Outlook and Issues Concerning the Domestic and International Renewable Energy Markets in 2023

～Accelerating Global Introduction and Examining VRE Measures～

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Key Points of the Report

- ✓ Global renewable output is expected to increase by about 10% year over year in 2022 and around 7% year over year in 2023. As a result, the share of renewable energy in total power generation could exceed 30% in 2022 and reach around 32% in 2023.
- ✓ In 2022–23, global renewable generation capacity is expected to grow even faster, and deployment of renewable power generation facilities is expected to proceed, with capacity reaching a high level of nearly 350 GW/year, significantly more than 280 GW/year in 2021.
- ✓ This is due to the accelerating trend to promote renewable energy deployment in China, Europe, and the U.S., which account for more than 75% of the global renewable energy market, amid growing interest in energy security, rising resource prices, and decarbonization.
- ✓ In 2023, about 90% of global renewable generation capacity growth will be provided by VRE, or "variable renewable energy," sources like solar PV and wind power. For this reason, the challenge will be to ensure the flexibility of the power grid to accommodate large amounts of VRE and to develop solutions accordingly.
- ✓ The annual growth rate for renewables deployment in Japan peaked in FY 2014 and has been on a long-term downtrend. The annual increase in FY 2023 is also projected to remain low at just under 60 GW/year, a slight increase over the previous year. This trend runs opposite to the acceleration of global renewables deployment.
- ✓ A number of factors are behind the low level of renewables deployment in Japan. There are structural problems such as the change of support system from FIT to FIP; gradual devaluation of FIT prices; stagnation of the business model shift from a low-risk model with high FIT prices to a price-competition model with FIP/FIT; lack of new business models such as PPAs that do not depend on FIT/FIP; decrease of suitable sites for commercial solar PV generation; and opposition from local communities against renewable energy development.
- ✓ Although policy measures are being taken to address these issues, the direct effects of these policies will not become obvious in the form of increased renewable energy deployment until FY 2023 or later, and additional policies may be necessary to accelerate the development of renewable energy in Japan.

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スライド 2

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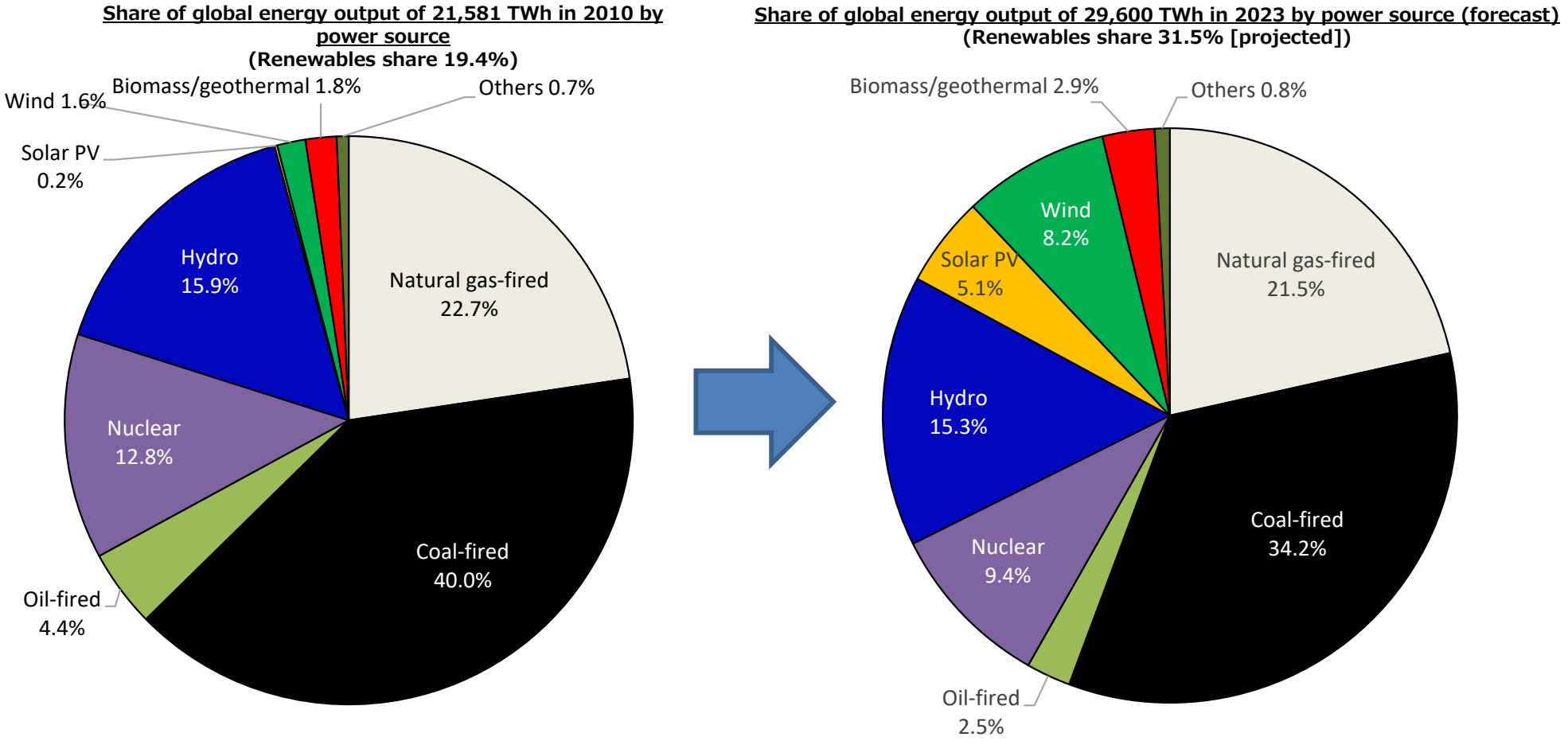
Share of renewables in global energy output in 2023 is expected to increase to around 32%

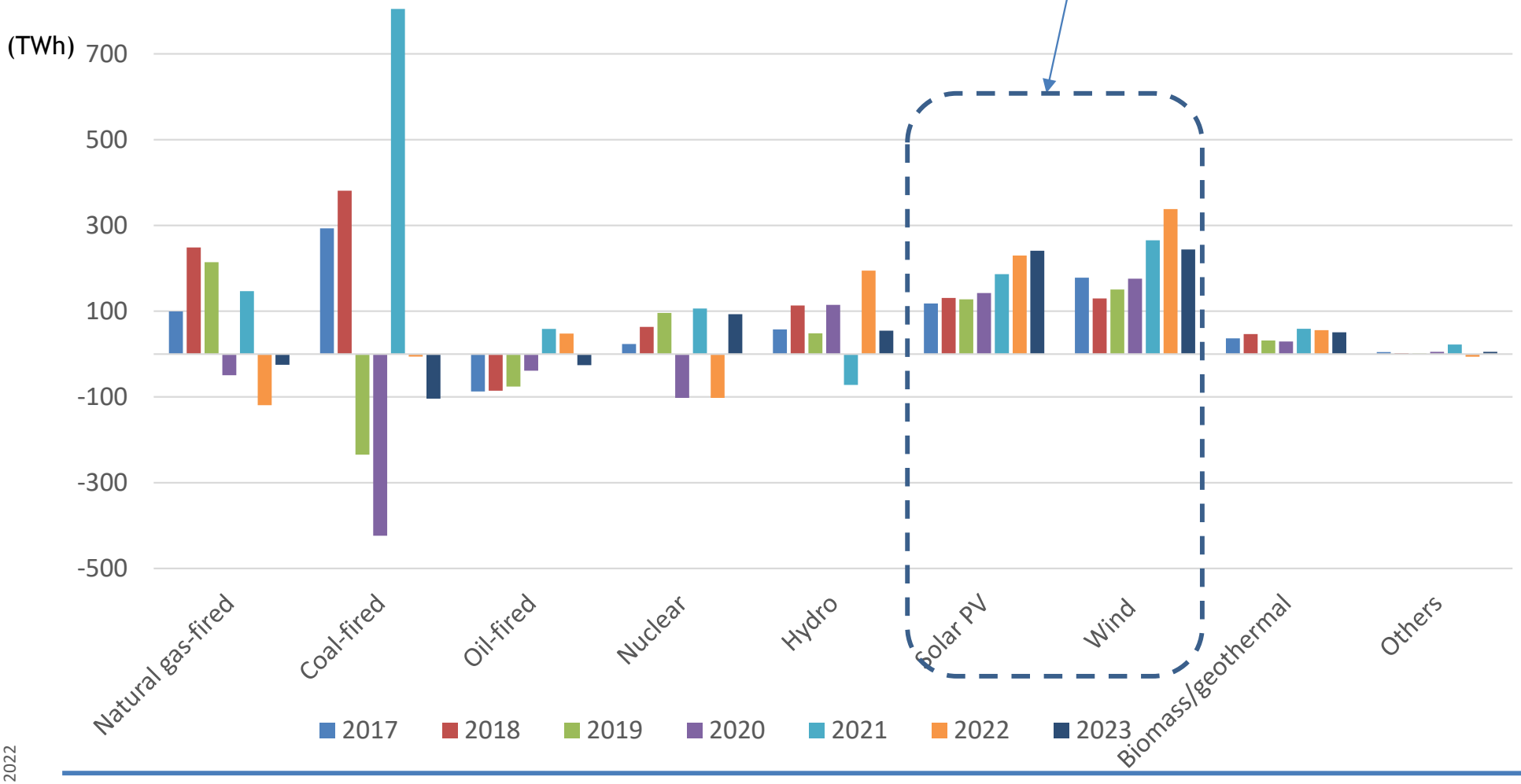
- In 2023, the share of renewables in total global energy output is expected to grow to about 32%.
  - At 19.4% in 2010, it exceeded 25% for the first time in 2018 and may exceed 30% for the first time in 2022.
  - Non-hydropower (solar PV, wind, biomass, and geothermal) output is expected to surpass hydropower for the first time in 2023.
  - The share of variable renewable energy (VRE) in 2023 will increase to 13.3% (5.1% solar PV + 8.2% wind = 13.3%).



Prepared based on sources including "BP Statistical Review of World Energy June 2022," "IEA Electricity Market Report July 2022 Update," and "IEA Renewables 2022."

2017-23 global year-over-year changes in energy output by power source: solar PV and wind power increase

- Only solar PV and wind power are expected to maintain a consistent upward trend, while thermal power generation is expected to fluctuate up and down year over year.
  - In 2022-23, renewable output is expected to increase by 7-10%/year, well above the increase in total power generation (about 2%/year).



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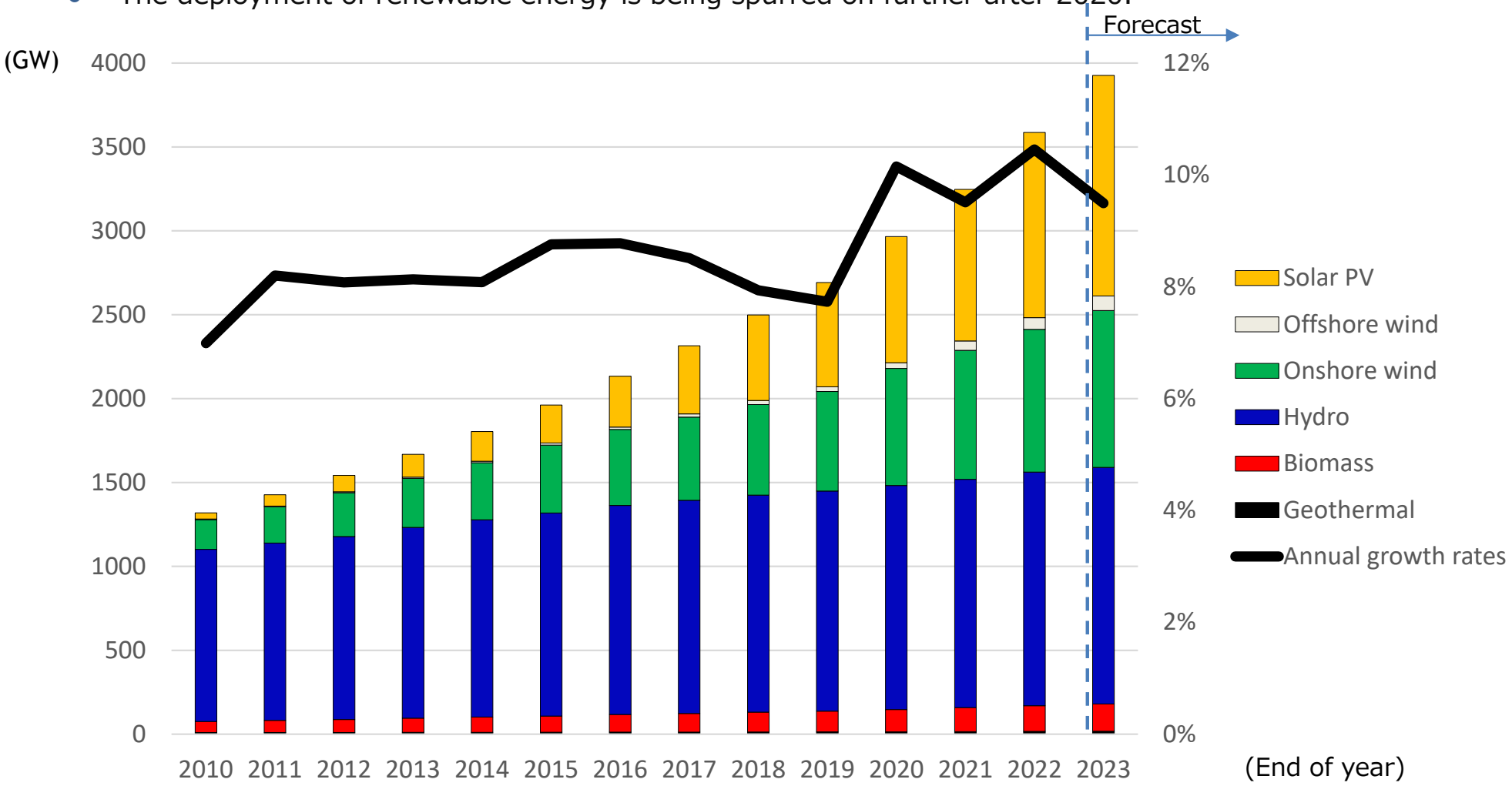
Cumulative global renewable generation capacity: 10% annual growth to around 4,000 GW by the end of 2023

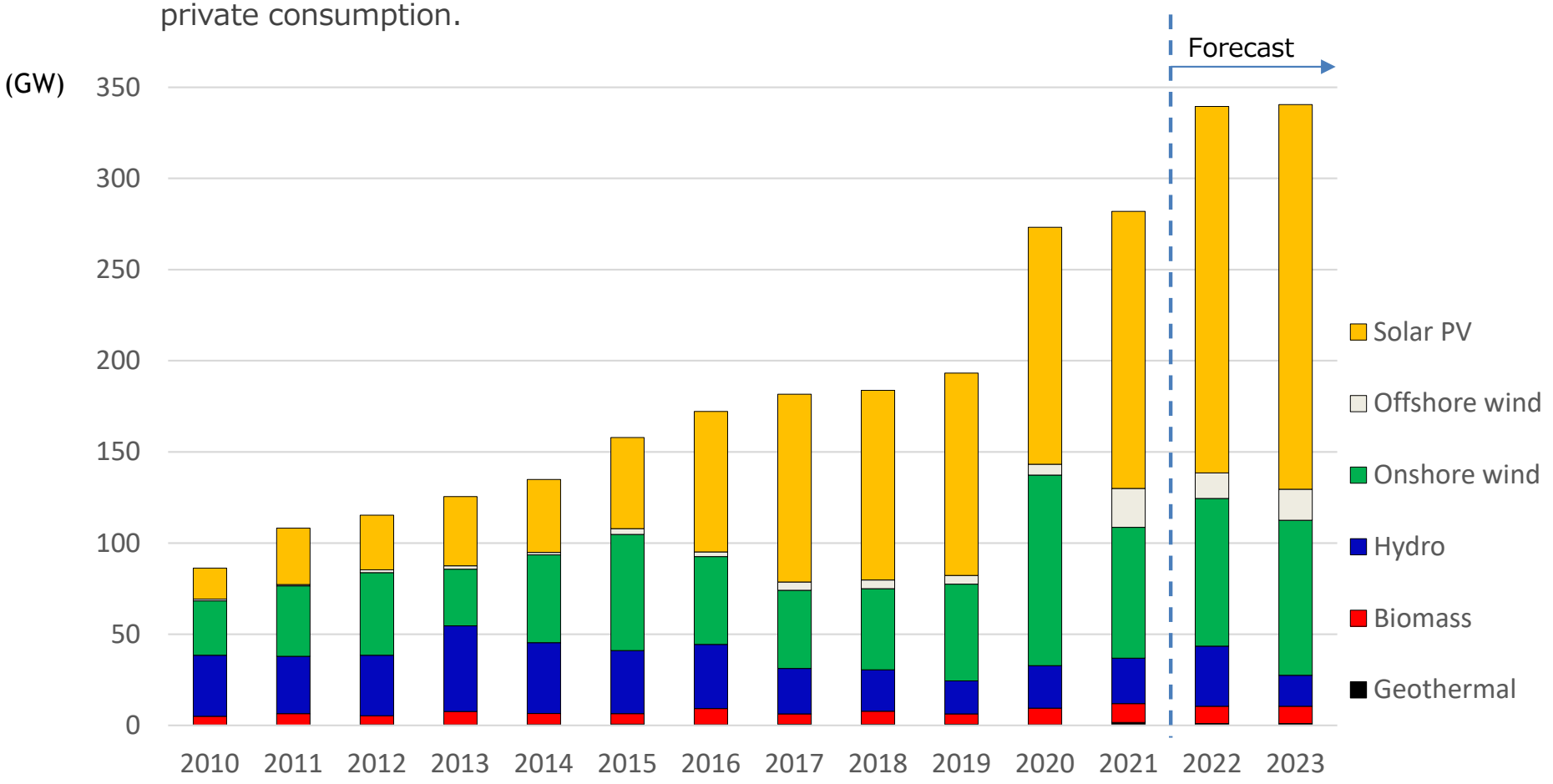
- The cumulative global renewable generation capacity is estimated to expand from 2,700 GW at the end of 2019 to 4,000 GW at the end of 2023, an increase of approximately 50% in four years.
  - The annual growth rate, which was around 8%/year in 2019 and earlier, has increased to around 10%/year since 2020.
  - The deployment of renewable energy is being spurred on further after 2020.



Prepared based on sources including “IRENA Renewable Electricity Capacity and Generation Statistics,” “IEA Renewable Market Update 2022,” “IEA Renewables 2022.”

Annual increase in global renewable generation capacity: projected to rise to just under 350 GW/year by 2023

- Output has reached a high level of nearly 350 GW/year in 2022 and is likely to further accelerate after 2023 with 350 GW/year as a minimum.
- Until 2019, the baseline was just under 200 GW/year, but it quickly rose to over 250 GW/year in 2020. After 2022, it rose sharply to just under 350 GW/year, nearly doubling the annual increase of 2019.
  - About 40% of the annual increase in solar PV generation in 2023 will be from grid-connected distributed generation, and there is a growing willingness for investment in renewable energy for private consumption.

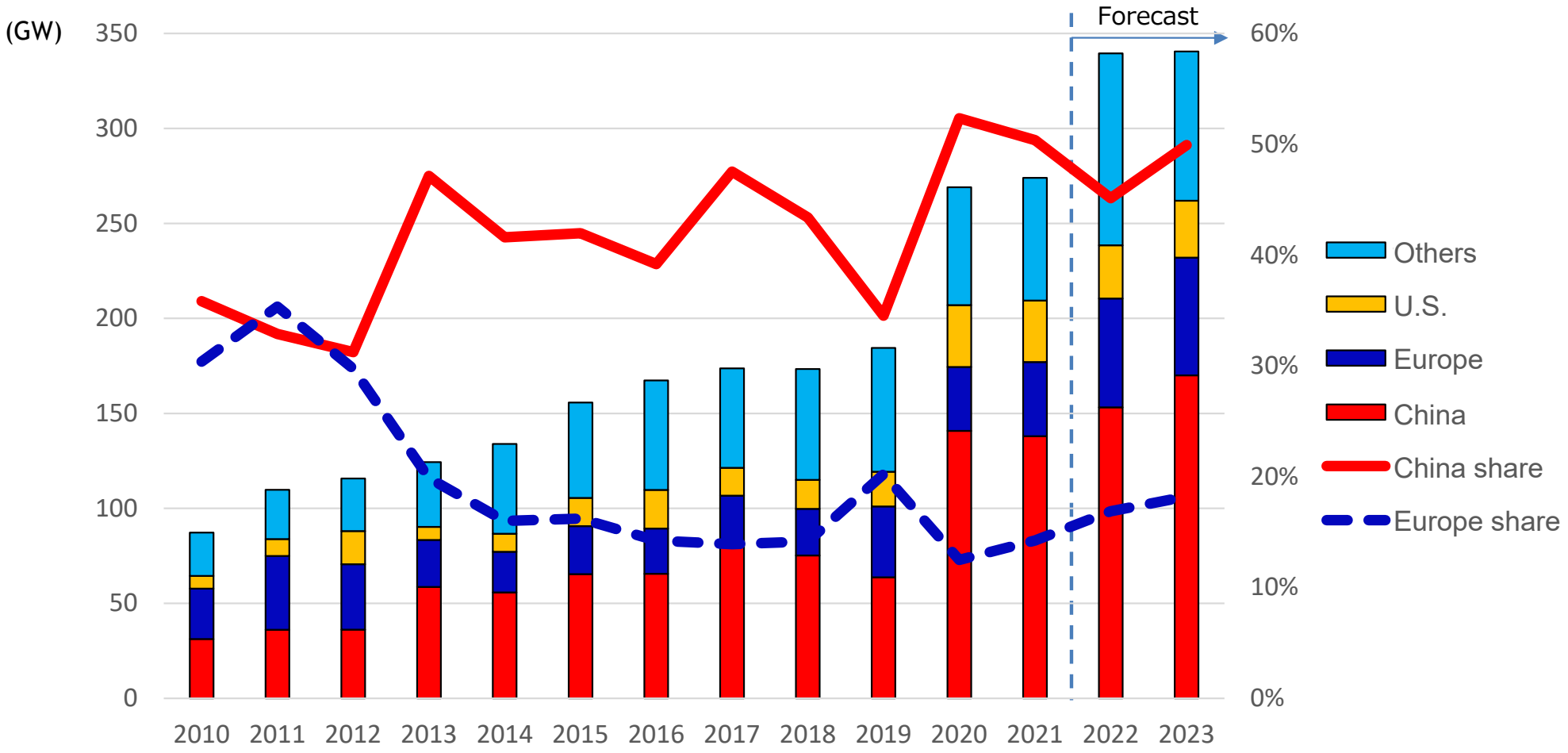


Prepared based on sources including "IRENA Renewable Electricity Capacity and Generation Statistics," "IEA Renewable Market Update 2022," and "IEA Renewables 2022."

Remarkable growth in renewable energy in China and Europe: together, account for about 70% of the total increase

- China will account for 50% of the annual increase in renewable generation capacity in 2023 and Europe 20%, together accounting for an overwhelming 70% of the market share.
  - China and Europe have set higher deployment targets in 2022, which will accelerate the deployment of renewable energy and lead the global renewables market.

Annual increase in global renewable generation capacity by major country (left axis) and changes in the share of China and Europe (right axis)

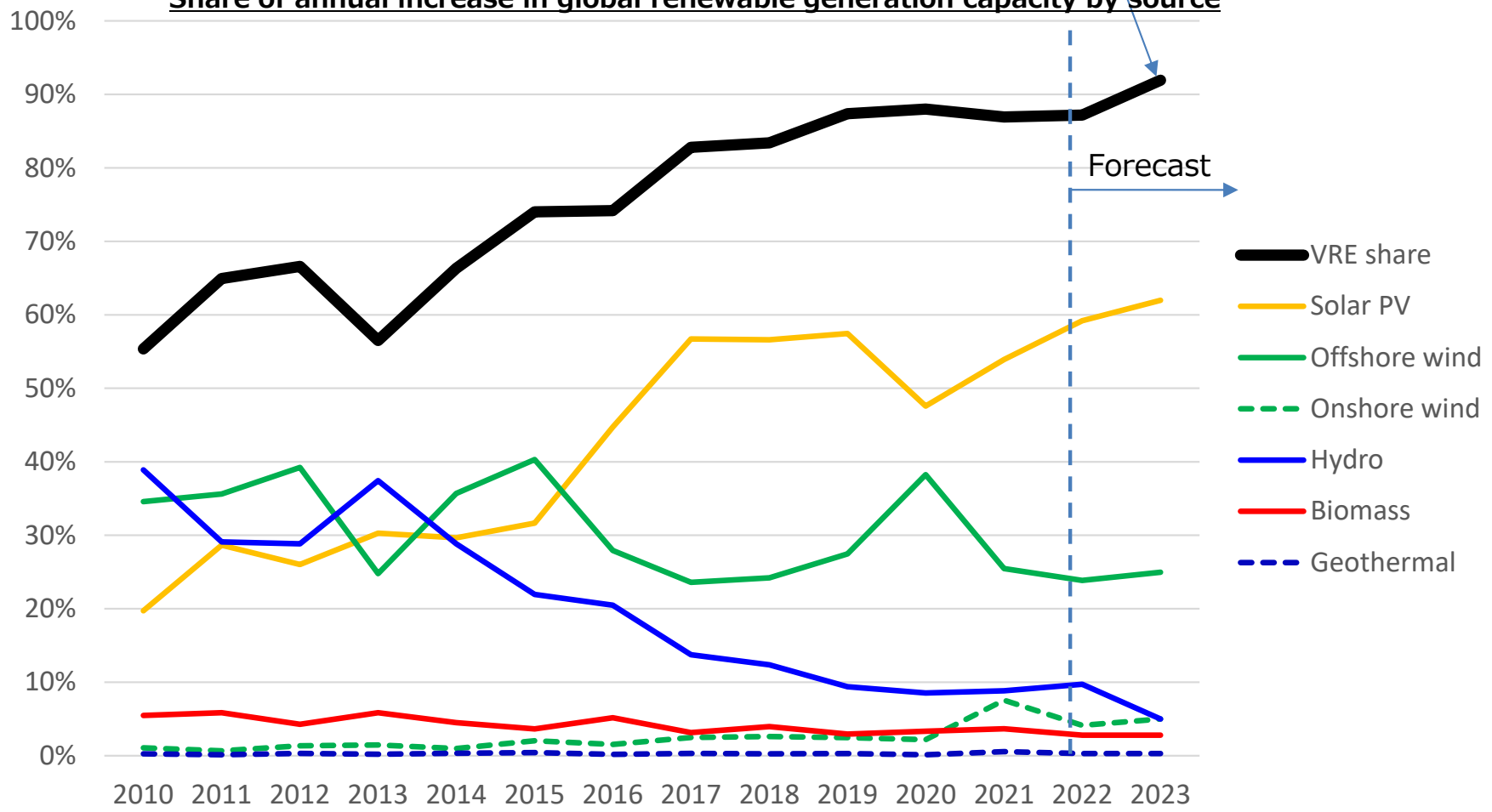


Prepared based on sources including "IRENA Renewable Electricity Capacity and Generation Statistics," "IEA Renewable Market Update 2022," "IEA Renewables 2022."

In 2023, 90% of the increase in renewable energy will come from two types of variable renewable energy (VRE): solar PV and wind power

- 60% of the 2023 renewable generation capacity growth will come from solar PV and 30% from wind (25% onshore, 5% offshore).
  - The share of variable renewable energy (VRE) is expanding every year and will account for more than 90% of the increase in 2023.
  - It is expected that VRE will continue to account for the majority of the increase in renewable energy over the long term. The challenge will be to ensure the flexibility of the power grid to accommodate large amounts of VRE and to develop solutions accordingly.

Share of annual increase in global renewable generation capacity by source



Prepared based on sources including “IRENA Renewable Electricity Capacity and Generation Statistics,” “IEA Renewable Market Update 2022,” and “IEA Renewables 2022.”

Why is global renewable generation capacity expected to continue to grow in 2023?

- Amid growing interest in energy security, rising resource prices, and decarbonization, in 2020, the trend to strengthen promotion of renewable energy deployment has accelerated in major countries like China, Europe, and the U.S., which account for more than 75% of the global renewable energy market.
- China: “14th Five-Year (2021-2025) Plan for Renewable Energy Development” (June 2022)
  - Renewable output target: 3,300 TWh in 2025 (major increase of 50% in 5 years from 2,183 TWh in 2020)
  - At least 50% share of renewable energy in the nation's total increase in electricity consumption (52% for the three-year average performance through 2020)
  - Upgrading of ultra-high-voltage transmission lines from the northeastern part of the country, an area suitable for renewable energy generation, to the western part, an area of demand, to 300 GW by 2025 (200 GW at present)
  - Regulatory changes to allow private companies to make individual purchase contracts with renewable energy projects → enable direct procurement of renewable energy power
  - Goal to install solar PV equipment on 50% of new public building roofs
- Europe: “RePowerEU Plan” (May 2022)
  - Increasing the share of renewable energy in final energy consumption to 45% in 2030 (previous target was 32%, actual in 2021 was 22%)
  - Raising solar PV generation capacity to a cumulative total of 320 GW by 2025 and 600 GW by 2030 (158 GW at the end of 2021)
  - Simplifying and expediting licensing procedures for renewable energy project development
  - If the plan is carried out as scheduled, the renewable energy generation capacity will expand to 1,236 GW in 2030. (The capacity at the end of 2021 was 512 GW, thus the capacity will increase by 2.4 times in 10 years. Under the previous target, the capacity was to expand to 1,067 GW in 2030.)
- United States: "Inflation Reduction Act" passed (August 2022)
  - Investing $369 billion in energy security and climate change
  - Extending tax credits for renewable power generation and biofuels until 2032 → greatly reduce uncertainty about renewable energy investment
  - However, the Uyghur Forced Labor Prevention Act, which came into effect in June 2022, is resulting in a serious and prolonged supply shortage of solar panels in the U.S. For this reason, deployment of renewable energy is projected to stagnate in the short term in 2023, while acceleration of renewables deployment due to the Inflation Reduction Act is expected to take place from 2024 onward
- In addition, the increasing procurement of renewable energy by the private sectors through PPAs and other means is also a factor that is raising willingness for investment in renewable power generation.

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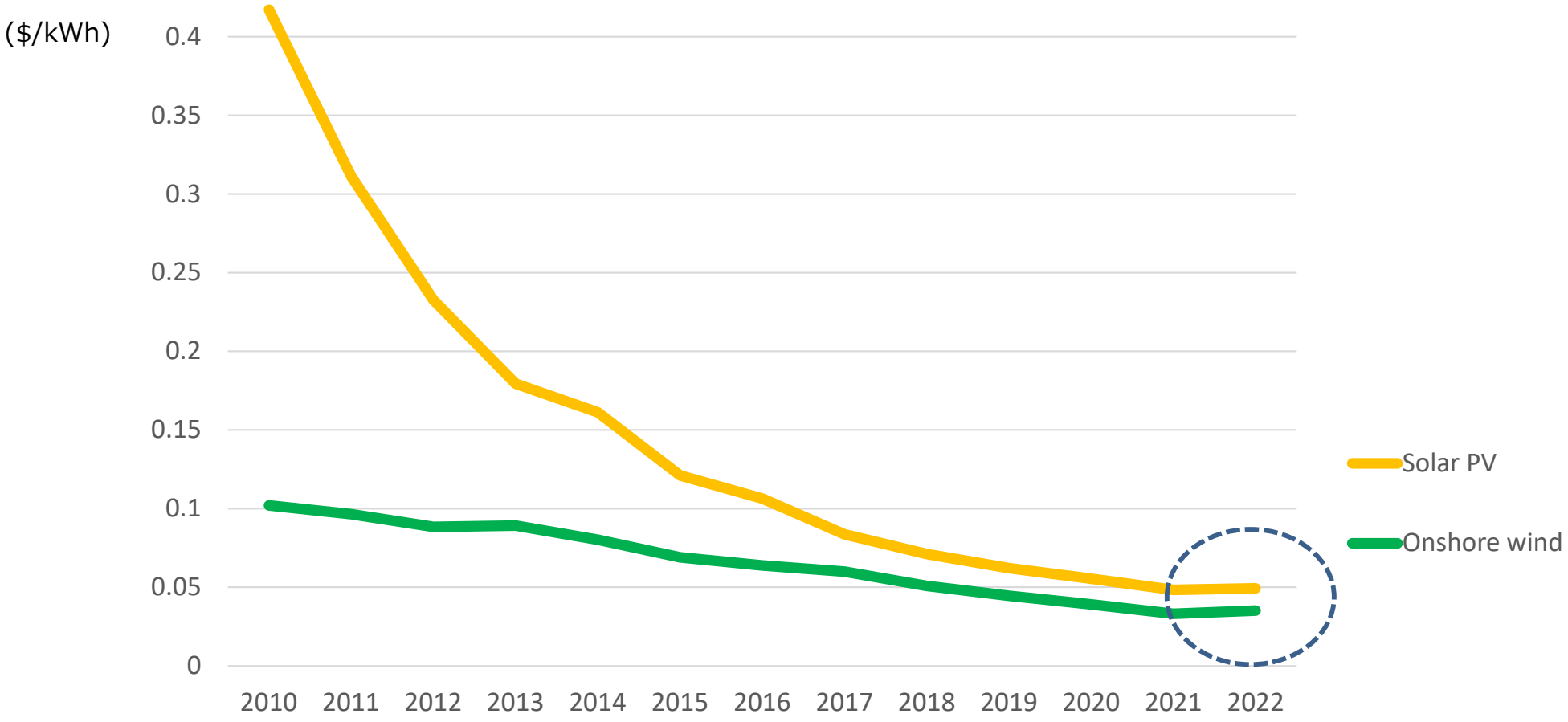
Cost of renewable power generation trending upward in 2022 due to soaring resource prices

- Due to the impact of the sharp rise in resource prices after 2021, the Levelized Cost Of Electricity (LCOE) entered an upward phase for the first time in 2022.
  - However, the increase in power generation costs is estimated to be relatively small, at around 2% for solar PV and around 5% for onshore wind, compared to 2021.
  - Costs in 2023 remain uncertain because they depend on trends in resource prices, and it is possible that costs could rise at the same level.

Global solar PV and onshore wind power generation costs (global weighted average LCOE)

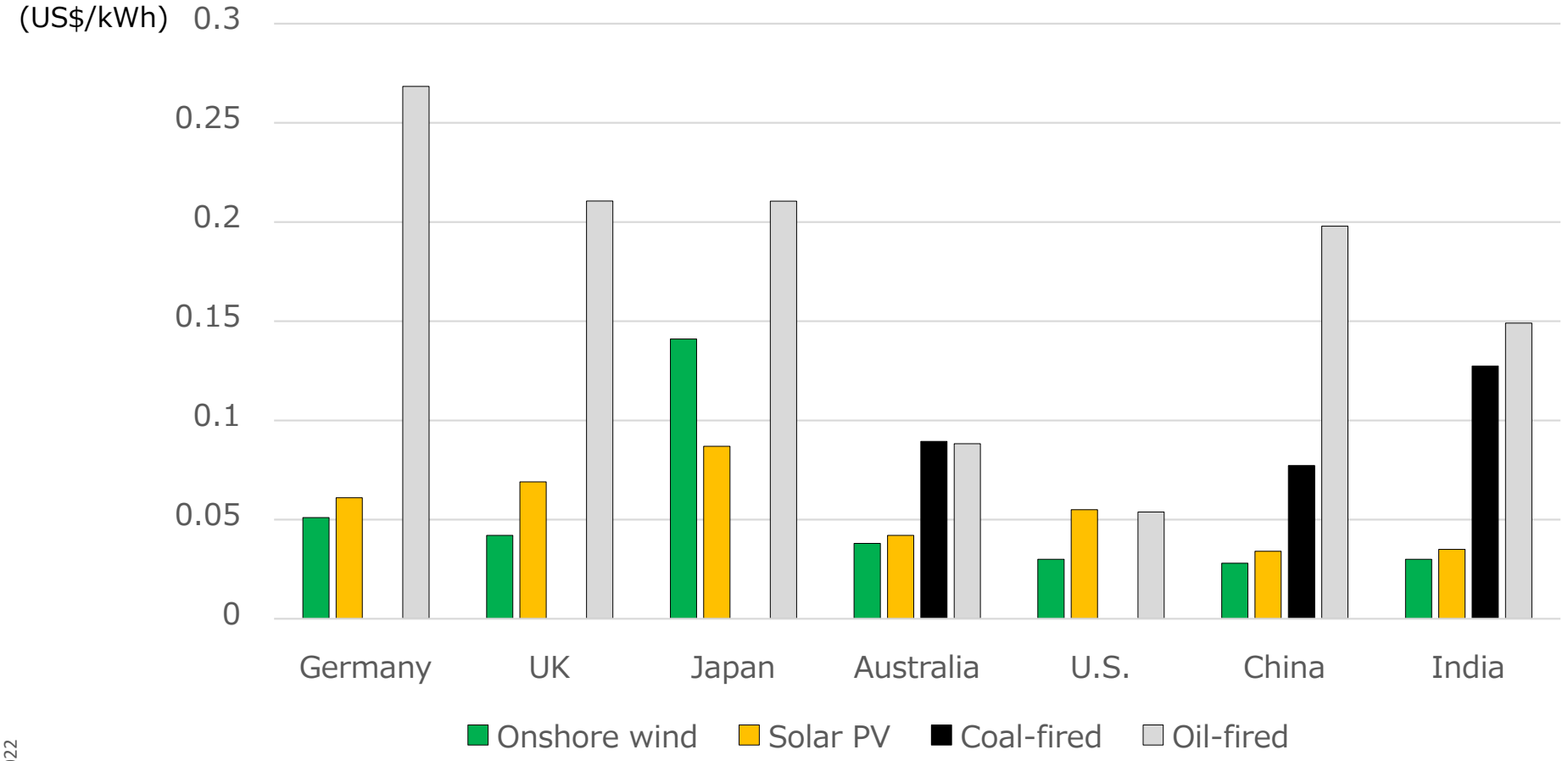


Prepared based on sources including “IRENA Renewable Power Generation Costs in 2021.”

Renewable energy maintains dominance over thermal power output despite cost increases

- Soaring resource prices and the crisis in Ukraine have also significantly increased thermal power output costs globally. Compared to the rising cost of thermal power output, increases in solar PV and wind power output costs have been relatively limited.
- As a result, solar PV and wind power's cost advantage has been maintained.
  - However, it is not necessarily clear whether the cost advantage of renewable output will be maintained over the long term, as the cost of thermal power output can change significantly in the future due to fluctuations in fuel prices.

Equalized output costs (LCOE) of gas-fired, coal-fired, solar PV, and onshore wind power in major countries in 2022



Prepared based on sources including "IRENA Renewable Power Generation Costs in 2021."

Issues in light of the massive deployment of renewables in 2023

- Ensuring the flexibility of the power grid to accommodate large amounts of VRE
  - More than 80% of the world's newly deployed renewable generation capacity since 2018 has come from VRE. In 2023, it is projected to exceed 90%, and this trend appears set to continue over the long term.
  - For this reason, VRE's share of global power generation is certain to increase year by year, and it is necessary to continue to take various measures in the short-to-long term to ensure the flexibility of the power grid.
  - VRE measures involve additional costs associated with renewables deployment and must be balanced with the decreasing costs of renewable output.
- The need to diversify the renewables supply chain, which is concentrated in China
  - The crisis in Ukraine has revealed the security risks of relying heavily on certain countries for energy supply. With regard to renewables, in particular there is a growing concern about the concentration of solar panel supply in China.
  - For this reason, there is a growing perception worldwide that diverse and multi-lined supply chains are indispensable for energy security.
  - In addition, from the perspective of supply chain diversification, there is growing interest in establishing a system for reuse and recycling of renewable generation waste, such as the large amount of solar panels that are certain to be produced in the future.
- Importance of measures to ensure a stable supply of rare mineral resources
  - Solar PV and wind power generation equipment are relatively more dependent on rare mineral resources compared to thermal power output.
  - Solar PV generation in particular is highly dependent on silicon, and trends in silicon are likely to have a significant impact on its prices and supply.
  - Along with soaring resource prices and the Ukraine crisis, there is increasing concern about the high dependence on certain mineral resources and the risk of supply constraints on these resources due to the massive deployment of renewables in the future global decarbonization trend.
  - Along with efforts to reduce dependence on rare minerals and other resources for solar PV and wind power generation equipment, it will be necessary to establish a global cooperative framework to secure a stable supply of these resources.

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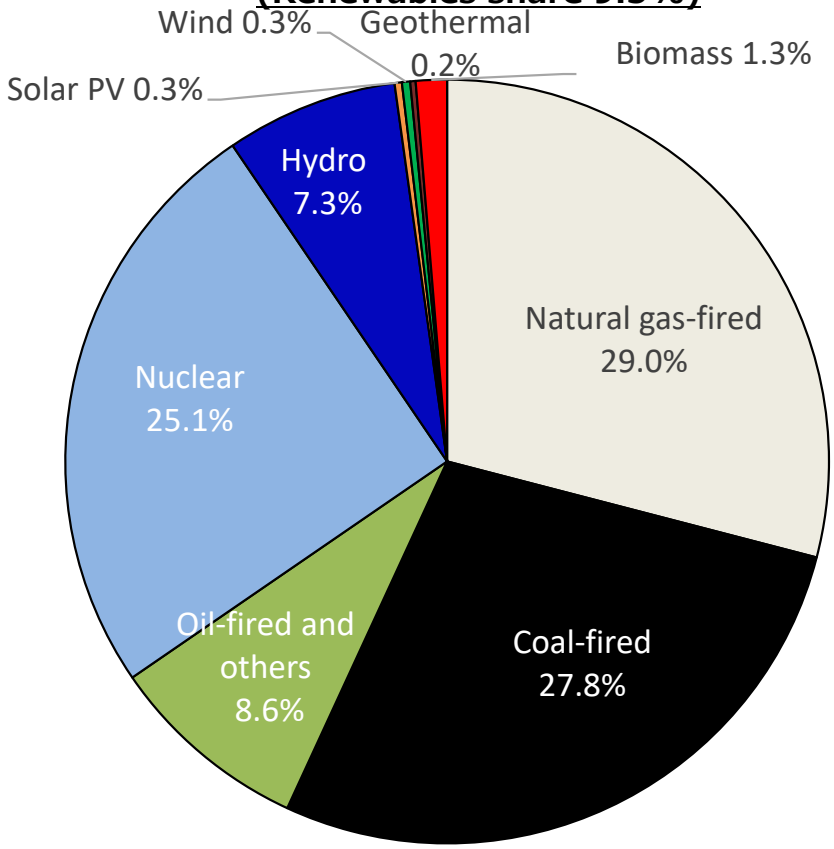
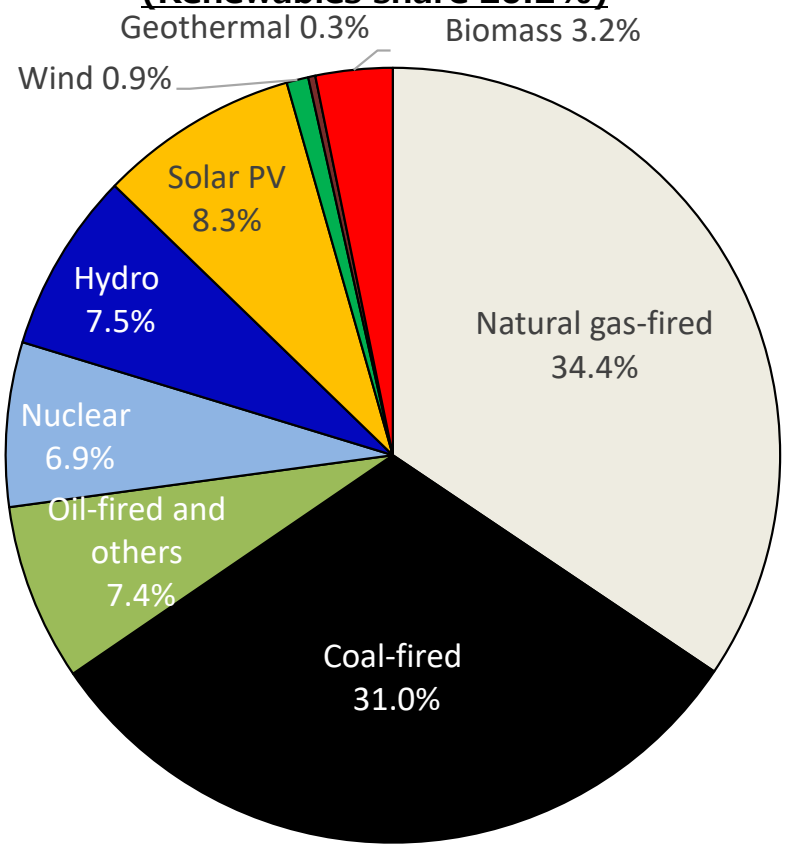
Share of renewables in Japan's electricity generation: Growing to 20.2% in 2021

- At 20.2%, the share of renewables in Japan's electricity generation exceeded 20% for the first time in 2021.
  - While solar PV increased significantly, the hydropower share, which accounted for the majority of renewables in 2010, remained virtually unchanged.
  - As a result, in 2021, the share of hydropower and solar PV reversed, with solar PV becoming the largest renewable output source.
  - In 2021, the share of variable renewable energy (VRE) increased to 9.2% (8.3% solar PV + 0.9% wind = 9.2%).

Share of Japan's power generation of 1,149 TWh in 2010 by source (Renewables share 9.5%)



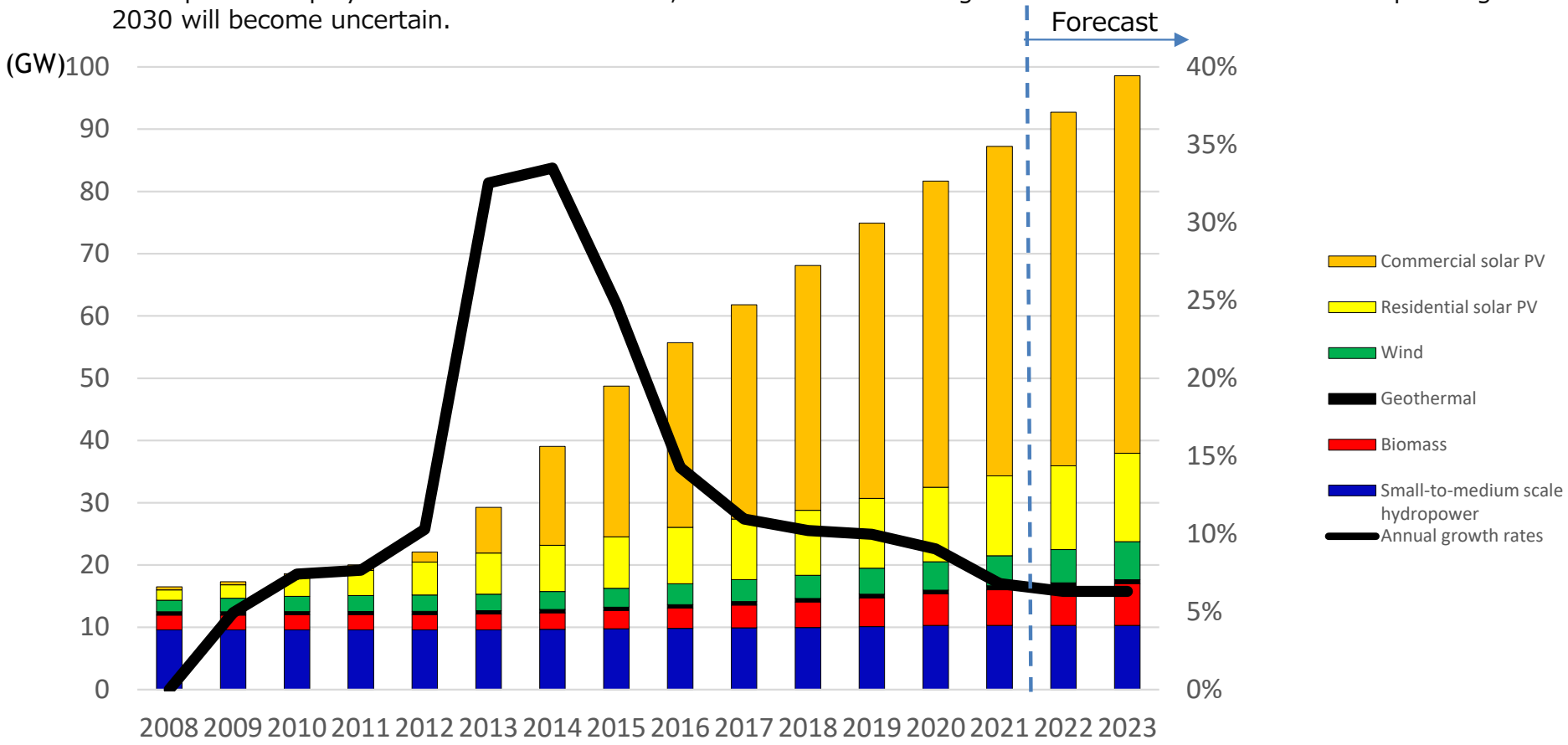
Share of Japan's power generation of 1,033 TWh in 2021 by source (Renewables share 20.2%)



Source: “Preliminary Report on the FY2021 Comprehensive Energy Statistics."

Japan’s cumulative renewable generation capacity will grow to just under 100 GW by the end of 2023

- Renewable generation capacity (excluding large hydropower of 30 MW or more) will reach 99 GW* by the end of FY 2023, with 190 TWh** of electricity generated.
- Share of renewables in total power generation for FY 2023, including large hydropower of 30 MW or more, is projected to be 22.5% (7.9% hydropower, 14.6% non-hydropower). → The former 2030 renewables target (share 22-24%) is expected to be achieved in FY 2023.
  - The annual growth rate of Japan's renewables deployment peaked in FY 2014 and has been on a long-term downtrend, declining further to 6%/per year from FY 2020 onward. → This trend runs opposite to the global acceleration of renewables deployment.
  - If the pace of deployment remains at this level, the achievement of target renewables share of 36–38% in power generation in 2030 will become uncertain.



*Solar PV output is calculated on an AC basis.
**Includes own-use generation of solar PV.

Source: Estimates from the Institute of Energy Economics, Japan.

Japan's annual increase in renewable generation capacity will remain at a low level of less than 6 GW in 2023

- Annual increase in 2023 is estimated to be as low as slightly less than 6GW/year*, a slight increase from the previous year.
  - This is chiefly due to the fact that the amount of solar PV generation deployment—the primary source of renewable power—will remain at 4.5 GW/year*, the lowest level since 2012.
  - Onshore wind power will gradually begin to benefit from relaxing the scale of environmental assessment subjects, which could increase the amount of wind power deployment to the 800 MW level in 2023.
  - Although the designation of suitable sea areas and bidding are proceeding, deployment of offshore wind power will not materialize in 2023.

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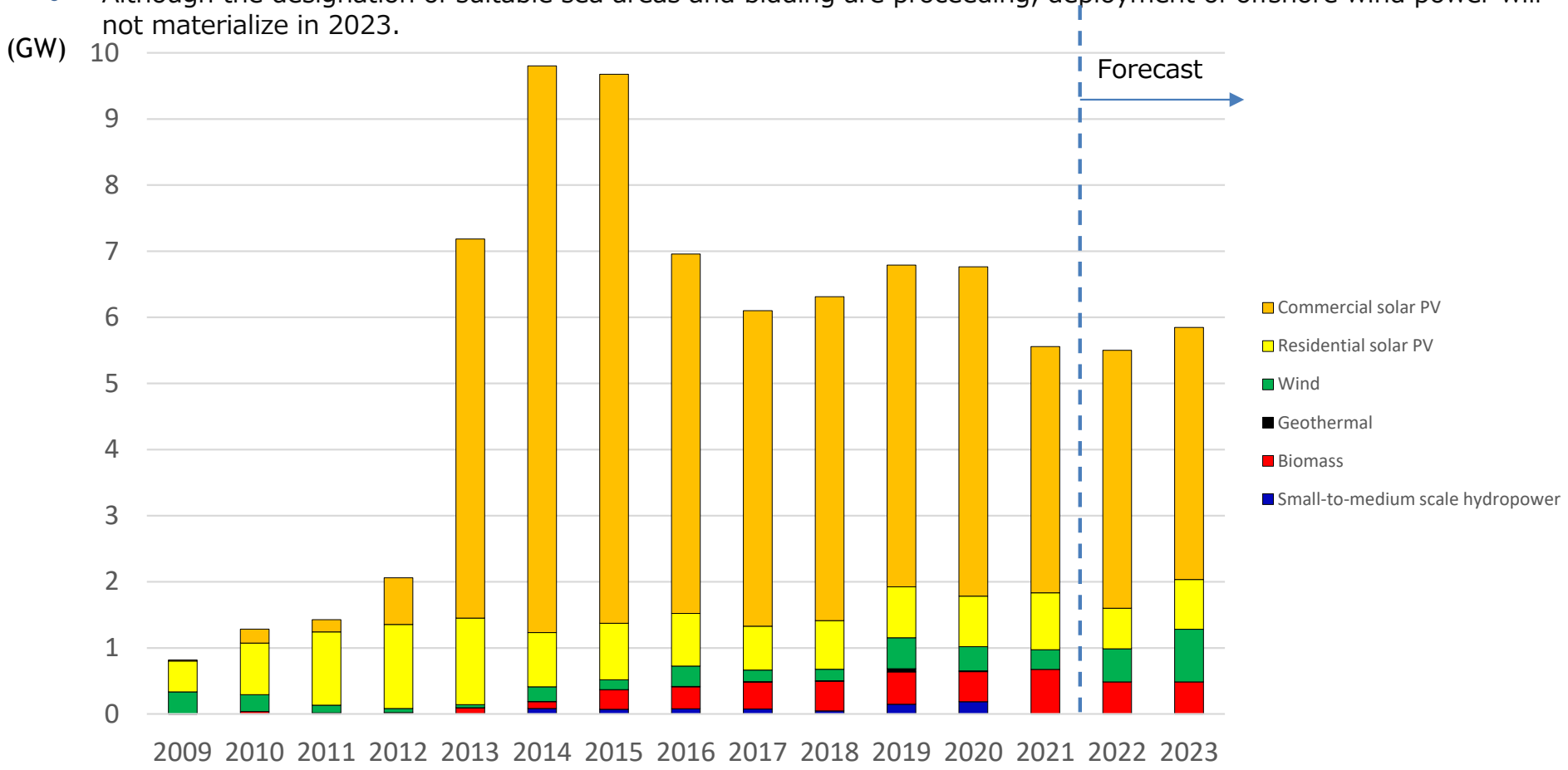

*Solar PV output is calculated on an AC basis and also includes own-use generation of solar PV.

Source: Estimates from the Institute of Energy Economics, Japan.

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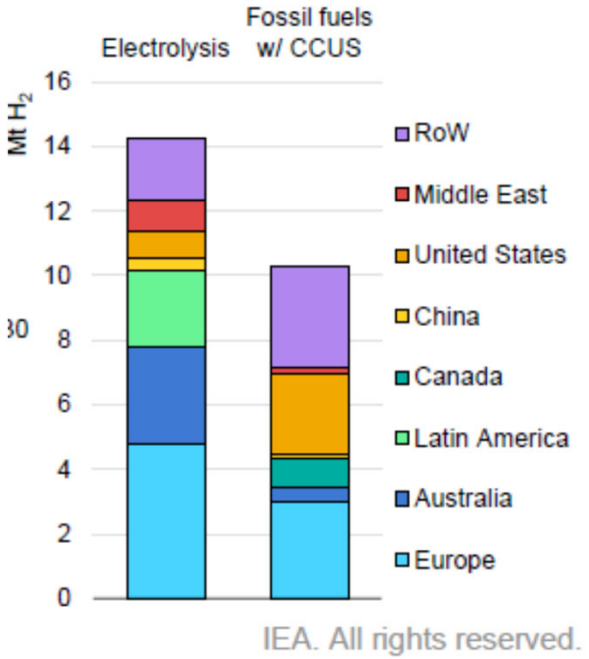
Why is the deployment of renewables slowing down in Japan but accelerating globally?

- Change of support policy from FIT to FIP starting in FY 2022 → Renewables businesses also encouraged to become independent through direct sales in the wholesale electricity market
  - From 2022, the scope of application has gradually expanded from FIT to FIP for solar PV and onshore wind power of 50 kW or more.
  - FIT purchase price drops to ¥10/kWh (solar PV of 50kW<250kW) level even at the medium to small scale, which is not subject to FIP.
  - Aggregators and VPP businesses that bundle small- and medium-scale renewable generation projects under the FIP have not yet fully developed.
  - The business model shift from a low-risk model with high FIT prices to a price-competition model with FIP/FIT has stagnated.
  - Germany, which introduced FIP earlier, has also been on a slowing trend of 6%/per year like Japan since the system change from FIT to FIP. However, it is expected to recover to an accelerated trend through additional policies under the RePowerEU Plan, which includes raising targets for renewables, increasing FIT/FIP prices, expanding the bidding volume for renewables, and simplifying licensing procedures for development.
- Off-site PPAs that do not rely on FIT/FIP and own-use business models are still developing and have not yet been established.
  - Off-site PPAs that do not rely on FIT/FIP and own-use business models are expected to gradually develop in the future. However, as of 2023, they will still be under development and will not expand on a large scale. Therefore FIT/FIP-approved projects are still considered to be the main source of new deployment for 2023.
- Decrease of suitable sites for commercial solar PV generation, such as former factories and business sites, and abandoned golf courses.
  - As countermeasures, policies have been formulated, including the utilization of undeveloped land with unknown owners and abandoned farmland, agrivoltaic solar farms, floating solar farms in reservoirs, utilization of unused public land in places like airport grounds, and strengthening the deployment of solar PV generation in new public facilities of national and local governments and in newly constructed housing. The effects of these measures are not likely to materialize in 2023.
- Opposition from local communities against renewables development and tighter development regulations by local governments
  - Countermeasures underway include a shift from conventional unregulated development of renewables projects to a positive zoning system, in which renewables promotion zones are publicly designated to actively formulate projects, as well as support for establishing ordinances for renewables development based on regional symbiosis.
- Insufficient free capacity in the power grid
  - Currently finalizing a long-term policy (master plan) for a push type wide-area grid in light of its renewable energy potential.
- Although policy measures are being taken to address these issues, the direct effects of these policies will not materialize in the form of increased renewables deployment until after 2023. Additional policies may be necessary to accelerate renewables deployment.

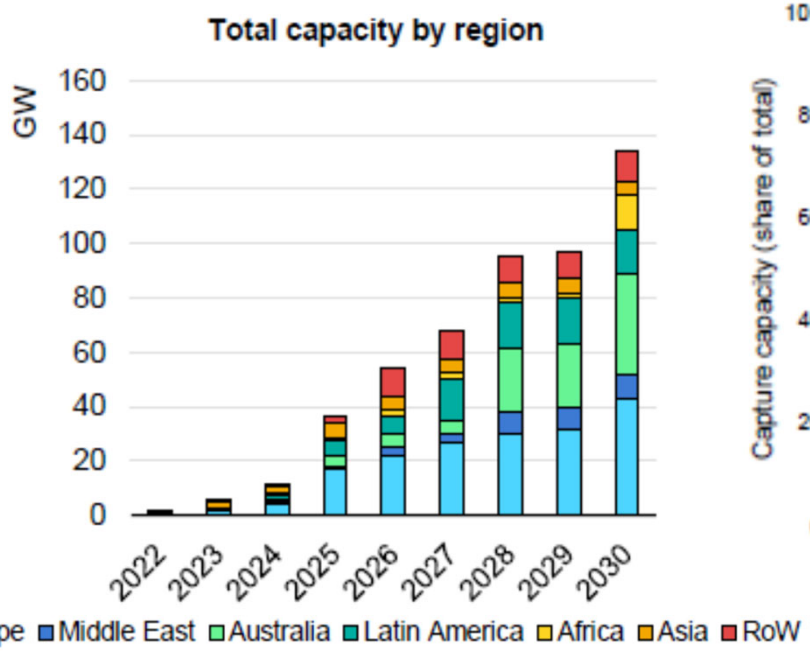
Outlook for Global Hydrogen Projects

- If all the published projects are implemented, hydrogen production is expected to reach 24 Mt-H_2 (14 Mt of water electrolysis hydrogen and 10 Mt of fossil CCUS hydrogen) by 2030.
- Water electrolysis hydrogen is mainly produced in Europe, Australia, and South America. Expansion of water electrolyzer manufacturing capacity in Europe and China is expected in the future.
- Fossil CCUS hydrogen is currently mostly used as a feedstock for industrial processes and chemical production, but by 2030, fuel applications, including ammonia, will dominate.

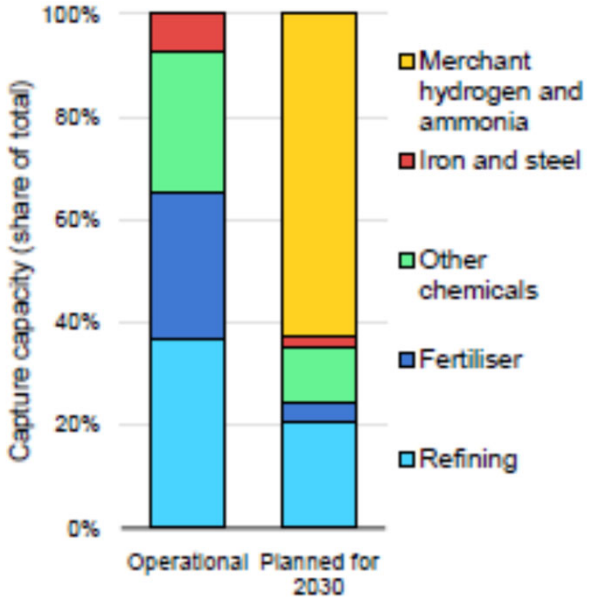
Hydrogen production volume forecast



Water Electrolysis Facility Capacity Forecast



Percentage of fossil CCUS hydrogen by use



Source: "Global Hydrogen Review 2022," IEA.

Domestic and international trends in hydrogen

- Number of countries with a national hydrogen strategy
  - From 3 countries in 2019 (Japan, South Korea, France) to 16 countries in 2021 (Australia, Chile, France, Germany, Netherlands, Norway, UK, EC, and others are new).
  - Expansion to 25 countries (Austria, Belgium, China, Denmark, Poland, South Africa, and others are new) as of 2022 (“Global Hydrogen Review 2022,” IEA).

- Global trends:
  - More countries set targets for the deployment of water electrolysis. The global water electrolysis facility capacity target for 2030 doubles from 74 GW a year ago to 145–190 GW (“Global Hydrogen Review 2022,” IEA)
  - If domestic renewables are insufficient to produce enough hydrogen, countries will have to rely on imported hydrogen. For example, the REPowerEU Plan targets the production of 10Mt-H_2 in the region in 2030 as well as the import of the same amount of renewable energy hydrogen. The global water electrolysis market is projected to expand.

- Trends in Japan
  - Concrete moves such as FS by private companies to establish a supply chain for imported ammonia (targeting the U.S., Australia, the Middle East, etc.) are gaining momentum.
  - With NEDO support, a number of studies and technological developments are also being conducted to build a model to promote the use of imported and domestic hydrogen locally.