

Strengthening Japan's Power System Resilience: Adapting to a Changing Climate

-Insights from a Nation Prone to Natural Disasters-

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Akiko URAKAMI

Resilient Infrastructure Consultant

Tokyo Disaster Risk Management Hub, World Bank



GFDRR
Global Facility for Disaster Reduction and Recovery



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Understanding Japan's Power System and Context

Japan's unique island geography and advanced economy drive its imperative for a highly resilient, complex power system.

- **Crucial Role:** Stable electricity powers highly industrialized, densely populated island nation.
- **Dual Grids:** East Japan (50Hz) and West Japan (60Hz) connected by HVDC.
- **Evolving Mix:** Shift towards renewables while maintaining thermal and nuclear.
- **Regulated Sector:** Generation, Transmission & Distribution (T&D), and retail are unbundled.

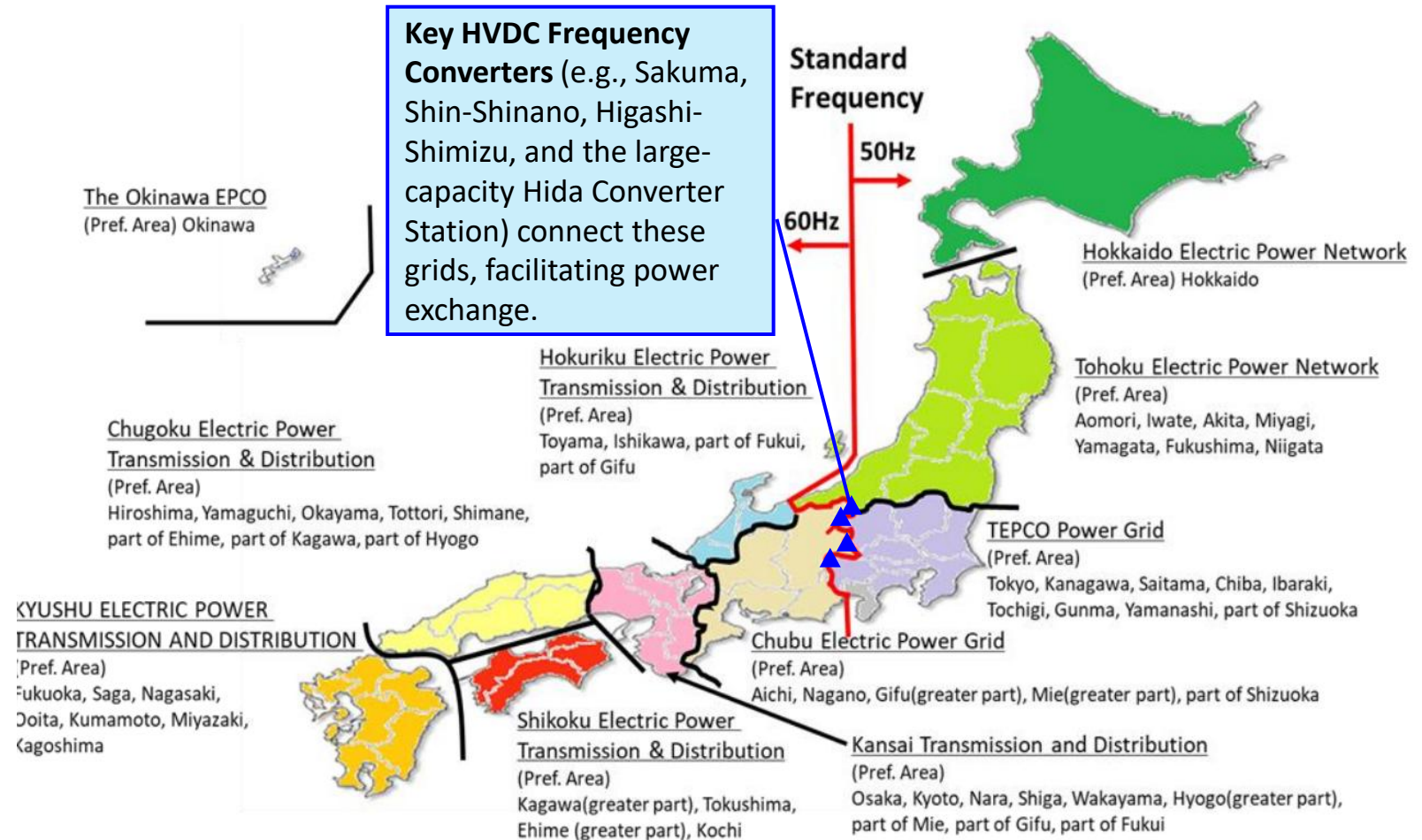


Figure 1-1: The 10 Regional Service Areas in Japan and their Prefectural Distribution

Map: p.5, OCCTO/ Annual Report 2024



Major Climate Impacts on Japan's Power Assets

Intensifying extreme weather events, particularly typhoons and heatwaves, increasingly inflict direct and widespread damage on Japan's power infrastructure.

Typhoons & Heavy Rain: Cause widespread physical damage to T&D assets; facilities flood.

- Example: Typhoon Faxai (No.15) (2019) led to **prolonged blackouts** in Chiba Prefecture from tower collapses.

Rising Temperatures/ Heatwaves: Increase peak demand, strain grids, reduce plant efficiency.

- Example: Summer 2022 saw **power crunch warnings for Tokyo area**, urging conservation.

Broad Impact: Disrupts daily life, economic activity, and critical services; incurs significant repair costs.



Reference: Nikkei Newspaper (11 September 2019)
<https://www.nikkei.com/article/DGXMZO49661310R10C19A9EAF000/>



Reference: Reuters (30 June 2022)
<https://www.reuters.com/world/asia-pacific/tokyos-june-flames-out-record-heatwave-power-plant-shutdown-stokes-blackout-2022-06-30/>

Strategic & Regulatory Responses: A Robust Framework

Japan's resilience strategy is firmly grounded in robust national policies and legally mandated frameworks, ensuring structured adaptation.

1. National Vision & Strategies:

- Strategic Energy Plan (METI): Defines energy security & resilience as core.
- National Resilience Basic Plan (Cabinet Office): Positions power as "critical infrastructure."

2. Legal & Regulatory Foundation:

- Electricity Business Act (METI): Mandates "stable supply"; enables investment cost recovery.
- Act on Strengthening Energy Supply Systems (METI/OCCTO): Directs grid reinforcement, BESS.
- Disaster Countermeasures Basic Act / Basic Disaster Management Plan (Cabinet Office/METI): Mandates utility disaster plans (e.g., BCPs).

3. Implementation & System Coordination:

- Power Utilities: Execute asset investments, implement BCPs, and operational resilience measures.
- OCCTO's Role: Coordinates nationwide grid stability, wide-area interconnections, and system planning.



Practical Measures & Solutions Implemented by Utilities

Japanese utilities are actively deploying advanced hardening, smart grid, and decentralized energy solutions to enhance grid resilience.

Grid Hardening:

Undergrounding power lines (e.g., TEPCO Power Grid), reinforcing poles/towers.

Image 1a



Physical Infrastructure Hardening & Undergrounding (TEPCO):

https://www.tepco.co.jp/toudenhou/pg/1287543_9043.html

Smart Grid & Digitalization:

Advanced Metering Infrastructure (AMI) and Distribution Automation (DA) for faster outage detection/automated restoration (Fault Location, Isolation, and Service Restoration: FLISR).

Image 2



Digitalizing for Faster Response & Resilience: TEPCO

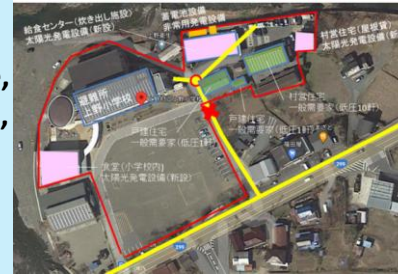
<https://www.tepco.co.jp/pg/technology/smartmeterpj.html>

Distributed Energy Resources (DERs) & Microgrids:

Critical facility microgrids (island mode), BESS for stability/backup.

Image 3a

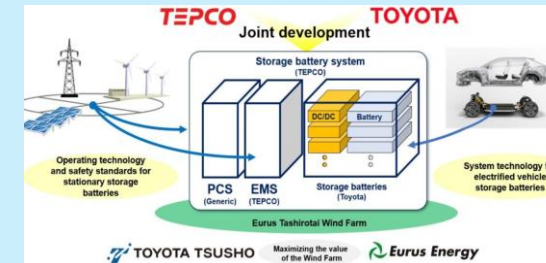
Ueno Village, Tano District, Gunma Prefecture



https://www.enecho.meti.go.jp/category/saving_and_new/saiene/community/dl/07_08.pdf

Image 3b

Decentralized Energy & Localized Resilience



<https://www.energy-storage.news/toyota-tepco-prepare-megawatt-scale-second-life-bess-for-wind-farm-in-japan/>

Enhanced Preparedness:

Mobile power generators, drone inspections, rigorous disaster drills.

Image 4a



Drone forces boost Japan quake relief: <https://www3.nhk.or.jp/nhkworld/en/news/backstories/3406/>

Image 4b



Nuclear Disaster Prevention Training (Kashiwazaki-Kariwa NPP) (TEPCO):

<https://photo.tepco.co.jp/date/2014/201411-j/141111-01j.html>



TEPCO

Image 1b

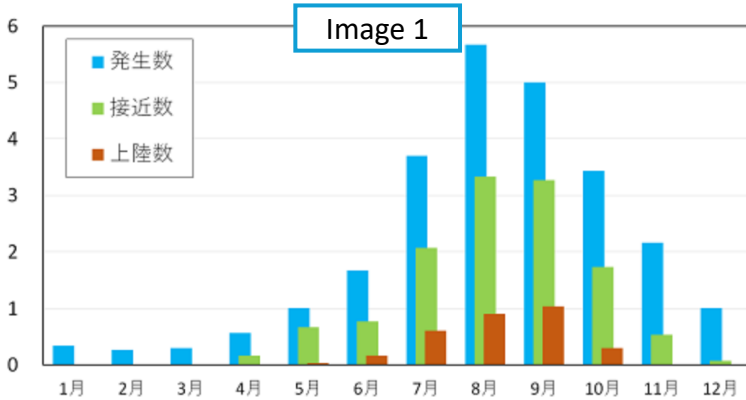
<https://www.tepco.co.jp/pg/consignment/partners/category-d/02-j.html>

Key Challenges in Japan's Power Sector Resilience

Japan navigates complex, interconnected resilience challenges shaped by its unique demographics, aging infrastructure, and ambitious energy transition.

1. Frequent Natural Disasters & Resilience Imperative:

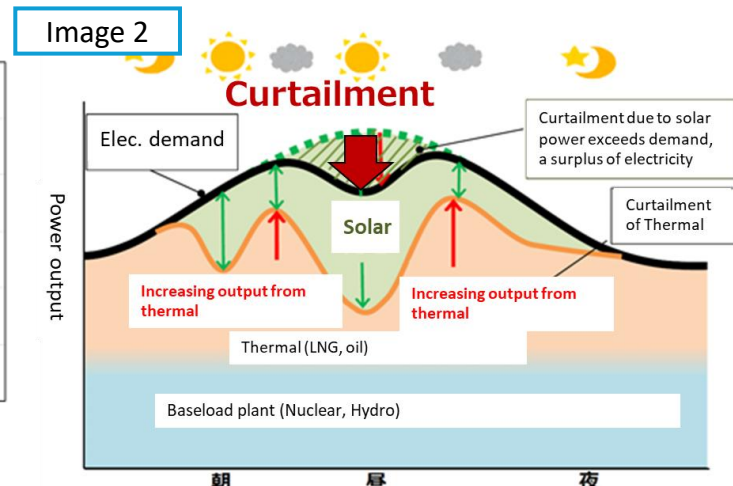
- **Highly prone to typhoons, floods, earthquakes, and landslides.**
- Disaster-induced outages significantly impact critical infrastructure.
- Enhancing physical and operational resilience is a national priority.



Monthly averages of typhoon occurrence, approach, and landfall (30-year average from 1991 to 2020) (JMA: <https://www.jma.go.jp/jma/kishou/known/typhoon/1-4.html>)

2. Grid Constraints Amid Large-Scale Renewable Energy Deployment:

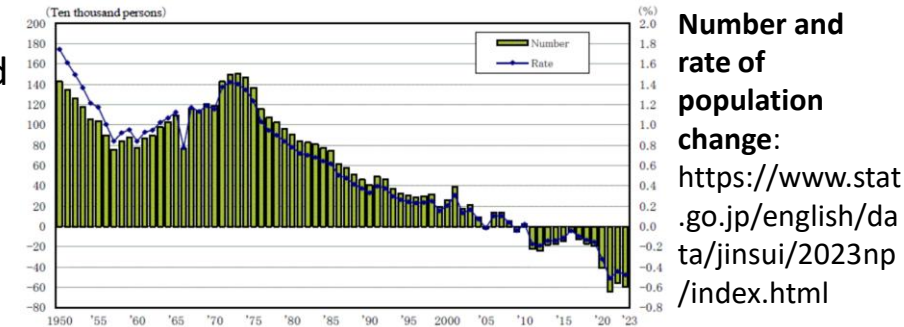
- Rapid growth of renewables exacerbates **grid congestion and curtailment.**
- Increasing pressure to expand interregional transmission capacity and upgrade grid flexibility.



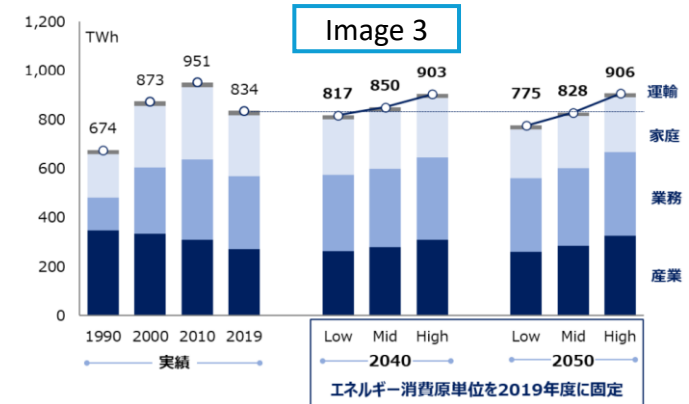
Supply-demand imbalance (entire area) (METI: https://www.enecho.meti.go.jp/category/saving_and_new/saiene/grid/08_syuturyokuseigyo.html)

3. Uncertainty in Electricity Demand & Supply Security:

- Declining population and industrial shifts complicate long-term demand forecasting.
- Ensuring sufficient supply capacity and demand-supply balancing remains critical.



Number and rate of population change: <https://www.stat.go.jp/english/data/jinsui/2023np/index.html>



Demand Volatility Challenge Future Supply Planning (https://www.occt.o.or.jp/iinkai/shorai_jukyuu/2023/files/s_horaijukyuu_03_02_01.pdf)

Key Takeaways & Conclusion: Future Focus & Stakeholder Roles

Japan's integrated resilience commitment fortifies its power sector for future climate challenges, driven by a broad ecosystem of interconnected public and private stakeholders.

- **Proactive, Data-Driven Adaptation:** Essential given intensifying climate impacts.
- **Holistic Framework & Broad Stakeholder Ecosystem** →
- **Persistent Structural Hurdles:** Navigating aging infrastructure, DER integration complexities, and workforce demographics.
- **Commitment to Sustainable Security:** Dedicated to building a resilient, decarbonized grid, sharing global insights.

