資料２－１

Renewable Electricity Markets & Policies

An IEA Perspective

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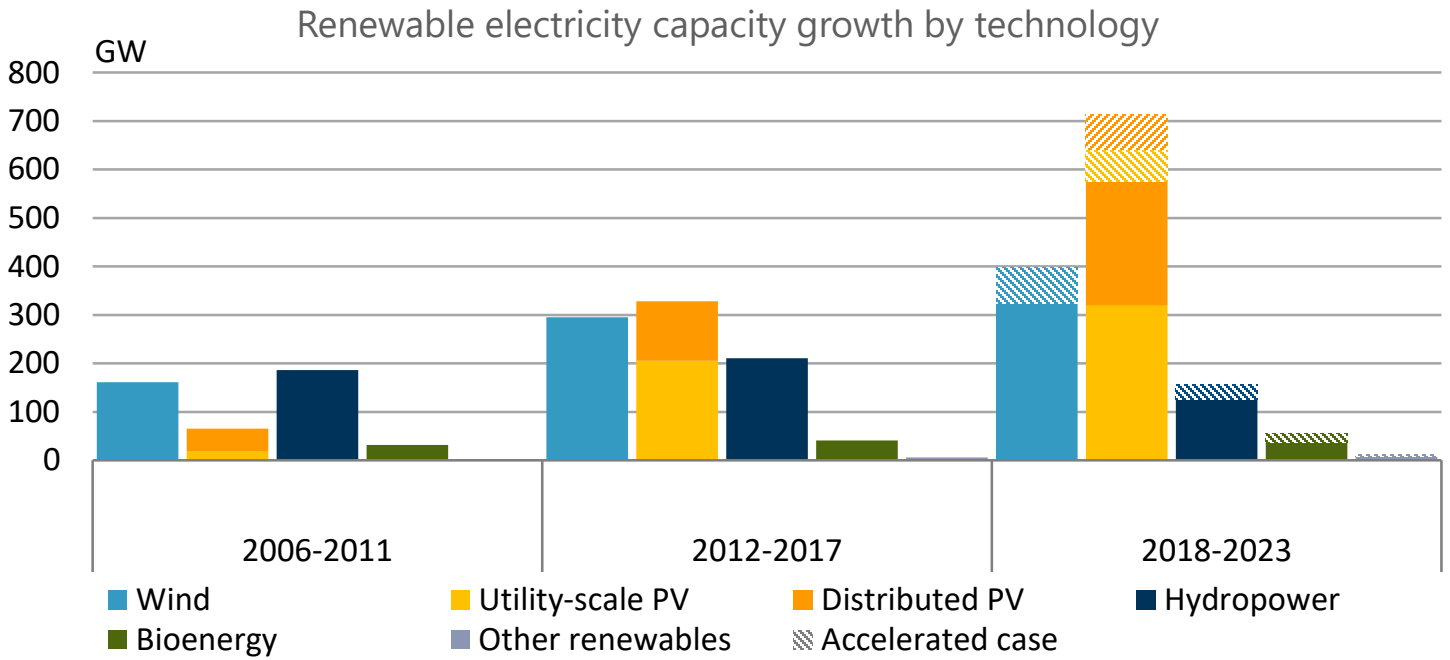
METI Sub-Committee, Tokyo, 10 June 2019

IEA

Solar PV and wind expanding very fast in the next five years

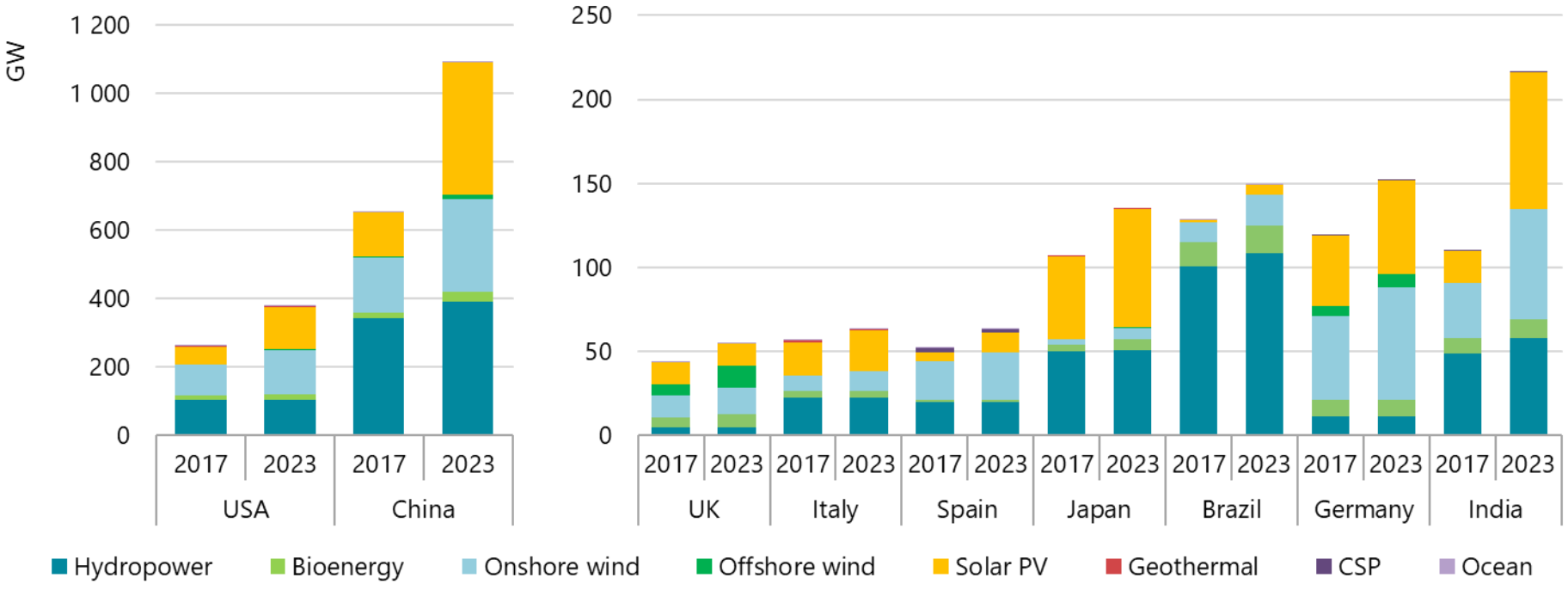


Notes: Utility-Scale PV: more than 1MW, Distributed PV: less than 1MW but the data also takes into account country definitions due to availability of information and may include projects larger than 1 MW under the distributed PV category. For instance, China's definition of distributed PV may include projects up to 5 MW but these are connected to the distribution grid.

Distributed generation capacity growth makes the difference in solar PV's leadership
Cumulative PV capacity could reach 1.1 TW and wind over 0.9 TW by 2023 under the accelerated case

Renewable electricity status and forecast

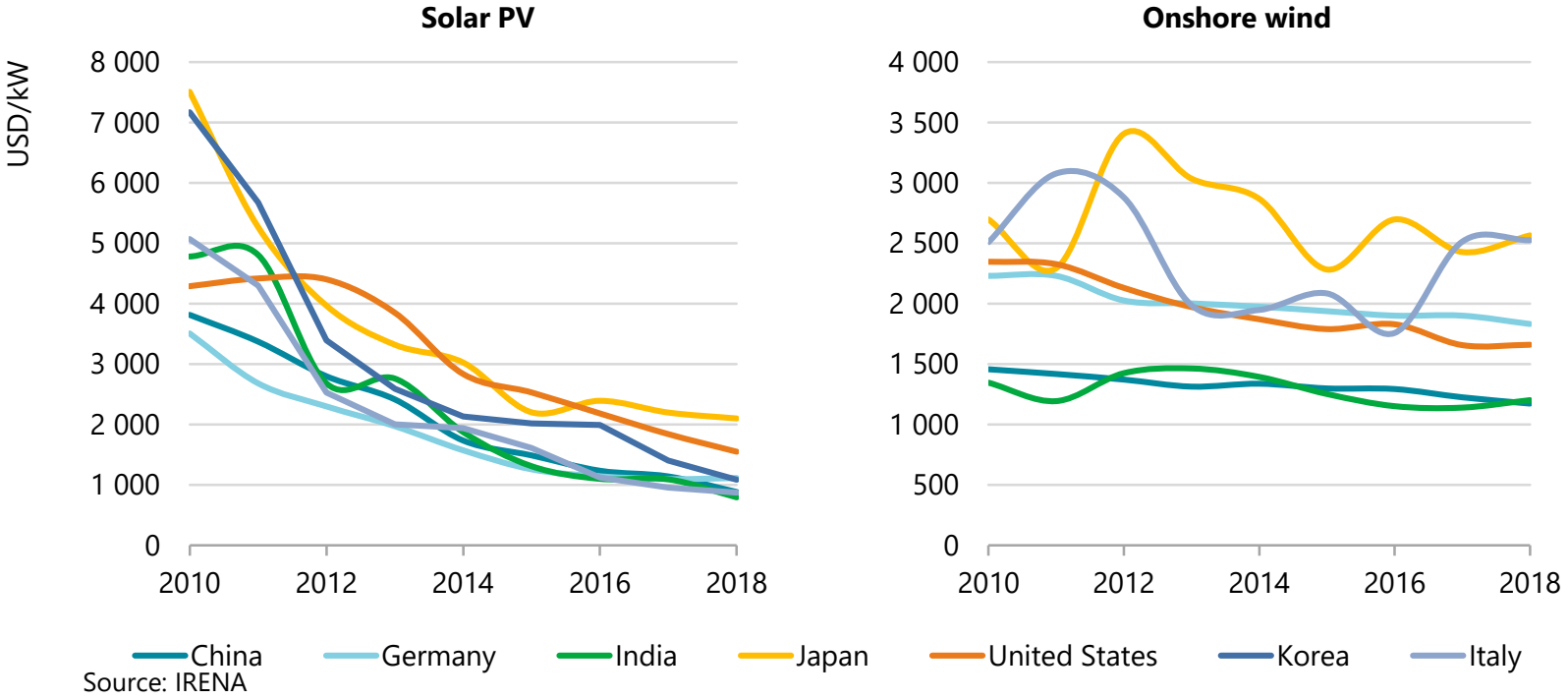
Cumulative installed renewable power capacity in selected countries, 2017 & forecast 2023



Japan is #6 worldwide in terms of cumulative installed renewable power capacity; #3 for solar PV

Renewable investment costs are relatively high in Japan

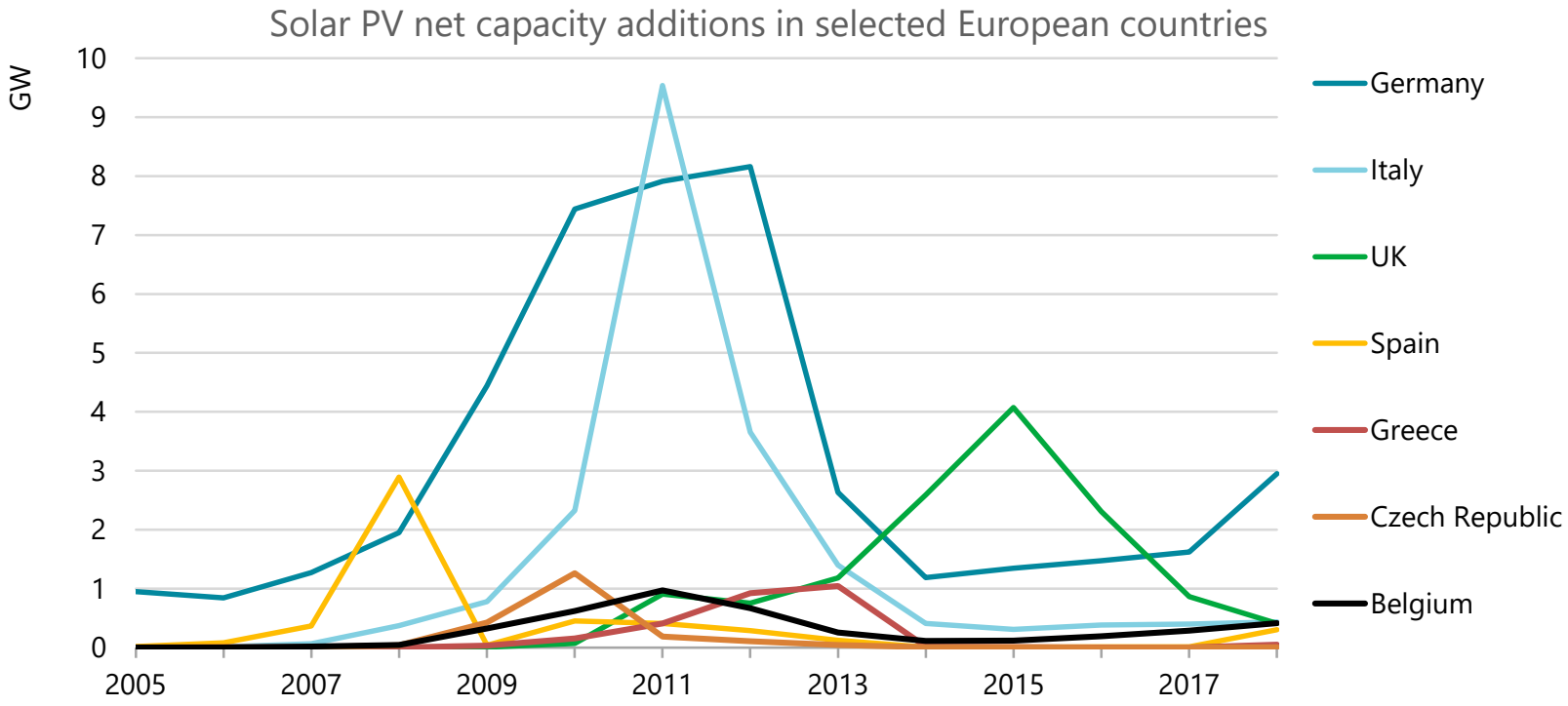
Investment cost of onshore wind and solar PV by technology



Source: IRENA

Both country-specific conditions and policy design influence the cost of wind and solar PV

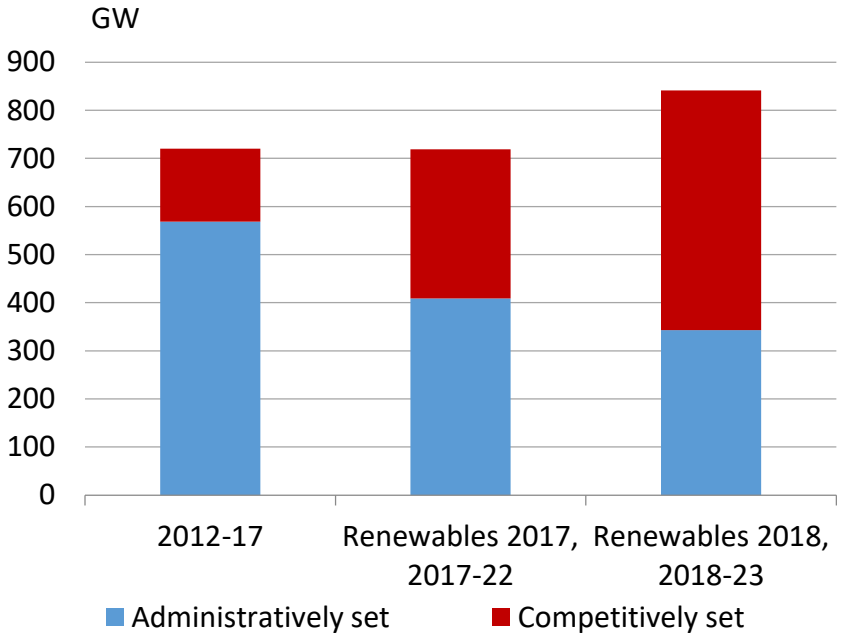
History of FIT schemes in Europe



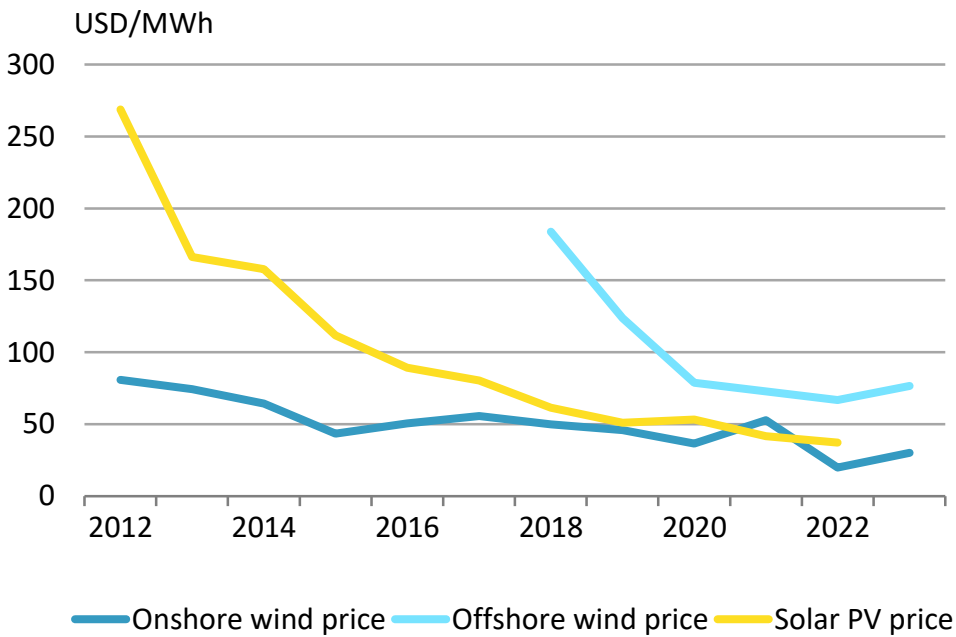
European countries repeatedly faced major challenges in controlling deployment and total subsidies, ultimately leading to boom and bust cycles, which are detrimental to the industry

Competition accelerating cost reductions

Fixed remuneration type of utility-scale projects



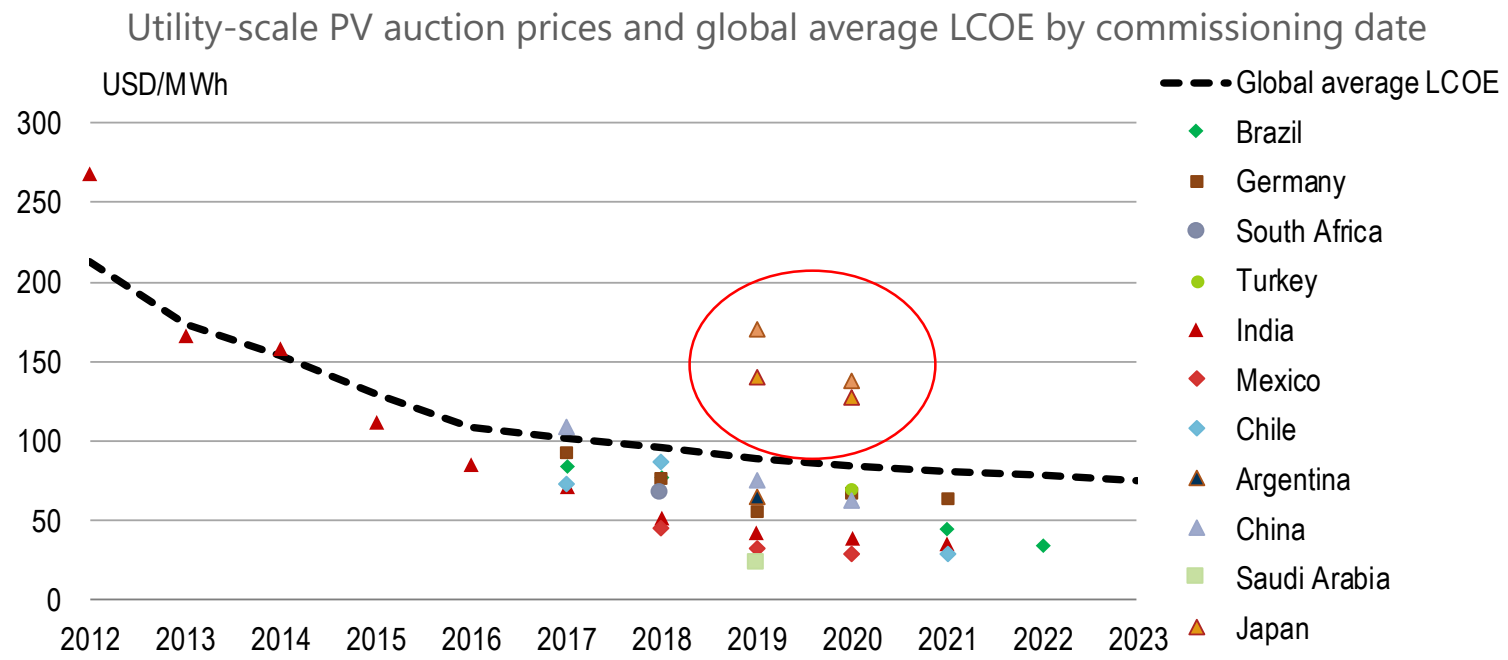
Average auction price by project commissioning date



Notes: For countries all over the world

Almost 60% of renewable capacity additions over 2018-23 remunerated by competitive auctions; announced contract prices need to be verified as project delivery schedules and final costs may differ

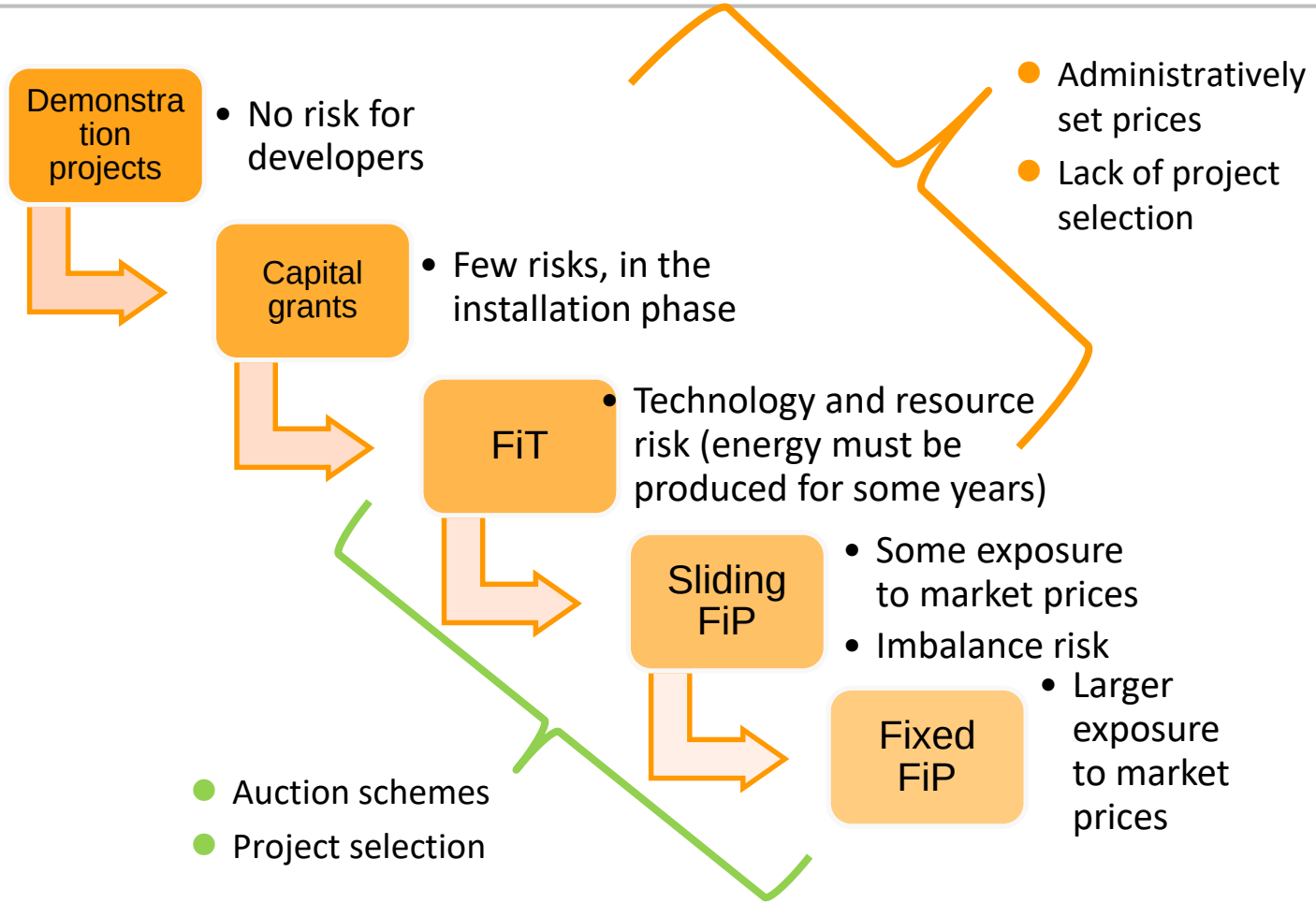
Auction design matters to achieve competitive prices



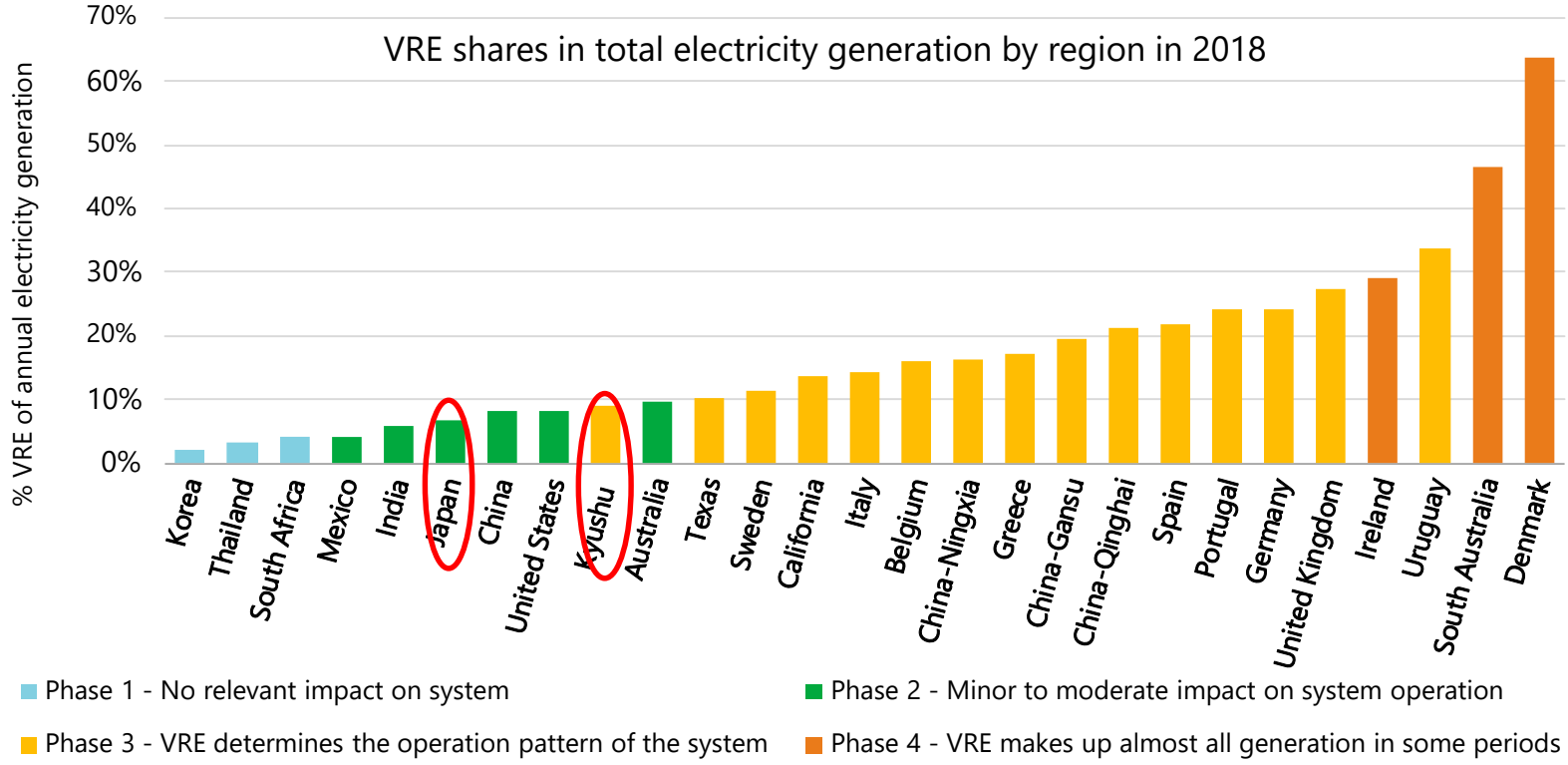
Notes: For countries without fixed commissioning date, 2 years was assumed. Japan prices reflect high and low winning bids

Auctions can provide certainty on prices giving long-term visibility to developers. They also allow governments to control volumes and total policy costs

Transferring risk



System integration: different phases



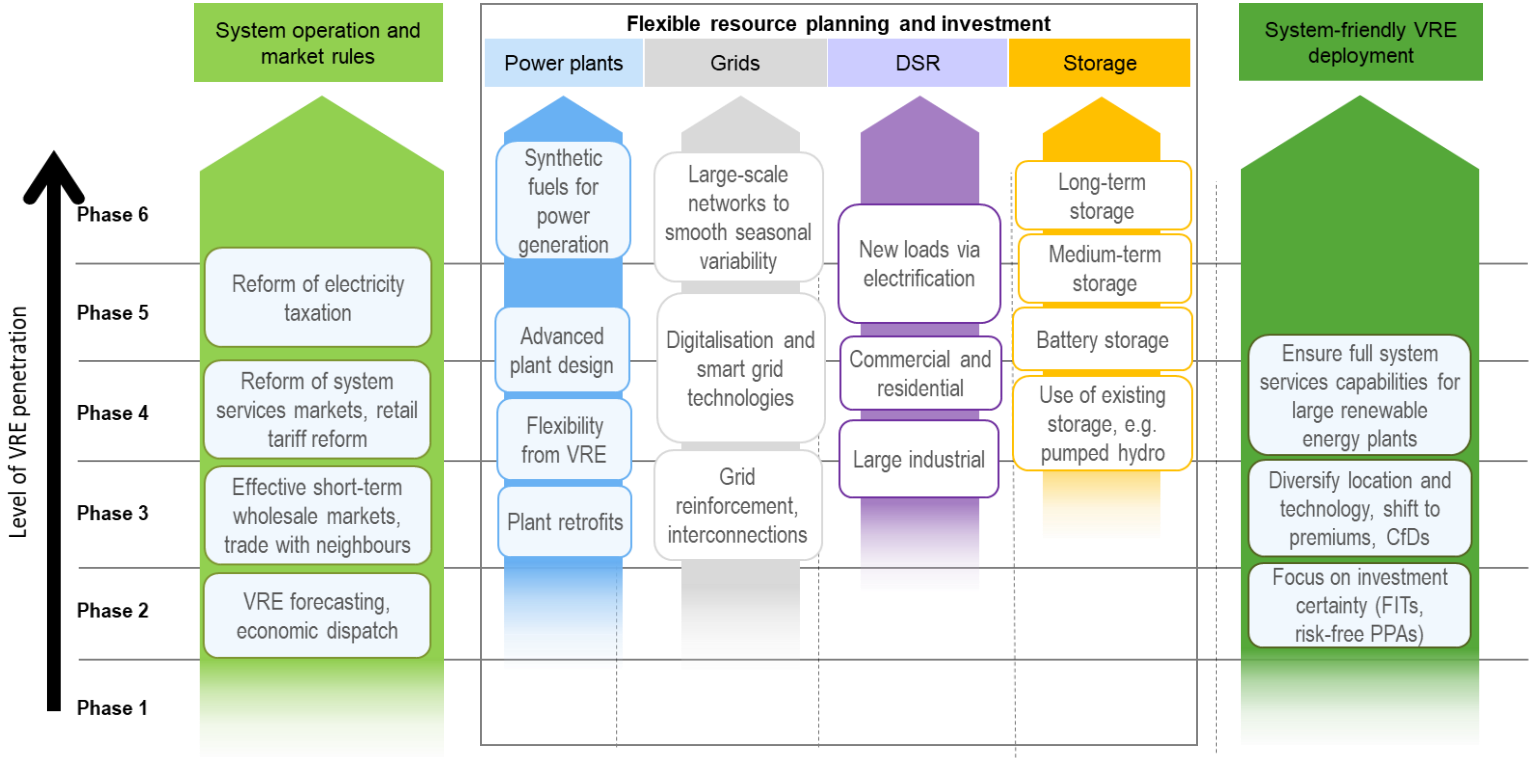
Specific power system regions can be at higher VRE integration phases due to limited interconnection and VRE penetration. This can require market reforms to meet increased flexibility requirements

Flexibility requirements depend on a combination of factors

	Denmark	Hokkaido	Ireland	Kyushu
VRE Share	63%	8%	29%	11%
Area (1000*km2)	42.9	83.4	84.4	36.7
Peak electricity demand (GW)	5.8	5.3	4.9	15.9
Total electricity demand (TWh)	31.7	30.6	28.2	87.8
Interconnector capacity	8 GW combined AC and HVDC	900 MW HVDC	420 MW	2.78 GW AC
Population (million)	5.75	5.28	4.78	12.97

The challenges faced by specific subsystems will vary according to the flexibility resources available. Even at low VRE shares, integration can require policy and regulatory innovation.

Flexibility requirements depend on phase



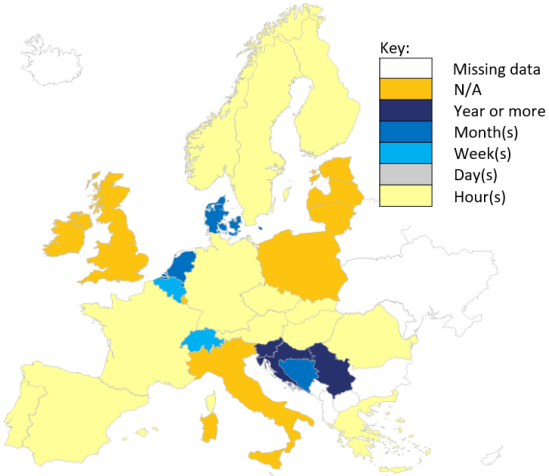
A comprehensive approach to system flexibility covers not only technical aspects, but also policy, market and regulatory frameworks, as well as institutional arrangements.

System-friendly renewables policies

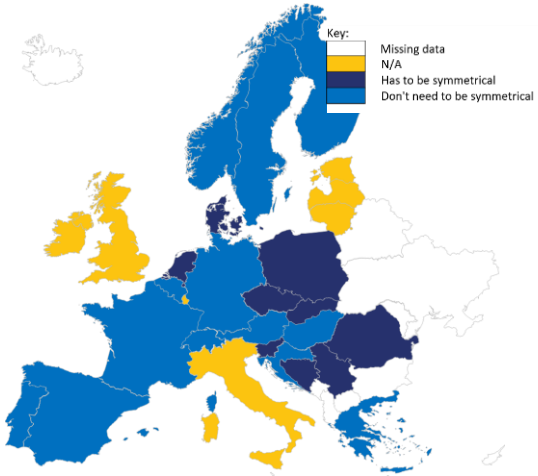
Action area	Policy example
Integrated planning: wind and solar embedded in energy strategy	**Denmark:** integrated energy strategy
Location: siting VRE closer to existing network capacity and/or load centers	**Mexico:** auctions reflect time- and location- value of electricity
Technology mix: balanced mix of VRE resources can foster lasting synergies	**South Africa:** Integrated Resource Plan
Optimising generation time profile: design of wind and solar plants	**California:** incentive to produce at peak times
System services: wind and sun contribute to balance system	**Spain:** wind active on balancing market
Local integration with other resources such as demand-side response, storage	**Australia:** incentives for self-consumption

Example of European balancing markets

The design of automated Frequency Restoration Reserves (aFRR or 'secondary reserves'), situation end of 2017



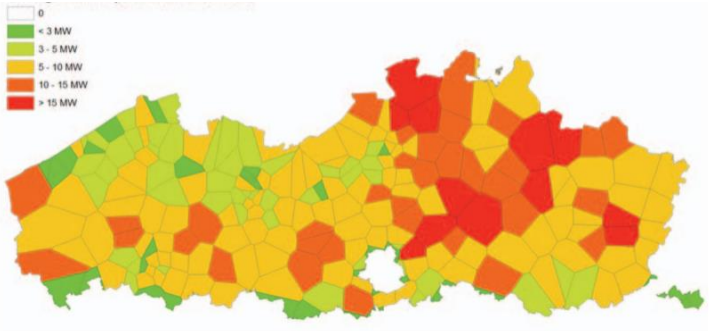
aFRR can be procured often on a per-hour basis to make use of high RES infeed times.



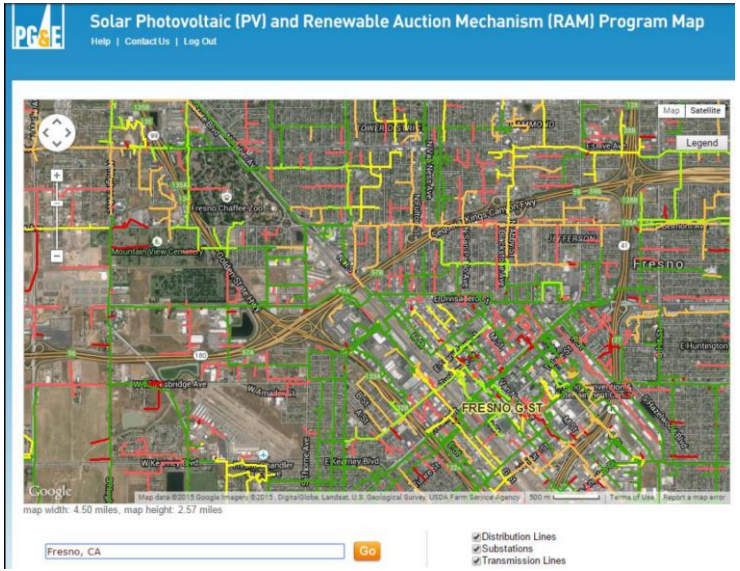
Bid can often be made only for downward reserves which is more advantageous for wind and solar.

European balancing markets are often technology-neutral. To attract VRE sources the market design needs to ensure it is feasible and attractive for these sources to participate. Similar considerations apply for attracting demand flexibility.

Pro-active communication on system hosting capacities



(Example: Vito, Belgian voluntary study on hosting capacity for PV on substation level)

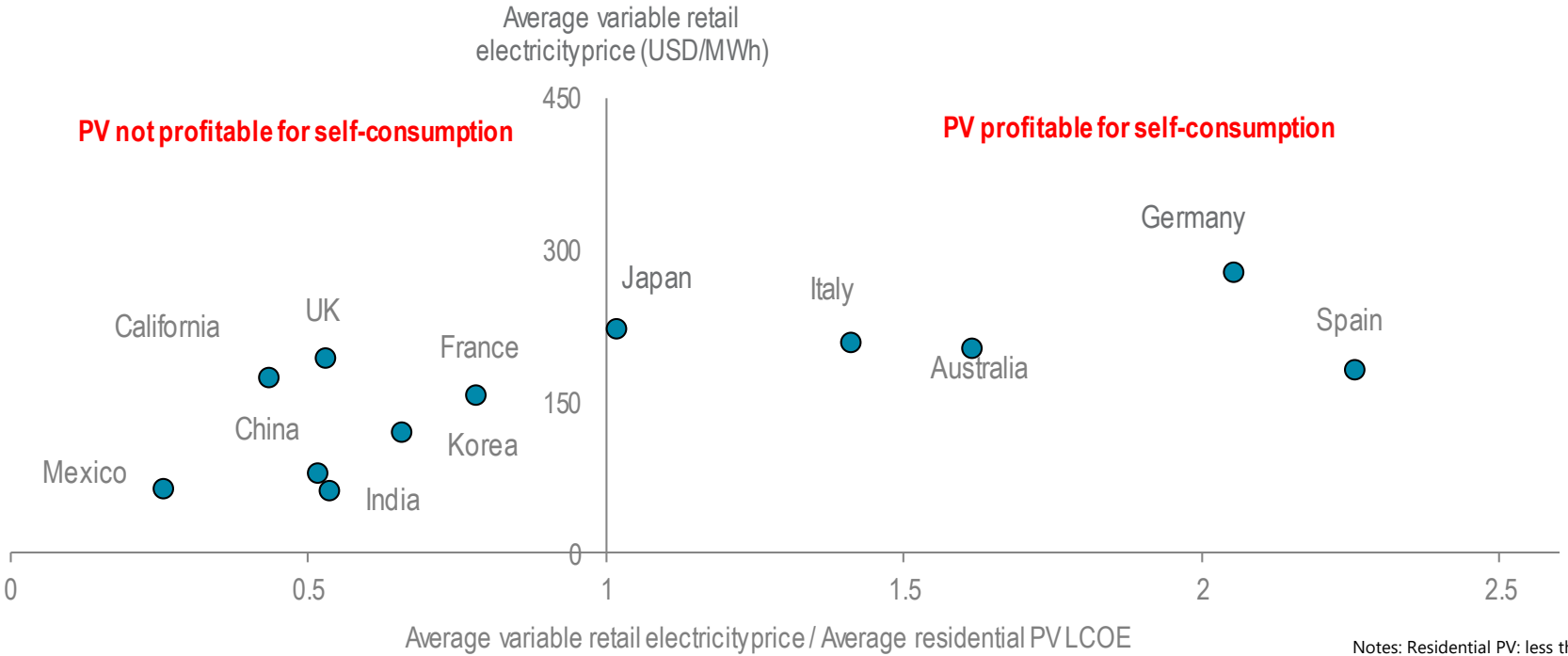


(Example: PG&E Distribution Resource Plan in line with CPUC code)

Also in liberalized energy markets, there is value in having an integrated planning exercise to understand system limits, guide investment plans and create incentives for VRE connection in suitable locations.

High retail prices are a driver for self-consumption

Residential electricity prices compared with average residential PV LCOE, 2017

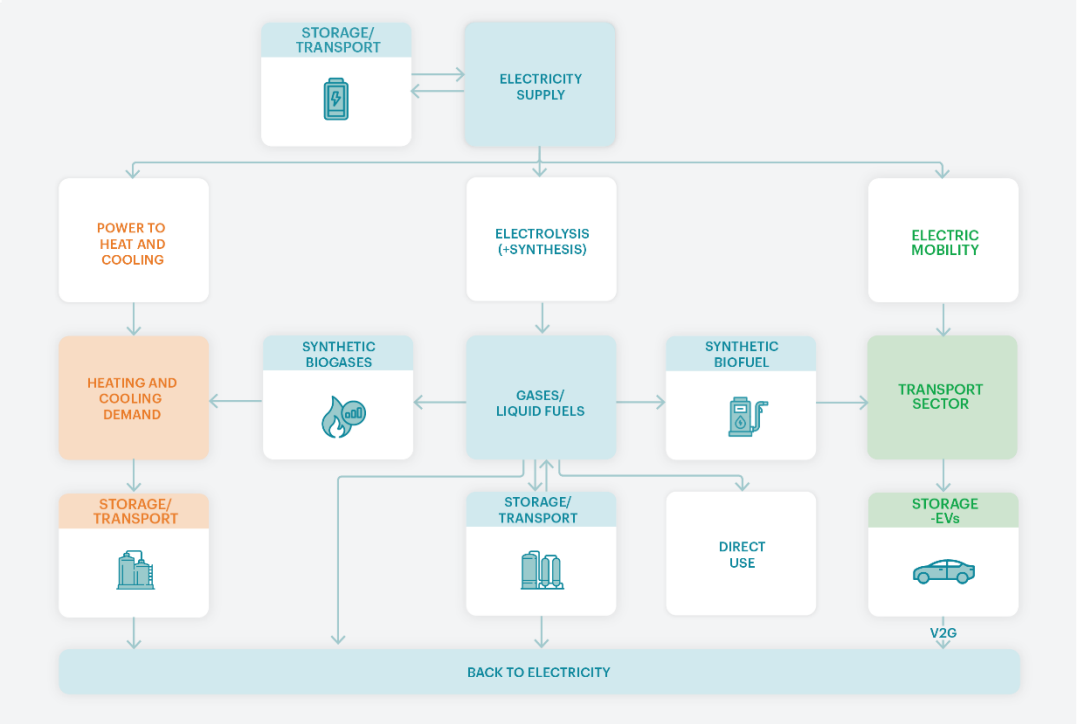


Notes: Residential PV: less than 10kW

Potential of self-consumption critically depends on the match between PV supply and load demand, which can strongly vary across countries, type of end-uses and remuneration schemes

Sector Coupling addresses wider energy system decarbonisation

- Sector coupling efforts have the potential to enroll new flexible loads at scale to enhance power system flexibility.
- As all energy sectors are impacted there is a need for coordination of economic policies beyond the power system.
- Interlinkage of taxes and tariffs between various sectors of electricity, fuels, gas and bioenergy should not become barriers for wider system decarbonization



A new Clean Energy Ministerial horizontal accelerator focused on sector coupling will be considered in 2019 to broaden understanding and share experiences of this trend.

Policy, regulatory & market frameworks for system transformation

Efficient operation of the power system	• Ensuring least-cost dispatch • Trading close to real time • Market integrations over large regional areas
Unlocking flexibility from all resources	• Upgrade planning and system service markets • Generation, grid, demand-side integration and storage
Security of electricity supply	• Improve pricing during scarcity/capacity shortage • Possibly capacity mechanism as safety-net
Sufficient investment in clean generation capacity	• Sufficient investment certainty • Competitive procurement (with long-term contracts)
Pricing of externalities	• Reflecting the full cost (i.e. environmental impacts)

Recommendations for Japan

- Increase competition and complete transition from FITs to auctions (except for small-scale installations)
- Aim at deploying a larger portfolio of renewables, including wind off-shore, bioenergy, geothermal
- Make renewables responsible for balancing and allow them to participate in ancillary service markets
- Implement integrated planning and provide information on system-readiness to integrate renewables
- Foster distributed energy resources, self-consumption and distributed flexibility
- Plan in advance coherent sector-coupling, including looking at tariffs and taxation