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Renewable Energy Outlook for Japan and the World

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Key points

1. In 2018, the share of non-hydro renewable generation in the global power output was 9.4% with wind at 4.8%, solar PV at 2.2%, and biomass and geothermal at 2.4%. Combined with hydropower at 15.8%, the share of renewable power output reached 25.2%, surpassing 25% for the first time. Renewables will account for one-third of the global power output (including hydropower) in 2025 if its installed capacity continues to grow at the current rate.
2. Installed renewable capacity increased by 171 GW in 2018, the second largest growth to date after 174 GW in 2017 and has exceeded 160 GW for three consecutive years since 2016. An increase of around 170 GW p.a., the same level as 2017-2018, is expected again in 2019-2020, as solar PV and wind become more competitive as their costs decrease.
3. The growth of solar PV is accelerating globally as its costs decrease rapidly. Solar PV replaced wind as the growth driver for renewable energy in 2016. This trend is expected to strengthen in the near future in 2019 and beyond.
4. Japan's installed renewable capacity (excl. large hydropower plants of 30 MW or more) is estimated to reach 78 GW at the end of 2020, generating 152 TWh. Combined with hydropower plants of 30 MW or more, the renewable power output of Japan is estimated to reach 18.7% of the total power generated in 2020.
5. Installation of facilities is well under way to achieve the 2030 energy mix levels for solar PV, wind and biomass, but not quite only for geothermal.
6. There are two major policy challenges: reducing the public burden by driving down renewable energy costs, and overcoming network constraints. Efforts are under way to address the former through a fundamental overhaul of the FIT Act in 2020, and the latter by implementing the Japanese Connect & Manage, grid enhancement, and new ways of allocating costs.

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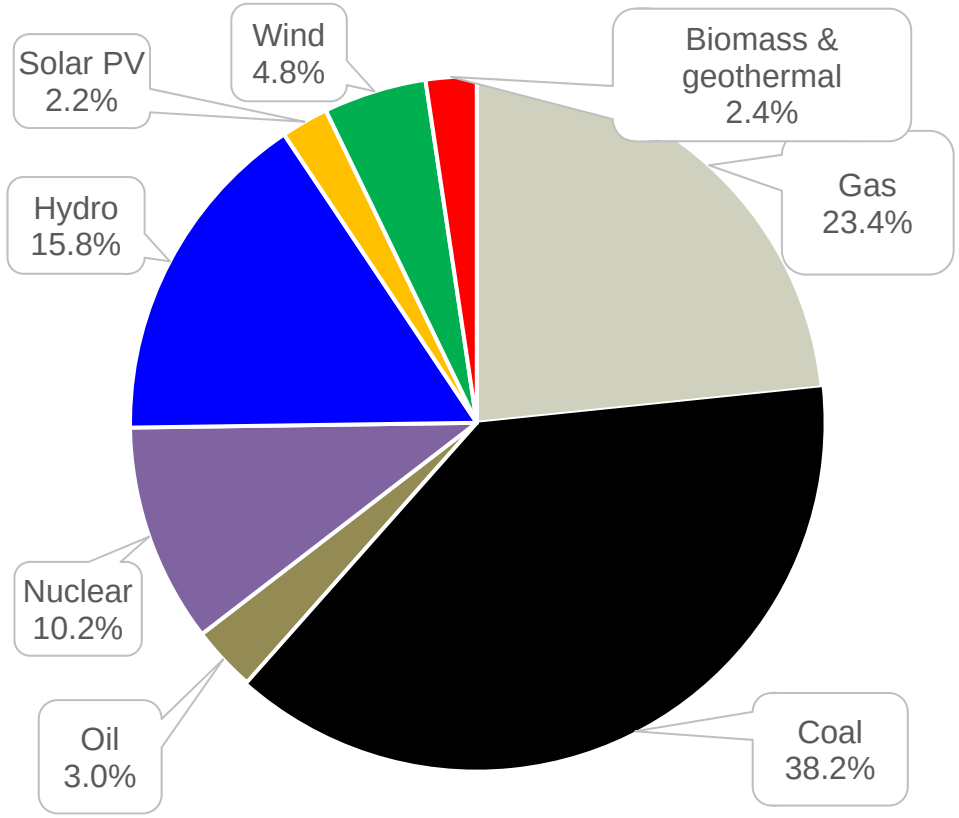
Global: share of power by resources (2018)

- 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 p.a. on average for the past five years and are to surpass 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

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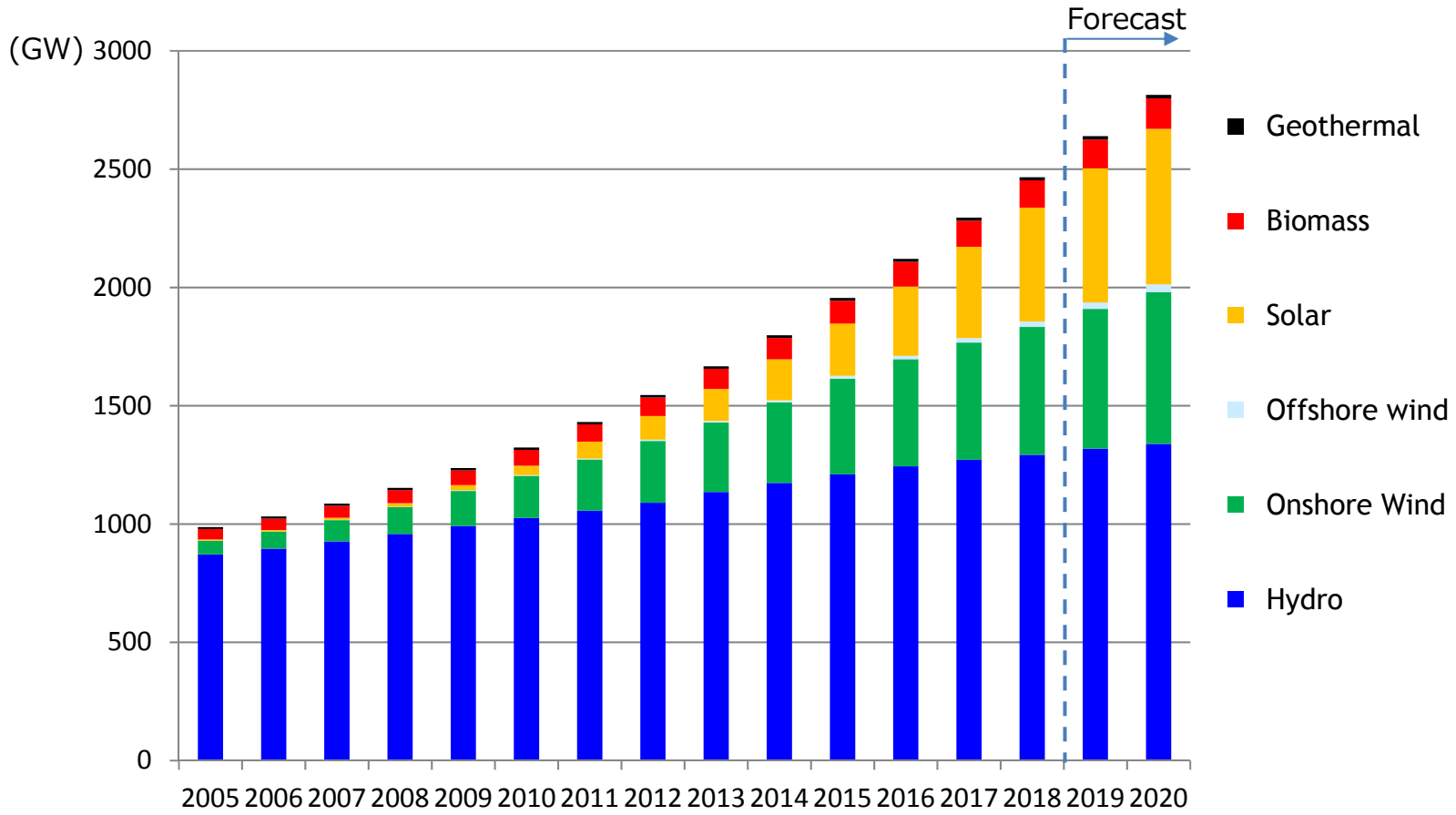
Global renewable power capacity: cumulative total (2005-2020)

- Renewable power capacity stood at 2,470 GW as of end-2018 and will reach 2,800 GW by end-2020.
  - The capacity has doubled in the past 10 years, with the growth rate exceeding 7% p.a. on average.
  - The trend will continue underpinned by lower costs, enhanced renewables policies in the EU and other countries, and the global expansion of ESG investment.



Source: IRENA Renewable Electricity Capacity and Generation Statistics, IEA Renewables 2018 and others

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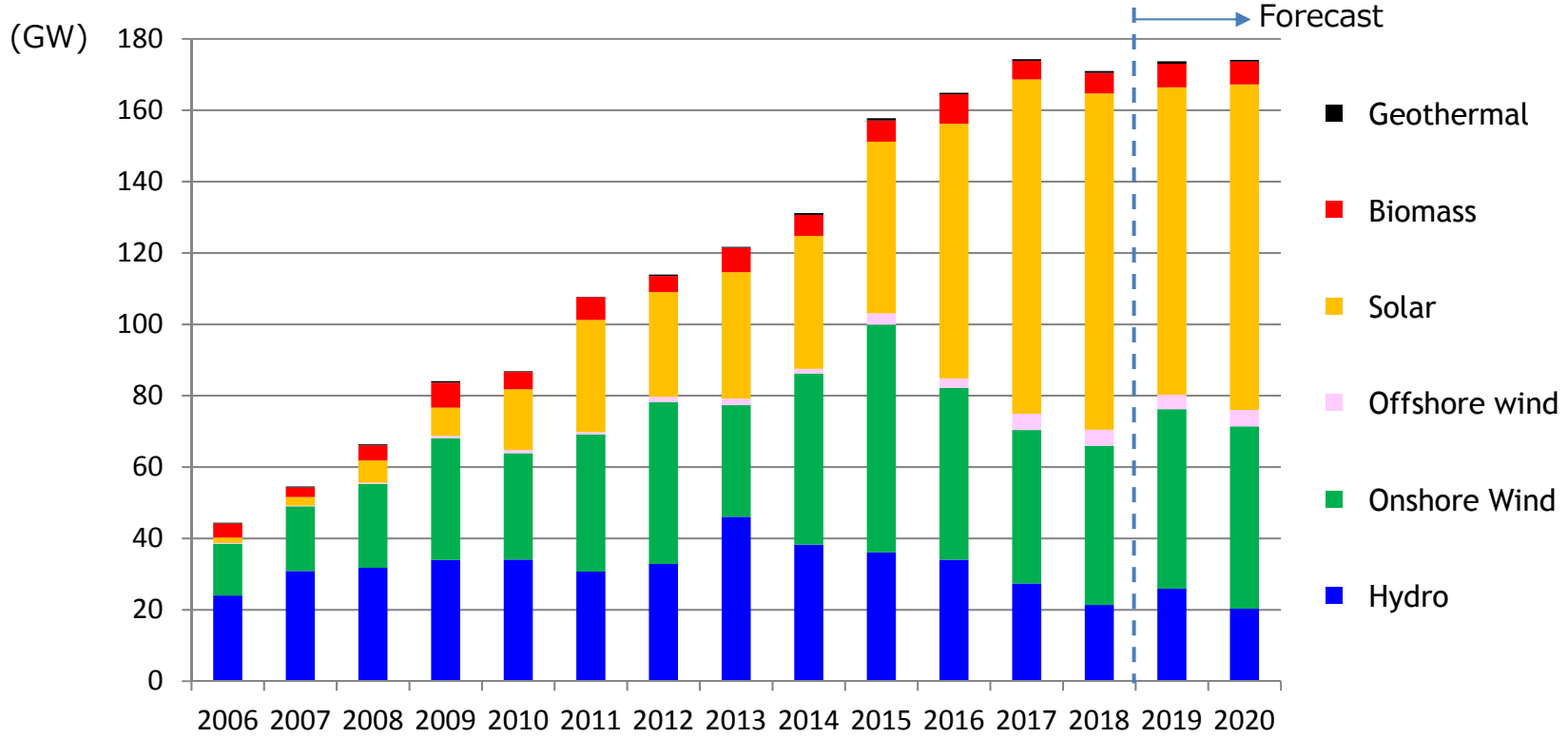
Global renewable power capacity: annual growth (2006-2020)

- 171 GW of renewable power capacity was installed in 2017. A similar amount is expected to be introduced in 2019-2020.
  - Despite a decrease in new solar PV capacity in China due to a change in policy, the renewable power capacity remained steadier than expected as a whole.
  - Expansion of solar PV is accelerating in the ME, Australia, Africa, Southern Europe, and other countries aside from China.
  - Residential distributed solar PV is on the rise, accounting for half of the overall increase of solar PV.
    - A global shift from “selling electricity to the power system” to “self consumption” is emerging.



Source: IRENA Renewable Electricity Capacity and Generation Statistics, IEA Renewables 2018, etc.

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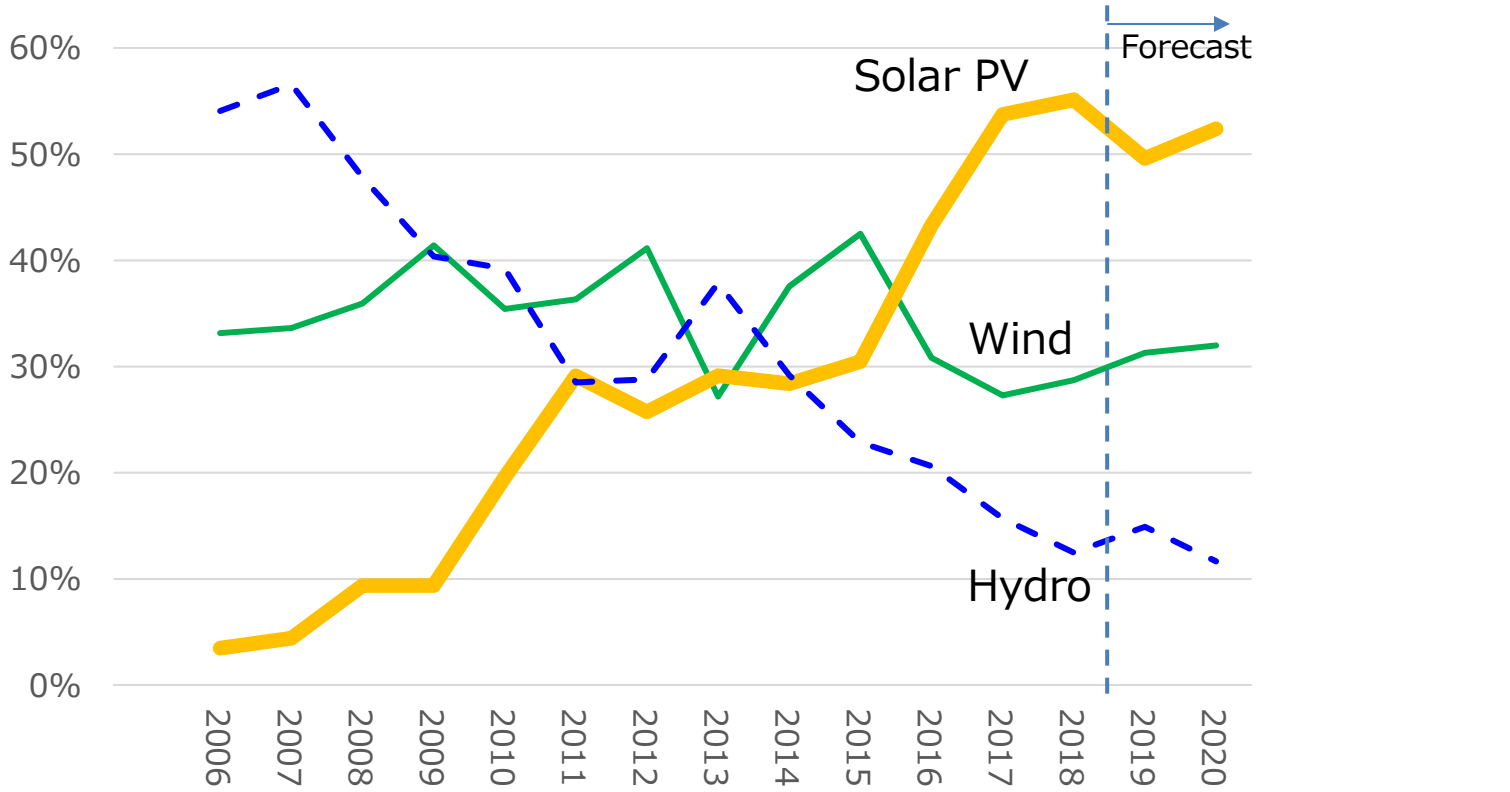
Solar PV overtakes wind as growth leader as costs decrease

- Growth of renewables was led by hydropower in the early 2000 and by wind in the first half of the 2010s. Solar PV has been the growth leader since 2016.
  - Solar PV is expected to become established as the growth leader as its generation cost is expected to come down overall and dispersed, residential-use capacity will increase.

Share of solar PV, wind, and hydropower in the annual increase in renewable capacity



Source: Based upon IRENA Renewable Electricity Capacity and Generation Statistics, IEA Renewables 2018, etc.

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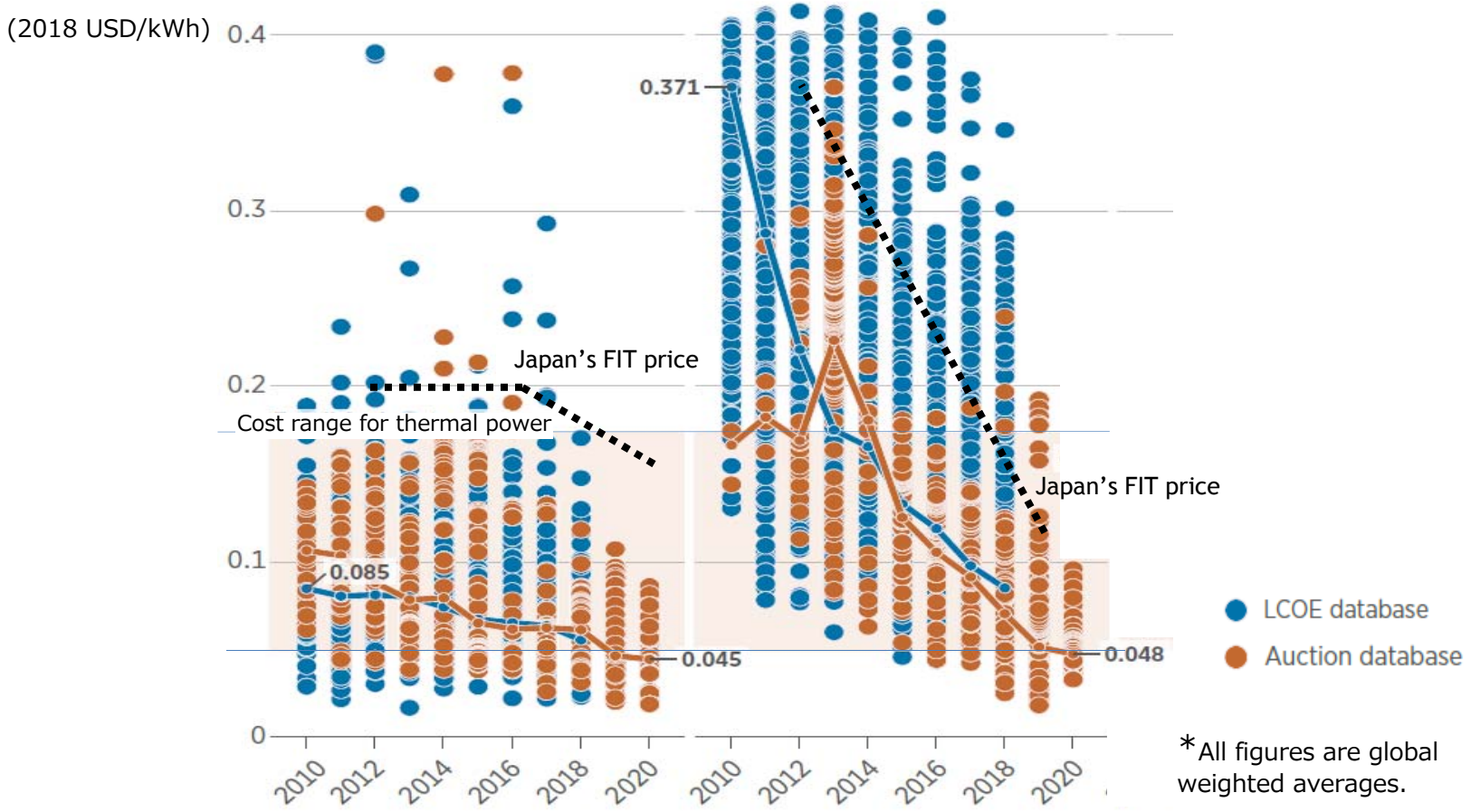
Wind and solar PV generation costs (LCOE) to continue to decrease

- The 2018 LCOE was $0.065/kWh for onshore wind and $0.085/kWh* for mega solar PV.
  - Estimated to decrease to $0.045/kWh for onshore wind and $0.048/kWh for mega solar in 2020.
  - Both will approach the bottom bounds of thermal power costs and become even more cost competitive.

Onshore wind (left) and mega solar (right): LCOE and bidding prices



*All figures are global weighted averages.

Source: IRENA Renewable Power Generation Costs in 2018 with modification

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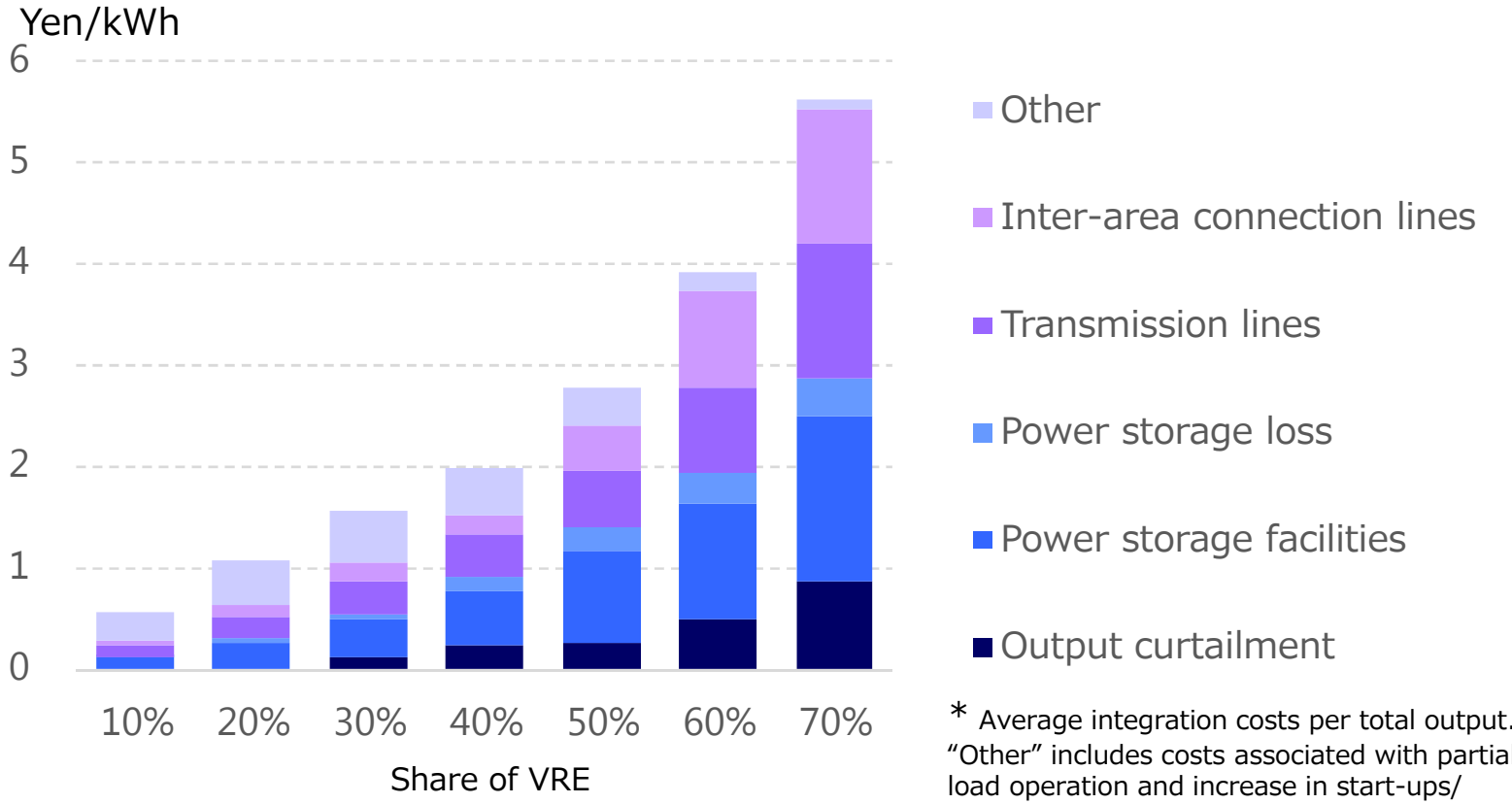
(Reference) Estimate of integration costs as VRE increases

- The increasing share of variable renewables (VRE) generates additional integration costs for grid enhancement, output curtailment, power storage and others in the long run.
- The below is an example of the estimated costs for Japan in 2050.



* Average integration costs per total output. "Other" includes costs associated with partial load operation and increase in start-ups/ shutdowns of existing power plants due to introducing large amounts of VRE.

Source: Estimate by IEEJ

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Developments in renewable energy in major countries

- China
  - A major drop in new solar PV capacity was expected with the announcement of a policy to reduce new solar PV facilities including FIT phase-out in May 2018, but 44 GW of new solar PV facilities were added in 2018 (75 GW for renewables in total), far exceeding expectations.
  - Studies are proceeding on new renewable policies such as introducing auctions and a province-based shift to RPS.
  - Nevertheless, renewables are expected to increase by around 70 GW p.a. in 2019-2020.
  - The planned launch of a 10% ethanol requirement for gasoline in 2020 is uncertain due to concerns about supply shortages.
- EU
  - The 2030 renewable energy target (covering 32% of final energy consumption with renewables) was finalised under the revised EU Renewable Energy Directive.
  - Renewables targets were set for heating and transportation sectors as well as the power sector.
    → tailwind for EV and next-generation biofuels.
  - Re-emphasized its strong resolve to integrate renewables into the energy system.
  - Remarkable growth of offshore wind based on overall growth rate, but solar PV has momentum in the Southern Europe.
- India
  - Added 10.8 GW of solar PV capacity in 2018, becoming a giant solar market second only to China.
  - The Modi government's 2022 solar PV target of 100 GW requires a 20 GW p.a. increase, which appears hard to achieve. Solar PV capacity would reach 70 GW in 2022 at the current pace of around 10 GW p.a..
- United States
  - New solar PV capacity was 10.6 GW in 2018, generally the same level as 2017, despite the 30% additional safeguard tariffs imposed on imported solar panels in Jan. 2018 by the Trump administration.
  - Around 10 GW p.a. of new solar PV capacity will continue to be added in 2019-2020 as solar PV remains robust owing to falling costs and last-minute installations before phasing out of the investment tax credit (ITC) begins in 2020.
  - More grid-side power storage systems are being installed in California, etc. as VRE increases; the market is expected to grow including demand-side power storage systems.

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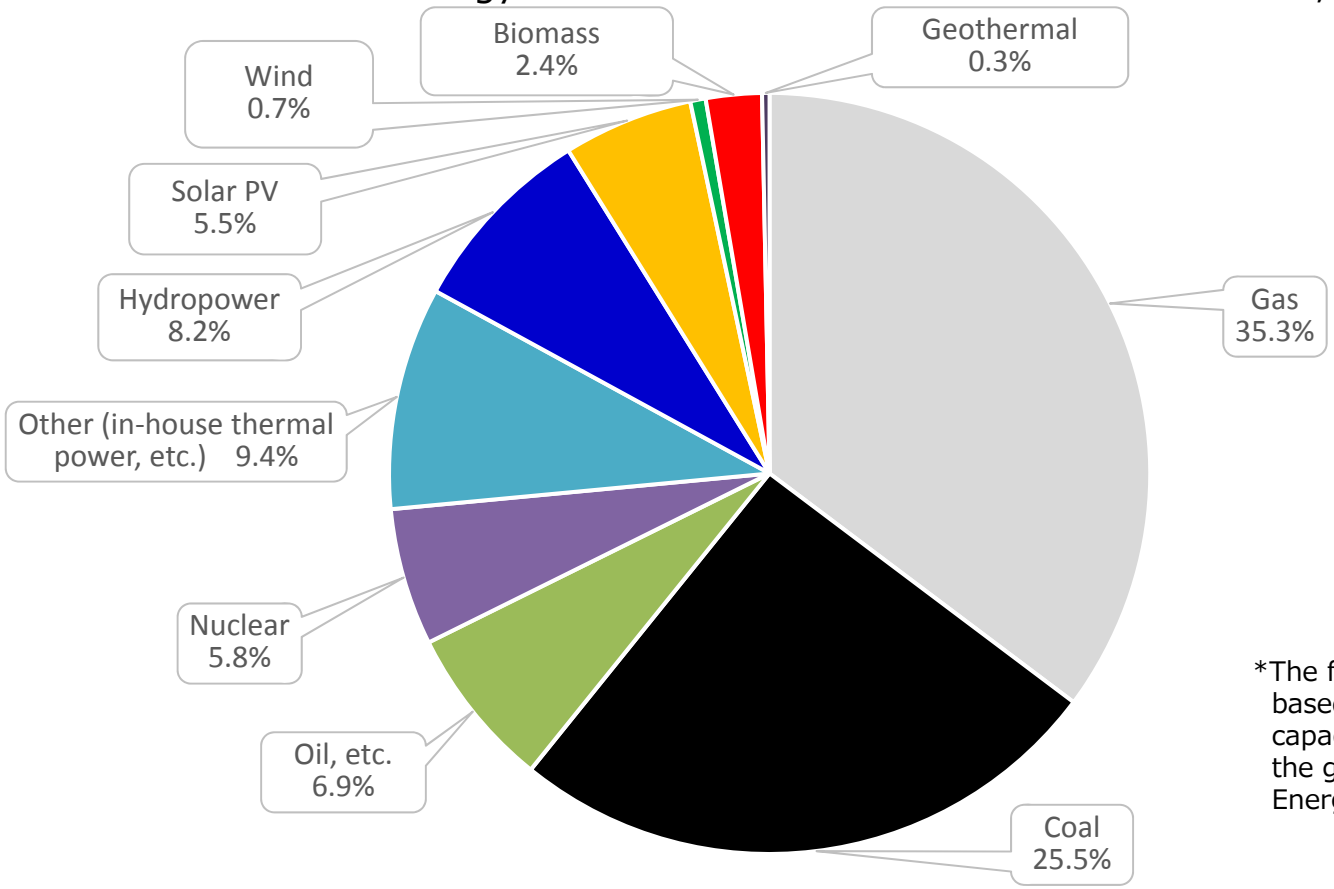
Japan: Share of power by resources (FY2018)

- Renewable energy had a share of 17.0%* in FY2018 in Japan including the output of large-scale hydropower capacities of 30 MW or more.
  - Solar PV increased in FY2017 from 4.8% to 5.5%. Wind, biomass, and geothermal power increased slightly, while hydropower decreased.
  - The share of renewable energy increased from 16.1% to 17.0% in FY2017, up 0.9% point.



*The figures are estimates based on operated FIT capacities and may differ from the government's General Energy Statistics of Japan.

Source: Estimate by IEEJ

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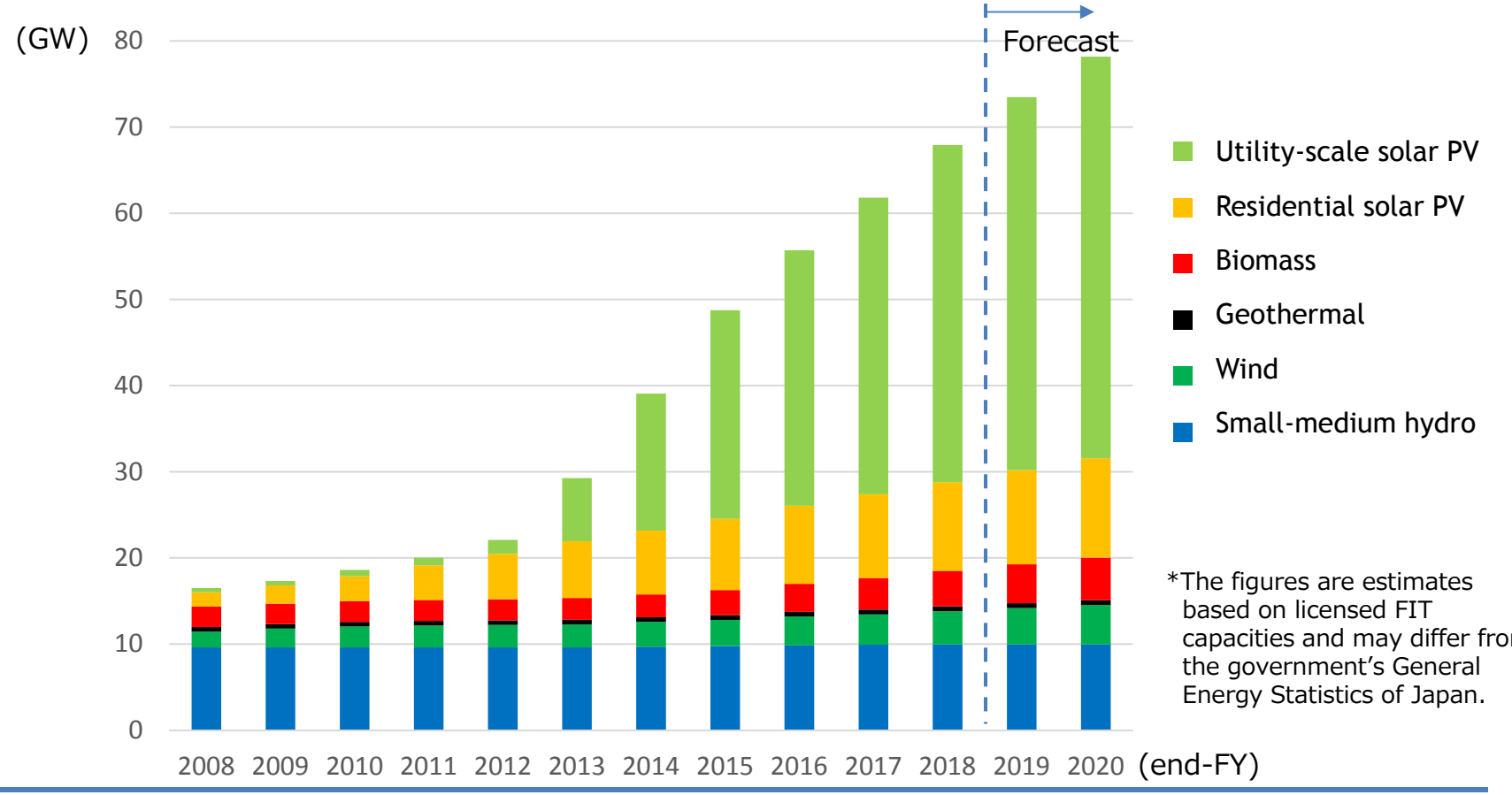
Japan's renewable power capacity: cumulative total (FY2008-2020) (excluding hydropower capacities of 30 MW or more)

- Japan's renewable power capacity is expected to increase to 73 GW by end-FY2019 and to 78 GW by end-FY2020.
  - The share of solar PV in installed renewable capacity continues to rise and will reach 74% in 2020.
  - The annual output will reach 152 TWh* in FY2020, and combined with the output of hydropower capacities of 30 MW or more, renewables will account for 18.7% of Japan's total power output.



*The figures are estimates based on licensed FIT capacities and may differ from the government's General Energy Statistics of Japan.

Source: Estimate by IEEJ

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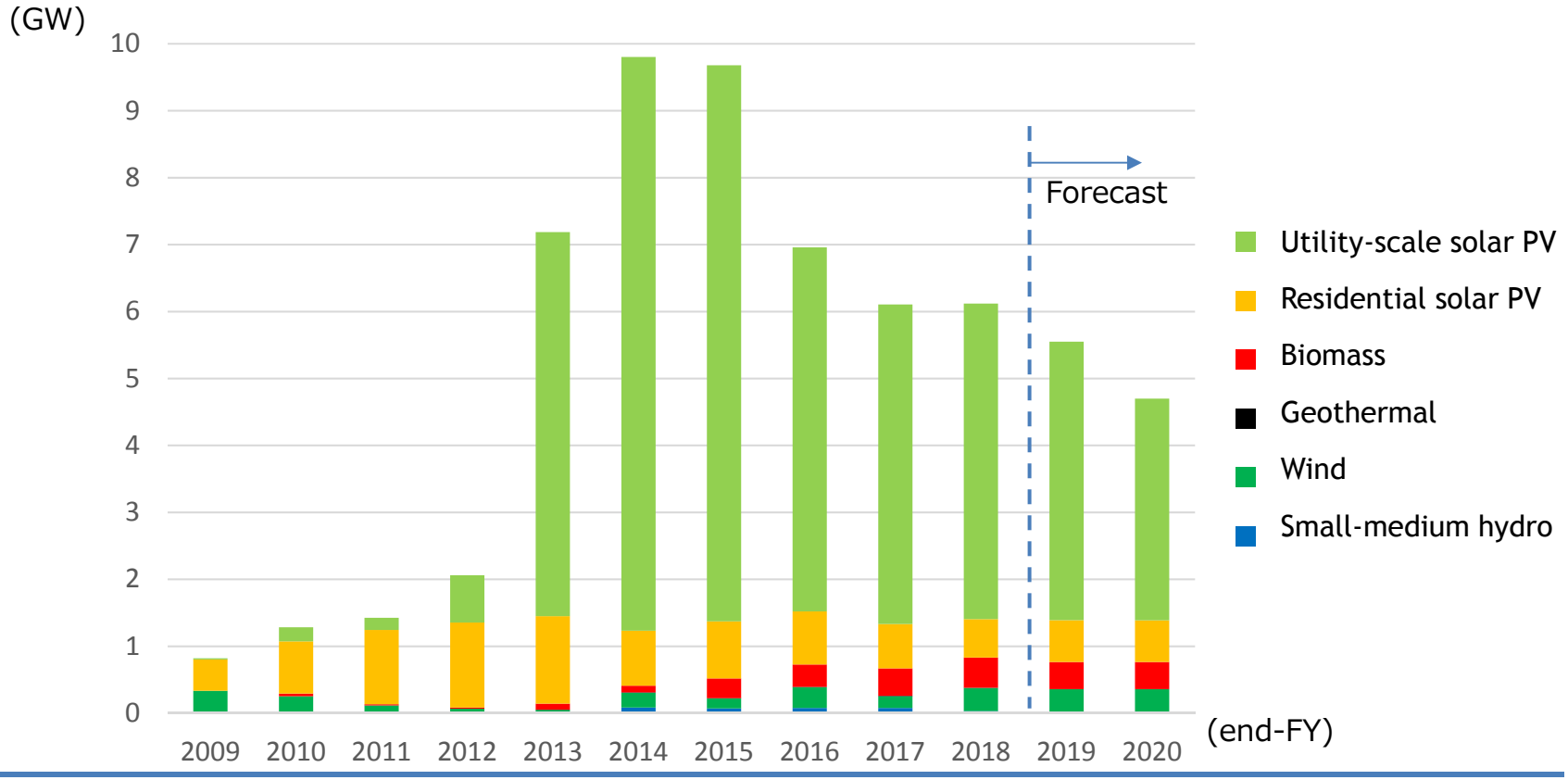
Japan's renewable power capacity: annual growth (FY2009-2020) (excluding hydropower capacities of 30 MW or more)

- The growth of renewable power capacity will fall to around 5 GW p.a. in FY2019 onwards due to the curb on the increase in utility-scale solar PV.
  - Meanwhile, residential solar PV will increase steadily by 0.6 GW p.a., and solar PV in total will account for 85% of the increase in capacity.
  - Increases will be seen in onshore wind starting in FY2019 as environmental impact assessments end one after another, and in biomass for which there are many licensed FIT projects.



Source: Estimate by IEEJ

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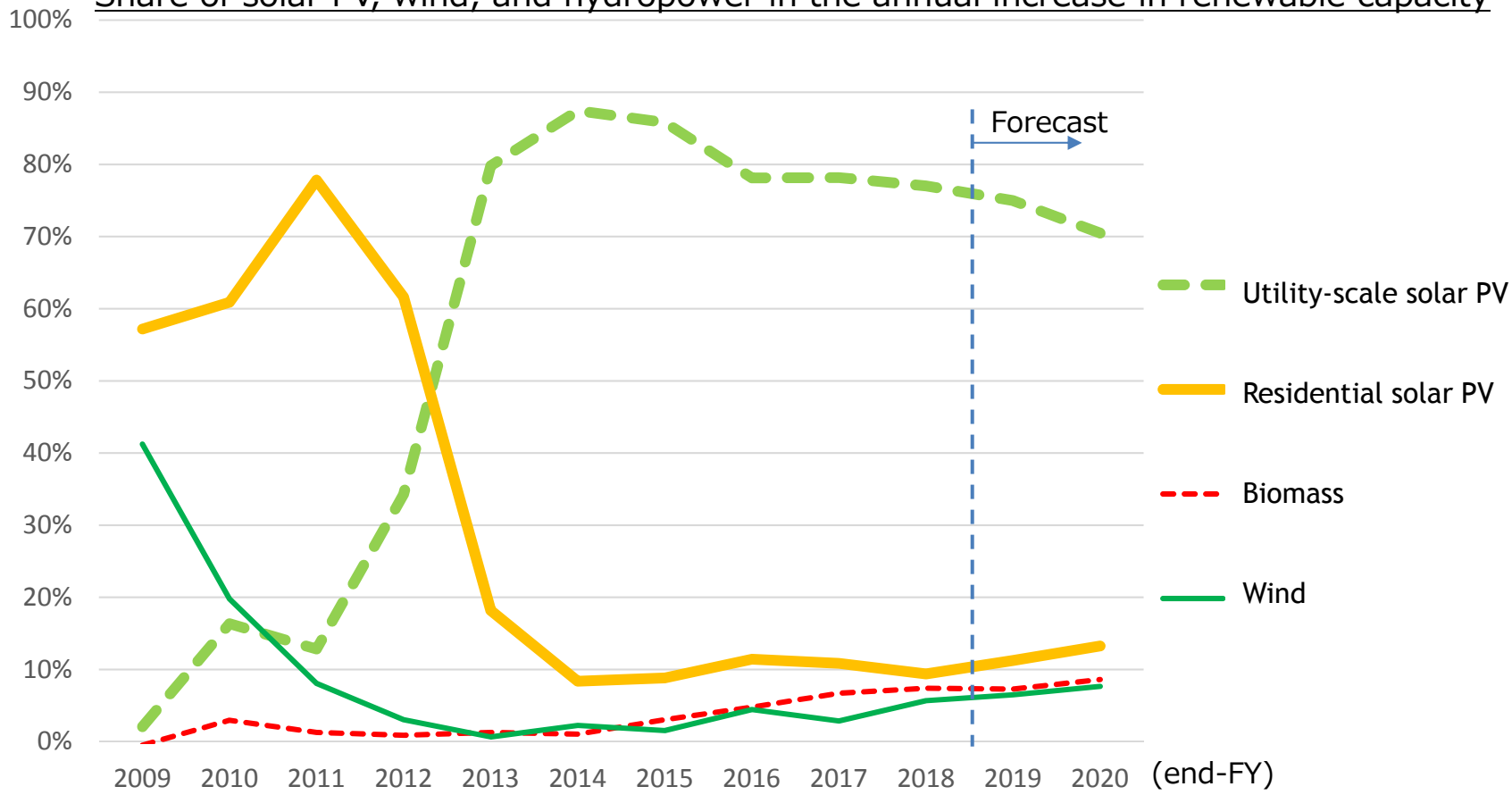
Utility-scale solar PV still accounts for much of the increase, but its share will gradually decline

- Utility-scale PV still accounts for most of the growth of renewable capacity, but its share is declining.
  - Instead, residential solar PV, biomass, and wind are increasing, though their shares are low.
  - In the long run, the shift from utility-scale solar PV for electricity sales to solar PV for self consumption will accelerate.

Share of solar PV, wind, and hydropower in the annual increase in renewable capacity



Source: Estimate by IEEJ

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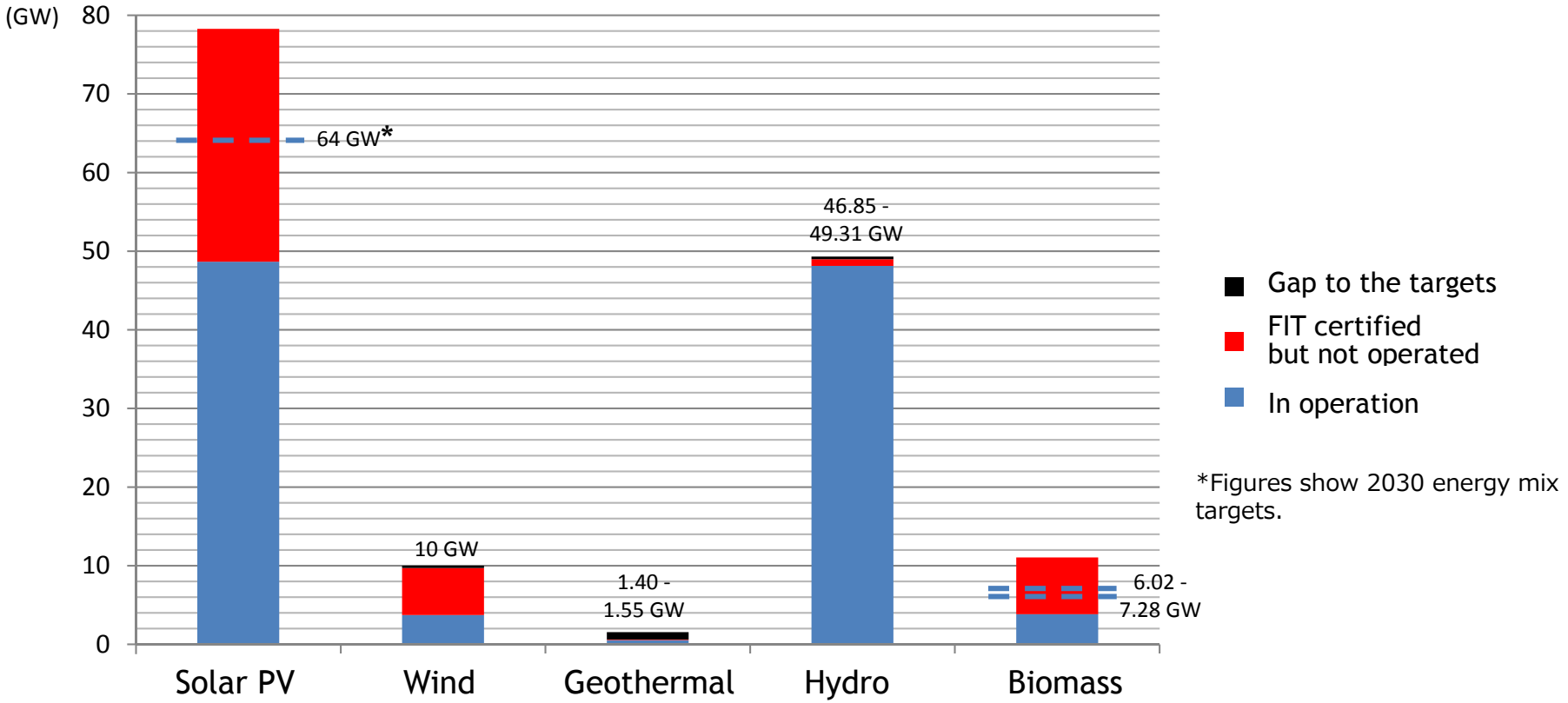
Renewable capacity vs. target levels in the 2030 energy mix (incl. hydropower capacities of 30 MW or more)

- Target levels for renewables in the 2030 energy mix are mostly achieved when considering both operating capacity and FIT certified capacity.
  - Solar PV will exceed the target even if around one-third of the non-operating FIT capacity certified in FY 2013-14, which accounts for most of the non-operating projects, is cancelled.
  - Assuming that grid constraints will gradually be resolved, the operation of biomass and wind capacities will also increase, and renewable capacity may reach the 2030 energy mix target (lower bounds of the renewable energy share of 22%) as early as in the mid-2020s.



*Figures show 2030 energy mix targets.

Source: Created by IEEJ using end-December 2018 data

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Challenge #1 Reducing the cost of renewables: shifting utility-scale solar PV and wind from FIT to FIP

- Efforts under the current FIT program: Introducing auctions and lowering the FIT price for non-operating solar PV projects
  - The third solar PV auction bid was held in November 2018: Lowest bidding price was 14.25 yen/kWh.
    - The price has come down compared to 17.2 yen/kWh in the first auction in 2017 and 16.47 yen/kWh in the second auction in August 2018, indicating a certain cost reduction effect, but is still 1.5 times higher than the global weighted average.
    - Planning to expand the solar PV auction to include capacities of 500 kW and above and offer 750 MWs for auction in FY2019.
  - Forced cut in FIT price for non-operating PV capacities FIT-licensed in 2012-2014, a symbol of high cost (40-32 yen/kWh) → Aim to cut cumulative surcharge burden by 60 trillion yen in total.
- Fundamental overhaul of the FIT Act in April 2020: Integration of utility-scale solar PV and wind markets is the main focus; Aim to make renewables an economically-independent key energy source.
  - Utility-scale solar PV>50 kW and wind may be removed from the FIT system
  - If so, FIP (Feed-in Premium) may be introduced to replace FIT
    - Direct sales of electricity by renewable power to the market, electricity retailers and end consumers including RE100 companies; power companies will be held accountable for imbalances and will require far greater ownership and skills.
    - Any difference will be compensated if the average wholesale price falls below the “benchmark price,” which will be determined preferentially among projects offering the lowest bidding price.
    - Improving the prediction accuracy for renewables and concerns about the market premium causing a rise in purchase price will emerge as new challenges.
  - Small residential solar PV systems < 50 kW may be for self-consumption in principle, making only excess power eligible for the FIT program
    - There is clear policy intent to guide solar PV from “electricity sale” to “self-consumption”.

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Challenge #2 Constraints of the Grid: Grid development and shouldering of costs

- Utilisation of the existing grid infrastructure: implementation of the “Japanese Connect & Manage”
  - Rationalisation of the anticipated current, N-1 power control* (both already applied), non-firm connection** (pilot study under way by TEPCO PG in Chiba area)
- Study on the direction of network enhancements and cost allocation
  - There is currently a regional imbalance in the allocation of network enhancement costs associated with the increase in renewables. A consensus has been reached to measure the benefit of enhancing inter-area connection lines and grid development (decrease in wholesale price, CO2 reduction, and higher supply stability achieved by introducing renewables) and to allocate the costs for achieving the reduction in price and CO2 to all regions in the country.
    - A study has begun on enhancing the HVDC Hokkaido-Honshu and Tohoku-Tokyo Interconnection Lines.
    - The enhancements are expected to increase new renewable capacities and the capacity factor of the existing capacity.
  - Switching from as-needed grid development to a planned development approach. Further, the Organization for Cross-regional Coordination of Transmission Operators (OCCTO) is set to draw up a master plan packaging principles and other frameworks within this fiscal year, by setting various scenarios as options.
- Renewables will be required to have their own adjustment functions and play an active role in network operation as a full-fledged constituent of the power system, rather than being dependent on the system as has been the case so far.

*Allows renewable electricity to be connected on condition that it will be limited (stopped) automatically and without guarantee when an incident occurs in a single power facility.
**Allows new power sources to be connected on condition of agreeing to power control without guarantee not only when an incident occurs but also during usual peak hours of the grid.

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Residential solar PV FIT contracts will start to expire

- "Pre-FIT Solar PV support programme" for purchasing excess solar PV was implemented from November 2009 through June 2012, before the FIT program was launched in July 2012.
  - This program required the purchase of excess power from solar PV plants < 10 kW at 48 yen/kWh in 2009 for 10 years which is almost the same as the FIT.
  - Starting end of October 2019, the ten-year purchase contracts will expire each day with the tatal capacity of more than 1.3 GW in 2019 alone.

- There are currently four options for post-FIT residential solar PV:
  1. Power is collected by general transmission and distribution companies without compensation (for cases where no purchase contracts exist after the FIT expires, which is expected to be rare.
  2. Purchase by retailers at a post-FIT price under a new contract
     - A very number of purchase programs are being launched by electricity retailers.
     - Post-FIT purchase prices vary greatly depending on the contract from 7 to 16 yen/kWh.
  3. More self-consumption in homes by means of energy storage with battery storage and EVs
     - The size of the fall in storage system prices will determine the advantage of self-consumption.
     - Utilization in VPPs through aggregation by aggregators is a possibility.
  4. P2P trading between prosumers using blockchain technology
     - Though it is still in the demonstration phase, this may become a promising option in the long run if IoT costs decrease.

- The possible uses of solar PV as a distributed energy resource will expand at the post-FIT era.
  - This may be a crucial turning point in the development of renewable energy in Japan.

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Offshore wind: may accelerate with the support programme under the new law

- "The Act for offshore wind development" became effective on April 1, 2019.
- Hereafter, the government will designate "offshore wind promotion areas" that have good wind and maritime conditions and meet grid connection requirements, and will hold a bid to invite offshore wind developers.
  - Studies are under way on the criteria and management of specific procedures for designating offshore wind promotion areas.
  - Meanwhile, attention will be paid to which areas will be designated.
- In parallel with the designation, the government is studying a mechanism to secure, in advance, grid connections necessary for offshore wind.
- Currently, capacity of 4.8 GW is undergoing environmental impact assessments in general sea areas. It is hoped that their introduction will accelerate as the designation of promotion areas and selection of power producers make progress under the new law, and as the government secures grid connection.
  - The actual increase in capacity is expected to start from 2022-2023. With its high potential, there are hopes that offshore wind will become a promising market in Japan.
- However, it is not clear how far Japanese companies can capitalise on the business opportunities associated with market expansion, as European companies dominate, having accumulated significant experience and knowledge in the manufacturing, installation and operation of offshore wind plants over the past decades.

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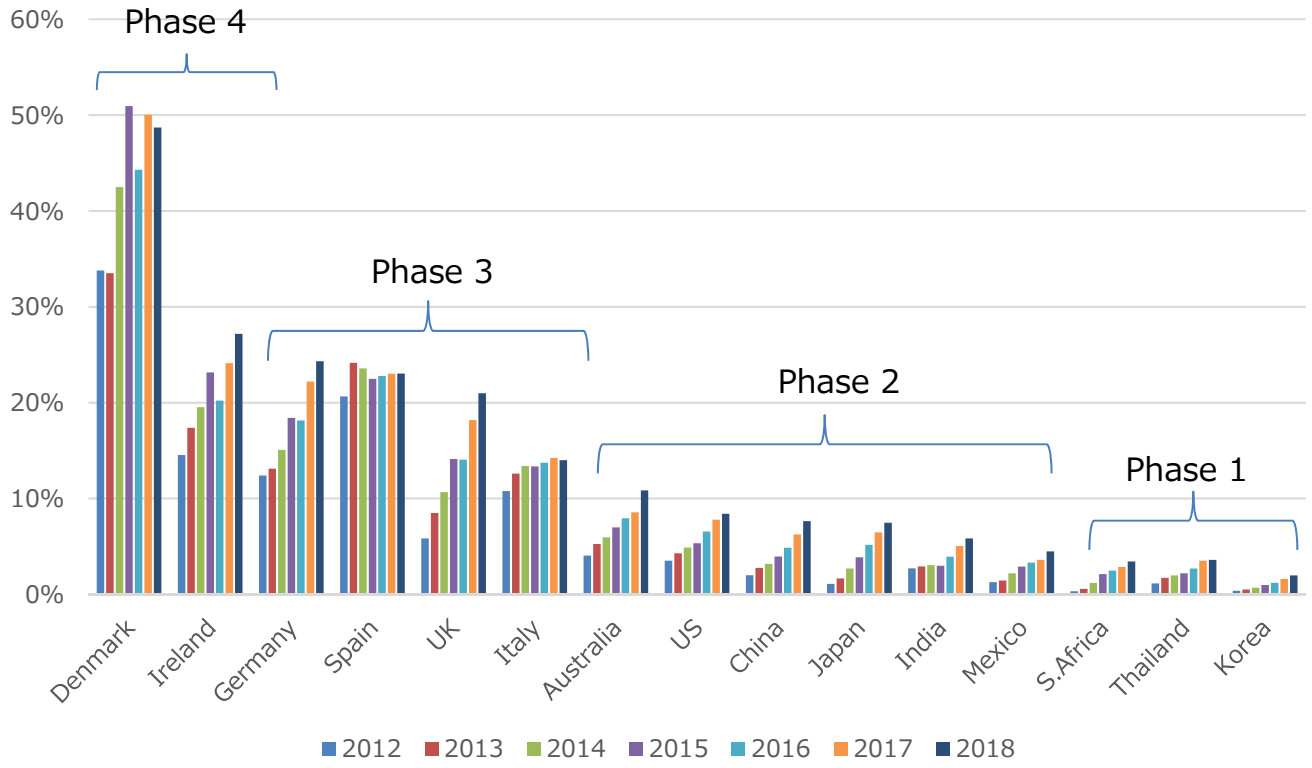
Variable renewable energy (VRE) increases its share in power output worldwide

- The share of VRE in total power output is increasing worldwide year by year.
  - European are in Phase 3 and Australia, the US, China, Japan and others are in Phase 2 of the IEA's VRE phased approach. All countries are expected to phase-up toward 2020 as their VRE shares grow.
  - Once VRE enters Phase 3, it will start to significantly affect the operating pattern of the power system, making it necessary to make the system more flexible by utilising the grid expansion/reinforcement, storage, and distributed resources such as DR, EV and P2G

Share of VRE in total power output (2012-2018) and IEA's VRE phase setting



Source: BP Statistical Review of World Energy June 2019

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EU's 2030 renewable target is set: Focus on increasing renewables in the heating/cooling and the transportation sectors

- The Clean Energy for All Europeans package including the revised Renewable Energy Directive was finalized in May 2019.
- 2030 renewable energy capacity target: Renewable energy to account for at least 32% of final energy consumption
  - The target will be reviewed and stepped up by 2023 reflecting the reduction in renewable energy costs.
  - However, biofuels and biomass not meeting sustainability requirements cannot be counted.
- Efforts must be made to increase the share of renewables in the final energy consumption of the heating and cooling sector by 1.3% p.a. on average from 2020 to 2030.
- Members must require fuel suppliers to supply a minimum of 14% of the energy consumed in road and rail transport by 2030 in the form of renewable energy.
  - Next-generation biofuels must account for at least 0.2% of the 14% in 2022, 1% in 2025, and 3.5% in 2030.
  - The share of biofuels produced from food (e.g. first-generation biofuels) must be no more than either 7% of the final consumption of energy in the road and rail transport sectors or 1% growth level achieved in 2020.
- A clear policy was established to use more EVs with renewable electricity, next-generation biofuels, and renewable hydrogen in the rail/road sectors.

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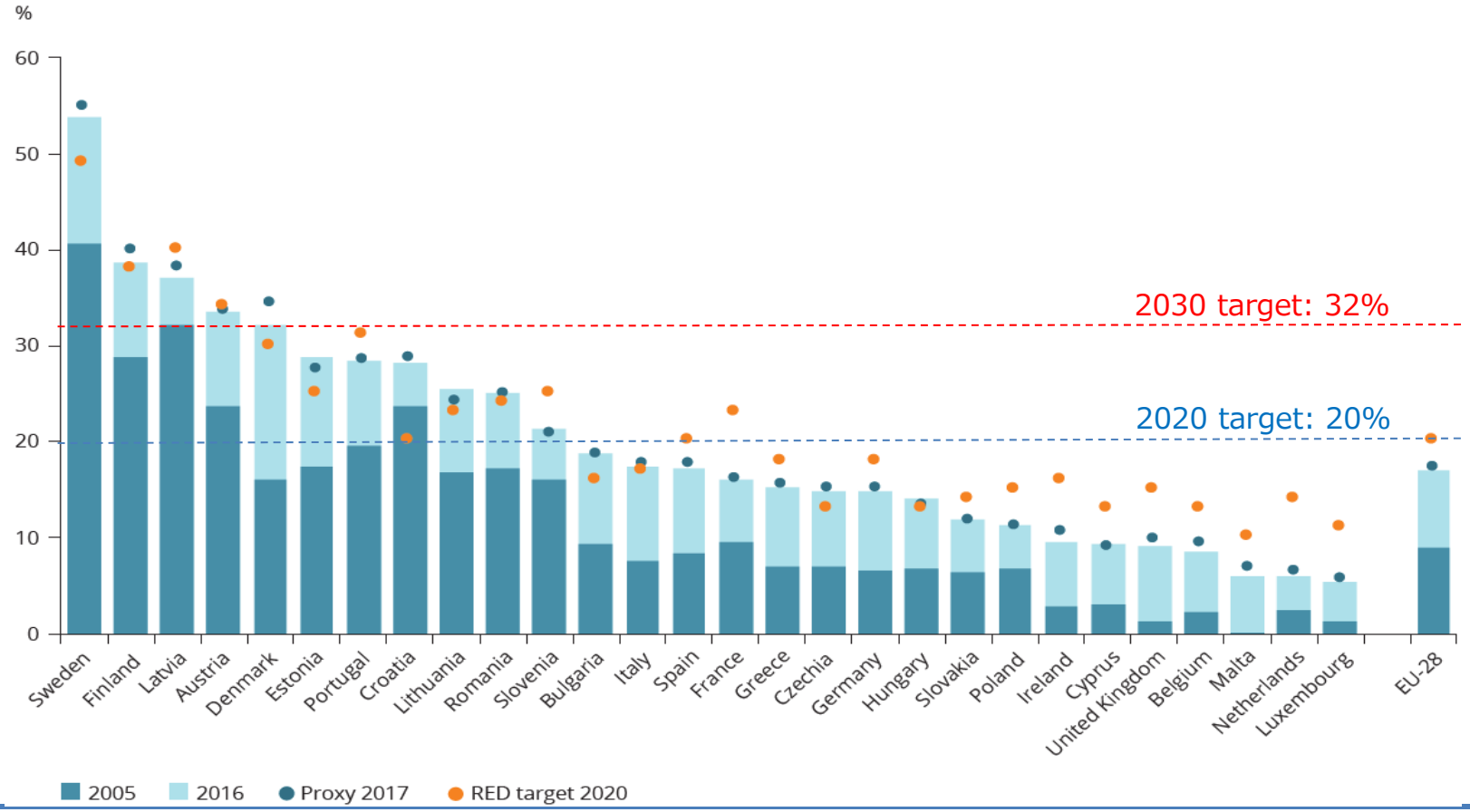
Share of renewables in the final energy consumption of EU Member States (2015-2017)

- The EU has set the target share of renewables in final energy consumption in 2020 at 20%. As of the end of 2017, the actual share was 17.5%.
  - Eleven countries including Denmark, Italy, Finland, and Sweden have already met the target while the Netherlands, France, Ireland, the UK, Luxembourg and others are lagging.
  - As such, the 2030 target of 32% seems to be rather ambitious.



Source: Renewable Energy in Europe 2018, EEA Report No. 20/2018, with added information.

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The 2050 Net-Zero GHG emission target expanding in Europe

- UK: The Committee on Climate Change (CCC) has proposed that net-zero GHG emissions in 2050 can be achieved with existing technologies with no great additional costs above that for the target of 80% by 2050 and should be set as a government target. The target was legislated at June 2019.
  - Some see the lower cost of renewable power and power storage systems as the reason.
    - CCC judged in 2016 that "net-zero emissions by 2050" is impossible due to costs.
  - "Net-zero emissions by 2050" will be achieved by:
    - Renewables must make up approx. 90% of electricity in 2050, with the rest from nuclear and biomass- and gas-fired thermal power with CCS.
      - Offshore wind, the main source of renewable power, will increase ten-fold to 75 GW in 2050 from 8 GW today.
    - Rapid electrification of heat and transportation demand such as heat pumps, EVs and others.
      - Accelerate the end of sale of all gasoline and diesel fuel cars from 2040 to 2035.
    - Utilisation of hydrogen for high-temperature heat, long-distance freight transport and bunkers in the industrial sector.
      - Hydrogen should be produced from renewables or reformed natural gas with CCS.
    - Any unavoidable GHG emissions such as aviation are to be offset by forest sinks.
- Germany: Started discussions to achieve net-zero GHG emissions by 2050 (June 2019).
- France: Achieving net-zero GHG emissions by 2050 became law (July 2019).
- EU: Released its strategic long-term vision to achieve net-zero GHG emissions in 2050 (Nov. 2018) → The EU summit failed to agree due to objections from some members (June 2019).
  - 80% or more of electricity to be supplied by renewables in 2050 and the remaining 15% by nuclear.

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ESG-minded companies boost renewable energy procurement: RE100

- Social responsibility for the environment, society, and corporate governance (ESG) gained significant attention in Japan from 2018 and has become an important issue for corporate management worldwide.
  - ESG investment, ESG indicators, ESG targets, ESG rating, and so on are in the media almost every day.
- As part of ESG efforts, companies are procuring more renewable energy.
  - RE100: A global initiative to declare making 100% of a firm's electricity consumption renewable, joined by 182 companies (27 added in the last six months).
    - Overseas: Ikea, 3M, Apple, Adobe, Allianz, Bank of America, Barclays, Bloomberg, BMW, Burberry, Citi, Coca-Cola, Facebook, GM, Goldman Sachs, Google, HP, HSBC, Johnson & Johnson, JP Morgan, Kellogg's, Lloyds, M&S, Microsoft, Nestle, Nike, P&G, Philips, SAP, Starbucks, Unilever, VISA, Walmart and others.
    - Japan: Aeon, Askul, Daito Trust Construction, Daiwa House, Fujifilm, Fujitsu, Fuyo General Lease, Konica Minolta, Marui, NRI, Ricoh, Sekisui House, Sony, Toda Corporation, Tokyu Land Corporation, Watami and others.
    - On average, the companies aim to achieve 100% renewable energy by 2026. The annual power consumption of the member companies is 188 TWh in total, around 20% of the power consumption of Japan.
  - In the US, about one-fourth of new mega solar power plants are assumed to be based on power purchase agreements (PPAs) with RE100 and other private companies, and the impact of RE100 on the market is increasing.
    - Google: 300 MW PPA with solar plants in Alabama and Tennessee (Jan. 2019)
    - Facebook: 350 MW PPA with solar plants in Virginia and other states (Apr. 2019)
    - 16 US major companies including Google, Facebook, and Walmart established the Renewable Energy Buyers Alliance (REBA), which aims to expand its collective renewable power contracts to 60 GW by 2025 (Apr. 2019).

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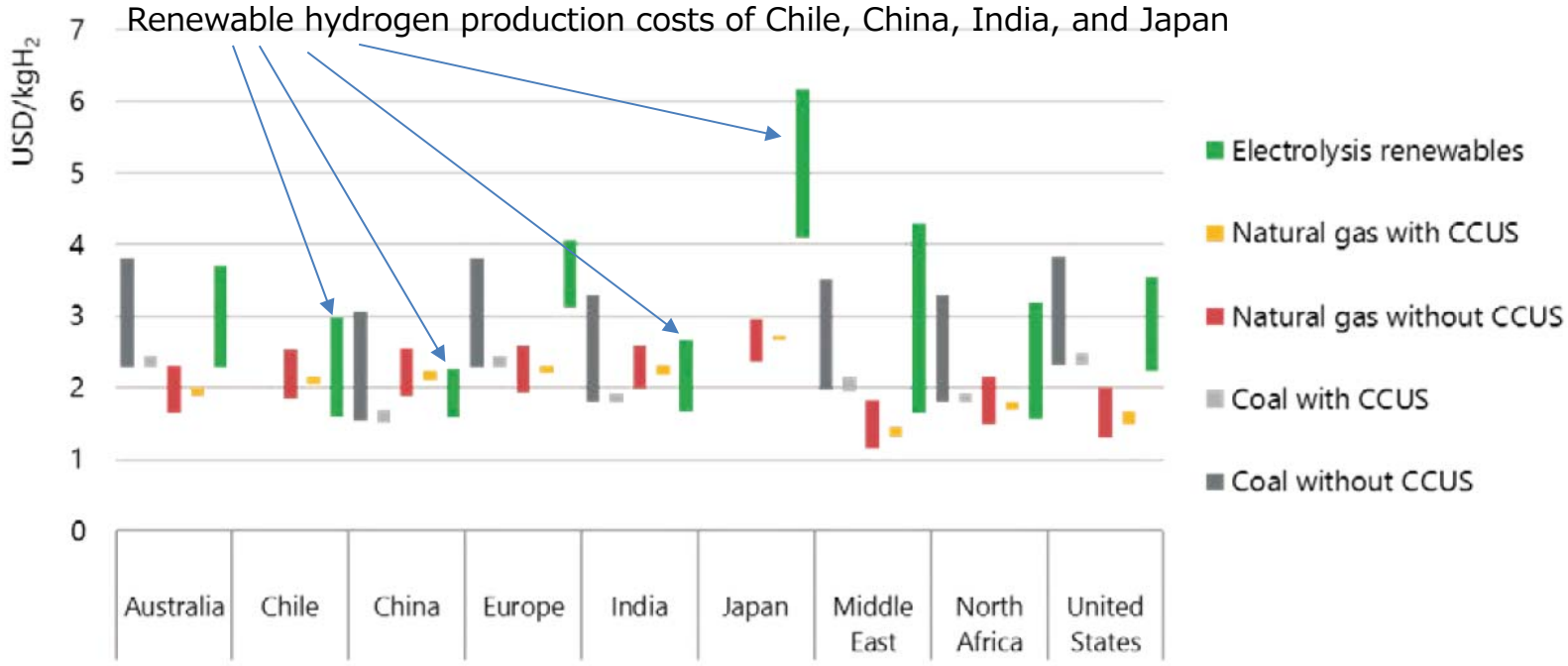
Hydrogen energy: Clean hydrogen produced from renewables attracting growing attention

- As the cost of renewable power falls rapidly, “clean hydrogen” produced from renewables is gathering more attention as a carbon-free energy source.
- Clean hydrogen is produced mainly by “electrolysis using renewable power (renewable hydrogen)” or “fossil fuel + CCS”. The economic efficiency varies greatly by region.
  - In regions such as Chile, China, and India where gas is relatively expensive and where there is abundant sunshine and wind, the economic efficiency of renewable hydrogen could match “gas + CCS”.
  - On the contrary, the cost of renewable hydrogen is very high in Japan reflecting its excessively high generation cost of renewables which cannot compete with “gas + CCS” in economic efficiency.

Hydrogen production costs by country: electrolysis with renewable power, coal + CCS, and gas + CCS



Source: IEA (2019) The Future of Hydrogen.

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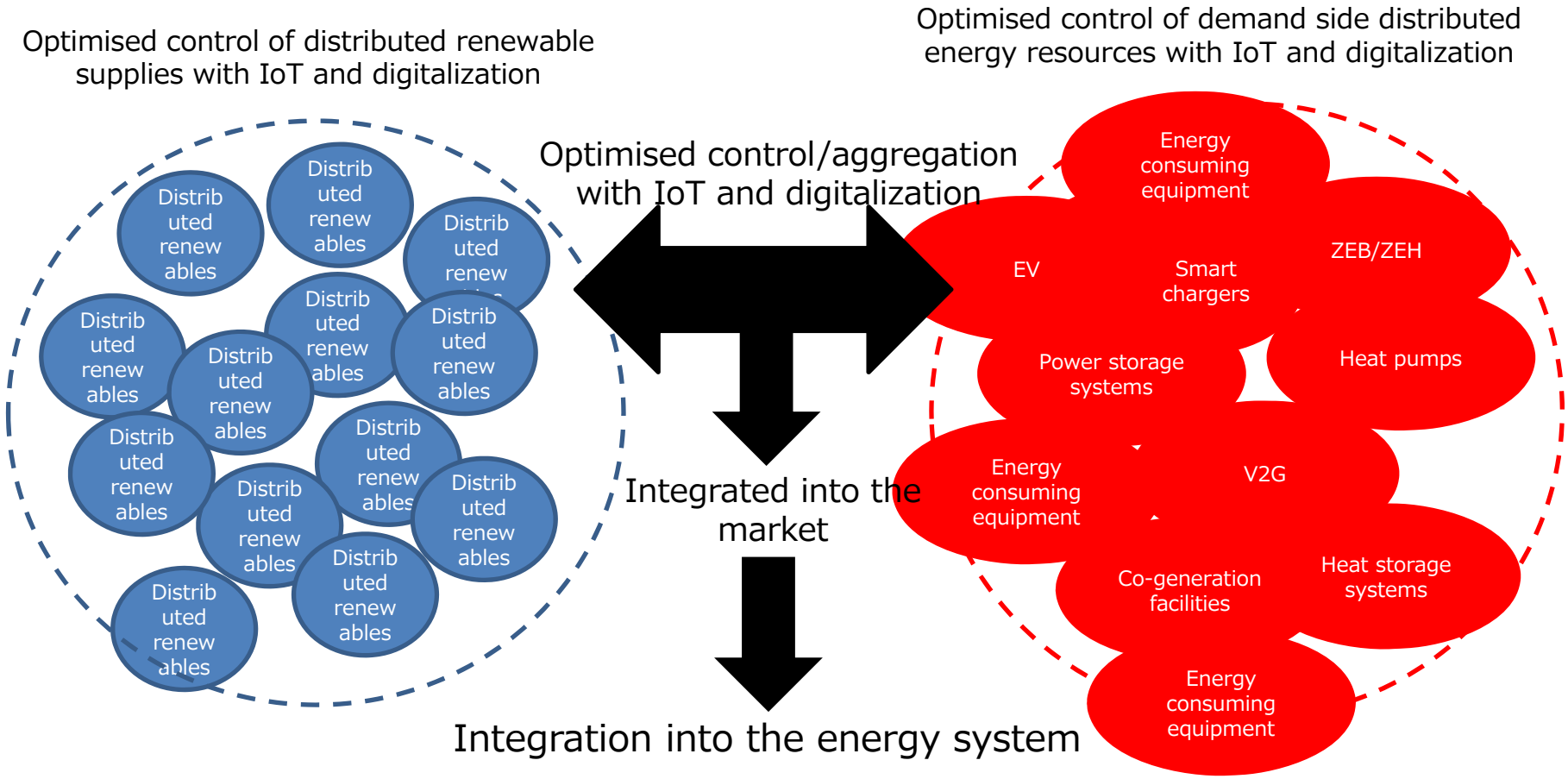
Trends of the increase in distributed renewables: Distribution, digitalization and integration

- The key trends of the upcoming increase in distributed renewable power can be summarized by three key words: Distribution, digitalization, and integration.
  - Integration means both integration into “the market” and “the energy system”.



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