Low-carbon transition

Transition Center of Expertise: Renewable Power

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New energy sources, new grid

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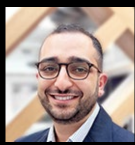

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Key takeaways

- The solar and wind industries hit record installations in 2023, even amid disruptions to the supply chain and the macro environment.
- Growth drivers for the renewables sector include falling costs, policy support for the transition to a low-carbon economy and, increasingly, energy security.
- Solar and wind are starting to benefit from new green industrial policies in the U.S., EU and around the globe.
- China's dominant position in the production of solar panels and components contributes to supply chain risks.
- Permitting and grid connections are perennial sticking points for infrastructure projects across many jurisdictions.
- Behind-the-meter energy generation is an opportunity, allowing regions and businesses to sidestep utility-scale bottlenecks.
- Jurisdictions with fewer regulatory restrictions have seen a recent windfall of investment in renewable power.

Introduction

Renewable power technologies are the draft horses of global emissions reductions – and most of them are just entering their prime.

In the BlackRock Investment Institute Transition Scenario, we see global electricity demand growing two-and-a-half times by 2050, as the electrification of energy demand across industries accelerates. Paired with the near-total decarbonization of the global grid by mid-century, these trends will combine to address 37% of total global energy demand from low-carbon electrons by mid-century.

The shift is already well underway. Largely due to renewables deployments and some coal-to-gas switching, power sector emissions have been falling in most OECD markets for more than a decade.[1] More than one-third of global power will likely be renewable as soon as 2025, including hydropower and biomass.[1]

Renewable power is also an essential part of the drive for energy security or energy independence in many countries. Low-carbon sources of power, including nuclear, will represent just under half of global electricity supply by 2026.[1]

While traditional energy sources will remain essential in the coming years, many jurisdictions with advanced power markets and flat load growth are seeing renewables deployments displace more emissions-intensive sources in the generation mix.

But a recent return to demand growth in much of the OECD (driven by data centers and demand for artificial intelligence, reindustrialization and cryptocurrencies) means renewables will be positioned to both outcompete new-build alternatives and displace existing coal and gas fleets.

In the U.S., for example, solar alone made up more than half[2] of new capacity additions in 2023, and solar and wind are set to comprise over 70% of new additions in 2024.[3]

Similarly, in many emerging markets, with strong positive load growth, new renewables are additive to meet growing or unmet demand and can displace higher-carbon alternatives that might have been built. But this demand growth is not uniform: many emerging, regulated power systems across

About BlackRock's Transition Centers of Expertise

The transition to a low-carbon economy is among a handful of major structural shifts that we see rewiring economies, sectors and businesses. The transition will likely cause ripple effects around the globe and change where revenues and profits are generated.

The transition's pace of change, however, is highly uncertain, which creates complexity and risk – as well as opportunity – for companies and investors alike.

At BlackRock, we define transition investing as: Investing with a focus on preparing for, being aligned to, benefitting from and/or contributing to the transition to a low-carbon economy. We recognize that clients across the world are investing in the transition to a low-carbon economy to generate returns, manage risk, or execute on commitments.

BlackRock's Transition Centers of Expertise (CoEs), of which our Renewable Power CoE is one, bring together the knowledge of our more than 600 sustainable and transition specialists across the firm, as well as external experts and industry associations. These virtual communities, organized by sector technology, encompass expert views throughout the capital stack and across industry value chains, contribute to the assumptions used in the BlackRock Investment Institute Transition Scenario, and help source new opportunities for our clients.

We hope the insights developed by the CoEs will lead to a better understanding of the uncertainty around the transition by bringing together a range of perspectives and experience.

As a fiduciary who puts our clients' needs and goals first by offering a broad range of investing options, we currently manage US$138 billion in transition-related assets globally, to identify opportunities arising as a result of structural trends shaping the economy, markets, and asset prices. This paper is produced in close cooperation with our Renewable Power CoE.

Source: BlackRock, as of December 31, 2023.

Africa have seen low to zero load growth for decades and very low penetration of renewables to date.

Boom time

In 2023 the renewables industry installed nearly 400 GW of photovoltaics (solar panels) and 100 GW of wind capacity.[4] This represents nearly 50% year-on-year growth, the fastest rate of growth in two decades and the 22nd straight year of growth.[4] Solar PV became a terawatt-scale market in 2022, and onshore and offshore wind together are expected to comfortably cross that threshold in 2024.[5]

China is responsible for much of the boom. Last year, it installed as much solar as the entire world[4] and as much as the U.S. has ever installed.[6] In wind, China saw 66% annual growth in installations while the rest of the world saw an 11% contraction.[5]

Over the next four years, China is expected[4] to install more than half of new capacity globally and is on pace to reach its national 2030 wind and solar targets by the end of this year, suggesting to analysts that its emissions may peak much sooner than previously estimated[7] – or may have already peaked. Clean energy sectors were the largest driver[8] of China's economic growth last year, accounting for 40% of GDP growth.

The U.S. solar market, led by Texas, grew 51% year-on-year in 2023, and is set to quadruple total installations[9] over the next decade, despite persistent interconnection challenges. Similarly, European installations have grown 40% or more for the past three years.[10]

Exceeding expectations

The growth in renewables deployments has been underestimated by researchers and modelers for years, mostly based on the assumption of linear growth amid exponential trends. But solar or wind are the cheapest forms of new bulk power[11] in countries comprising two-thirds of the global population and 90% of global electricity generation. After a bounce in prices in 2022 due to macro headwinds and inflation, costs resumed falling in 2023. Solar PV generation costs fell 9%, wind generation costs fell 13%, and benchmark solar module prices dropped 50% - driven in part by supply overcapacity in China.[12]

Despite a historically patchy policy environment, solar and wind value chains are starting to experience tailwinds from new green industrial policies around the world.

And against a backdrop of rising global instability, energy security is becoming a key driver in the adoption of renewable power. Countries across the EU, as well as Japan, Korea and even the U.S., are taking steps to reduce their dependence on energy imports and eliminate supply chain vulnerabilities. The wind and solar industries have an essential role to play in helping nations meet their targets.

The world will almost completely rely on China for solar panel and component production through 2025, however, as it dominates the solar PV manufacturing chain.

At the same time, the renewable power industry faces sticking points. Bouts of cost inflation (especially for electrical components), higher-for-longer rates, siting and permitting challenges, delays in grid system upgrades and increased trade protectionism for cleantech could represent chokepoints that cloud an otherwise sunny growth story. How quickly these issues resolve will dictate the pace of growth in the coming years.

At COP28 in Dubai, nearly 130 countries committed to triple their renewable energy capacity by 2030. That would require maintaining the 17% average annual growth rate in renewables over the past seven years for the next seven.

Most estimates suggest that with existing policies and market conditions, renewables deployments would grow between two to two-and-a-half times in that period. Our latest view is on the lower end of this range. It should be noted that achieving this target would require roughly tripling grid investments and significant – 16X – growth in battery deployments.

Source: 1. International Energy Agency, "Electricity 2024" January 2024. 2. Solar Energy Industries Association, "U.S. Solar Market Insight" March 6, 2024. 3. U.S. Energy Information Administration website, accessed February 15, 2025. 4. IEA, "Renewables 2023" January 2024. 5. Wood Mackenzie, "2024 Outlook" January 25, 2024. 6. Bloomberg News, January 26, 2024. 7. CarbonBrief, November 13, 2023. 8. CarbonBrief, January 25, 2024. 9. Solar Energy Industries Association, "Solar Market Insight Report 2023 Year in Review" accessed March 15, 2024. 10. SolarPower Europe, December 12, 2023. 11. BloombergNEF, June 30, 2022. 12. Wood Mackenzie, "2024 Outlook" January 17, 2024.

Investor Q&A

BlackRock's Centers of Expertise bring together our leading experts for specific industries that we believe will play a key role in the low-carbon transition. Our Renewable Power CoE includes Alastair Bishop, an investor in public renewable energy companies, David Giordano, the Global Head of Climate Infrastructure, Isabella Pacheco, who invests in private renewables companies in the Asia-Pacific region, and Peter Raftery, Chair of the BlackRock Renewable Power CoE.

What's your current view of renewable energy?

Alastair Bishop: To be very clear: 2023 was a record year. Everywhere you look, across wind, solar and energy storage – all of these things were record years for installations. But if you ask the average public-markets investor, that would not be their impression. They perceive that there was a demand issue, and the business model is broken in some way.

There were high-profile issues in a very small part of the market, which is U.S. offshore wind. These reflected challenges to the supply chain and the nature of power price contracts that were fixed many years ago before the re-emergence of inflation.

There's also been growing overcapacity within the solar supply chain. In the context of higher interest rates, these headwinds have created the impression that renewable energy is somehow a business that only worked in an ultra-low interest rate environment.

But actually, demand for solar and wind was very strong in 2023, as is the outlook for future demand. Many wind turbine manufacturers saw record order intake in 2023.

Isabella Pacheco: Renewable energy is a major theme across Asia. Europe is expected to phase in tax on imports from all over the world based on the quantity of climate-changing carbon dioxide emitted during their production, which means that many businesses are already taking steps to decarbonize their supply chain.

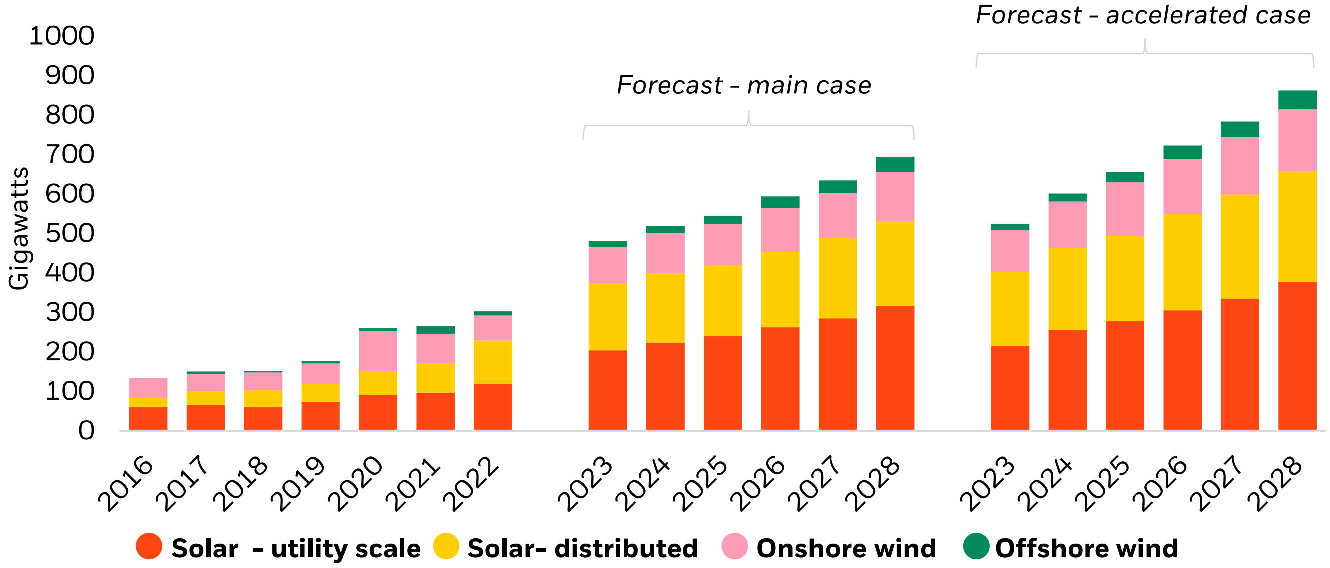
So you see a lot of the manufacturing that happens in non-OECD countries across Asia, like clothing manufacturers, moving to renewable energy so that the whole supply chain can become greener. You see global shrimp producers, for example, starting to buy renewable power privately so that they will not be penalized once these new regulations come into effect.

From our view, it's very much a regional story. If you look at Japan, they still have these incredibly high targets to hit by 2050. They're going to have to do that with offshore wind, or by importing hydrogen or ammonia.

Offshore wind will also be a big part of the renewables push in the long-term where countries run out of available land for large-scale installations.

Ramping up

Global net additions of renewable power are rising fast – and growth looks set to continue



Source: International Energy Agency's Renewable Energy Progress Tracker, January 11, 2024.

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Pretty much all the growth we expect to see in solar in Japan will be on a distributed basis, because there's no space anymore to build at utility scale.

David Giordano: The growth of renewables in the U.S. is significant, but it's happening quietly in the background. Among renewable sources, I think solar will continue to be the highest growth.

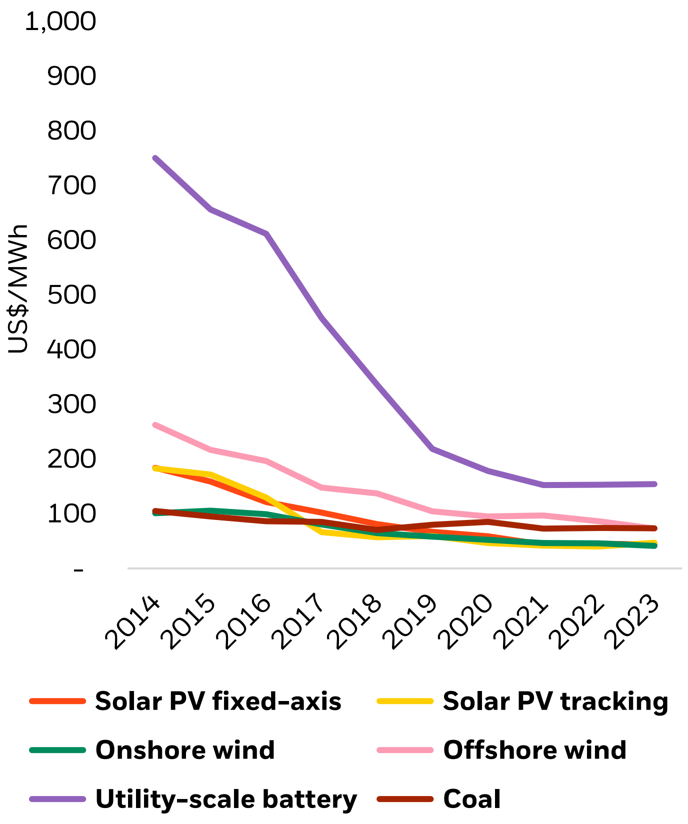
And it's an important market segment for us to continue to play in, even though it's somewhat harder to invest in because the dollars trickle out. Onshore wind continues to be interesting, especially in the U.S. Some of the best wind sites in the world still have early-2000 vintage turbines operating on them.

At the same time, they've been collecting data, and manufacturers in this space have gotten smarter and developed a kit that can utilize existing tower infrastructure. That's why I think that there's an underappreciated opportunity onshore, both for new build and repowering.

Peter Raftery: Certainly in solar it's an up arrow. Costs are at unbelievably low levels, and that's partly due to oversupply in China.

Falling costs

Renewable power technologies have become as economical as traditional sources such as coal



Source: BloombergNEF, January 2024.

Batteries also, to a significant extent, are an area where there's a lot of room for growth. Offshore wind is going through a hiatus and, to me, onshore wind is somewhere in the middle.

As Isabella suggested, while everybody loves the big 500 megawatt-gigawatt projects, there's a definite school of thought that a real powerhouse of the transition will be the smaller, local, behind-the-meter installations.

Can you say more about behind-the-meter?

I.P.: We're seeing a huge emergence of renewables being deployed in distributed power generation. Sometimes that power can be fed into the grid and sometimes it can't, depending on the country.

If you look at a country like Indonesia, they have said, if corporates start to put panels on their buildings, that's fine, but they can't feed any of that electricity onto the grid.

For investors, there are pros and cons to small-scale renewable energy installations: It's a purely commercial contractual agreement, so you have to make different considerations; credit risk will be very different when you're looking at corporate off-takers as opposed to government-backed subsidies; and it's harder to deploy large amounts of capital all at once with these strategies. You have to be quite focused when you're underwriting in terms of the actual business plan.

P.R.: The power industry has grown up in a world where you have big, centralized projects, and you transmit your power to the big cities. But there are real opportunities for this more-dispersed form of generation and power usage.

That could be a suburb or perhaps whole cities – maybe they can't necessarily be totally self-sufficient, but they could, for large periods of time, be semi-autonomous through renewable generation, dispersed storage and local grid support.

These regions need to have their own ancillary services to ensure a stable grid, which can largely be delivered by modern distributed batteries with the right control and regulations.

This way, even without big projects, you can potentially have whole regions that are mostly self-sufficient and hardly use the grid at all.

We've got platforms in New Zealand in particular that are building their business very much on that premise.

The big advantage here is that many of the grid constraints, regulatory constraints and permit constraints can be solved or bypassed in a pretty efficient way. And suddenly, you've got substantial renewable energy contribution being delivered at the local level.

A.B.: I totally agree, Peter. The way I'd put it is that the transition isn't just a matter of how energy is generated, it's also a shift from a fully centralized grid to one that is more a mix of centralized functions and all sorts of micro grids. This can work when you start playing the centralized and decentralized parts together.

Utilities can also use this to manage load. If you can start to pull on those systems when you want to, you can have demand response and be more efficient as a grid system.

And if we can do this more efficiently, it reduces CapEx burden and bridges the gap to where you're ultimately going.

What are the biggest trends you're seeing right now?

I.P.: From my perspective in Asia, India is making a play to be the next China in the renewables space, with all sorts of incentives and subsidies and programs that support renewables across every vertical.

Valuations are looking rich at the moment, but in terms of deal flow, we are seeing large volumes in India across all renewables segments. We are also seeing significant activity in both the Philippines, which is expected to add roughly 8GW of solar in the next two years, as well as Vietnam, which has an offshore-wind target of 6 GW by 2030.

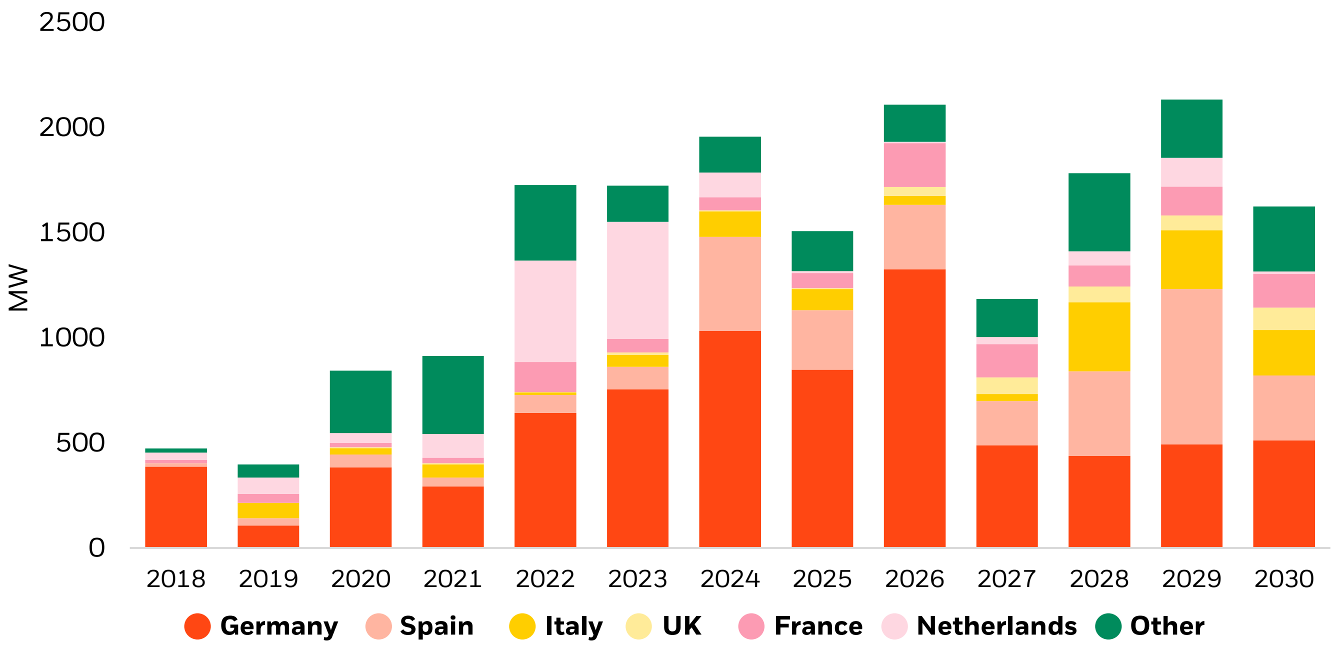
In OECD markets that have liberalized electricity markets like Japan or Australia, you still have challenges in the form of transmission and permitting. Permitting takes a long time for utility scale projects. That's why there's this growing interest in smaller applications of renewables that we were talking about. In Japan, planning for an onshore wind project takes about seven to nine years, while for solar over a certain size it can take as long as five years.

The longer the permitting period takes, the harder it is to make investment decisions. We try to limit our exposure to permitting, as outcomes can be binary.

Transmission is an additional cost we have to consider. In India and in the Philippines, when you build a project, you also have to build, as part of your project cost, the substations and all of the transmission lines. This differs from places in Europe where you already have pretty robust grid infrastructure in place.

Second wind

Repowered wind installations will add capacity



Source: BloombergNEF, January 2024. Note: Other = European countries other than those present in the chart. For detailed assumptions and more on onshore wind end-of-life, see Repower or Life Extend: Wind's Retirement Plan. Chart shows gross repowered capacity.

What role does surging power demand for AI and digital infrastructure play?

A.B.: So, for context, data centers today account for a little more than 1% of global electricity consumption. The rapid emergence of AI, which requires the use of more power-intensive processing chips, has the potential to notably increase this. In fact, the International Energy Agency estimates that within three years, AI servers alone could represent an additional 0.5% of global electricity consumption.

Importantly, this increase in power demand will not be uniformly distributed geographically and will instead be highly localized in areas hosting data center clusters. This will likely put pressure on existing grid capacity in those regions and require significant investment in new power generation, including from low-carbon renewable sources.

P.R.: Totally agree – we do think that AI data center demands will have a profound effect on electricity systems. To some extent, they are likely to be strongly overlapping with renewable generation resources due to the lower cost electricity as well as their environmental credentials. We have already seen the beginning of this trend with purchase power agreements we've signed in Nordic countries, where the climate is conducive for data centers. But as we have mentioned elsewhere, this is part of a larger trend of electrification and power demand growth across multiple industries, heating and transport modes.

I.P.: There are also opportunities for AI to help spur renewables growth even while contributing to more electricity consumption. For example, grid operators may be able to better optimize existing infrastructure and match demand loads more efficiently or even by anticipating weather patterns to predict renewable power availability.

How do concerns about energy security play into what you're seeing in renewable power?

A.B.: The supply chain is changing. For decades, this industry – especially solar - was always solving for lowest cost, which effectively meant using China. And I think that has shifted meaningfully over the last couple of years in many countries to being about solving for energy security.

That means that you have to be prepared to pay a higher price. The solar panel price is the cheapest it's ever been, everywhere apart from the U.S. – because the U.S. is making it very clear that it wants to have a domestic solar supply chain, and it will nurture that.

Geopolitics is an impetus for deploying domestic sources of energy. And energy security is a non-partisan issue in every country. Right now, Europe has an energy security problem and we're starting to see more deployment there, notably in Germany.

The U.S. doesn't have that issue today. But it has become more cognizant of its reliance on outside suppliers, especially in solar. That's one of the dynamics that informed the Inflation Reduction Act.

I.P.: Yes, exactly – the vast majority of the renewables supply chain still comes out of China, and there is this growing theme of other countries realizing that they need to build their own supply chain. You see India doing quite a lot of activity through policies requiring domestically manufactured components to avail of certain tariffs.

You see more corporates stepping in to expand the solar module supply chain, but the issue remains that raw materials still mostly come from China. But you start to have domestic component minimum requirements to incentivize people to use things that are made in that country.

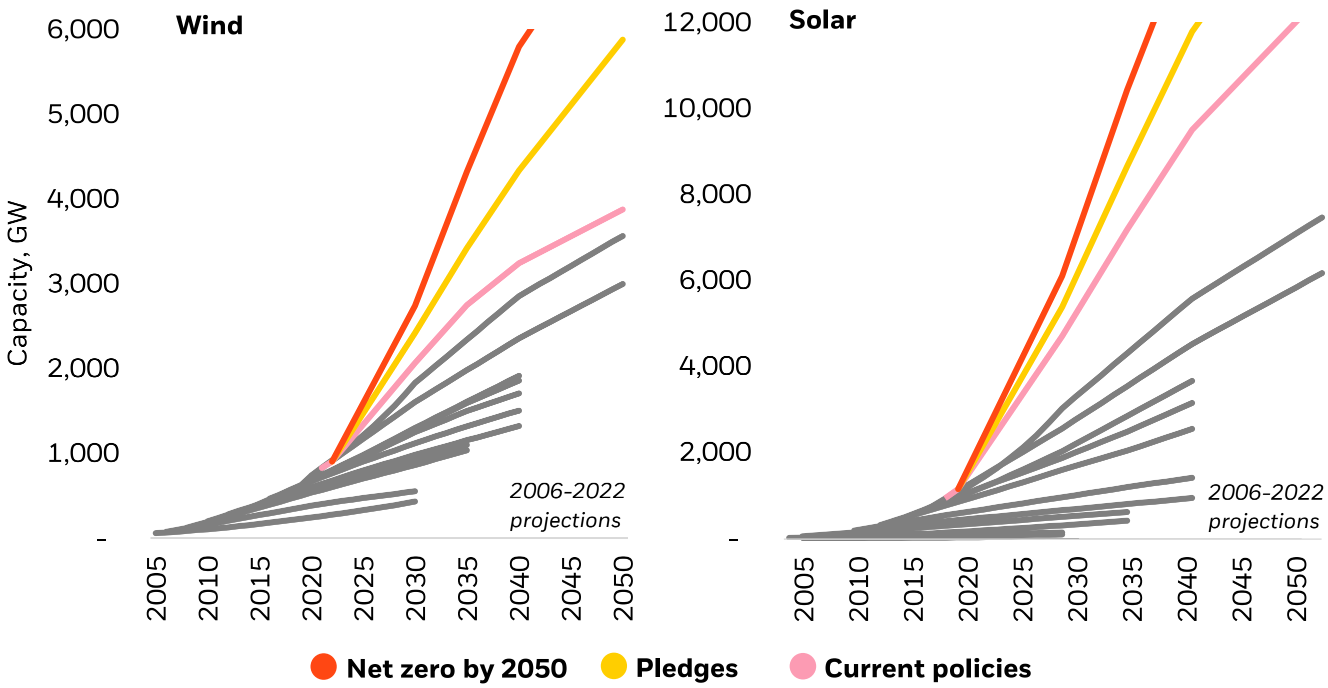
Headwinds: Permitting

Around the globe, we hear from companies and investors that permitting is the single most common, costly and consistent obstacle facing renewable power projects. The permitting process varies from country to country and even within national borders.

Some jurisdictions that are committed to building renewable power have taken steps to expedite the permitting process. And we have seen a windfall of investment in renewable power in markets where permitting has been streamlined.

Rising expectations

Projections of wind and solar energy capacity have been constantly revised upwards



Source: BlackRock Investment Institute with data from IEA and ThunderSaid Energy, November 2023. **There is no guarantee that any forecasts made will come to pass.**

Where do you see the best opportunities?

D.G.: I think solar is a major opportunity, but especially behind the meter, which as we've talked about avoids some of the grid-congestion issues. I think you're going to finally start to see the virtual power plant technology start to take shape, as well. That's where you've got these behind-the-meter systems talking to each other to manage load at the distribution level. And I think the data and tech piece is an opportunity that will unfold over time.

In addition to solar, wind is going to play a big role in balancing out that so-called duck curve of demand and supply mismatches, and battery energy storage is also going to play a role. When you think about a regional transmission organization like PJM in the U.S. – which coordinates wholesale electricity in 13 states - if they can get their transmission queues straightened out, there's tons that can be built there.

I.P.: The opportunity set varies widely by region. In Vietnam, for example, there's a huge amount of solar. But the curtailment rates we've seen can vary between 30% and 50% because the demand/supply load is mismatched. There's too much solar and there's no storage. As David says, we remain long on solar, but it's going to be a solar-plus-storage story going forward on a utility-scale basis.

In Australia, because the grid is not as big or as developed as other countries, I think it's slightly easier for them to do that. They are focusing a lot on storage. And I think that's because the energy market since renewables have been introduced has been very volatile.

So they realized early that if you want to incentivize people to invest in energy, you need less volatility in your energy markets, and storage is going to be a big part of that.

A.B.: In the public equity space, there has been a clear disconnect between the strength of demand and the valuation of the companies exposed, which have meaningfully de-rated as a result of concerns around interest rates, supply chain challenges and question marks over future political support. This divergence looks interesting to us.

I think markets misunderstand the economics of what's driving the deployment of renewables. People's perceptions of long-term power prices have shifted up, and that is offsetting higher rates to a large degree. For new projects, you're generally seeing the economics remain robust. And markets that have been pretty quiet, like Germany, are ramping up their auctions.

P.R.: Private markets are slower to react and less volatile than public markets, so I think the valuations are holding up reasonably well.

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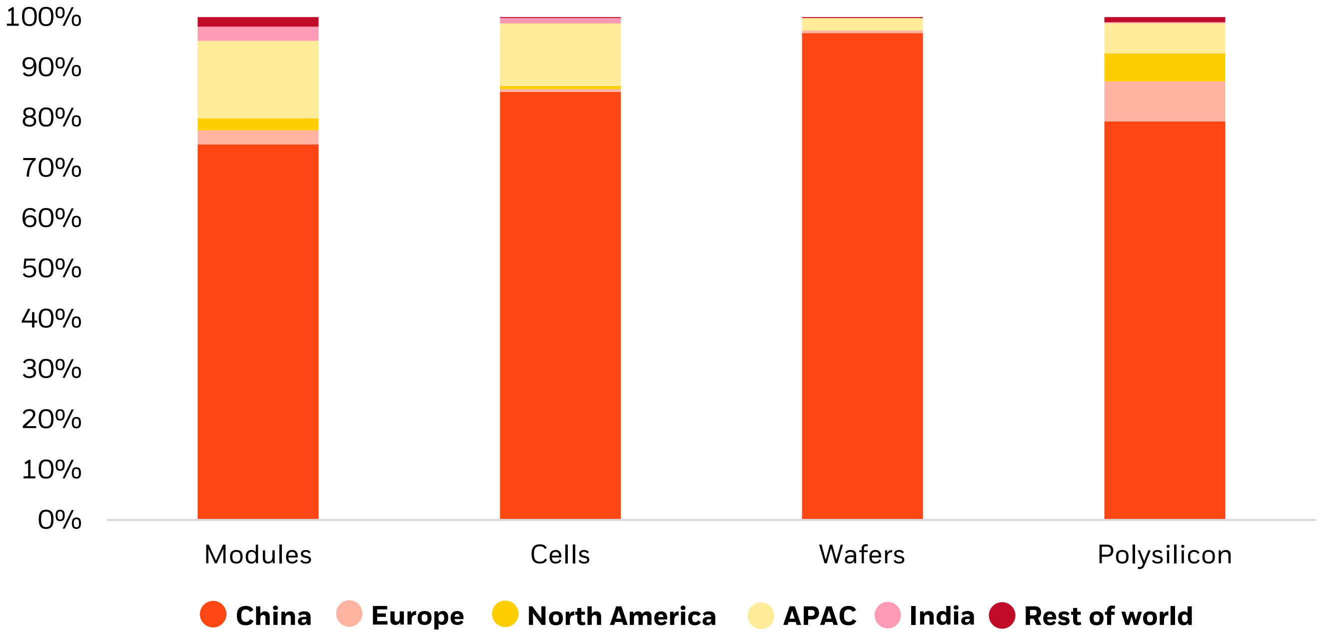
Solar dominance

China is the largest manufacturer of most the elements of solar arrays by a wide margin.



Source: IEA analysis based on BNEF (2022a), IEA PVPS, SPV Market Research, RTS Corporation and PV InfoLink.

But there are cycles – as we've discussed, we've seen that in offshore wind. As an industry we have been through these cycles many times. In wind, because of equipment and labor inflation we are in a dip, but there are still record orders. I can see us coming out the other side and accelerating.

Solar doesn't seem to have dipped at all, it's full speed ahead. And battery is poised for exponential growth as far as we can see.

There are definitely pockets of light. Australia is one, as Isabella mentioned – it's amazing to see a jurisdiction go from being so heavily coal-generated and restricting renewables to understanding the need to transition straight to renewables from coal.

There are really innovative things going on there. Across all these cycles, we remain interested in the projects themselves. But to finish things up, I'd say that good, high-quality projects in the right places remain limited.

It's hard to find the right land with the right resources and obtain the land leases, the permits, and get the right grid connection. And, ultimately, that's where the expertise comes in.

Conclusion

Wind turbines and solar panels have been part of our landscapes for so long that it's easy to assume that their growth trajectory has flattened – but the reality is very different.

Renewable power has seen significant growth in the past decade, and last year wind and solar hit records for installations. Their use is expected to keep rising – so much so that renewable power may account for as much as 35% of global generation by 2025.[1]

As an investment opportunity, along with the broader electrification trend, renewables also benefit from the rising global demand for electricity that is being driven by the mega forces of digital disruption and geopolitics.

The rapid advances in computing, with artificial intelligence leading the way, will dramatically add to demands on the grid and require more sources of power generation. And in an uncertain world, energy security concerns in many nations are driving the creation of new projects.

Technological change within the industry is also playing a role in the sector's development. For example, today's turbines can generate about 10 times more energy than those installed just 20 years ago,[2] making repowering a compelling investment option for sites with attractive solar and wind resources that have been well-studied and established.

At the other end of the opportunity set, there are VC investments in new technologies – while we think of renewable power in terms of large-scale utilities, small-scale behind-the-meter tech can be easier to deploy and is helping to reshape local grids.

There are differences across regions, from new builds to meet demand in emerging markets to replacing fossil fuels with renewable sources in developed nations. And the scale of the required investment in renewable power is unlocking new use-cases, such as companies' need for incremental capital.

But for all the tailwinds, challenges remain in the industry. In particular, permitting and grid connectivity are longstanding issues that faces investors, while supply chain changes may trigger cost inflation and delays.

China has historically controlled a large part of the supply chain, but many countries are now looking to decouple and build out their own supply. Regions that navigate these challenges well could emerge as beneficiaries of new capital and investment.

Renewables are essential in the transition to a low-carbon economy, and often provide sticky, long-term contracted revenues and inflation protection that can bring balance to portfolios. This industry provides investment opportunities across the risk-return spectrum spanning public and private markets, playing an important role in portfolios.

Source: 1. IEA, Electricity Market Report 2023. 2. Financial Times, February 21, 2024.

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