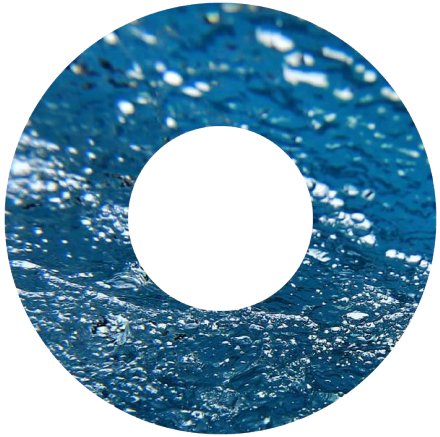
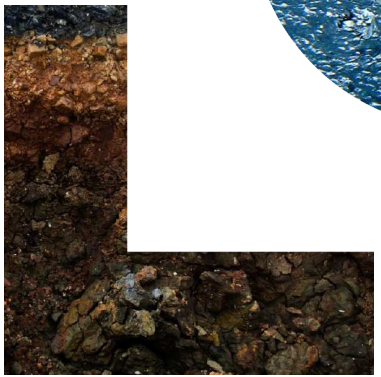
Climate Integrate

Mainstreaming Renewable Energy in Japan

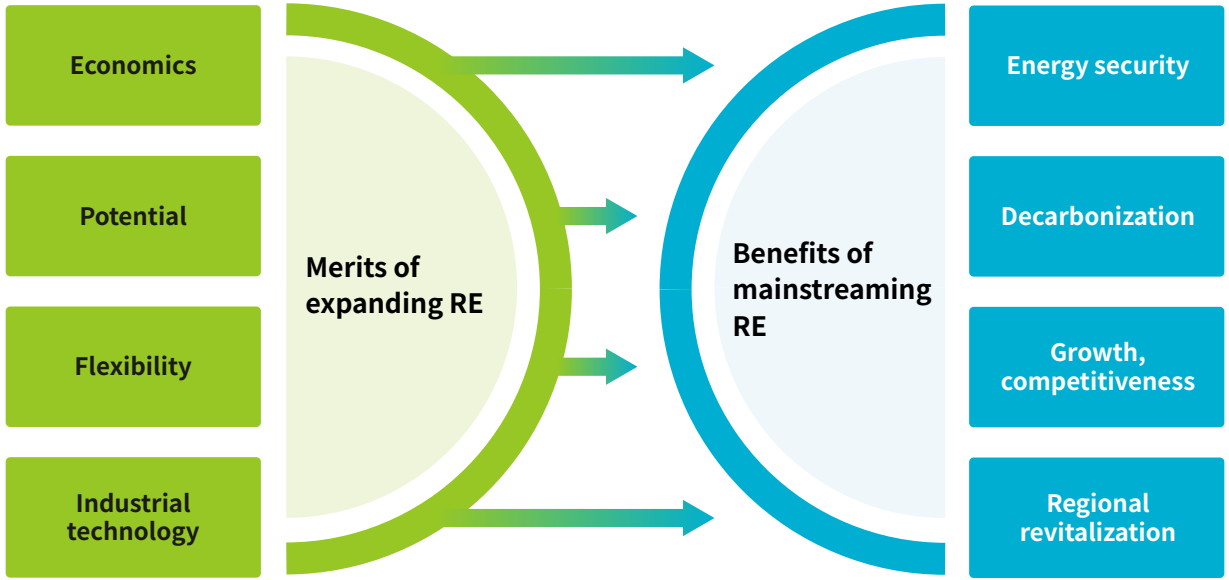


The government has declared a policy of making renewable energy a major power source.
What would be the impacts and significance of a major push for the use of renewable energy?
This is a summary of the key issues.



November 20, 2024

Mainstreaming Renewable Energy (RE) in Japan



Benefits for Japan from mainstreaming RE

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Energy security

- Reduce risk of overseas resource dependency
- Better balance of trade
- Enhance electricity self-sufficiency

Decarbonization

- CO_2 emission reductions toward the 1.5°C goal
- Conserve natural capital
- Reduce climate-related risks

RE protects national interests, economy, citizens' lives

Growth and competitiveness

- New industries, job creation
- Gain global competitiveness in the growing RE market
- A strong economy unaffected by rising fuel prices

Regional revitalization

- Local economies, revitalized thru community-driven RE projects
- New industries, job creation
- Disaster risk reduction, synergies with agriculture/fisheries

Benefits for Japan from mainstreaming RE

Energy security: > 80% self-sufficiency in electricity possible

Current situation

Japan relies heavily on fossil fuel imports. Energy security is threatened by price hike and supply disruptions due to geopolitical factors beyond Japan's control.

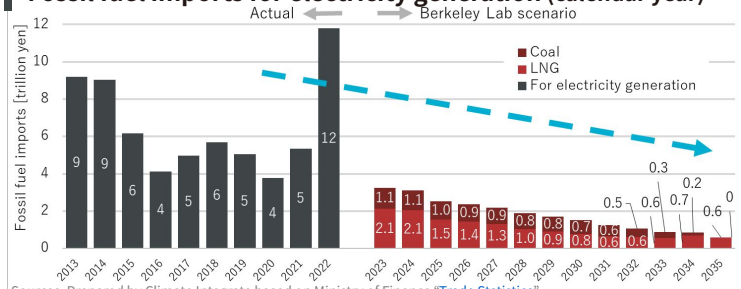
- Energy current status (FY2022 data)
  - Primary energy supply: **83%** reliant on fossil fuel imports (1)
  - Generation mix: Thermal **72.8%**, nuclear **5.5%** (2)
  - Renewable electricity share: **21.7%** (3)
  - Fossil fuel imports increased sharply: total **34 tril. yen** (incl. **12 tril. yen** (35%) for electricity generation) (4)

Benefits from mainstreaming RE

Japan's electricity self-sufficiency rate would increase with a greater supply of domestic RE (mainly solar and wind). This would also help avoid long-term price fluctuations and improve the trade balance.

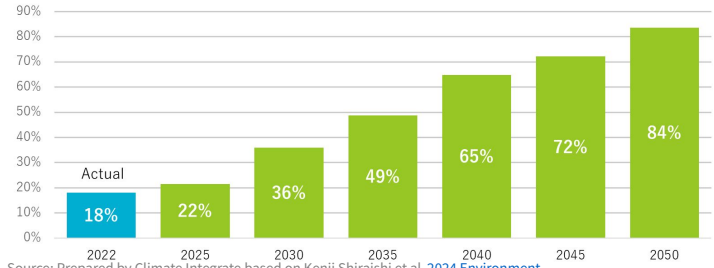
- Lawrence Berkeley National Laboratory (Berkeley Lab) scenario (5)
  - Fossil fuel imports decrease to **~ 0.6 tril. yen by 2035**
  - Electricity self-sufficiency (RE ratio, excl biomass) increase from 18% in FY2022 to **49%** in 2035, **84%** in 2050.

Fossil fuel imports for electricity generation (calendar year)



Sources: Prepared by Climate Integrate based on Ministry of Finance "Trade Statistics", Agency for Natural Resources and Energy "Total Energy Statistics", Berkeley Research Institute "2035 Japan Report" (base year 2020), with cooperation from Kenji Shiraishi (Berkeley Lab). All converted to calendar year.

Projections of Japan's electricity self-sufficiency (RE excl biomass) (based on Berkeley Lab scenario)*



Source: Prepared by Climate Integrate based on Kenji Shiraishi et al. 2024 Environment. Res. Lett. 19 084011., and Agency for Natural Resources and Energy "Total Energy Statistics".
*RE ratio: Ratio of all electricity generated by RE excluding biomass (solar, wind, geothermal, hydro).

Benefits for Japan from mainstreaming RE

Decarbonization: Significant reductions in emissions, risks

Current situation

Extreme weather events are becoming more frequent and intense due to climate change, expanding social impacts and economic losses. The loss of natural capital and biodiversity is also becoming more serious.

- Heatwaves: July 2024 average temp reached record high **2 yrs in a row** (1)
- Heatstrokes: **~97,000** ambulance transport cases (May–Sep 2024) (2)
- Floods: **~7.3 tril. yen** in flood damage last 10 yrs (3)
- Insurance: **~1.6 tril. yen** in claims paid last 5 yrs for wind and flood damage, etc. (4)
- Power outages: Households affected by typhoons, **2.4 mil.** (No. 21) and **1.8 mil.** (No. 24) in 2018, **930,000** in 2019 (No. 15) (5)

Benefits from mainstreaming RE

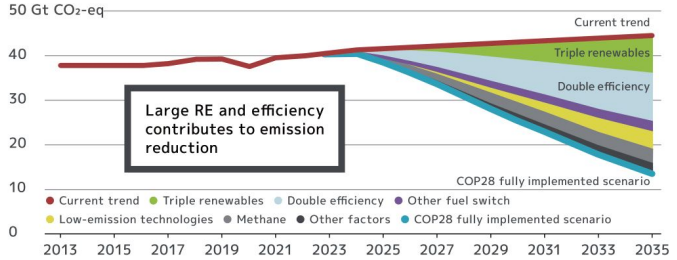
Rapid and substantial CO_2 emission cuts could help achieve the 1.5°C goal, conserve natural capital, and mitigate climate risks.

- Solar and wind, already proven technologies, can be rapidly deployed
- Short lead times, from planning to start of operation
  - **1–3 yrs** for solar/onshore wind, **~5 yrs** for offshore wind (6)
- Support the move toward the 1.5°C goal and decarbonization

Major risks posed by climate change

Source: Prepared by Climate Integrate based on IPCC "Sixth Assessment Report"

Contribution of key elements to reduce energy-related emissions in the COP28 Full Implementation Case (IEA)



Source: Prepared by Climate Integrate based on IEA "From Taking Stock to Taking Action."

Benefits for Japan from mainstreaming RE

Growth and competitiveness: RE investment boosts industries

Current situation

Japan depends on fossil fuels for >70% of its power mix. RE Investment is lagging.

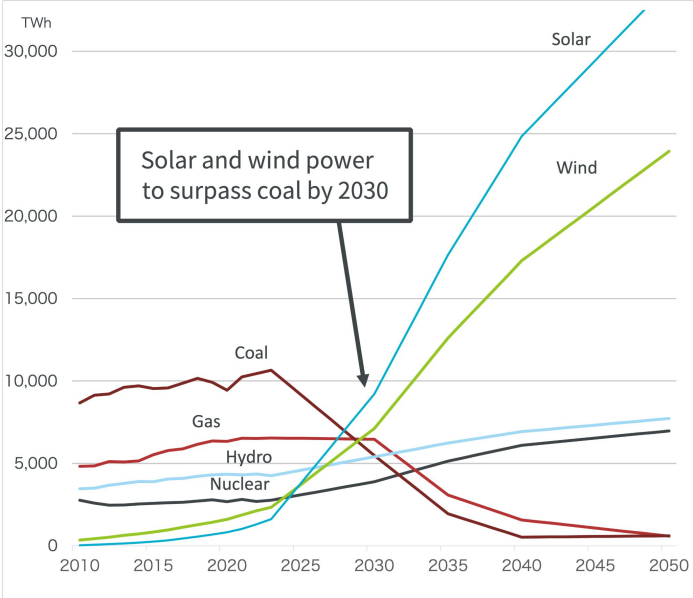
- Surges in fuel prices have hampered industrial competitiveness
- Japan lags the world in promoting the RE industry
  - The RE share in the generation mix below global average (1)
  - RE investment in FY2023: **~1/9** of US, and **1/2** of UK, Germany, Brazil (2)

Benefits from mainstreaming RE

Mainstreaming RE can boost competitiveness in the global energy market, and support economic growth. Regionally, it can create new industries and jobs.

- World electricity generation outlook (IEA Net Zero Scenario)
  - The ratio of RE in the generation mix (kWh): **59% by 2030**, **85% by 2040** (3)
  - Solar and wind expected to surpass coal-fired power generation by 2030 (4)
- Impacts of RE on employment in Japan
  - Solar jobs: **200K by 2030** and **500K by 2050** (Japan Photovoltaic Energy Association, JPEA) (5)
  - Wind jobs: **355K by 2050** (Japan Wind Power Association, JWPA) (6)

Global electricity generation by source (IEA Net Zero Scenario)



Source: Prepared by Climate Integrate based on IEA "World Energy Outlook 2024"

Benefits for Japan from mainstreaming RE

Regional revitalization: RE boosts communities

Current situation

Declining populations are weakening the vitality of regional communities. Supply risk increases in the event of natural disasters due to their dependency on large-scale thermal and nuclear power plants outside the region.

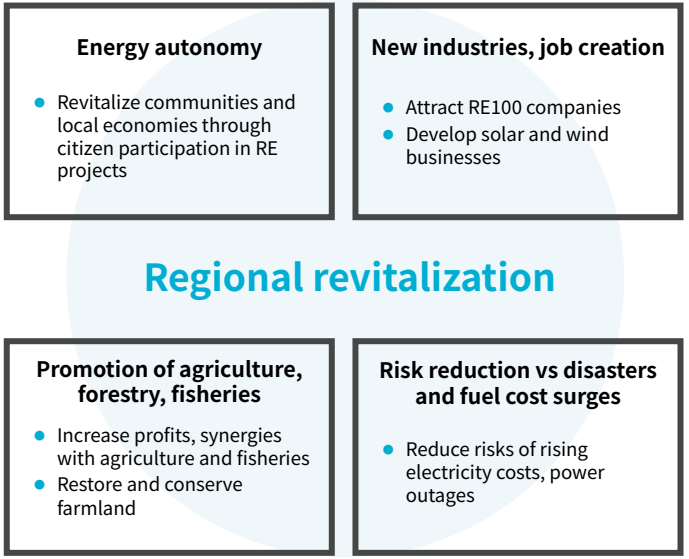
- **744 municipalities** (> 40% of Japan total) **"at risk of disappearing"** (1)
- **The Fukushima nuclear power plants, 19 thermal power plants shut down** due to the 2011 Fukushima earthquake and tsunami (2)
- **Shutdowns of 3 thermal power plants,** a blackout in entire Hokkaido due to the 2018 Hokkaido earthquake (3)

Benefits from mainstreaming RE

RE resources are local assets that can create industries and jobs, promote local economic flows, and strengthen communities.

- Economic, social benefits
  - **Revitalize local economies** with RE projects with citizen
  - **Create new jobs** by attracting RE100 companies and RE industries
  - **Increase profits and synergies with agriculture and fisheries** via agrivoltaics, offshore wind
- Benefits for disaster risk reduction, electricity costs
  - **Improve resilience** by securing power supplies
  - **Reduce risks of rising electricity costs** associated with soaring fuel prices

Regional RE benefits



Source: Prepared by Climate Integrate based on award-winning cases of Agency for Natural Resources and Energy.

Merits of expanding RE

Economics

- Significant reductions in power generation costs
- Reduce risks of dependence on foreign resources
- Better balance of trade

Potential

- Great potential for expanding RE
- Solar: Installations without large-scale developments (rooftops, agrivoltaics)
- Offshore wind: EEZ expansion

Domestic RE supplies cost-effective electricity

Flexibility

- Various approaches to respond to variability of RE
- Cost reductions thru combinations of approaches
- Enhance flexibility with low-cost demand response

Industrial technology

- Quick deployment with existing technologies
- Industrial promotion and job creation
- Business opportunities in Asia Pacific (offshore wind)

Merits of expanding RE

Economics: RE keeps electricity costs low and stable

Issues

Govt subsidies continue amid soaring fossil fuel prices. Besides being vulnerable to overseas energy crises, Japan has yet to introduce carbon pricing aligned with its decarbonization targets.

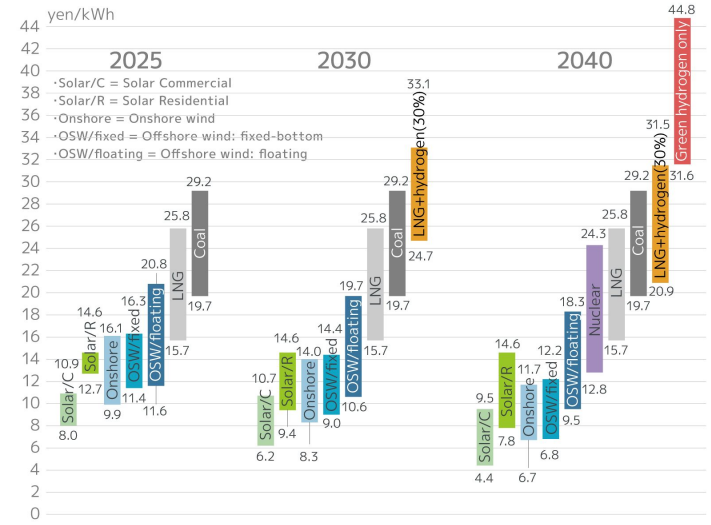
- **The coal and LNG-fired power generation cost** as high as or even higher than that of solar and wind power, even at the current low carbon prices (1)
  - Carbon price: J**apan 289 yen/t-CO_2** vs. **EU-ETS about 13,000 yen/t-CO_2** (2),(3)
- New thermal power plants far more expensive than new RE projects

The merits of using RE to expand generation capacity

The costs of solar and wind continue to drop significantly. Rapid innovation and economies of scale are expected to drive further cost reductions. Cost-effective RE keeps electricity prices low and stable (1).

- No fuel costs for solar and wind
- RE generation costs expected to keep dropping due to better generation efficiency, larger scale of power generation
- Generation costs of green hydrogen (co-firing or 100% at LNG plants) expected to increase
- System costs can be reduced with a balanced combination of solar and wind

Projected cost of electricity generation in Japan (new installations) (Berkeley Lab)



Source: Calculated by Kenji Shiraishi (Berkeley Lab) based on K. Shiraishi et al. 2023, K. Shiraishi et al.2024, and K. Shiraishi et al. 2024 for solar PV, wind and hydrogen, and based on materials from the Agency for Natural Resources and Energy for thermal power. Carbon prices are calculated at 13,000 yen/t-CO_2 (referring to EU-ETS emission pricing, at equivalent to 10 yen/kWh for coal, 4 yen/kWh for LNG), and hydrogen is assumed to be carbon neutral green hydrogen. Graph prepared by Climate Integrate based on the above.

Merits of expanding RE

Potential: Vast potential for solar and wind

Issues

70% of Japan's land is covered by forests. A lack of proper zoning has led unsuitable siting for some installations, leading to local opposition due to visual impacts and safety concerns, etc.

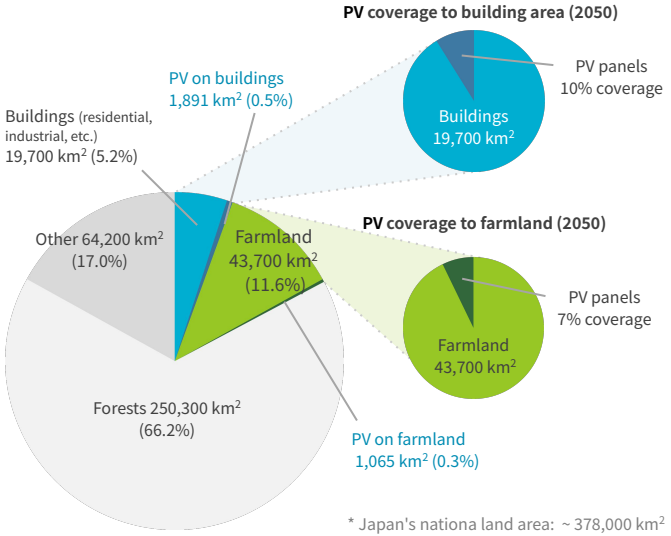
- Cases of environmentally-destructive projects such as photovoltaic (PV) installations in forests and the lack of consensus building with local community
- Slowdown in solar and onshore wind deployments where community opposition has not been addressed

The merits of using RE to expand generation capacity

Japan has vast potential for solar and wind to adequately meet demand if deployed in the right places, utilizing a portion of land, rooftops, and sea areas.

- Solar: In case of achieving 400 GW (JPEA 2050 Vision scenario)(1)
  - **PV would cover ~1%** of Japan's total land area (assuming all panels are installed on flat ground)
  - **Agrivoltaics** (107 GW, at 35% shading) **would cover 7%** of farmland
  - **Rooftop PV** (228GW) **would cover 10%** of roof area (excl wall area)
- Wind: In case of achieving 140 GW (JWPA 2050 scenario) (2)
  - Vast potential for offshore wind with sea area **ranked 6th in the world** (3)

Ratio of PV panel coverage to Japan's total land area (scenario under JPEA 2050 Vision of 400 GW)



Source: Estimated and prepared by Climate Integrate based on materials from the Ministry of Land, Infrastructure, Transport and Tourism, and JPEA.
Cooperation: Manabu Utagawa (National Institute of Advanced Industrial Science and Technology).

Merits of expanding RE

Flexibility: Expanding variable RE while reducing costs

Issues

The concept of flexibility in power systems to respond to variability in supply and demand including solar and wind have not been widely adopted in Japan. Most of the supply and demand balancing capacity depends on thermal power plants.

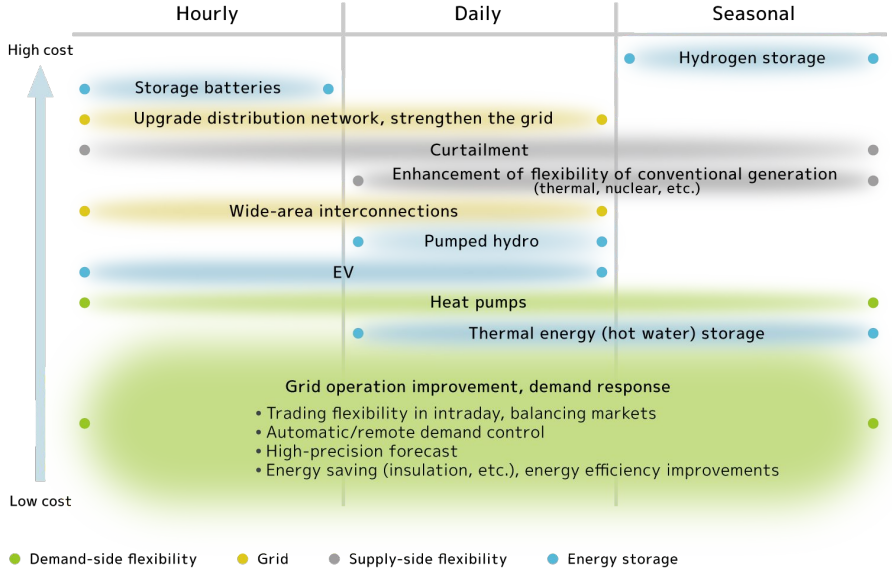
- FY2022 generation mix (1)
  - Thermal 72.8%
  - Nuclear 5.5%
  - Variable RE (VRE: solar, wind) 10.1%

The merits of using RE to expand generation capacity

By increasing flexibility in cost-effective ways, RE can be used effectively, and dependence on thermal power plants to provide flexibility can be reduced.

- Enhancing flexibility in a grid enables a large amount of RE to be accepted into the grid
- Various flexibility resources available to manage **time, day, and seasonal** fluctuations of RE
- RE can also be a flexibility resource
- Costs can be reduced through various means (e.g. market /regulatory reforms, technological innovations)

A variety of ways to enhance flexibility



Source: Prepared by Climate Integrate from IEA and IRENA and other materials. (Costs are indicative and may change depending on conditions and level of deployment, etc.).
Cooperation: Yoh Yasuda (University of Strathclyde).

Merits of expanding RE

Industrial technology: Domestic supply chain development

Issues

Despite concerns about dependence on imported solar panels, the ratio of panels to the overall cost is not necessarily high. Supply chains for offshore wind have not yet been established.

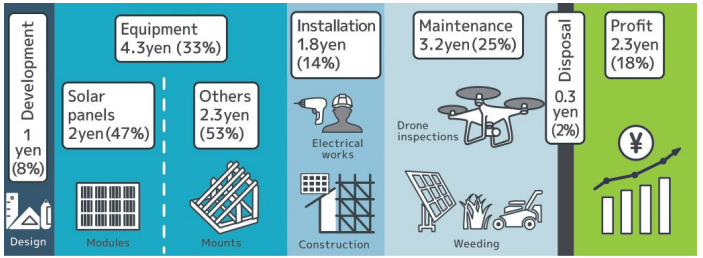
- Solar panels account for **~ 15%** of the solar power generation cost (LCOE) (2 yen / 13 yen/kWh) (1)
- Large wind turbine manufacturers in Japan currently have no production, but component parts can be produced

The merits of using RE to expand generation capacity

RE can be deployed quickly with existing technologies, provide opportunities for industrial promotion, jobs, and regional revitalization. Offshore wind presents business opportunities in the Asia-Pacific region.

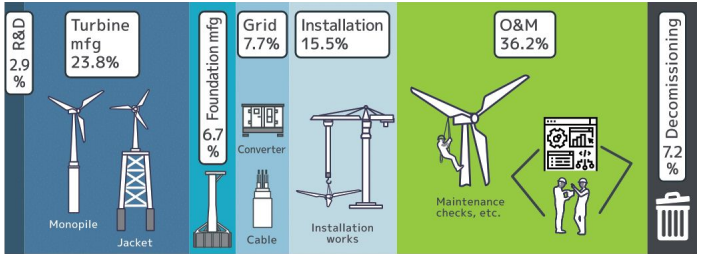
- Short development, construction periods (1-3 yrs for solar/onshore wind, ~5 yrs for offshore wind(2)
- Opportunities in component manufacturing, operations and maintenance (O&M)
- Technology development underway for floating structures (offshore wind), Perovskite solar cells
- Offshore wind requires **30,000 components,** a wide range of industries
- Companies have started entering the parts, shipbuilding, and O&M sectors (3)

Cost structure for solar (LCOE: 13 yen/kWh, plants connected to HV grid commissioning in Oct. 2023)



Source: Prepared by Climate Integrate based on Japan Photovoltaic Energy Association (JPEA) materials.

Cost structure for fixed-bottom offshore wind



Source: Prepared by Climate Integrate based on documents from Cabinet Secretariat GX Implementation Promotion Office.

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