ACCR

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Investing in coal plant flexibility:

A strategic approach for J-POWER's transition

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Contents

1. Executive Summary

Introduction

Repurposing coal plants for flexibility has been a widespread and successful strategy amongst coal-powered nations since the earliest days of the energy transition. As more renewable energy enters the grid, particularly solar energy, flexibility mitigates the financial risks of a coal plant generating power during low-price periods and contributes to grid reliability in high-demand periods. The International Energy Agency (IEA) also identifies the flexible usage of repurposed coal plants as the single largest decarbonisation lever under the Announced Pledges Scenario (APS) for the world's existing coal fleet - accounting for 60% of projected global CO_2 emissions reductions through to 2050.[1]

Solar is already the largest contributor among Japan's sources of renewable energy. With the government's 6th Strategic Energy Plan (SEP) aiming to increase the share of solar and the upcoming 7th SEP anticipated to accelerate that ambition, the penetration of solar into Japan's grid is set to increase. The anticipated significant volume of low-cost solar will likely drive midday electricity prices materially lower and increase intraday volatility.

J-POWER is particularly vulnerable to this evolution in market dynamics. Almost 80% of its domestic electricity sales are generated from inflexible coal plants[2] – more than double that of the next most coal-dependent of Japan's five largest generators – putting it at risk of exposure to low-pricing periods driven by rising solar.

Recognising this risk, J-POWER recently acknowledged the growing importance of flexibility in thermal power to support renewable energy expansion[3], saying it aims to reduce the financial impact of lower load factors by enhancing coal plant flexibility.[4] However, the company has not disclosed any plans on how it will achieve this.

The focus of J-POWER's coal fleet decarbonisation strategy is still on unproven and costly technologies, including converting higher-efficiency thermal power plants[5] using ammonia co-firing, coal gasification, and carbon capture, utilisation and storage (CCUS).[6] This does not align with the IEA's recommendations for Japan's newer coal power plants, which includes retrofitting or repurposing them as flexible energy sources to prevent them from becoming stranded assets.[7]

To protect long-term shareholder value in an evolving market, J-POWER needs to prioritise investment in initiatives that lower minimum load levels and increase the flexibility of domestic coal plants – and clearly articulate this in its decarbonisation strategy.

[1] IEA, Coal in Net Zero Transitions, Nov 2022, p66.
[2] Excluding procured electricity; J-POWER, 2024 Integrated Report, p105. (Japanese version)
[3] J-POWER, 2024 Integrated Report, p19. (Japanese version)
[4] J-POWER, 2024 Integrated Report, p30. (Japanese version)
[5] J-POWER, 2024 Integrated Report, p19. (Japanese version)
[6] J-POWER, 2024 Integrated Report, p63. (Japanese version)
[7] IEA, Innovation and market reform needed to drive Japan's clean energy transition, IEA policy review finds, Mar 2021.

Key Findings

- **Solar power is expected to be the dominant source of renewable energy in Japan's energy mix during midday periods as Japan scales up renewables over the next decade.** Japan is currently aiming to increase solar's share from 10% in 2023 to 14-16% by 2030, [8] and ACCR expects solar is likely to remain the largest renewable source in Japan's 2035 energy mix targets in the upcoming 7th SEP.

- **Rising solar penetration drives down midday prices and increases intraday volatility of the electricity grid, exposing J-POWER's domestic inflexible baseload coal plants to the risk of being forced to generate power during low-pricing periods.** Bloomberg New Energy Finance (BNEF) forecasts this trend will materialise in the short-term, especially during upcoming summer and shoulder seasons, if it isn't already underway.[9]

- **J-POWER is particularly vulnerable to low-pricing periods due to its heavy reliance on coal as an inflexible generation source.** Coal accounted for 79% of J-POWER's domestic sales in FY23[10] - more than double that of the next most coal-dependent of the five largest Japanese electricity utilities.[11]ACCR projects a 16% decline in domestic thermal revenue by 1H26 compared to 1H24.[12, 13]

- **Global coal capacity factors are on a downward trajectory, and Japan and J-POWER are unlikely to be immune from this long-term global trend.** Japan's coal capacity load is expected to fall from 82% in FY18 to a projected 66% in FY25,[14] aligning with global trends in the IEA's APS and Net Zero Emissions (NZE) scenarios.[15, 16] J-POWER has consistently underperformed the national average,[17] highlighting the urgent need for the company's baseload coal plants to invest in flexibility to adapt to changing market dynamics.

- **Repurposing coal plants for flexibility has been a widespread and successful strategy amongst coal-powered nations since the earliest days of the energy transition.** Flexibility mitigates the financial risks of a coal plant generating power during low-pricing periods and contributes to grid reliability in high-demand periods. The IEA also recommends retrofitting newer coal plants for flexibility to support renewable energy integration and prevent them from becoming stranded. [18]

[8] METI, Outline of Strategic Energy Plan, Oct 2021, p12. (Japanese version)
[9] BNEF, Japan Power Market Outlook 1H 2024, May 2024, p7.
[10] Excluding procured electricity; J-POWER, 2024 Integrated Report, p105. (Japanese version)
[11] Top 5 generators by volume in FY23 according to METI; Excluding procured electricity.
[12] Assuming J-POWER's domestic coal capacity factor remains at the FY24 forecast level of 61%, mirroring FY22 and FY23 seasonal variations, selling 100% of electricity generated from its thermal assets, without accounting for transmission or other losses, and that all electricity is sold on the wholesale market.
[13] BNEF, Japan Power Market Outlook 2H 2024: Tailwinds Ahead, Oct 2024, p2. (Japanese version)
[14] BNEF, Japan Power Market Outlook 2H 2024: Tailwinds Ahead, Oct 2024, p21. (Japanese version)
[15] IEA, World Energy Outlook 2024, Oct 2024, p305, 311.
[16] Implied capacity factors under the APS and NZE scenarios for unabated coal power plants were calculated using generation volumes and capacity projections.
[17] J-POWER, 2024 Integrated Report, p105. (Japanese version)
[18] IEA, Innovation and market reform needed to drive Japan's clean energy transition, IEA policy review finds, Mar 2021.

- **While J-POWER says it aims to reduce the financial impact of lower load factors by enhancing coal plant flexibility,[19, 20] it has not disclosed any plans on how it intends to achieve this.**

Recommendations

1. J-POWER should prioritise investments in initiatives that lower minimum load levels and increase the flexibility of domestic coal plants.

2. J-POWER should incorporate these initiatives into its decarbonisation strategy.

2. Solar expansion is expected to drive down electricity prices, leaving J-POWER financially vulnerable

As Japan moves towards 2030 and implements its 6th Strategic Energy Plan (SEP), it is expected to increase its reliance on solar power. The significant volume of low-cost solar will likely drive midday electricity prices materially lower in the short-term, with Bloomberg New Energy Finance's (BNEF) Japan Power Market Outlook report projecting lower midday prices in the upcoming seasons. Beyond short-term projections, this trend could continue as renewable energy increases its share in the mix, with the Renewable Energy Institute (REI) and Berkeley Lab modelling also suggest that solar power emerges as the primary source in high-renewable scenarios.

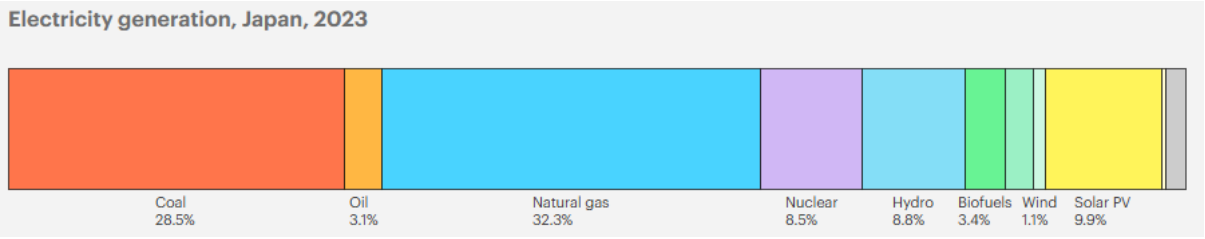
J-POWER is particularly vulnerable to this risk because the majority of its domestic electricity sales are generated from its inflexible coal plants, which must operate at or above the technical minimum load levels. This inflexibility will likely force J-POWER to sell electricity during the low midday pricing period at depressed prices, when solar energy increases its share in the generation mix, straining profitability.

2.1 Rising solar penetration in Japan drives down midday prices and increases intraday volatility

As of 2023, solar energy accounted for approximately 10% of Japan's electricity generation, making it the largest contributor among the country's renewable sources (Chart 1). Under the 6th SEP, Japan aims to increase solar's share from 10% in 2023 to 14-16% by 2030,[21] indicating a clear trajectory for continued growth of solar in the energy mix.

[19] J-POWER, 2024 Integrated Report, p19. (Japanese version)
[20] J-POWER, 2024 Integrated Report, p30. (Japanese version)
[21] METI, Outline of Strategic Energy Plan, Oct 2021, p12. (Japanese version)

Chart 1: Solar is already the largest contributor among Japan's renewable sources



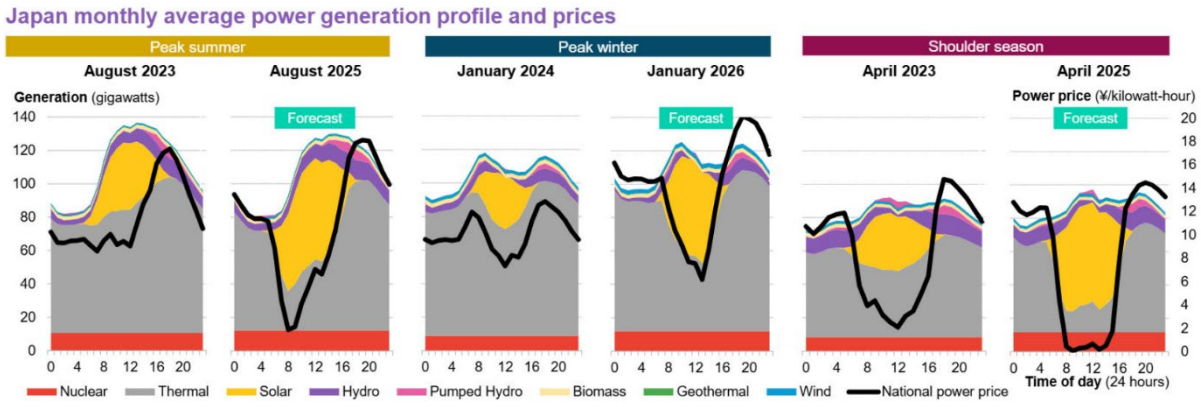
Source: IEA, Japan Energy Mix, 2023.

Japan is reviewing its SEP and aims to publish an updated 7th SEP by March 2025, where it will likely set 2035 energy mix targets. Under Japan's maximum renewables deployment strategy, ACCR anticipates a greater share of renewables in the energy mix, with solar energy remaining the dominant renewable source.

The anticipated rise in solar penetration over the short- to medium-term is expected to drive greater wholesale price volatility, with significantly lower prices during midday periods, particularly in summer and shoulder seasons (Chart 2).

BNEF forecasts that solar will be contributing 14% to 25% of Japan's generation mix in this outlook period (April 2025 to January 2026).[22] This dynamic could compress margins for coal plants, as their operational inflexibility constrains their ability to adjust output. J-POWER faces heightened exposure to these pricing changes, as the majority of its domestic electricity sales are generated from its coal plants (79% in FY23, excluding procured electricity[23]).

Chart 2: BNEF expects more solar generation will cause a bigger dip in midday prices and higher volatility



Source: BNEF, Japan Power Market Outlook 1H 2024, May 2024, p7.

[22] BNEF, Japan Power Market Outlook 1H 2024, May 2024, data for the chart on p7.
[23] J-POWER, 2024 Integrated Report, p105. (Japanese version)

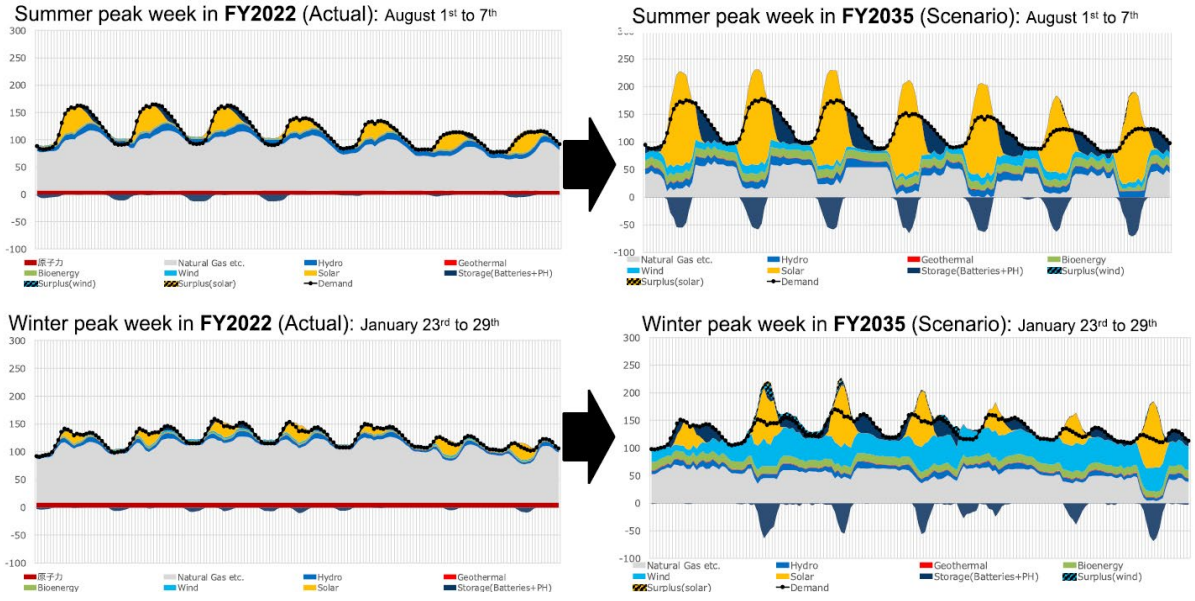
2.2 Solar's dominance in high-renewable scenarios further increases the potential for midday price suppression

ACCR reviewed several high-renewable energy scenarios to assess projected trends in Japan's generation mix. Both REI and Berkeley Lab modelling suggest that solar power emerges as the primary source in high-renewable scenarios, indicating that midday prices will be further suppressed as Japan increases renewable generation in the next decade.

Under the REI's 80% renewable energy scenario[24, 25] for 2035 (Chart 3):

- solar energy dominates in summer, generating excess electricity during the day, which is stored in batteries for evening use or later periods
- wind energy takes a larger share of power generation in winter, reducing the grid's reliance on batteries due to wind's ability to produce electricity at night.

Chart 3: Solar dominates summer generation under the REI's 80% renewable energy scenario



Source: Renewable Energy Institute, Energy Transition Scenarios for Decarbonization Based on 80% Renewables Electricity by 2035, August 2024, p21.

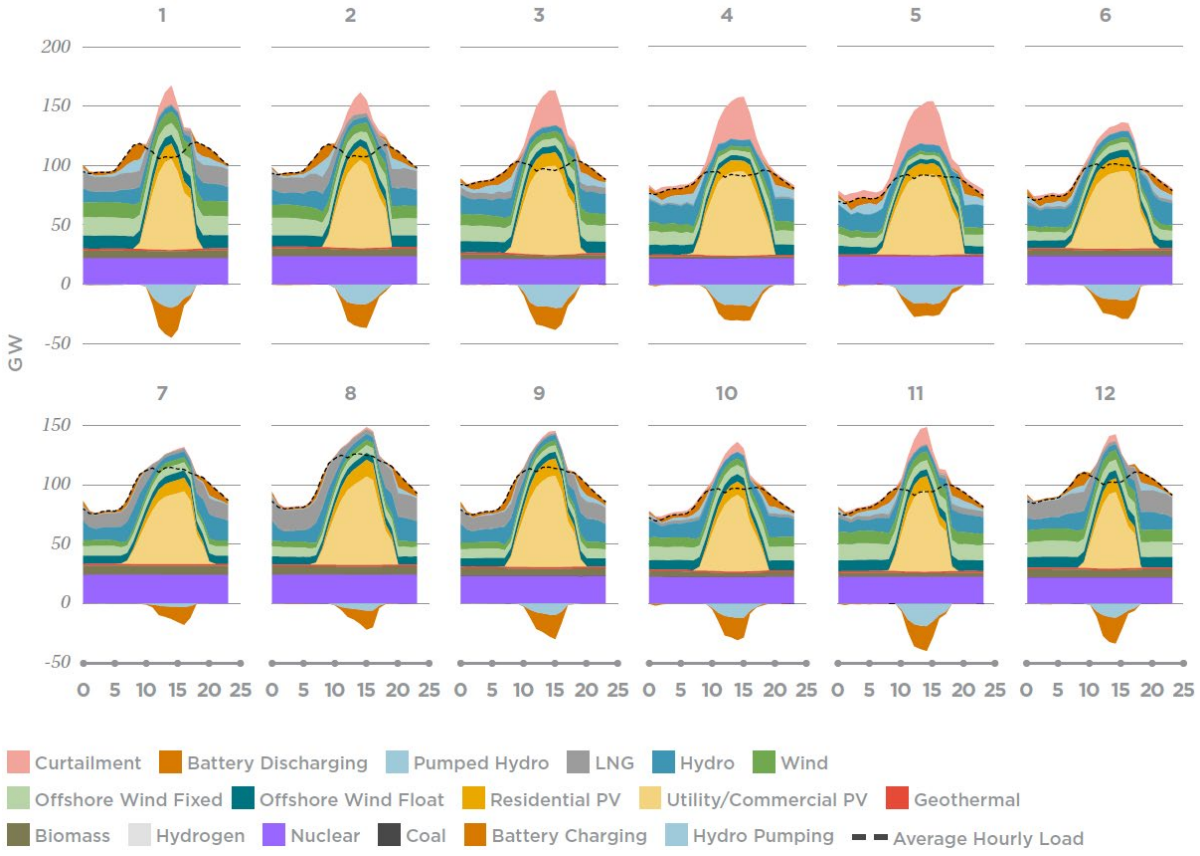
Under Berkeley Lab's Clean Energy Scenario[26] with 90% renewables:

[24] REI, Energy Transition Scenarios for Decarbonization Based on 80% Renewables Electricity by 2035, August 2024, p3, 21. (Japanese version)
[25] The scenario does not account for dynamic pricing, which if included, would likely align electricity demand more closely with renewable output as it could incentivise consumers to modify their energy usage behaviours following the natural solar and wind patterns.
[26] The Clean Energy Scenario limits annual deployment of clean energy generation to that needed to exceed the Japanese government's goal of non-fossil energy commanding a 59% share of electricity generation by 2030, and a 90% share by 2035.

- solar power emerges as the dominant generation source during midday periods throughout 2035 (Chart 4)

- clean energy deployment reduces Japan's wholesale electricity costs by 6%, reflecting the economic benefits of transitioning to a renewable-dominated energy mix.[27, 28]

Chart 4: Berkeley Lab's Clean Energy Scenario with 90% renewables projects solar energy as the dominant generation source during midday periods year-round in 2035



Source: Berkeley Lab, The 2035 Japan Report, February 2023, p28.

3. J-POWER is financially vulnerable to low-pricing periods in an evolving power market

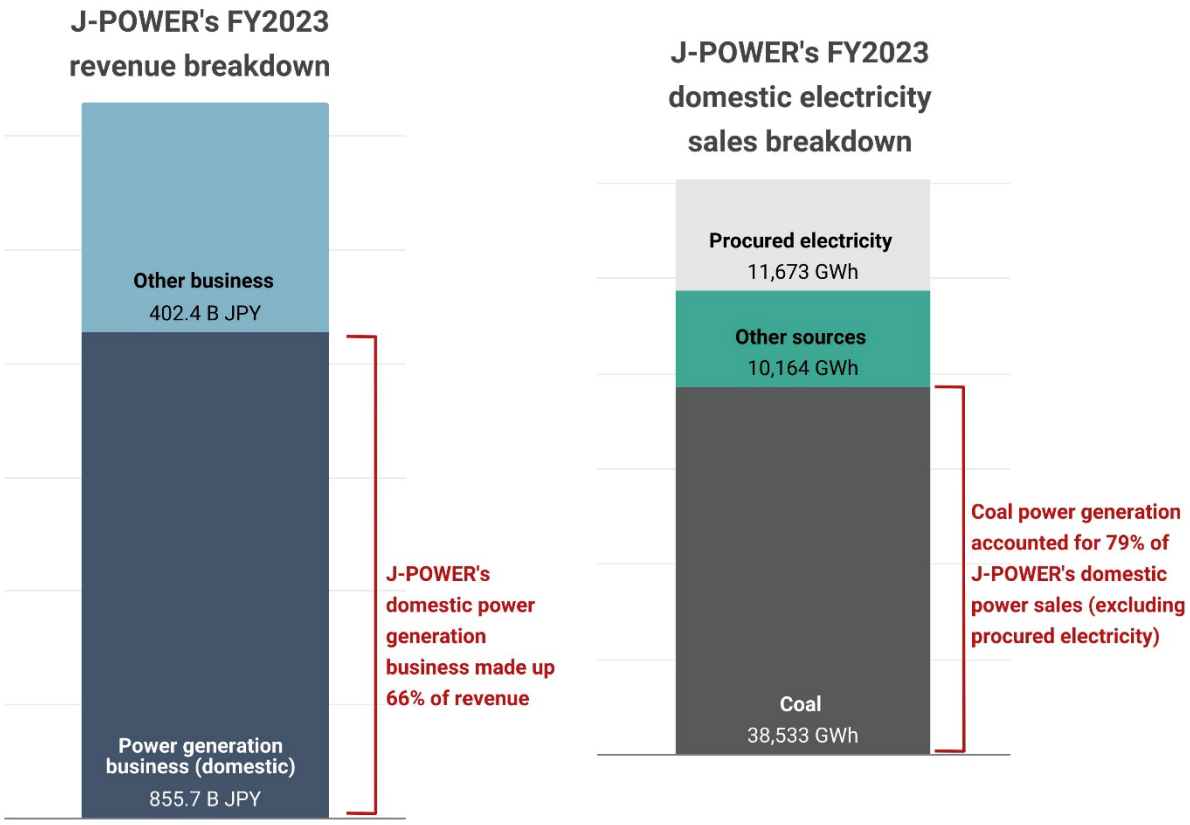
Baseload coal plants risk losing money during low pricing periods because the technical requirement to maintain generation output above minimum load levels means they cannot easily ramp down generation. As a major coal generator in Japan, J-POWER is highly exposed to the risk of having to sell electricity during low pricing periods.

[27] Average wholesale electricity costs are total wholesale electricity costs divided by total generation; wholesale electricity costs include costs for installed capacity, fixed O&M, fuel for generation, energy storage, and incremental inter-regional transmission investments. Distribution costs and existing transmission costs are not included.
[28] Berkeley Lab, The 2035 Japan Report, Feb 2023, p32.

J-POWER's vulnerability is heightened by its heavy reliance on domestic coal assets. In FY23, thermal power generation accounted for 79% of J-POWER's electricity sales in Japan,[29, 30] while domestic power sales represented 66% of its operating revenue[31] (Chart 5).

J-POWER's own Integrated Report quantifies the sensitivity of its domestic revenue to changes in generation volume and electricity prices. In FY23, J-POWER reported a 32% decline in consolidated operating revenue and a 31% decline in consolidated ordinary profit, with lower domestic thermal generation and electricity prices contributing to this drop.[32]

Chart 5: J-POWER's domestic power generation business makes up two thirds of the company's revenue (left). Within this, coal accounts for 79% of domestic electricity sales (right; excluding procured electricity)



Source: Company disclosures.

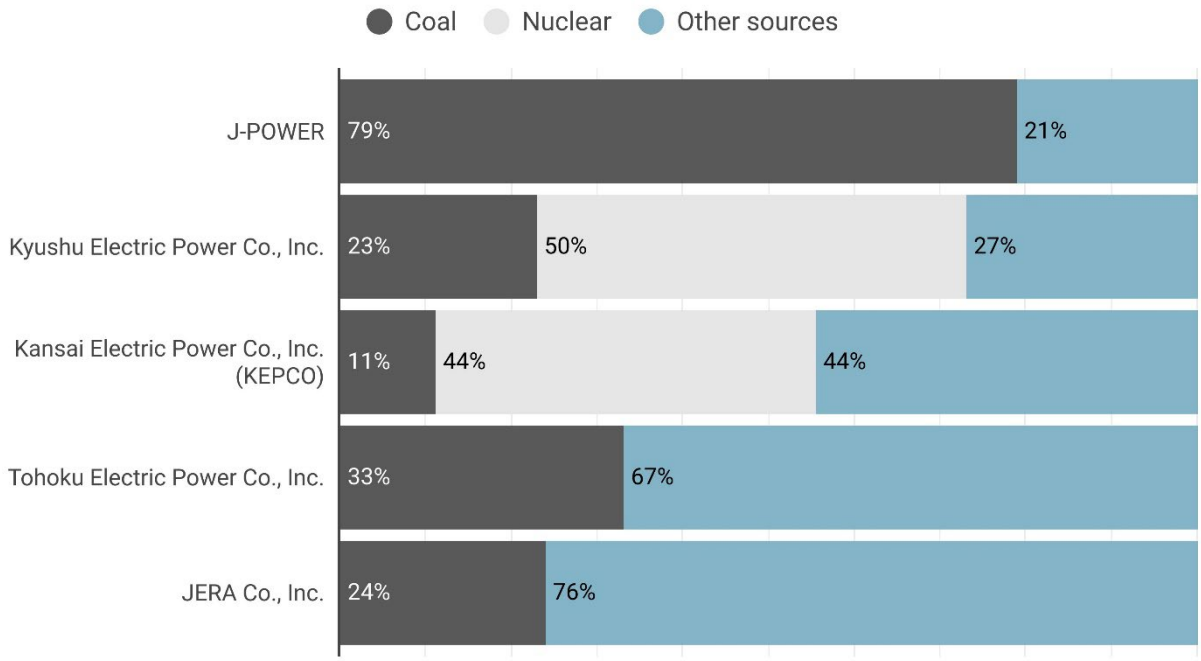
3.1 J-POWER's domestic generation portfolio is more coal-dependent than peers

ACCR's analysis of Japan's five largest power generation companies[33, 34] reveals that in FY23, 79% of J-POWER's coal-based domestic sales were more than double that of the next most coal-dependent

[29] Excluding procured electricity. 64% if including procured electricity.
[30] J-POWER, 2024 Integrated Report, p105. (Japanese version)
[31] J-POWER, 2024 Integrated Report, p31. (Japanese version)
[32] J-POWER, 2024 Integrated Report, p29. (Japanese version)
[33] Top 5 generators by volume in FY23 according to METI.
[34] By volume; excluding procured electricity.

company, Tohoku Electric Power (Chart 6). J-POWER's coal dependency places it at a significant disadvantage compared to peers, because volatile electricity prices and reduced demand for baseload coal pose greater risks to the company's profitability. Even when recognising that Japan's existing nuclear fleet is also a baseload generation source with limited flexibility, J-POWER remains the most dependent on inflexible generation sources compared to its peers.

Chart 6: J-POWER's domestic portfolio relies more heavily on inflexible generation sources compared to peers (by sales or generated volume in FY23)



Source: Company disclosures.

3.2 Short-term pricing forecasts see a decline in J-POWER's domestic thermal revenue throughout upcoming summer periods

ACCR assessed the pricing impacts on J-POWER's domestic thermal revenue using BNEF's power price outlook:[35, 36]

- Domestic thermal revenue is projected to peak in 2H24 (see chart 7), driven by higher forecast prices, which reflect higher fuel import costs due to the upcoming colder-than-average winter temperatures, a tighter supply outlook, and demand tailwinds expected by BNEF.

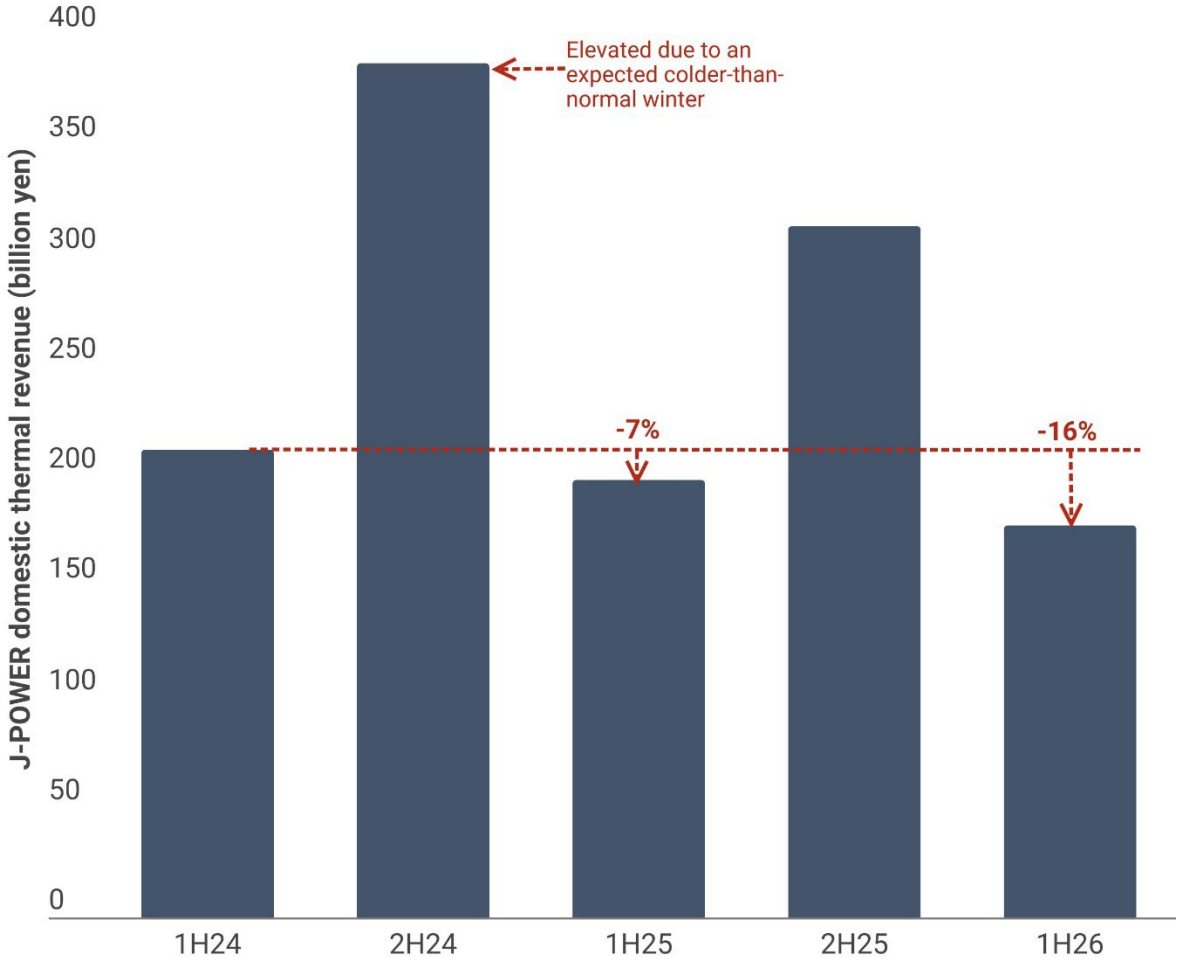
- Revenue is then expected to decline because of the:

[35] The estimation assumes J-POWER's domestic coal capacity factor remains at the FY24 forecast level of 61%, with seasonal variations mirroring those from FY22 and FY23. It also assumes J-POWER sells 100% of electricity generated from its thermal assets, without accounting for transmission or other losses, and that all electricity is sold on the wholesale market.
[36] BNEF, Japan Power Market Outlook 2H 2024: Tailwinds Ahead, Oct 2024, p2. (Japanese version)

- downward pressure exerted by increased solar generation on wholesale prices in summer periods 1H25 and 1H26
- easing of fuel import costs in the winter 2H25, relative to 2H24.

- When focusing on the summer periods, where solar output is expected to be higher, J-POWER's revenue could decline by 7% in 1H25 compared to 1H24, with a further drop of 16% expected in 1H26.

Chart 7: ACCR projects J-POWER's domestic thermal revenue will decline as solar growth suppresses summer prices



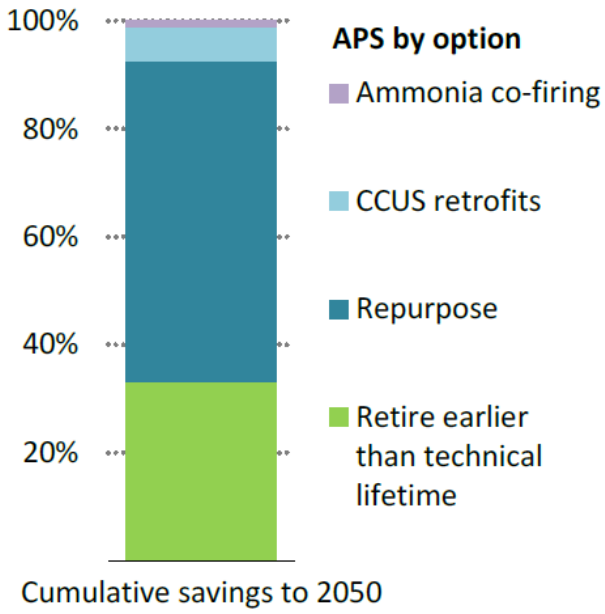
Source: BNEF price forecasts and ACCR estimates.

4. Coal plant flexibility is often enhanced early in an energy transition

4.1 Enhancing coal plant flexibility as a strategic lever in the energy transition

The IEA recommends that Japan should address emissions from its newer coal power plants - and limit the risk of stranded assets - by repurposing them as flexible energy sources.[37] The flexible usage of repurposed coal plants accounts for 60% of projected global CO_2 emissions reductions through to 2050 under the IEA's Announced Pledges Scenario (APS), with early retirements contributing the second largest share at 33%. (Chart 8)

Chart 8: The repurposing of coal plants for flexibility is widely adopted under the IEA's APS



Source: IEA, Coal in Net Zero Transitions, Nov 2022, p66.

In addition to reducing coal use and lowering carbon emissions, the repurposing of coal plants for flexibility is an effective strategy that:

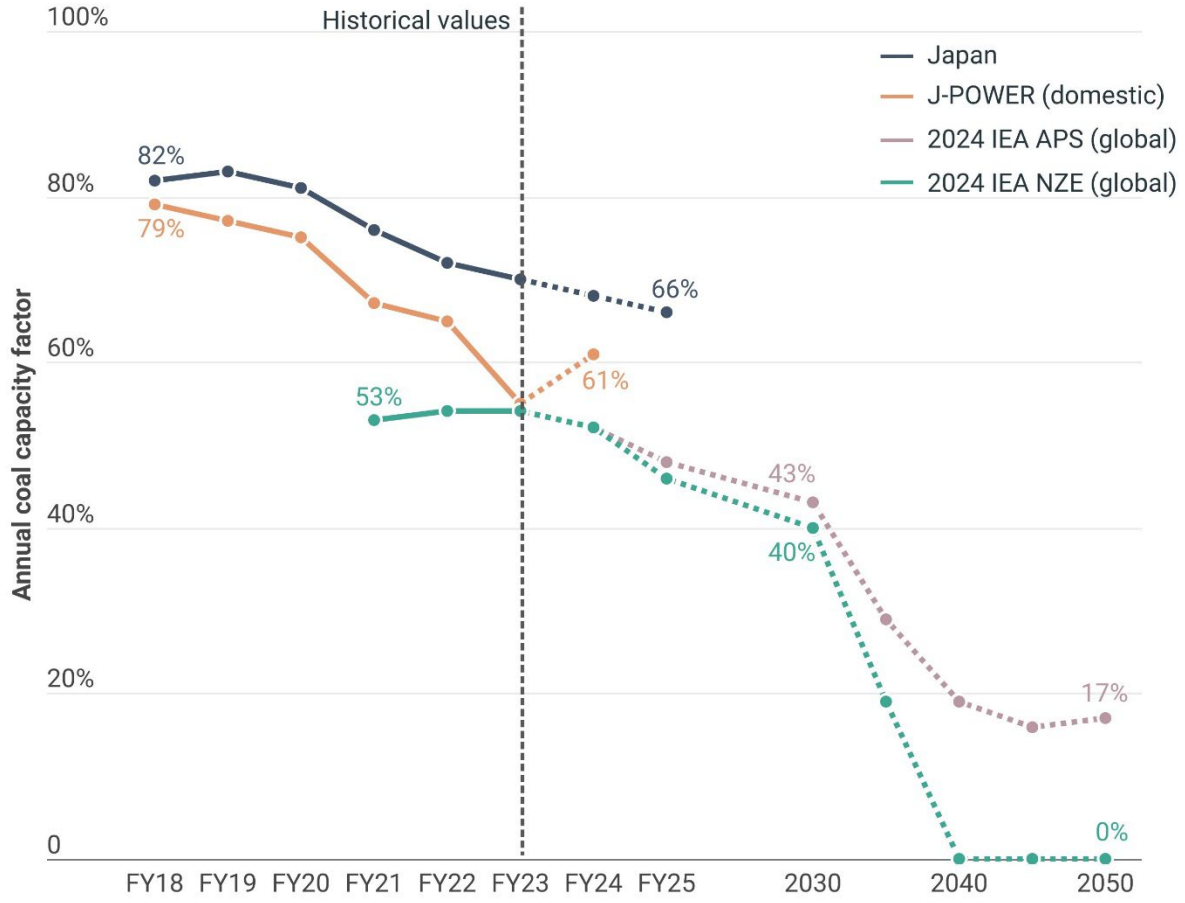
- manages financial risk by mitigating:
    - the company's exposure to low pricing periods, minimising coal generation when solar power is abundant and preventing revenue cannibalisation
    - the carbon levies on fossil fuel imports expected to be introduced within Japan from 2028
- allows them to be available and support system reliability during periods of peak demand

[37] IEA, Innovation and market reform needed to drive Japan's clean energy transition, IEA policy review finds, Mar 2021.

- makes way for more renewable energy integration and reduces renewable energy curtailment.

J-POWER's domestic thermal capacity factor[38] has been consistently below Japan's national average across FY18 to FY23 (see Chart 9). Based on both historical and BNEF forecasts, the national average coal capacity factor for Japan has a clear downward trend, declining from 82% in FY18 to 66% in FY25.[39] This is also supported by the IEA's global APS and Net Zero Emissions (NZE) scenarios, which both suggest that the world's average coal capacity is in decline (see Chart 9).[40, 41] Japan and J-POWER are unlikely to be immune from this long-term global trend, highlighting the urgent need for the company's baseload coal plants to invest in flexibility to adapt to changing market dynamics.

Chart 9: J-POWER's declining coal capacity factors reflect efficiency challenges and align with the downward trends forecast for Japan and global coal utilisation



Source: Company disclosures, BNEF (forecast for Japan coal capacity factor), IEA

Reducing thermal capacity factors by operating a flexible coal fleet represents an opportunity for J-POWER to reduce emissions. For example, if J-POWER were to achieve the capacity factors of 43%

[38] J-POWER, 2024 Integrated Report, p105. (Japanese version)
[39] BNEF, Japan Power Market Outlook 2H 2024: Tailwinds Ahead, Oct 2024, p21. (Japanese version)
[40] IEA, World Energy Outlook 2024, Oct 2024, p305, 311.
[41] Implied capacity factors under the APS and NZE scenarios for unabated coal power plants were calculated using generation volumes and capacity projections.

and 40% by 2030, as suggested under the IEA's global APS and NZE scenarios respectively, this could translate to domestic Scope 1 emissions reductions of 62% and 64% from 2013 levels.

Increasing coal plant flexibility and lowering minimum load levels are common international practices (Table 1) and are critical to navigating the complexities of the energy transition.

Table 1: Global examples show repurposing coal is a proven strategy

Country	Current state of coal phase out	Coal flexibility retrofit examples/policies
China	Although China has been increasing coal capacity, the increase in renewable power is driving down China's coal power generation.[42]	The Chinese government now has a program mandating "flexibility retrofits" on more than 200 GW of coal plants, requiring them to be able to cycle up and down as required.[43]
India	In the first quarter of 2024, India's share of coal-fired power capacity dropped below 50% for the first time since the 1960s.[44]	Last year, the central electricity authority of India published a comprehensive report on the flexible operation of thermal power plants.[45]
Indonesia	Indonesia has recently announced plans to retire all coal plants by 2040, bringing forward an earlier target of 2056.[46]	Coal flexibility retrofits, along with early retirements, are one of the investment focus areas in Indonesia's JETP Comprehensive Investment and Policy Plan (CIPP).[47]
Australia	Ten large coal-fired power stations have closed since 2012, and the market operator expects that 90% of remaining capacity will be closed by 2035, and all before 2040.[48]	Australia's largest coal generation company has achieved an initiative that enables it to shut down coal units during midday hours, effectively making way for rooftop and large-scale solar to dominate the grid.[49]
United Kingdom	The last coal-fired power station was shut down in September 2024.[50]	The idea of making coal plants more flexible to survive the transition was explored as early as 2013.[51]
United States	On track to close half of its coal capacity by 2026.[52]	It was demonstrated that coal plants can become

[42] The Guardian, China's coal-fired power boom may be ending amid slowdown in permits, Aug 2024.
[43] The Oxford Institute for Energy Studies, Guide to Chinese Climate Policy, Part II: Domestic Policies, 5: Coal, 2022.
[44] Institute for Energy Economics and Financial Analysis, Surge in India's renewables tendering set to keep coal's share below 50% in total installed capacity, May 2024.
[45] Indian Government, Flexibilisation of coal fired power plant, Feb 2023.
[46] Argus, Indonesia advances coal-fired power phase-out to 2040, Nov 2024.
[47] JETP Indonesia, Comprehensive Investment and Policy Plan 2023, Nov 2023, p3.
[48] Australian Energy Market Operator, Energy roadmap lights the way to net zero, Jun 2024.
[49] RenewEconomy, Coal generator switches off to make room for solar in significant boost to renewable switch, Oct 2024.
[50] The Guardian, End of an era as Britain's last coal-fired power plant shuts down, Sep 2024.
[51] Reuters, To survive, coal power plants must become more flexible: Kemp, Nov 2013.
[52] IEEFA, U.S. on track to close half of coal capacity by 2026, Apr 2023.

		flexible resources in 2013.[53] Since then, the average capacity factor has decreased, with more plants operating at lower capacity factors and cycling production to meet demand.[54]
Germany	Coal capacity is underused because of the growing share of renewable energy in the mix. The share of coal in the mix has dipped from 48% nine years ago to 19% in the first half of 2024.[55]	Minimum load levels of 12% were achieved in 2019 for some coal power units.[56]

4.2 J-POWER should prioritise investment in flexibility, which is a proven strategy in decarbonising coal plants

Based on ACCR's analysis, we recommend that J-POWER should:

1. prioritise investments in proven initiatives that lower minimum load levels and increase the flexibility of domestic coal plants, and
2. incorporate this into its decarbonisation strategy.

Although J-POWER recognises the growing importance of flexibility in thermal power to support renewable energy expansion[57], and aims to reduce the financial impact of lower load factors by enhancing plant operations, including lowering minimum load levels and scheduling shutdowns based on supply and demand forecasts,[58] the company has not disclosed detailed plans as to how it will achieve this.

Further, as highlighted in ACCR's previous briefing[59], J-POWER is still relying heavily on unproven and costly technologies to decarbonise its coal fleet, such as ammonia co-firing, coal gasification and CCUS.[60] This contrasts with the IEA's APS scenario, which projects that ammonia co-firing and CCUS retrofits will contribute to only 7% of emissions reductions globally (see Chart 8).

As Table 1 demonstrates, there are numerous real-world case studies where companies - and governments in other countries - have invested in flexibility and emphasised established, lower cost methods of decarbonisation. The IEA has also commented that adjusting the control systems of coal plants to expand their operational range could be enough to achieve the flexibility needed.[61]

[53] National Renewable Energy Laboratory, Flexible Coal: Evolution from Baseload to Peaking Plant, Dec 2013.
[54] National Association of Regulatory Utility Commissioners, Recent Changes to U.S. Coal Plant Operations and Current Compensation Practices, Jan 2020.
[55] Clean Energy Wire, Germany's coal exit on track, no forced closures needed, Sep 2024.
[56] United Nations Economic Commission for Europe, Increase flexibility in coal-fired electricity generation, 2019.
[57] J-POWER, 2024 Integrated Report, p19. (Japanese version)
[58] J-POWER, 2024 Integrated Report, p30. (Japanese version)
[59] ACCR, Investor brief: Electric Power Development Co. Ltd. (J-POWER), June 2023.
[60] J-POWER, 2024 Integrated Report, p63. (Japanese version)
[61] IEA, Coal in Net Zero Transitions, Nov 2022, p67.

To ensure J-POWER is working to avoid any deterioration in the profitability of its domestic business, investors should ask the company to clarify how it will decarbonise its domestic thermal plants, and whether it will prioritise proven, lower cost emissions reduction methods that are used globally.

Doing so will help drive the company to keep pace with its domestic and international peers, and position it to deliver immediate emissions reductions, limit stranded asset risk (as highlighted by the IEA[62]) and protect long-term value for shareholders.

5. Questions for investors to ask J-POWER

Investors can incorporate the following questions into future engagements with J-POWER to better understand the risks of its strategy:

- How is J-POWER addressing the risk to long-term profitability as Japan's renewable energy share grows and demand for coal declines? Has the company evaluated the potential impacts if these assets remain inflexible? If no adjustments are made, the risk of the company's domestic business deteriorating in profitability may impact J-POWER's competitive position.
- Hydrogen, ammonia co-firing and CCUS retrofits for coal plants are high-cost and unproven emerging technologies. How will J-POWER manage the financial risks of these investments in these technologies, given the global trend towards the adoption of flexible coal operations over emerging technologies?
- How are J-POWER's domestic coal plants adapting to an electricity grid that features more solar and increasing price volatility?

[62] IEA, Innovation and market reform needed to drive Japan's clean energy transition, IEA policy review finds, Mar 2021.

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About ACCR

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