KONRAD ADENAUER STIFTUNG

Japan's Energy Security, Decarbonisation, and the Green Transformation (GX)

Dr Lorenz Granrath

Executive Summary

Japan is a highly industrialized island nation with few domestic resources and heavily dependent on atomic energy and fossil fuels, which still deliver around 83% of the primary energy supply. Atomic power was scaled back after the Fukushima catastrophe in 2011 but has revived somewhat and is now being pushed by the current government, which does not favor renewable energies. Japan, however, has very good potential for renewable energies, with more sun, wind and biomass plus volcanoes with excellent geothermal energy sources when compared to Germany. Nevertheless, it has just half the RE quota.

In the energy sector, Japan has a very well-organized industry with 10 utilities and trading houses, which use and even partly own (!) fossil fuel sources in other Asian countries. They collaborate well with the government and of course prefer the traditional fossil and nuclear energy sources. Adding to this low incentive to switch to renewables are also some natural challenges, like vast mountainous areas covering 70% of Japan, many islands, and steeply sloping coastal shelves, which increase the costs for exploitation. On the other hand, renewable generation is cheap and would make Japan more independent of imports.

Japan committed early to reducing emissions and now faces a critical energy crossroads due to geopolitical change, the necessity of securing a stable supply, and the environmental mandate of achieving net-zero emissions. Consequently, the national strategy is governed by the energy doctrine S+3E: Safety, Energy Security, Economic Efficiency, and Environment. The lessons from the 2011 Fukushima Daiichi Nuclear Power Station accident remain the "starting point for Japan’s energy policy," establishing safety as the highest priority.

The strategy guided by the S+3E principle has been laid out in the 7th Strategic Energy Plan (SEP) approved in 2025 with the following Key Strategic Pillars:

Renewable Energy: The 7th Strategic Energy Plan is the first to designate renewables as the largest future power source, but with a non-binding target of 40–50% by 2040. Despite high potential (solar, wind, geothermal) in Japan, deployment is slow due to structural barriers, utility monopolies, and physical constraints such as a lack of suitable land.

Nuclear Power: The strategy involves a controversial recommitment to nuclear power, aiming for it to make up approximately 20% of the electricity mix by 2040 to provide stable base load power. Critics argue that this is a political decision to avoid retiring old reactors, which, however, present safety risks in an "earthquake country" and which are also inflexible and block the deployment of renewables. However, just this January, the current Prime Minister, Takaichi, announced a stronger focus on nuclear power.[1]

Fossil Fuels: Thermal power is to maintain a significant role (30–40% by 2040) to ensure grid stability. The government is promoting hydrogen and ammonia co-firing and carbon capture (CCUS) technologies to decarbonize this sector, a strategy that risks "carbon lock-in" and stranded assets. Critics say this is because of the engagement of many Japanese companies, especially the trading houses, in fossil fuel sources in other Asian countries.

The **GX Initiative** is Japan's core industrial policy to stimulate ¥150 trillion in public-private investment through state-led financing mechanisms, such as GX Transition Bonds and phased carbon pricing. While it successfully mobilizes capital and supports the narrative that decarbonization can drive economic growth, it has been criticized for reversing market liberalization and protecting incumbent power companies.

Challenges and Outlook

After falling energy consumption for years, Japan faces an imminent "demand crisis" as electricity demand is expected to increase by up to 20% by 2040, driven by digitalization, AI, and data centers. The central challenge in the transition is balancing energy security with the need for rapid decarbonization, while overcoming powerful institutional inertia and the influence of incumbent industries who favor centralized, large-scale assets and fossil fuels over decentralized renewables.

A positive development can be seen in local governments, which are already acting in a more environmentally friendly way, but the central industry-government nexus – which has very strong advantages in efficiently facing challenges – must still move collectively towards renewable energies to escape import dependencies and reduce prices.

Challenges for the Energy System in Japan

Introduction

Japan is a highly industrialized nation with a high standard of technology. For its energy, Japan relied in the past primarily on nuclear energy and fossil fuels, which had to be imported. A big change came after the reactor accident at Fukushima Daiichi in 2011, when nuclear reactors were shut down and the population developed an aversion to nuclear power. This led to more fossil fuel usage which has now become a critical problem because of its environmental impact, recent geopolitical risks that have become greater since the Ukraine war, and political changes in many other countries.

Japan is now at critical energy crossroads defined by the need to secure a stable supply and respond to global warming. Additionally, the decline in energy consumption over past years will change into an increase in energy demand due to Digitalization DX with the growth of AI and data centers, with an estimated increase of up to 20% by FY2040. Simultaneously, Japan is striving to achieve its climate goal of a 73% GHG reduction by FY2040 (versus FY2013).[2]

One side of the problem is Japan's low energy self-sufficiency, even by international standards, as can be seen from a graph on the website of METI, showing just 12.6% in 2022, rising to 15.2% in FY2023[3]. The value is still less than half of Germany's, which also fell in the past few years due to the Ukraine war and the retirement of atomic power plants, with a rate of 35.3% in 2022 falling to 30% in 2024. Higher values are found in France, due to nuclear power, and other countries are over 100% due to domestic sources of fossil fuels.[4]

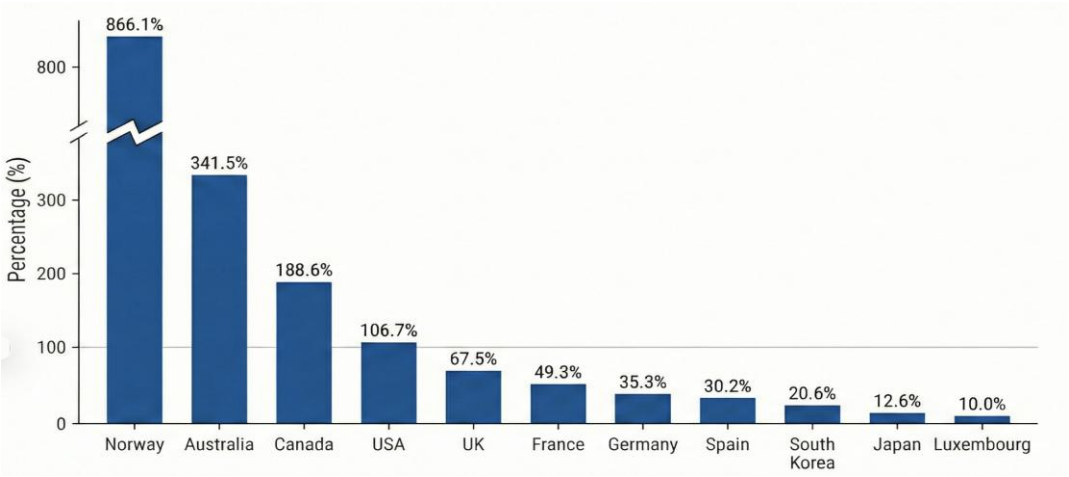

Figure 1: Comparison of primary energy self-sufficiency rates among major nations; graphic provided by the author

Japan had to switch off nuclear reactors after the accident in 2011 and is working on slowly increasing its self-sufficiency rate again. The graph below gives an excellent picture of how atomic power influenced self-sufficiency, even if there is room for debate over whether atomic power really falls under self-sufficiency, as the nuclear fuel itself had to be imported from other countries.[5]

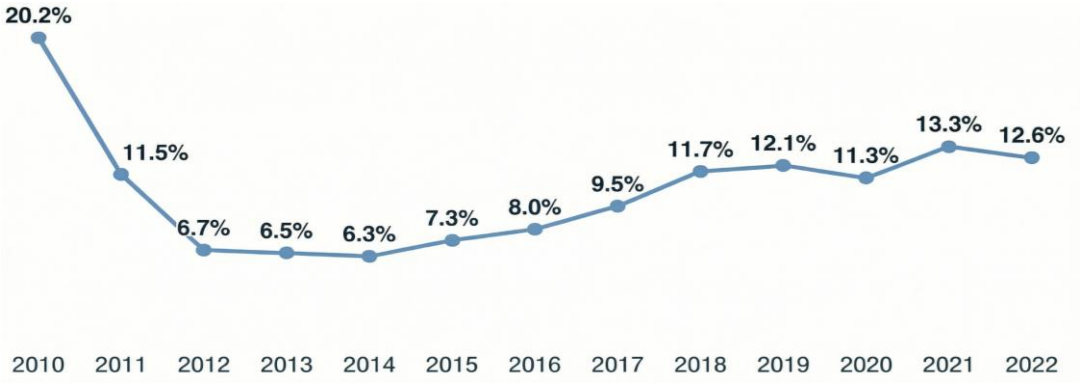

Figure 2: Energy self-sufficiency ratio in Japan[6]; graphic provided by the author

The continued reliance on fossil fuels, despite a temporary reduction due to nuclear power before 2011, highlights the system's persistent vulnerability. After the Fukushima accident (post-2011), the dependency on fossil fuels increased again.

Table 1: Trends in Japan's Primary Energy Supply Mix (FY1973–FY2019)

Energy Source	FY 1973 (1st Oil Crisis)	FY 2010 (Pre-Fukushima)	FY 2019	FY 2024*
Dependency on Fossil Fuels	94.0%	81.2%	84.8%	83.5%
Oil	75.5%	40.3%	37.1%	36.5%
Coal	16.9%	22.7%	25.3%	26.1%
LNG	1.6%	18.2%	22.4%	20.9%
Nuclear Power	0.6%	11.2%	2.8%	6.5%
Renewable Energy (≠Hydro)	1.0%	1.0%	4.4%	6.3%
Hydroelectric	4.4%	3.3%	3.5%	3.7%

*Source: Ministry of Economy, Trade and Industry Japan A (2022) / *IEA 2025*

Regarding Renewable Energy, Japan has greater potential than Germany in all areas. It has more sunshine, more forests that also grow faster because of the climate, more wind and also many volcanoes that deliver plenty of geothermal energy.

The realization of renewable energies however also faces challenges. Japan is not much bigger than Germany with an area of 377.975 km^2 compared to 357.580km^2, but this area is spread over many islands. In addition, 70% of the country is covered with forests and the rest is densely populated. The forests are not cultivated and it is difficult to harvest wood even for biomass, as there are no roads, but it is also hard to set up wind turbines. The coastal shelf falls very steeply, so that only floating wind turbines are possible there. Despite the challenges, the potential is high, but the expansion of renewable energies has been and continues to be very slow. Despite this great potential and the need to produce domestically-sourced energy, the share of renewable energies in Japan's energy mix is only half that of Germany's.

This is reflected also in the national strategy, which is planned and implemented by METI (Ministry of Economy, Tade and Industry) through the 7th Strategic Energy Plan (SEP), the Green Transformation (GX) Initiative and Global Warming Countermeasures. They are based on a crisis-driven, portfolio approach called S+3E: Safety, Energy Security, Economic Efficiency, and Environment. The resulting FY2040 energy mix aims for diversification: Renewable Energy (40–50%), Nuclear Power (approx. 20%), and Thermal Power (approx. 30–40%).

Key Strategic Challenges and Criticism

Focus Area	Policy Rationale	Core Reason for Slow Transition
Low Renewables (40–50% by 2040)	Maximizing RE as a "major power source" while minimizing integration costs and national burdens.	Structural Inertia: Utility monopolies and METI are "organized to not fast increase" solar, wind; a "new kind of monopoly". Physical Constraints: Lack of suitable land, scarcity of EPC (Engineering, Procurement, Construction) resources drives up costs, making RE total system costs high.
Revival of Atomic Power (approx. 20% by 2040)	Nuclear provides excellent supply stability, technological self-sufficiency, and the constant output required by critical infrastructure (data centers etc.).	Political Safeguarding: The 20% target is primarily a "political issue" to avoid the difficult decision of retiring old reactors. Experts cite the danger of old reactors in an "earthquake country" and call claims regarding nuclear clean-up "false reality".
Sticking to Fossil Fuels (30–40% by 2040)	Thermal power provides essential inertial and synchronous power for grid stability. Transition relies on decarbonization of fossil fuels via Hydrogen/Ammonia co-firing and CCUS.	Lock-in Risk: Investments in CCUS and ammonia co-firing risk locking in fossil fuel infrastructure. The pursuit of a high "self-development ratio" (overseas control of LNG) is a strategic risk that increases exposure to geopolitical and market fluctuations.

Japan's strategy has two key aspects that could be lessons for Germany's Energiewende: the value of an "All-of-the-Above" portfolio approach (using nuclear as a decarbonized hedge against uncertainty) and the utility of the GX Initiative as an integrated industrial policy framework that uses upfront state financing (GX Transition Bonds) and phased carbon pricing to de-risk critical investments.

Tomas Kåberger, Renewable Energy Institute, claims that the “only consistent explanation of all political decisions in Japan since 2011 is the overarching target of the Government of Japan to ensure that none of the incumbent power companies goes bankrupt. The reason is that banks, pension funds and insurance companies are heavily invested in these companies and if the power companies go bankrupt, they may bring down such institutions which in turn would have to be rescued by the government. So, changing the power system in Japan is not a technical problem. Nor is it an economic problem. It is a problem of financial institutions.”

The S+3E Principle and Geopolitical Influences

Japan's energy policy is fundamentally shaped by its acute vulnerability as a resource-poor island nation. Its primary energy self-sufficiency rate is extremely low, and this dependency makes Japan highly susceptible to fluctuations in international energy prices and geopolitical risks. This leads to the foundational principle guiding the energy policy S+3E:

Figure 3: The Energy Strategy of METI, the S+3E and Green Transformation strategy; graphic provided by the author

The elements in detail:

- Safety (S): The experiences and lessons from the 2011 Fukushima Daiichi Nuclear Power Station accident remain the "starting point for Japan’s energy policy," establishing safety as the highest priority. The concept also includes the strengthening of disaster-prevention measures and building public trust through stricter regulations and transparent oversight.

- Energy Security (E): Heightened geopolitical risks, such as Russia’s aggression against Ukraine and soaring tensions in the Middle East, have reinforced the need for a stable energy supply. The concept calls for diversifying energy sources (nuclear, renewables, LNG, hydrogen, etc.), and the reduction of reliance on specific foreign suppliers. At home the domestic and regional energy infrastructure has to be strengthened and resilience against geopolitical risks or supply-chain disruptions has to be built up.

- Economic Efficiency (E): This principle is about ensuring that energy remains affordable and supports economic growth. Reducing costs in electricity generation, transmission, and consumption can be done through promoting competition in energy markets, encouraging innovation and efficient technologies and balancing energy prices with industrial competitiveness

and household affordability.

- Environment (E): This pillar encompasses Japan's commitment to lowering GHG emissions, expanding renewable energy, and pursuing carbon-neutral technologies to address climate change.

In practice, the application of these principles is heavily influenced by established interests.

According to Mika Ohbayashi, Director of the Renewable Energy Institute (REI), incumbent heavy industry and major power companies have successfully promoted a narrow definition of Energy Security. Their perspective prioritizes a stable supply from large-scale, centralized assets like imported fossil fuels and nuclear power, often downplaying the security benefits of leveraging domestically produced renewable energy. This narrow focus on centralized assets serves to protect existing business models and provides the justification for resisting a faster, more decentralized transition to renewables – a core challenge detailed later in this analysis.

This creates a significant tension between Economic Efficiency and the Environment. Globally, the levelized cost of electricity (LCOE) for new utility-scale solar is already lower than that of new nuclear power. However, the establishment in Japan frequently counters this trend by highlighting the "integration costs" of renewables – such as grid reinforcement and backup power – to argue for the continued economic viability of their conventional assets.

This inherent conflict underscores the need for a pragmatic and diversified approach. A former executive at one of the top Electric Power Companies, who does not want to be named, argues that a successful S+3E strategy cannot afford to be dogmatic but must leverage a wide portfolio of technologies and resources. How this philosophy is applied is being put to the test by an imminent surge in national energy demand.

The Imminent Demand Crisis

The challenge of decarbonization is threatened by a dramatic shift in consumption trends. After declining since 2007, electricity demand is now expected to increase by up to 20% by 2040. This surge is driven primarily by electrification and the rapid proliferation of the Digital Transformation (DX), especially the increasing usage of AI and data centers to do the necessary computational work. They run 24 hours a day and can go up to hyperscale facilities using 100MW energy, which is almost equivalent to a small city. The prediction of the increase in Japan can be said to be rather cautious.

For new data centers it is of course necessary that the energy is produced with, ideally, renewables or at least carbon neutral energy sources, necessitating a huge investment in enlarging the electricity supply infrastructure. To prevent this increase from undermining economic growth, Japan must provide "enough decarbonized electricity that matches the demand at competitive prices"[7].

Policy Framework: SEP, GX and GWC

Japan's response to its profound energy challenges is not a single policy but a complex, interconnected framework comprising the Green Transformation (GX) strategy, the Strategic Energy Plan (SEP), and the Plan for Global Warming Countermeasures (GWC). These three pillars guide the nation's decarbonization pathway, relying on simultaneous implementation across different timelines and mechanisms. Understanding how they interact is crucial to deciphering the nation's strategic direction, its internal contradictions, and its prospects for achieving a secure, affordable, and decarbonized energy future.

The 7th Strategic Energy Plan (SEP)

In 2002 Japan passed the Energy Policy Basic Act under which the national government must periodically formulate a Strategic Energy Plan. The draft plan is prepared by the Advisory Committee at the Agency for Natural Resources and Energy, ANRE, under the Ministry of Economy, Trade and Industry (METI). After public consultations and possible revision, the plan is formally adopted by a decision at a Cabinet meeting.[8]

Japan's long-term policy vision serves as a critical roadmap for its industrial and economic future. The integrated implementation of the Strategic Energy Plan goes together with the Green Transformation (GX) 2040 Vision and includes the expected rise in electricity demand driven by the progress of Digital Transformation (DX) and AI data centers. The core objective is to provide a sufficient supply of competitive, decarbonized electricity that can support sustained economic growth and strengthen the nation's industrial competitiveness.

The core principles guiding Japan's policy direction toward 2040 are the following:

- Prioritize Economically Rational Measures: as Japan follows decarbonization goals, it is essential to adopt a perspective that prioritizes measures that are economically rational and effective in reducing CO2 emissions.

- Twin Pillars of Efficiency and Non-Fossil Fuels: The strategy recognizes the importance of thorough energy efficiency improvements to enhance resilience against energy crises. Simultaneously, it places great importance on electrification and a decisive shift to non-fossil fuel sources to meet the 2050 carbon neutrality goal.

- Maximize Use of Both Renewables and Nuclear Power: The policy explicitly calls for an end to "dichotomous discussions" where renewable energy competes against nuclear power. Instead, it mandates a strategy that maximizes the use of both energy sources to build a robust, decarbonized power system.

- Foster an Environment for Large-Scale Investment: Recognizing that this transition is a massive industrial and financial undertaking, the framework aims to fundamentally strengthen the supply of decarbonized power by improving the business and financing environments. This includes enhancing the predictability of returns on investment and promoting active, large-scale, long-term investments in new power sources and grid development.

The strategy of METI follows of course the strategy favored by the industry, that is the utilities with their existing atomic power plants as well as the many Japanese companies that invest in or operate fossil power sources and plants. Table 2 shows the outlook for FY 2040:

Table 2: Outlook for Energy Supply and Demand in FY2040[9]; graphic provided by the author

		Fiscal Year 2023 (Preliminary Report)	Fiscal Year 2040 (Outlook)
Energy self-sufficiency rate		**15.2%**	**Approx. 30-40%**
Amount of electricity generated		**985.4 billion kWh**	**Approx. 1.1 to 1.2 trillion kWh**
Power generation mix	**Renewable energy**	**22.9%**	**Approx. 40-50%**
	Solar PV power	9.8%	Approx. 23% to 29%
	Wind power	1.1%	Approx. 4-8%
	Hydropower	7.6%	Approx. 8-10%
	Geothermal power	0.3%	Approx. 1-2%
	Biomass	4.1%	Approx. 5-6%
	Nuclear power	**8.5%**	**Approx. 20%**
	Thermal power	**68.6%**	**Approx. 30-40%**
Final energy consumption		**300 million kL**	**Approx. 260 to 270 million kL**
GHG reduction rate (compared to FY2013)		**22.9% (%)** (Actual results in FY2022)	**73%**

Mika Ohbayashi (REI) acknowledged that this is the first SEP where renewables are projected to be the largest portion of the mix but called the overall plan "not very ambitious". The target of 40–50% for 2040 leaves only a minimal increase (10–20%) necessary to meet the assumed 50–60% goal for 2050, suggesting a decelerating effort where growth occurs at the beginning but stalls in the crucial final years before the carbon neutrality deadline. Based on these numbers, Japan is well below international standards and the goals set here are not advancing the country to international leadership.

The Green Transformation Strategy (GX2040)

The Green Transformation (GX) Initiative represents Japan's core strategy for achieving a "triple breakthrough" of emissions reduction, economic growth, and energy security. Framed as a thorough overhaul of industrial and energy policy, it aims to stimulate ¥150 trillion in public-private GX investment over the next decade by transforming Japan's industrial structures and leveraging its technological advantages in decarbonization. This strategy is operationalized through a suite of state-led financial and regulatory tools. The primary financing mechanism consists of ¥20 trillion in government-issued GX Economy Transition Bonds, designed to provide upfront support for innovation and high-risk decarbonization projects. Additionally, a "growth-oriented carbon pricing" concept has been introduced, consisting of two pillars: a future Carbon Levy (starting FY2028 at a low initial rate, targeting fossil fuel importers) and an Emissions Trading Scheme (GX-ETS). The GX-ETS starts with a voluntary trading market among the GX League (over 550 companies), with auctioning of allowances for power companies introduced gradually starting around FY2033 to expedite power sector decarbonization. This phased approach is designed to prevent carbon leakage and avoid hurting the Japanese economy.

According to Mika Ohbayashi of the Renewable Energy Institute (REI), the GX strategy has initiated a significant narrative shift within the Ministry of Economy, Trade and Industry (METI), fostering the recognition that decarbonization can be a driver of economic growth rather than a loss. However, Ohbayashi argues that this reliance on state-led financing signifies a partial reversal of the past decade's emphasis on market liberalization. By deploying massive state-backed financial instruments, the government is reasserting control over strategic assets like nuclear and decarbonized thermal power, viewing market mechanisms as too slow and unreliable to deliver the investments required to meet its ambitious GX goals.

The GX strategy also supports technological development to utilize captured CO_2 (CCU), aiming for widespread consumption of concrete products and chemicals derived from recycled carbon by Phase 3 (Post-2050). Table 3 provides an overview of the CCU plan:

Table 3: Carbon Recycling Technology Roadmap (Summary)

Phase	Expected Spread	Cost Target
Phase 1 (Current)	Focus on high-value added materials and technologies not requiring hydrogen (e.g., specific concrete products).	Concrete Products: Must be reduced to 1/3–1/5 of current cost.
Phase 2 (expected by 2030)	Spread of technologies for large-volume commodity production, enabled by inexpensive hydrogen supply from 2050 onward.	Hydrogen: JPY 20/N-m^3 (cost at delivery site).
Phase 3 (from 2050 onwards)	Highly consumed: Chemicals, Liquid Fuels, Fuels (Gas, Liquid), Concrete Products.	Less than ¼ of current cost.

Source: Ministry of Economy, Trade and Industry Japan (2019)

Global Warming Countermeasures and Sectoral Targets

Japan began recognizing global warming as a policy issue in the late 1980s, alongside growing international scientific consensus. The Environment Agency (predecessor of today's Ministry of the Environment) started climate-related research and monitoring. In 1990, Japan first formulated an "Action Program to Arrest Global Warming". It was followed by the Kyoto Protocol in 1997, with Japan committing to reduce total greenhouse gas emissions by 6% compared to the FY 1990 level. Further initiatives followed until the Paris Agreement in 2015, a groundbreaking international agreement on global warming to which Japan committed.

Now the Global Warming Countermeasures and related acts also enforce decarbonization beyond the power sector. In the economy, roughly one third of the energy is used for power (electricity), while the other two thirds are used for buildings and industry.

- Building Efficiency: Measures mandate improvements in efficiency, setting a goal for new houses and buildings constructed after 2030 to achieve ZEH (Net Zero Energy House) and ZEB (Net Zero Energy Building) standards. In fact, the ZEH and ZEB standards include production of renewable energy through the house, for example through solar PV, and are not based on insulating buildings and making the building itself more energy efficient.

- Transport Decarbonization: The goal is for 100% of new passenger car sales to be EVs and HEVs by 2035. If all internal combustion vehicles were replaced by electric vehicles, an estimated 100 GW of solar panels would be required, demonstrating the scale of infrastructure investment needed.

- Industrial Decarbonization: The policy encourages the shift to non-fossil fuel energy sources in five key industries: iron and steel, chemical, cement, paper, and automotive, which together consume 40% of industrial energy.

Challenge I: Low Use of Renewable Energy

Japan has more sunny days and greater insolation than Germany; it has more forests that also grow 15% faster than in Germany; it has more and stronger winds – although sometimes also typhoons – and it has very good potential for geothermal energy. Despite this high potential and low fossil fuel reserves, the Japanese renewable energy share of 27% (estimate) is only half that of Germany, which has a 56% RE share in electricity.[10] The slow pace of adoption is attributable to deep structural, bureaucratic, and economic constraints.

Structural and Bureaucratic Impediments
Interviews conducted by the author with energy experts expose a pervasive institutional resistance to the expansion of decentralized renewables:

- Utility Monopoly and METI Influence: Tetsunari Iida (ISEP) argues that electricity policy is controlled by METI and incumbent utilities, which maintain a "new kind of monopoly". He claims the industry is structured to "try hard not to so fast increase or even try to decrease renewable energy" deployment.

- Bureaucratic Slowdown (Grid): Martin Messmer (M2PV) notes that the grid infrastructure is inadequate and aging (average age 42 in the USA, Japan likely similar). Expansion is slowed by bureaucracy, specifically the "check and act" policy, where utilities require proof of load before building necessary lines, which is deemed "complete nonsense".

- Political Culture: Martin Messmer (M2PV) describes the government's overall approach as "unambitious" and "very, very cautious" and focused on risk avoidance. Tetsunari Iida attributes the conservative policy core to career METI officials who are often "literature peoples" (non-technical) who rotate jobs frequently, leading to a failure to understand rapid changes in science and technology.

- Local vs National Government: Local authorities move faster than the national government. The Tokyo Metropolitan Government, for example, has moved ahead of the national government by requiring the installation of solar panels on newly built houses. Fukushima Prefecture is maintaining their goal to have 100% renewable energy by around 2040.

Physical and Economic Constraints
Japan's geography makes high-volume RE integration technically and financially difficult. First there are physical limits. Nicolas Vierge (Carbon 50) notes that most "good land" is already taken, forcing new solar projects onto sites with difficult terrain (e.g., 30-degree slopes). Offshore wind faces major cost problems, with targets rising to ¥30/kWh, due to high material and development costs, and the scarcity of specialized vessels and EPC resources.

System Cost vs. LCOE: While the Levelized Cost of Electricity (LCOE) for utility-scale solar has dropped significantly (to ¥9.9/kWh in 2023), experts argue that RE is not cheaper than dispatchable power when total system costs (integration, storage, flexibility) are included. METI is criticized for considering RE a "mature technology" and being unwilling to subsidize this cost gap.

Curtailment: Grid inflexibility remains a primary bottleneck, leading to the increasing curtailment, or wasting, of renewable energy. According to analysis by the think tank E3G, grid operation rules that prioritize nuclear power have led to record levels of renewable energy being discarded, reaching 1.76 TWh in FY 2023, up 3 times from the year before.[11] This practice of restricting the output of viable renewable assets is driven by dispatch rules that often favor the inflexible output of thermal and older nuclear plants.

Geopolitical Dependency
The reliance on imported RE components creates a security risk that discourages domestic deployment and investment. Tetsunari Iida from ISEP warns that Japan is highly dependent on China for the supply chain of solar PV and advanced batteries (e.g., Lithium Iron Phosphate (LFP) technology). He calls LFP the "new oil for coming decades," but notes that Japanese and Korean companies have "no capacity and no technology" to produce it.

According to Iida, this dependency has fueled a "negative security narrative" in Japan, amplified by right-wing elements, claiming that “solar is destroying the environment" and citing security risks because components like power conditioners come from China.

Challenge II: Revival of Atomic Power

The 7th Strategic Energy Plan's decisive recommitment to nuclear power represents one of the most controversial aspects of Japan's energy strategy. The plan marks a departure from the post-Fukushima approach of reducing nuclear dependency, and Japan is now aiming for nuclear power to supply approximately 20% of the electricity mix by FY2040. This revival is not for technical reasons, as the existing nuclear power plants are mostly very old and with an inflexible old technology that does not allow an adaptation of their power output to adapt to fluctuating renewable energies.

The decision is a political and strategic decision driven by the S+3E principles of security and stability, which stands in direct conflict with deep-seated public safety concerns and a legacy of unresolved technical challenges stemming from the Fukushima accident, like the cleaning up and final storage of used nuclear fuel. Also, many reactors will require a lifetime prolongation beyond 60 years, as building new ones will take too much time.

The envisaged usage of modern nuclear reactors that have less risk and a better usage of nuclear fuel, which Japanese companies would be interested in developing and building, will however not be possible on the timescale of this energy plan.

Rationale for Continuous Utilization: Prime Ministerial Preference
The official preference for nuclear power is driven by its perceived contributions to energy security and economic development. Nuclear is prized for its "excellent supply stability" and "technological self-sufficiency[12]," with the restart of a single 1 GW plant estimated to reduce annual LNG imports by one million tons.

Its ability to provide stable, constant power is also cited as essential for meeting the rising electricity demand from new high-tech industries like data centers and semiconductor plants. This push was accelerated by the post-Ukraine energy crisis, leading Prime Minister Kishida to fast-track reactor restarts and support legislation allowing reactors to operate beyond 60 years.

This rationale is reinforced by the narrow definition of 'Energy Security' promoted by incumbent industries, which, as Mika Ohbayash (REI) argues, prioritizes stable supply from large-scale, centralized assets over domestically produced renewable sources.

This expectation was proved in the beginning of January, when Prime Minister Takaichi pleaded for more usage of nuclear power.[13]

Political and Safety Concerns
The revival of nuclear energy faces significant institutional and safety questions. Mika Ohbayashi (REI) contends that maintaining the 20% target is primarily a "political issue" because reducing the target

would compel the government to specify which of the existing 24 reactors must be permanently retired.

Critics note that Japan's existing reactors are old and have some risk of failure, especially in an "earthquake country". The author of this report, Dr Lorenz Granrath, believes that the structural integrity of the Fukushima reactor was massively compromised by the earthquake itself, even before the tsunami damaged the emergency generators. He learned this during his visit to Germany after the accident when visiting the Fraunhofer Institute for Nondestructive Testing (IZFP), which had been set up in Germany to test nuclear reactors and that works for the French nuclear company Areva which itself serviced the Fukushima atomic power plant.

Nuclear power, particularly the current generation of plants in Japan, is also inflexible and needs to be run with a constant power output. French reactors are newer and more flexible, said Tetsunari Iida (ISEP) and can ramp up and down quickly in contrast to Japanese ones. This inflexibility forces utilities to prioritize nuclear base load, leading to the curtailment of renewable energy.

Iida also criticized the persistence of a "false reality" (Back-end Cycle) in nuclear politics, citing TEPCO's unrealistic targets for fuel debris retrieval at Fukushima and the continued push for opening the Rokkasho Reprocessing Plant, despite Japan already holding a more than 44-ton stockpile of plutonium.

Challenge III: Sticking to Fossil Fuels

Despite its decarbonization mandate, Japan's 7th Strategic Energy Plan preserves a significant and prolonged role for thermal power from fossil fuels, a strategy officially justified by the critical need to maintain grid stability. However, this approach is also supported by the Green Transformation (GX) industrial policy and calls for the decarbonization of fossil fuel with new technologies to recover the carbon (CCS or CCU). This in fact creates a dangerous long-term dependency on fossil fuels and a fundamental policy contradiction, where state-sponsored innovation in decarbonizing fossil fuels actively undermines the timeline for their substitution. The biggest risk is a prolonged carbon lock-in which will be costly and persistent, as the investments must be recovered.

Japanese Companies active in Fossil Fuel Business
Another aspect is the importance of industry and its close collaboration with the government. Japan is a country of keiretsu, big industrial groups, that are involved in trading, and include production companies, banks and sometimes fossil fuel businesses.

Several Japanese companies hold ownership stakes in fossil resource projects in various other countries, with the primary entities involved in oil and natural gas exploitation and production (E&P) being INPEX Corporation, Japan Petroleum Exploration (JAPEX), JX Nippon Oil & Gas Exploration, and Mitsui Oil Exploration. Major trading houses (Sogo Shosha) such as Mitsubishi Corporation, Mitsui & Co., Marubeni, and Itochu also have significant investments.

Key Japanese companies with self-owned fossil fuel sources or E&P (exploration and production) operations in Asia include:

- INPEX Corporation: Japan's largest oil and gas exploration and production company. It has significant investments and operates projects in Indonesia, Malaysia, and Australia.[14]
- JX Nippon Oil & Gas Exploration Corporation: A core operating company within the ENEOS Group, JX Nippon is actively involved in E&P projects and serves as an operator in countries

such as Malaysia and Vietnam.

- Mitsui Oil Exploration Co. (MOECO): A subsidiary of the Mitsui Group, MOECO is also involved in various oil and natural gas development projects in Southeast Asia.
- JAPEX (Japan Petroleum Exploration Co.): JAPEX participates in international projects, including the Kangean Project in Indonesia, and is involved in evaluating and developing other potential projects in the region, such as in Sarawak, Malaysia.
- General Trading Houses (Sogo Shosha):
    - Mitsubishi Corporation and Mitsui & Co. have major stakes in the Sakhalin 2 project in Russia, which includes onshore and offshore LNG export facilities. Both also have significant investments in Australia's gas industry.
    - Marubeni, Itochu, and Sumitomo are also involved in a variety of fossil fuel projects, including coal and gas power generation projects and oil/gas exploration across the globe, such as in Indonesia and the US.

These companies often receive support and financing from Japanese governmental financial institutions, such as the Japan Bank for International Cooperation (JBIC) and the Japan Oil, Gas and Metals National Corporation (JOGMEC), to ensure a stable energy supply for Japan.

This major engagement of big Japanese Companies is a fundamental reason why fossil fuels have not been dropped from the Strategic Energy Plan and are maintained as a source for Japan. Even decarbonization activities like CCS/CCU are welcomed, as those companies have the capabilities to develop such technologies.

Grid Stability and Transitional Fuels

The government's official rationale for retaining a 30-40% share for thermal power in the 2040 energy mix is rooted in technical necessity. Thermal power generation, which currently meets approximately 70% of Japan's electricity supply, is valued for providing essential grid services that renewables alone cannot. These include "regulating power," which compensates for the fluctuating output of solar and wind, and the "inertial and synchronous power" required to maintain the fundamental stability of the grid.

To make this continued reliance consistent with climate targets, the government has positioned Liquefied Natural Gas (LNG) as a "practical means of transition." The long-term strategy, however, looks to promote hydrogen and ammonia as decarbonization carriers. Japan has set ambitious targets to build entire supply chains for these fuels, aiming to introduce 3 million tons of ammonia per year and 3 million tons of hydrogen per year by 2030. The hydrogen target is set to expand dramatically to 20 million tons per year by 2050, envisioning the widespread use of these materials for co-firing in existing thermal plants and as primary fuels for hard-to-abate industrial sectors.

Financial Support and Lock-in Risk

Japan's GX strategy provides a powerful financial architecture to support this fossil fuel transition. A core mechanism is the provision of "price gap support" for emerging technologies like low-carbon hydrogen, ammonia, and Carbon Capture, Utilization, and Storage (CCUS). This support, funded by government-issued GX Transition Bonds, is designed to de-risk private investment and cover the high costs of these nascent industries. The first projects approved under the Hydrogen Society Promotion Act, for example, will receive 15 years of financial backing.

This financial architecture exposes a central tension in the GX strategy: it simultaneously funds the energy sources of the future while subsidizing technologies designed to prolong the life of the energy

infrastructure of the past. This heavy reliance on technological fixes, particularly CCUS, has drawn sharp criticism. According to Mika Ohbayashi of the Renewable Energy Institute (REI), CCS functions as a "magic technology" within the policy framework. Its primary role is not necessarily its technical viability but its political utility in justifying the continued large-scale operation of thermal power plants. She argues that this approach serves to protect the vast asset base of incumbent power companies. The plan's goal of a 100% carbon-reduced power sector alongside a 30% share for fossil fuels is only mathematically coherent through the massive, and yet unproven, application of carbon capture.

This protectionist impulse is intensified by the direct economic threat that renewable energy poses to the traditional utility business model. As Mika Ohbayashi (REI) explains, the proliferation of solar power directly covers daytime peak electricity demand. This erodes the profitability of the expensive fossil fuel-fired peak-plants that utilities have historically relied upon to meet short-term demand spikes and generate significant revenue. The significant state-backed investments in ammonia co-firing and CCUS, therefore, risks locking in fossil fuel infrastructure for decades, creating a structural barrier that delays a comprehensive transition to a fully renewable energy system. The financial structure of the GX strategy heavily supports the role of fossil fuels in this transition.

False Security and Investment Risk

As part of its energy security doctrine, the 7th Strategic Energy Plan aims to increase Japan's "self-development ratio" – the share of overseas fossil fuel production controlled by Japanese corporations – to 60% by 2040. This policy is intended to secure stable supply chains, particularly for LNG.

However, critics argue that this ratio is a "false measure of energy security"[15]. Rather than insulating Japan, this strategy increases its exposure to volatile global markets and geopolitical risks. By encouraging Japanese companies, often backed by public financial institutions like JOGMEC, to invest heavily in new overseas fossil fuel projects, the policy creates a significant fiscal risk. As the global energy transition accelerates and demand for fossil fuels declines, these large-scale investments are in danger of becoming stranded assets, leading to substantial financial losses. Indeed, this risk has already materialized, with JOGMEC reporting cumulative losses reaching ¥621.3 billion from such ventures.

This persistence with fossil fuel-centric security models, despite clear financial and strategic risks, produces a series of market and policy impacts that define the current state of Japan's energy transition.

Impacts and Outcomes of the Strategies

This section evaluates the real-world impacts and market implications of Japan's three core policy pillars: the 7th Strategic Energy Plan (SEP), the Plan for Global Warming Countermeasures (GWC), and the Green Transformation (GX) strategy. Together, these frameworks are reshaping the nation's energy markets, industrial pathways, and international posture, though their combined effect is a complex mixture of genuine progress and institutional inertia. Ultimately, the tangible impacts of these strategies expose a deep-seated philosophical divergence from market-driven, renewables-first models, making a direct comparison essential for understanding Japan's unique path.

Impact of the 7th Strategic Energy Plan (SEP)

The 7th Strategic Energy Plan is in a way a dual-edged policy instrument. Its landmark achievement is the formal designation of renewable energy as the largest future electricity source, with a target of 40-50% by 2040. This marks a significant political and rhetorical turning point for a nation historically dominated by conventional power. However, even if this target is higher than ever before, it is very low and unambitious internationally and far behind both other countries and the potential of Japan.

Additionally, this progressive stance is counterbalanced by the plan's firm commitments to a 20% share for nuclear power and a 30-40% share for thermal power. This target structure reveals the foundational policy choice, to preserve the centralized energy system of the past and with that constraining the shift toward a more distributed, renewables-led model. The fundamental weakness of the plan's targets is further highlighted by a critical structural flaw. As Mika Ohbayashi (REI) points out, the SEP is a cabinet-approved plan, not a formalized law with legally binding targets. This lack of legal enforcement power reduces accountability and renders its goals more aspirational than mandatory.

In the marketplace, the SEP is already driving a significant review of electricity system reform, a clear shift away from the market liberalization policies of the past decade. Citing a lack of private investment in large-scale nuclear and decarbonized thermal power, policymakers are moving back toward a centralized system characterized by direct government intervention. Critics warn that this policy shift is a reversion to the pre-Fukushima paradigm, which will likely result in higher electricity prices and limited renewable energy deployment.

Impact of the Global Warming Countermeasures
The GWC (Plan for Global Warming Countermeasures) provides the legal and regulatory drive for efficiency and sectoral change. The plan imposes legally binding targets for energy efficiency and standards (ZEH/ZEB by 2030), although it is not addressing the historic issue of poorly insulated housing noted by interviewees.

The plan also encourages the development of new, complex industrial pathways, such as producing steel with less hydrogen and carbon recycling in cement production. The Carbon Recycling Technology Roadmap (Table 3) outlines phases for commercializing technologies using captured CO_2 to create chemicals and concrete products, prioritizing those that do not require hydrogen initially.

Impact of the Green Transformation Strategy (GX2040)
The GX strategy functions as a comprehensive, state-led industrial policy designed to bolster national competitiveness in the global green technology race. Its main impact is to mobilize capital and direct innovation. Through mechanisms like GX Economy Transition Bonds and a phased-in carbon pricing scheme, it successfully channels investment toward high-risk, high-reward projects that private markets might otherwise avoid. This financial mobilization is complemented by a strategic focus on R&D in fields such as next-generation nuclear reactors and all-solid-state batteries.

The GX strategy also extends its reach internationally. By establishing platforms like the Asia Zero Emission Community (AZEC), Japan aims to promote its vision for decarbonization across Asia, creating new markets for its transition technologies like LNG, CCUS, and Ammonia. According to Mika Ohbayashi (REI), a crucial impact of the GX strategy has been to shift the narrative within the powerful Ministry of Economy, Trade and Industry (METI). For the first time, the ministry has begun to publicly acknowledge that decarbonization is not an economic burden but can be a powerful driver of future economic growth.

Comparative Analysis: Japan vs. Germany

While Japan and Germany share the fundamental challenges of being highly industrialized, resource-poor nations dependent on energy imports, their strategic responses have diverged significantly. Germany's Energiewende has been a mission-oriented project focused on the accelerated replacement of nuclear and fossil fuels with renewables. In contrast, Japan's approach is a form of crisis-driven pragmatism, prioritizing a diversified portfolio of energy sources to hedge against geopolitical, technological, and economic uncertainty. This fundamental difference in philosophy has produced two distinct pathways toward the shared goal of decarbonization, providing a valuable basis for

comparison and mutual learning.

Foundational Doctrine Comparison

Feature	Japan (S+3E / GX)	Germany (Energiewende)
Core Doctrine	Crisis-driven pragmatism: Safety is important. Focus on portfolio diversification against geopolitical and technological risks.	Mission-oriented: Achieving climate neutrality while remaining competitive ("wettbewerbsfähig bleiben").
Nuclear Power	Continuous Utilization (approx. 20% by 2040) for stable, decarbonized base load.	Deliberate decommission and phase-out.
Fossil Fuel Role	Transitionally essential (30–40% thermal by 2040). Emphasis on decarbonizing fossil fuels via CCUS/Ammonia.	Accelerated Reduction and Substitution. Goal is near 100% RE by 2035 in the power sector.
Policy Mechanism	Integrated industrial policy (GX), using bonds and phased carbon pricing to stimulate private investment in transition technologies.	Market-based tools like Carbon Contracts for Difference CCfD to de-risk green industrial investments.
Grid Context	Island state; no power trade with neighbors. Grid reinforcement is difficult due to bureaucracy and geography.	Land-connected; relies on interregional exchange and accelerated expansion (Wasserstoff-Beschleunigungsgesetz).

The Central System Debate

The core of the strategic divergence between Japan and Europe lies in the debate over system architecture. The ongoing review of Japan's electricity system reveals a clear intention to revert to a centralized model, where government intervention is used to secure investment in large-scale nuclear and decarbonized thermal power sources. This approach stands in sharp contrast to the decentralized, market-driven model pursued in Europe.

According to Tetsunari Iida of the Institute for Sustainable Energy Policies (ISEP), this conservatism is deeply rooted in the bureaucratic culture of METI. He argues that this stems from a system where career officials, who are often without deep technical backgrounds, rotate positions frequently. This prevents the development of the specialized expertise needed to grasp rapid technological shifts, leading to a reliance on established paradigms and "false realities," particularly concerning the viability of nuclear power. The alternative path, advocated by critics in Japan and practiced in Europe, views a decentralized system as the "fast track to decarbonization and the stability of electric power supplies[16]." This model combines competitive market mechanisms, battery storage, and sophisticated demand-side management to integrate high shares of renewable energy efficiently and reliably. Japan's reluctance to fully embrace this model represents a critical strategic choice with long-term implications for its energy transition.

Strategic Lessons

Japan's pragmatic, security-focused energy strategy, while fighting with internal contradictions, offers valuable and actionable lessons for Germany in its own industrial and energy challenges. By looking at the strengths of Japan's integrated policy approach, the collaboration with industry and its implementation failures, German policymakers can get new perspectives on managing the complex trade-offs inherent in a rapid energy transition.

Lesson 1: The Value of Portfolio Resilience
The primary strategic rationale behind Japan's retention of nuclear power is to de-risk its industrial base. The policy aims to secure a stable supply of low-carbon, dispatchable electricity for critical high-growth industries like semiconductors and data centers. This "all-of-the-above" portfolio approach serves as a hedge against the uncertainties and high integration costs associated with a system that relies solely on intermittent renewables and flexible gas plants.

Lesson 2: The Integrated Industrial Policy Framework (GX)
Japan's Green Transformation (GX) Initiative serves as a powerful model for an integrated industrial policy that aligns decarbonization with economic competitiveness. Two key strengths offer important lessons:

1. Upfront Investment: The GX Initiative provides a model for using government-backed financial instruments (GX Transition Bonds) to stimulate massive private investment in necessary, high-risk green technologies. This structure allows the state to assume risks that private finance cannot, accelerating the shift in nascent sectors like hydrogen and CCUS.

2. Phased Carbon Pricing: The GX's "growth-oriented carbon pricing" concept (phasing in the levy and ETS) is designed to avoid immediately harming industrial competitiveness while securing future funding for the bonds. Germany could examine the applicability of phasing price signals to accelerate structural change.

Learning from Failures (Inertia and Protectionism)
Perhaps the most critical lessons come from Japan's implementation failures, which reveal the powerful forces of institutional inertia and protectionism. The slow pace of Japan's renewable energy deployment is not primarily a result of technical or geographical constraints but of deep-rooted structural barriers. Expert commentary exposes how this inertia is driven by the powerful influence of incumbent utilities and heavy industry. Mika Ohbayashi (REI) describes this influence as a "disturbance" that consistently crafts policy to preserve existing assets and business models at the expense of a faster transition. This is compounded by the bureaucratic and cultural barriers within METI, which Tetsunari Iida (ISEP) identifies as a source of unrealistic and overly conservative policymaking. From the author’s point of view, a successful energy transition requires more than just ambitious targets and technological innovation. It demands the enforcement of market competition and the maintenance of genuine grid neutrality to prevent incumbent interests from throttling the growth of renewable energy and locking in the energy systems of the past.

Conclusion

Japan's energy strategy is a pragmatic attempt to reconcile ambitious decarbonization targets with acute energy security needs, driven by a political shift toward utilizing nuclear power as a stable, decarbonized base load. While the GX Initiative provides a potent industrial and financial framework, its success is undermined by deeply embedded institutional resistance to decentralized renewables and the reliance on costly transitional fossil fuel technologies. The German Energiewende, focused on the accelerated replacement of fossil fuels through RE and efficiency, stands in stark strategic contrast to

Japan's portfolio-based approach, yet both countries share the ultimate goal of carbon neutrality and face similar technological and geopolitical challenges.

The author argues that achieving climate goals requires integrated industrial strategy (the GX model) alongside technological diversification (the Japanese portfolio hedge). The collaboration between government and industry is a very positive aspect, however reliance on industry alone will slow down the application of renewable energies, which is the biggest challenge in Japan.

Suggested Points of Collaboration

Bilateral cooperation can leverage the complementary strengths and shared strategic challenges of Japan and Germany.

Area of Collaboration	Japanese Focus	German Focus	Potential Joint Action
Hydrogen and Ammonia	Developing supply chains and price gap support for co-firing in thermal power.	Fast-tracking infrastructure development and defining standards (Wasserstoff-Beschleunigungsgesetz).	Global Supply Chain Development: Joint establishment of international standards and supply contracts for green hydrogen/ammonia to enhance energy security for both nations.
Offshore Wind Technology	Developing floating offshore wind power in deep ocean areas due to steep coastal shelf.	Deep expertise in offshore wind infrastructure and development.	Joint R&D for Deep Sea Solutions: Collaboration on floating offshore wind and specialized EPC resources to reduce development costs and accelerate deployment in the Asia-Pacific region.
International Strategy	Promoting energy transition in Asia via the Asia Zero Emission Community (AZEC) platform.	Strong EU policy drive and experience in third-country climate action.	Joint AZEC Engagement: Germany could partner with Japan in the AZEC platform to jointly support practical decarbonization in Southeast Asia, creating new markets for clean technologies and sharing expertise in regulatory frameworks.

Interviews

Interviewee	Affiliation	Date
Mika Ohbayashi	Director for Advocacy and Grant Program, Renewable Energy Institute (REI)	14 Oct. 2025

Nicolas Vierge	Founder of Carbon 50, Energy & Environmental sustainability consultant	27 Oct. 2025
Martin Messmer	CEO of M2PV (PV power plants and Microgrids consulting)	28 Oct. 2025
Tomas Kåberger	Executive Board Chair, Renewable Energy Institute (REI)	29 Oct. 2025
Tetsunari Iida	Executive Director, Institute for Sustainable Energy Policies (ISEP)	29 Oct. 2025
N.N.	Former executive level, one of the top Electric Power Companies (wanted confidentiality), responsible for nuclear and fossil fuel power production	03 Dec. 2025

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10 https://www.cleanenergywire.org/news/germany-covers-nearly-56-percent-2025-electricity-use-renewables
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16 Assessing the Review of Electricity System Reform: Making Use of Market Mechanisms | Column | Renewable Energy Institute

The Author

Dr Lorenz Granrath
Dr Granrath has more than 30 years' experience in science-industry cooperation. An Industrial Engineer (KIT) and researcher (Tokyo University) with a PhD from St. Gallen, he moved to Japan in 2001. Since then, he set up the Fraunhofer Representative Office, served as an AIST Innovation Coordinator and a Professor at Tohoku University, and acted as an advisor for the microelectronics, 3D printing, software, and H2 production industries. He has organized trade shows and events, such as the German-Japan Solar Day, and currently lectures on Renewable Energy at Waseda University.

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Konrad-Adenauer-Stiftung Japan
Paul Linnarz
Representative Tokyo Office and Director Regional Program "Economic Governance in Asia" (SOPAS)
kas-tokyo@kas.de

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