

Renewable Energy Outlook and Challenges for Japan and the World

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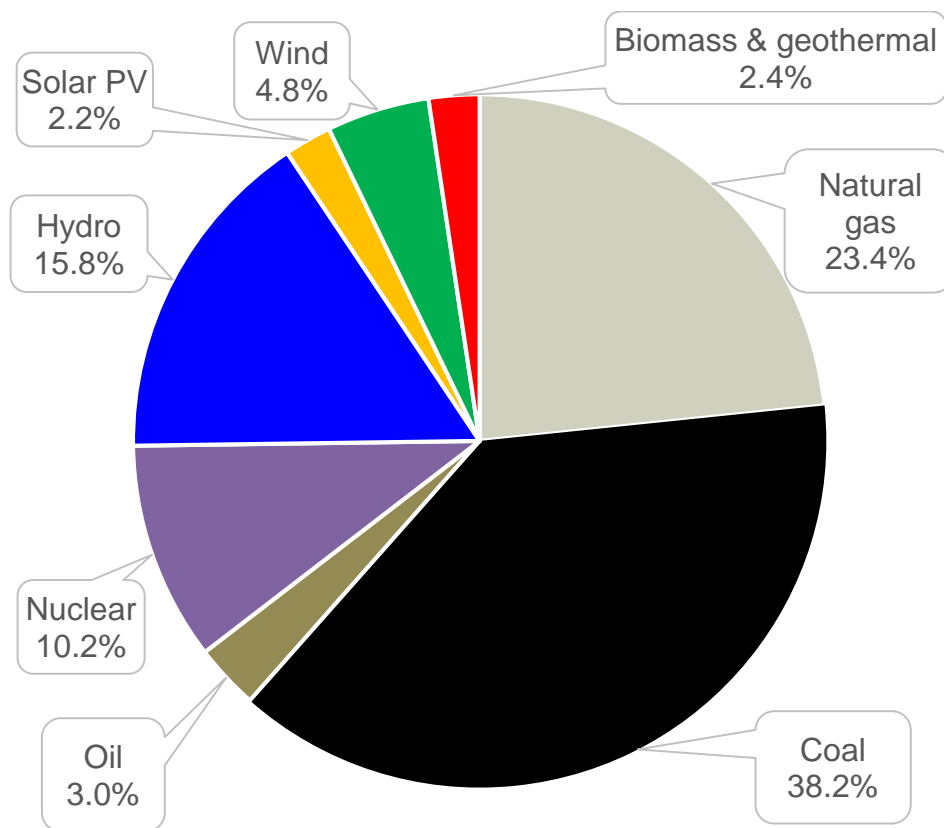
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Key points

- ✓ The world's total installed capacity for renewable power generation was 2,470 GW (1,300 GW from hydro, 1,170 GW from non-hydro renewables) at the end of 2018. The figure is expected to increase annually by around 8% in 2019-2020 to reach 2,900 GW (1,300 GW from hydro, 1,600 GW from non-hydro renewables) at the end of 2020. The total electricity production from renewables in 2018 was 6,670 TWh (4,190 TWh from hydro, 2,480 TWh from non-hydro renewables). The share of renewables in the full generation mix was 25.2%.
- ✓ The installed capacity for renewable power generation grew by 175 GW in 2018, almost equals to the largest recorded annual growth of 177 GW in 2017. Although the capacity growth in China dropped by about 6% from the previous year, the world has achieved annual growth of more than 160 GW consecutively since 2016 thanks to growth in countries other than China.
- ✓ In 2019-2020, the installed capacity for renewable power generation is expected to grow by about 40 GW per year in China, while the capacity growth will be faster in the rest of the world. As a result, the annual capacity growth worldwide including China is likely to reach the unprecedented level of nearly 200 GW in 2019-2020. Aside from China, there is strong growth in regions such as Europe, the United States, India and the Middle East. In each region, the growth is driven by solar PV.
- ✓ There are three factors that contribute to the growth of the installed capacity for renewable power generation: the falling cost of renewable power generation, the strengthening of national/sub-national target for renewables, and the expanded purchasing of renewable power by corporations.
- ✓ Although growth in the total installed capacity for renewable power had been slow in recent years in Japan, the growth in FY2018 increased greatly to 7 GW thanks to the setting of a deadline for starting operation for solar PV projects that have not yet started generating power after being certified under the FIT scheme. As the impact from this measure persists, the capacity growth of about 7 GW per year is expected to continue in 2019-2020. As a result, the total of the renewable capacity, excluding more than 30 MW of hydro, is expected to reach 83 GW at the end of FY2020 which would produce 158 TWh of electricity in FY 2020. Combined with outputs from more than 30 MW of hydro, the contribution of renewables to power generation in 2020 is expected to total 19.0% in which 7.9% from hydro and 11.1% from non-hydro renewables.
- ✓ The challenges that Japan is facing in 2020 include lowering the cost of renewable power generation which is exceptionally high compared with the global level, reconfiguring the power grids to be able to integrate the expanded renewables, and deciding how to share costs, and developing a scheme for shouldering the cost of disposing of disused solar PV panels, as a large number of disused panels will have to be disposed of from 2030 onward.

Global: Share of power sources by output (2018)

- Renewable energy accounted for 25.2% of the global power output of 26,461 TWh* in 2018:
 - Hydropower at 15.8% (down 0.2 point from 2017), non-hydro renewables at 9.4% (up 1.0 point from 2017)
 - The share of renewables climbed 0.7 percentage point from 24.5% in 2017, surpassing 25% for the first time.
 - Renewables have increased by 0.7% point/year on average for the past five years and are set to exceed one-third of total power output in 2025 if the current growth continues.

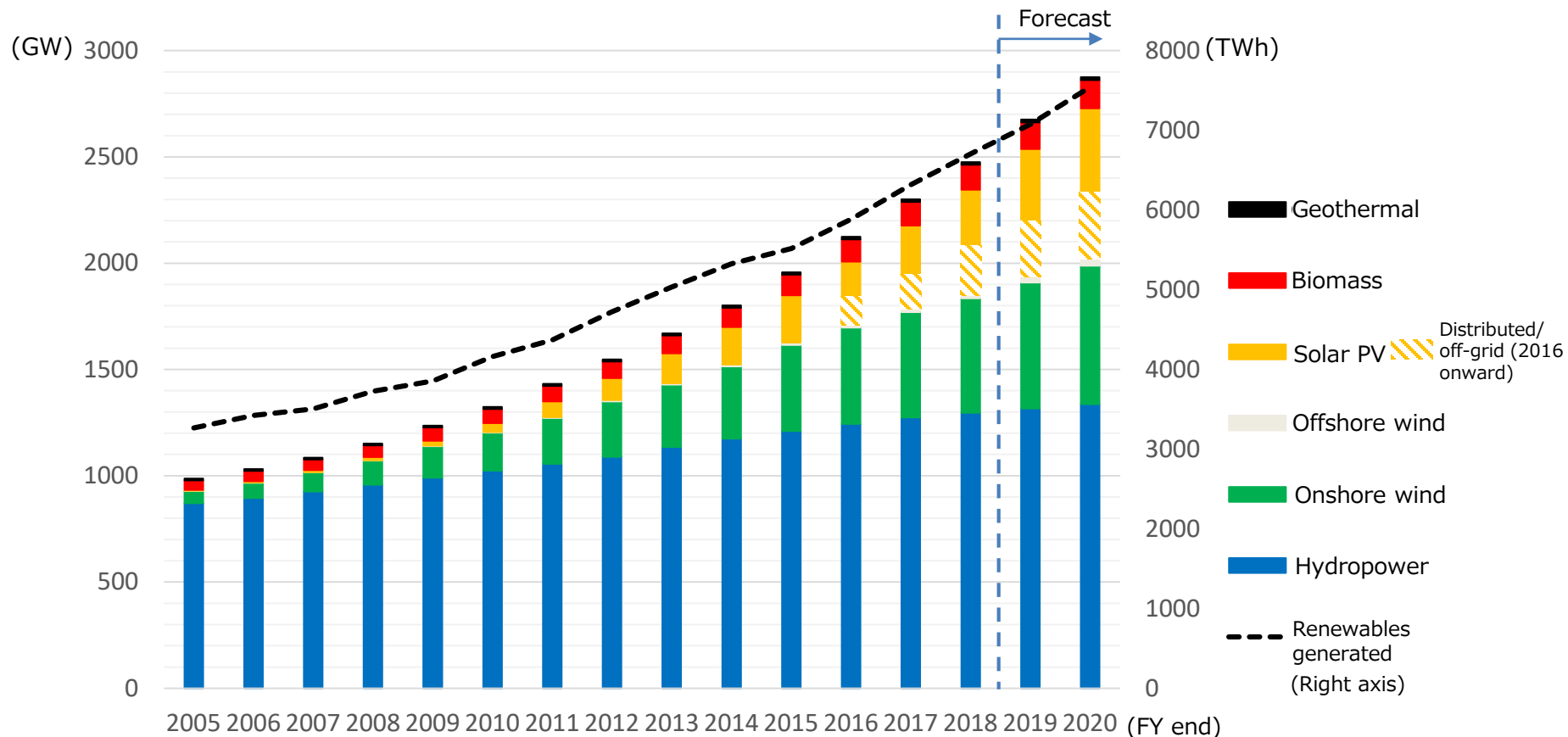


* Excluding a statistical error of 153.8 TWh

Source: BP Statistical Review of World Energy June 2019

Cumulative global renewable power capacity and generated power (2005-2020)

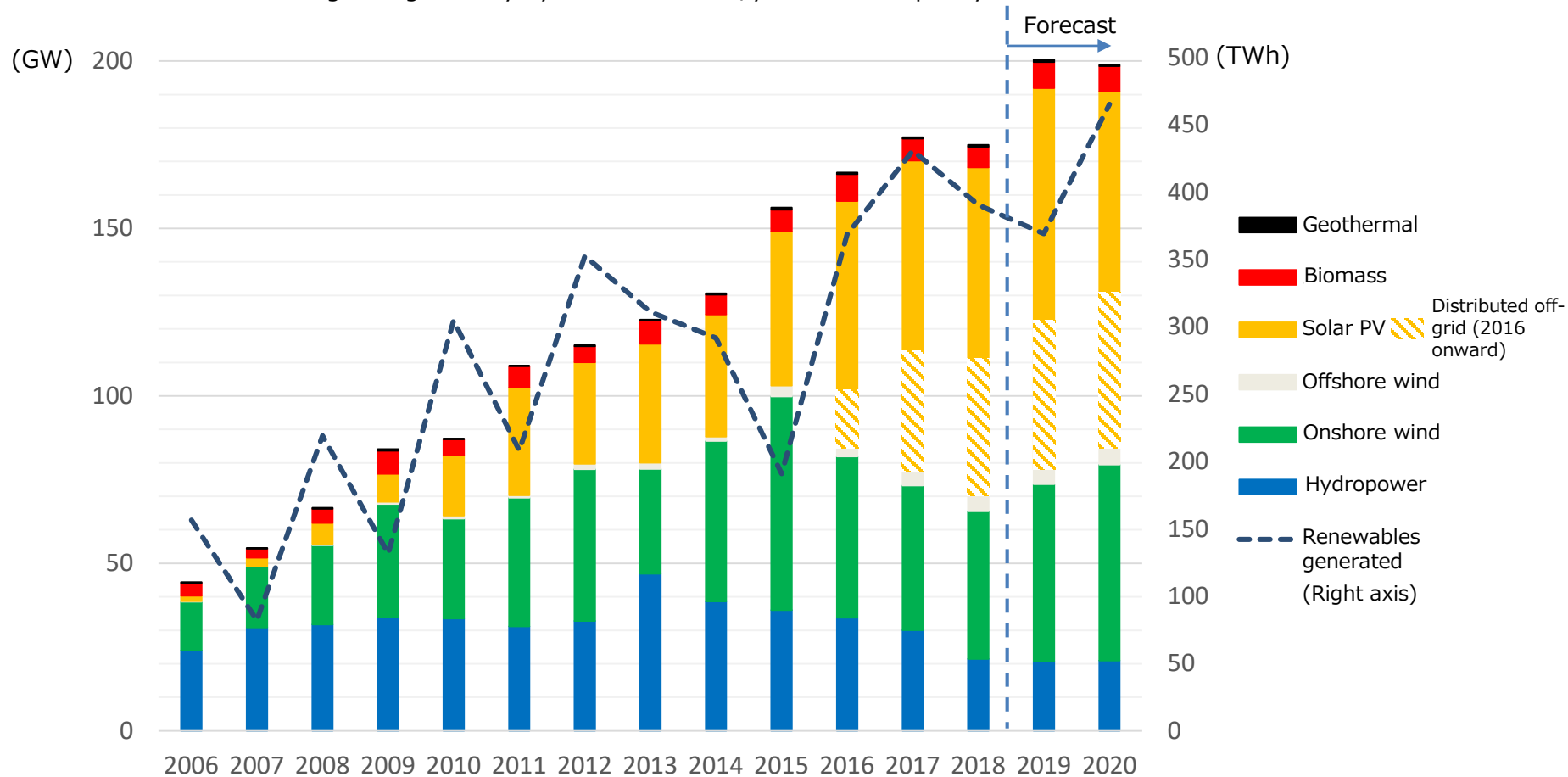
- Renewable power capacity has continued growing at about 8% p.a. for the last 10 years
- With the same rate in 2019-20, cumulative capacity is expected to reach nearly 2,900 GW at the end of 2020
 - Power generated by renewables has been growing generally at 6% p.a.; From 2010 to 2020, it is expected to grow 1.8-fold from 4,160 TWh to 7,500 TWh.
 - Within the solar PV sector, the capacity of distributed/off-grid systems doubled in four years from 140 GW in 2016 to 300 GW in 2020. → This suggests a relative decrease in the demand for grid-connected power.



Source: IRENA Renewable Electricity Capacity and Generation Statistics, IEA Renewables 2019, etc.

Annual growth of global renewable power capacity and generated power (2006-2020)

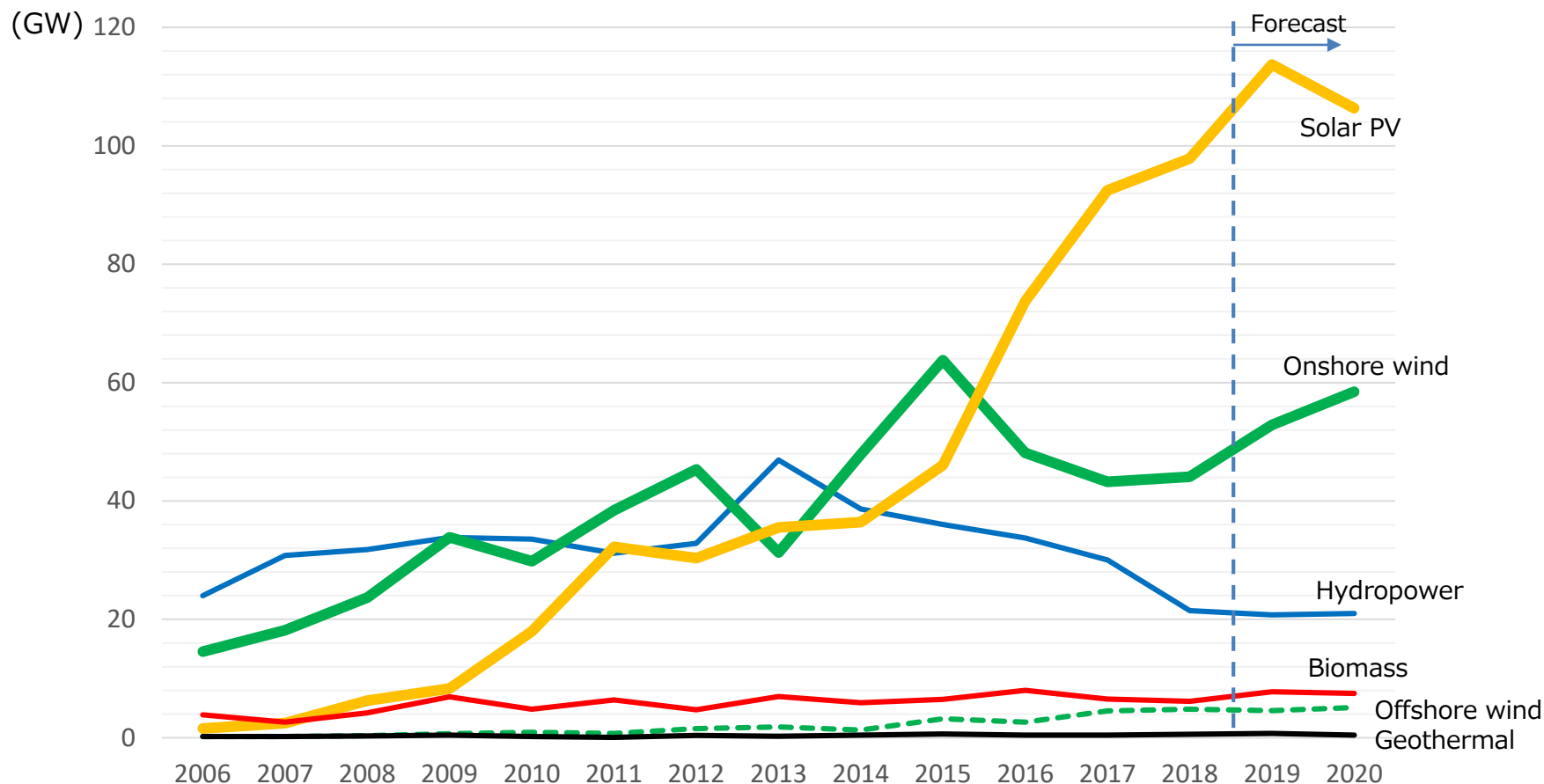
- Renewable power capacity is expected to grow in 2019-2020 at the unprecedented rate of nearly 200 GW per year due mainly to increases in the capacity of solar PV and onshore wind power.
 - Aside from China, growth of solar PV is prominent in regions such as Europe, US, India and M.East, boosting global capacity.
 - Annual total of power generated by renewables is impacted by large year-to-year fluctuations of hydro, which is directly affected by the amount of rainfall. Even if the contribution from hydro is excluded, the annual total of the power generated by renewables has been growing steadily by about 400 TWh/year over the past years.



Source: IRENA Renewable Electricity Capacity and Generation Statistics, IEA Renewables 2019, etc.

Annual growth of installed capacity for renewable power generation of different resources (2006-2020)

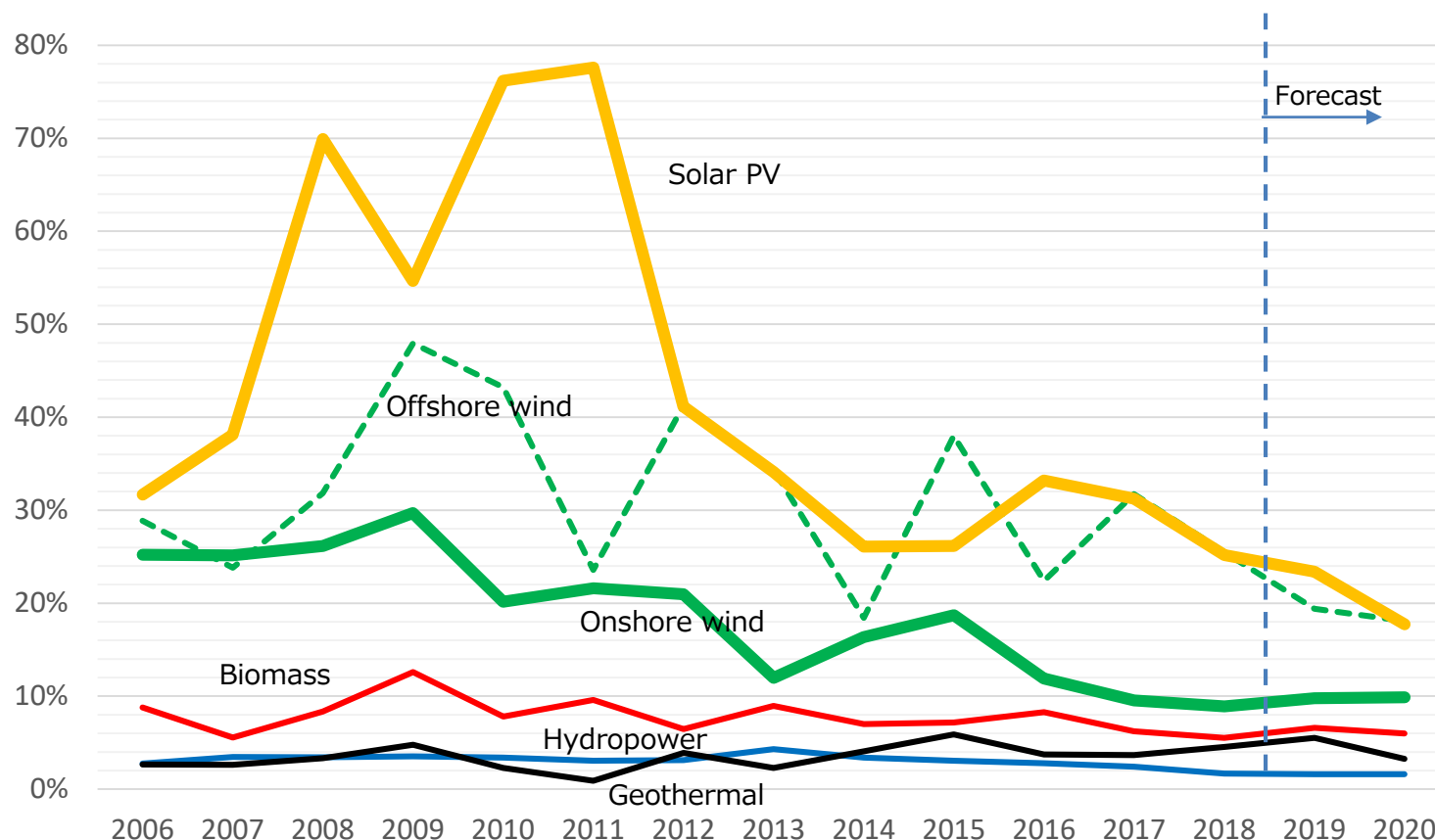
- Since 2016, solar PV has exceeded growth of any other renewable power option, and is expected to continue growing by more than 100 GW/year.
 - Onshore wind is likely to be limited to about 50 GW/year due to factors such as decrease in suitable area
 - Hydro has already peaked due to decrease in suitable area, and is expected to grow slowly by about 20 GW/year.
 - Biomass is expected to remain the same, while offshore wind is gradually increasing the level of biomass (7 GW/year).



Source: IRENA Renewable Electricity Capacity and Generation Statistics, IEA Renewables 2019, etc.

Rate of annual growth of installed capacity for renewable power generation of different resources (2006-2020)

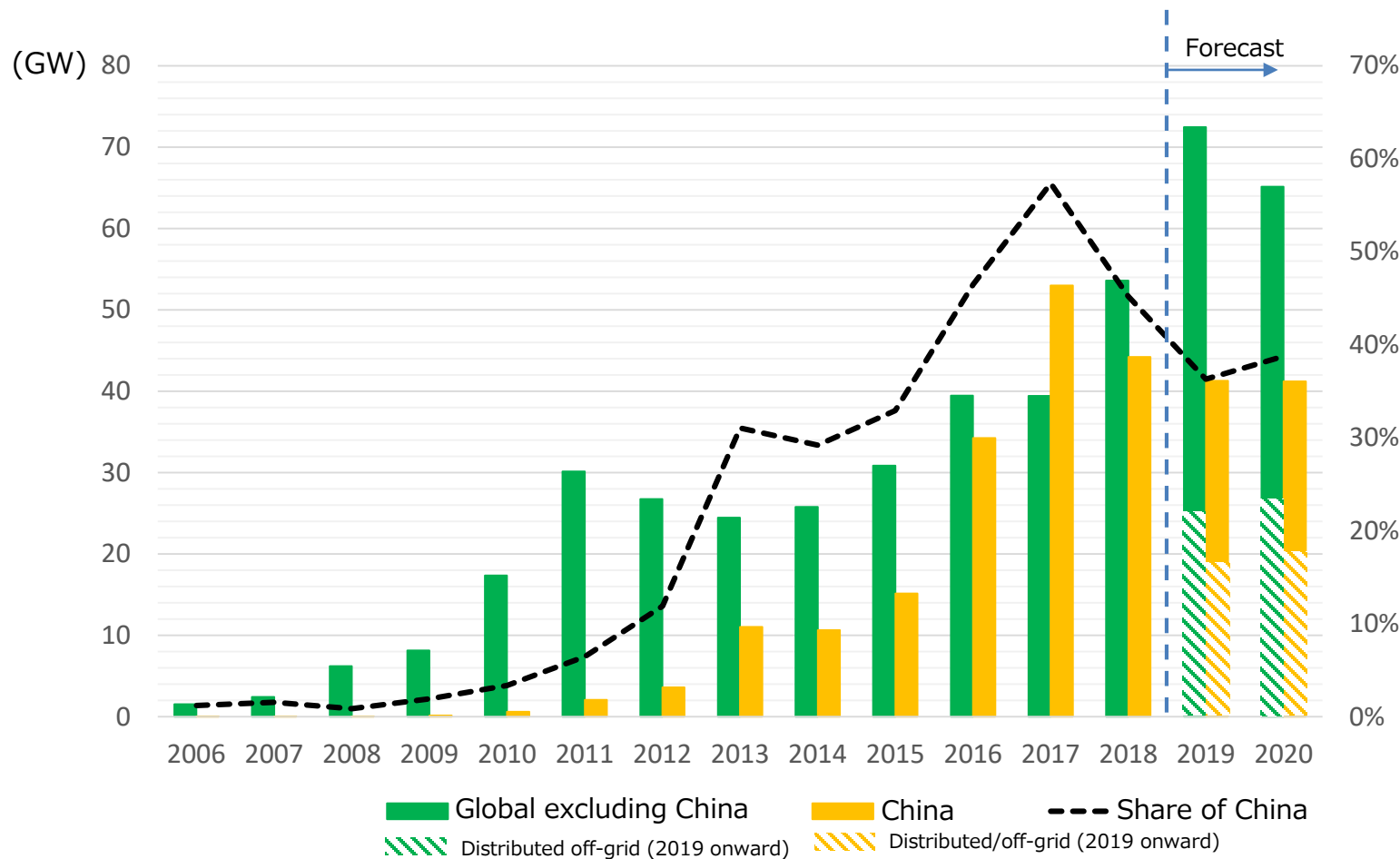
- Other than solar PV, offshore wind is growing the fastest at 20% p.a.; Since 2012, offshore wind market has been expanding as fast as solar PV, and is expected to continue growing.
 - Solar PV, after an explosive increase during 2008-11, has gradually entered a period of stable growth of 20% p.a.
 - Annual growth of other renewables are low: onshore wind 10%; biomass-fired 5%; geothermal 3 to 5%; hydro 2% or less.



Source: IRENA Renewable Electricity Capacity and Generation Statistics, IEA Renewables 2019, etc.

Annual growth of solar PV capacity: prominent growth in countries other than China with increasing contribution from distributed systems

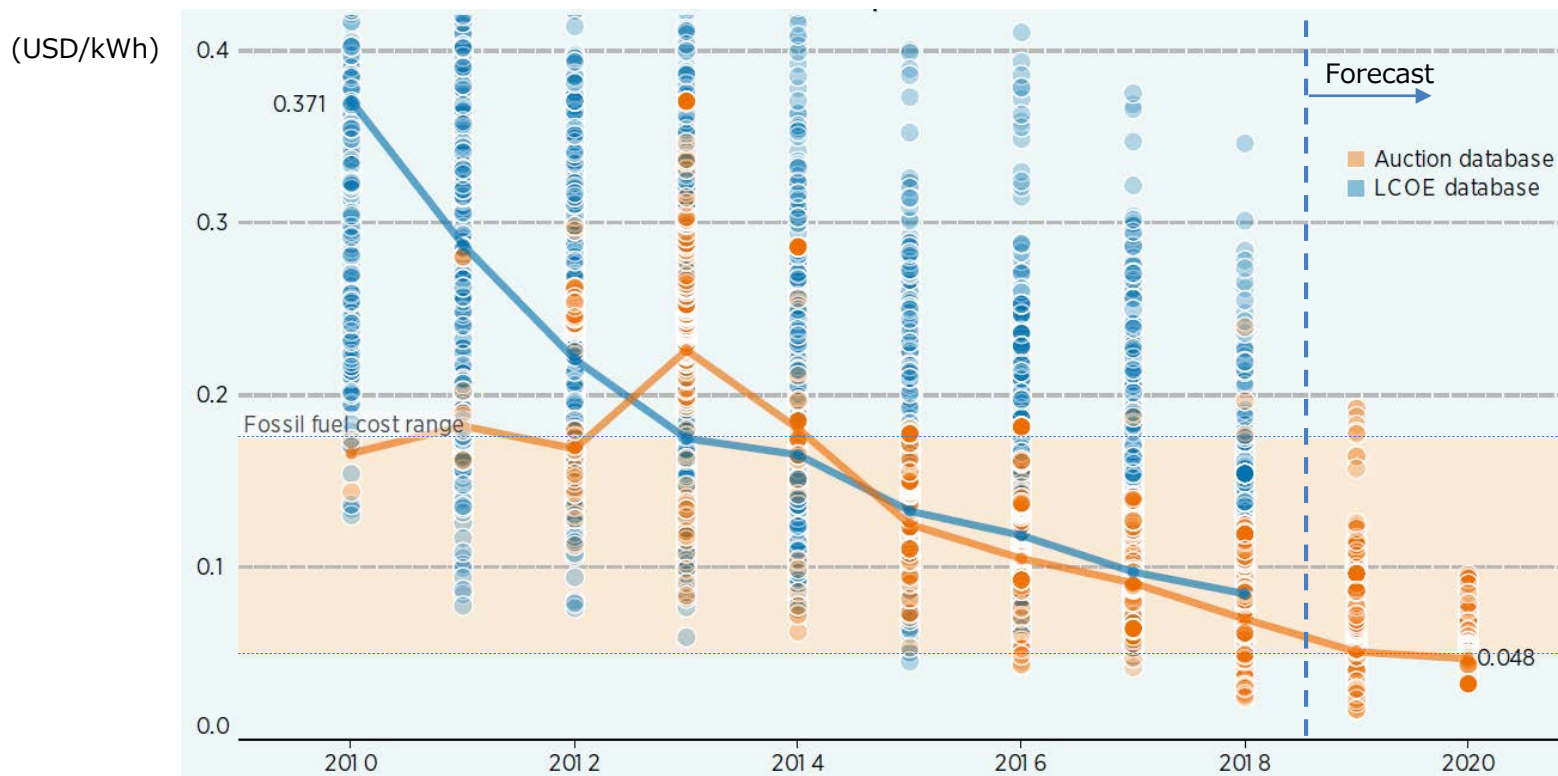
- China's share of growth in solar PV capacity will drop to about 40% in 2019-2020, but China still leads the world in the deployment of solar PV
 - Share of distributed/off-grid systems is currently about 50% in China which is expected to increase.
 - In 2019-20, growth of solar PV will be outstanding in Europe, US, India, where the share of distributed/off-grid systems is currently about 40% which is expected to increase.



Source: IRENA Renewable Electricity Capacity and Generation Statistics, IEA Renewables 2019, etc.

What factors are expected to contribute to the growth of renewable power generation? (1) Continuing decline of cost

- The levelized cost of electricity (LCOE) from solar PV in a global weighted average is continuing to fall which is expected to reach \$0.048/kWh in 2020, 44% lower than in 2018.
- For countries with good sun conditions, solar PV is becoming one of the cheapest power options
- In southern Europe, the generation cost has become lower than the wholesale electricity price in some cases, triggering an increase in the number of solar PV plant construction projects that have started without subsidies.



Source: IRENA (2019) "Future of Solar Photovoltaic: Deployment, investment, technology, grid integration and socio-economic aspects"

What factors are expected to contribute to the growth of renewable power generation? (2) Strengthening of renewable targets by governments

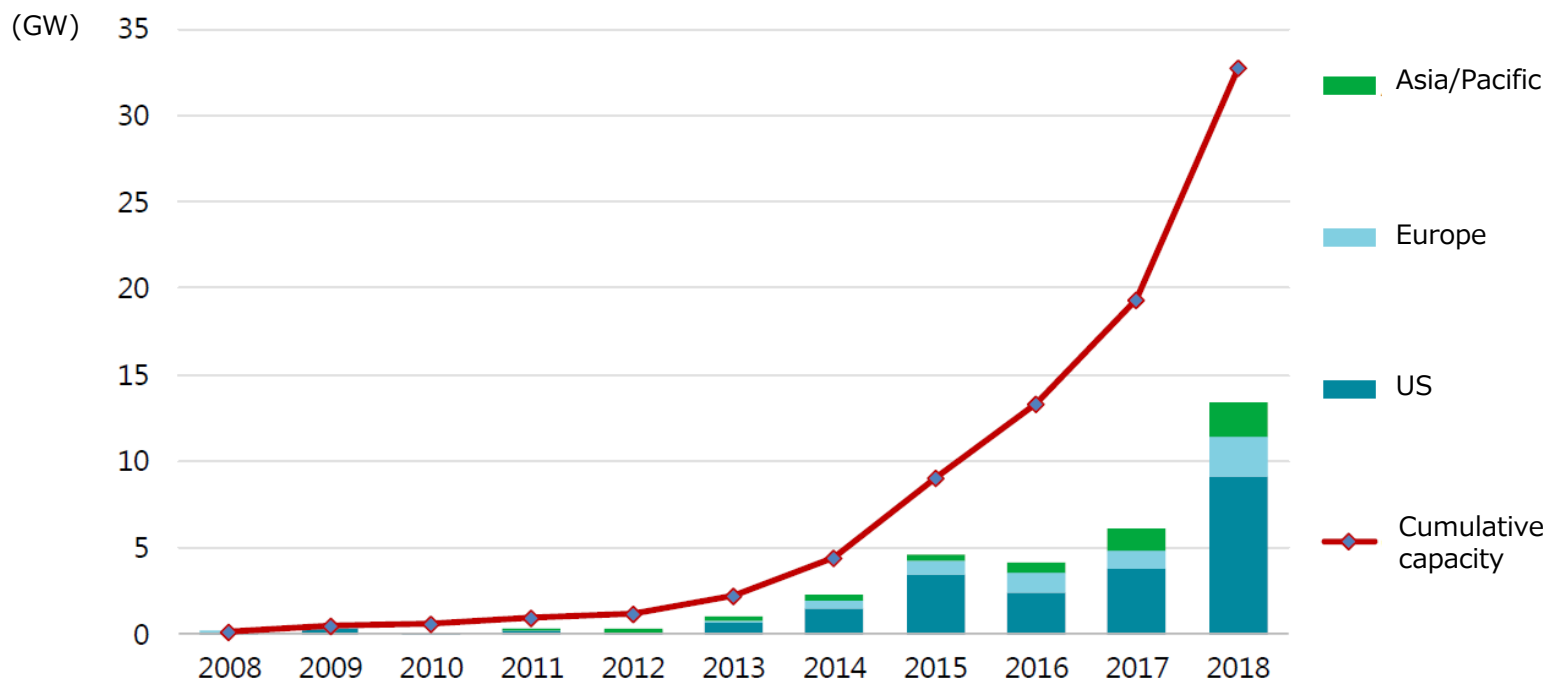


- EU: In May 2019, EU finalized its renewable deployment target to be achieved by 2030, letting EU countries raise their national targets for renewable energy.
 - Target is “at least 32% share for renewable energy” in final energy consumption by 2030
 - Besides expanding renewable power generation, progress is sought in deploying renewable energy in the cooling/heating and transportation sectors, and in the area of sector-coupling
 - Each EU member countries will raise their renewable targets in line with the EU target for 2030.
 - Some have proactively raised their targets already; Germany raised from 50% to 65% for renewable share in total power consumption in 2030 and Spain raised the same from 70% to 74%
- US: Although the Federal Government took the decision to withdraw from the Paris Agreement, this is in contrast with state governments which are raising their renewables deployment targets.
 - State governments have raised their renewable portfolio standard (RPS) target or established a new target.
 - California: 2030 RPS target raised from 50% to 60%; realization of zero coupon by 2045; solar PV made obligatory for new residential houses built in 2020 or later.
 - Nevada: RPS target raised from 25% by 2025 to 50% by 2030; decarbonization of all retail electricity by 2050.
 - New York: 2030 RPS target raised from 50% to 70%; 100% decarbonization of electric power by 2040.
 - Massachusetts: RPS target is to be raised 2% p.a. from 2020 to 2030, by 1% p.a. from 2030. Power generation by offshore wind turbines is to be expanded to 1.6 GW by 2035.
 - New Mexico: 2040 RPS target 80%; decarbonization of all retail electricity by 2045.
- India: plans to raise renewable target from 175 GW by 2022 to 500 GW by 2030.
 - The government seeks to raise the 2030 target share of renewables in the generation capacity from 40% to 55%.
- Middle East: In countries such as UAE (Dubai and Abu Dhabi), Saudi Arabia, Morocco and Oman, competitive biddings have been held one after another for massive solar PV projects of several hundred MW class.
 - Leveraging their superb sunshine conditions, they expect to generate power at very low cost in the order of \$0.01 to \$0.02/kWh.

What factors are expected to contribute to the growth of renewable power generation? (3) Corporations investing more in ESG

- With the growing focus on ESG (Environment, Society and Governance) in investing and making selections, more corporations are trying to use renewable power to meet their electricity demands.
 - Particularly in the US, there is a prominent trend of corporations preferring to purchase power from wind and solar PV plants. Combined with cost reduction of renewables, this is driving the deployment of renewable energy
- More companies are joining RE100 (an international initiative supporting the declaration of meeting 100% of electricity demand by renewable energy).

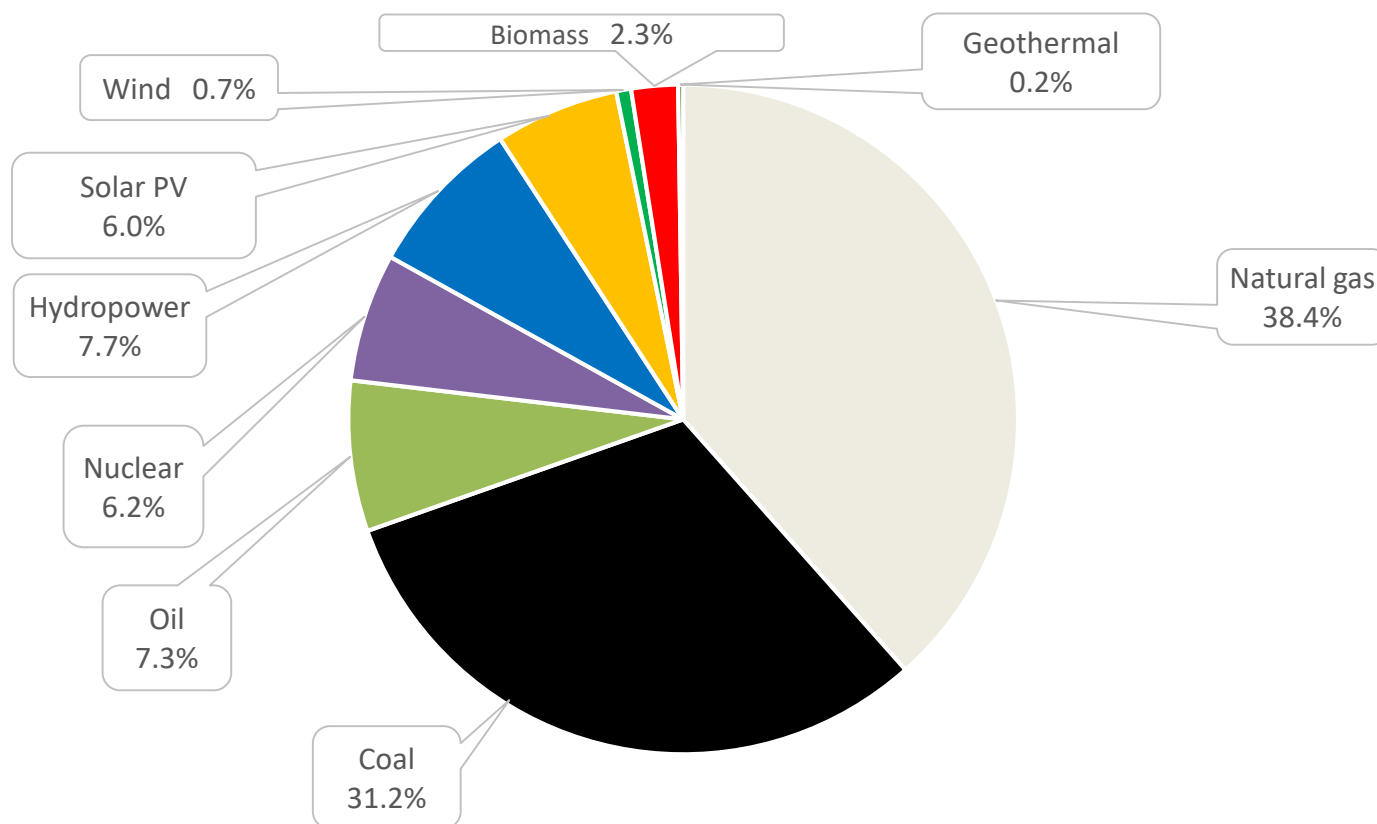
Total installed capacity of wind and solar PV power under PPA by corporations



Source: IEA Renewables 2019

Share of Power Sources by Output in Japan (FY2018)

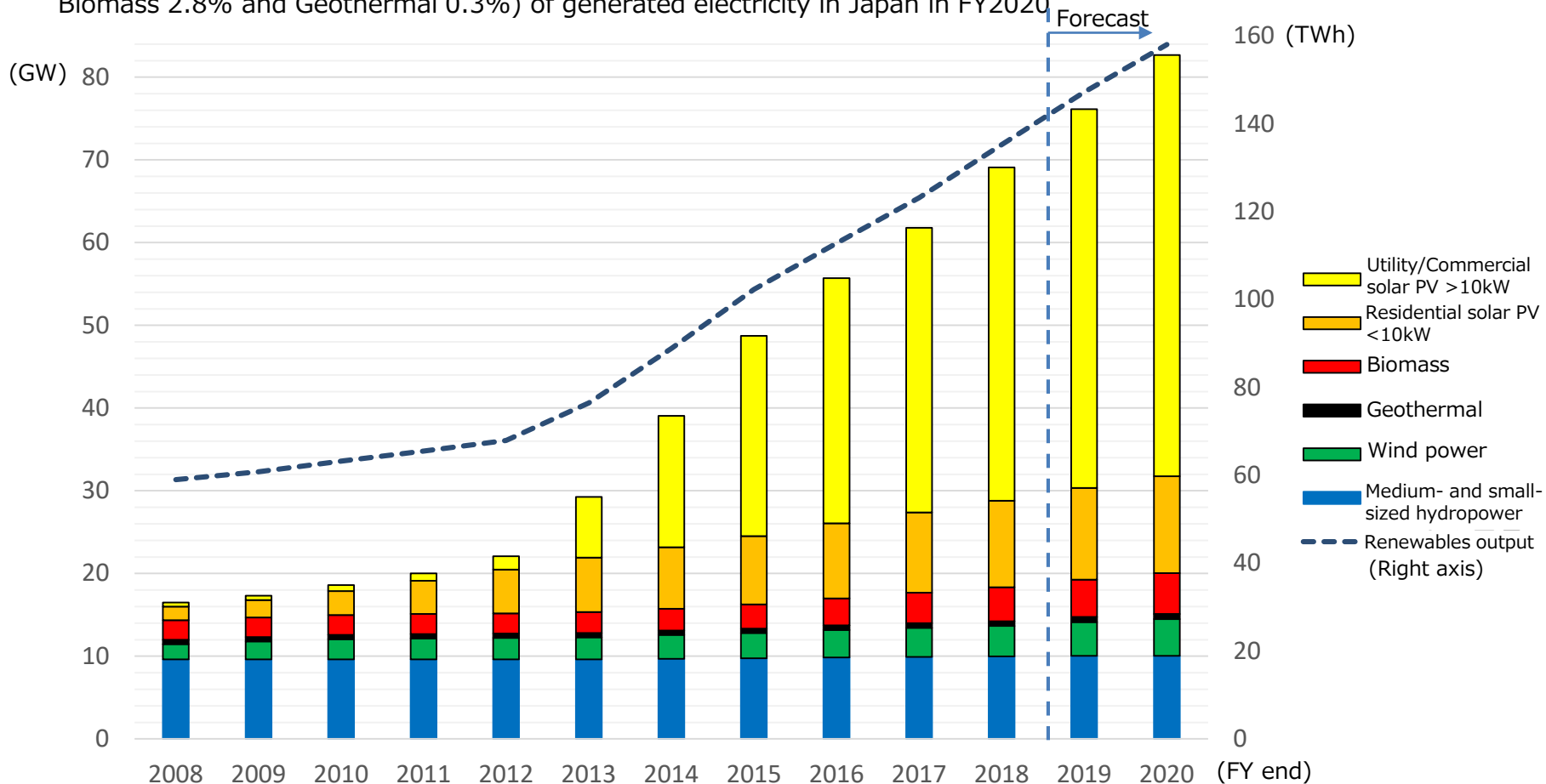
- Renewables had a share of 16.9%* in FY2018 in Japan.
 - Hydropower accounted for 7.7% and non-hydro for 9.2% in renewables in which solar PV 6.0%, Wind 0.7%, Biomass 2.3%.
 - Share of solar PV increased in FY2017 from 5.2% to 6.0%. Wind, biomass, and geothermal power increased slightly, while hydropower decreased.



Source: General Energy Statistics of Japan by METI

Cumulative renewable power capacity and generated power (FY2008-2020) (excl. >30 MW larger hydro)

- Renewables excl. large hydro has increased by around 10% p.a. over the past years which is expected to reach 83 GW by the end of FY2020.
 - Output from renewables has also increased by about 9% p.a. which is expected to reach 158 TWh by the end of FY2020.
 - Renewables as a whole incl. large hydro are expected to capture 19.0% (Hydro 7.9%, Solar PV 7.1%, Wind 0.8%, Biomass 2.8% and Geothermal 0.3%) of generated electricity in Japan in FY2020

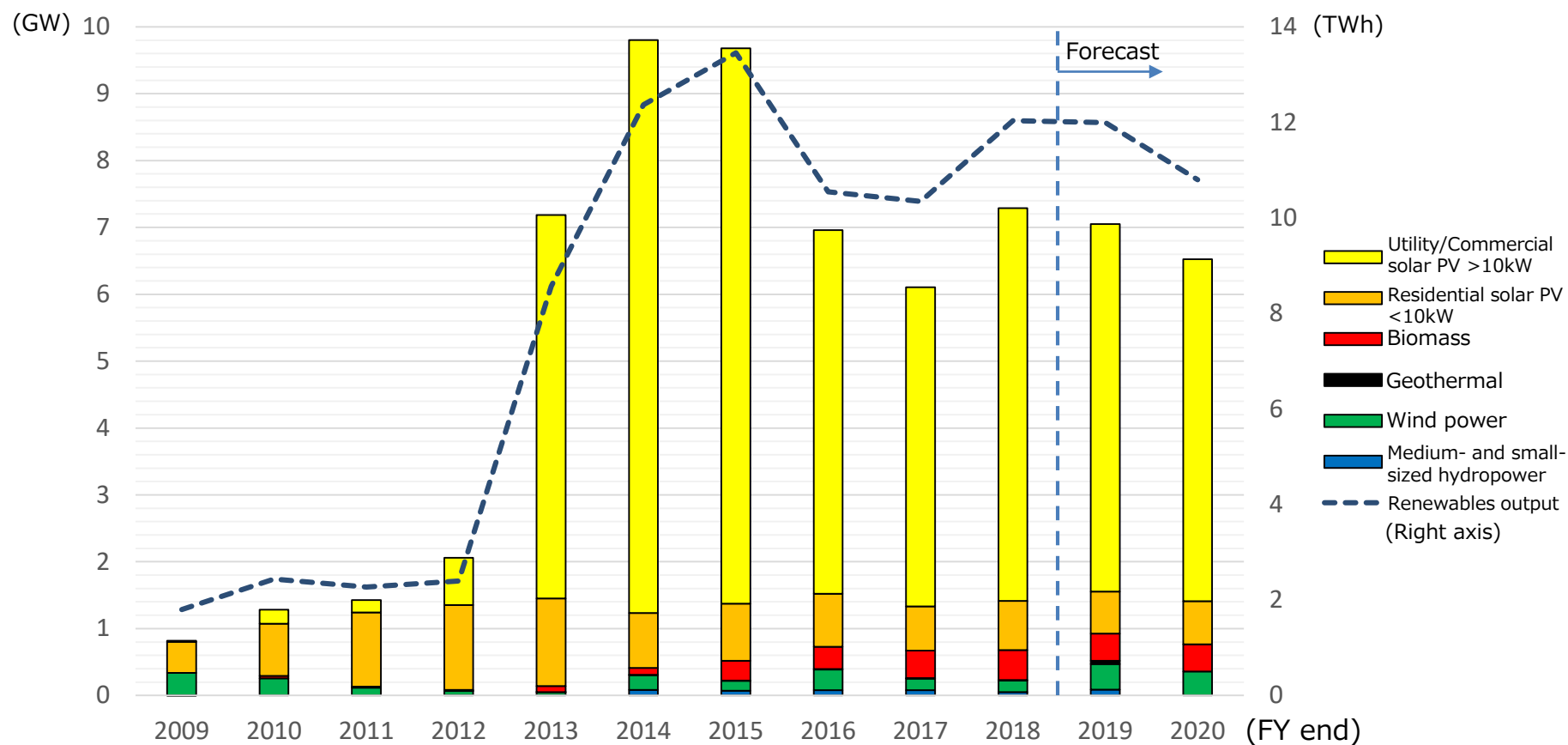


Source: Estimation by IEEJ

Annual growth of installed capacity and output of renewables in Japan (FY2008-2020) (excl. >30 MW of larger hydro)

- Utility/commercial solar PV grew more than 7 GW in FY2018, creating a rebound, which is expected to continue at the high rate of 6 to 7 GW/year in FY2019-20*.
- For solar PV projects that were FIT-certified but have not yet started operation, the operation start deadline was set at the end of FY2020 → Project owners are expected to rush to start operation to preserve their entitlement to obtain the very generous FIT prices of USD 0.3-0.4/kWh offered in 2012-2014.

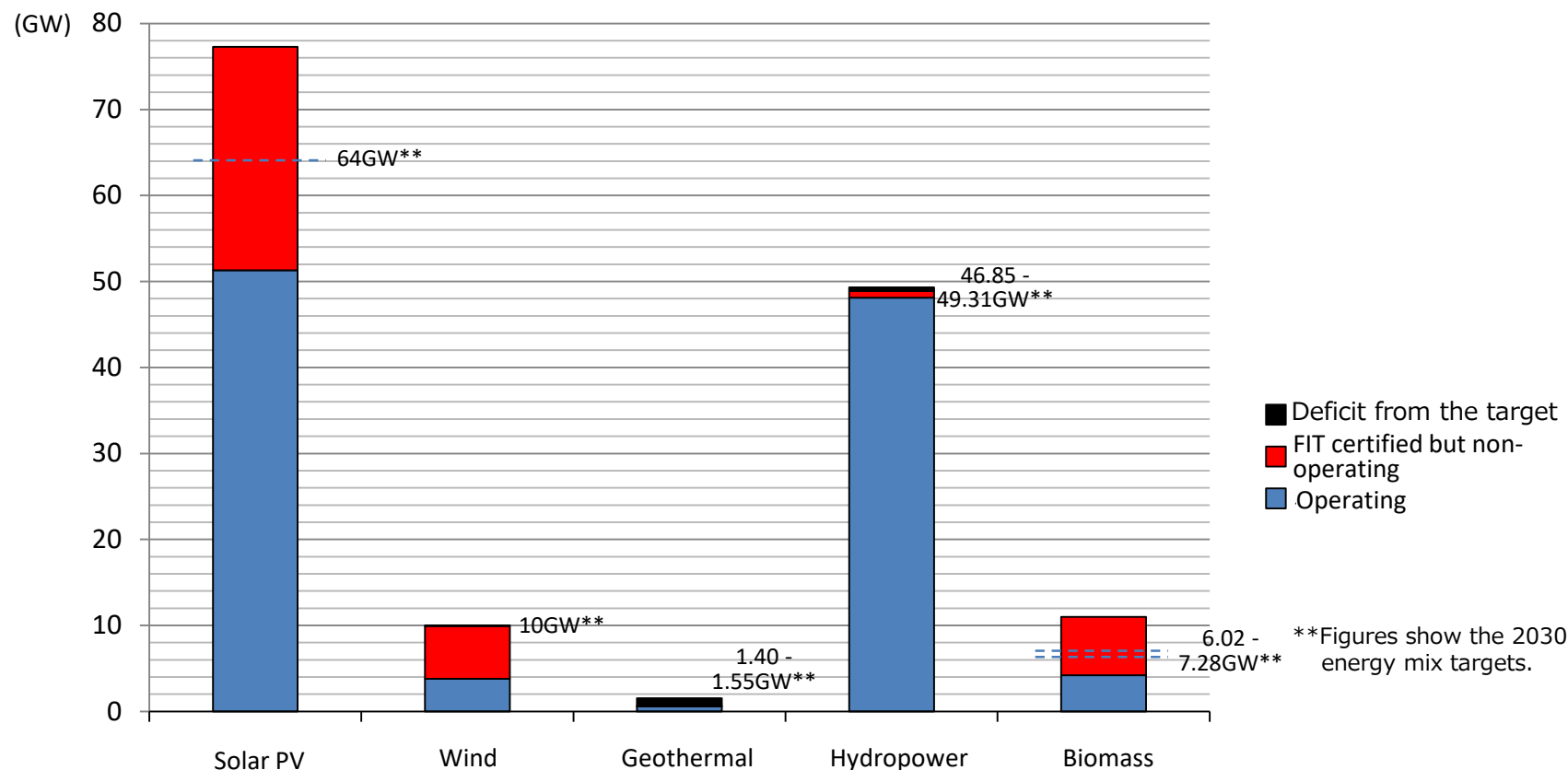
* For solar PV, the shown value is on an AC basis



Source: Estimation by IEEJ

Renewables deployment against the 2030 energy mix target (as of the end of June 2019) (excl. >30 MW of larger hydro)

- Solar PV is expected to reach 63 GW by the end of FY2020 and likely to surpass the 2030 target of 64 GW in FY2021.*
 - * For solar PV, the shown value is on an AC basis
- Capacity for biomass, including uninstalled but FIT-certified capacities, is already well over the 2030 target. Even when contributions from projects facing difficulties in fuel procurement are ignored, meeting the lower end (6 GW) of the 2030 target range is deemed feasible.
- Since wind and biomass are both expected to increase by around 0.4 GW per year in the coming years, the total power generated by renewables may reach the lower end of the 2030 target range (which is 22% share of the total generated power) as early as the mid 2020s.



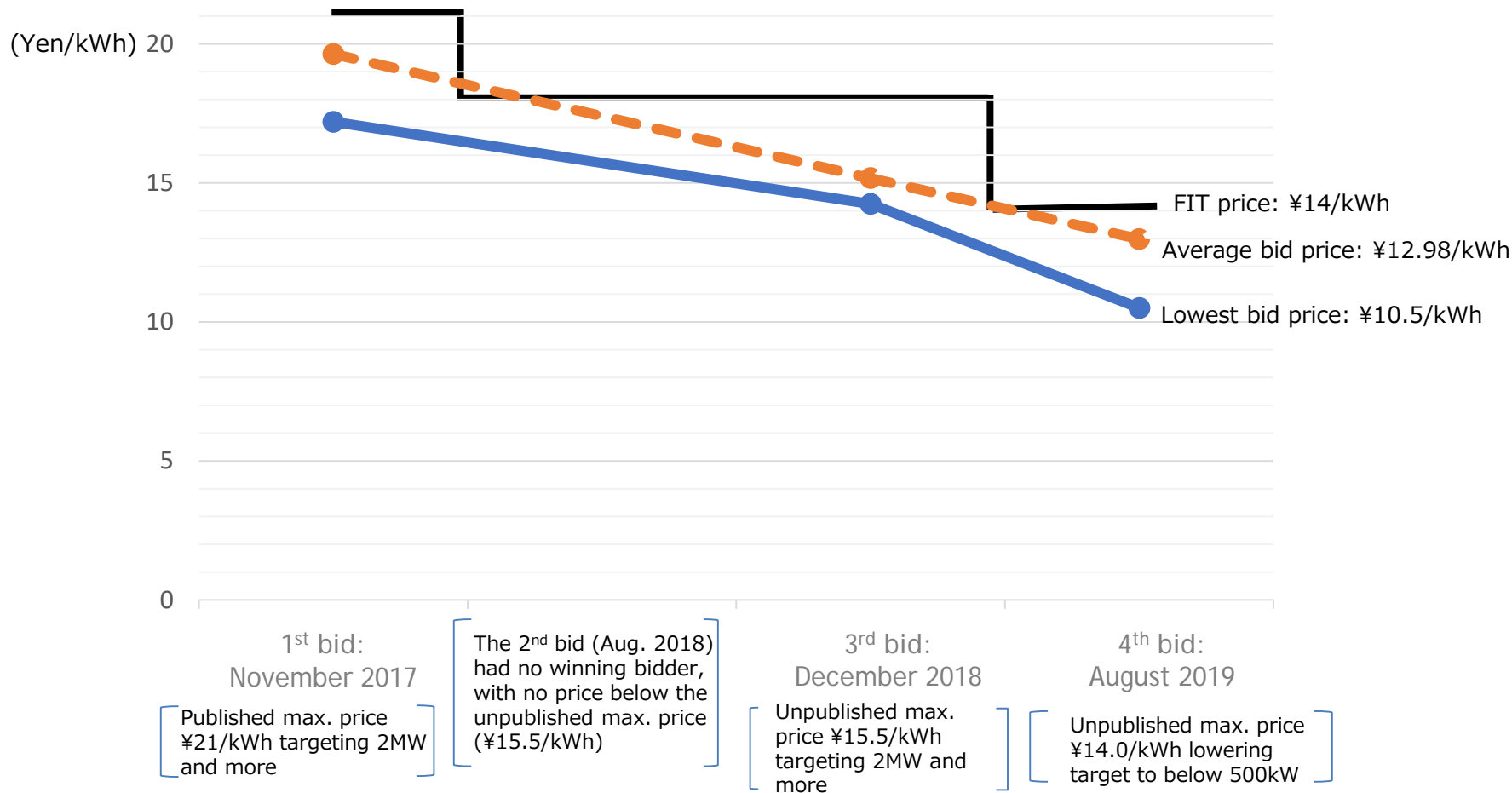
Challenge: Lowering cost of renewable power generation Cost

- Revision of the current FIT scheme in preparation for a new framework that will be implemented after a major reform of the FIT in FY2020
 - Competitive sources such as solar PV >250kW and wind: reducing FIT prices by expanding auction
 - Solar PV>250kW has been shifted to auction FIT from pre-determine FIT.
 - Onshore wind, currently under pre-determined fixed FIT will be shifted to auction FIT.
 - Ground-mounted offshore wind, presently under the pre-determined FIT, will be shifted to auction FIT. For floating offshore wind on floating platforms, a decision is pending.
 - Large-scale biomass and palm oil-fired projects are already put out to auction FIT.
 - For FIT-certified solar PV projects that have not yet started operation, the deadline for starting operation has been set. If it is exceeded, the FIT price is substantially lowered automatically.
 - Regionally utilized power sources incl. 10 - 50 kW class small commercial solar PV, small-geothermal, small-hydro and regional biomass projects: FIT prices are continued to be pre-determined conditionally for regionally consumed power fed into local area
 - 10-50kW solar PV: must be installed for self-consumption; pre-determined FIT applies to excess power fed into to grid only after self-consumption
 - Solar PV projects on farming land are subject to less stringent criteria for qualifying as in-house power generation projects.
 - 50-250kW solar PV: After 2022, pre-determined FIT applies only to the eligible projects to meet the strict criteria of locally utilised renewables incl. micro-grid
- Reducing renewable generation cost through “a major reform of FIT” to be implemented after FY2020
 - Competitive renewables such as utility/large scale solar PV projects and onshore/offshore wind projects will be integrated into the markets and become economically independent.
 - Replacing FIT by an FIP (Feed-in Premium), expecting the renewable producers to directly engage in selling their power in the wholesale electricity market.
 - For regionally utilised power sources such as residential/small commercial solar PV, small geothermal, regional biomass, small-to-mid size hydro projects, government plans to maintain coverage by FIT for the time being, encouraging self-consumption and the pursuit of local production for local consumption in line with regional characteristics.
 - Measure for the FIT-certified utility/large solar PV projects that have not yet started operation: Setting the specified deadline for starting operation; When it is not met, the certification expires automatically.

The results of auction for Solar PV: Cost reduction is realised

- In the auction for solar PV taken place in August 2019, the lowest contract price was 10.50 yen (USD0.095)/kWh, and the average contract price was 12.98 yen (USD0.12) /kWh. These are comparable with LCOE of coal (12.3 yen(=USD0.11)/kWh*) and gas (13.7 yen(=USD0.125)/kWh*).
- From the 1st auction in November 2017, the lowest and average contract prices dropped by 39% and 34%, respectively.

* Cited from the estimation by the government's 2015 Power Generation Cost Verification Working Group.



Source: Author's own figure

Challenge: reconfiguring power grids to address the expansion of VRE and approach to the sharing of costs

- Seeking progress in "Japanese Connect & Manage" with emphasis on full use of existing power system infrastructure.
 - Enabling more rational responses to the anticipated power flow (changing the way available capacities are calculated): This is implemented from April 2018, contributing to expanding the available capacity by about 5.9 GW.
 - N-1 power control (conditionally permitting the use of emergency reserve capacity): This is partially implemented from October 2018, contributing to expanding the interconnection capacity by about 40.4 GW.
 - Non-firm access (with output control requirement): The scheme is now in the design stage. Trials are being conducted in TEPCO Power Grid's service area.
- While the conventional power grids are the "pull type" design as they passively respond to demands from renewable power generators, they will be reconfigured, starting from 2020, into "push type" grids that can proactively respond to demands considering the distribution of renewable resources.
- The government plans to introduce a "nationwide cost sharing scheme" to cover the cost of enhancing/reinforcing inter-regional connection lines.
 - Among the benefits of enhanced inter-regional connections (lower wholesale electricity price, reduced CO₂ emissions and improved supply stability), the reduction of price and the reduction of CO₂ emissions should be paid according to the basic principle of nationwide sharing, and payment should be collected through the grid-charge system nationwide. As to benefits specific to renewables, however, the cost is recovered by the FIT surcharge.
 - Considering the uneven distribution of renewable resources across regions e.g. wind resources are concentrated in the Northern Japan and solar PV resources are concentrated in the Southern Japan, the leveling of burden is achieved by spreading from specific areas to the whole nation.
- To minimize the need for grid enforcement and output control, attempts are being made to reduce demands on power grids by promoting the in-house and local consumption of renewable power.
- These measures are expected to increase the capacities and flexibility of power grids, enabling the expanded use of VRE (variable renewable energy).

Challenge: bearing the cost of disposing of large numbers of solar PV panels from 2030

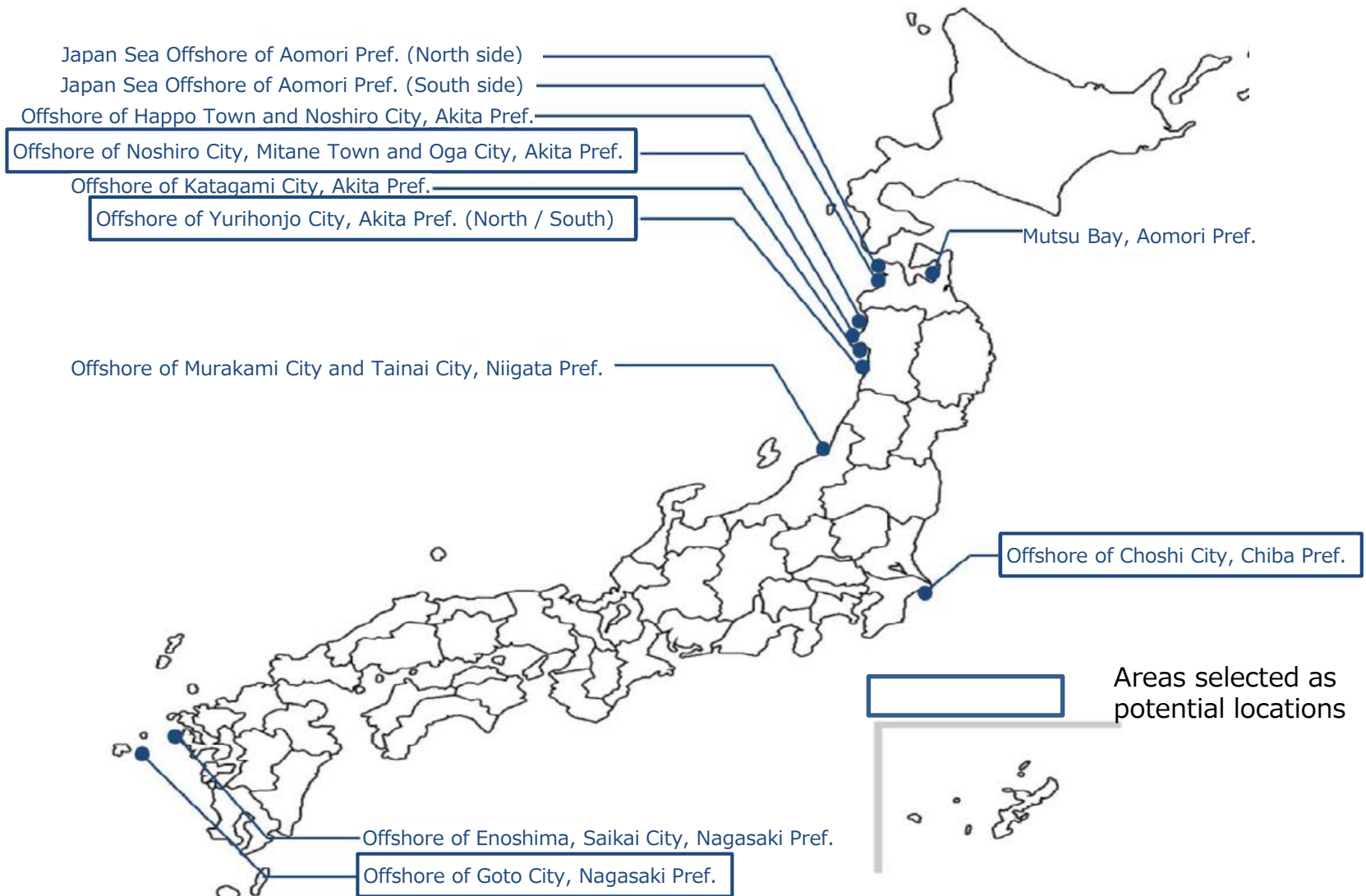
- Since the life of solar PV panels is limited to 25 to 30 years, a large number will have to be disposed of as waste starting from 2030. There are concerns that some unscrupulous operators may illegally dump panels or leave them on site.
- In 2022, the new scheme will be introduced that obliges the FIT-licensed operators to deposit with an external fund the future cost of dismantling and removing their solar PV facilities, and to dispose of solar PV panels and other waste so that their facilities may be properly decommissioned after ceasing operation.
 - Targeting all operators of >10 kW solar PV projects including existing projects, OCCTO (Organization for Cross-Regional Coordination of Transmission Operators) will collect at source by deduction from the income they make from selling power 0.7-0.8 yen (USD 0.006-0.007)/kW from FIT-covered power sales to cover the cost of dismantling solar PV facilities, and removing and disposing of the panels, and to deposit the money with an external fund.
 - This collection and depositing of money will be uniformly done in the 10-year period before the termination of FIT-based power purchasing.
 - Although the money is collected at source, the depositing of money with the external fund does not apply to self-consumption of power. As the money accumulated for waste disposal may not be sufficient in the case of self-consumption oriented projects, some additional rules will be enforced.
 - Reclaiming the deposited funds will require the submission of documents demonstrating the certainty of waste disposal operation.

Accelerated moves toward the commercialization of offshore wind power projects in Japan



- Under the new law to promote offshore wind, steady progress is being made to establish a scheme for the development of offshore wind projects.
- In July 2019, four areas in Japan were designated as “promising areas” where early development is promoted under the new act. Preparatory activities such as holding local council meetings and national government sponsored investigations on wind conditions have begun. → This will be followed by “promoted area” designation after negotiations with local stakeholders at local council meetings. → A power generation project operator will be selected through a public call for proposals and auction.
 - Offshore of Goto City, Nagasaki Prefecture, will be the first designated promotion area (exclusively for floating platform type projects).
- In November 2019: An amendment to the Port and Harbor Law was passed.
 - To enable the long-term stable use of piers that are capable of handling large/heavy equipment and components as key infrastructure for offshore wind power projects (few ports in Japan satisfy this condition in terms of load-bearing capacity and space), the government developed a scheme for long-term renting of such ports to wind power project operators, helping them to secure a base for wind turbine installation works, etc.
 - The validity of an approval for a plan for the dedicated use of a port/harbor areas is extended from 20 years to 30 years.
- Although negotiations with local stakeholders such as fishermen are the greatest challenge, the first tender for the selection of offshore wind power project operators is expected to be held by the end of FY2020. The moves of interested private business owners are becoming prominent in respective localities.

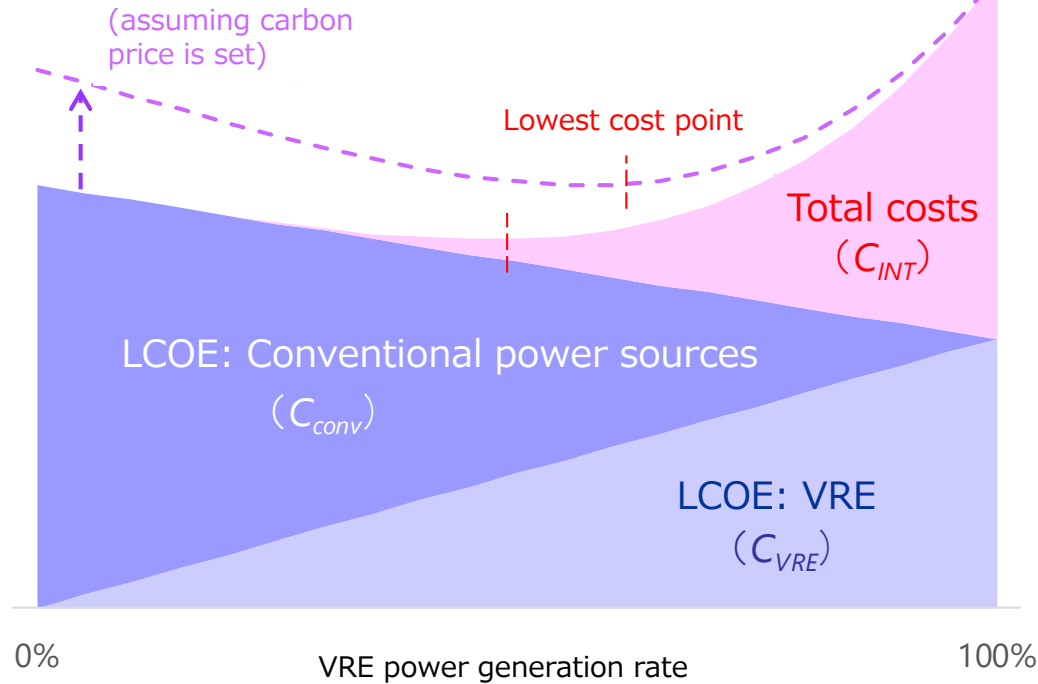
Eleven districts where preparations for offshore wind power projects are underway under the new law



Source: Cited from the document at the 1st Council at the Offshore of Goto City, Nagasaki Pref.

(Reference) Concept of the integration cost accrued by the massive deployment of VRE Sources

Vertical axis: Total cost in the power sector



- When the levelized cost of electricity (LCOE) from VRE is lower than LCOE from conventional power sources, the total cost of electricity appears to become less as the share of VRE increases, when considering only the LCOE-proportional part of the cost (the generation cost according to the conventional model, which corresponds to " $C_{conv} + C_{VRE}$ " in the figure above).
- In reality, however, the massive deployment of VRE generates additional costs because of the need for output control, power storage systems, grid enhancement, and so on. The total of such costs (irrespective of the needs from which they arise (C_{INT} in the chart above), which are additional to LCOE, is called **the integration cost** accrued by the massive deployment of VRE.