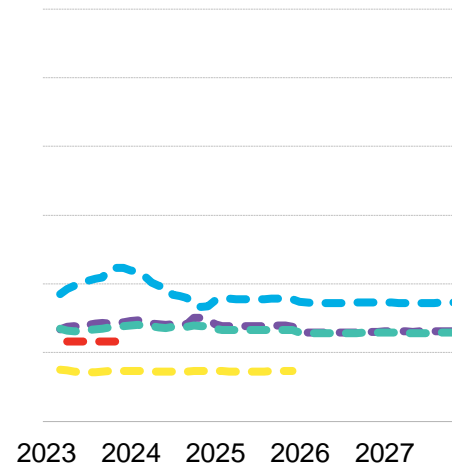
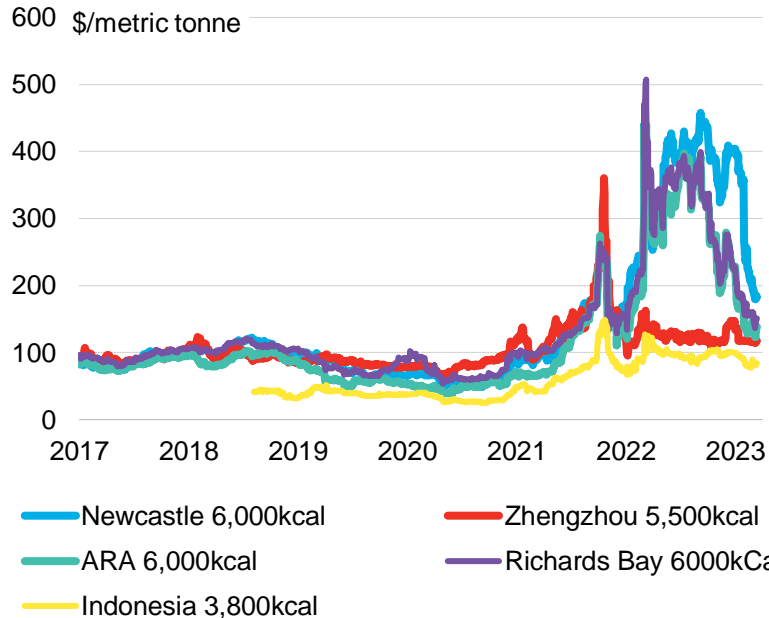
Energy volatility, energy security



Coal prices remain higher than historic averages for the coming years

Key thermal coal benchmark price, historical

...and futures

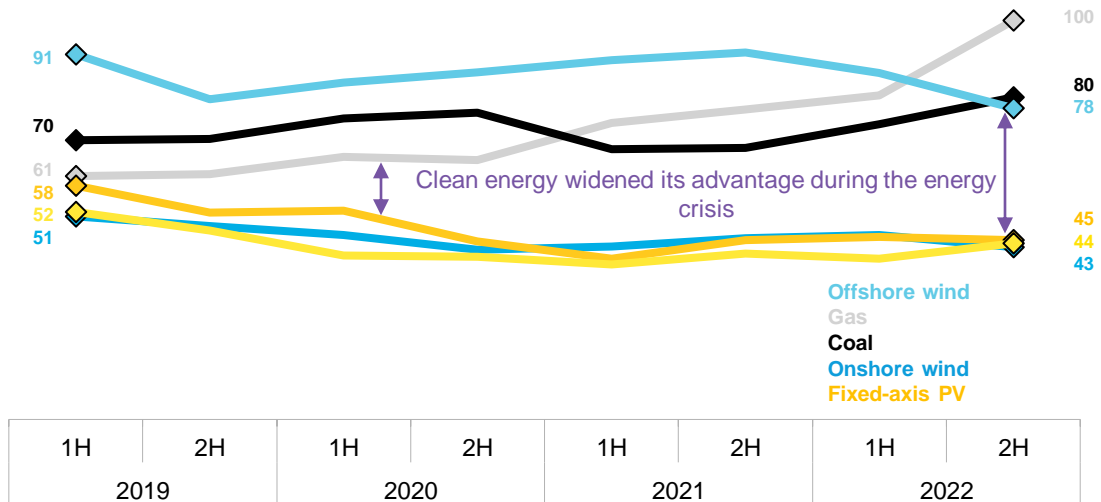


Source: Bloomberg Terminal, ICE

Volatility is here to stay, but clean energy has the enduring advantage

Global levelized cost of electricity benchmarks

\$/MWh (nominal)

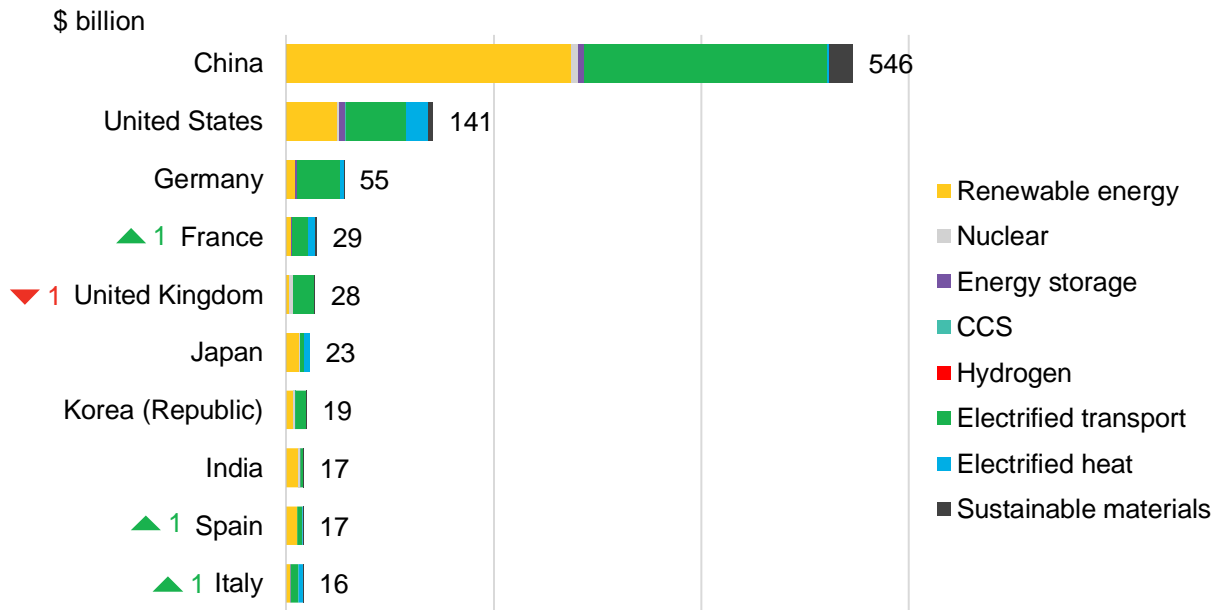


Countries in competition



China spends 1 of every 2 dollars in the global energy transition

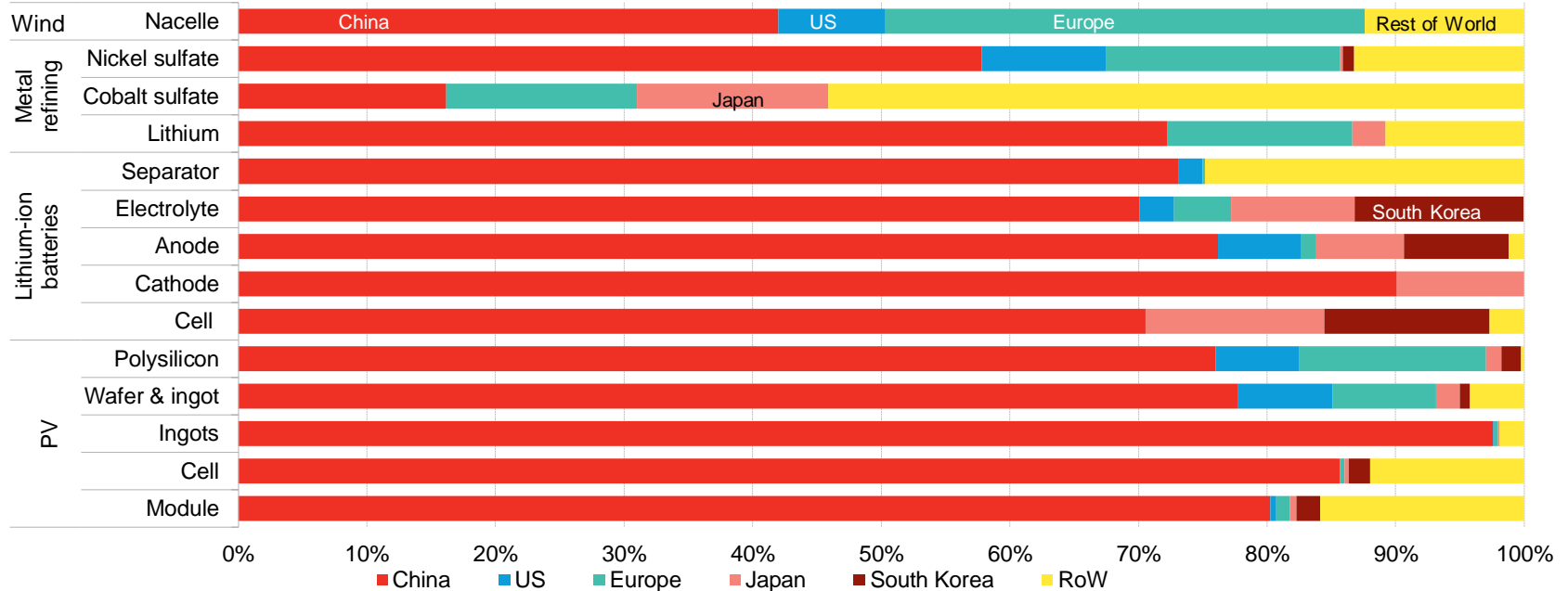
Top 10 countries for energy transition investment, 2022



Source: BloombergNEF

Clean energy supply chains are dominated by China

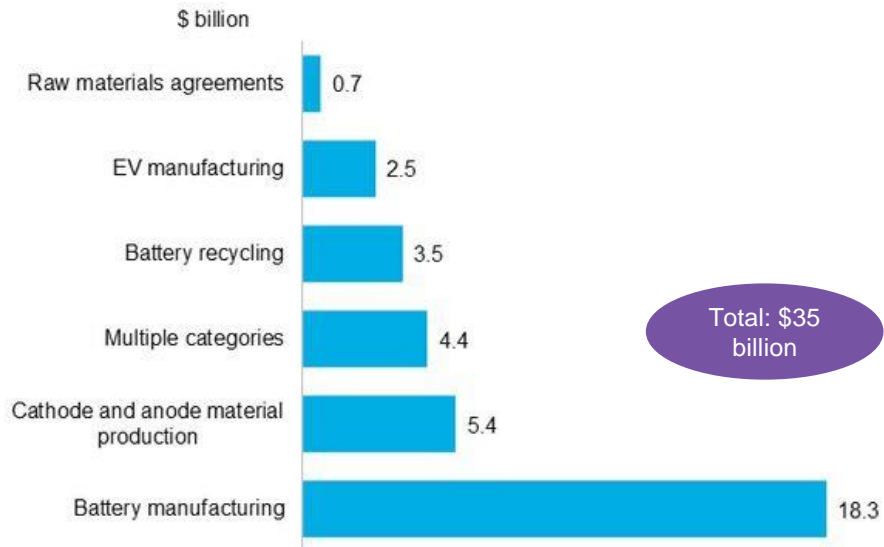
Clean energy manufacturing capacity by location



Source: BloombergNEF. Note: Manufacturing capacity by factory location. PV, hydrogen and battery components expressed in MW, MWh, m² or tons. Nickel is the class 1 variety, and lithium is in lithium carbonate equivalent. H₂ is hydrogen.

But other countries are starting to challenge China

New corporate EV and battery investments announced in the US since IRA



Europe's response to the IRA

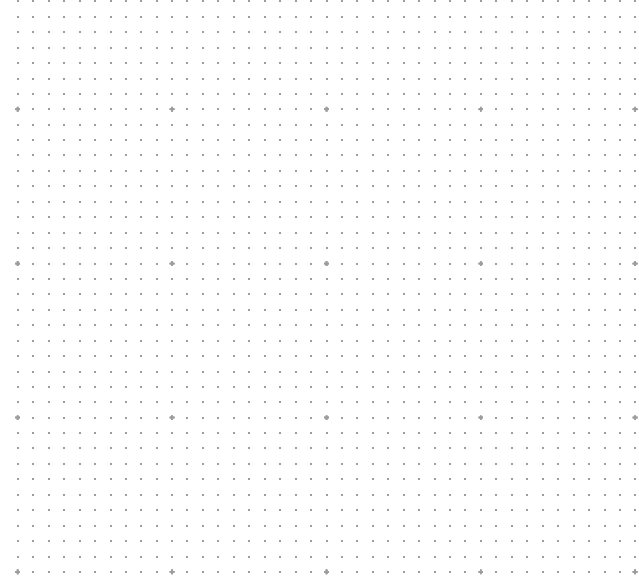


Ursula von der Leyen, president of the European Commission, launches the Green Deal Industrial Plan, Feb. 1, 2023

Source: BloombergNEF, press releases. Note: includes investments in the North America region through February 7, 2023. 'Multiple categories' is for investments that fall into two or more of the other investment types, but where the percentage in each is undisclosed.

Transition scenarios for India and the world

New Energy Outlook



Energy and climate scenarios to navigate the energy transition



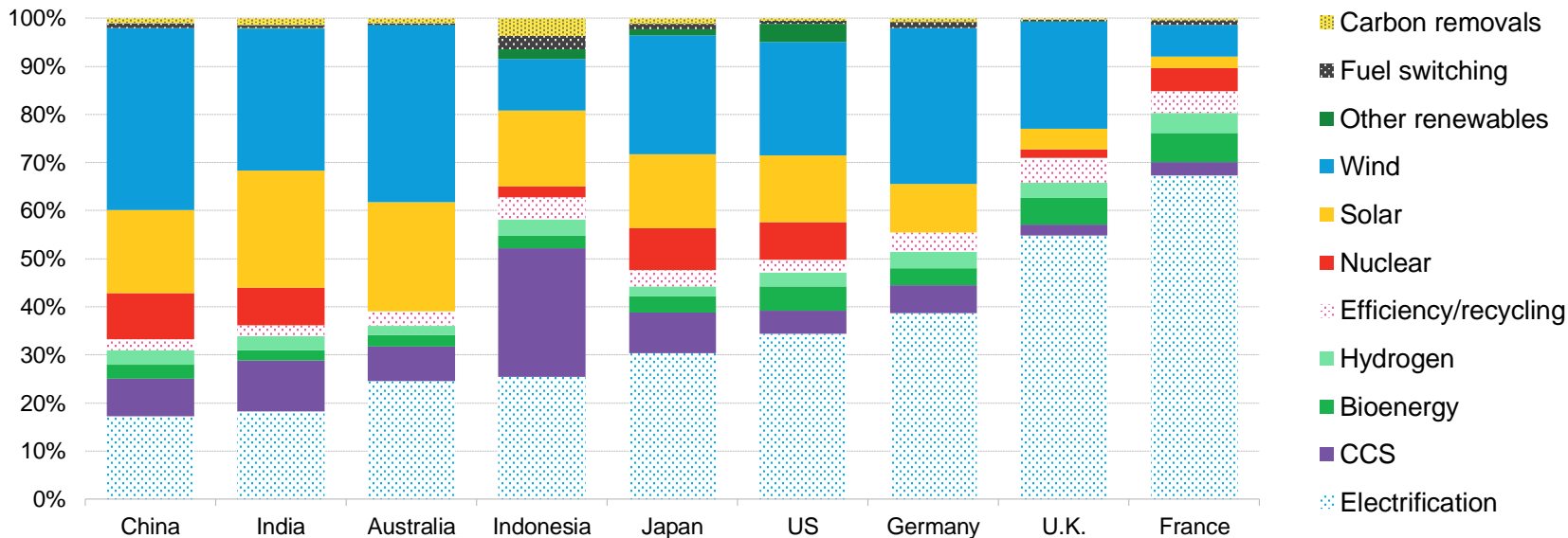
What's new?

- Two scenarios:
 - Economic transition scenario (ETS)
 - Net zero scenario (NZS)
- Country-level pathways to 2050:
 - Country specific net-zero pathways for 9 countries
- Hydrogen demand and supply modeling
- Improved power grids and metals analysis
- Modeled gas price forecast
- Least-cost pathways for steel, aluminum

Getting to net zero will require a mix of all technologies

CO2 abatement by technology/type, NZS vs no transition

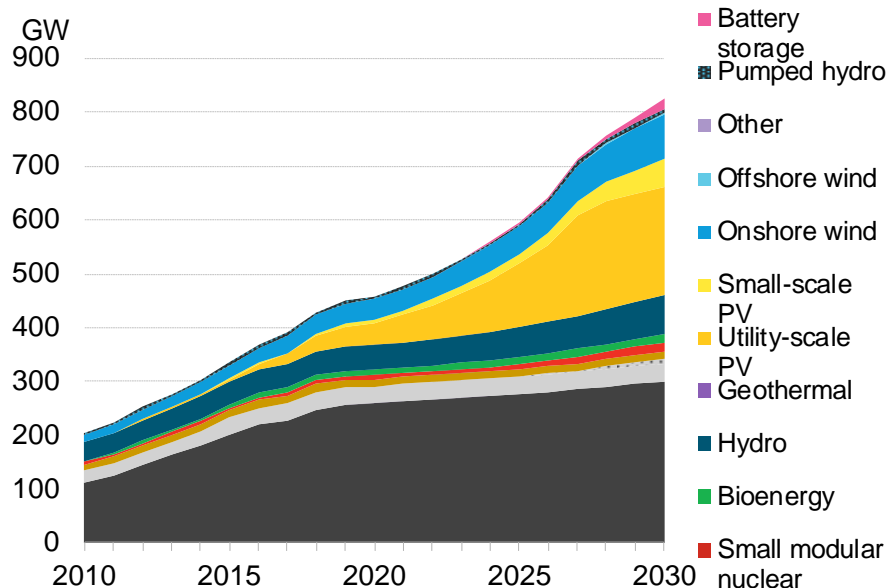
Abatement 2022-50



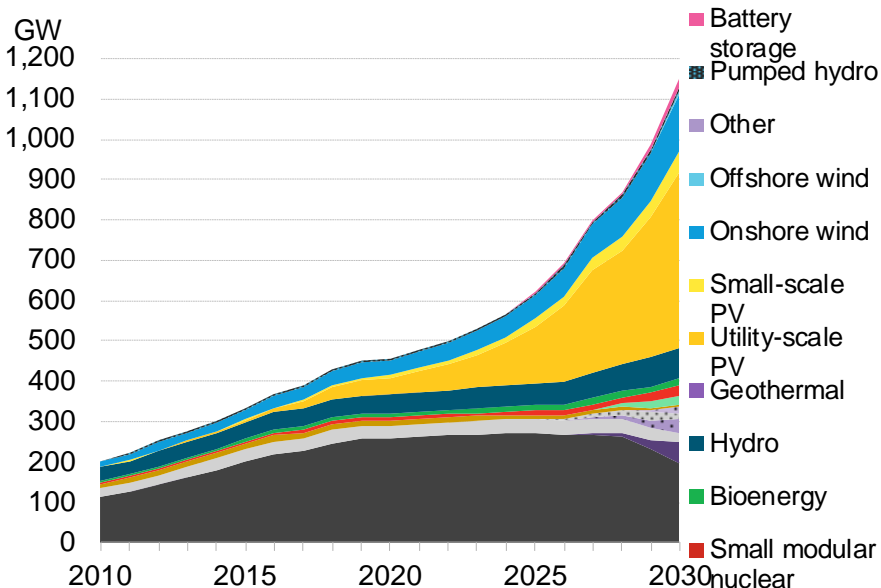
Source: BloombergNEF.

Under NZS, India has **39%** more total power capacity in 2030 compared to ETS. Coal is down by **18%**

ETS power capacity mix



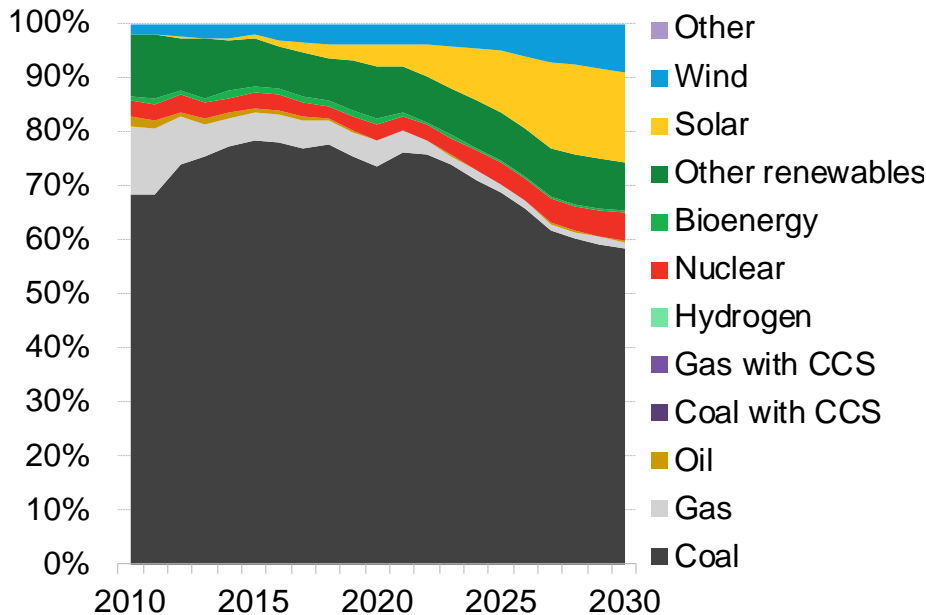
NZS power capacity mix



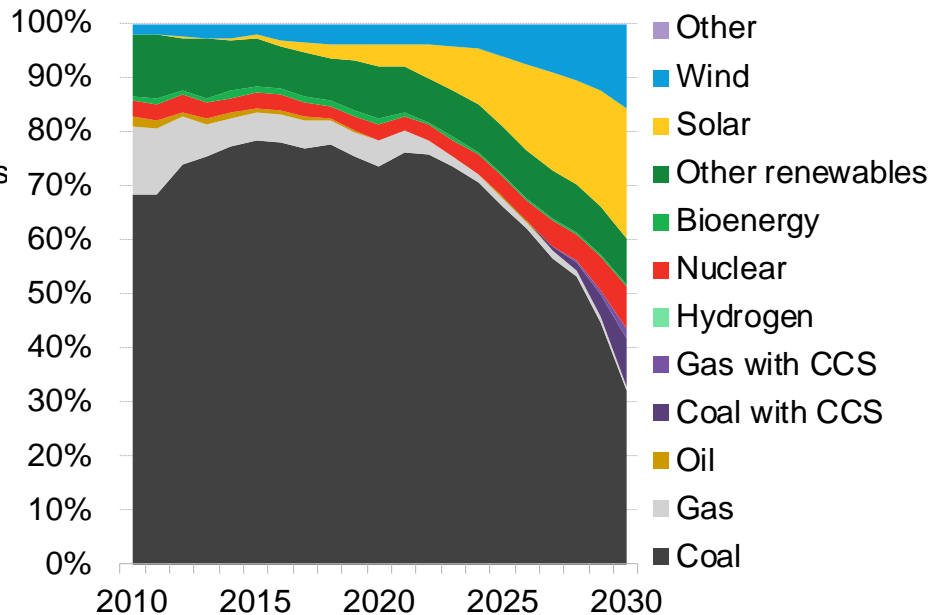
Source: BloombergNEF

Under NZS, wind and solar would provide 40% of India's annual electricity supply in 2030

Electricity generation mix, ETS



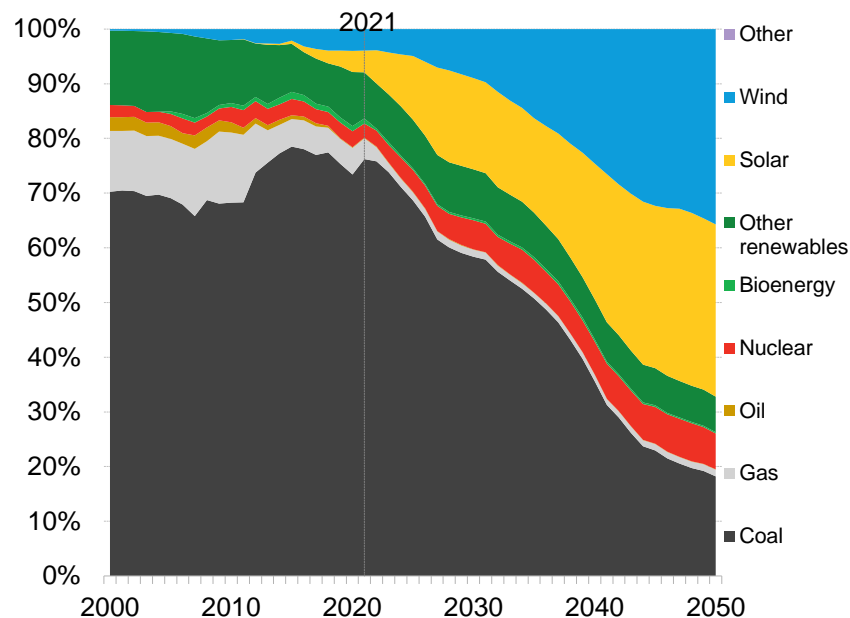
Electricity generation mix, NZS



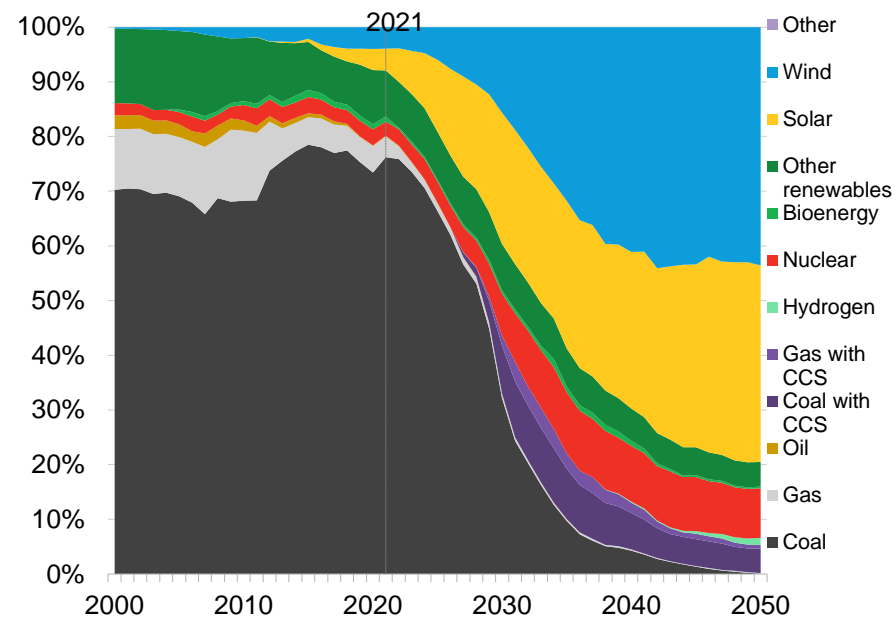
Source: BloombergNEF. Note: Represents grid-level fuel mix of final electricity consumption. Does not account for captive power generation (in industry) that may result in a different fuel mix than the grid's. Other renewables includes hydro

Under NZS, wind and solar would provide 80% of India's annual electricity supply in 2050

Electricity generation mix, ETS



Electricity generation mix, NZS



Source: BloombergNEF

Agenda

Where we are: Global energy transition trends

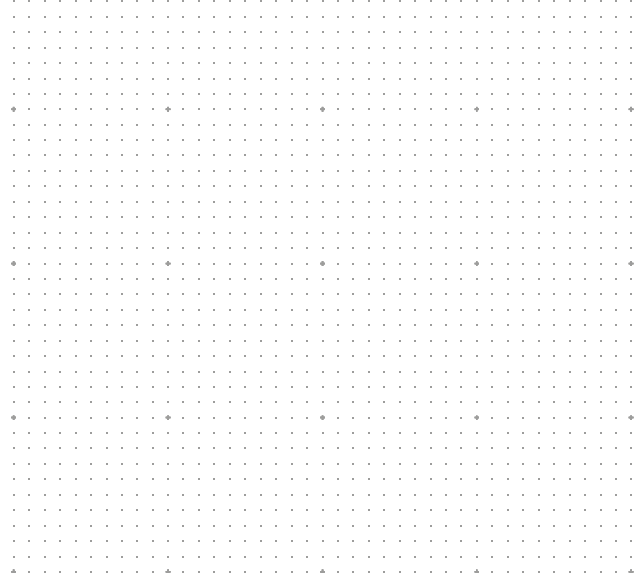
Where we're going: Transition scenarios for India and the world

▶ **Sectoral deep dives:**

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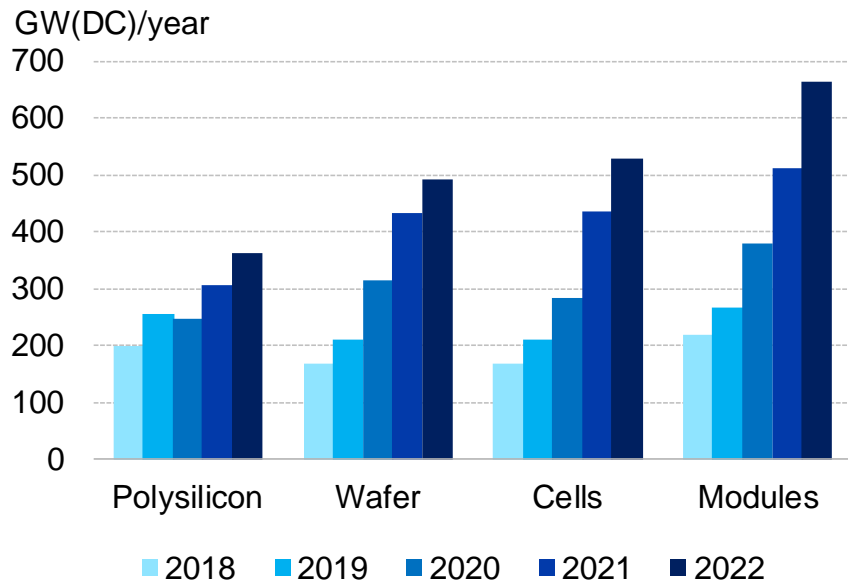
Solar outlook

Prices, manufacturing, exports



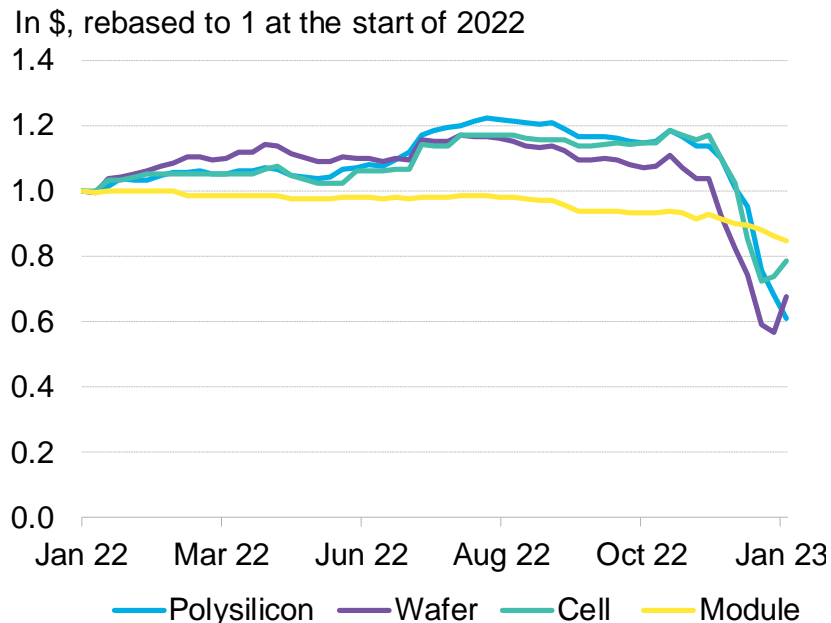
Global PV manufacturing capacity keeps growing, prices have fallen

Commissioned PV manufacturing year-end



Source: BloombergNEF. Note: 2.72g/W polysilicon assumed for conversion. Modules includes thin-film technology.

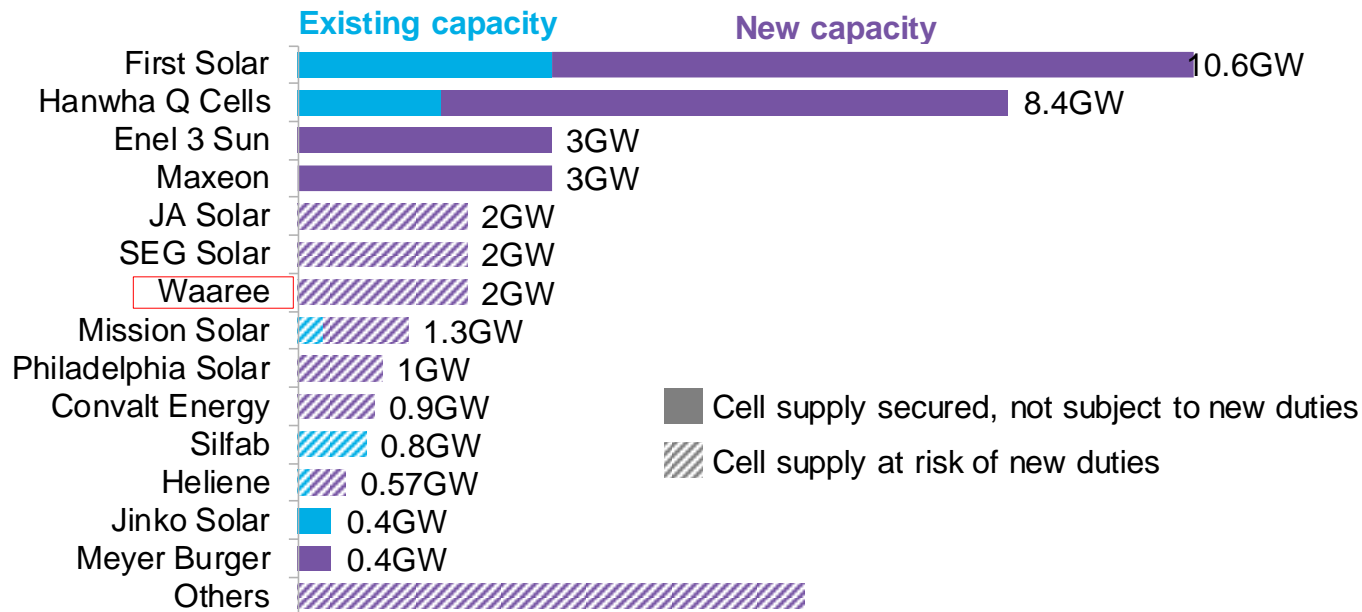
PV supply chain prices in 2022



Source: BloombergNEF, PV Infolink

A rush of new solar factory announcements in the US

Existing and announced US annual module manufacturing capacity

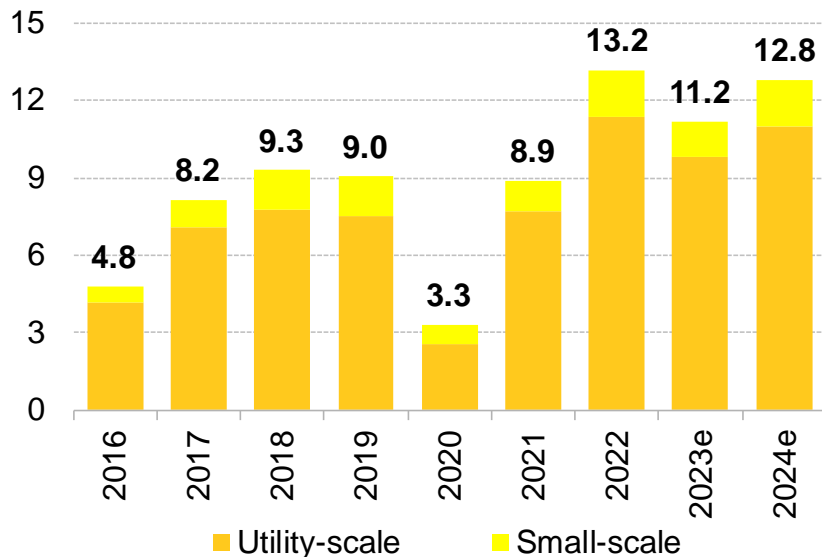


Source: BloombergNEF. Note: Some of the companies plan to make their own cells or will not be subject to existing and new US duties on cells.

India's 2023 new-build solar capacity could fall below last year's levels

India's annual solar additions

GW(AC)

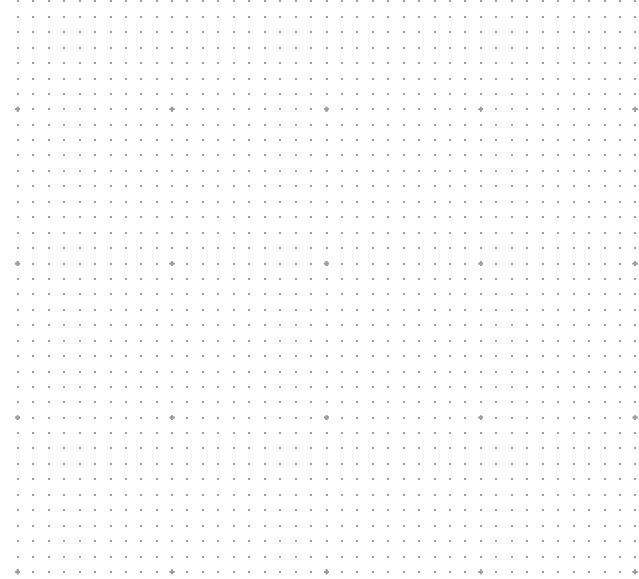


- Rise in module prices and import tax (40%) have **raised mid-case capex** by 34% in the last year.
- **Financing costs** went up in 2022 and the trend could continue this year.
- CPSU, standalone solar and some hybrid projects can get completion **deadline extended** to March 2024.

Source: BloombergNEF.

Auctions

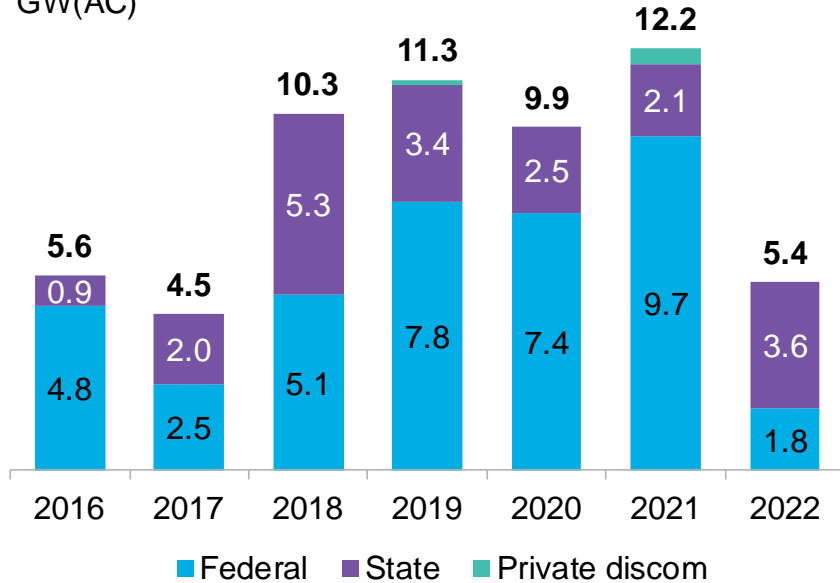
From standalone to complex



Tariff-based solar auctions slowed down in 2022, with only two states active

Annual solar auction capacity, by type of agency

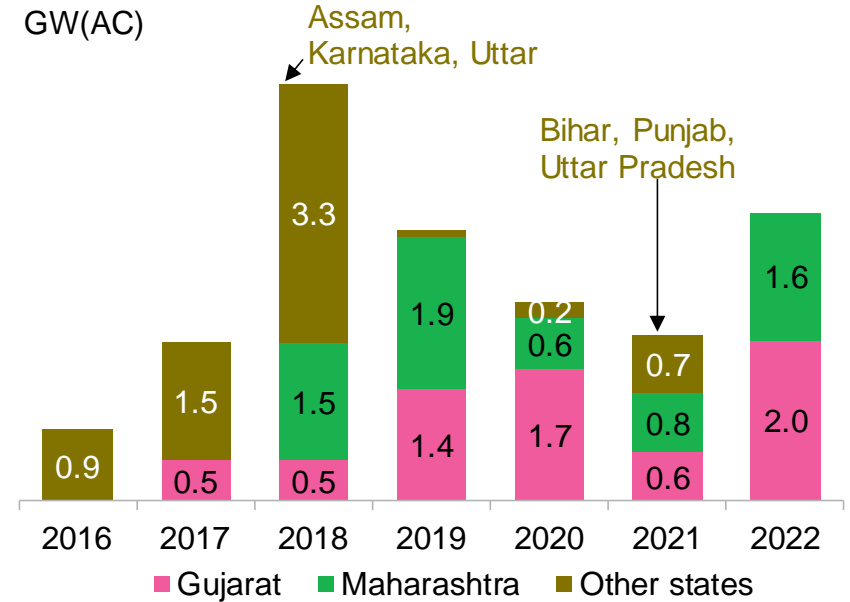
GW(AC)



Source: BloombergNEF. Note: Chart only shows auctions for utility-scale projects. It excludes the manufacturing-linked auction of December 2019 that awarded 12GW of solar power plant capacity.

Annual state-wise auctioned solar capacity

GW(AC)



Source: BloombergNEF. Note: Chart only shows auctions for utility-scale projects. Names of top states auctioning under 'other states' category are shown for selected years.

The future of auctions is increasingly 'complex'

Auction type	Agency	Key features	Outcomes
Wind-solar hybrid	SECI	35% minimum annual capacity factor (CF). Each technology must be at least 20% of total project capacity	Five auctions from Dec 18 to May 22 awarded a cumulative of 5GW
	Other agencies	Similar to SECI auctions with minor tweaks tailored to the needs of the auctioning state or private discom	Five auctions from Sep 2019 to Dec 2022 awarded 2.4GW

Source: BloombergNEF, tender documents. Note: SECI is Solar Energy Corp of India.

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Peak power renewables	SECI	Minimum annual CF 35%. 3MWh/MW of project capacity to be supplied for six of the nine defined peak hours	Auction in Jan 20 awarded 1.2GW to two IPPs.
Renewables+ storage	Maharashtra	3MWh/MW of project capacity to be supplied during non-solar hours. Minimum monthly availability of 85% during non-solar hours	Auction in Dec 22 awarded 250MW to two IPPs.

Source: BloombergNEF, tender documents. Note: SECI is Solar Energy Corp of India.

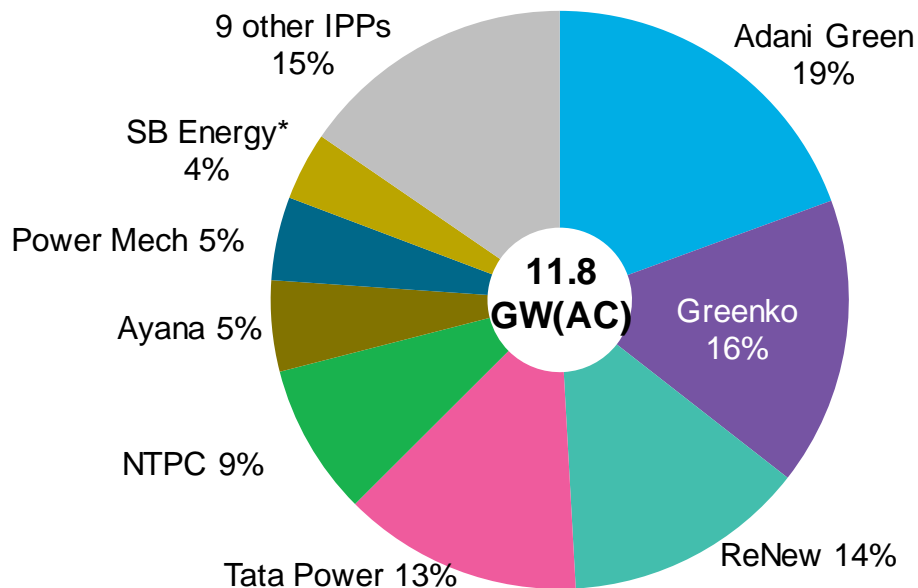
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Round-the-clock (RTC) renewables	RTC-I by SECI	Minimum annual CF 80% with monthly CF of 70%. No time-of-day supply constraints. Storage not mandatory but likely to be deployed.	Auction in May 20 awarded 400MW to ReNew Power.
	RTC-II by SECI	85% availability annually and 85% during peak hours. At least 51% of annual supply from renewables	Auction in Oct 21 awarded 2.5GW to five IPPs but faces cancellation

Source: BloombergNEF, tender documents. Note: SECI is Solar Energy Corp of India.

The top IPPs have taken a lead in winning at complex auctions

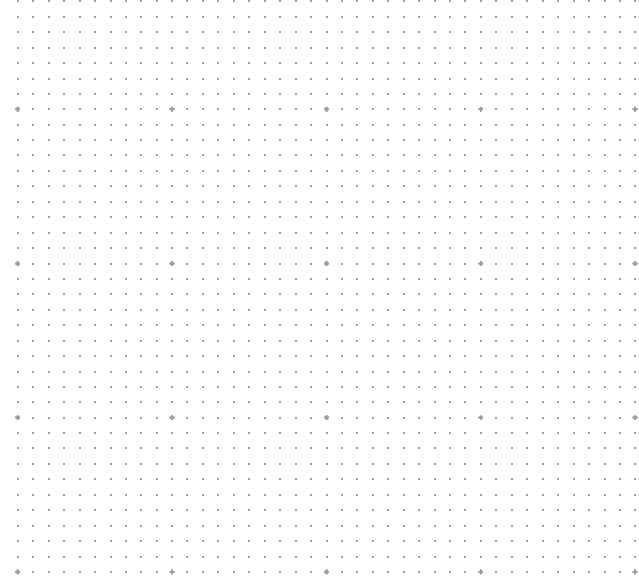
Winners of complex auctions, 2018-2022



Source: BloombergNEF. Note: Complex auctions require integration of two or more technologies. Wind-solar hybrid auctions are included here but auctions for standalone energy storage are excluded. *SB Energy's India operations were acquired by Adani Green in 2021.

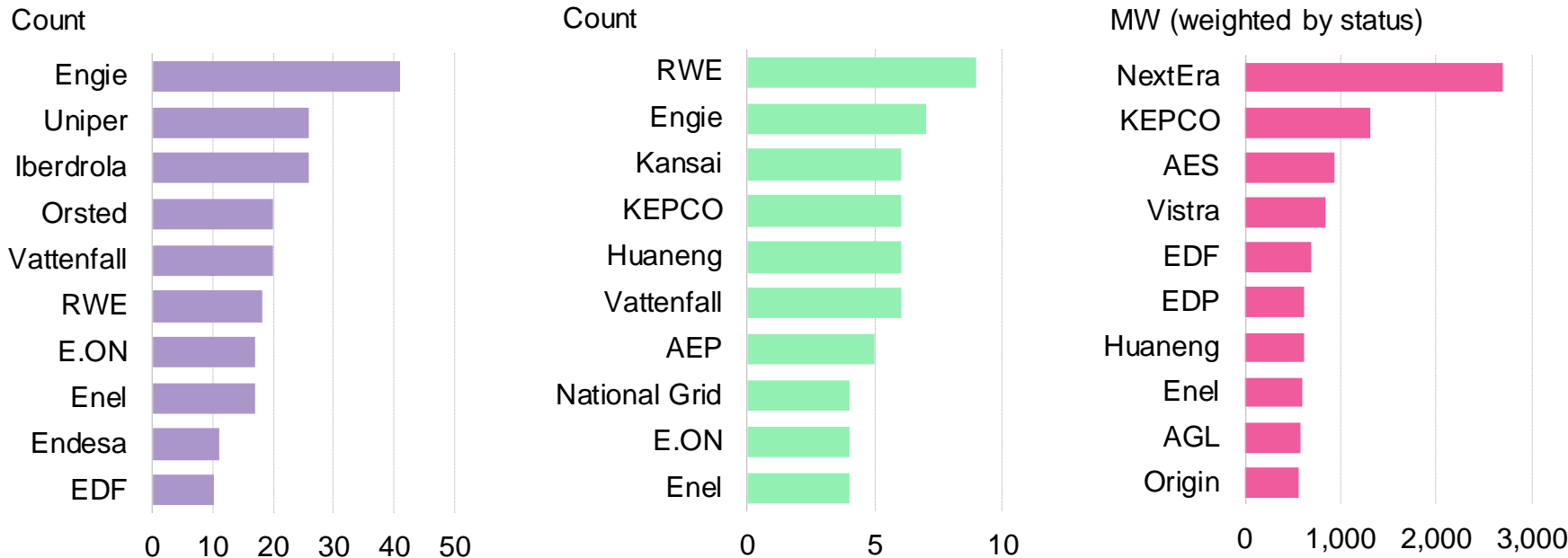
Utility strategies

Transition and diversification











Power companies are stepping up investments in new growth areas

Activities of utilities in hydrogen, CCUS and battery storage













Source: BloombergNEF. Note: each chart only lists the leading companies in that metric. Data from April 2022 publication.

Utilities will face tough competition in the power sector from oil majors

Value chain	Upstream and generation					Midstream					Downstream					
	Gas power	Solar	Onshore wind	Offshore wind	Bioenergy	Transmission	Distribution	DR&VPP	Grid-scale storage	C&I retail	C&I energy mgt	Residential I retail	Residential I energy mgt	Rooftop solar	Micro-grid	EV charging
	Dark Green	Dark Green	Dark Green	Dark Green	Light Green	Light Green	Light Green	Dark Green	Dark Green	Dark Green	Light Green	Light Green	Light Green	Light Green	Dark Green	Dark Green
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Source: Company announcement, news reporting, BloombergNEF. Note: Dark green = deeply involved; mid green = somewhat involved; light green = little or no involvement.

IPPs in India are diversifying into sectors allied to renewable generation

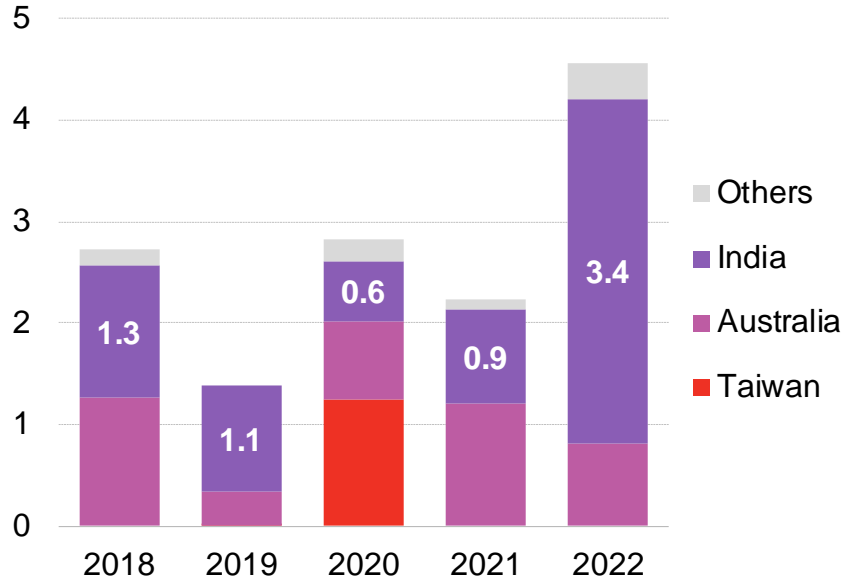
Strategy/ focus area	 ACME Leading Through Innovation	 adani Renewables	 greenko	 JSW Energy	 एनटीपीसी NTPC	 Reliance Industries Limited	 ReNew POWER		 एसजेवीएन SJVN	 TATA TATA POWER
Manufacturing		✓*								✓
Firm renewables		✓								✓
C&I consumers			✓	✓			✓	✓		✓
EV charging					✓			✓		✓
Green fuels	✓									
Energy storage								✓		✓

Source: BloombergNEF, company filings, news reports. Note: Green shows actions taken, yellow are planned and grey is no presence based on BNEF's assessment of announcements and market activity. *Equipment manufacturing is done by Mundra Solar, which is part of the Adani Group, but not under Adani Green. Shell's activities are based on assessment of the companies in which it has invested. Firm renewables covers wind-solar hybrid, peak power, round-the-clock and other projects where different renewable technologies are paired with energy storage. EV = electric vehicle. Green fuels covers green hydrogen and green ammonia.

India is the largest market in APAC for C&I clean power purchases

Annual corporate clean energy PPAs in APAC

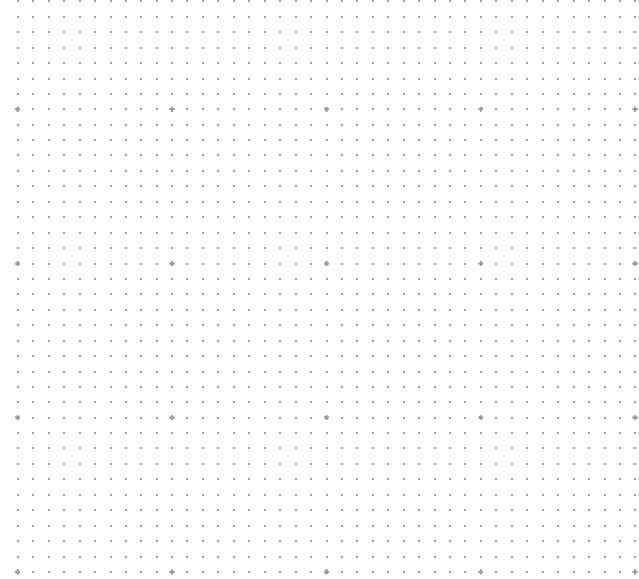
GW



Source: BloombergNEF.

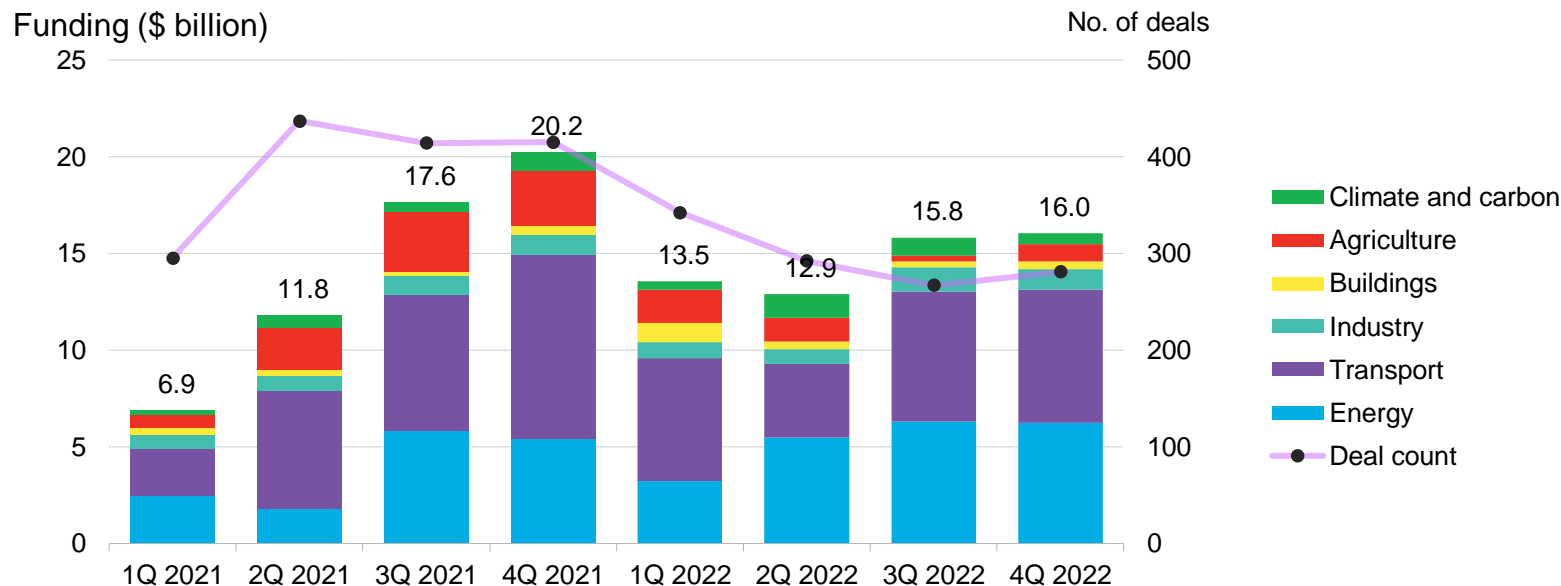
Other technologies

Nuclear, PV, long-duration storage, CCS



Funding for low-carbon innovation remained strong in 2022

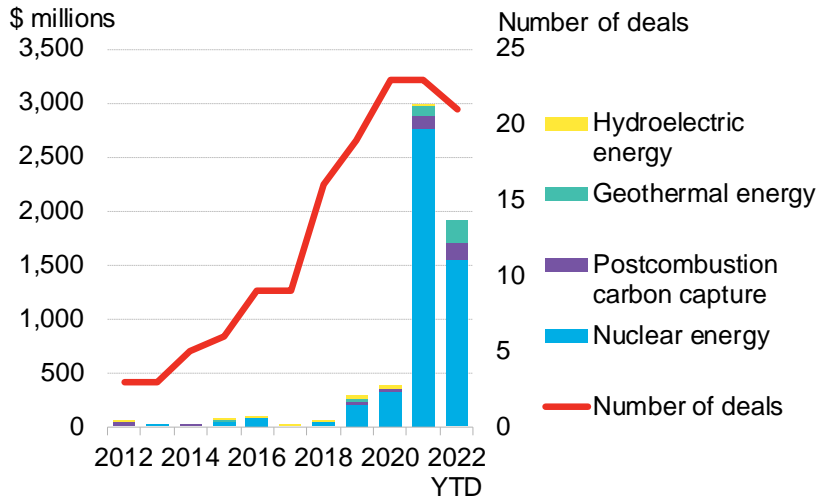
VC/PE investment in climate-tech companies



Source: BloombergNEF, PitchBook.

Nuclear

Global baseload energy VC/PE investment by technology category



- **New approaches and technologies**

- **Making reactors smaller** – cheaper and modular
- **Advanced reactors** – redesign heat transfer methods and fuels
- **Fusion** – less risk of waste and no risk of runaway meltdown

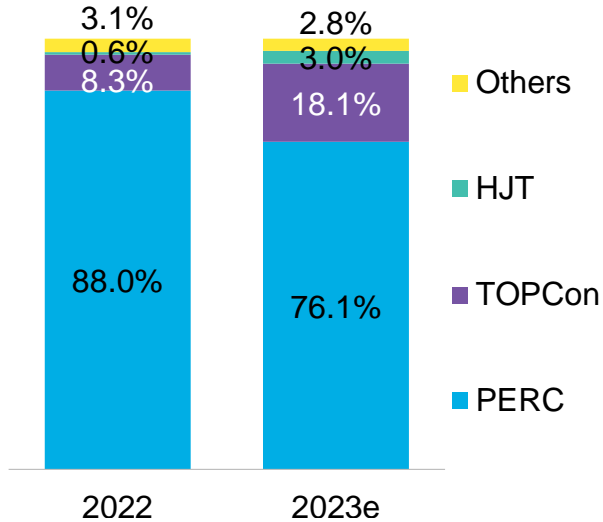
- **Limitations**

- **Social acceptance** – has less political support
- **Regulatory barriers** – risk averseness and permitting delays
- **Poor knowledge** – regulators don't understand

Source: BloombergNEF, CB Insights. Note: Data complete through August 15, 2022. Post-combustion carbon capture only includes companies focused primarily on the power sector.

TOPCon is gaining market share

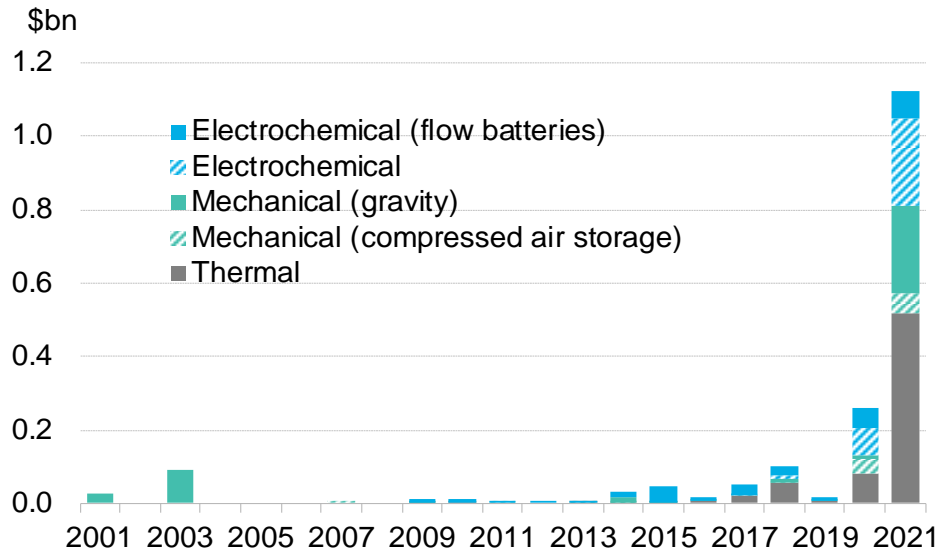
Estimated market share of silicon-based solar cells by technologies



Source: China PV Industry Association (CPIA), BloombergNEF. Note: Market share in 2023 is estimated by the CPIA. PERC is passivated emitter rear contact. TOPCon is tunnel oxide passivated contact. HJT is heterojunction, thin-film silicon on crystalline silicon

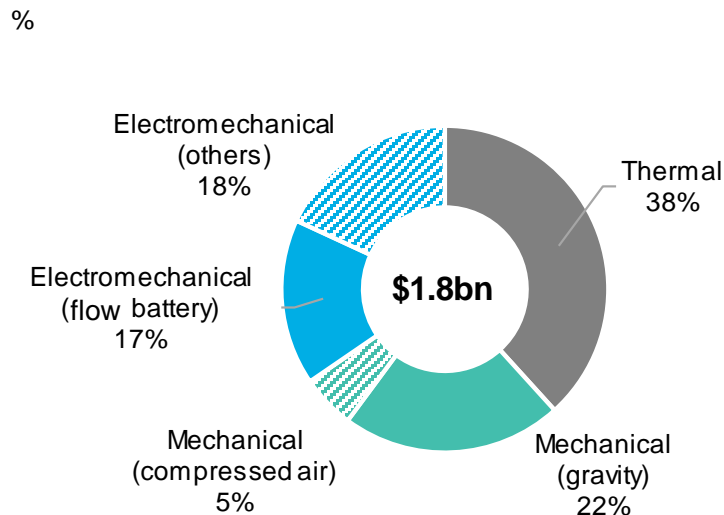
Long-duration storage is attracting funding, but no clear technology winner

Long-duration storage annual PE-VC fundraising, 2001-21



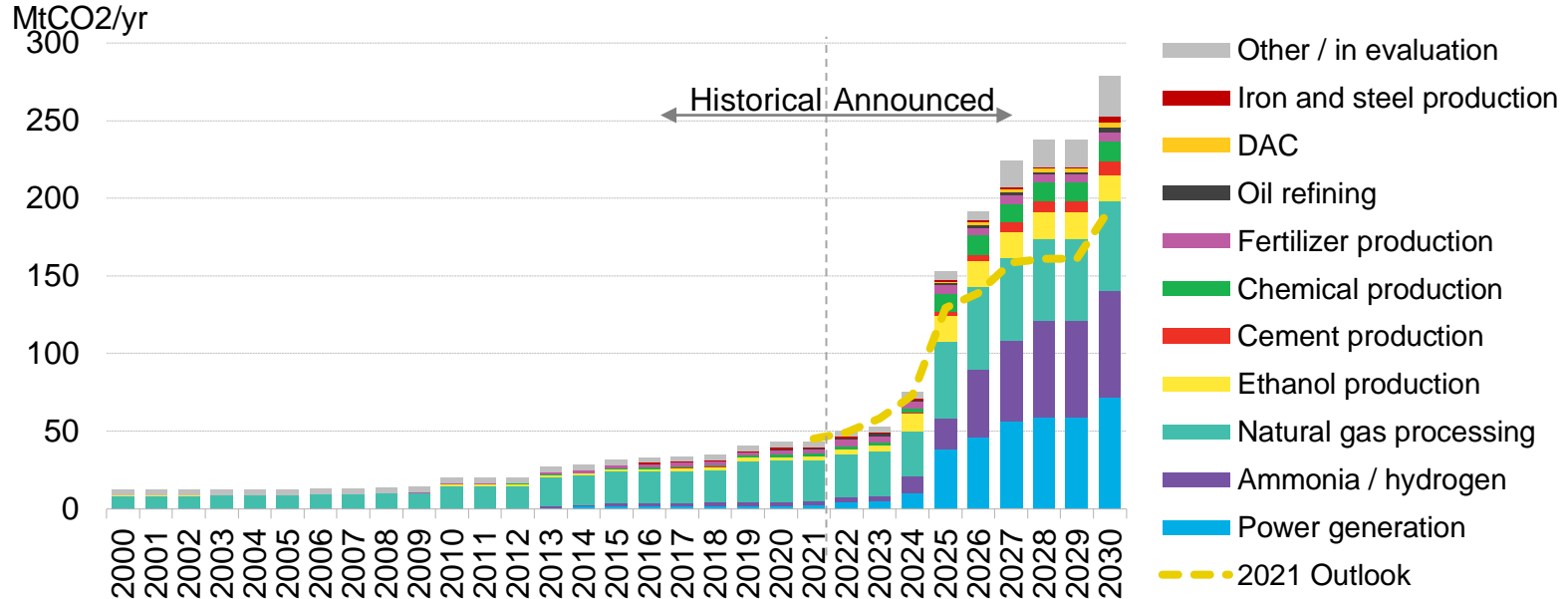
Source: BloombergNEF, Pitchbook. Note: *These charts represent VC-PE investments of 40+ long-duration energy storage start-ups developing thermal storage, mechanical storage and flow batteries and other non-lithium long-duration batteries. Data updated as of October 2021. Data does not include investments in lithium-ion battery technologies, hydrogen storage, traditional pumped hydro, and others.

Long-duration storage cumulative PE-VC fundraising by technology type, 2001-21



Carbon capture is rising

Global capture capacity by source, historical and announced (cumulative)



Source: BloombergNEF

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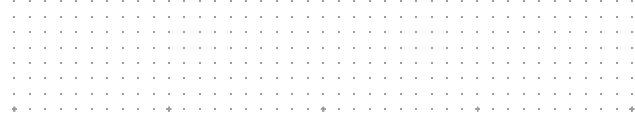
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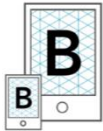
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