24/7 Carbon-Free Energy Procurement in APAC: Pathways for Companies and Countries

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BloombergNEF

Contents

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Section 1. Executive summary

73%

Share of emissions abated directly and indirectly via clean electricity by 2050 under BNEF's Net Zero Scenario

>70%

Share of hourly matched electricity demand with renewable generation in APAC by 2050 under BNEF's Net Zero Scenario

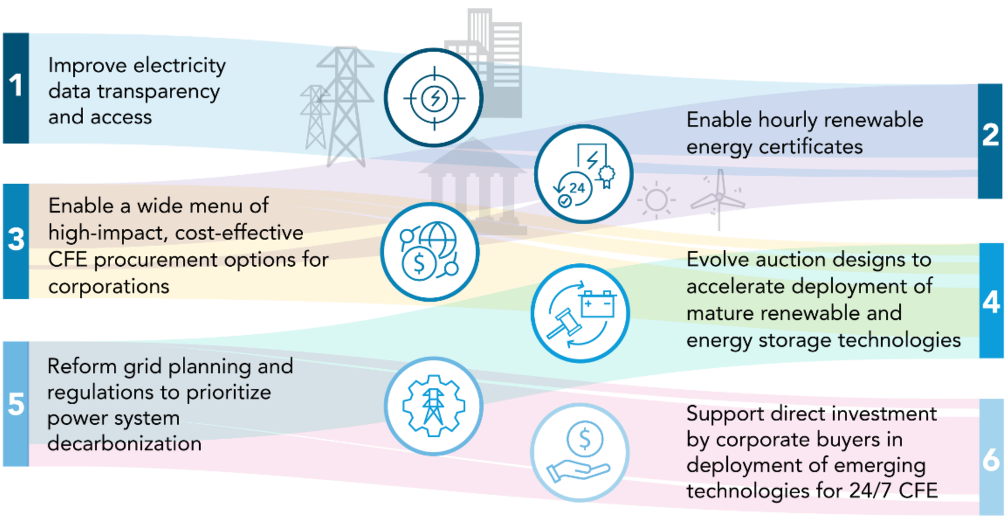
17

Number of 24/7 Carbon-free Energy Compact signatories based in markets covered by this report

The Asia-Pacific region's share of global greenhouse gas emissions has doubled since 1990, led by growth of emissions from the power sector. Decarbonizing the region's power system by 2050 is critical to fulfilling the Paris Agreement goal and continued economic growth. This report examines how enabling 24/7 carbon-free energy corporate power procurement pathways in APAC can support an orderly transition of the region's power system.

- **24/7 carbon-free electricity procurement:** Clean power procurement by corporations has become a key source of funding to accelerate deployment of clean electricity and reduce corporations' emissions. Today when a company considers clean power procurement, the most common strategy is to match its annual electricity consumption with purchases of renewable energy. This means that a company may not fully match its electricity consumption in many hours of the year with clean electricity supply, instead relying on electricity supplied by its local grid which is not emission-free at all hours. Additionally, some companies buy renewable energy in one market to match their electricity consumption in one or several other markets. To ensure 100% of emissions associated with their electricity consumption is reduced, companies need hourly and locational matching of their electricity demand with carbon-free electricity supply.

Table 1: Recommendations for enabling 24/7 carbon-free electricity procurement



Source: BloombergNEF

- **Importance of diverse technology mix:** Decarbonization of the power sector requires an immediate acceleration of investment in deployment of solar, wind and batteries along with grid expansion. More investment is also needed to scale and bring down the costs of dispatchable clean energy such as geothermal as well as long-duration energy storage technologies. Corporations pursuing 24/7 carbon-free energy procurement can bring

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additional resources to complement incumbent power utilities, independent power producers and grid operators to support the orderly transition of the power sector.

- **Geographic coverage:** This report reviews current decarbonization plans and corporate clean power procurement frameworks of 11 different markets: Bangladesh, India, Indonesia, Japan, Malaysia, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, and Vietnam. The report also analyzes the pathways to decarbonize the power systems of India, Japan, Thailand, and Vietnam using New Energy Outlook's Paris-Aligned Net Zero Scenario. By aligning their procurement strategies with these countries' grid decarbonization pathways, companies would be able to achieve significant 24/7 carbon-free energy progress through renewables and energy storage by the early 2030s.

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Section 2. Introduction

Decarbonization of Asia-Pacific's electricity systems is a global climate imperative: APAC region accounts for approximately half of global greenhouse gas emissions

This report examines 24/7 carbon-free energy (CFE) corporate power procurement pathways in the Asia-Pacific (APAC) region and their role in accelerating deployment of renewables and low-carbon dispatchable power to enable an orderly transition to net-zero emissions by mid-century. The report reviews current decarbonization plans and corporate clean power procurement frameworks of 11 different markets across the APAC region: Bangladesh, India, Indonesia, Japan, Malaysia, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, and Vietnam. The 11 APAC markets examined have been chosen based on the diversity of socioeconomic, regulatory and physical challenges they represent. The report also analyzes the pathways to decarbonize the power systems of India, Japan, Thailand, and Vietnam, and describes how 24/7 CFE procurement can support national decarbonization objectives. The report concludes with recommended measures to enable 24/7 CFE procurement in these markets.

This report has been commissioned by the Global Renewables Alliance (GRA), founded by the Global Wind Energy Council, Global Solar Council, International Hydropower Association, Green Hydrogen Organisation, Long-Duration Energy Storage Council and the International Geothermal Association. The report has benefitted from feedback by reviewers from the Climate Group, EnergyTag, Google, and Sustainable Energy for All.

This chapter lays out the importance of the APAC region for global greenhouse mitigation, the role of renewables in mitigation and how 24/7 CFE can accelerate renewable deployment.

2.1. The role of renewables and APAC in climate change mitigation

Global greenhouse gas emissions have continued to rise due to the increase in unabated fossil fuel combustion for energy. APAC's share of global emissions has almost doubled from 25% in 1990 to 47% in 2021. Provisional recent data from the UN Environment Programme suggests this trend is continuing.

Figure 1: Global greenhouse gas emissions by source

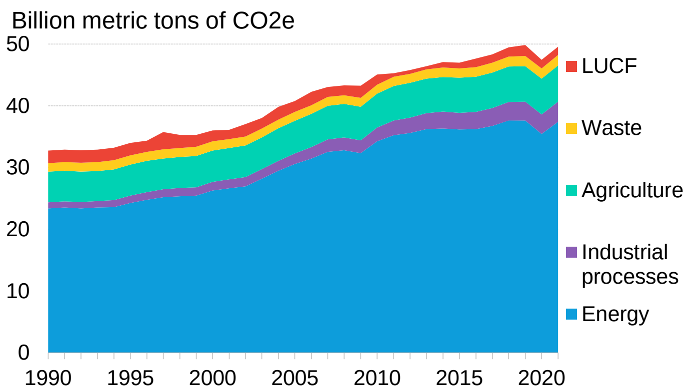
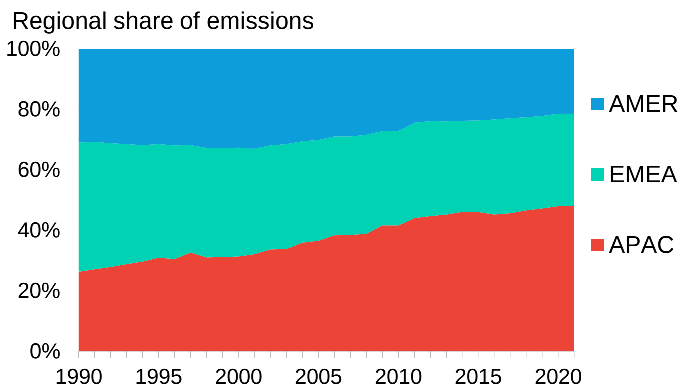


Figure 2: Global greenhouse gas emissions by region



Source: Climate Watch. Note: Data is through 2021. LUCF stands for land-use change and forestry. AMER refers to the US, Canada and Latin America; EMEA stands for Europe, Middle East and Africa. Emissions from former members of the Union of Soviet Socialist Republics in Central Asia are included in EMEA. CO2e is carbon dioxide equivalent.

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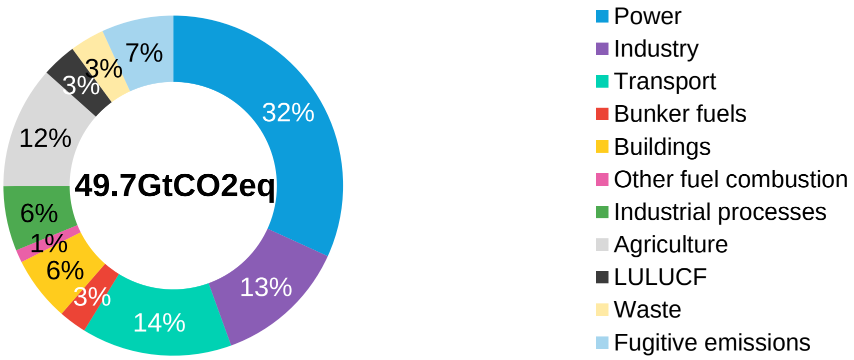
To meet the Paris Agreement goal of keeping the average rise in global surface temperature to well below 2 degrees Celsius by the end of the century compared to pre-industrial levels, global emissions need to decline by at least 25% by 2030 relative to 2019 levels, on the way to reaching net zero by mid-century.

Figure 3: Estimated greenhouse gas emissions by source, 2019

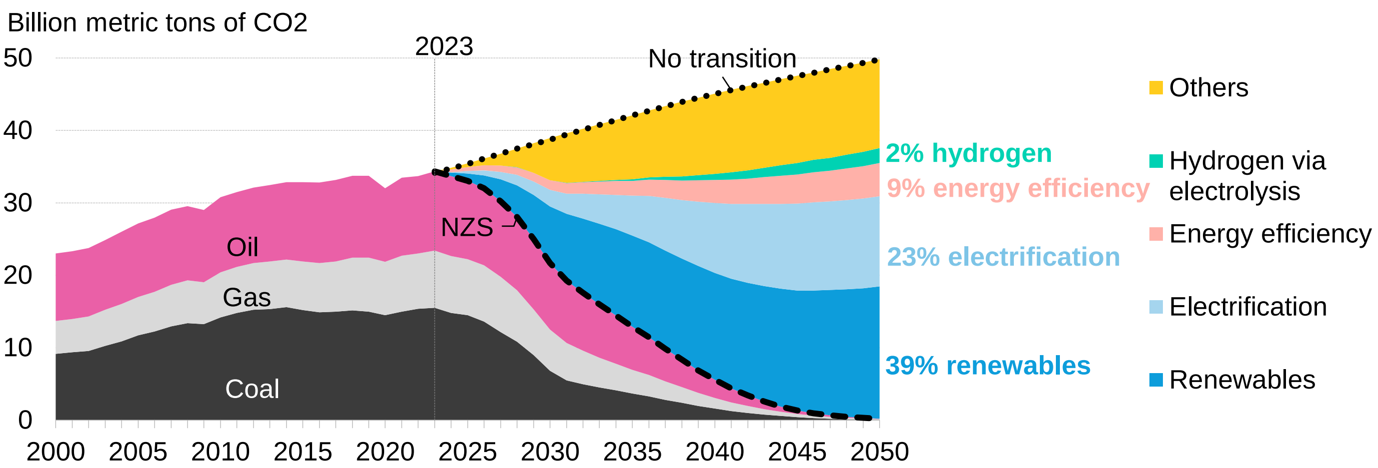


Source: World Resources Institute, IEA, BloombergNEF. Note: Chart shows all greenhouse gas emission in CO2 equivalent value. GtCO2eq is billion metric tons of CO2 equivalent. LULUCF is land use, land-use change and forestry.

Globally, the power sector is the single largest source of emissions (Figure 4). To fulfill the Paris Agreement goal, BloombergNEF's New Energy Outlook (NEO) shows renewables will be the single most important lever in tackling emissions from fossil fuel combustion. For more information regarding the NEO modeling methodology, please refer to Appendix A.

The Paris-aligned NEO Net Zero Scenario (NZS) shows renewables directly account for 39% of emissions avoided between today and 2050, compared with a no-transition scenario where there is no further action on decarbonization.

Figure 4: Carbon dioxide emissions reductions from fuel combustion – historical and Net Zero Scenario versus 'no transition' scenario



Source: BloombergNEF New Energy Outlook 2024. Note: The 'no transition' scenario is a hypothetical counterfactual that models no further improvement in decarbonization and energy efficiency. 'Energy efficiency' includes demand-side efficiency gains and more recycling in industry.

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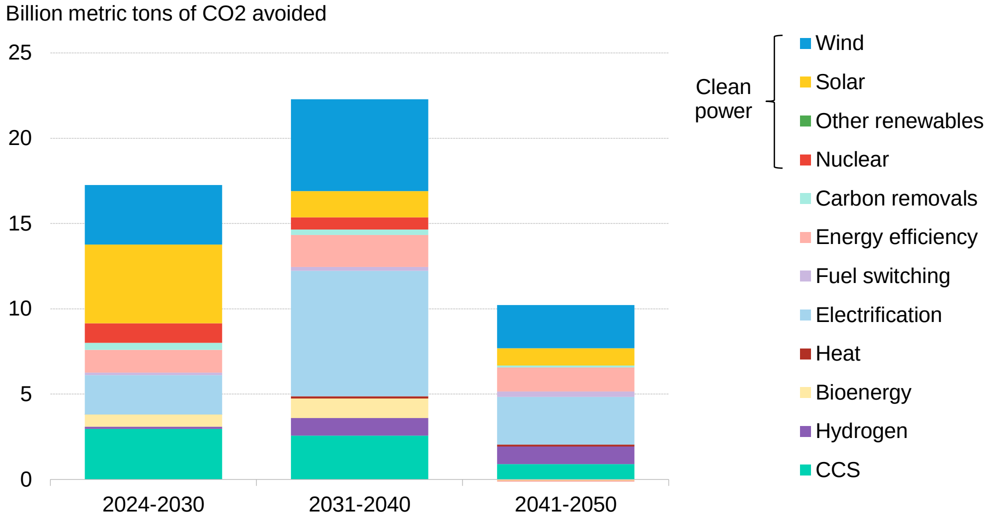
The electrification of end-use sectors, including road transport, buildings and industry, powered by an increasingly cleaner electricity supply accounts for another 23%. Clean hydrogen produced via electrolysis and energy efficiency primarily enabled by increased electrification account for an additional 11% of emissions abatement. In total, renewables, directly and indirectly, would enable almost three quarters of emissions abatement needed by 2050.

Renewables, directly and indirectly, enable almost three quarters of emission abatement needed by 2050

Progress in the next 10 years is critical

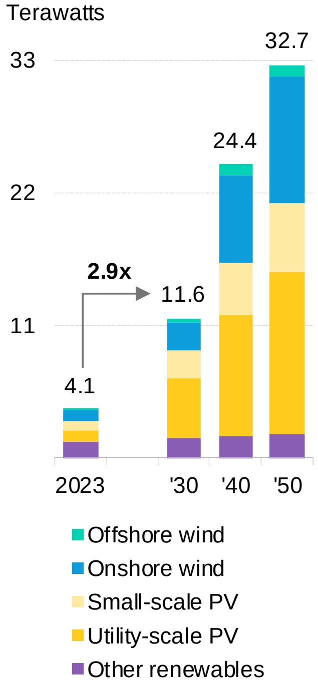
Early emissions reductions are crucial to meet the Paris Agreement goal. Under the NEO NZS, the period 2024-2030 is dominated by rapid power-sector decarbonization. Wind and solar capacity additions are responsible for half of emissions abatement during this seven-year period.

Figure 6: Global net carbon dioxide emissions reductions by period and measure/technology – Net Zero Scenario versus 'no transition' scenario



Source: BloombergNEF New Energy Outlook 2024. Note: Data shows the net contribution of each technology to carbon emissions abatement by time period compared to a counterfactual 'no transition' scenario in which there is no further action toward decarbonization. Time period lengths differ. CCS is carbon capture and storage. 'Other renewables' include all other non-combustible renewable energy in electricity generation, including hydro, geothermal and solar thermal.

Figure 5: Installed renewables capacity – Net Zero Scenario



Source: BloombergNEF New Energy Outlook 2024. Note: PV is solar photovoltaic.

Under NZS, cumulative renewables capacity triples from 2023 to 2030 and then triples again from 2030 to 2050 (Figure 6). Fossil fuel generation meanwhile falls almost 60% between today and 2030. By 2040, unabated fossil fuel generation needs to be effectively phased out. The power system under the NZS shifts from relying on unabated baseload fossil fueled thermal power plants, to one dominated by renewables (Figure 8).

Solar and wind alone provide almost three-quarters of all electricity in 2050. The dominance of solar and wind is driven by their economic competitiveness and scalability. Since 2017, the global levelized cost of electricity generation benchmark for new solar and onshore wind power plants has been lower than new thermal power plants. Battery-based energy storage systems have also become economically viable thanks to cheaper lithium-ion batteries. Under the NZS, the share of electricity supplied by all renewables combined (including hydro, biomass, geothermal and other renewables) rises to 81% in 2050.

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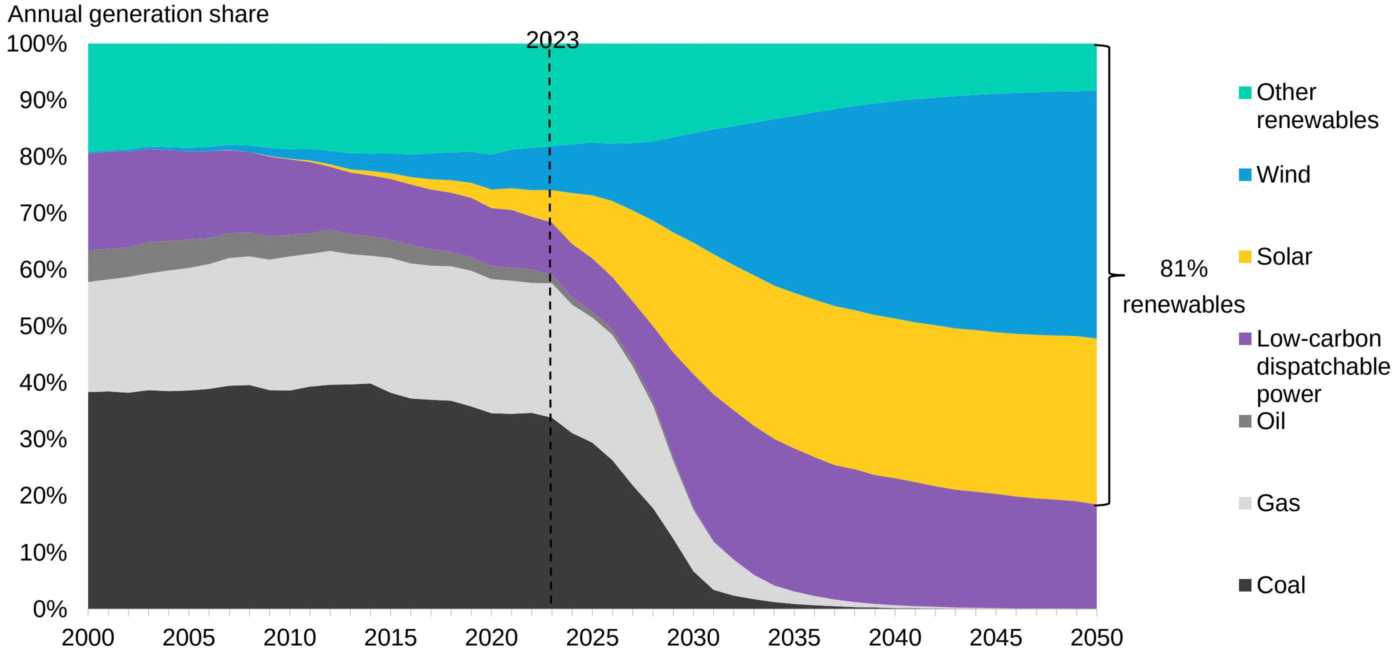
Figure 7: Global annual electricity generation by technology/fuel – Net Zero Scenario



Source: BloombergNEF New Energy Outlook 2004. Note: 'Other renewables' include hydro, bioenergy, geothermal and solar thermal. 'Low-carbon dispatchable power' includes nuclear, thermal power plants equipped with carbon capture and storage and/or those fueled by clean hydrogen and its derivatives.

Under Paris-aligned Net Zero Scenario electricity demand growth is led by corporations

Compared with 2023, electricity demand in the NZS more than triples to just under 78,000TWh in 2050 from 25,000TWh (Figure 9). Industry and buildings are the two largest consumers of electricity in 2050, with 31% of total demand each. Most industrial demand growth comes from sectors with low heat needs, such as food processing, machinery, and pulp and paper, but chemicals and cement production also see an increase as they partly electrify their processes.

The single largest source of new demand for electricity is from electrolyzers used to produce hydrogen. Even though hydrogen 'just' contributes 3% toward emissions abatement over 2024-2050, its production takes up about 16,500TWh, or 19%, of electricity demand in 2050. Hydrogen from electrolysis beats other production methods on cost from the 2030s in all markets.

Corporate demand for electricity, fueled by industrial and commercial activities, will be a major driver of future electricity demand growth by 2050

The majority of electricity demand growth under the NZS will come from commercial and industrial activities led by corporations. And enabling clean power procurement options for corporations will be critical to funding the power capacity and grid expansion needed under the NZS.

Under NZS annual power capacity investment needs to triple

Under NEO NZS, renewables – which include biomass, hydro, geothermal, solar and wind technologies – account for the largest portion of power sector investment by 2050, at almost $23 trillion, with solar and wind collectively taking up 94% of this total. Around $7.1 trillion of renewables investment is called for in the remainder of this decade as the world aims to hit the COP28 pledge of tripling renewable energy capacity by 2030, relative to a 2022 baseline.

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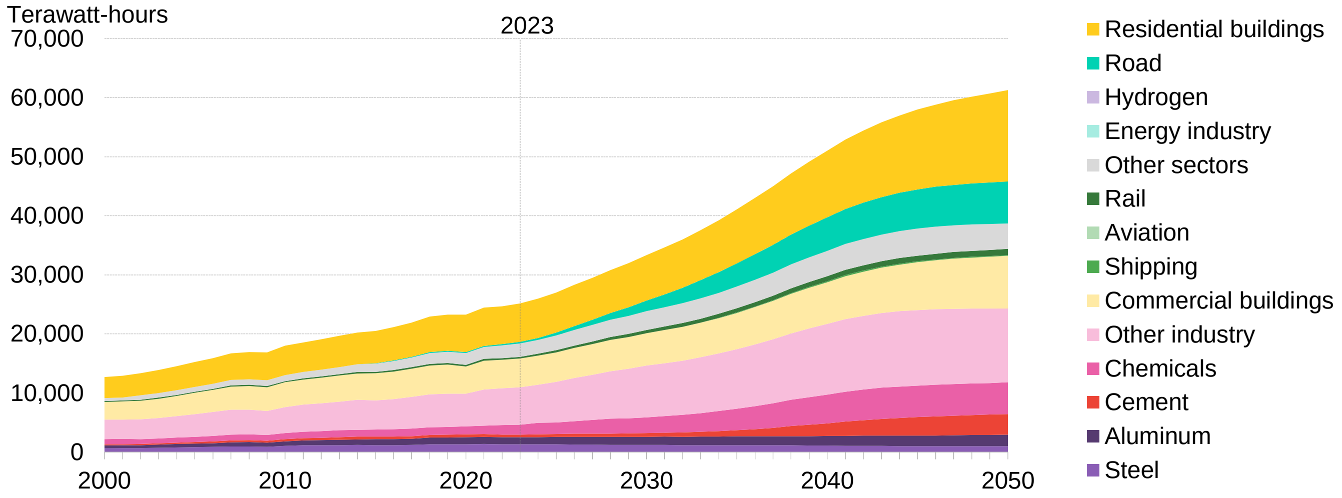
Figure 8: Global annual electricity consumption by sector – Net Zero Scenario

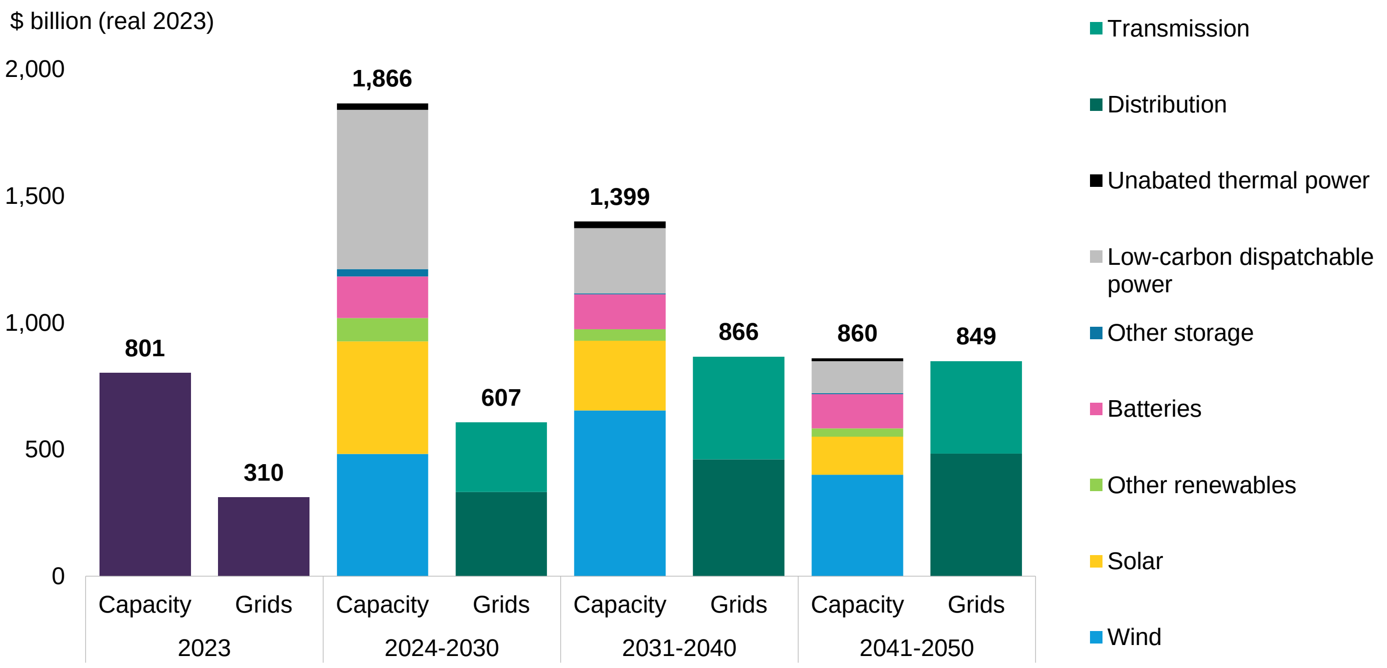


Source: BloombergNEF New Energy Outlook 2004

Power network investment needs to double within this decade

Achieving net-zero emissions globally by 2050 calls for $21.4 trillion in power grid investment to support the build-out of renewables and energy storage. Corporate clean energy procurement will be a critical source of funding to meet the increased power capacity and grids investment required under the NZS.

Figure 9: Global annualized investment in power capacity and grid – Net Zero Scenario



Source: BloombergNEF New Energy Outlook 2004. Note: Low-carbon dispatchable power refers to nuclear and thermal power plants equipped with carbon capture and storage.

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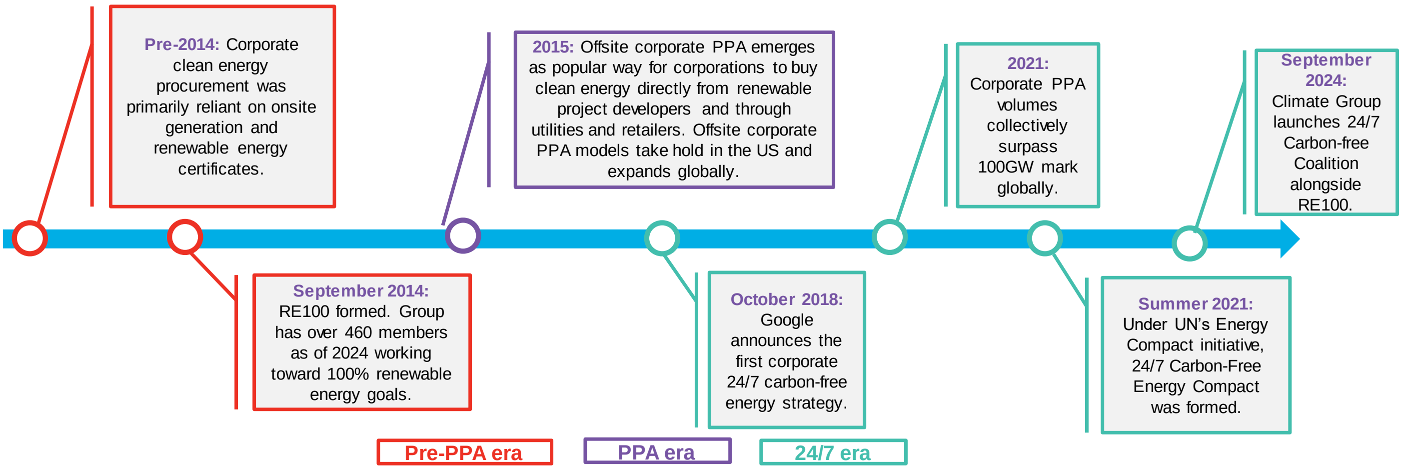
2.2. Corporate clean power procurement

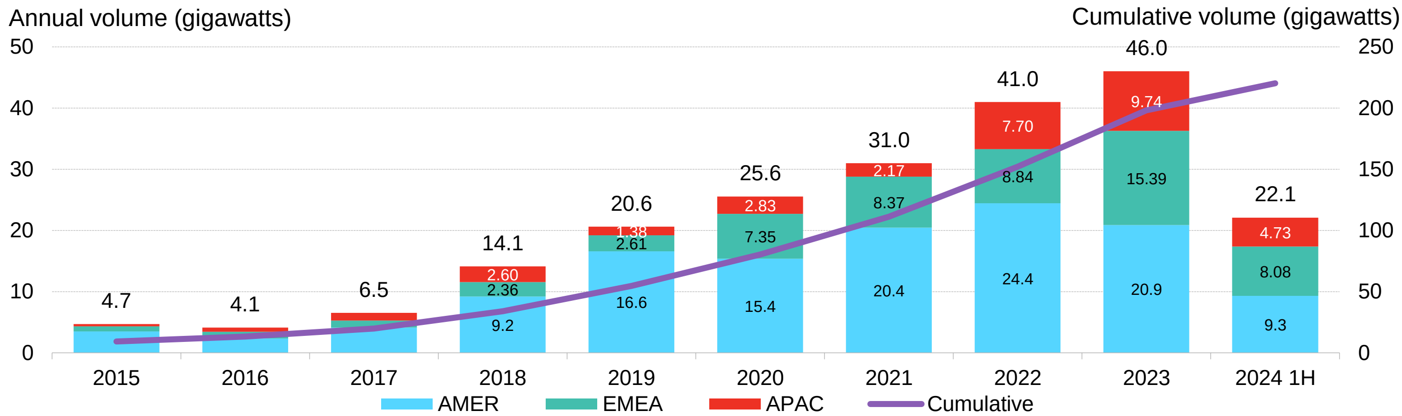
Historically, corporations with large electricity needs have tried to reduce electricity procurement cost volatility and improve reliability by investing in options such as captive power plants and offsite power purchase agreements (PPA) with independent power producers (IPP). As corporations became aware of the need to reduce emissions associated with their electricity supply (Scope 2 emissions), they started to pursue clean power procurement opportunities. In the late 2000s, larger corporations such as Google started signing PPAs with renewable IPPs in competitive wholesale electricity markets.

Figure 10: The evolution of corporate clean power procurement



Source: BloombergNEF

Figure 11: Global corporate clean power purchase agreement volumes



Source: BloombergNEF. Note: Chart shows only offsite power purchase agreements; Onsite PPAs excluded. AMER = the US, Canada and Latin America; EMEA = Europe, Middle East and Africa; APAC = Asia Pacific. Asia Pacific capacity is estimated.

The 2014 launch of the RE100 by the Climate Group increased awareness among corporations leading to more demand. The rising demand from corporations led to enactment of power market reforms widening the portfolio of available options to corporations beyond on-site installations and renewable energy certificates (REC), thus enabling offsite clean power purchase agreements first in parts of North America and Europe, and more recently in APAC.

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Clean power procurement by corporations has already led to new renewable capacity that would have not been built otherwise, thanks to the companies' focus on 'additionality'. Additionality refers to prioritizing clean power procurement options that lead to building of new renewable capacity instead of using power from existing renewables. As of June 2024, BNEF estimates support from RE100 members has led to 37GW of solar and 20GW of wind. If the current 463 RE100 members met their clean electricity shortfall entirely through offsite solar and wind PPAs, we estimate it will catalyze an additional 32.8GW of incremental solar and wind build through 2025 and 74GW of build between 2026 and 2030. Corporate demand for clean power procurement has been a critical driver for continued investment in renewable capacity expansion in APAC markets such as Australia and Japan once direct subsidies were reduced.

Figure 12: Global solar build driven by RE100 members

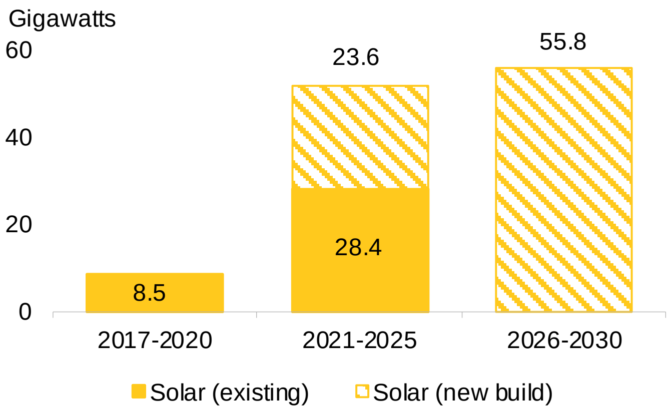
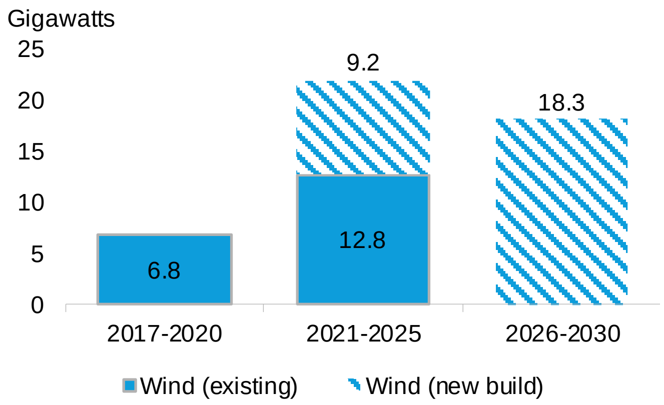


Figure 13: Global wind build driven by RE100 members



Source: BloombergNEF. Note: Charts assume 57% of new generation will come from solar, and the remaining 43% from wind. Solar capacity is in direct current terms.

Corporate clean energy procurement has undergone a significant evolution in the last two decades. Corporations leading in clean power procurement are now looking to go beyond annual matching of their electricity demand with annual supply of renewables towards pursuing a more ambitious goal: hourly and locational matching of clean electricity supply and demand via 24/7 carbon-free energy procurement.

2.3. The role of 24/7 CFE

Today when a company considers clean power procurement, the most common strategy is to match its annual electricity consumption with purchases of renewable energy, either through bundled electricity and RECs (such as via PPAs) or through unbundled REC purchases. This means that a company may not fully match its electricity consumption in many hours with clean electricity supply, instead relying on electricity supplied by its local grid which in many cases is not 100% renewable powered at all hours. Figure 14 shows that matching 100% of annual demand with solar or wind provides only partial alignment with a typical demand profile. Figure 15 shows that even companies that match 100% or more of their annual demand with renewables operate on carbon-intensive grids, meaning they rely on fossil fuels when the renewables they have procured are not generating. Additionally, some companies often buy renewable energy and/or RECs in one market to match their electricity consumption in one or several other markets.

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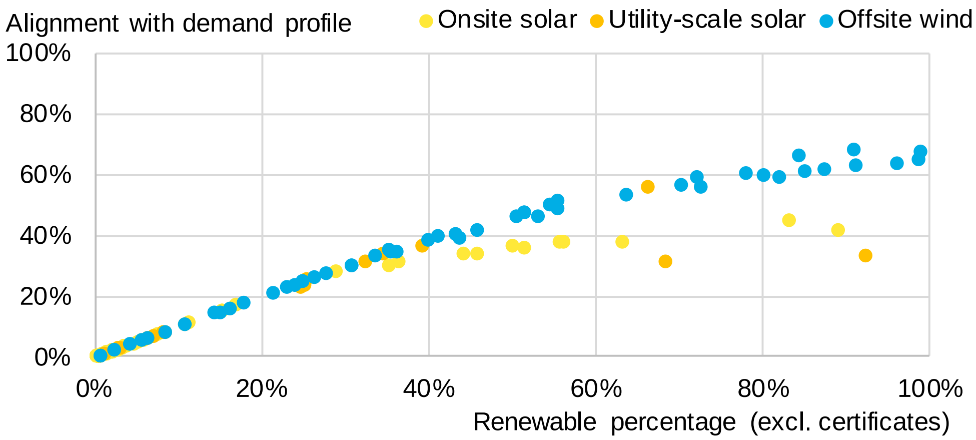
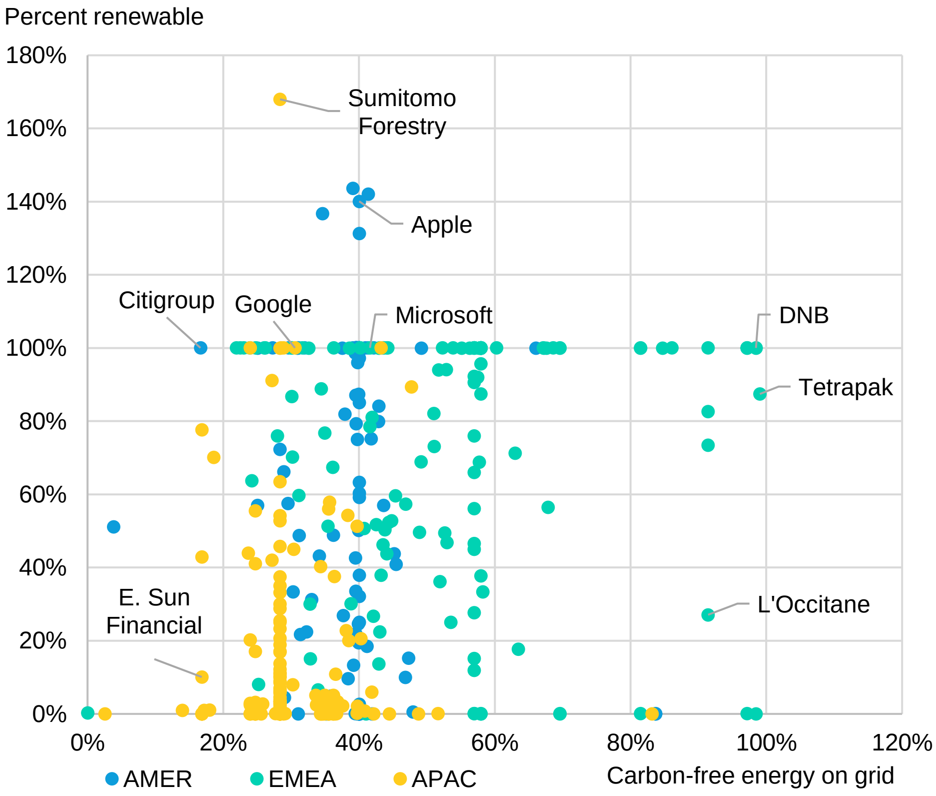
Figure 14: Company renewable percentage and alignment of clean energy purchases with hourly demand profile, colored by dominant renewable technology purchases



Source: BloombergNEF. Note: Chart excludes purchase of unbundled RECs; it shows current renewable power purchases (including projects not yet commissioned) against electricity consumption in latest reporting year; it may include a mix of technologies.

Figure 15: Select RE100 members by renewable percentage and carbon-free energy percentage of major grids they operate on



Source: BloombergNEF. Note: Data is based on publicly disclosed revenue for each company, which is used as a proxy for electricity consumption. For companies to disclose revenue at the regional level, weighted carbon-free energy estimates are made for each.

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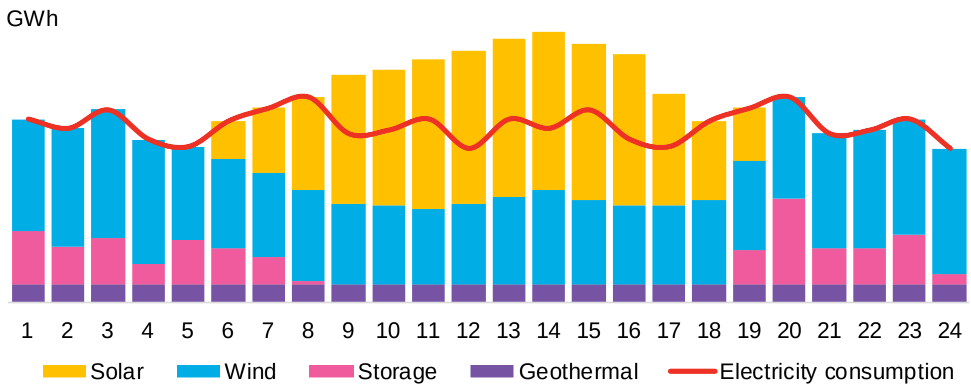
To ensure 100% of emissions associated with their electricity consumption is reduced, companies will need to consider 24/7 hourly and locational matching of their electricity demand with carbon-free electricity supply.

Figure 16: Illustration of a company implementing 24/7 carbon-free energy procurement



Source: BloombergNEF. Note: The numbers in the x-axis denote the hour of the day.

In September 2020, Google became the first major corporation to set a 2030 target for matching all its electricity demand with 24/7 carbon-free supply. Since then, companies such as Microsoft and Iron Mountain, as well as the US federal government have also announced 24/7 carbon-free power procurement targets. Several initiatives have also been launched, most notably the United Nations-backed 24/7 Carbon-free Energy Compact to support governments, corporations and civil society in the pursuit of 24/7 carbon-free electricity procurement. The principles of the United Nations backed 24/7 Carbon-free Energy Compact are:

- Time-matched procurement: 24/7 CFE focuses on matching each hour of electricity consumption with carbon-free electricity generation. Hourly matching helps connect clean energy purchasing to underlying electricity consumption.
- Local procurement: 24/7 CFE means purchasing clean energy on the local/regional electricity grids where electricity consumption occurs. This is the only way to drive the electricity-related emissions that a consumer is directly responsible for to zero.
- Technology-inclusive: 24/7 CFE recognizes the need to create zero carbon electricity systems as fast as possible, and that all carbon-free energy technologies can play a role in creating this future.
- Enable New Generation: 24/7 CFE focuses on enabling new clean electricity generation, in order to support the rapid decarbonization of electricity systems.
- Maximize System Impact: 24/7 CFE focuses attention on maximizing emissions reductions and solving for the dirtiest hours of electricity consumption.

In September 2024, Climate Group launched the ‘24/7 Carbon-Free Coalition’, a pilot campaign to enable commitments and measurable performance by companies towards 24/7 CFE. The campaign calls on ambitious business leaders to take action by committing to measure and match their electricity with defined zero-carbon sources each hour, every day, from the same local grid where they consume power.

Companies pursuing 24/7 CFE would not only benefit themselves by lowering their own Scope 2 emissions, they could also enable their host countries to decarbonize their power systems in an orderly least-cost manner. Decarbonization of the power sector requires an immediate

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acceleration of investment in deployment of mature renewable technologies such as solar and wind along with grid expansion. At the same time, more investment is needed to scale and bring down the costs of dispatchable clean energy such as geothermal as well as energy storage technologies such as batteries, and pumped hydro. Corporations pursuing 24/7 CFE procurement can bring additional resources to complement incumbent power utilities, independent power producers and grid operators to support the orderly transition of the power sector.

Table 2: Benefits of enabling 24/7 carbon-free energy procurement

Benefits for corporate electricity buyers	Benefits for the local power system and society-at-large
• Leads to greater emission reduction from buyer's electricity consumption • Reduces exposure to electricity price volatility • Initially in some markets, 24/7 CFE procurement may cost more than annual matching of demand with renewable supply, however the initial premium will dissipate over time • Reduces corporation's climate risk exposure	• Provides additional funding for accelerating deployment of mature clean energy technologies and grid expansion • Leads to greater system-level emissions reduction than annual clean electricity procurement • Enables orderly retirement of existing thermal power plants and/or "brown to green" transition • Provides additional funding for commercialization of nascent technologies such as long-duration energy storage • Encourages more companies to locate their operations in regions conducive to 24/7 CFE • Incentivizes development of clean energy generation in areas where, and at times when value to the electricity system is greatest • Lowers the burden on residential electricity consumers in funding power system decarbonization

Source: BloombergNEF summarizing findings of the following reports: System-level impacts of voluntary carbon-free electricity procurement strategies; 24/7 Carbon-Free Electricity Transition Tariffs: A Regulatory Tool for Accelerating Decarbonization; The value of space-time load-shifting flexibility for 24/7 carbon-free electricity procurement; Advancing Decarbonisation through Clean Electricity Procurement.

24/7 CFE would also enable timely coordination between corporate electricity consumers, renewable IPPs, grid operators and regulators leading to lower power system decarbonization costs. Companies pursuing 24/7 CFE will be attracted to locate in countries that provide opportunities for 24/7 CFE procurement.

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Section 3. Current state of selected APAC markets

This chapter examines the current state of energy transition as well as clean power procurement in the 11 selected APAC markets. It also explores the long-term targets of these markets.

3.1. State of energy transition

Emissions by the 11 markets covered in this report doubled over the last three decades, driven by the energy sector. Among these markets, Vietnam has experienced the highest emission growth rate, while Japan is the only one whose emissions have already declined below 1990 levels. South Korea is the only other market to have already reached peak emissions back in 2018.

Figure 17: Selected APAC markets' greenhouse gas emissions, by market

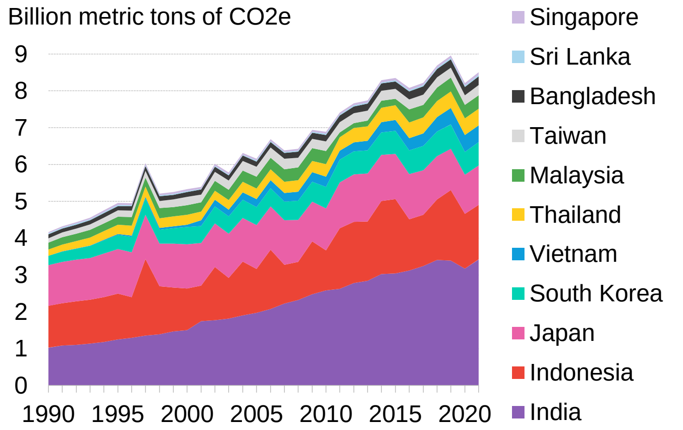


Figure 18: Selected APAC markets' greenhouse gas emissions, by source

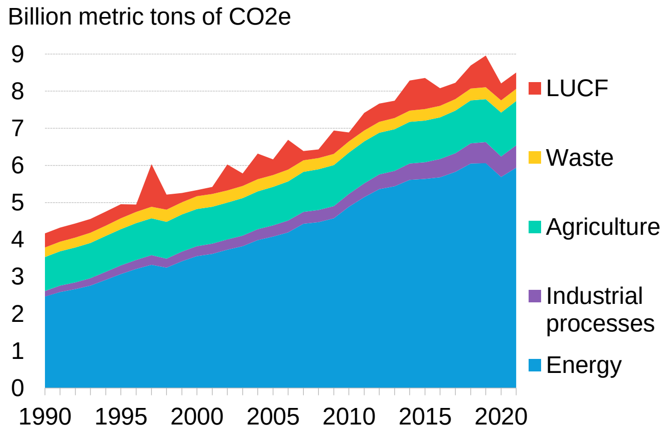
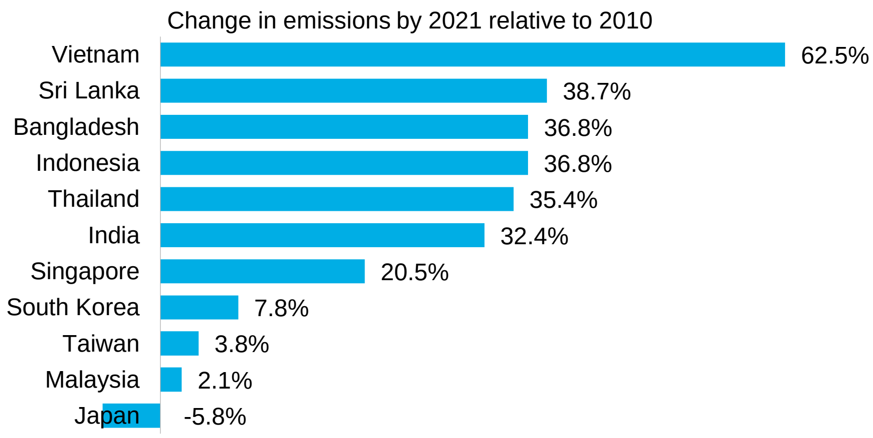


Figure 19: Change in greenhouse gas emissions in the selected APAC markets



Source: BloombergNEF based on data from Climate Watch and Taiwan Climate Change Administration. Note: Includes all greenhouse gas emissions. CO2e is carbon dioxide equivalent; LUCF is land-use change and forestry.

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Table 3: Selected APAC markets' relevant targets

Market	Nationally determined contributions 2030 emission target	COP28 global renewables pledge signatory	Renewables 2030 target	Long-term target
Bangladesh	Unconditional target of 5% emission reduction relative to BAU; conditional target of 10% emission reduction relative to BAU	Yes	15% of electricity annual supply	No formal target yet
India	Reduce emission intensity (GDP based) by 45% by 2030 relative to 2005 level	No, however, India's 2030 non-fossil fuel power capacity target puts it close	50% of power capacity from non-fossil fuel sources	Net zero by 2070
Indonesia	Unconditional target of 31.89% emission reduction relative to BAU, conditional target of 43.2% emission reduction relative to BAU	No	28.8GW under PLN-RUPTL; 62.4GW under JETP-CIPP	Aims to achieve net-zero emissions by or before 2060
Japan	46% emission reduction in fiscal year 2030 relative to fiscal year 2013	Yes	36~38% of annual generation*	Net zero by 2050 (legislated target)
Malaysia	Reduce emission intensity (GDP based) by 45% by 2030 relative to 2005 level	Yes	31% of power capacity (7GW of solar)	Net zero by as early as 2050
Singapore	Absolute emission cap of 60MtCO2eq in 2030	Yes	At least 2GW of solar*	Net zero by 2050
South Korea	40% emission reduction relative to 2018 level	Yes	21.6% of annual generation*	Net zero by 2050 (legislated target)
Sri Lanka	Unconditional target of 4% emission reduction relative to BAU; conditional target of 10.5% emission reduction relative to BAU	No	70% of annual generation	Carbon neutrality by 2050 in electricity generation
Taiwan	23-25% emission reduction relative to 2005	–	25% of annual generation	Net zero by 2050 (legislated target)
Thailand	Unconditional target of 30% emission reduction relative to BAU; conditional target of 40% emission reduction relative to BAU	Yes	17.38GW (27.7% of total capacity) under the revised PDP 2018.	Targets to achieve carbon neutrality by 2050 and net-zero emissions by 2065
Vietnam	Unconditional target of 15.8% emission reduction relative to BAU; conditional target of 43.5% relative to BAU	No	74.4GW (51% of capacity) under the implementation plan for Power Development Plan VIII	Net zero by 2050

Source: BloombergNEF, based on public sources available as of September 2024. Note: BAU is business as usual; MtCO2eq is million metric tons of carbon dioxide equivalent. Green means target is aligned with the Paris Agreement goal; yellow means target may leave gap to fulfilling the Paris Agreement goal; red means target is not aligned with the Paris Agreement goal. Singapore's domestic renewable target is complemented by plans for clean power imports; Japan and South Korea's renewable targets are complemented by nuclear power targets.

Among these markets, only Japan, Singapore, South Korea, Taiwan and Thailand have set 2030 emissions reduction targets that would correspond to an absolute reduction relative to current levels. The remaining markets have submitted nationally determined contributions to the United Nations Framework Convention on Climate Change that would leave room for continued rise in their emissions, putting the Paris Agreement goal at risk. Six of these markets – Japan, Malaysia, Singapore, South Korea, Taiwan, and Vietnam – have set net-zero by 2050 targets. Bangladesh has not yet set a long-term decarbonization target, while the rest are targeting timelines beyond 2050, putting the Paris Agreement goal at risk.

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Figure 20: Installed renewables capacity in selected APAC markets, by market

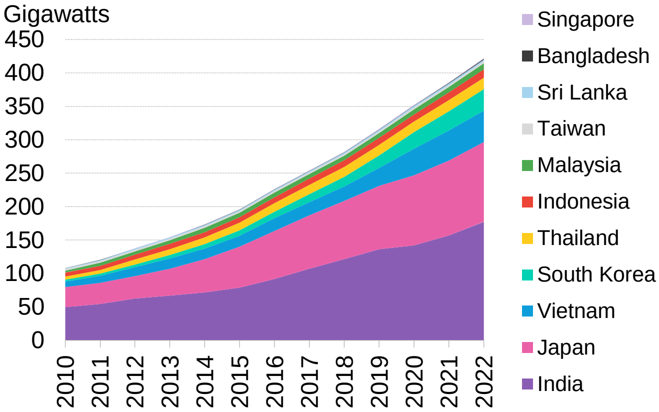
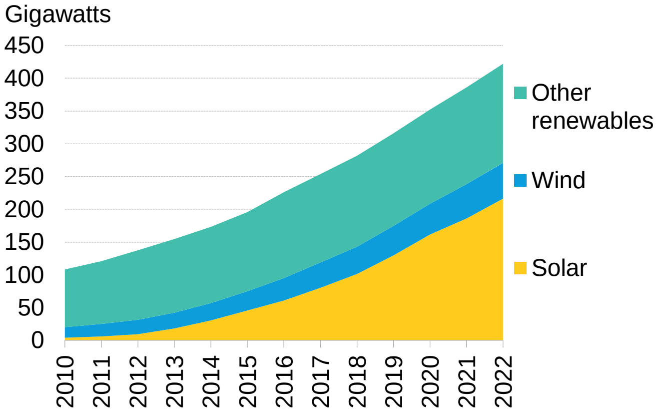


Figure 21: Installed renewables capacity in selected APAC markets, by technology



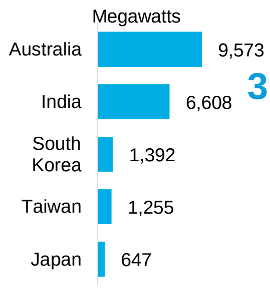
Source: BloombergNEF based on public sources

None of the 11 analyzed APAC markets are on track to triple RE by 2030; accelerating the deployment of mature RE and concurrently expanding access for corporate procurement is critical to close the gap

In 2023, six of these markets – Bangladesh, Japan, Malaysia, Singapore, South Korea and Thailand – signed onto the COP28 Global Renewables and Energy Efficiency Pledge which calls for tripling global renewables capacity by 2030 to least 11,000 GW, and doubling the global average annual rate of energy efficiency improvements from around 2% to over 4% every year until 2030. The combined 2030 renewable targets (Table 3) of these 11 markets along with the recent pace of their renewable capacity additions suggest they would fall short of the tripling renewable growth target. The combined renewable capacity (Figure 20) of these markets doubled between 2014 and 2022, led by rapid growth of solar and to a lesser extent wind (Figure 21). The combined capacity of other renewables such as hydro and geothermal across these markets has barely changed over the last 12 years. The lack of progress by geothermal and hydro reflects the combination of lack of progress on technology cost reduction and limited targeted policies for deployment of these technologies.

For these markets to contribute to the global tripling renewable capacity goal, they will have to continue the pace of solar additions, while accelerating deployment of wind and other renewable technologies such as geothermal and hydro. To accelerate renewable capacity expansion in the region, enabling more clean power procurement options including 24/7 CFE will be critical.

Figure 22: Cumulative disclosed clean PPA volume in top five APAC markets



Source: BloombergNEF. Note: Based on publicly disclosed data through 1H 2024. Excludes onsite PPAs and non-disclosed estimates included in Figure 11.

3.2. State of corporate clean power procurement

Globally, corporations announced 211 clean PPAs in the first half of 2024 (Figure 12), totaling 22.1GW, 36% higher than the first half of 2023. Global volumes are on track for their eighth year of growth in a row, with firms having collectively signed 220GW of deals since 2008. The market has grown 43% annually, on average, since 2015, as companies play their part in driving the energy transition.

Activity in APAC hit a record 9.7GW of PPAs in 2023 (Figure 11), up 26% from the previous year. Australia and India are the largest clean PPA markets in APAC (Figure 22), while growth in Northeast Asia is accelerating. The first half of 2024 has seen the momentum continue, with 30 PPAs (4.7GW) announced through June, exceeding the 23 contracts signed at the same point in 2023. The average deal size is also growing, sitting at 120MW, up from 80MW through the whole of 2023 and 56MW in 2022. Australia made up the bulk of activity in the region in 1H 2024, at

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2.5GW. South Korea (339MW) and Japan (249MW) also had big starts to the year, relative to activity in previous years. Still, APAC remains the smallest region for clean power procurement despite leading the world in electricity consumption. APAC's smaller clean power procurement market size relative to Europe and North America is a reflection of the region lagging behind on power market reforms necessary to enable clean power procurement options. This is set to change in the coming years due to rising demand for clean power procurement across APAC.

Figure 23: RE100 renewables supply and electricity demand

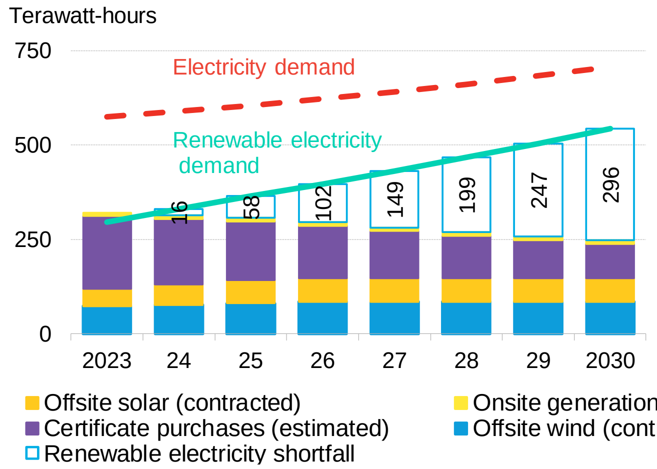
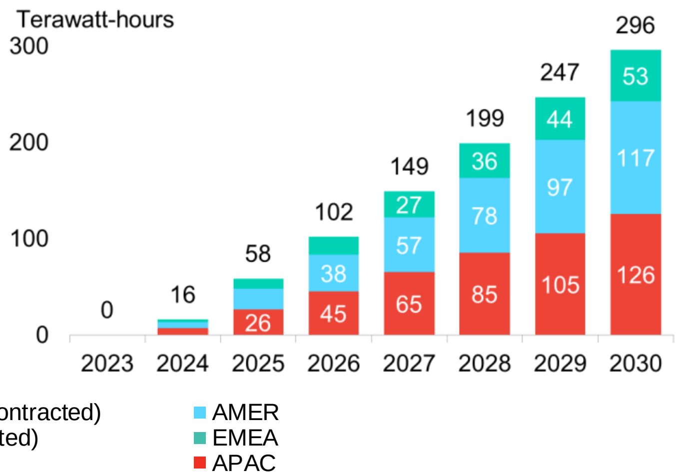


Figure 24: Incremental clean electricity demand for the RE100, by region



Source: BloombergNEF, The Climate Group, company sustainability reports. Note: AMER refers to the US, Canada and Latin America; EMEA is Europe, the Middle East and Africa; APAC is Asia Pacific. Certificate purchases are assumed to step down 10% each year. Onsite generation and contracted wind and solar purchases remain flat through 2030. Regional breakdown of shortfall is estimated based on each company's share of revenue by region. Electricity demand and renewables electricity demand don't intersect in 2030, as some companies have targets extending out past 2030.

As of June 2024, annual electricity consumption of the 463 members in the RE100 is 574TWh based on their latest reported data. These RE100 members met an estimated 321 terawatt-hours, or 56%, of their electricity consumption with clean energy purchased in 2023, up from 256TWh in 2022. We estimate current RE100 members will need an additional 296TWh of clean electricity in 2030 to meet their 100% clean energy goals, which could catalyze 99GW of renewables build. Asia Pacific is projected to become the largest region of future clean electricity demand, accounting for 43% of consumption between 2024 and 2030.

61% of new RE100 members since 2020 are from Asia Pacific. The growth of corporate demand for clean energy in APAC is being driven by both these local companies as well as multinational corporations with significant operations in the region.

Among the 11 APAC markets under focus in this report, India has the largest and most developed clean PPA market, thanks to both growing availability of renewable power, and increased corporate clean power procurement options in some states. Japan, South Korea and Taiwan are also experiencing growing clean PPA markets, partly due to recent power market reforms enabling more clean power procurement options. Among the three Northeast Asian markets, Japan has seen the biggest improvement in both increased renewable supply as well as clean power procurement options. Vietnam approved the regulation for direct power purchase agreements (DPPA) on July 3, 2024, allowing large users to buy electricity directly from renewable generators via private and national grids. Implementation details of the DPPA such as

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wheeling charges are still under discussion. Existing policies and market regulations across these 11 markets continue to pose challenges which restrict access to affordable clean energy and constrain expansion of renewable energy supply. The electricity retail market in the majority of these markets is still not fully open to competition thus limiting procurement options for corporations. Markets such as South Korea and Malaysia, have imposed high wheeling charges for corporate PPAs; Vietnam's proposed wheeling charge may also undermine the economics of corporate PPAs. Local content requirements for renewable projects in markets such as Taiwan and South Korea push up the cost of renewable power generation. Overall, the supply of renewable power in these markets remains limited.

Table 4: Corporate clean power procurement options for selected APAC markets covered in this report

Market	Retail choice?	Renewable energy certificates available*?	Onsite PPA?	Offsite PPA?
Bangladesh	No	Yes	Yes	No
India	State-dependent	Yes	Yes	Yes
Indonesia	No	Yes	Yes	No
Japan	Yes	Yes	Yes	Yes
Malaysia	Green option offered by sole electricity retailer	Yes	Yes	Yes
Singapore	Yes	Yes	Yes	Yes
South Korea	Green option offered by sole electricity retailer	Yes	Yes	Yes
Sri Lanka	No	Yes	No	No
Taiwan	No	Yes	Yes	Yes
Thailand	Green tariff under discussion	Yes	Yes	In progress
Vietnam	No	Yes	Yes	Yes**

*Source: BloombergNEF. Note: *The renewable energy certificates include issuance under voluntary standards such as International Renewable Energy Certificates. **Vietnam has approved the direct power purchase agreement scheme; however, it is still in the process of implementation.*

Vietnam and Sri Lanka lead among these markets in share of renewables in annual electricity generation. However, hydro output in both markets has experienced significant fluctuations due to droughts. Japan is the only other market to have reached over 20% renewable share of annual electricity generation. South Korea, Malaysia, Taiwan and Thailand have shown significant growth in renewables share of annual electricity generation over the last decade, albeit from a very low base. India has experienced the largest absolute growth in renewable electricity generation among these markets over the last 12 years. However, it has also experienced rapid electricity demand growth. Indonesia has made limited progress, due to growth of electricity demand far outpacing the tepid renewable supply growth. Similarly, Bangladesh has made relatively limited progress. Singapore has experienced significant growth in rooftop solar, however the country's land constraints limit contributions from domestic renewable resources.

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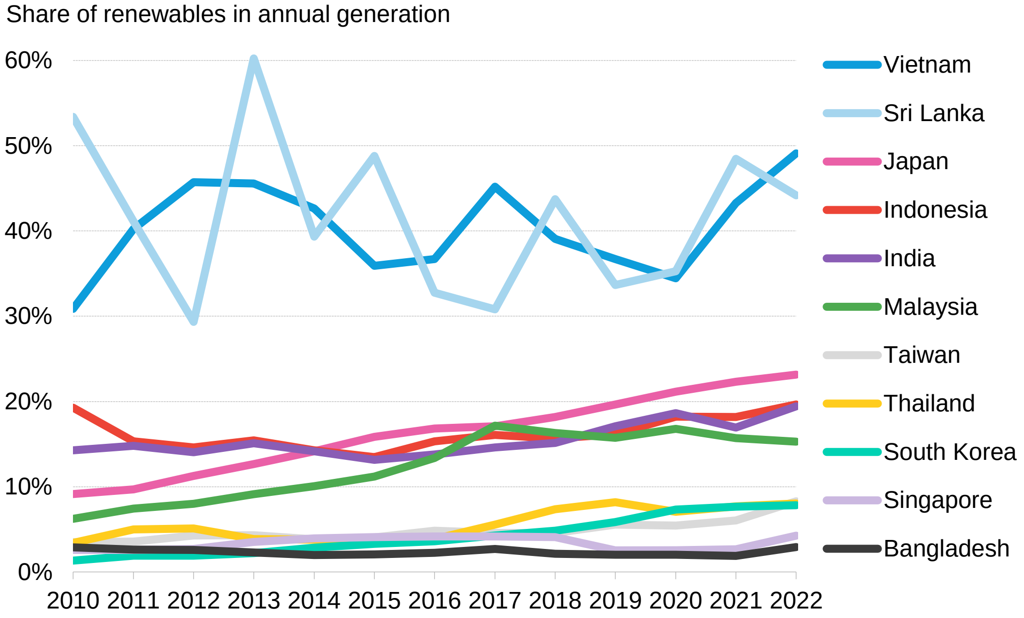
Figure 25: Renewables' share of annual generation in selected APAC markets



Source: BloombergNEF based on public sources. Note: Renewables include hydro.

Despite the challenges facing clean power procurement in these markets, 17 local companies (Table 4) have signed onto the UN-backed 24/7 Carbon-free Energy Compact. Four of these are large incumbent electricity generators:

1. Greenko is one of the leading renewable IPPs in India; it already has the ability to provide corporate customers with 24/7 carbon-free electricity thanks to its portfolio of solar, wind and energy storage via batteries and pumped hydro.
2. Jera, formed by Tokyo Electric Power Company and Chubu Electric Power Company, currently owns the largest fleet of thermal power plants in Japan. It also has set renewable expansion targets both at home and abroad.
3. Korea Hydro and Nuclear Power (KHNP), the subsidiary of majority state-owned Korea Electric Power Company, owns all of Korea's nuclear power plants as well as a majority of hydro assets.
4. State-owned Electricity Generating Authority of Thailand is the country's largest power plant operator. It is also the country's transmission system owner operator, and acts as the single buyer for electricity generated by IPPs.

While EGAT, Jera and KHNP are not yet ready to supply 24/7 CFE – unlike Greenko – as leading local players, their support bodes well for the future of 24/7 CFE in these markets.

It is also important to note that out of the six founding partners of Climate Group's 24/7 Carbon-Free Coalition – Google, AstraZeneca, Iron Mountain Data Centers, Shree Cement, AirTrunk and Vodafone (UK) – two are APAC-headquartered companies: AirTrunk (headquartered in Australia) and Shree Cement (headquartered in India). And the rest of the founding partners such as Google and AstraZeneca have significant operations in the region.

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Table 5: 24/7 Carbon-free Energy Compact signatories based in markets covered by this report

Headquarters	Companies
India	greenko, TERANO
Japan	booost technologies, D-Sharing, ENECHANGE, JERA, 北九州市 CITY OF KITAKYUSHU, MITSUBISHI ELECTRIC, REPO, UPDATER, INC.
Singapore	Envision digital, W3RE Web3 Renewables
South Korea	ENlighten, KEI Consulting Delivering Effective Solutions, KHNP
Thailand	EGAT Power for Thai Happiness
Taiwan	KINGWHALE

Source: 24/7 Carbon-Free Energy Compact. Note: Data as of October 28, 2024.

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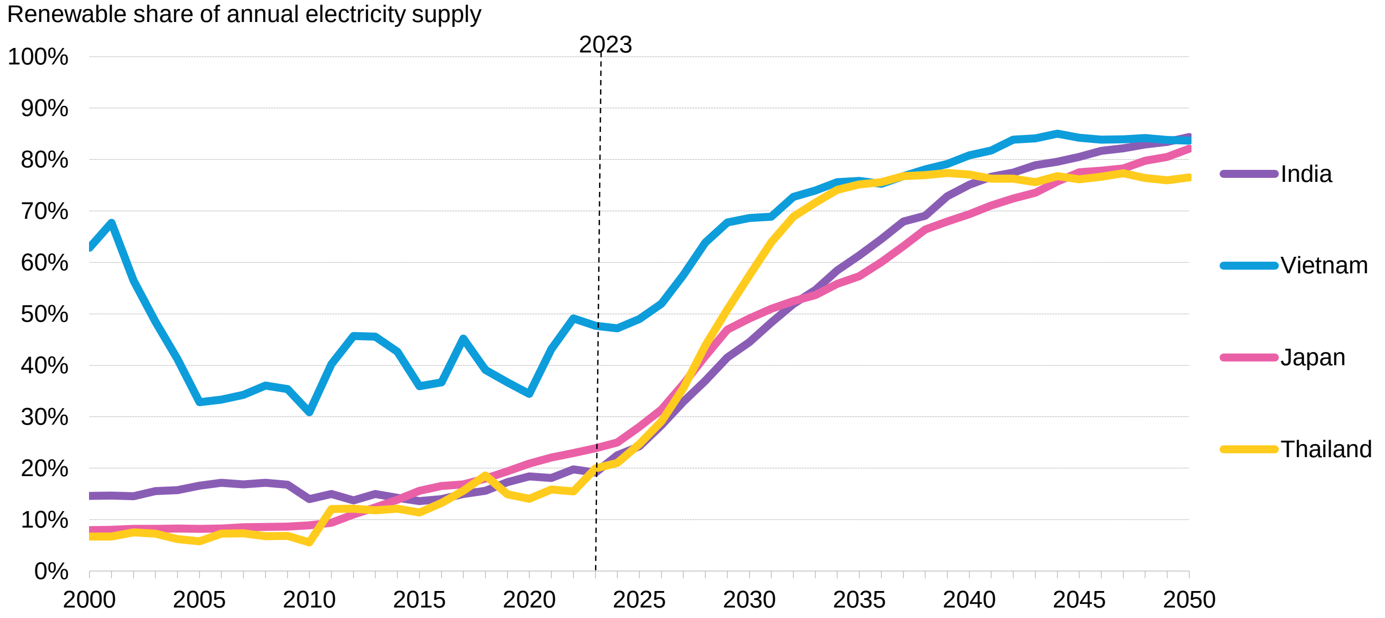
Section 4. 24/7 CFE technology pathways in APAC

This chapter utilizes the NEO NZS to lay out the least-cost technology pathway towards enabling 24/7 CFE in India, Japan, Thailand, and Vietnam. The technology pathways discussed here would enable these markets to meet over 70% of their annual electricity demand with renewables alone by 2050, while enabling 100% 24/7 CFE.

Figure 26: Renewables' share of annual electricity supply in selected APAC markets – historical and Net Zero Scenario



Source: BloombergNEF New Energy Outlook 2024

The NEO NZS is based on least-cost modeling of local renewable resource potential as well as energy storage and low-carbon dispatchable technologies. As a result, in all these markets, solar and wind dominate the power mix in 2050. As a share of annual generation in 2050, the combination of solar and wind provide at the low end 60% of Thailand's electricity and at the high end 81% of India's electricity. In the case of India, Thailand and Vietnam, utility-scale solar will be the top supplier of electricity in 2050. In Japan, offshore wind will have the top spot.

To address hourly and seasonal variability of solar and wind, each market will need a complementary diverse mix of other renewable resources as well as energy storage. Any shortfalls will need to be addressed by low-carbon dispatchable power technologies such as nuclear, thermal power plants equipped with carbon capture and storage and/or hydrogen/ammonia-fueled turbines. Alternatively, the need for low-carbon dispatchable power can be reduced via expansion of interconnections with neighboring countries to enable clean power trading. East-west grid connections in particular can help with managing hourly variability of solar and wind, while north-south grid connections can help with managing seasonal variability. The NEO NZS does not consider the building of new international inter-connections beyond those already in place or under construction.

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The following sections provide more details on the technology mix relevant to each market. For more information on the NEO modeling methodology, please refer to Appendix A.

Table 6: Technology share of installed capacity by market in 2050 – Net Zero Scenario

Technology		India	Japan	Thailand	Vietnam
Solar	Utility-scale	48.1%	30.4%	43.8%	43.5%
	Small-scale	6.4%	14.2%	6.5%	9.7%
Wind	Onshore	19.0%	14.2%	17.7%	14.0%
	Offshore	0.8%	11.9%	1.2%	3.7%
Other renewables	Bioenergy	0.4%	1.3%	6.0%	0.6%
	Geothermal	0.0%	0.1%	0.1%	0.0%
	Hydro	1.8%	4.0%	1.2%	4.9%
Energy storage	Batteries	10.9%	5.9%	8.7%	12.9%
	Pumped hydro	2.3%	3.7%	0.2%	0.4%
Low-carbon dispatchable power		9.0%	11.4%	13.1%	8.6%

Source: BloombergNEF New Energy Outlook 2024

Table 7: Technology share of annual generation by market in 2050 – Net Zero Scenario

Technology		India	Japan	Thailand	Vietnam
Solar	Utility-scale	41.0%	16.3%	28.6%	32.8%
	Small-scale	5.5%	7.6%	4.2%	7.4%
Wind	Onshore	32.4%	21.5%	24.8%	22.5%
	Offshore	2.1%	23.8%	2.3%	8.2%
Other renewables	Bioenergy	0.3%	4.9%	15.0%	1.6%
	Geothermal	0.0%	0.5%	0.2%	0.1%
	Hydro	3.1%	7.5%	1.5%	11.1%
Low-carbon dispatchable power		15.5%	17.8%	23.4%	16.2%

Source: BloombergNEF New Energy Outlook 2024

4.1. India

Thermal power plants led by coal supplied 78% of India's 2023 electricity, while renewables accounted for 19%. Under NEO NZS, by adding 377GW of new renewable capacity – 282GW of solar, 75GW of wind – and 112GW of energy storage over the period of 2024-30 (Figure 35), India would raise renewables' annual share of electricity supply to 45% by 2030, while meeting growth in electricity demand. Continued expansion of renewables and energy storage capacity enables renewables alone to supply 75% of annual generation in 2040 and 84% in 2050.

The share of hourly electricity demand met by renewables widely varies due to both demand-side changes such as higher air conditioning demand during hotter months as well as daytime over nighttime, as well as supply-side hourly and seasonal changes e.g., higher solar generation around noon as well as during dry clear days. In 2023 (Figure 31), the share of hourly demand met by renewables in India ranged from as low as 7% to as high as 48%.

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Figure 27: India's annual electricity generation by technology – Net Zero Scenario

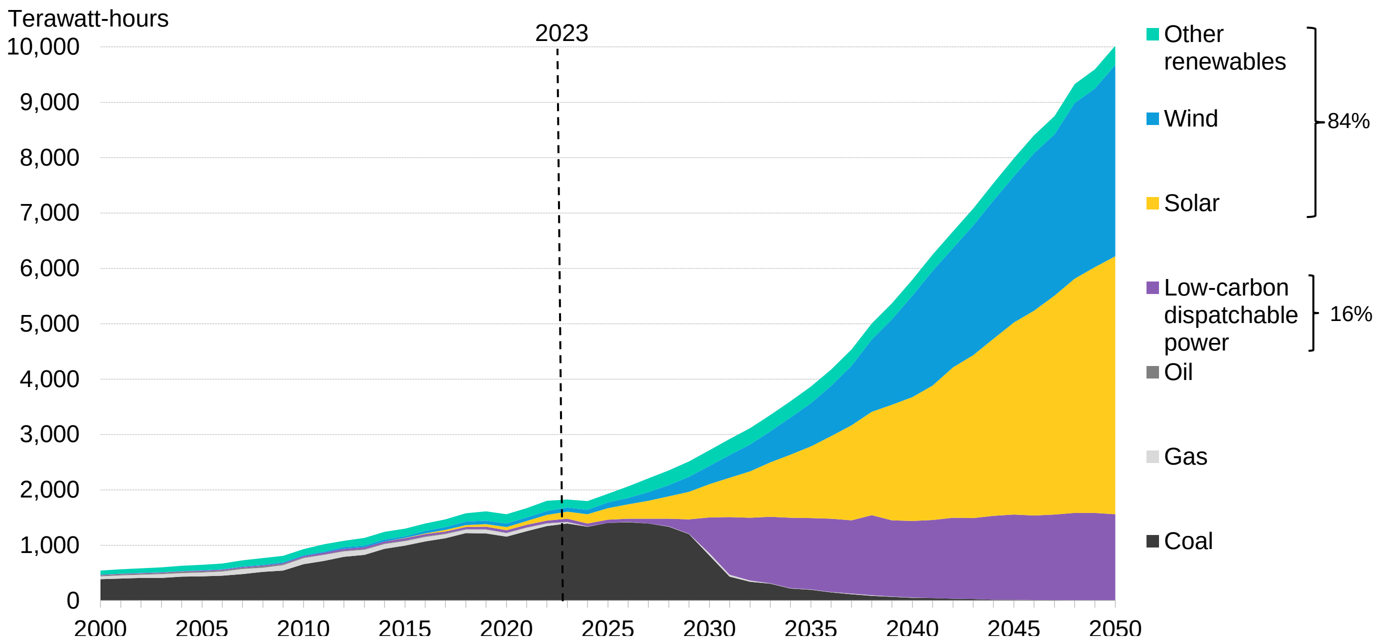
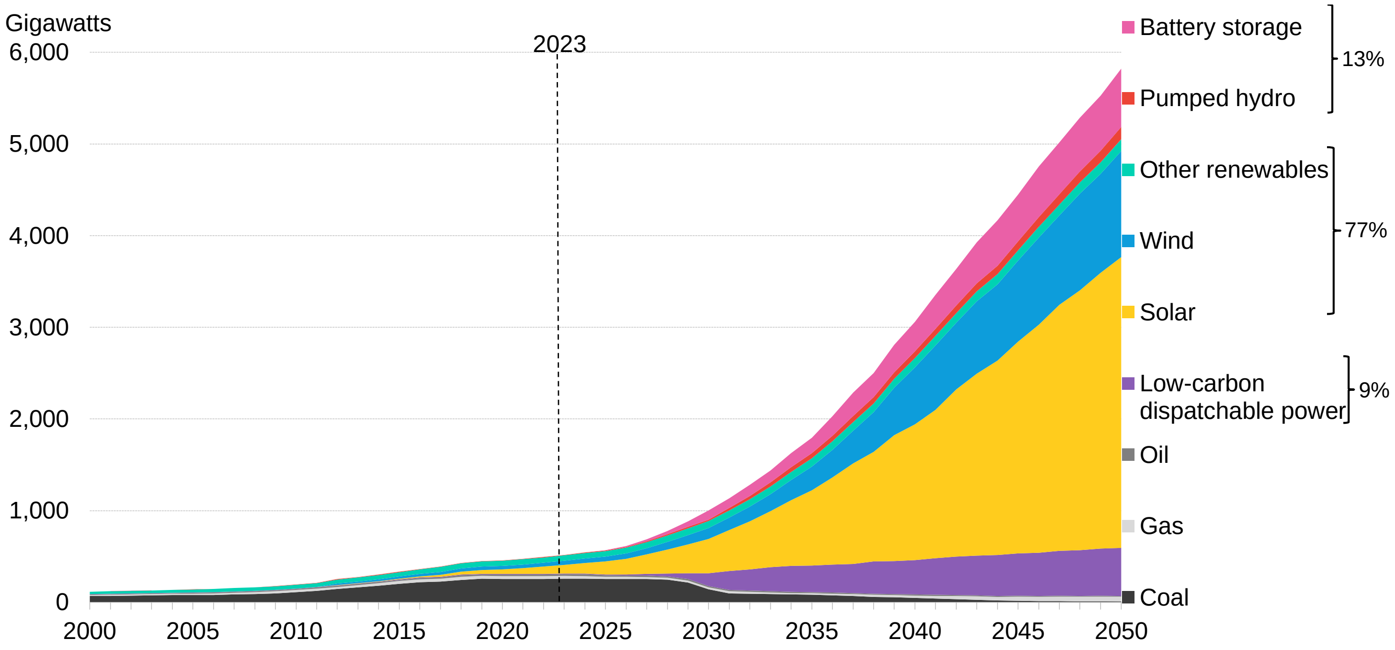


Figure 28: India's power capacity – Net Zero Scenario



Source: BloombergNEF New Energy Outlook 2024. Note: Percentages indicate share of total in 2050.

Under NEO NZS, the range of hourly demand met by renewables in India steadily improves to reach an average of 84% by 2050. By the early 2030s, the majority of hourly electricity demand is already matched with renewables. As a result, many corporations would be able to achieve significant 24/7 CFE progress by relying on renewables and energy storage capacity. For energy storage, while lithium-ion batteries will be helpful for shorter durations (4hrs or less), long-duration energy storage technologies such as pumped hydro will be critical for overcoming challenges during days of low solar and wind generation.

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Figure 29: Range of hourly demand met by renewables in India's grid, 2023

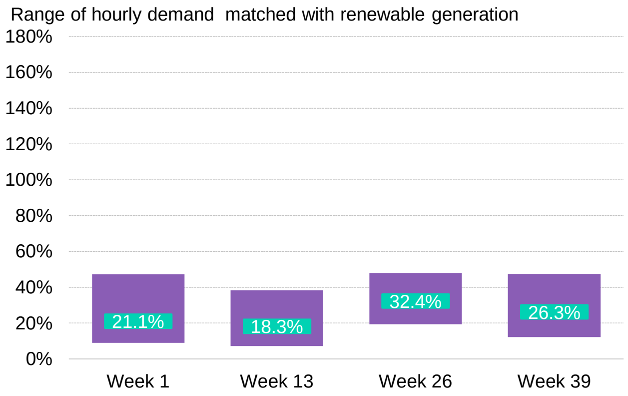


Figure 30: Range of hourly demand met by renewables in India's grid, 2030 – Net Zero Scenario

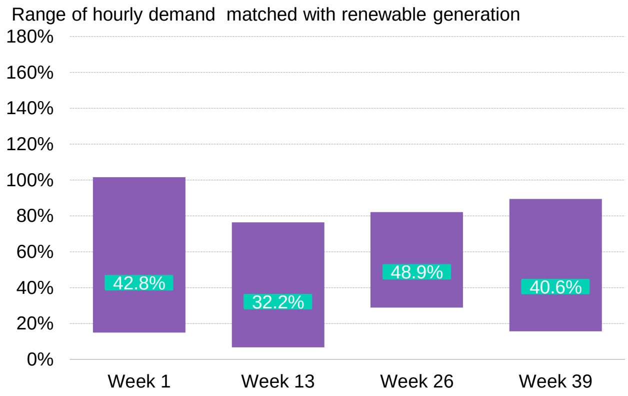


Figure 31: Range of hourly demand met by renewables in India's grid, 2040 – Net Zero Scenario

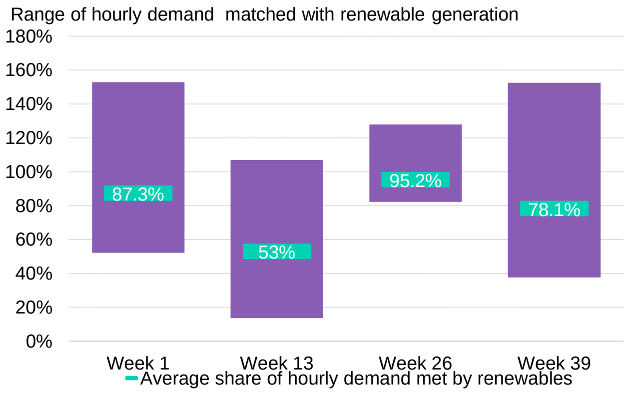
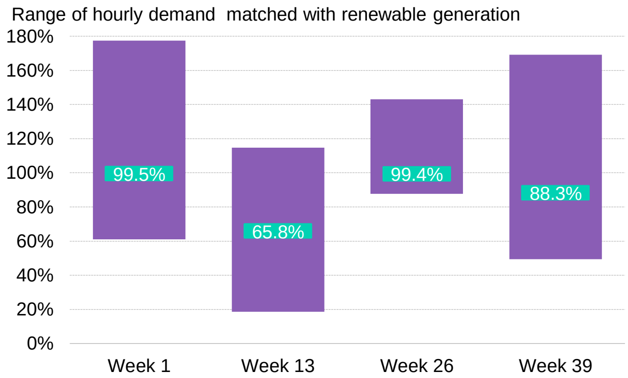


Figure 32: Range of hourly demand met by renewables in India's grid, 2050 – Net Zero Scenario



Source: BloombergNEF. Note: Calculation assumes demand is being met by all generators supplying the grid in that hour. Volume of renewable electricity shifted by energy storage is reflected in the calculation. Each bar represents one week of hourly supply-demand data. Four bars are shown to illustrate seasonal changes.

As discussed earlier, for a corporation to achieve 24/7 CFE procurement, it will need a mix of renewables complemented with energy storage and low-carbon dispatchable power to ensure each hour of demand is met with clean electricity supply. The same principle applies to decarbonization of a country's power system. In the case of India, utility-scale solar and onshore wind will become the dominant sources of power, accounting for 41% and 32% of electricity generation in 2050, respectively. While rooftop solar only provides 5% of annual 2050 electricity generation under the NZS, it still plays a critical role as an onsite source of clean electricity closest to demand. Thanks to its high onshore domestic renewable potential, the need to rely on offshore wind in India is more limited. Still, the round-the-clock performance of offshore wind will benefit corporate customers in coastal regions.

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Figure 33: Hourly power supply and demand in a summer week in India, 2023

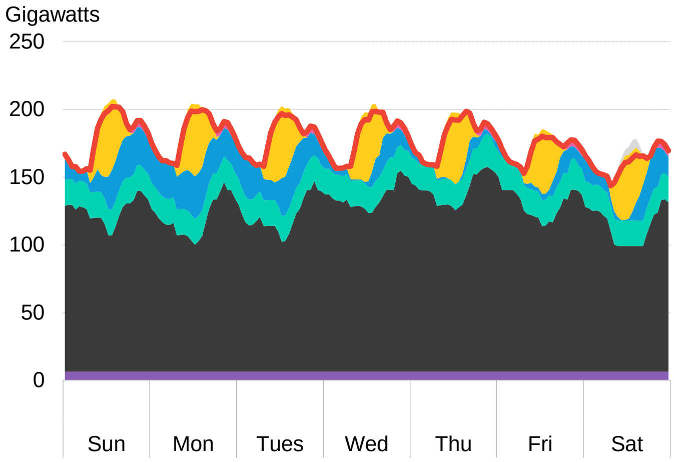
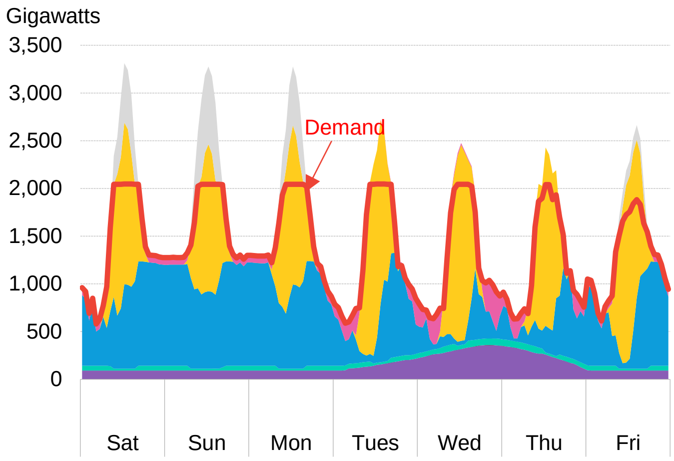


Figure 34: Hourly power supply and demand in a summer week in India, 2050 NZS



Source: BloombergNEF New Energy Outlook 2024. Note: Results shown for the 21st week of the year. For energy storage only discharge periods are shown (charging of energy storage is accounted for). Other RE refers to other renewable energy sources.

To complement solar and wind, India will need to scale up energy storage and low-carbon dispatchable capacity by 20x within this decade from the current low base of 12GW dominated by nuclear power and pumped hydro. Battery-based energy storage systems are the most economic option that can be deployed quickly. Longer term, India will also need more long-duration energy storage options such as pumped hydro.

Figure 35: India's cumulative renewable capacity, Net Zero Scenario

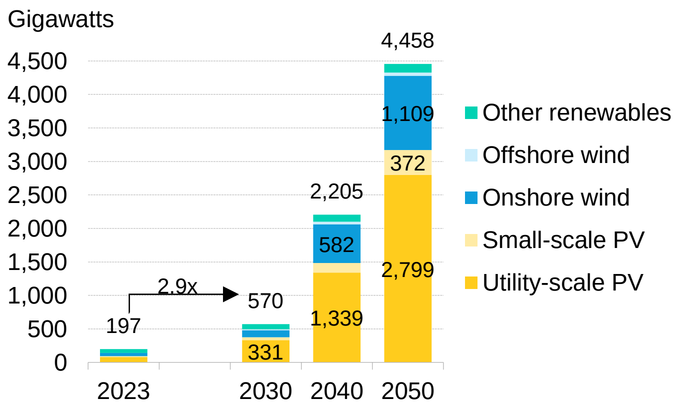
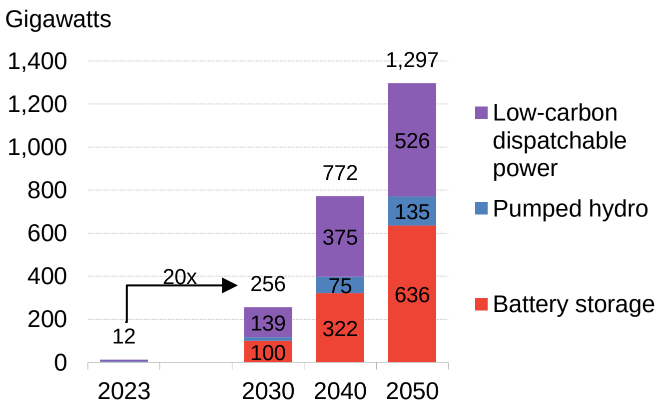


Figure 36: India's cumulative energy storage and low-carbon dispatchable power capacity, Net Zero Scenario



Source: BloombergNEF New Energy Outlook 2024. Note: PV is solar photovoltaic.

Within this decade, India will need $853 billion for clean power capacity expansion and $178 billion for the grid to get its power system on track for decarbonization by 2050. Enabling 24/7 CFE procurement can provide a critical source of funding.

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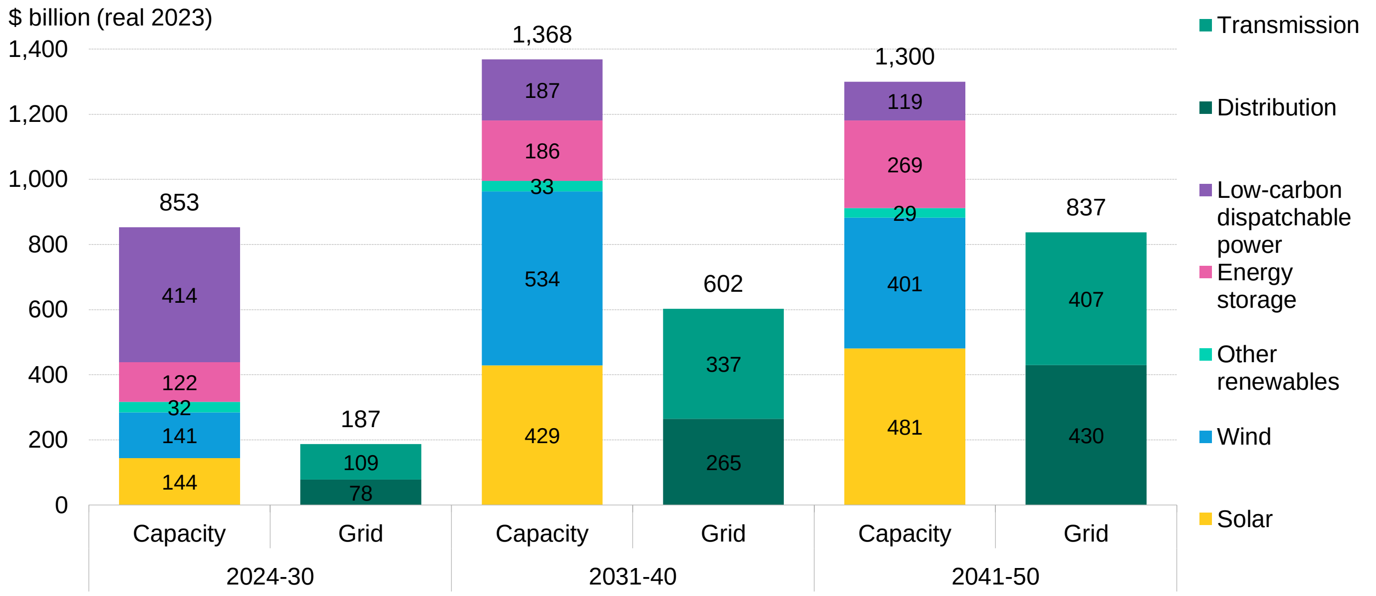
Over the last 10 years, India's clean energy auctions have been very successful in efficiently channeling funding to accelerate deployment of utility-scale solar and onshore wind. In recent years, the introduction of new auction designs requiring delivery of clean electricity in specific hours of the day have led to growth in deployment of a portfolio of solar and wind assets complemented with batteries and pumped hydro. India can continue to evolve its auction design to also enable more corporate investment in low-carbon dispatchable power and the grid.

Figure 37: Investment required for clean power capacity and grid in India, Net Zero Scenario



Source: BloombergNEF New Energy Outlook 2024

4.2. Japan

Thermal power plants supplied 68% of Japan's 2023 electricity, while renewables accounted for 24%. Under NEO NZS, by adding 175GW of new renewable capacity – 131GW of solar, 32GW of wind – and 27GW of energy storage over the period of 2024-30, Japan would raise renewables' annual share of electricity supply to 49% by 2030, while meeting growth in electricity demand. Continued expansion of renewables and energy storage capacity enables renewables alone to supply 69% of annual generation in 2040 and 82% in 2050.

In 2023, the share of hourly demand met by renewables in Japan ranged from as low as 4% to as high as 58%. Under NEO NZS, the range of hourly demand met by renewables in Japan steadily improves to an average of 82% by 2050. By the mid-2030s, the majority of hourly electricity demand is already matched with renewables. This would allow many corporations to make significant 24/7 CFE progress, although there will be significant geographic variance due to differences in local demand and renewable resource potential.

Japan faces a unique challenge as the only country with two different power system frequencies (50 hertz in eastern Japan; 60 hertz in western Japan). The limited frequency converter capacity – currently at 1.2GW set to increase to 3GW by 2027 – limits the amount of power that can be physically transferred between the eastern and western power systems. To account for this issue, we have modeled the two systems separately.

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Figure 38: Japan's annual electricity generation by technology – Net Zero Scenario

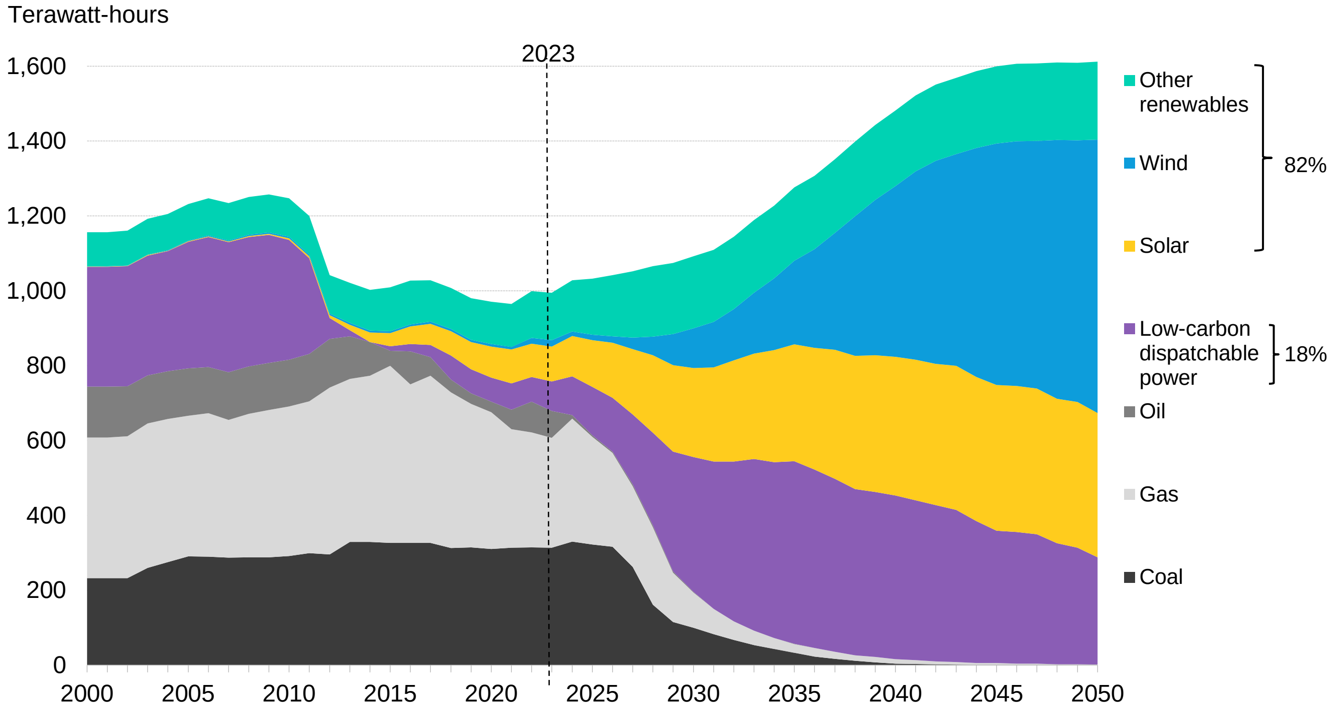
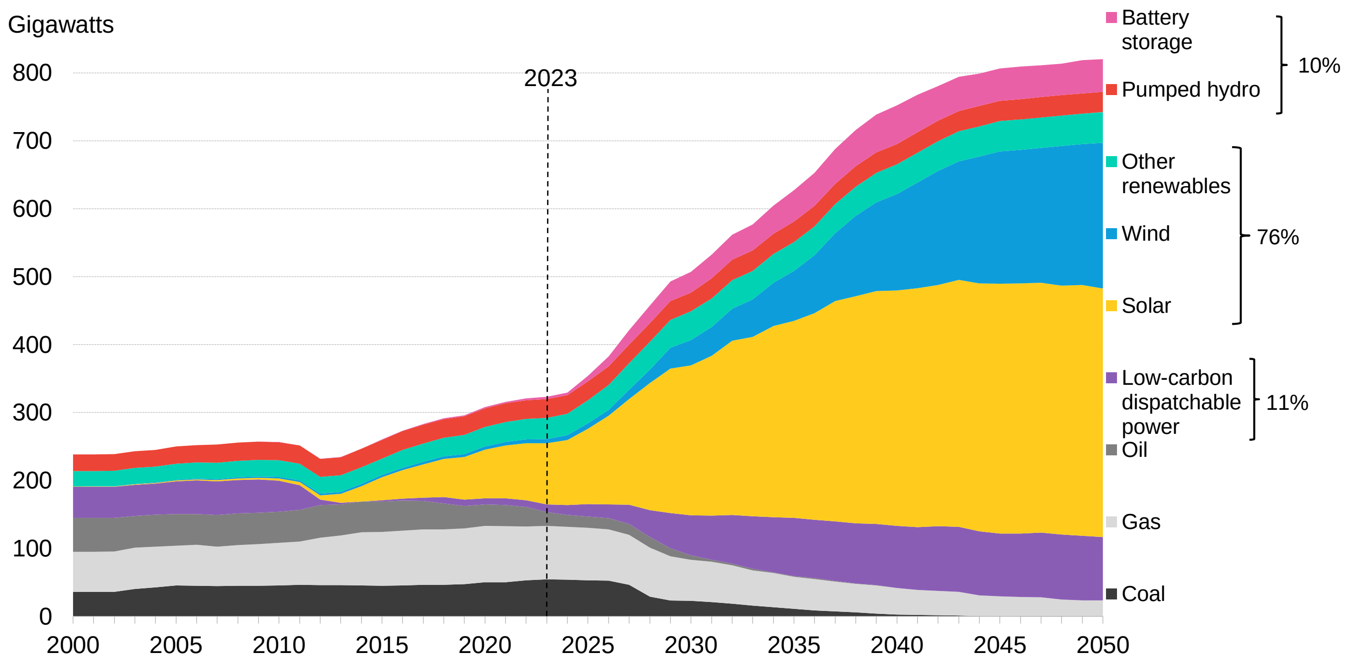


Figure 39: Japan's power capacity – Net Zero Scenario



Source: BloombergNEF New Energy Outlook 2024. Note: Percentages indicate share of total in 2050.

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Figure 40: Range of hourly demand met by renewables in Japan's Eastern grid, 2023

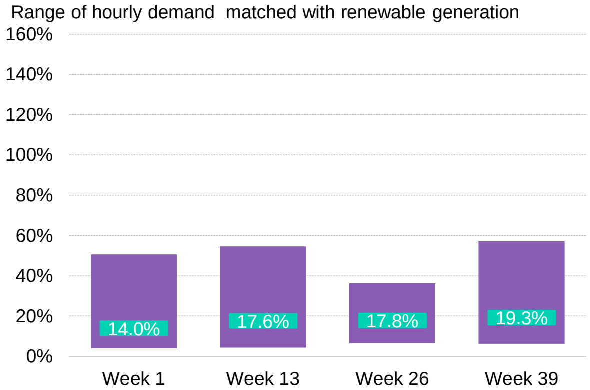


Figure 41: Range of hourly demand met by renewables in Japan's Eastern grid, 2030 – Net Zero Scenario

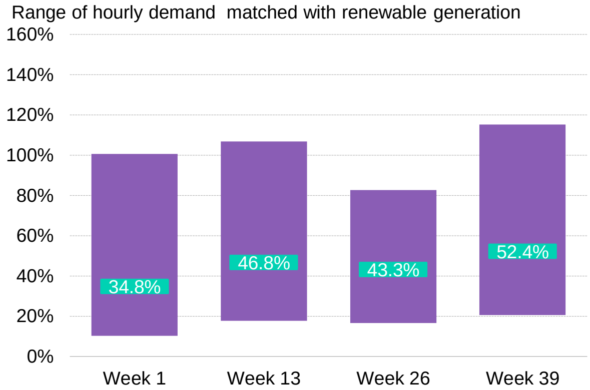


Figure 42: Range of hourly demand met by renewables in Japan's Eastern grid, 2040 – Net Zero Scenario

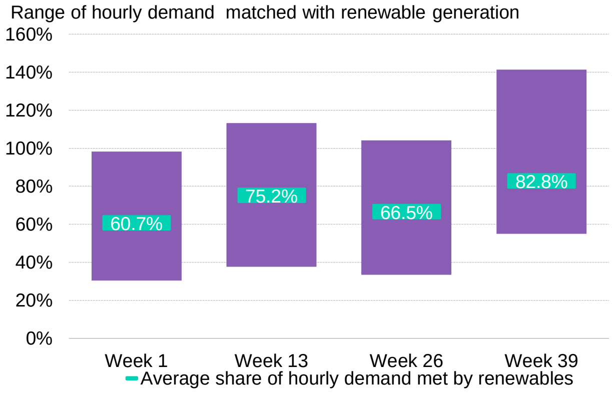
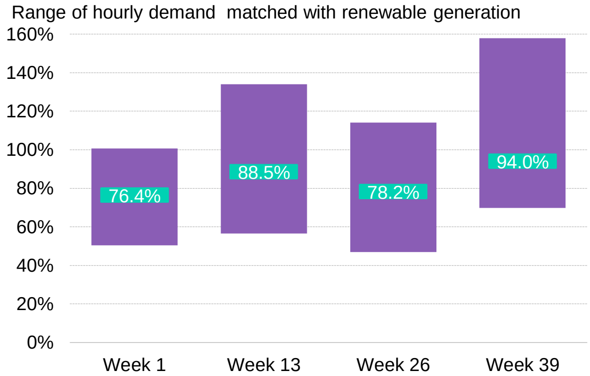


Figure 43: Range of hourly demand met by renewables in Japan's Eastern grid, 2050 – Net Zero Scenario



Source: BloombergNEF. Note: the calculation assumes demand is being met by all generators supplying the grid in that hour. Volume of renewable electricity shifted by energy storage is reflected in the calculation. Each bar represents one week of hourly supply-demand data. Four bars are shown to illustrate seasonal changes. The values for Japan's Eastern and Western grid networks are shown separately as the two networks operate on different frequencies.

In the Hokkaido, Tohoku, Hokuriku, Shikoku and Kyushu regions, due to more renewable resources and lower existing electricity demand, corporations would find it easier to achieve 24/7CFE by solely relying on renewables and energy storage connected to the local grid. In the current electricity demand centers of Kanto (Tokyo and its surroundings), Kansai (Osaka and its surroundings) and to a lesser extent the Tokai region (Nagoya and its surroundings), some corporations – particularly those with round-the-clock electricity demand – may need to also consider PPAs with renewables outside their local grid regions and/or other low-carbon dispatchable technologies to achieve 24/7 CFE.

Over the last decade, the growth of renewables in Japan has been dominated by solar. For Japan to get its power sector decarbonization on track, for the remainder of this decade the growth of solar capacity needs to continue. Japan will also need to accelerate wind, geothermal, and battery additions. By 2030, Japan needs onshore wind capacity to increase 4x and offshore wind capacity by 48x relative to 2023. Japan will also need almost 9x battery-based energy storage capacity by 2030 relative to 2023.

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Figure 44: Range of hourly demand met by renewables in Japan's Western grid, 2023

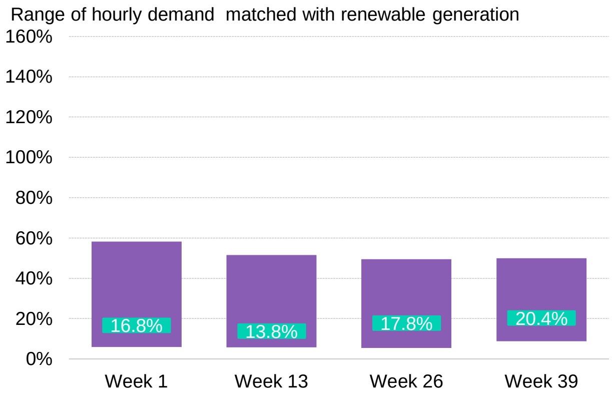


Figure 45: Range of hourly demand met by renewables in Japan's Western grid, 2030 – Net Zero Scenario

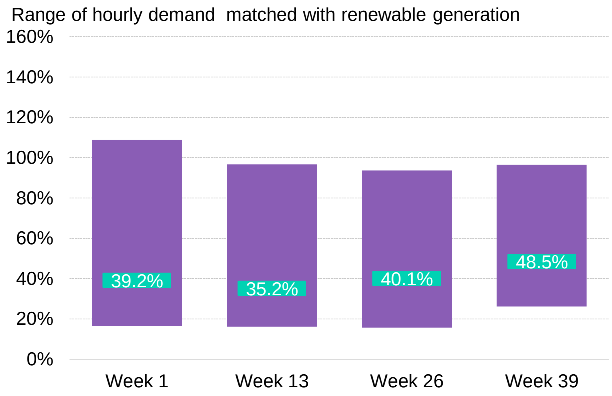


Figure 46: Range of hourly demand met by renewables in Japan's Western grid, 2040 – Net Zero Scenario

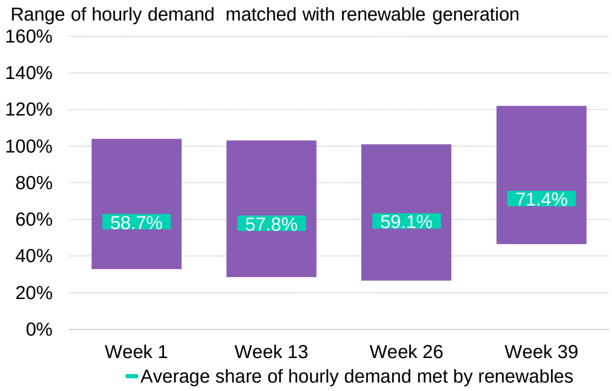
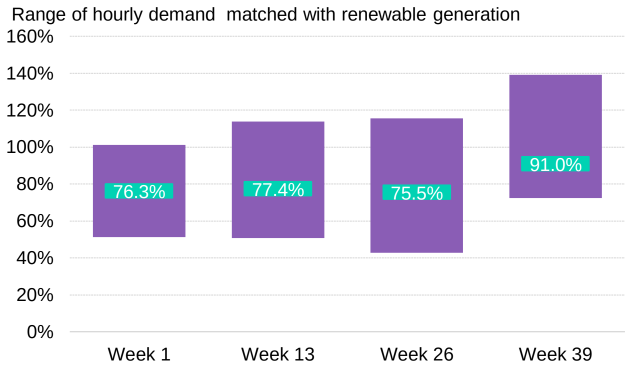


Figure 47: Range of hourly demand met by renewables in Japan's Western grid, 2050 – Net Zero Scenario



Source: BloombergNEF. Note: the calculation assumes demand is being met by all generators supplying the grid in that hour. Volume of renewable electricity shifted by energy storage is reflected in the calculation. Each bar represents one week of hourly supply-demand data. Four bars are shown to illustrate seasonal changes. The values for Japan's Eastern and Western grid networks are shown separately as the two networks operate on different frequencies.

By 2050, while utility-scale solar will account for the largest share of Japan's power capacity, offshore wind and onshore wind will contribute more annual electricity generation due to their higher capacity factor. Offshore wind will provide 24% of Japan's electricity supply in 2050, followed by onshore wind at 22%. Offshore wind's round-the-clock generation profile will be very beneficial for corporations pursuing 24/7 CFE procurement.

Unless Japan can overcome geopolitical challenges to build interconnections with neighboring countries – a daunting challenge – the country will also need to accelerate deployment of low-carbon dispatchable capacity as considered by the NEO Net Zero Scenario. Recent changes made to the capacity market auction run by Japan's Organization for Cross-Regional Coordination of Transmission Operators are starting to support deployment of low-carbon dispatchable capacity. However, the scope of technologies including non-zero emission sources such as LNG-fueled thermal plants supported by the capacity auction is still too broad.

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Figure 48: Japan's cumulative renewable capacity – Net Zero Scenario

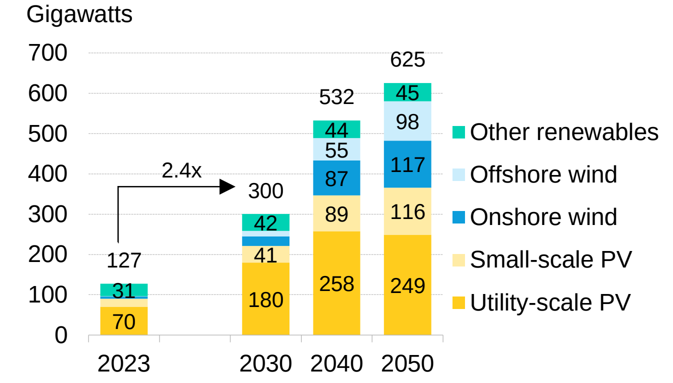
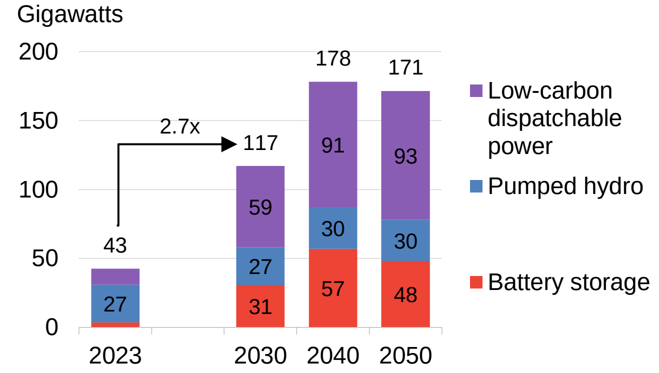


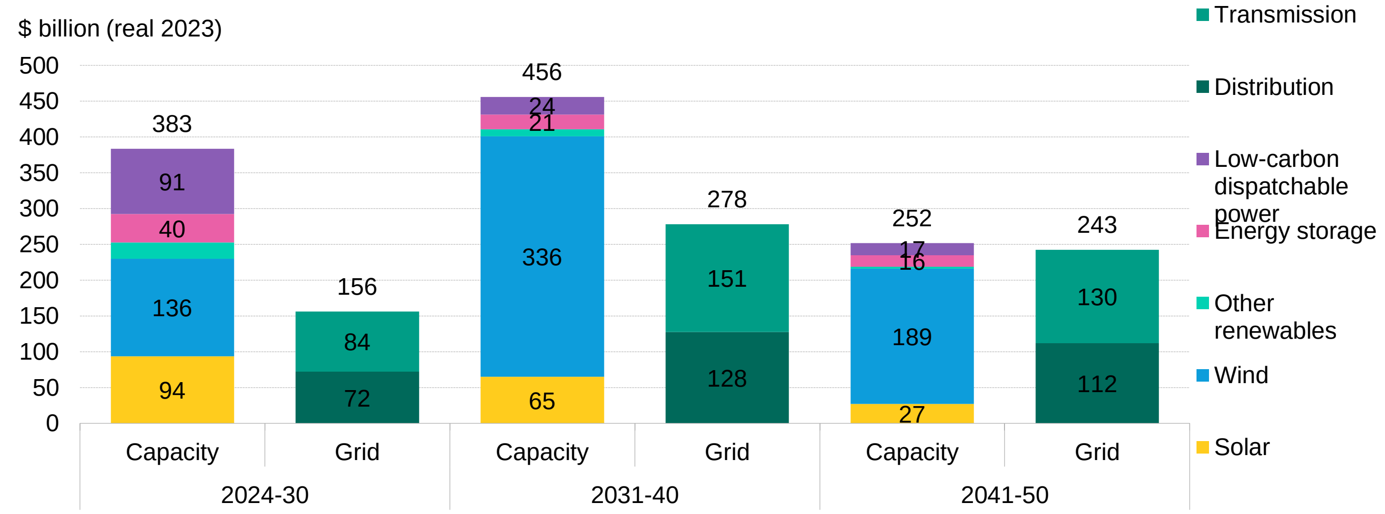
Figure 49: Japan's cumulative energy storage and low-carbon dispatchable power capacity – Net Zero Scenario



Source: BloombergNEF New Energy Outlook 2024. Note: PV is solar photovoltaic.

Japan will need $383 billion for clean power capacity and $156 billion for the grid during the remainder of this decade. Annual investment in Japan's renewable energy market has been declining since peaking in 2014. Japan's initial boom in renewable energy investment during 2012-14 was driven by overly generous feed-in tariffs, particularly for solar. Post 2014, changes to the feed-in tariff program, followed by the introduction of competitive auctions, have reduced over-reliance on subsidies. In parallel, power market reforms conducted over the last decade have addressed some of the challenges renewable developers faced. Many challenges remain, however, specifically around grid connections and land procurement. While recent power market reforms have also enabled more corporate clean power procurement options, high grid connection charges for renewable projects and restrictive rules governing grid investment, still hamper the growth of the renewable power capacity. Japan will need to undertake further regulatory reforms to attract more investment for clean power and grid expansion.

Figure 50: Investment required for clean power capacity and grid in Japan, Net Zero Scenario



Source: BloombergNEF New Energy Outlook 2024

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4.3. Thailand

Thermal power plants supplied 80% of Thailand's 2023 electricity, with the rest coming from renewables. Under NEO NZS, by adding 55GW of new renewable capacity – 36GW of solar, 12GW of wind – and 9GW of energy storage over the period of 2024-30, Thailand would raise renewables' annual share of electricity supply to 58% by 2030, while meeting growth in electricity demand. Continued expansion of renewables and energy storage capacity enables renewables alone to supply 77% of annual generation in 2040. Renewable share of annual generation thereafter remains the same, as growth in renewable capacity is only sufficient to keep up with growing electricity demand.

Figure 51: Thailand's annual electricity generation by technology – Net Zero Scenario

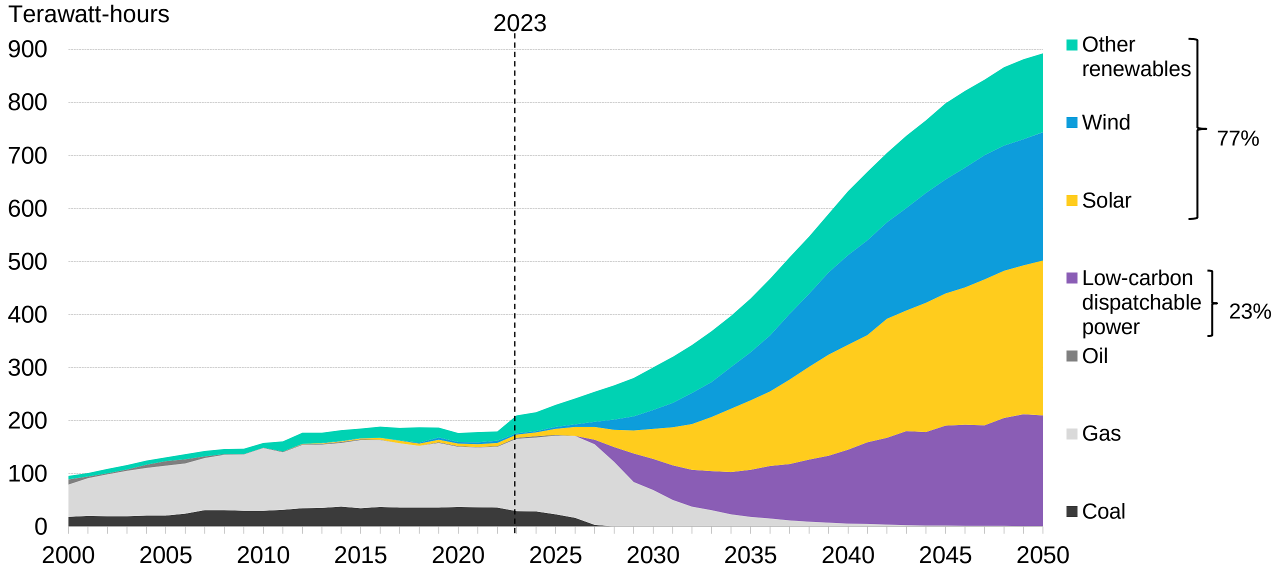
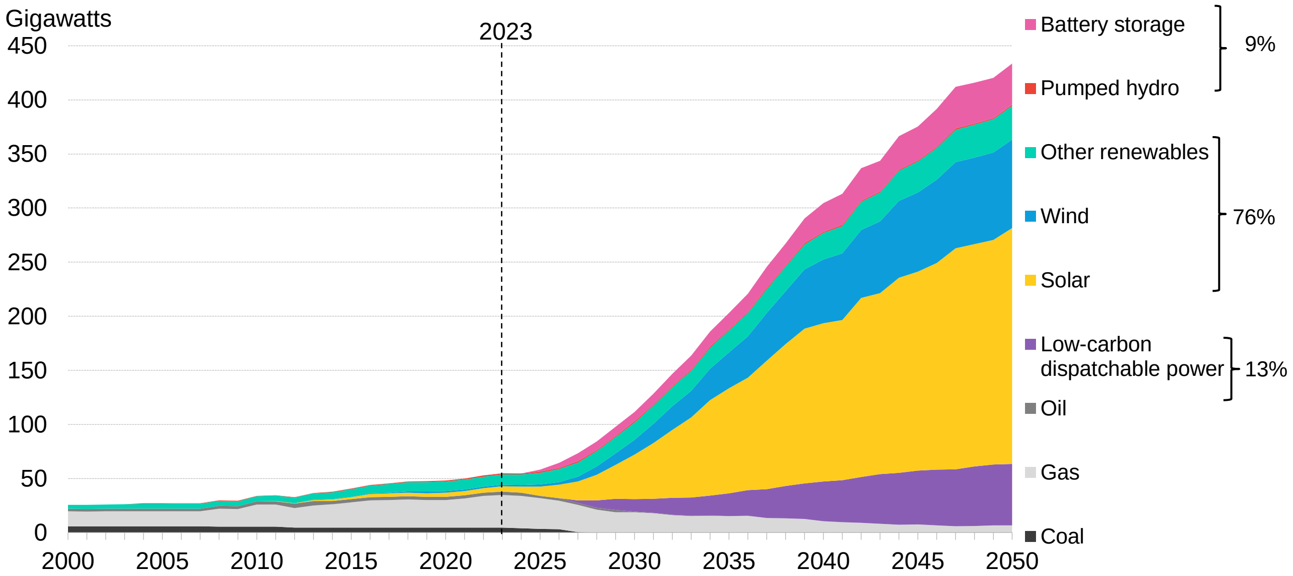


Figure 52: Thailand's power capacity – Net Zero Scenario



Source: BloombergNEF New Energy Outlook 2024. Note: Percentages show share of total in 2050.

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In 2023, the share of hourly demand met by renewables in Thailand ranged from as low as 3% to as high as 25%. Under NEO NZS, the range of hourly demand met by renewables in Thailand steadily improves to an average of 77% by 2050. By the mid-2030s, the majority of hourly electricity demand is already matched with renewables. By this time, many corporations will be able to achieve significant 24/7 CFE progress by relying on renewables and energy storage capacity within Thailand. The share of hourly-matched renewable electricity does not significantly improve post 2040s. Additional renewable capacity is only sufficient to keep up with growth in electricity demand. This challenge can be overcome by building more interconnections with neighboring countries such as hydro-rich Laos to increase imports of renewable electricity. Thailand would likely also need to diversify its sources of renewable power import, as its existing hydro power imports from Laos in recent years have suffered from droughts. Otherwise, Thailand will need to rely on low-carbon dispatchable technologies as utilized by the NEO NZS.

Figure 53: Range of hourly demand met by renewables in Thailand's grid, 2023

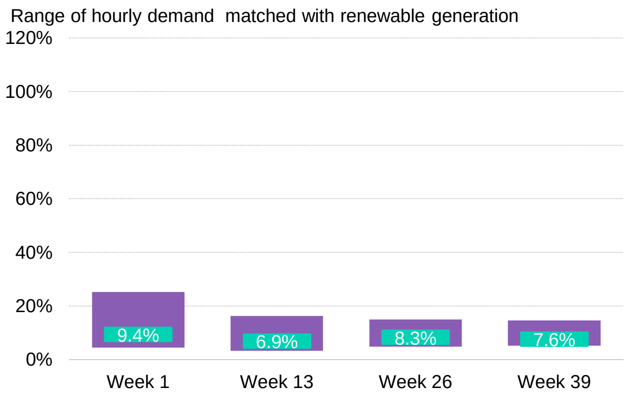


Figure 54: Range of hourly demand met by renewables in Thailand's grid, 2030 – Net Zero Scenario

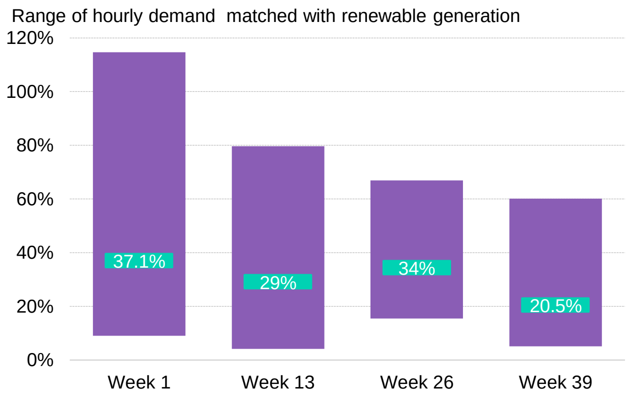


Figure 55: Range of hourly demand met by renewables in Thailand's grid, 2040 – Net Zero Scenario

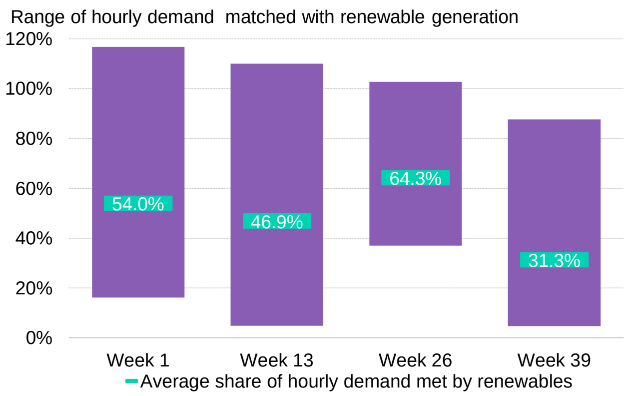
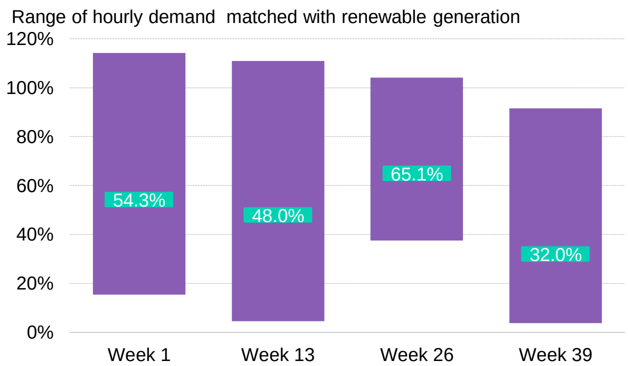


Figure 56: Range of hourly demand met by renewables in Thailand's grid, 2050 – Net Zero Scenario



Source: BloombergNEF. Note: Calculation assumes demand is being met by all generators supplying the grid in that hour. Volume of renewable electricity shifted by energy storage is reflected in the calculation. Each bar represents one week of hourly supply-demand data. Four bars are shown to illustrate seasonal changes.

Thailand will need 4.5x renewable capacity by 2030 relative to 2023. This is three times faster than the renewable capacity growth rate achieved over the last seven years. Enabling corporate customers to sign offsite PPAs with renewable energy developers, as Thailand is already considering, would be critical to attract more investment to accelerate deployment of renewables.

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Within this decade, Thailand will also need to kickstart deployment of energy storage starting with batteries. NEO NZS requires Thailand's battery capacity to reach 9GW by 2030 from less than 100MW at the end of 2023.

Figure 57: Thailand's cumulative renewable capacity – Net Zero Scenario

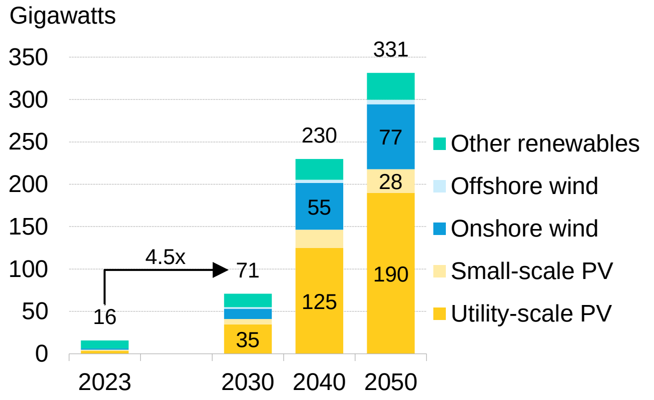
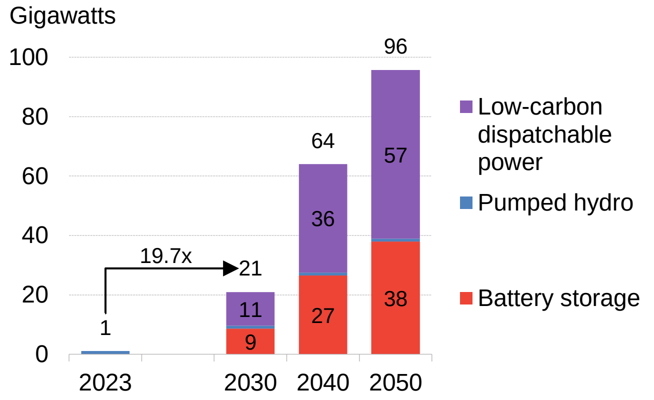


Figure 58: Thailand's cumulative energy storage and low-carbon dispatchable power capacity – Net Zero Scenario



Source: BloombergNEF New Energy Outlook 2024. Note: PV is solar photovoltaic.

4.4. Vietnam

Thermal power plants supplied 53% of Vietnam's 2023 electricity, with the rest coming from renewables. Vietnam currently leads in share of renewable electricity supply among the markets covered by this report. Under NEO NZS, by adding 112GW of new renewable capacity – 76GW of solar, 22GW of wind – and 19GW of energy storage over the period of 2024-30, Vietnam would raise renewables' annual share of electricity supply to 69% by 2030, while meeting growth in electricity demand. Continued expansion of renewables and energy storage capacity enables renewables alone to supply 84% of annual generation by the early 2040s.

Within the remainder of this decade, Vietnam would need to increase its renewable capacity by 3.3x. The biggest difference between the renewable 2030 capacity under NEO NZS and Vietnam's latest power development plan (PDP VIII) is for the solar sector. NEO NSZ 2030 solar capacity (97GW) is 3.7x that of PDP VIII, as the latter expects only 32% growth in solar capacity. Vietnam will also need to kickstart deployment of batteries. PDP VIII has a very modest 2030 target for batteries at just 300MW, compared to 17.4GW under NEO NZS.

In 2023 (Figure 51), the share of hourly demand met by renewables in Vietnam ranged from as low as 21% to as high as 93%. There is also a wide geographic distribution, with southern and central Vietnam having a higher share of renewables and lower demand, whereas the northern region suffers the opposite trend. Under NEO NZS, the range of hourly demand met by renewables in Vietnam steadily rises to over 80% by late 2030s. By the late 2020s, a majority of hourly electricity demand is already matched with renewables. By this time, many corporations will be able to make significant progress towards 24/7 CFE solely by relying on renewables and energy storage capacity within Vietnam. As Vietnam continues to expand transmission capacity within the country as well as build new interconnections with Laos, the geographic challenges facing 24/7 CFE will diminish.

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Figure 59: Vietnam's annual electricity generation by technology – Net Zero Scenario

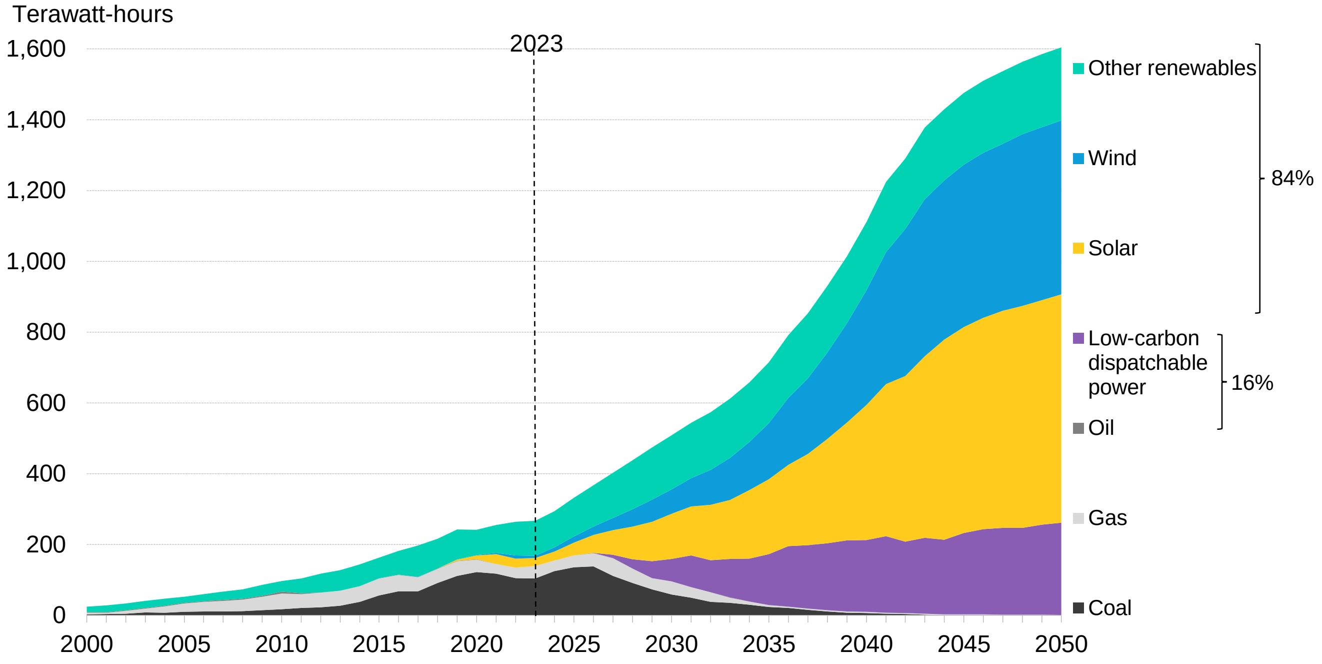
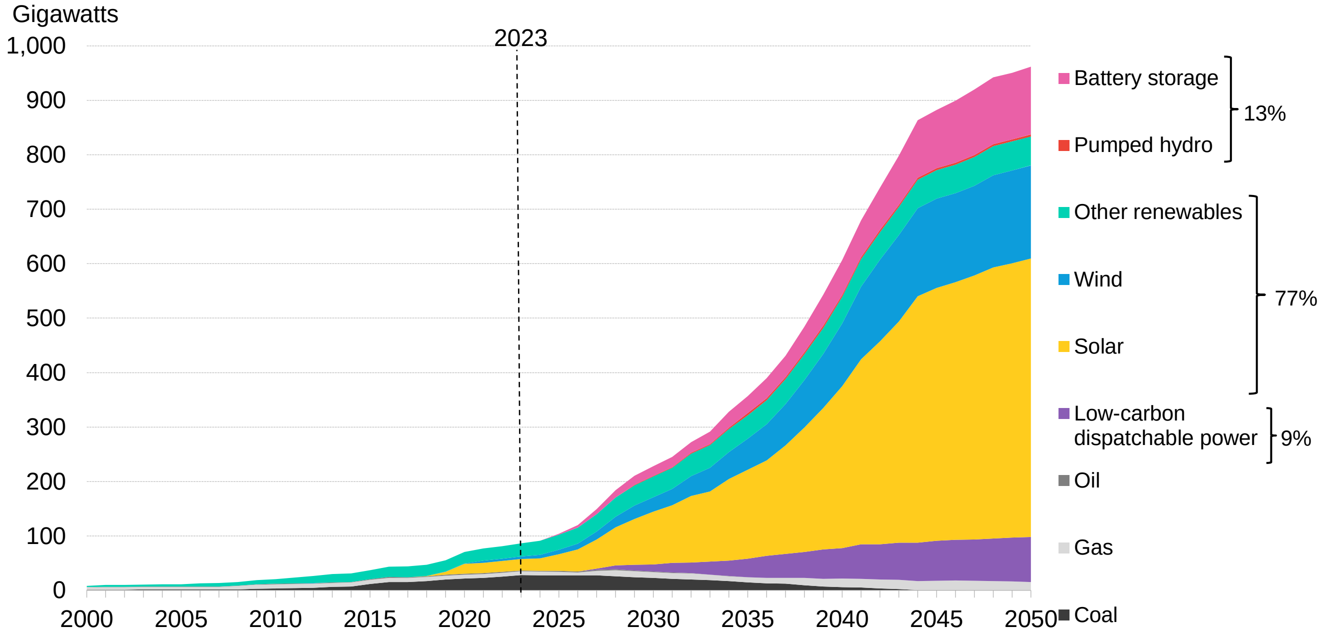


Figure 60: Vietnam's power capacity – Net Zero Scenario



Source: BloombergNEF New Energy Outlook 2024. Note: Percentages show share of total in 2050.

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Figure 61: Range of hourly demand met by renewables in Vietnam's grid, 2023

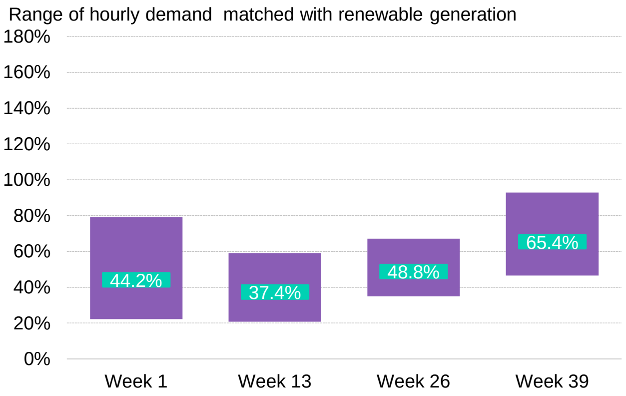


Figure 62: Range of hourly demand met by renewables in Vietnam's grid, 2030 – Net Zero Scenario

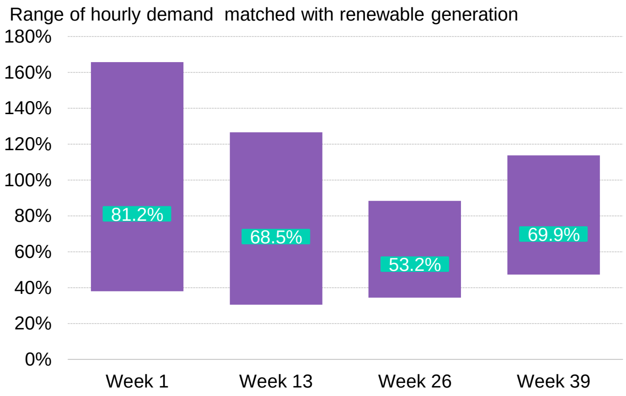


Figure 63: Range of hourly demand met by renewables in Vietnam's grid, 2040 – Net Zero Scenario

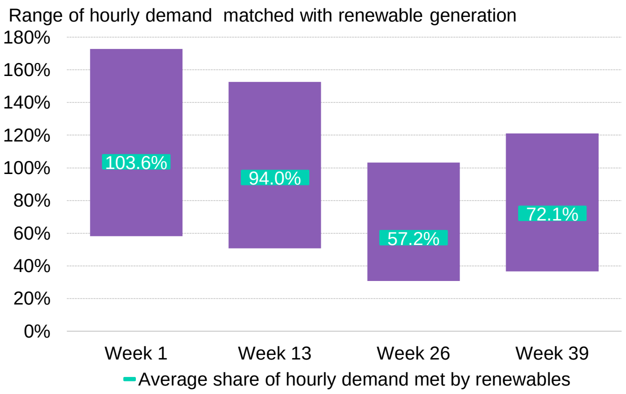
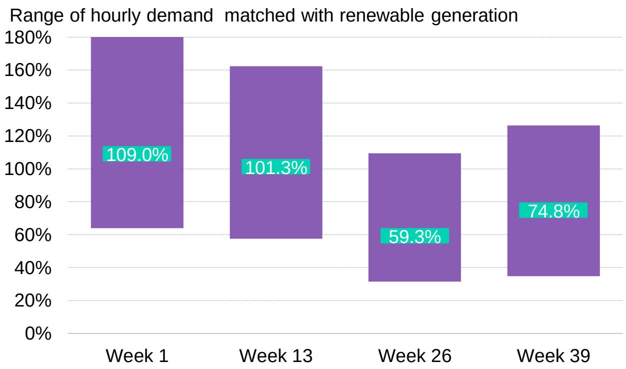


Figure 64: Range of hourly demand met by renewables in Vietnam's grid, 2050 – Net Zero Scenario



Source: BloombergNEF. Note: Calculation assumes demand is being met by all generators supplying the grid in that hour. Volume of renewable electricity shifted by energy storage is reflected in the calculation. Each bar represents one week of hourly supply-demand data. Four bars are shown to illustrate seasonal changes.

Vietnam will need $171 billion for clean power capacity and $53 billion for the grid during the remainder of this decade. During the period of 2018-20, Vietnam experienced rapid growth of investment in solar and wind, driven by its feed-in tariff program. Post expiry of the feed-in tariff program, investment in renewables declined. Investment in renewables will start growing again from next year, if Vietnam is successful in implementation of the much delayed direct power purchase agreement scheme. Vietnam is the manufacturing base for an ever-growing number of RE100 members. The number of Vietnamese companies who have signed up to the Science Based Targets initiative has also grown from just one in 2021 to 29 as of November 2024. Enabling 24/7 CFE procurement options for these companies will be critical in raising the funding Vietnam will need for its clean power capacity and grid expansion.

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Figure 65: Vietnam's cumulative renewable capacity, Net Zero Scenario

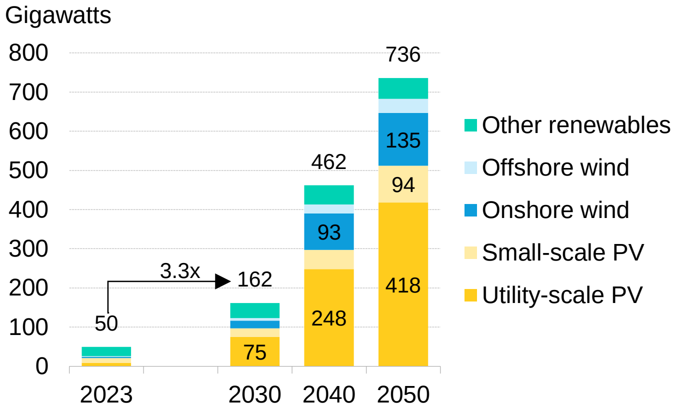
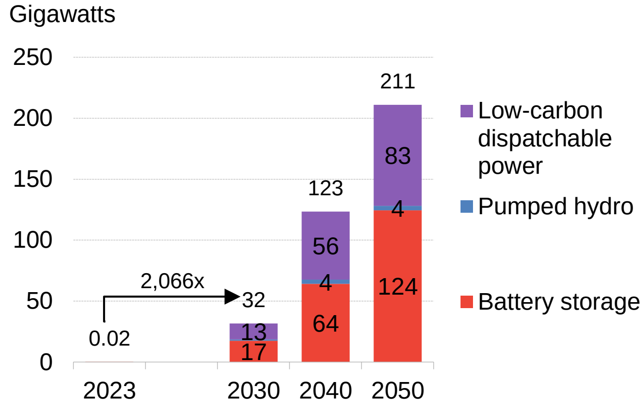
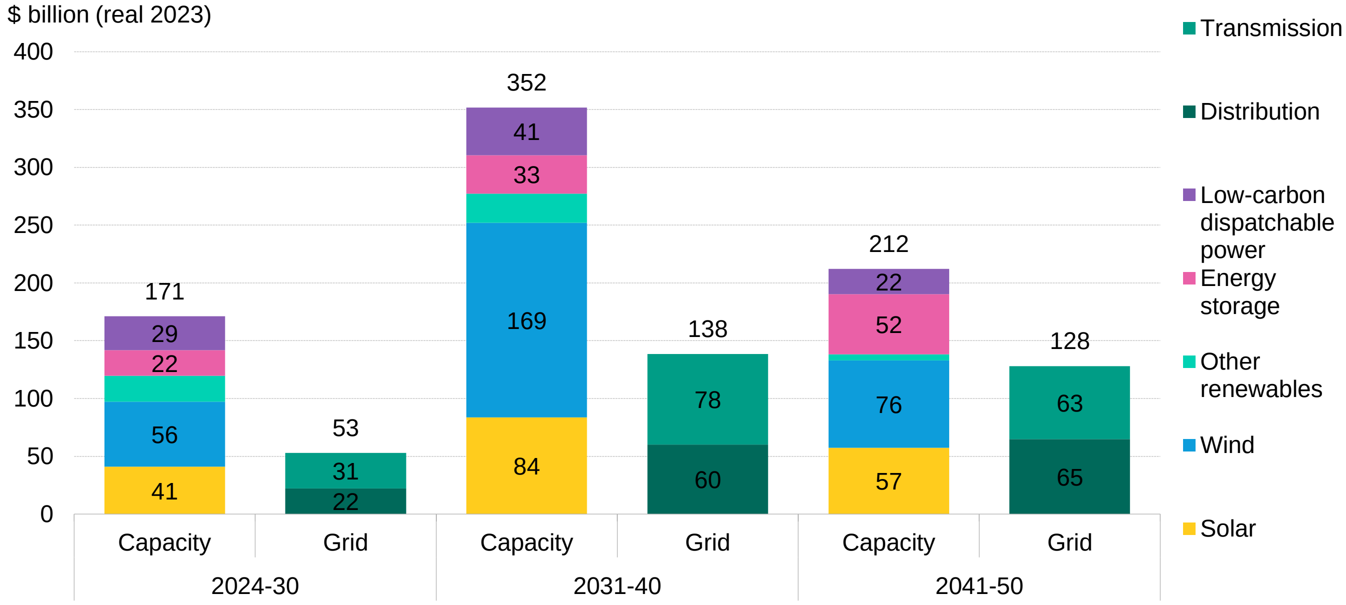


Figure 66: Vietnam cumulative energy storage and low-carbon dispatchable power capacity, Net Zero Scenario



Source: BloombergNEF New Energy Outlook 2024. Note: PV is solar photovoltaic.

Figure 67: Investment required for clean power capacity and grid in Vietnam – Net Zero Scenario



Source: BloombergNEF New Energy Outlook 2024

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Section 5. Recommendations

The combination of rising electricity demand and increased corporate interest in clean power procurement across APAC provides a unique opportunity for accelerating the region's decarbonization through 24/7 CFE. Policymakers in the APAC region can support the ability of companies to advance national-level electricity decarbonization by supporting an enabling environment for 24/7 CFE procurement. Past studies such as the International Energy Agency's Advancing Decarbonisation Through Clean Electricity have included detailed recommendations for policymakers, system operators, and electricity buyers. To speed up the deployment of clean energy supply, implementing the four actions identified by GRA to deliver the COP28 goal of tripling renewables by 2030 is critical. The four actions are:

- **Finance:** Increase renewable energy investment in terms of speed, scale, and distribution. Focus on scaling up investment flows – especially in EMDEs – by mobilizing both public and private finance to deliver the $10 trillion required to triple renewables by 2030.
- **Supply chains:** Establish robust, secure and resilient renewable energy supply chains. These serve as a critical foundation necessary to achieve the scale and speed required to reach the tripling renewables target by 2030.
- **Permits:** Streamline planning and permitting processes to reduce time and cost constraints of renewable energy projects. Acceleration is urgently needed to triple renewables by 2030 – it still takes longer to permit a project in many markets than it does to build one.
- **Grids:** Increase much-needed investment in new grid infrastructure and optimize the existing grid system to create a renewables-fit energy system. Investment in power generation needs to go hand-in-hand with transmission and distribution infrastructure investment to triple renewables by 2030.

These four actions are also the prerequisite for any market considering power sector decarbonization and, by extension, enabling 24/7 CFE. Here we expand on these four actions, with six recommendations for APAC-based regulators to enable 24/7 CFE procurement:

1. **Improve electricity data transparency and access:** Regulators should require system operators make public grid-electricity supply mix and demand on hourly or sub-hourly basis. Regulators also need to ensure detailed contracted demand data is securely accessible by the contracting party and by third parties digitally authorized on their behalf. This will enable renewable IPPs and corporate buyers to develop better strategies for 24/7 CFE. It will also lead to more accurate tracking instruments to support corporates in their 24/7 CFE claims and enable creation of options such as hourly RECs as discussed next.
2. **Enable hourly RECs:** Policymakers and regulators should support the introduction of hourly RECs according to existing international standards such as EnergyTag and develop clean energy procurement solutions that allow companies to track clean electricity supplied against their consumption. REC registries such as I-TRACK (founder of I-REC), which is widely used in APAC, have already built functionality into their registry (serviced by Evident) to enable hourly certification in locations where hourly energy data is available. Introducing hourly RECs will allow to more accurately represent and validate when clean energy is produced. Regulators should also support development of markets for trading of hourly RECs. Such hourly REC exchanges would help companies achieve high CFE targets and support the development of flexible clean energy. This in turn will create price signals to direct corporate

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investments towards clean energy solutions at times when it's most needed. For example, energy storage systems would be able to better time their charge and discharge cycles in accordance with timing of excess availability and deficit of clean electricity supply relative to demand.

3. **Enable a wide menu of high-impact, cost-effective CFE procurement options for corporations:** Policymakers and regulators should facilitate corporate procurement solutions which allow access to clean energy around the clock. This requires legal frameworks that allow offsite PPAs between corporate buyers and operators of renewables, energy storage and low-carbon dispatchable assets. Regulators should ensure wheeling charges for offsite PPAs are set in a fair, transparent, and predictable manner. Unpredictable changes to wheeling charges over the duration of the PPA term undermines the economic viability of these offsite PPAs. Regulators should also ensure utility green tariffs are designed to provide additionality (lead to build out of new renewable capacity), as well as ensure the benefits of renewable energy sources' stable generation costs are passed onto corporate consumers. To support corporate 24/7 CFE strategies, regulators should also design utility green tariffs based on a mix of clean electricity technologies, which can deliver a specified level of hourly matched clean energy supply.
4. **Evolve auction designs to accelerate deployment of mature renewable and energy storage technologies:** Policymakers and regulators should move away from schemes that maintain the price of clean energy artificially high due to policies such as overly generous feed-in tariffs, uneconomic local content requirements or plant-level firming requirements. Instead, regulators should introduce different types of auctions that accelerate least-cost deployment of technologies enabling 24/7 CFE supply. India's evolving auction program is a useful model to benchmark. Regulators can consider introducing different categories of auctions such as hybrid auctions allowing bids from a mixture of technologies subject to minimum capacity factor requirements. They can also include peak power auctions to target clean energy dispatch for specific hours of the day. Additionally, they can introduce round-the-clock auctions subject to minimum availability and capacity factor requirements. When designing these auctions, regulators as much as possible should de-risk the project development phase by easing land-procurement and grid connection processes.
5. **Reform grid planning and regulations to prioritize power system decarbonization:** Policymakers and regulators need to improve the current approach to grid planning and operation to accelerate investment in grid expansion to support growth of clean power capacity. In all markets covered in this report, existing regulations leave grid investment decisions in the hands of incumbent power network operators, and limit grid infrastructure investment by other corporations. Most regulators and grid operators across these markets continue to use outdated grid planning and operational approaches that result in higher rates of curtailment of renewable power, and implicitly prioritize existing thermal power plants. For example, while many European transmission network operators have already adopted dynamic line rating, thus more efficiently utilizing existing transmission network capacity for transferring power from renewables, transmission system operators in these APAC markets have yet to do so. When designing wheeling charges, regulators need to ensure fees are transparent and designed in an equitable manner consistent with power system decarbonization. Placing excessive wheeling charges on corporate buyers of clean power undermines power system decarbonization. Policymakers also need to put more effort behind interconnections with neighboring countries. Building out more interconnection capacity with neighboring countries would both lower the cost of decarbonization of the power sector as well as accelerate the pace of transition. In Northeast Asia, both geography and geopolitics

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makes such efforts more challenging. The realization of the long-awaited ASEAN Power Grid can both accelerate and lower the cost of decarbonization of Southeast Asia, as detailed in this report by Asia Clean Energy Coalition.

6. **Support direct investment by corporate buyers in deployment of emerging technologies for 24/7 CFE:** To enable development of renewable sources such as geothermal, as well as long-duration energy storage technologies, regulators need to remove barriers and provide incentives for corporate electricity buyers to invest. For example, in the case of geothermal, a major challenge is the cost associated with the exploration drilling phase. As the quality of the geothermal resource cannot be fully assessed before completion of the exploration drilling phase, the investment risks for corporate electricity buyers are too high initially. Governments can provide targeted funding to support the exploration phase and de-risk investment by corporate buyers. Such approaches have already been used in select cases, however they need to be significantly scaled up. And governments need to ensure the de-risked projects are accessible to corporate electricity buyers. Similarly, for developers of emerging long-duration energy storage technologies, securing funding for first-of-a-kind (FOAK) projects is very challenging due to lack of a track record. Governments can provide incentives for corporate electricity buyers to directly invest and sign offtake agreements with such FOAK projects.

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Appendices

Appendix A. NEO modeling methodology

BNEF follows a sectoral approach in the modeling for the *New Energy Outlook*. Our scenarios are rooted in country-specific inputs and modeling for each sub-sector in power, transport, industry and buildings. This methodology section gives an overview of the main models used in this report.

Barriers assessment in modeling

BNEF generally minimizes constraints in the modeling. The following lists barriers that were modeled explicitly, assessed for materiality based on outputs of the core modeling work, or barriers that were not modeled or explicitly addressed or unknowns.

In-model barrier assessment

BNEF aims to take account as much as possible of the following barriers:

- **Manufacturing constraints**: We aim to curb excessive deployment peaks without pre-supposing what manufacturing capacity can be made available. A normative climate scenario will inevitably call for a steep rise in production capacity.
- **Short-term policy**: We account for legislated firm near-term policy in two ways.
  - Explicitly: Legislated market mechanisms (such as carbon compliance markets, production tax credits); technology phase-outs (asset-level forecasts for coal, nuclear and other asset retirements).
  - Implicitly: Short-term policy is taken into consideration in our five-year country-level clean power forecasts, commodity price forecast, project pipeline for other low-carbon generation (hydro, geothermal), short-term road transport assumptions, and analysts' reading of company targets in aviation and shipping.
- **Cross-border power flows**: Interconnectors are modeled statically where applicable (eg, Europe, inter-regional China connectors).
- **Sources of finance**: The least-cost determination includes assumptions regarding investor hurdle rates. If, incorporating these hurdle rates, modeling determines a project is the least cost solution to demand at a given time, finance will be available, and it will be built.

Post-modeling barrier assessment

BNEF accounts for the following both within the models and in more detailed post-modeling assessments:

- **Grids**: We apply 'reasonable' constraints on power grid buildout during modeling by constraining the size of the grid in each year to meet firm, non-flexible demand. BNEF models the power system in hourly resolution. This approach avoids oversizing the grid for the highest peak. We then provide extensive analysis on the implications for power grids post-modeling. We do not model potential other grid needs (such as gas, hydrogen and CO2).
- **Metals and critical materials supply**: BNEF annually updates its 10-year forecast on battery chemistries in stationary and vehicle applications. By incorporating this, and the metals

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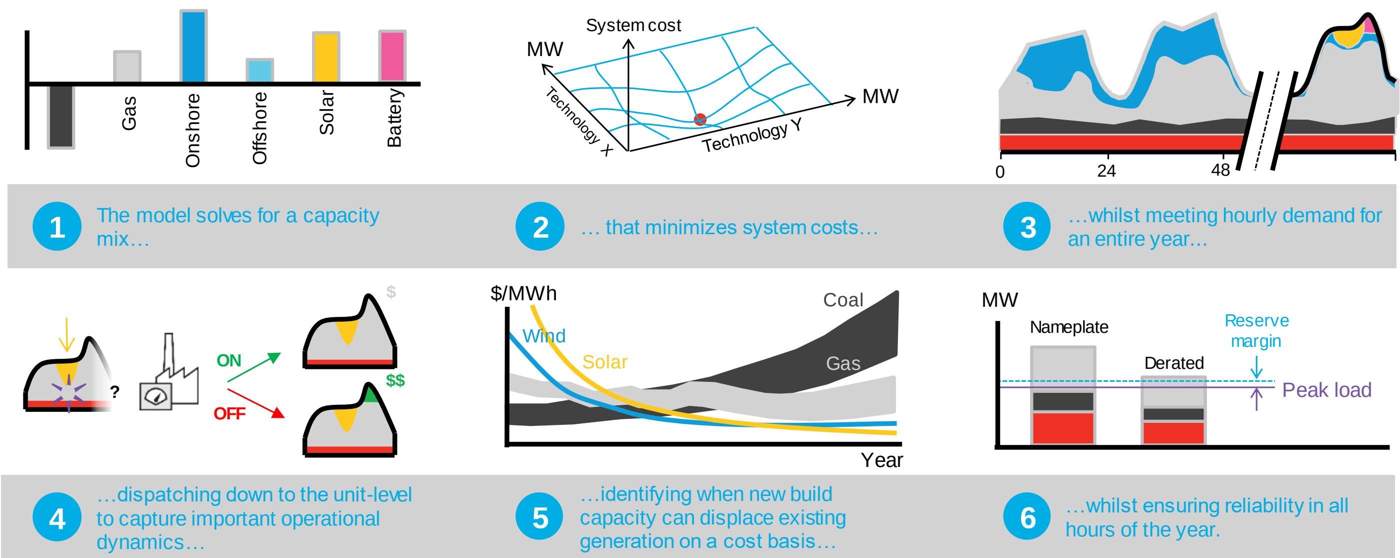
intensity of renewables and grids (accounting for changing needs), we produce a post-modeling demand forecast for metals and other critical materials.

We model country and regional power systems at an hourly resolution from today until 2050, using our proprietary model. The model solves for a capacity mix that minimizes system costs (a least-cost approach), while dispatching to meet demand at every hour. In doing so, the model acknowledges the variability in output from renewables, at an hourly, daily and seasonal level.

Thermal assets are dispatched at the unit level to ensure that real-world operational restrictions inform decision-making, including the cost of ramping and operational flexibility throughout the day. This enables the model to capture the inherent trade-offs between operating baseload plants inefficiently versus the cost of building new flexible capacity, such as batteries. The model simultaneously guarantees sufficient back-up capacity for all hours of generation. We use country-specific technology cost and fuel price data from our levelized cost of electricity (LCOE) analysis.

Figure A.68: NEFM modeling logic



Source: BloombergNEF

System cost

Our modeling solves for a least-cost system. The definition of 'system cost' includes all variable and fixed operating expenses (opex), fuel costs, capital expenditure (capex), and carbon cost (where applicable). While we do not explicitly capture the cost of power grids, we constrain the maximum grid capacity dynamically to prevent over-build.

Demand

Our hourly demand forecasts combine top-down economic demand modeling with bottom-up sector demand forecasts. We combine demand projections and peak demand data to produce individual demand forecasts. Forecasts combine macroeconomic trends with real-world load profiles to create hourly demand profiles from today until 2050. In addition to demand profiles for 'general' power demand, we net out and layer new and emerging demand segments, where they

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add accuracy to the model. These demand segments may include electric vehicle (EV) charging patterns, air-conditioner use, or electrification of industry or other sectors.

In modeling demand segments separately, we can assign them varying degrees of flexibility to dynamically shift power demand based on system signals. For example, some consumer EVs may have a high degree of charging flexibility, but only during nighttime hours. Alternatively, some commercial EV fleets may have less flexibility in how they charge, but will respond much more strongly to price signals. These smart loads interact with the general demand profile, and renewable generation, to push flexible demand, where possible, to the cheapest hours of the day.

Renewable dispatch

All renewable technologies are dispatched based on hourly real-world profiles. Where these are unavailable or inconclusive, we model country generation profiles using a sample fleet of wind turbines, using modeled hourly wind speed data in partnership with a third-party wind data provider. For wind technologies, we look at evolutions in turbine power curves and BNEF's forecast for future wind turbine characteristics to predict future generation based on historical hourly wind data. Reservoir hydro is dispatched with real-world restrictions to balance the dispatchability of the resource with its seasonality.

In its decision-making, NEFM considers the cost of adding additional renewables to the system against the marginal cost of the basket of generators they displace – during the actual hours of their generation. This captures the opportunities for renewables to displace existing generators when their new-build costs fall below the marginal value of incumbent technologies, while also considering the impact of curtailment and price cannibalization on the marginal value of additional renewables generation in a given hour. Renewable technologies are not given preference in the dispatch order. Any curtailment is assigned proportionally to observed generation at an hourly level.

Thermal dispatch

The NEFM-2 model dispatches thermal assets at the unit level, capturing the hour-by-hour decision-making processes that determine the plant stack over the course of each day, including the impact of ramp rates and other actual dispatch limitations. This granularity is key to model the decision-making of thermal plant operators in high-renewables systems. For example, on sunny days in California, the 'duck curve' effect forces thermal plant operators to make cost-based decisions on whether to stay online at midday or turn off. Aggregated to the fleet level, decisions about operational flexibility at midday in turn determine the evening generation mix and system cost.

In capturing these dynamics, NEFM-2 can explore the limits to flexibility of the thermal fleet, and its associated costs and value compared with alternatives, such as batteries. In markets where granular thermal fleet data are unavailable, or where these plants are not yet built, NEFM-2 can create its own detailed fleet from aggregate data.

Batteries and storage

Storage assets are dispatched for energy shifting only, with two main objectives. The primary objective is to reduce absolute peak load in the system as much as possible. Shaving peak load enables the model to identify opportunities to reduce the firm capacity requirement from existing plants. A secondary objective is to smooth out variations in net load as much as possible. This not only reduces ramping costs for the thermal fleet, but also increases renewable penetration. In

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practice, this means that storage assets are not limited to charging only from renewables (although they often do) but can also charge from thermal plants, where this benefits the system and lowers overall cost. Storage assets are allowed to have some degree of co-location with renewables and may therefore charge above grid capacity limits imposed elsewhere.

Reliability

NEFM-2 is designed to ensure a reliable system, where all forecast load is met at every hour, from now until 2050. In thinking about reliability, we must take a different approach based on the technology in question. For renewables, reliability means that we must consider various weather years in order to judge the most challenging year for the model to meet load. For the thermal fleet, reliability concerns are factored into the model by de-rating the plants' contribution to meeting load (also known as capacity credits). The dispatch decisions for batteries are weighted toward a rolling window of 24 hours so that the model does not underestimate the challenges in forecasting real-world demand and renewables generation. In addition to this, we also define a capacity reserve margin in the model, which ensures redundancy in the system during hours of peak demand.

Capacity build

In a least-cost system, excess capacity is almost always inefficient and NEFM-2 tends to only build as much capacity as strictly needed. This creates a solution space that tends to be zero-sum; by this we mean that if one technology gains, another tends to lose. Furthermore, several complex interactions are at play among the capacity mixes under consideration in NEFM-2. For example, building solar capacity can make building batteries more attractive by providing cheaper charging opportunities.

The complex dynamic between the technologies under consideration means that the power systems we build are only as robust as our weakest assumption. Therefore, we only allow NEFM-2 to build technologies that have reliable data and a commercially proven record to back this up. Finally, when NEFM-2 builds capacity, it is not a step-by-step process. The model builds capacity by simultaneously considering generation, capacity, and flexibility costs.

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