Role of Energy Storage and Flexible Resources in Karnataka

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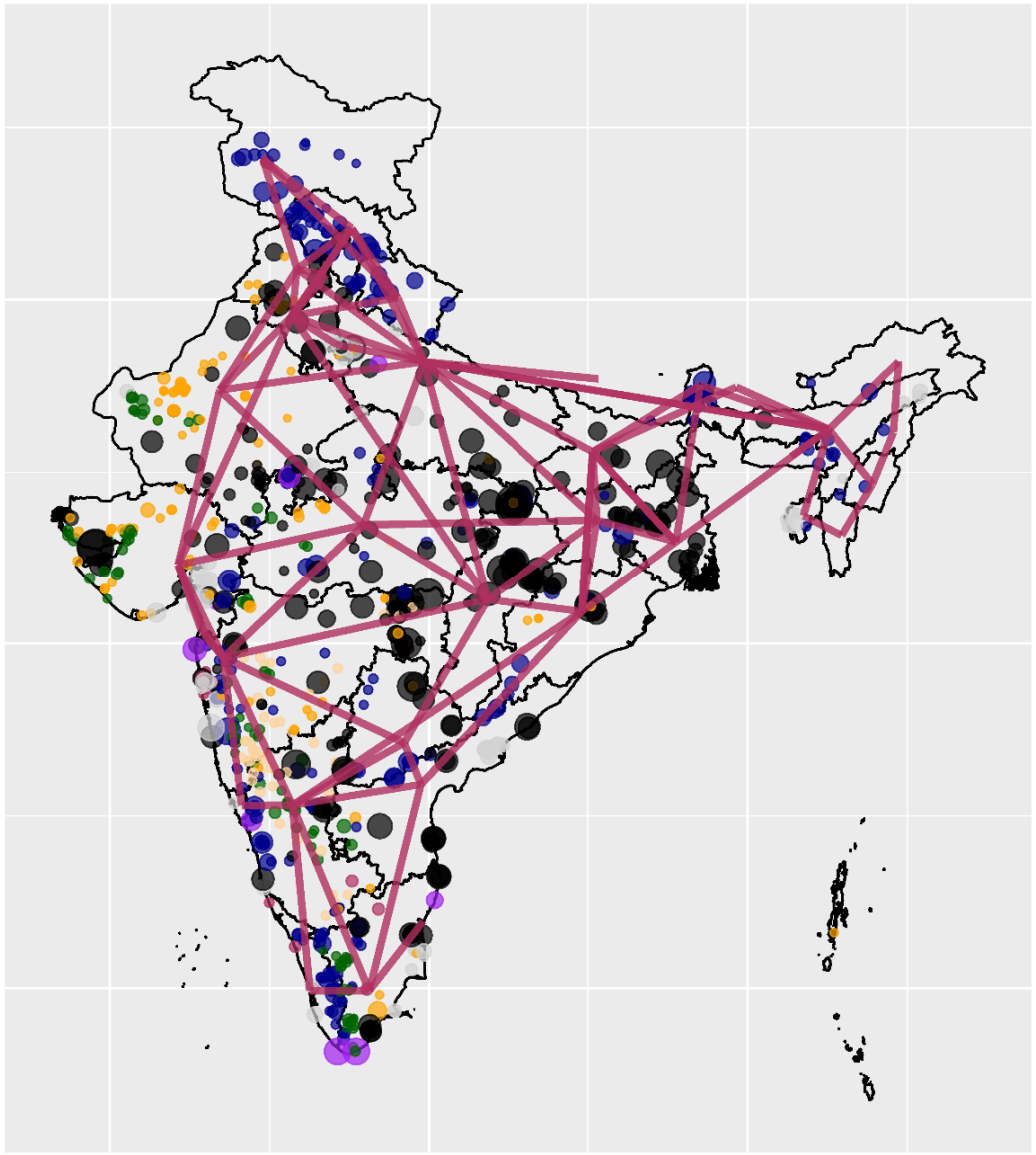
International Energy Agency Workshop

January 19, 2021

What did we do? (*Flexible Resources Initiative*)



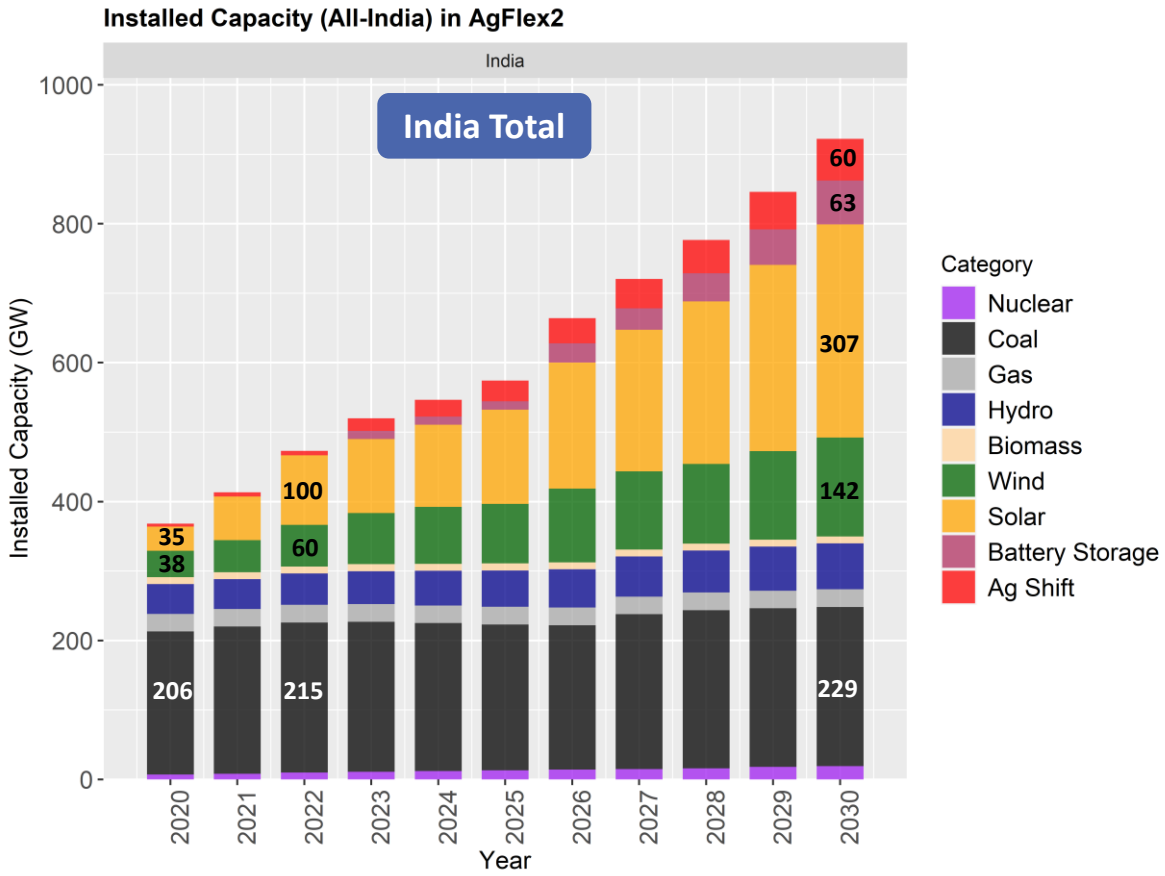
State Level
Optimal Capacity Expansion
FY 2020-30

Power Plant Level Hourly
Dispatch Simulation for FY 2030

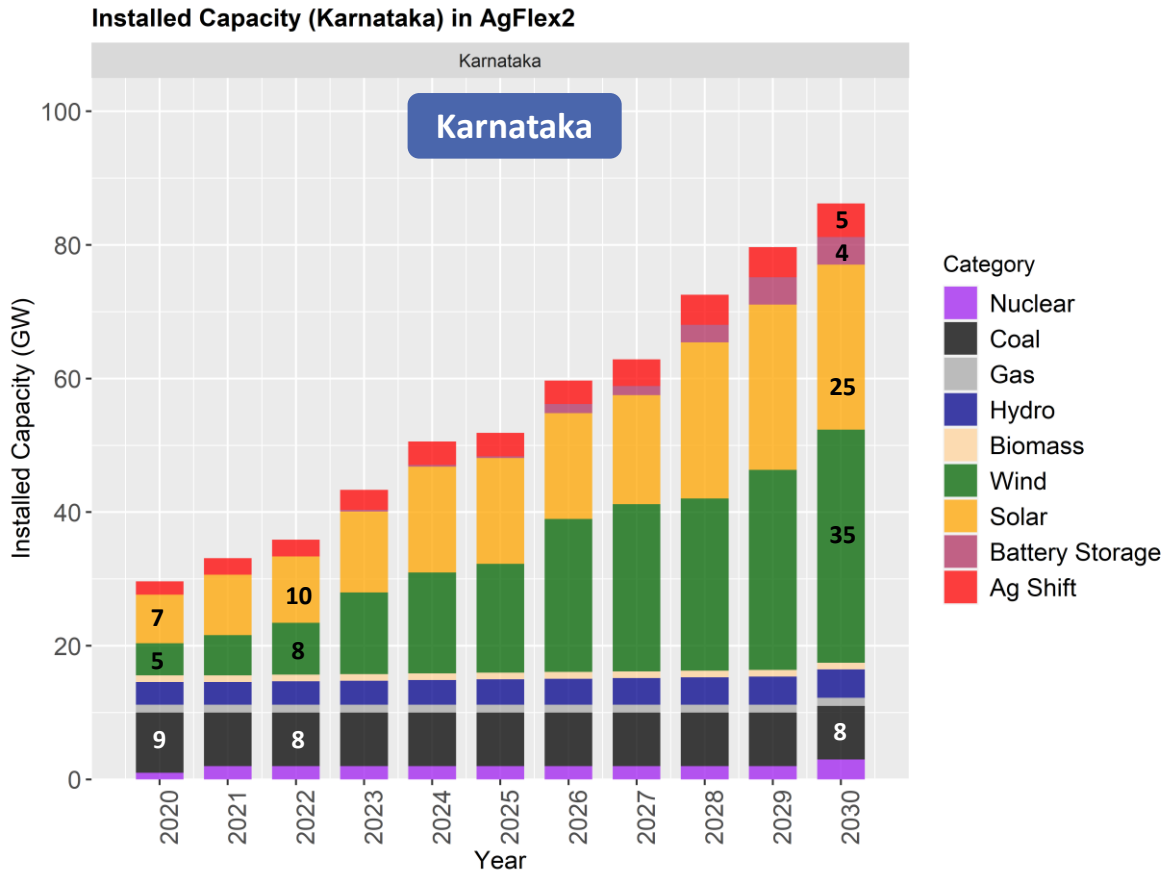
National Study + 4 State level studies (KA, MH, GJ, RJ)

By 2030, Least Cost Resource Mix Includes >450GW of RE + FRs

Results of the Optimal Capacity Expansion (FY 2020-30)



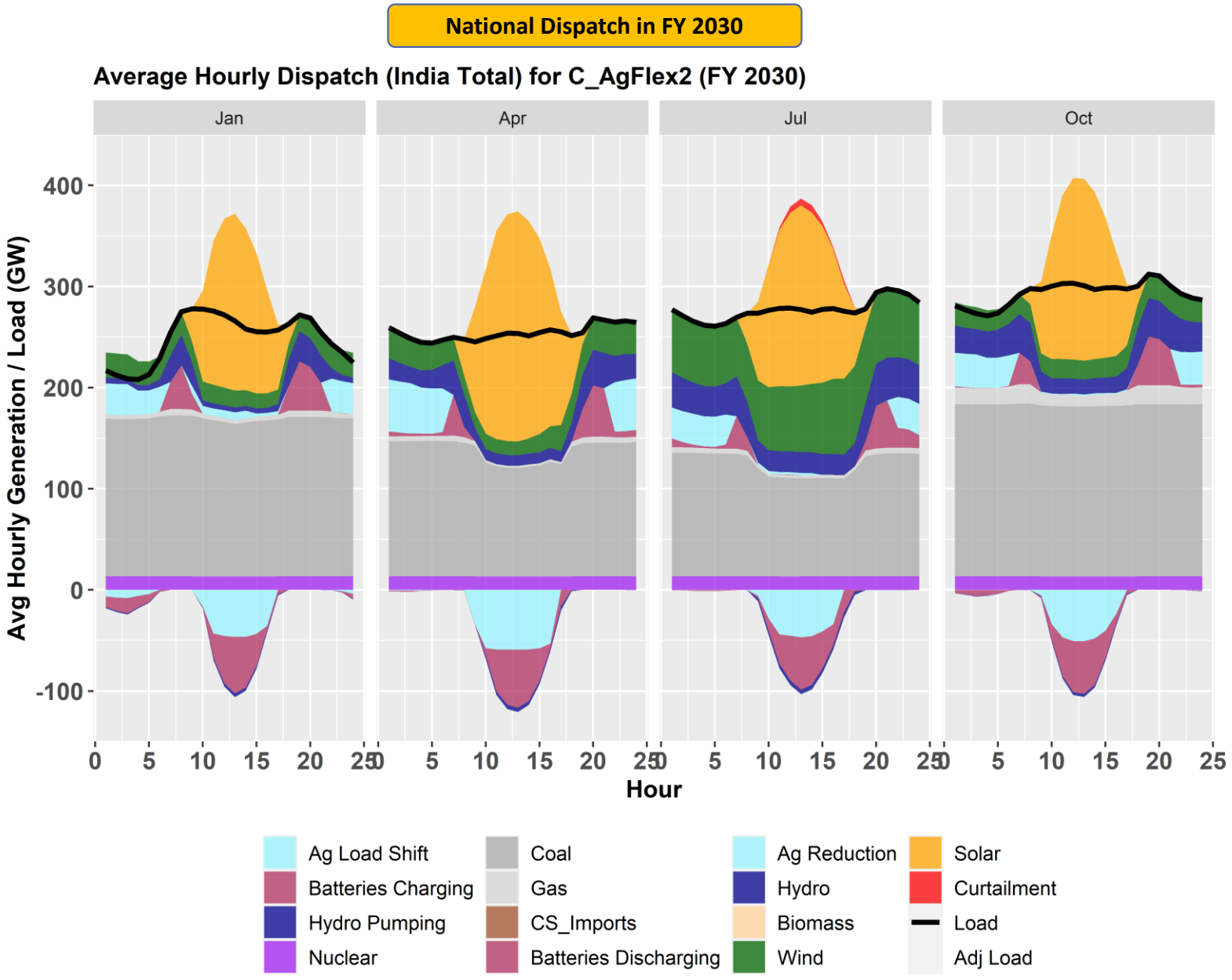
RE share in 2030 = ~35% by energy



RE share in 2030 = ~75% by energy

KA becomes net energy exporter by FY2030

Flexible Resources play a crucial role in system balancing in 2030



How is the grid balanced ?

Ag load shifting and energy storage provide diurnal balancing while gas provides seasonal balancing

How much storage is required ?

By 2030, ~250GWh of energy storage is found to be optimal by 2030 (~15% avg daily RE generation).

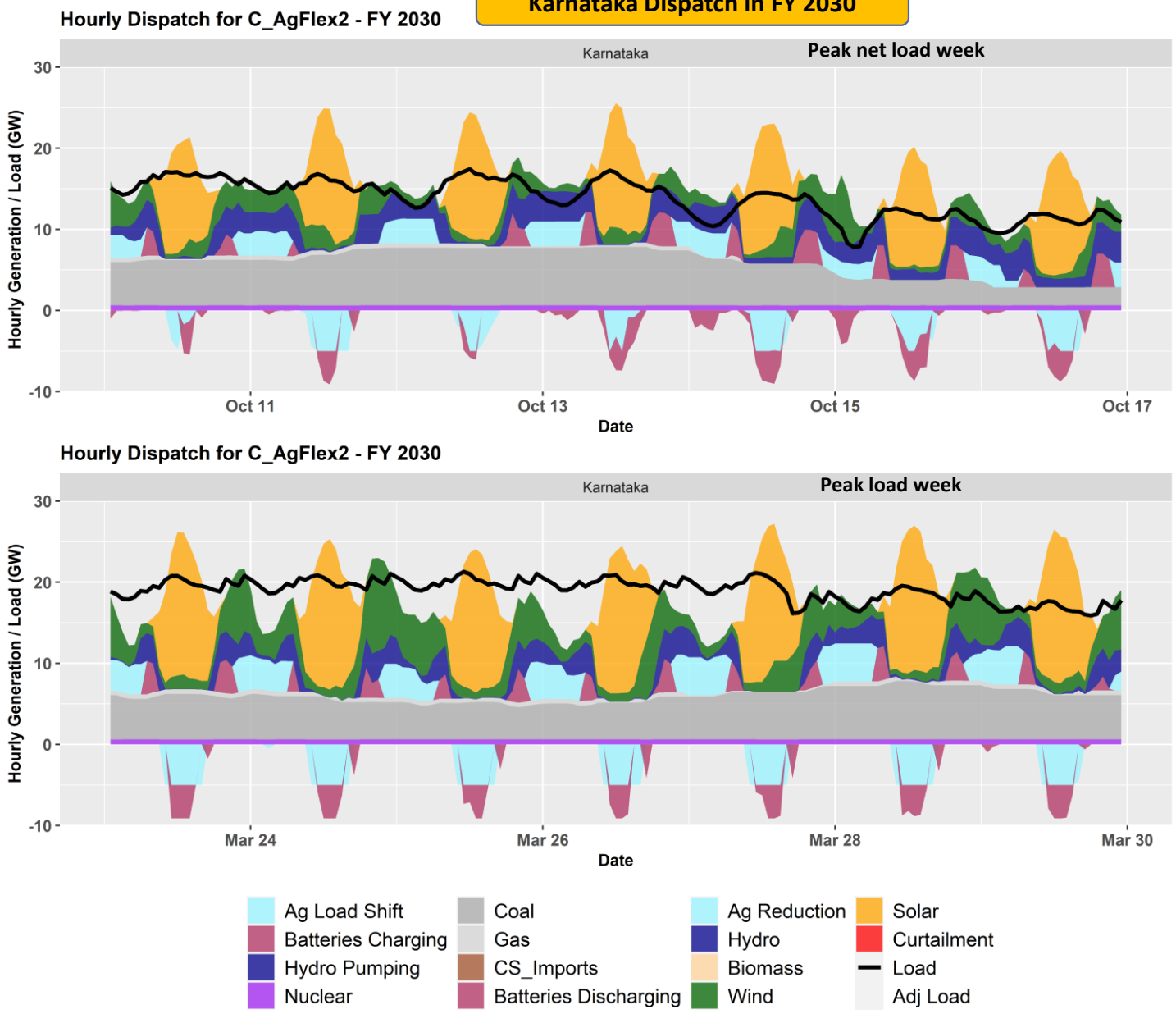
How is the storage operated ?

Charged during the day, discharged during the morning and evening peak (***3-6 hours/day***).

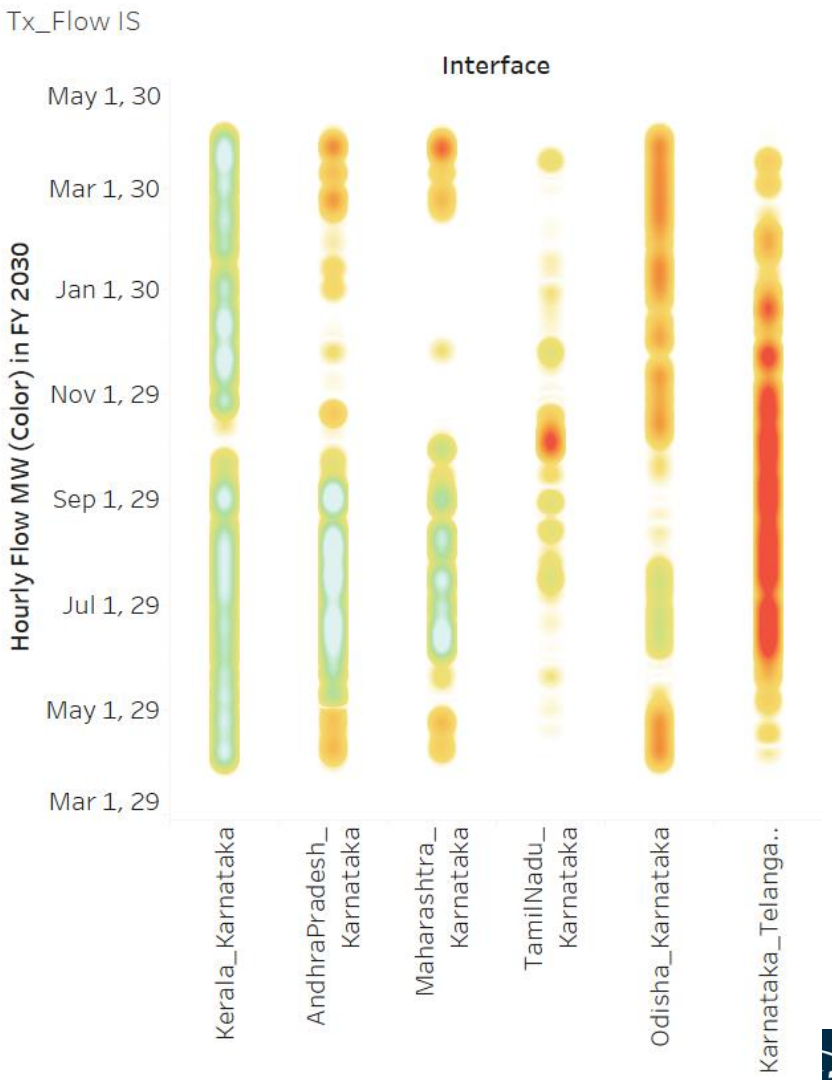
In winter, some early morning charging is needed.

In KA, complementarity bet. wind and solar enables grid integration at modest storage levels

Karnataka Dispatch in FY 2030



Markets and power exports become crucial

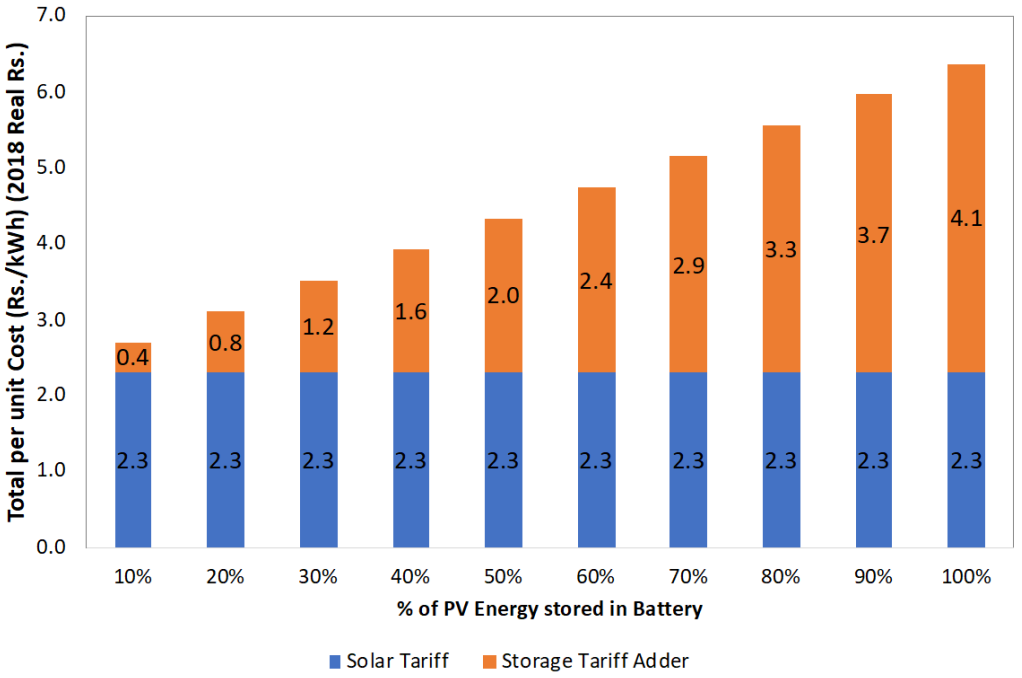


Pumped Storage or Battery Storage ?

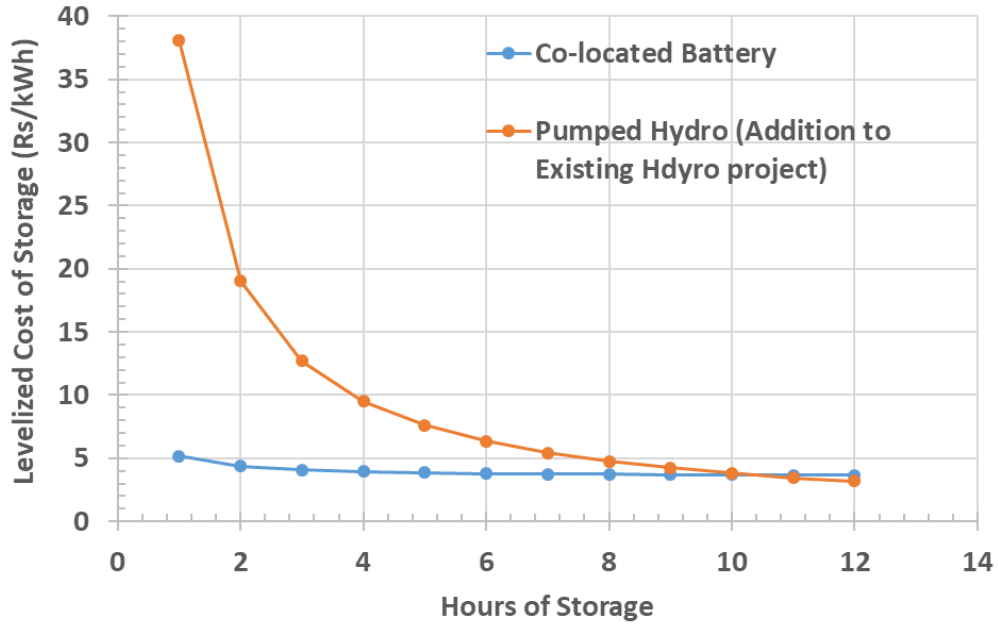
LCOE of Solar + Co-located Battery storage =
~Rs 3.5/kWh for 30% storage by 2025

Batteries are energy (MWh) constrained while pumped hydro resources are power (MW) constrained.
➔ For low storage hours, PH systems are more expensive

Storage Adder and Total Cost of Solar + Co-located Battery Storage (2025)



Levelized Cost of Storage – Pumped Hydro and Battery Storage (2025)



For up to 8-10 hours/day of storage, battery storage is more cost-effective than pumped hydro

By 2030, we find 4-6 hours of energy storage to be cost-optimal for diurnal balancing.

Policy and Regulatory Strategies

- A combination of RE (>450GW$_{DC}$) + FRs: 30-60GW energy storage, 60GW of load shifting, flexible operation of the 25 GW of gas, ~140GW of new ISTS, and market-based economic dispatch (MBED)
  - ➔ Can avoid building new coal assets that could exacerbate the problem of stranded assets

- Energy storage will play a key role and needs an appropriate regulatory framework to capture its full value
  - Capacity value in avoiding inefficient thermal investments
  - Energy arbitrage opportunity for shifting the energy within a day/week
  - Ancillary services for managing the system ramps etc
  - Optimizing the T&D investments

- Gas is crucial for seasonal balancing; supply/pipeline flexibility and regulatory issues need to be addressed

- Nuanced resource adequacy framework needed to drive planning and procurement strategies, and avoiding potential future stranded assets
  - Owing to the shorter lead times, RE + FRs can make system planning flexible and robust in responding to deviations from the expected trajectory (e.g. lower or higher load growth)

Thank you !

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