NITI Aayog

International Energy Agency

Renewables Integration in India 2021

Renewables Integration and Secure Electricity

22/07/2021

British High Commission New Delhi

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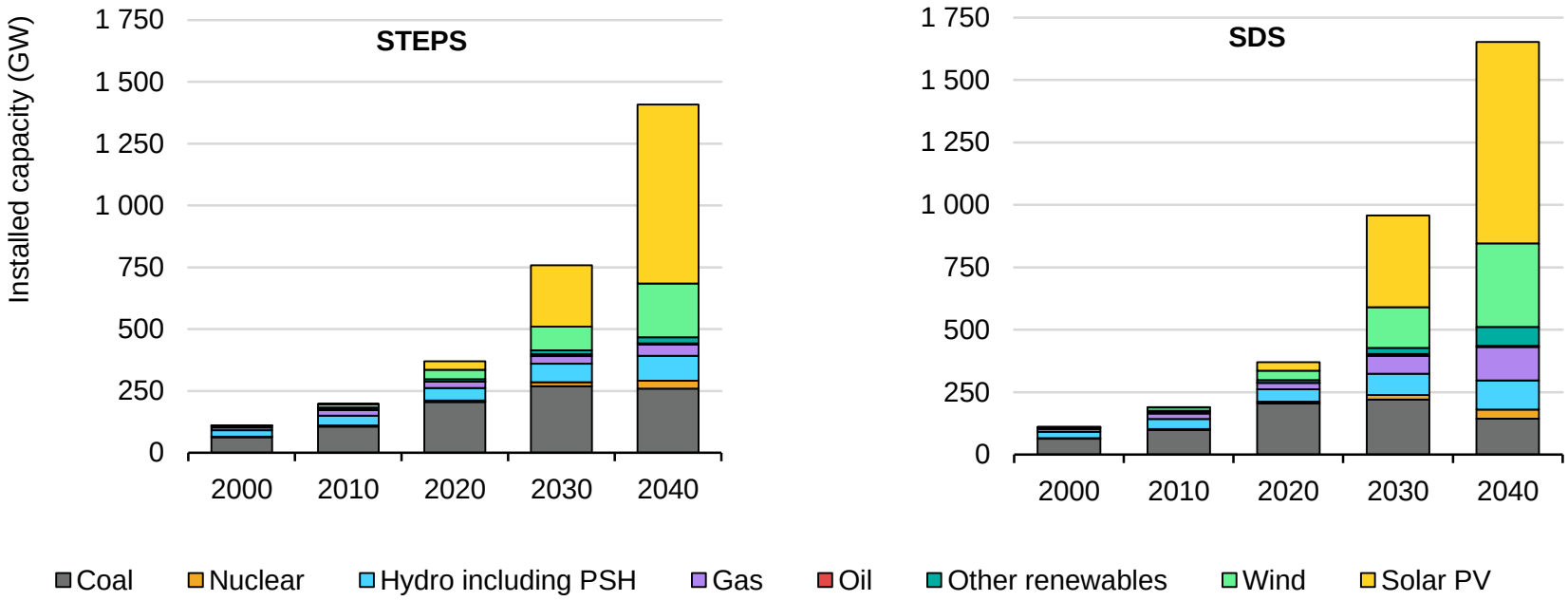
India targets 450 GW of Renewables by 2030

The evolution of India's electricity capacity mix in the Stated Policies Scenario and the Sustainable Development Scenario



Variable renewables (solar and wind) become dominant across all major pathways in India.

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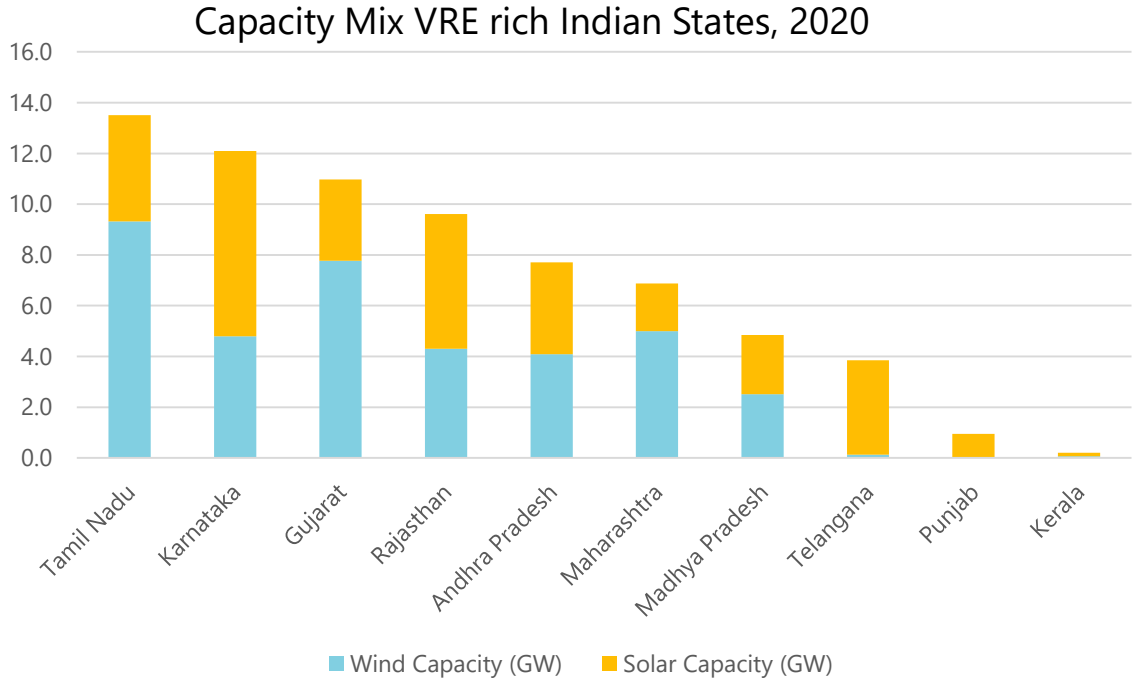
10 States are leading the deployment of VRE in India



Even RE rich states are dominated by coal capacity today, while solar, wind and hydro being significant. By 2030 the capacity mixes will change completely, with substantial increase of solar and wind.

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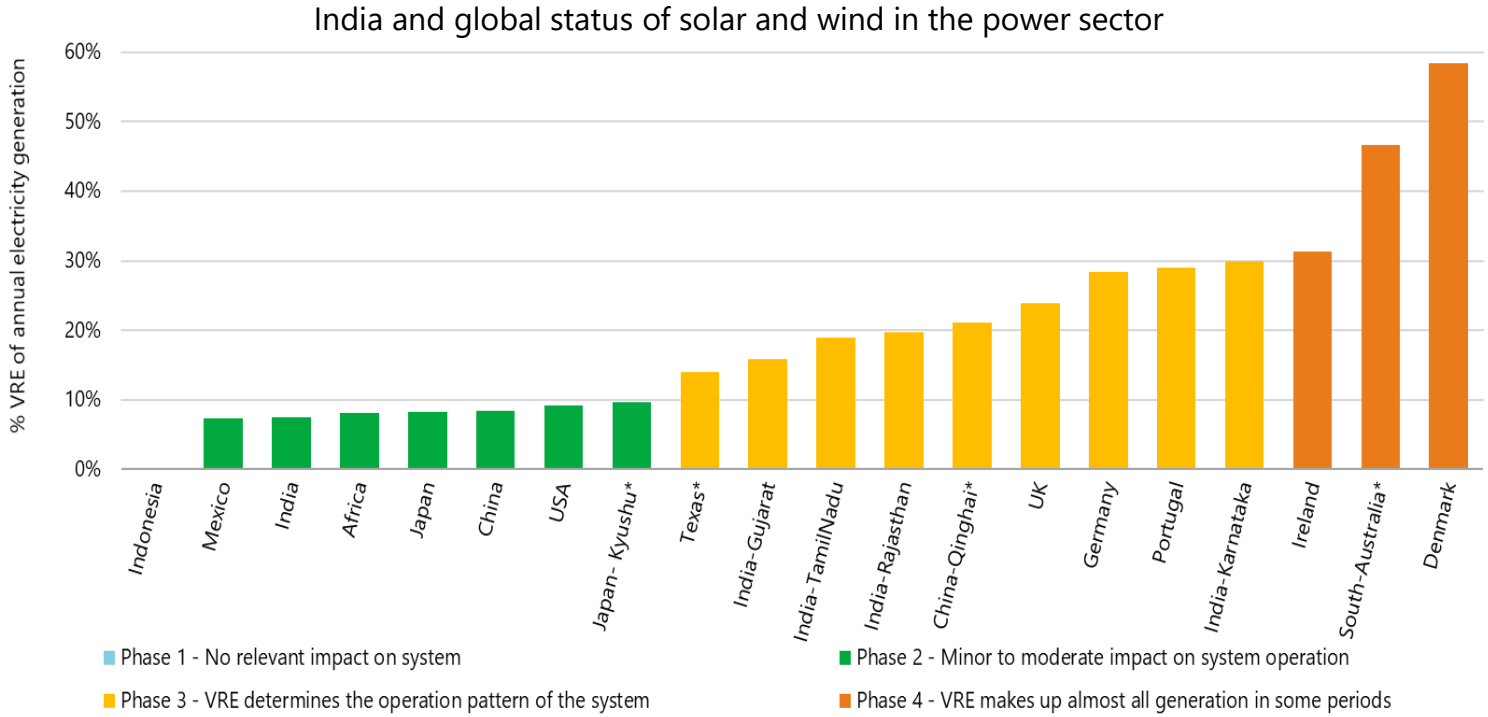
High renewables increasingly challenge the power systems



India's rapid energy transition already places the country at the forefront of renewables integration internationally. The State of Karnataka for instance had more solar and wind generation (30 %) than Germany, UK or Texas in 2019.

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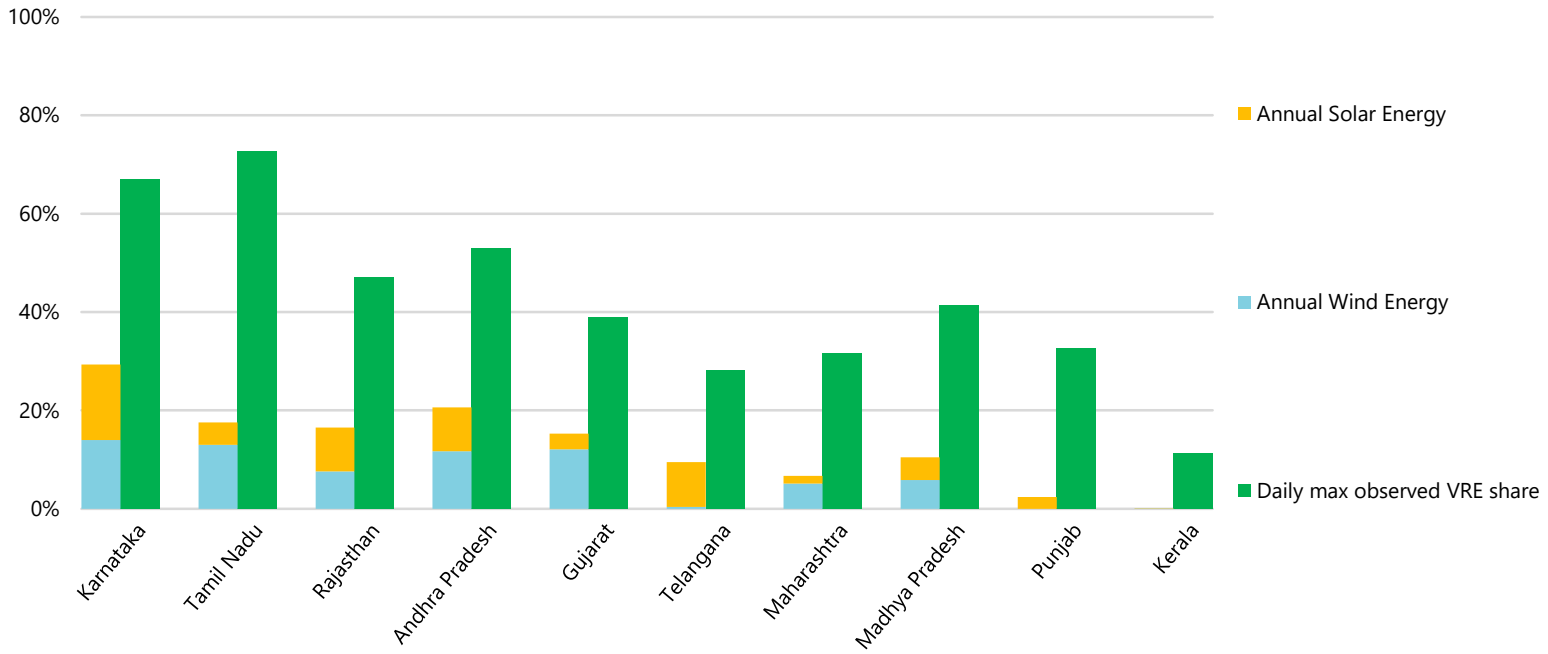
Solar and wind already reached challenging level on daily basis

Electricity generation from VRE as a percentage of all generation in VRE-rich Indian states, 2020



the highest daily share of solar and wind in year 2020 was already close to 70% in both Tamil Nadu (73%) and Karnataka (69%).

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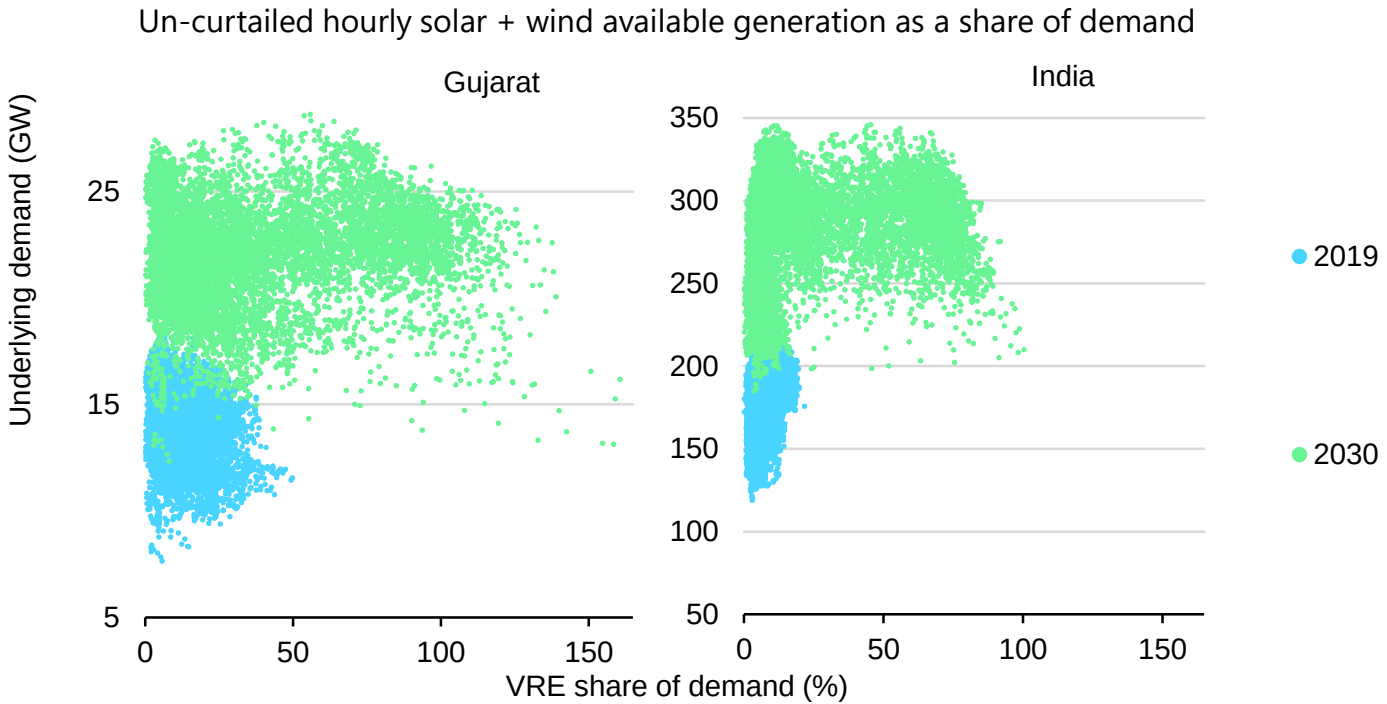
Hourly penetration increases by 2030 to over 100% of demand



Increase in annual VRE by 2030 leads to higher hourly shares exceeding total demand in India and reaching over 150% of demand in Gujarat, leading to integration challenges.

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Key RE integration opportunities in Indian states

- Power systems are already flexible systems.
- Increasing power system flexibility is the key solution to address renewables integration challenges.
- Different Indian states will follow different paths. In this report we highlight some key options for states based on
  - international experience
  - IEA India five-region power system model results
  - IEA Gujarat power system model results
  - Power System Transformation workshops held in 5 regions and 3 states: Karnataka, Gujarat and Maharashtra

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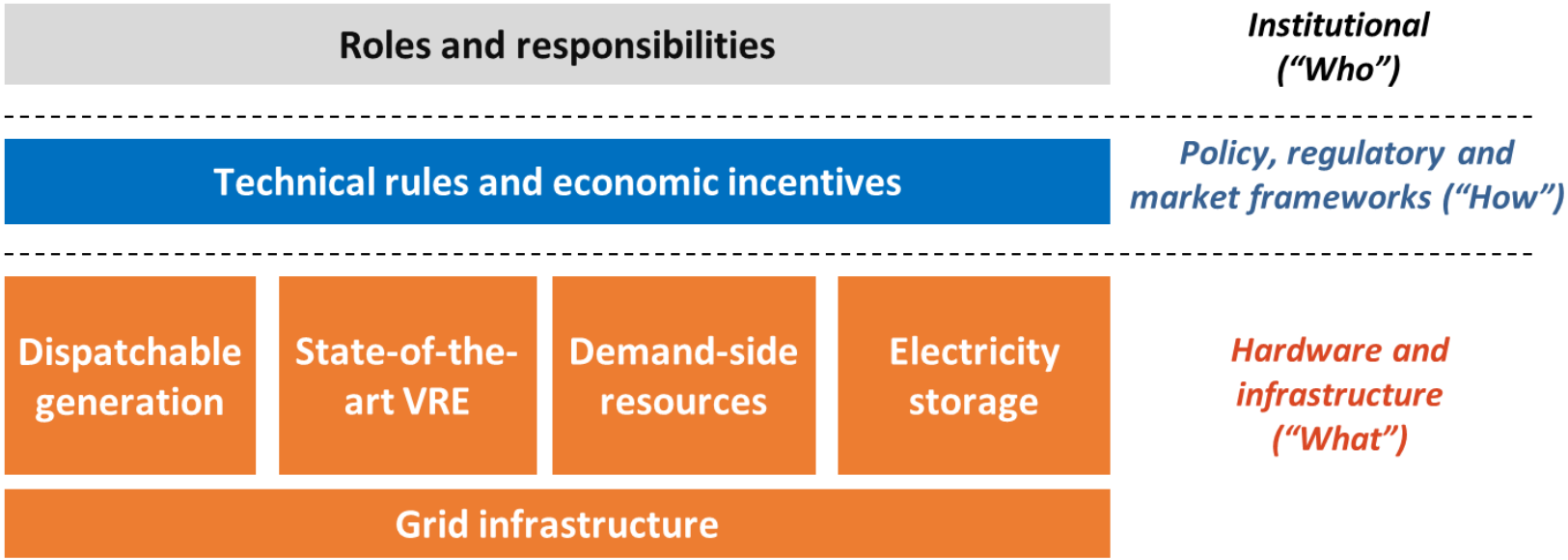
Key RE integration opportunities in Indian states

States have multiple options to increase the flexibility of their power systems



The specific flexibility measures developed should depend on the particular conditions of each state

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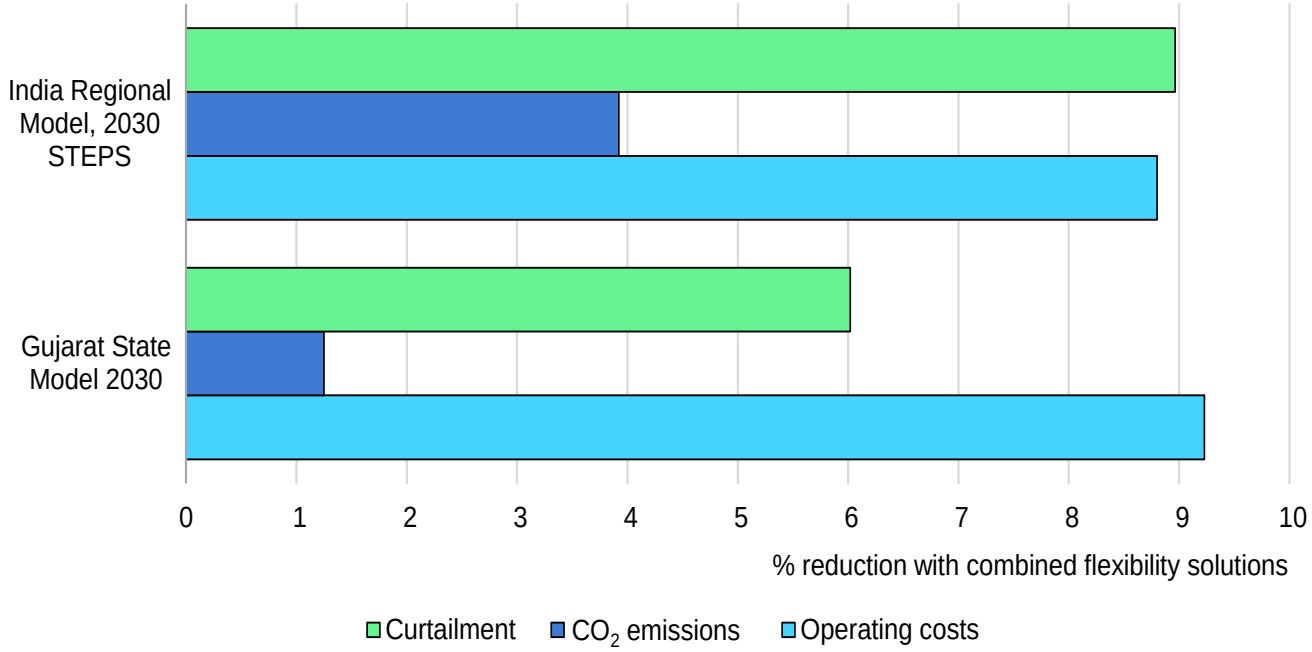
Benefits of power system flexibility go beyond RE integration

Power System Flexibility reduces curtailment, and lower curtailment means reduced system operating costs and lower CO_2 emissions for India



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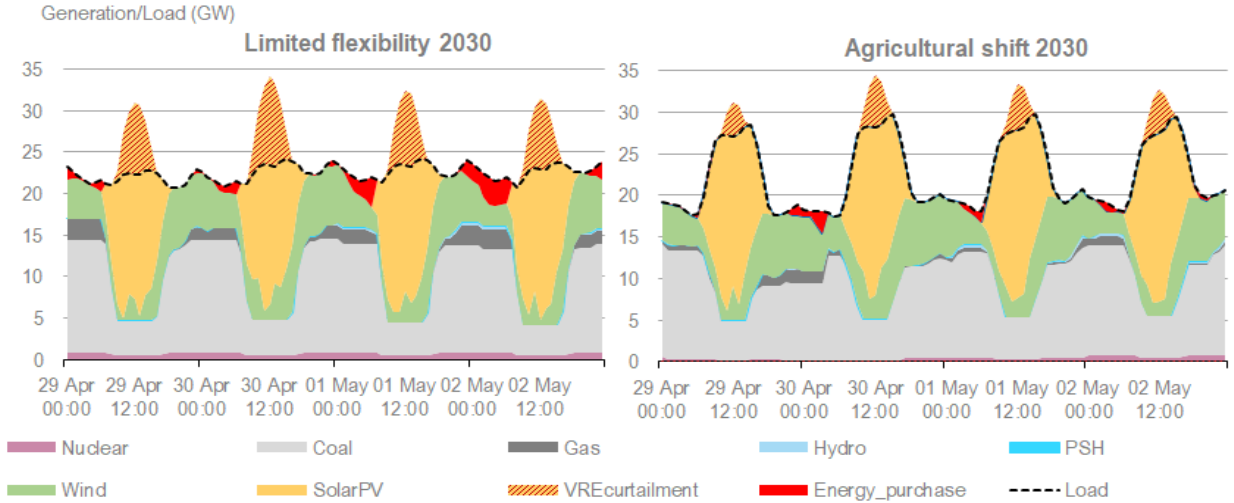
Agricultural demand shift is the most cost-effective demand response

- In 2019, agricultural demand made up 18% of India's electricity consumption, but this share in many states is above 30%.
- The existing agricultural demand shifting practice already provides significant low-cost power system flexibility in India and has assisted some states in reaching high levels of solar and wind without major system events.
- In Gujarat by 2030 it can reduce curtailment (from 7 to 3%), and unit starts (with 40% reduction for coal and gas) and can also reduce variable costs from fuel, startups and ramp costs.



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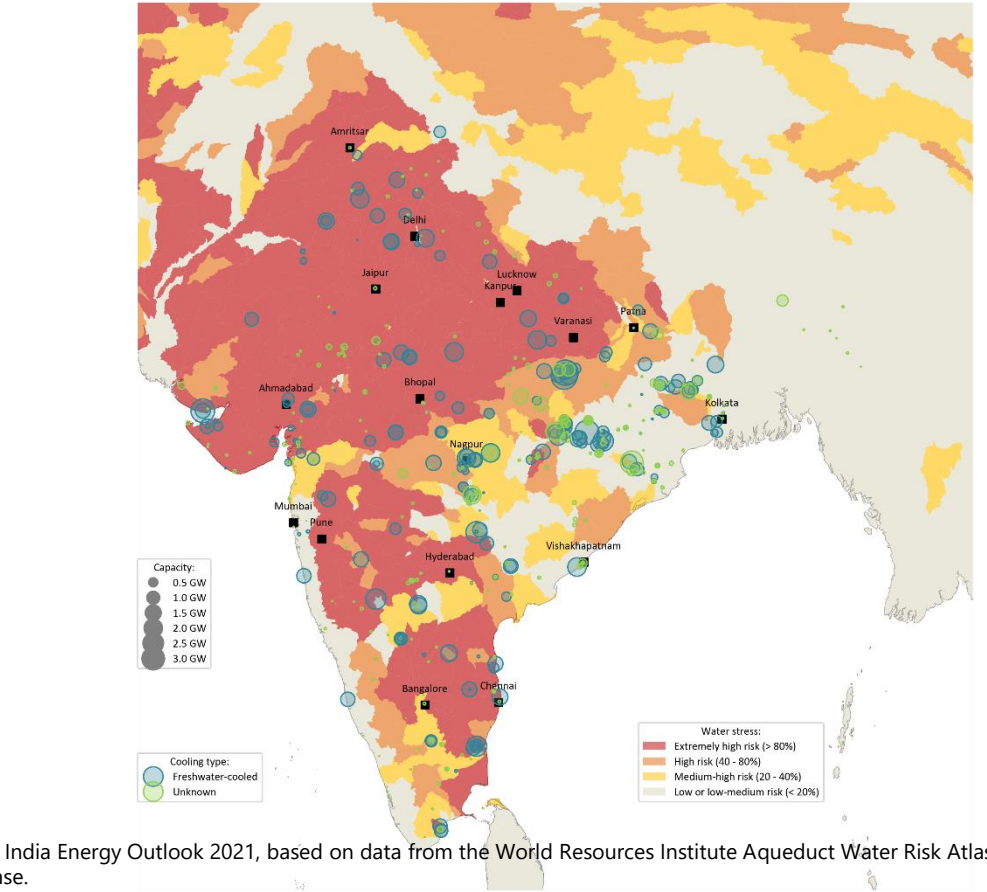
Water is key for agricultural DR, pumped hydro and coal plants

- Shifting agricultural water supply from night to the day might lead to higher water consumption or evaporation losses
- Half of India faces the highest water stress levels in the world, including many RE rich states and hydro and coal power plants.
- The improvement of water management practices therefore will also result in a more flexible, secure and resilient power sector.
- Uncertain water stress outlook due to climate change pushes for additional demand response measures: for example through ToU tariffs.



Source: Expanded based on analysis presented in India Energy Outlook 2021, based on data from the World Resources Institute Aqueduct Water Risk Atlas and the Platts World Electric Power Plants Database.

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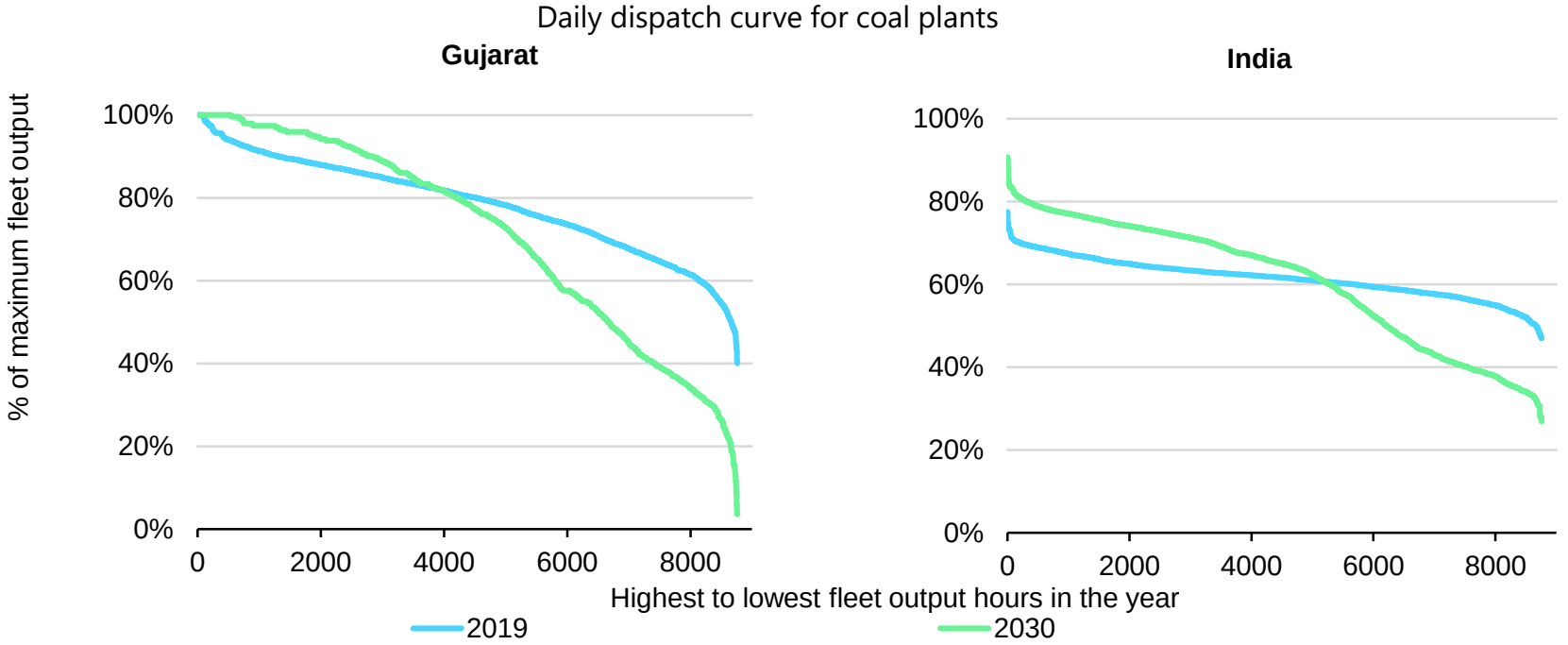
Power plant flexibility remains a largely untapped potential for states



Future coal power plants will need to change their operating patterns, to accommodate for increased VRE generation. Increasing the flexibility of existing plants, by decreasing their lower minimum stable levels and improving their ramping rates are an effective source of additional flexibility.

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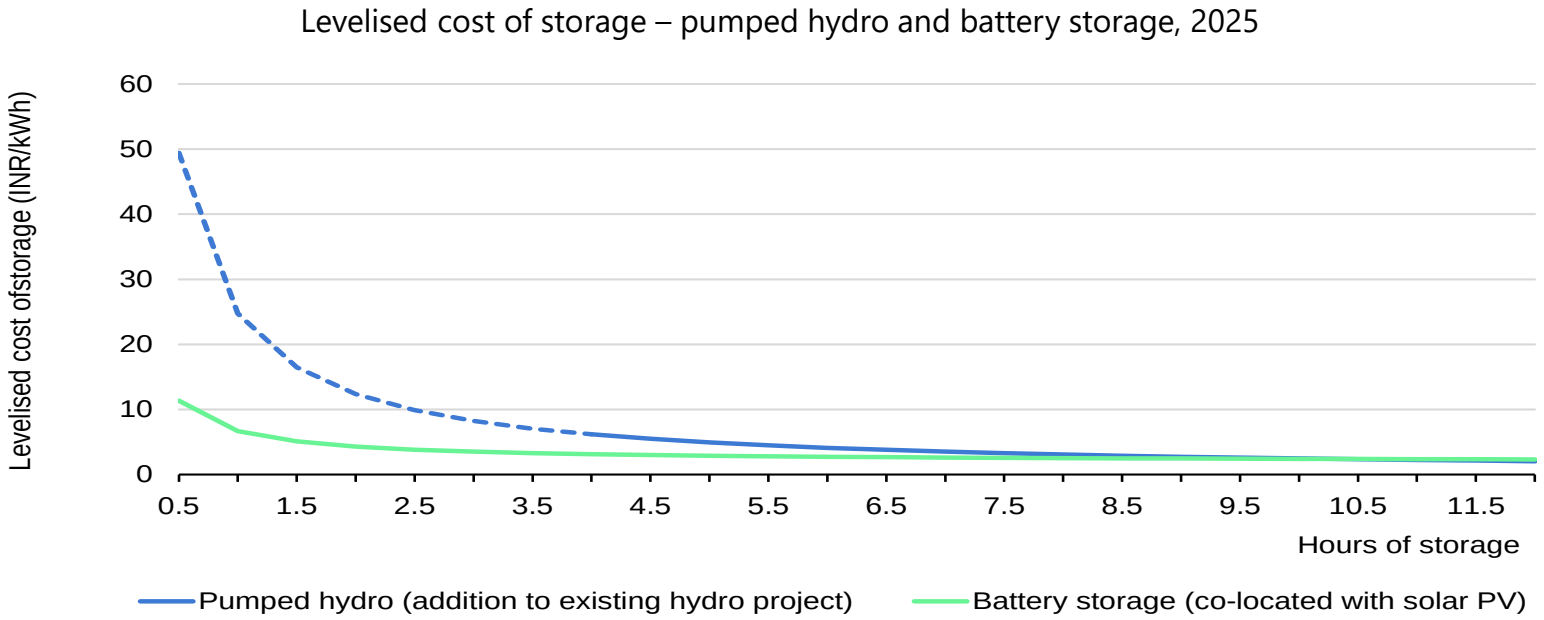
Batteries and pumped hydro need new regulatory frameworks



Source: Reproduced with permission from Abhyankar et al, 2021 (forthcoming).

For short duration power system flexibility needs, battery storage co-located with solar generation is a more cost-effective solution than a pumped hydro retrofit in India. New regulatory and remuneration framework batteries and Pumped Storage Hydro is needed to benefit from their full value.

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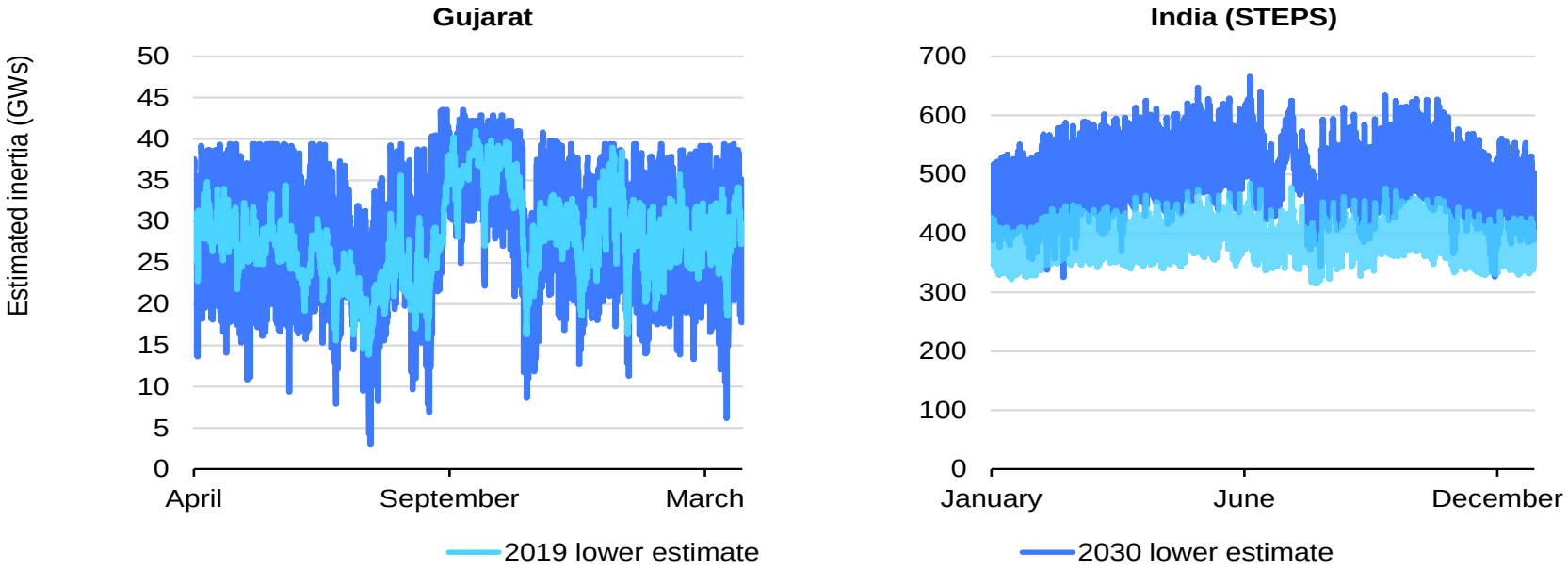
System strength and inertia may need attention in some states before 2030

Inertia estimate for Gujarat contracted capacity (left) and whole India (right), 2019 and 2030



According to POSOCO, between 2014 and 2018 system-level inertia dropped slightly at certain moments, when renewable output was high. Going forward on the national level, inertia is not expected to decline significantly as the increase of solar and wind comes with an increase of thermal generation in STEPs.

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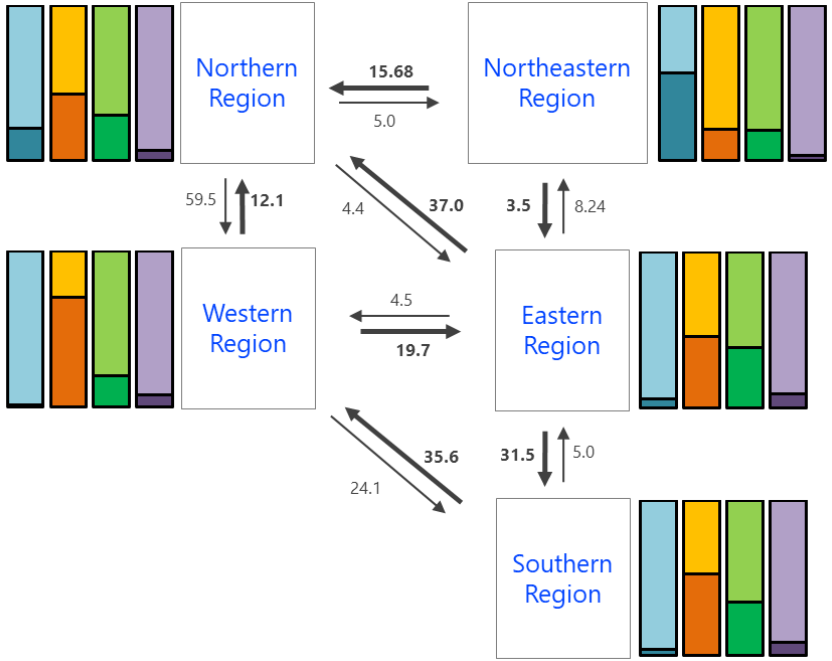
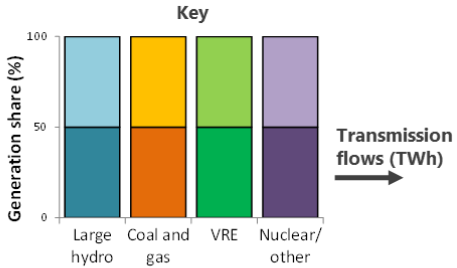
Inter-state trading still faces technical and economic barriers

Annual transmission flows between regions in the Stated Policies Scenario, as well as generation share by region, 2030





The IEA's five-region India model show that by 2030 flows between regions could increase more than 40% smoothing variability across states and providing access to low-cost generation in other states.

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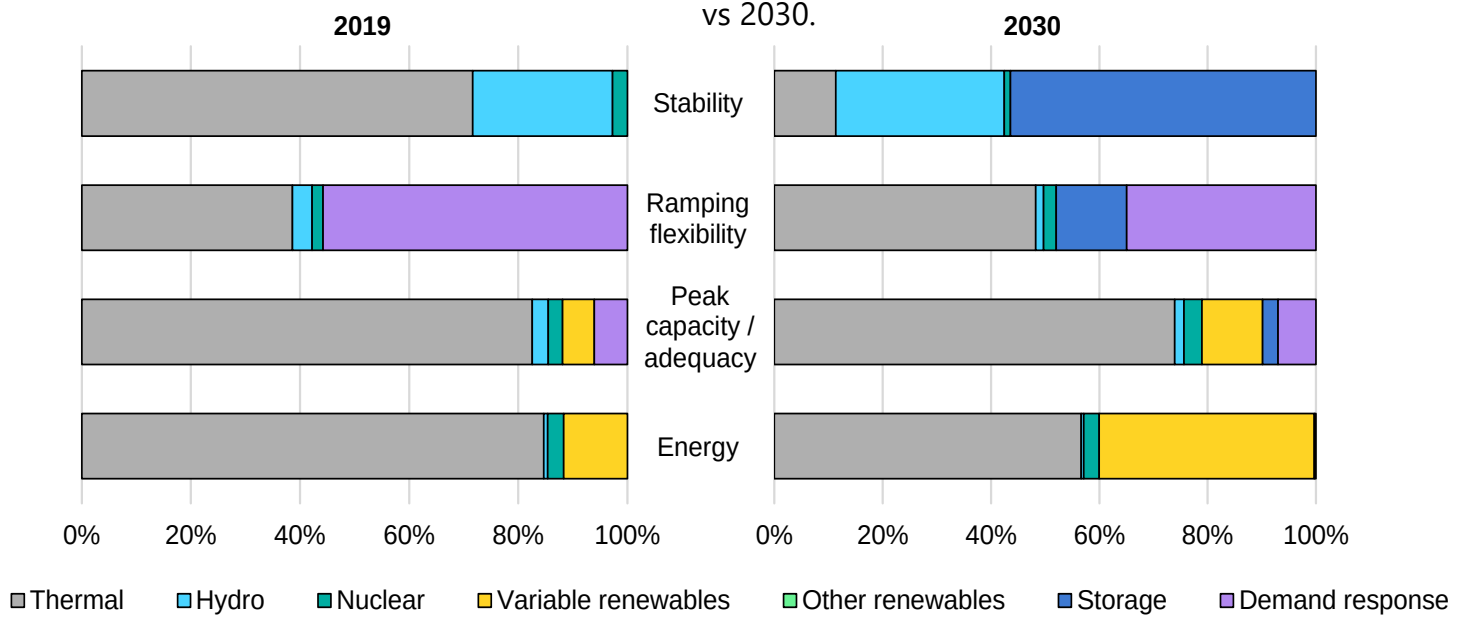
Electricity security will depend on different technologies and services

Contributions of different technologies in energy and services needed to maintain electricity security in Gujarat, India, 2019 vs 2030.



Technologies proving system security will change in the next 10 years. The optimal combination will be different for each state, accounting for regional and national context. The report highlights key missing policy frameworks for each flexibility option.

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