CHINA 2035 REPORT

How the falling cost of wind, solar, and storage can help China achieve 80% clean electricity by 2035

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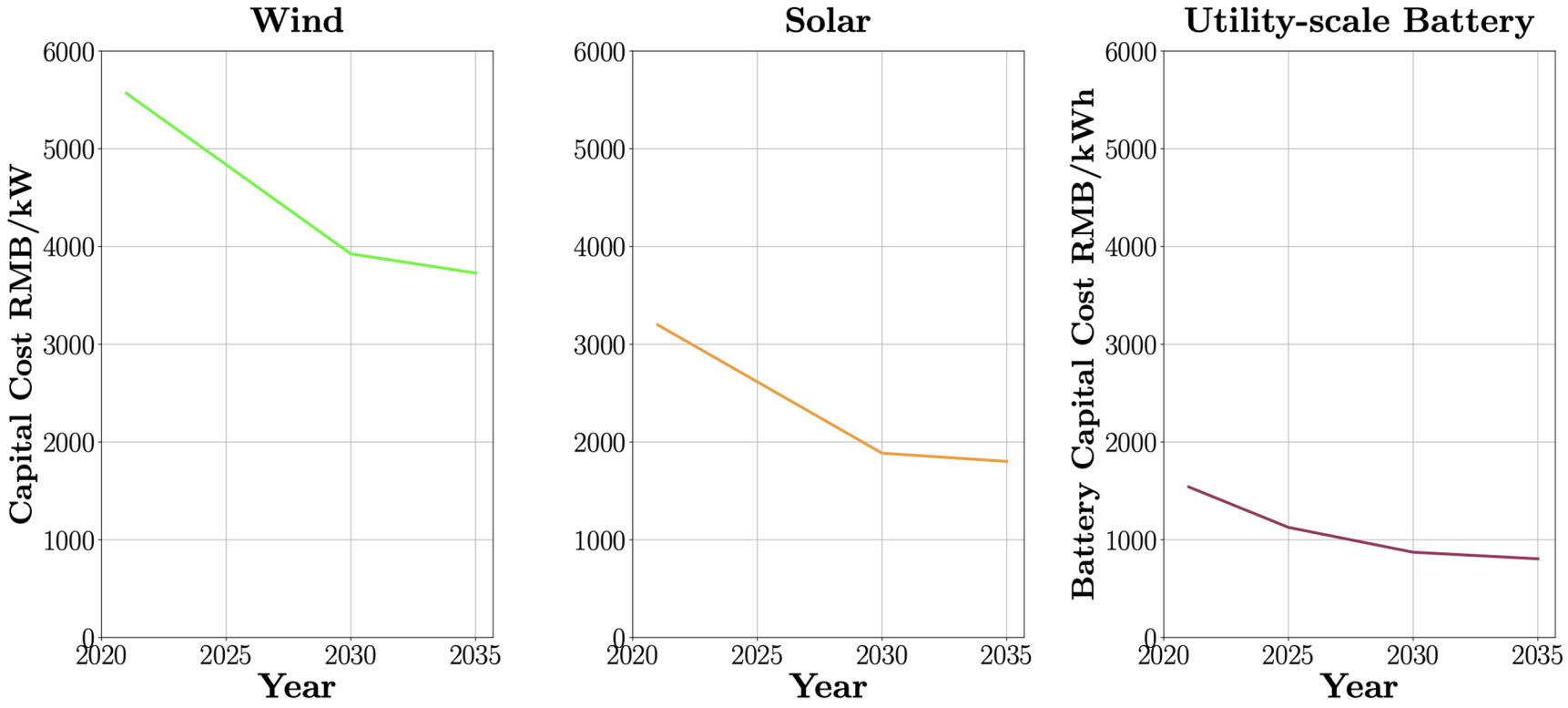
WHY 80% CLEAN BY 2035?

- There is currently a gap on what interim targets could look like for supporting China's 2060 neutrality goal.
- Deep solar, wind and battery price reductions and new offshore wind technologies create new opportunities while saving money.
- A critical aspect of economy-wide decarbonization is electrification, which requires a clean power system.
- A clean power system also helps improve air quality to meet national goals.

Photo credit: EPA-EFE, South China Morning Post, 4 March 2021

DRAMATIC COST DECLINES ARRIVED SOONER THAN ANTICIPATED

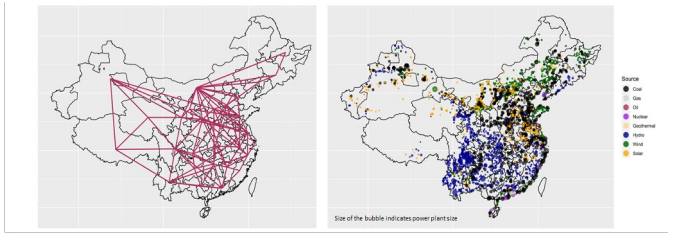


Sources: BNEF for China (2020)

METHODS AND SCENARIO DEFINITION

Using PLEXOS, we conducted:

- *Capacity expansion modeling: 2020-2035*
- *Production cost modeling: 2025 and 2035*
  - *Main scenarios*
  - *Sensitivity: Demand shock (10%)*
  - *Lowest historical renewable outputs in 35 years*

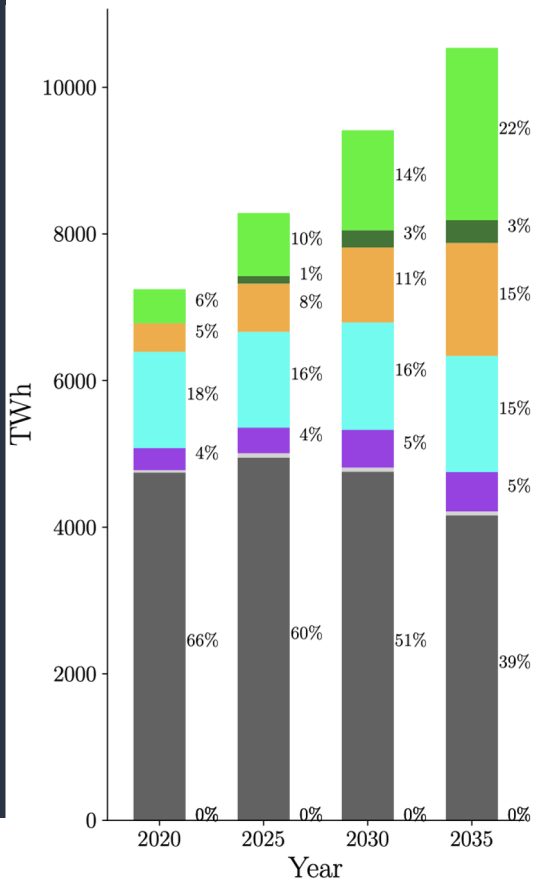


	Current Policy Case	***Clean Energy Case* (80% Non-Fossil Generation by 2035)**	***Constrained Transmission Case***	***High Offshore Case***
Coal assumptions	150 GW of new coal plants is built (2021-25)	No new net coal plant additions after 2020	Same as Clean Energy Case	Same as Clean Energy Case
Wind and solar generation capacity additions	Annual additions are limited to policy targets (1200 GW by 2030)	Annual additions decided by model to meet 80% clean electricity by 2035	80% clean by 2035, with constraint in inter-regional transmission	80% clean by 2035 with greater share of offshore wind
Other Non-Fossil Policy targets (By 2035)	Nuclear: 100 GW Hydro: 400 GW Pumped Hydro: 199 GW	Same as CPC	Same as CPC	Same as CPC

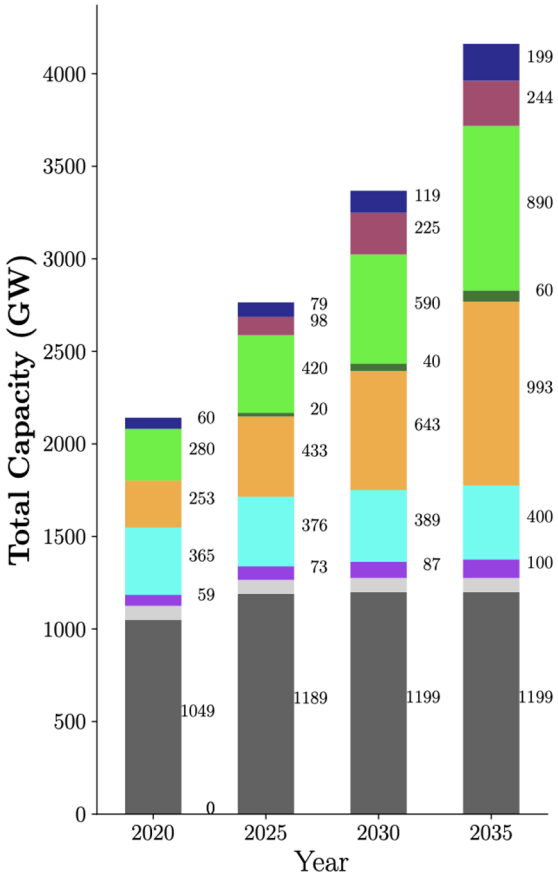
Current Policy Case

CURRENT POLICIES PLACE CHINA ON A PATH TOWARD CONTINUED RELIANCE ON COAL-FIRED GENERATION

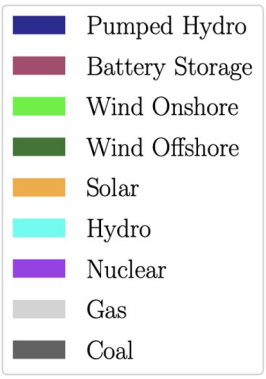
Energy



Capacity



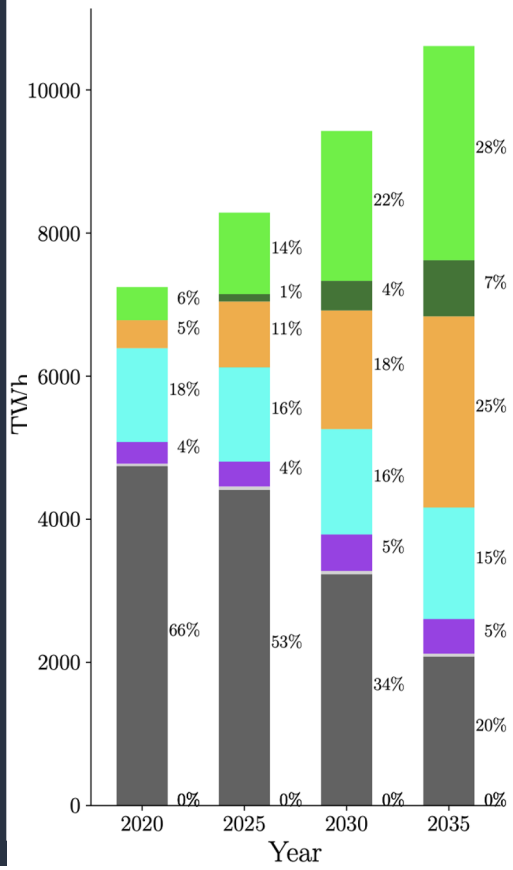
- *Coal generation peaks in 2030*
- *~50% clean electricity by 2030*
- *1,200 GW wind and solar target by 2030*



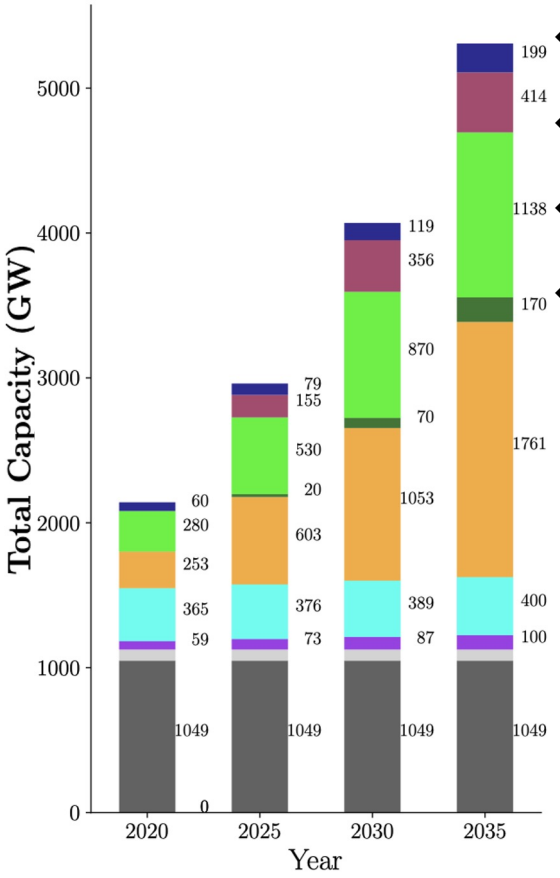
Clean Energy Case

OUR ANALYSIS SHOWS AN 80% CLEAN ELECTRICITY SYSTEM IS AFFORDABLE, FEASIBLE, AND RELIABLE IN 2035.

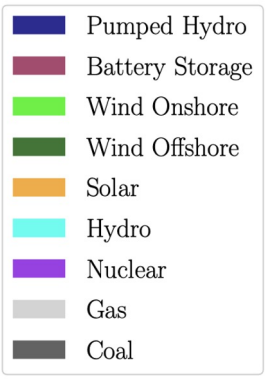
Energy



Capacity

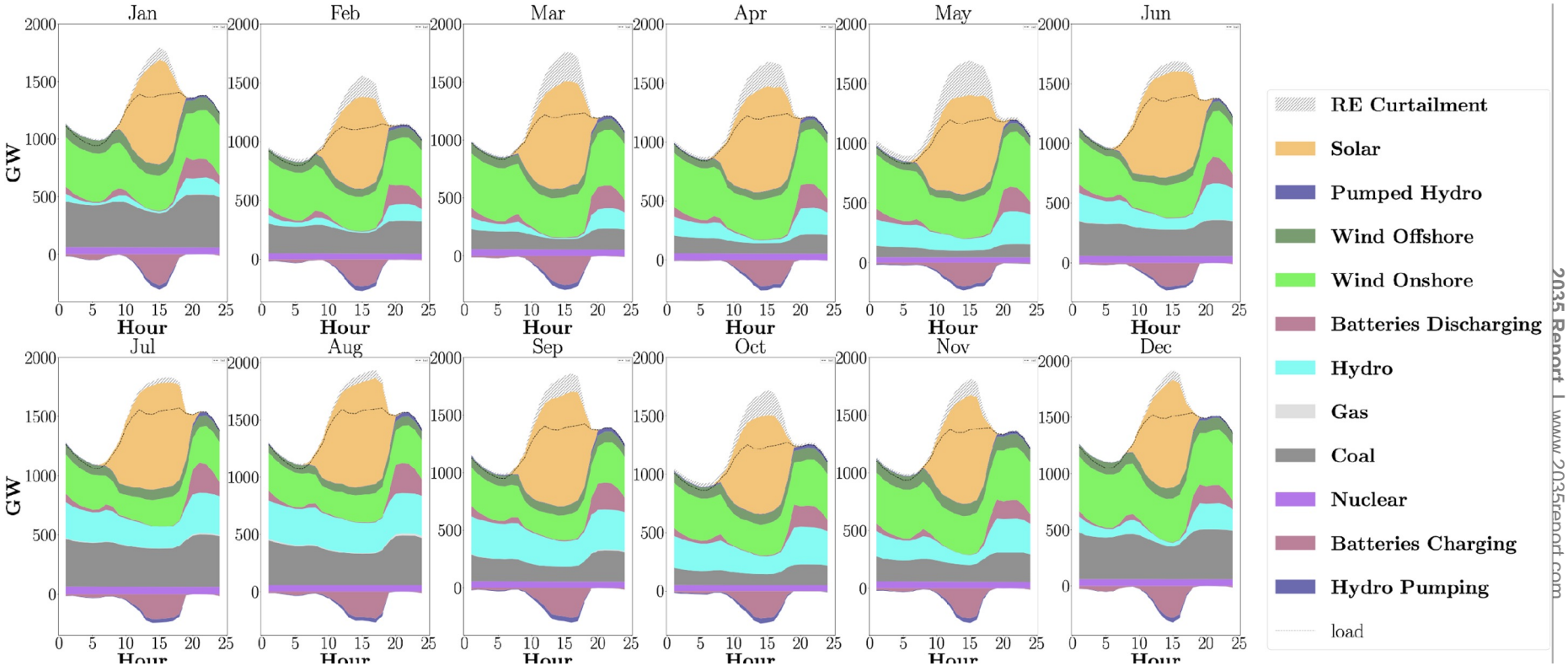


- *Coal can peak before 2025*
- *80% clean electricity by 2035*
- *2,000 GW renewables by 2030*
- *3,000 GW renewables by 2035*



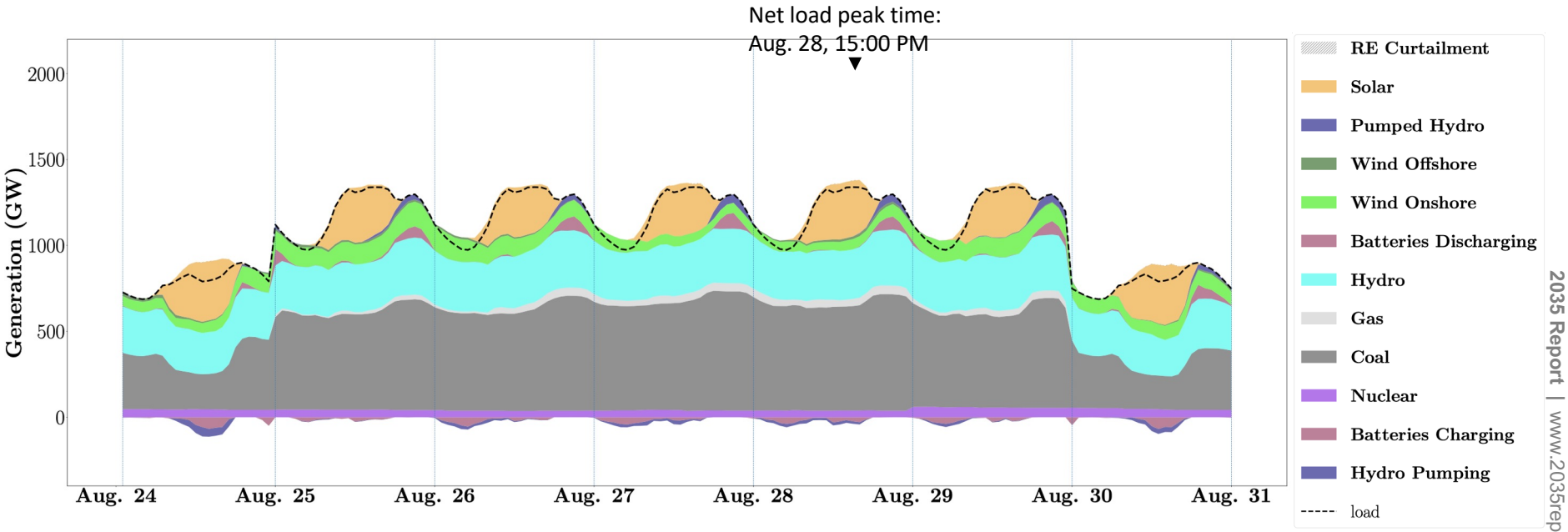
DEPENDABLE POWER IN ALL SEASONS, WITH 80% CLEAN GRID, IN 2035

2035 Hourly Average Dispatch



DEPENDABLE GRID WITHOUT NEW COAL CAPACITY - 2025

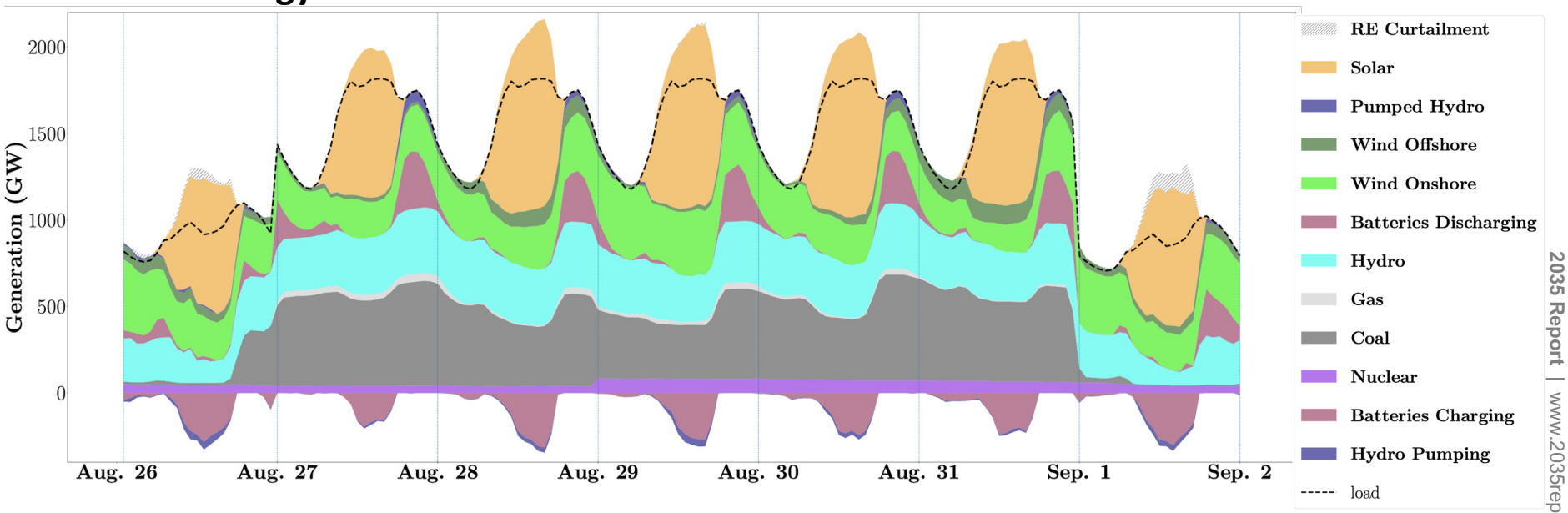
2025 Peak Net Load Week – Clean Energy Case



- System is dependable to meet peak net load even in 2025 without any new coal.
- Percentage **renewable energy for peak net load week is ~24%** (percentage of renewable contribution of the overall generation)

DEPENDABLE GRID WITHOUT NEW COAL CAPACITY - 2035

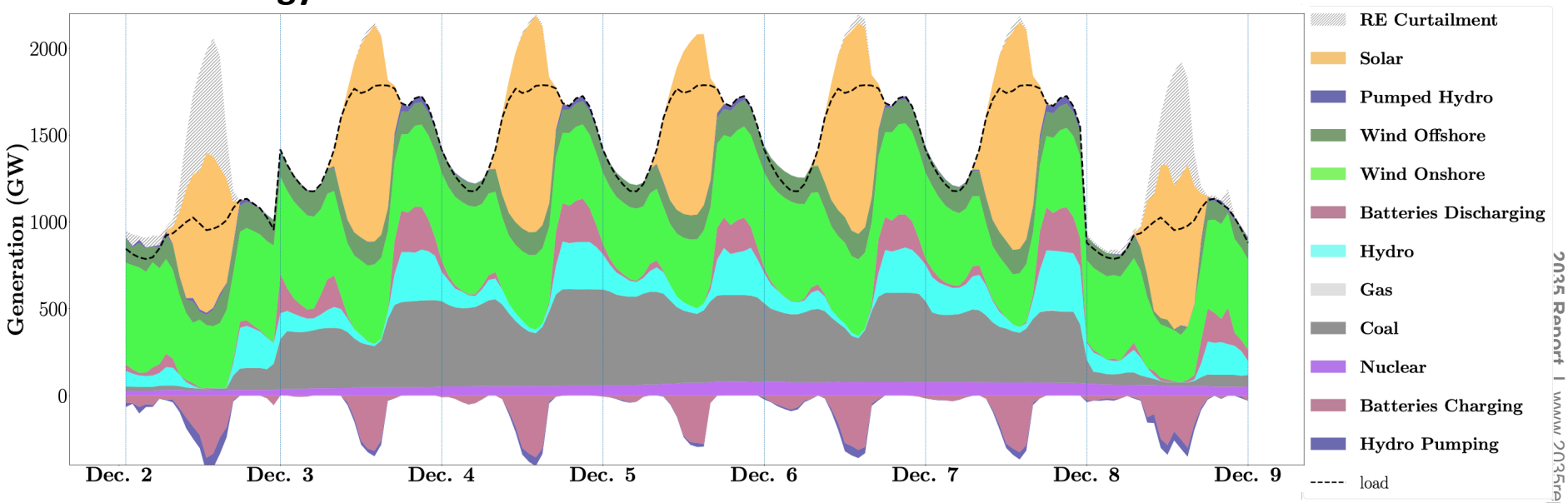
2035 Peak Net Load Week in Summer – Clean Energy Case



- By 2035, max coal dispatch is **613.2** GW, **33.8%** of peak load, and **58.5%** of total coal capacity
- Percentage **renewable energy for peak net load week is 37%** (percentage of renewable contribution of the overall generation)

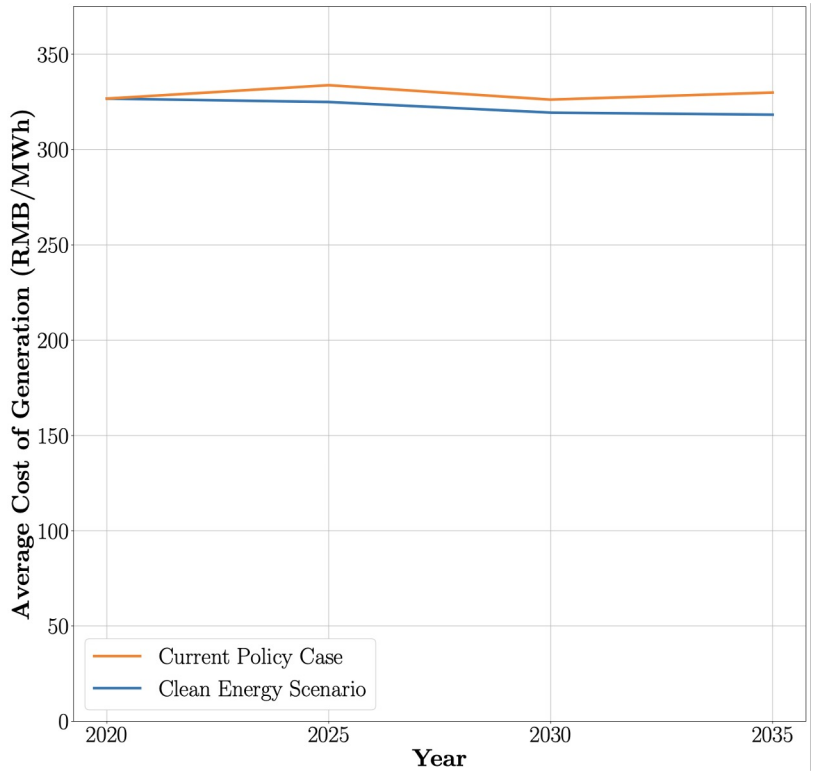
DEPENDABLE GRID WITHOUT NEW COAL CAPACITY - 2035

2035 Peak Net Load Week in Winter – Clean Energy Case



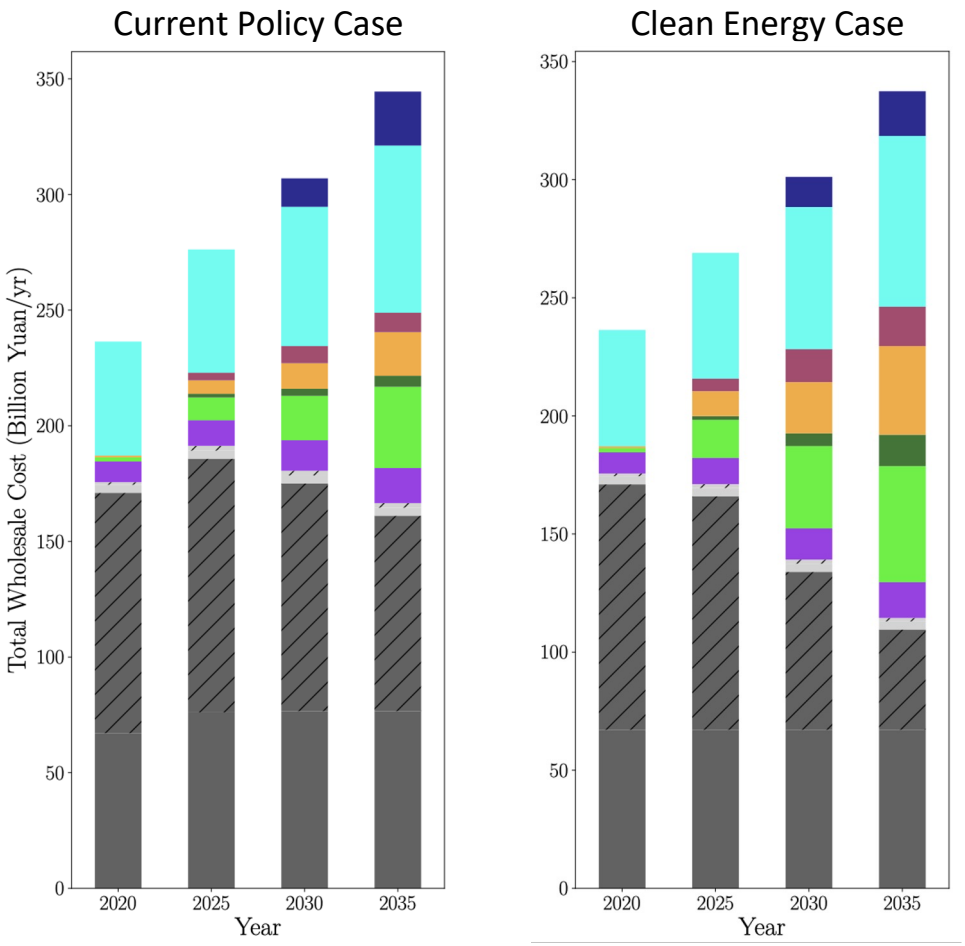
- By 2035, max coal dispatch is **593.2** GW, **32.9%** of peak load, and **56.6%** of total coal capacity
- Percentage **renewable energy for peak net load week is 35%** (percentage of renewable contribution of the overall generation)

ELECTRICITY COSTS: AVERAGE COST OF GENERATION ~6% LOWER UNDER CLEAN ENERGY SCENARIO BY 2035



Total Annual Wholesale Cost

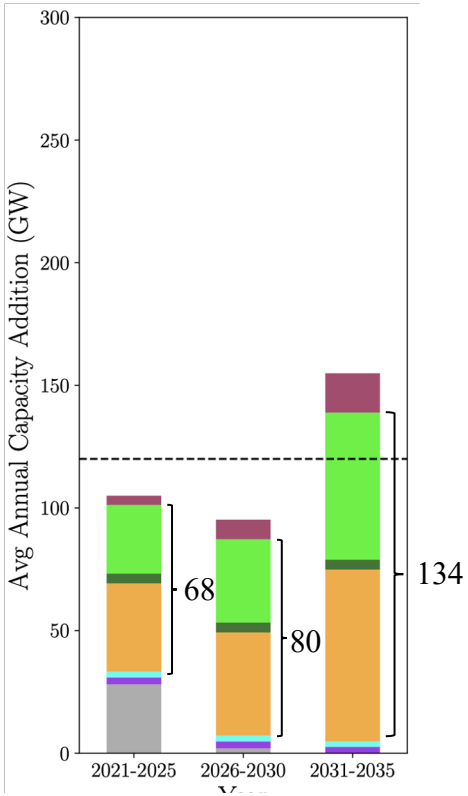
FUEL COST SAVINGS OFFSET THE COST OF NEW WIND, SOLAR, AND BATTERIES



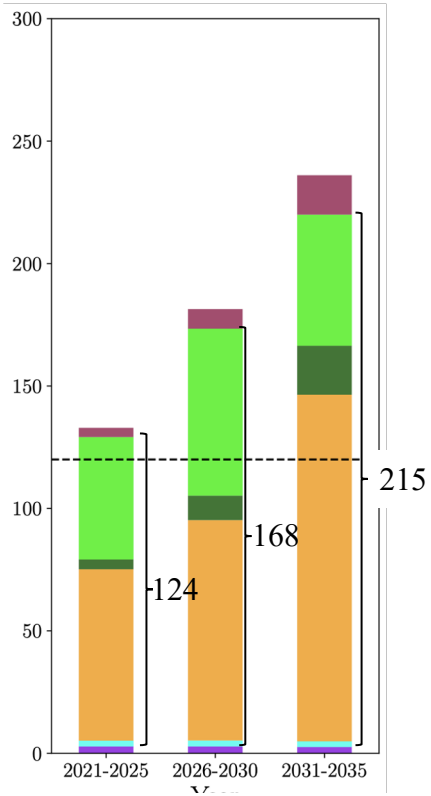
Cost of a cleaner power system will depend less on the ***volatile costs of fuel***, and more on the cost of capital.

CLEAN ENERGY CASE IMPLIES RAPID BUT FEASIBLE WIND & SOLAR DEPLOYMENTS

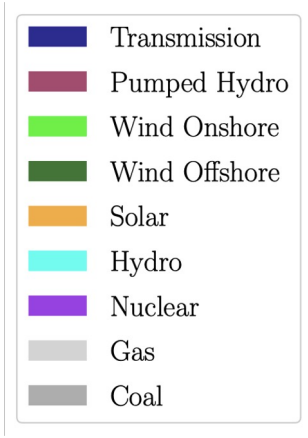
Current Policy Case



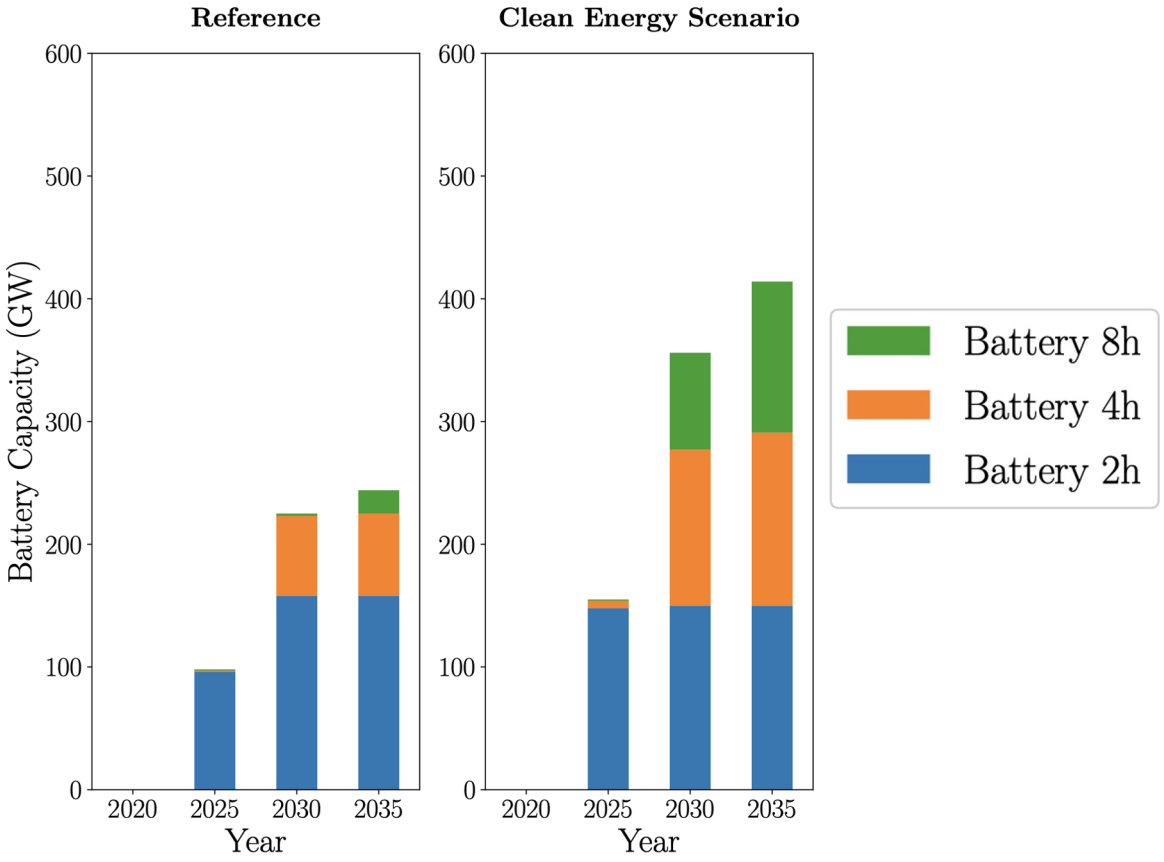
Clean Energy Case



In 2020, China deployed 120 GW of wind & solar

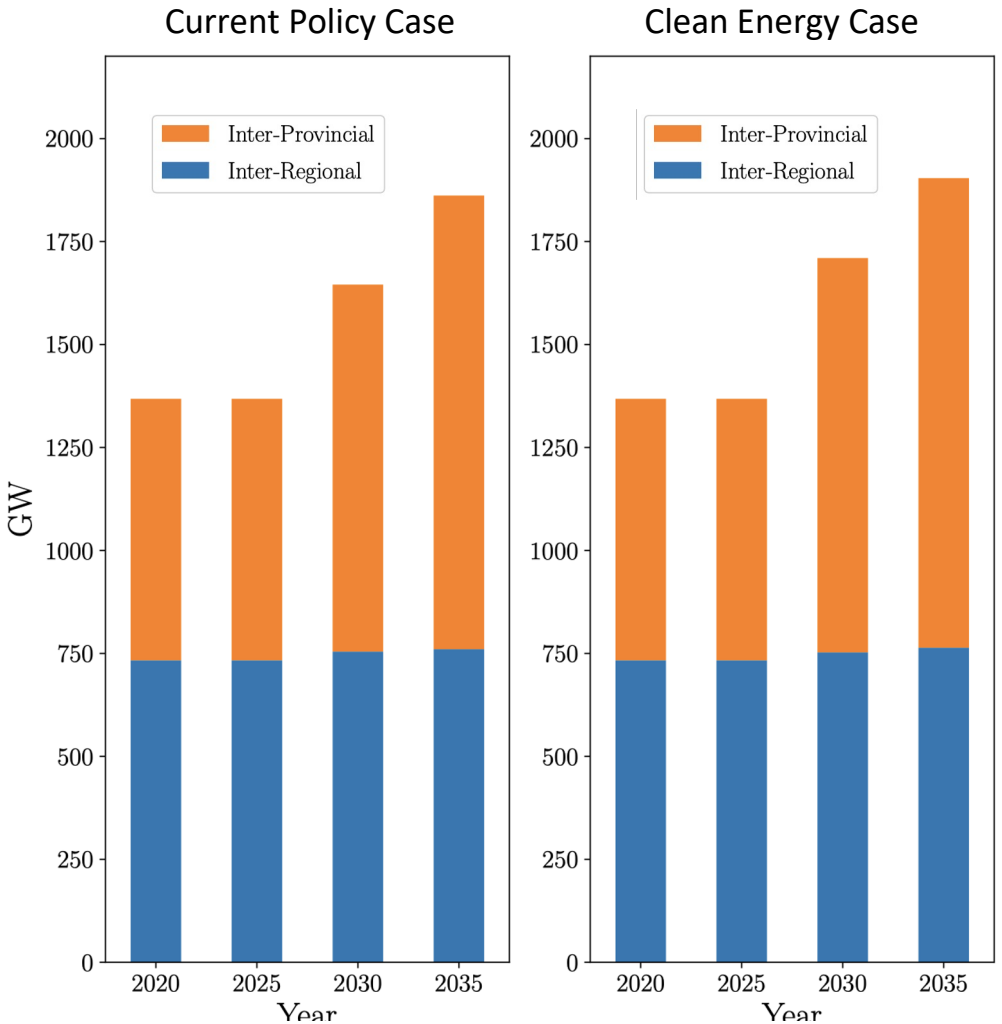


BATTERY INSTALLATION RATES ARE FEASIBLE AND EFFECTIVE TO MEET PEAK DEMAND

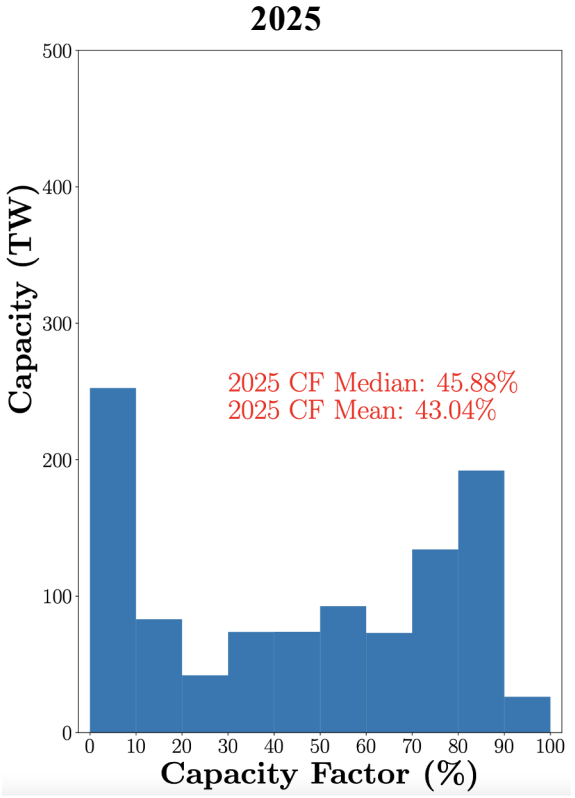


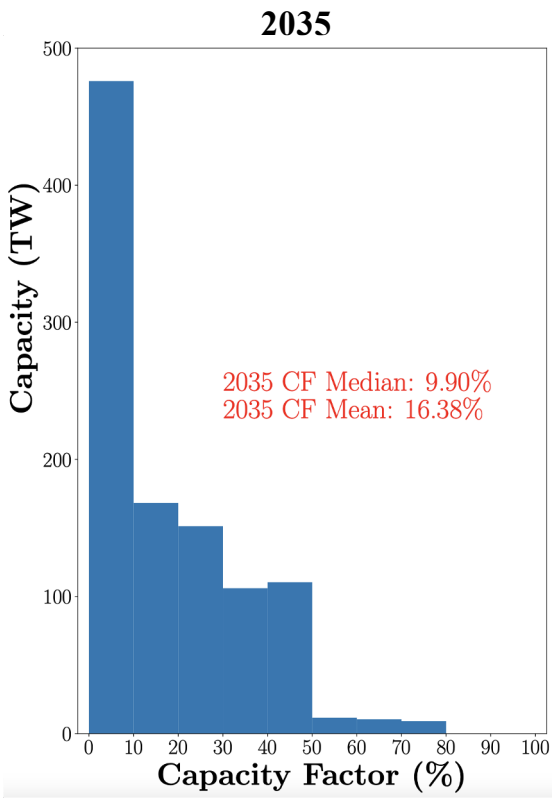
Clean Energy Scenario requires short-duration (2 hour) batteries in the near-term, while longer duration batteries are needed in later years.

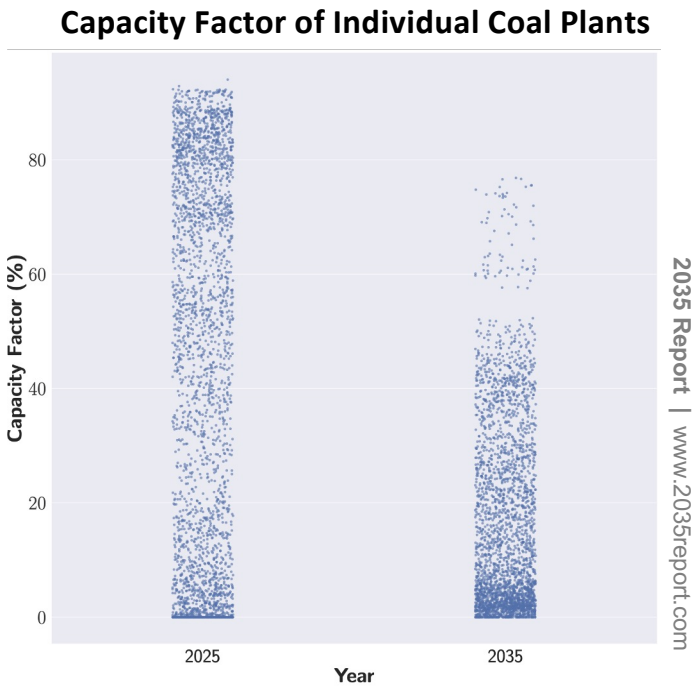
TOTAL TRANSMISSION BUILDOUT REMAINS SIMILAR IN CURRENT POLICY and CLEAN ENERGY POLICY SCENARIOS



INDIVIDUAL COAL PLANTS OPERATE AT VERY DIFFERENT CAPACITY FACTORS: HALF ARE RUNNING <10% BY 2035

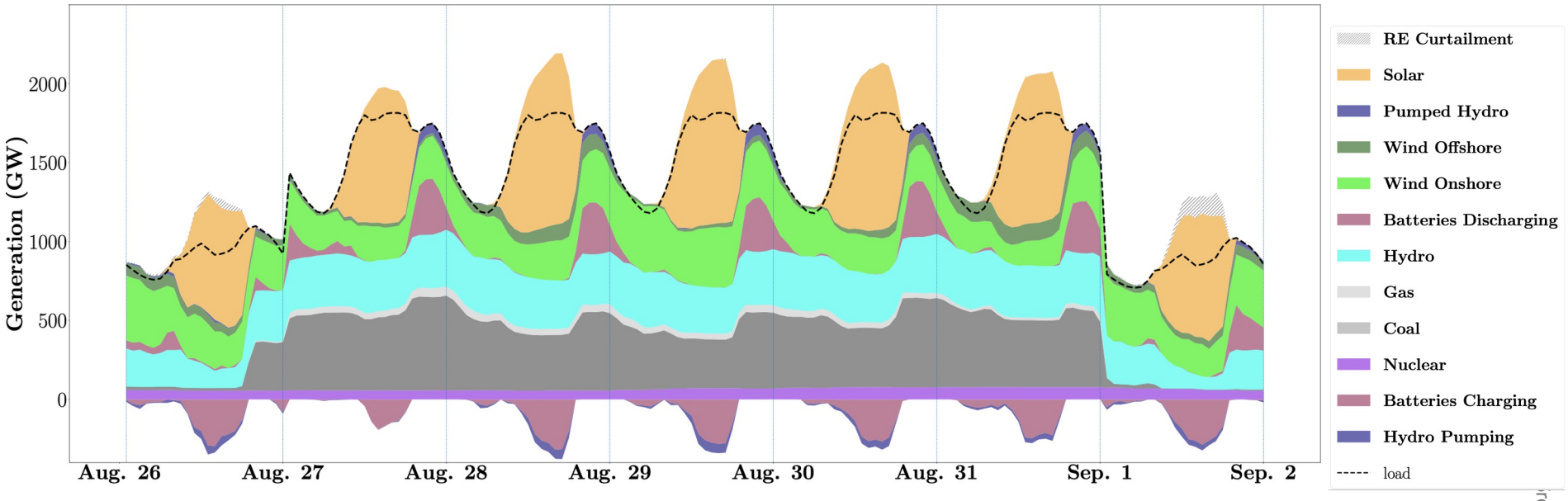






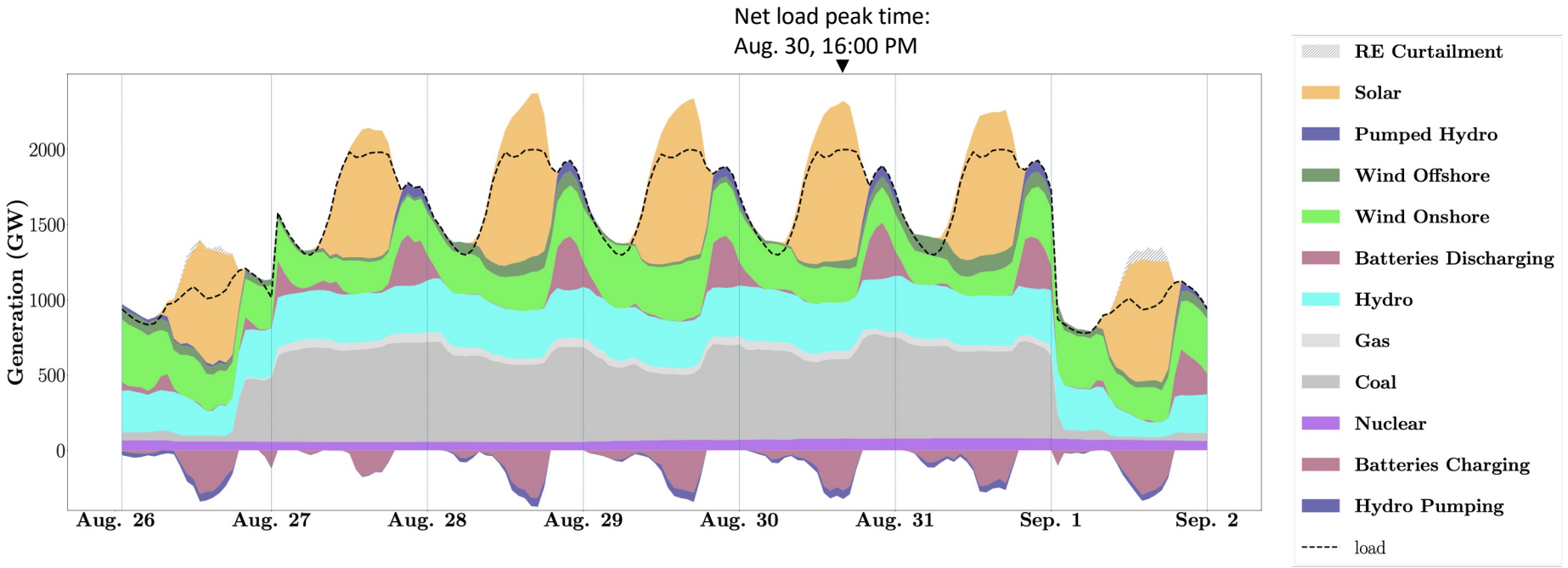
What if coal follows a ~30 year retirement schedule ?
(~266 GW Coal retirement by 2035)

To illustrate the system dependability, we test the net load peak week's performance with the coal retirement setting.



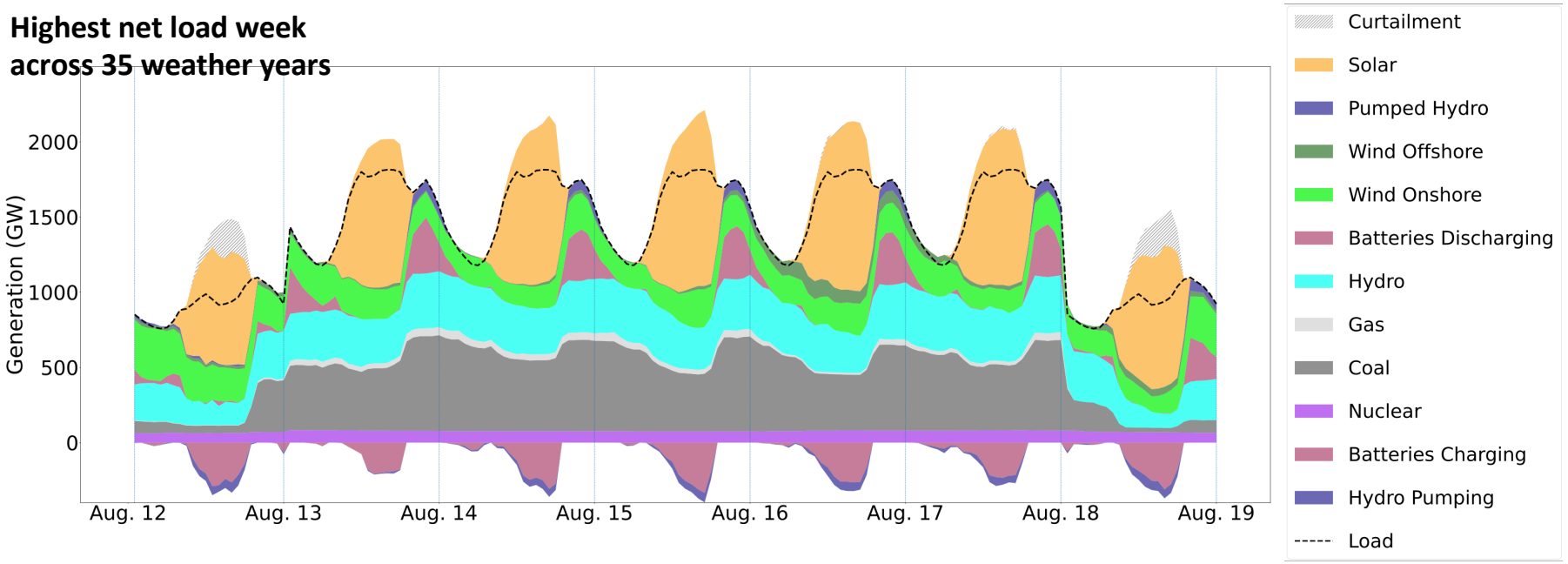
- With retirement, the maximum coal generation reduces to 599 GW, whereas the hydro, gas, and battery power increase their contributions to cover the load.
- The loss of load is zero upon retirement during the peak net load week.

What if there is an unanticipated demand increase (~10%)?



What about the days with historically low RE Generation ? (Summer)

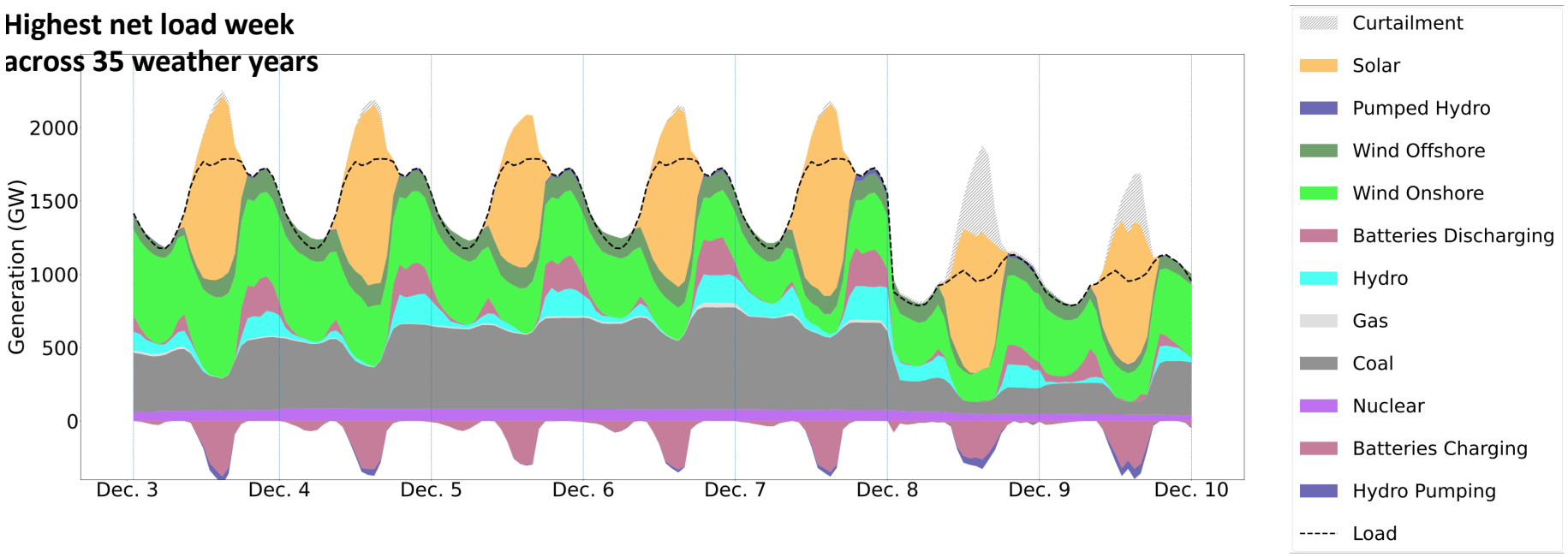
Highest net load week across 35 weather years



RE generation drops by 12% **(162 GW)** and as a result, the net load increases by **162 GW**.
Even if 266 GW of coal capacity is retired and historically low RE generation, the grid still remains dependable.
Existing coal and gas capacity fills this gap.
(max coal + gas generation = **732** GW against **690** GW in the base year).

What about the days with historically low RE Generation ? (Winter)

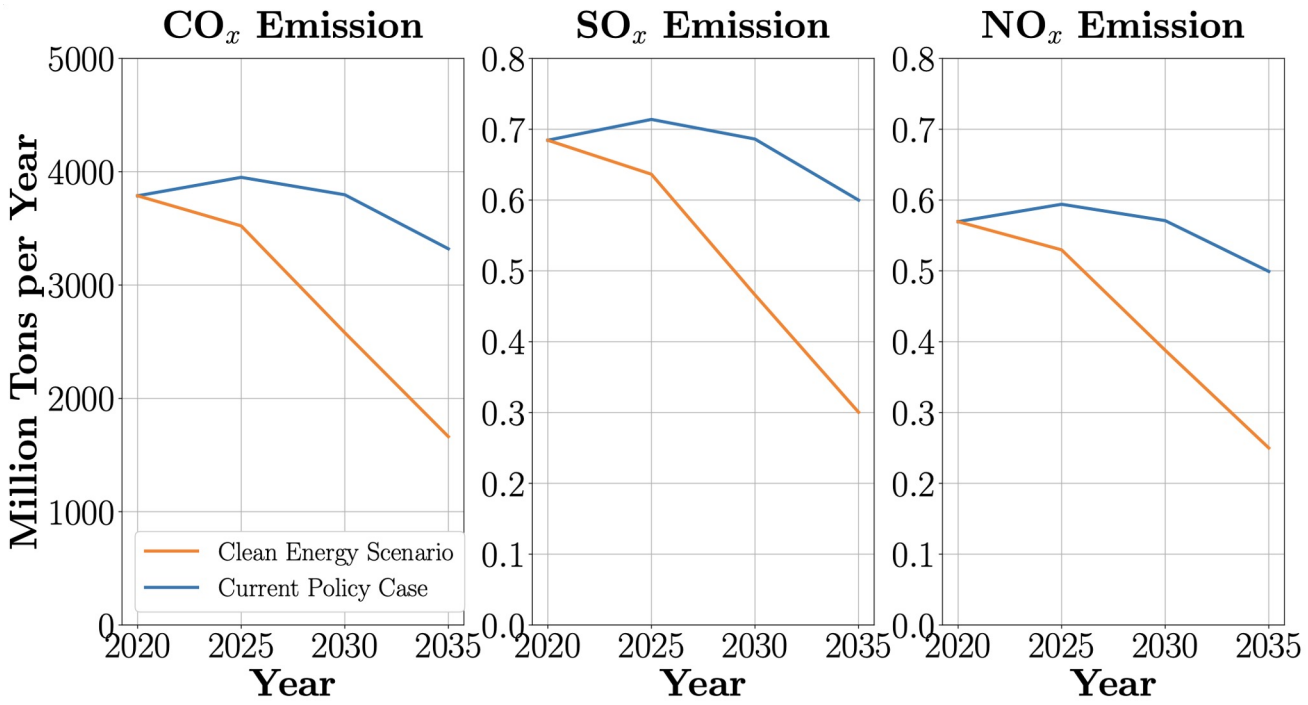
Highest net load week across 35 weather years



RE generation drops by 29% **(XXGW)** and as a result, the net load increases by **YYGW**.
Even if 266 GW of coal capacity is retired and historically low RE generation, the grid still remains dependable.
Existing coal and gas capacity fills this gap.
(max coal + gas generation = **ZZZ** GW against **AAA** GW in the base year).

AN 80% CLEAN GRID ENSURES CHINA CAN PEAK EMISSIONS BEFORE 2030, WITH MASSIVE CLIMATE AND PUBLIC HEALTH BENEFITS

China's Electricity Sector Emissions



Note: CO_2 emission factor based on current average thermal fleet, SOx and NOx emission reductions shown assumes full compliance with existing Chinese coal power plant emission standards.

POLICY RECOMMENDATIONS

Market Regulations:

- Consolidate approaches to renewable energy procurement and focus on participation in forward contract markets.
- Continue progress in developing electricity spot markets.
- Strengthen the renewable quota and green certificate system.
- Develop market participation models for electricity storage.
- Integrate distributed energy resources into wholesale markets.
- Leverage international experience with renewable integration to develop resource adequacy processes and mechanisms.

POLICY RECOMMENDATIONS

Policy Targets:

- Increase targets for non-fossil generation and renewable generation capacity, and consider adding storage and offshore wind targets
- Set targets for the share of non-fossil generation and renewable generation capacity for 2035 (80% non-fossil is achievable).

Land use:

- Prioritize land use efficiency
- Integrate wind and solar development into land use and conservation planning
- Address local land taxation policy that creates revenue risk for renewable energy projects
- Adopt best practices for offshore wind development and interconnection

Photo credit: EPA-EFE, South China Morning Post, 4 March 2021

QUESTIONS/DISCUSSION

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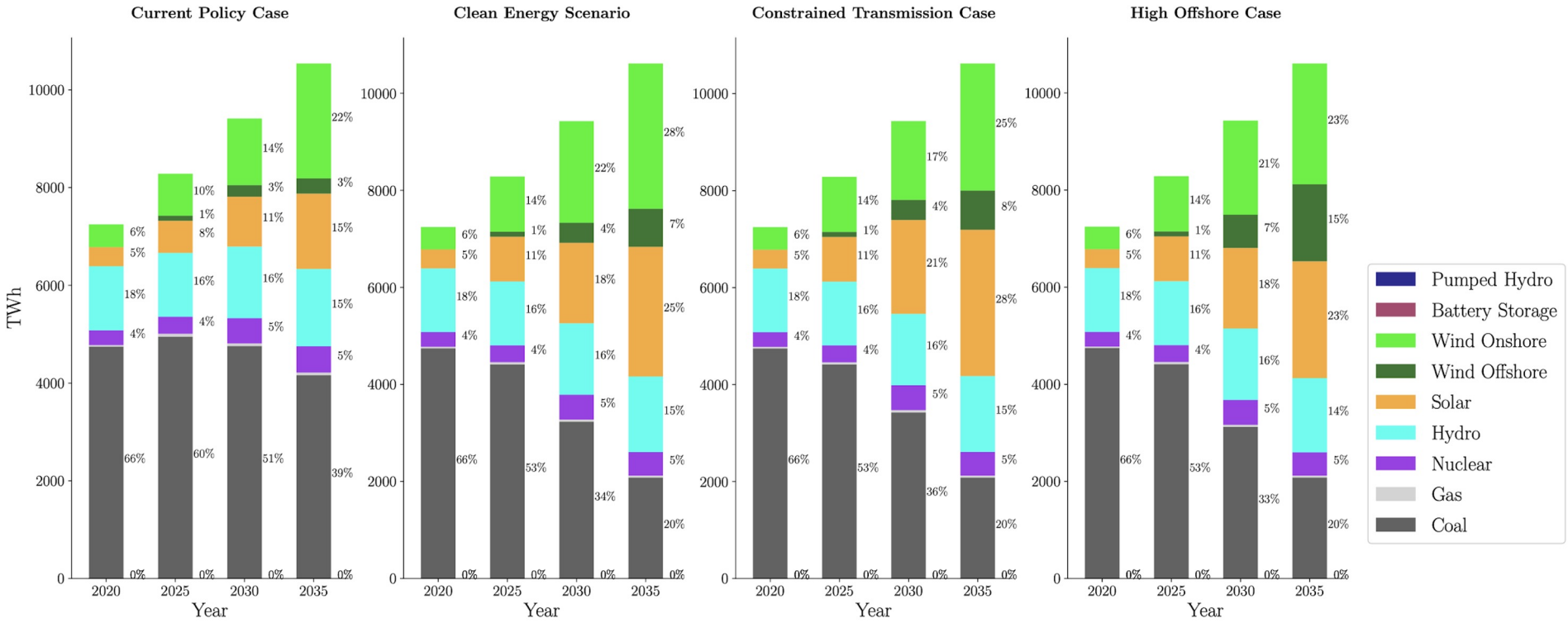
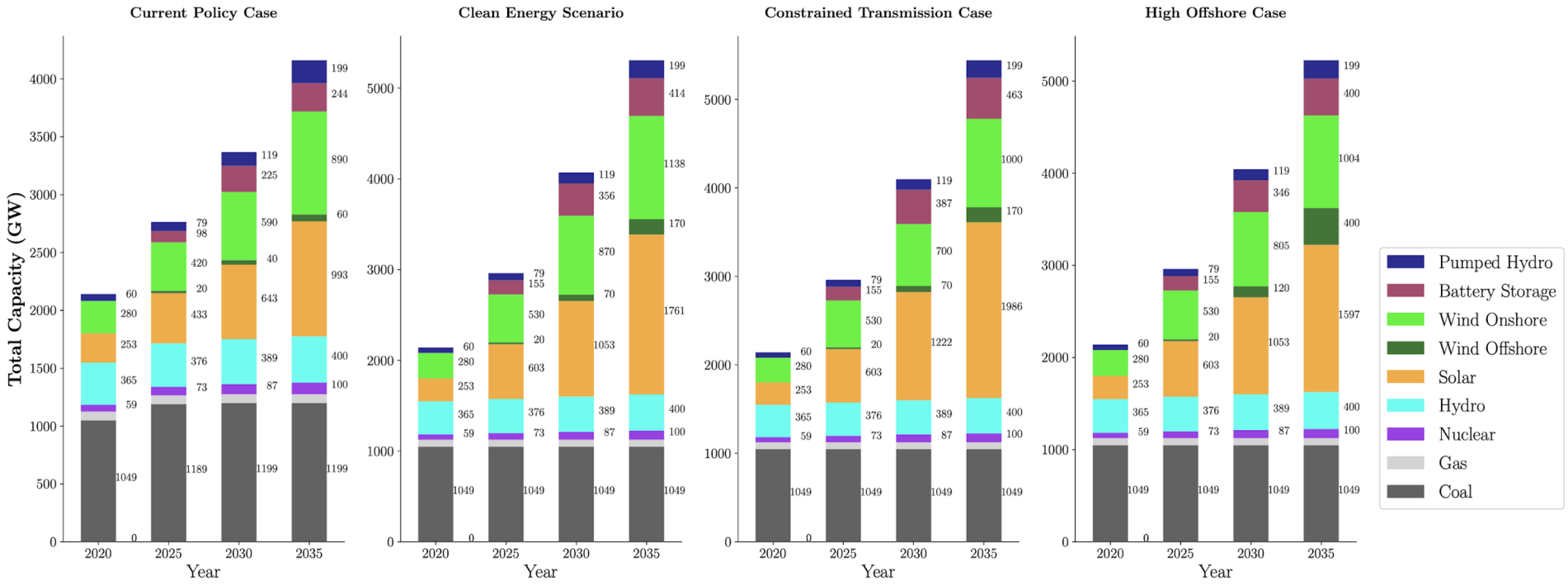
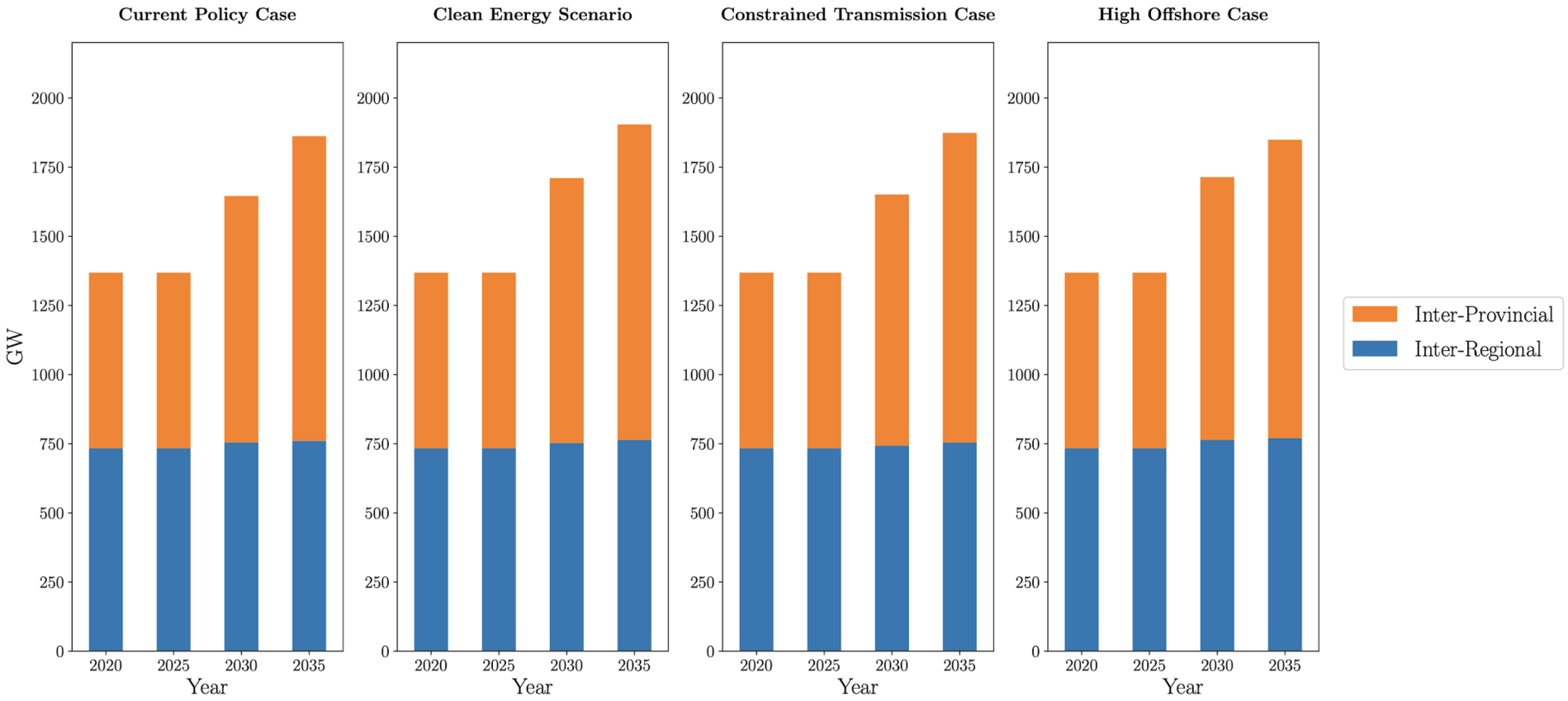
ANNUAL GENERATION



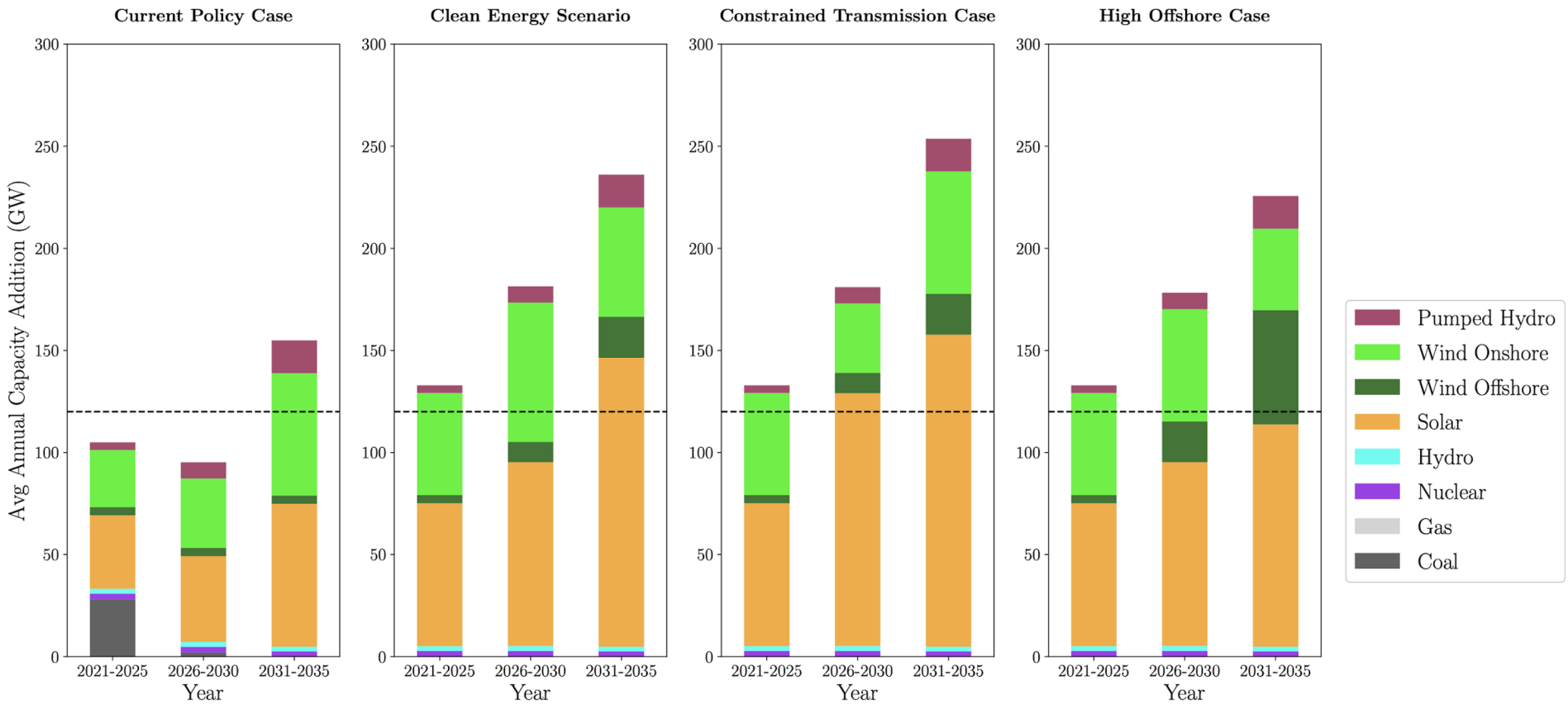
INSTALLED CAPACITY



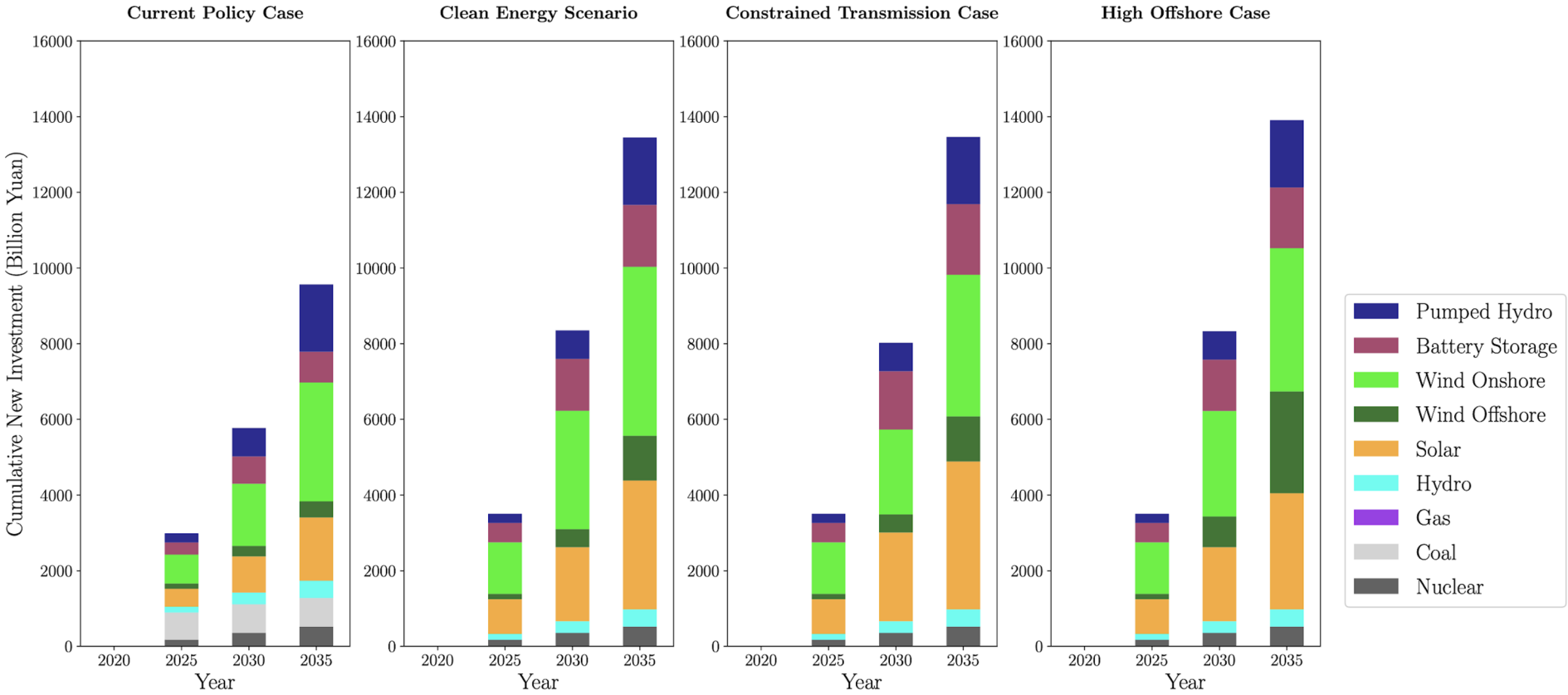
TOTAL TRANSMISSION BUILDOUT



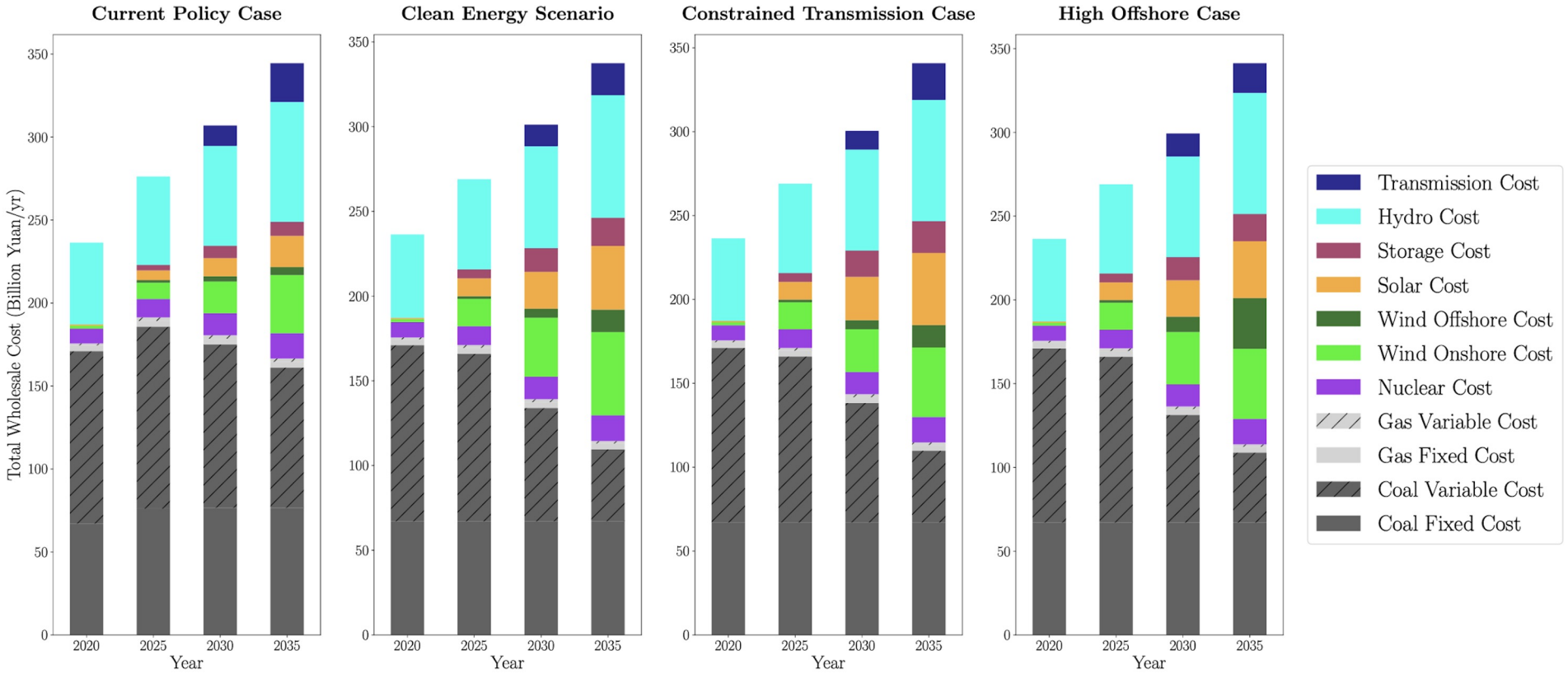
AVERAGE ANNUAL CAPACITY ADDITION



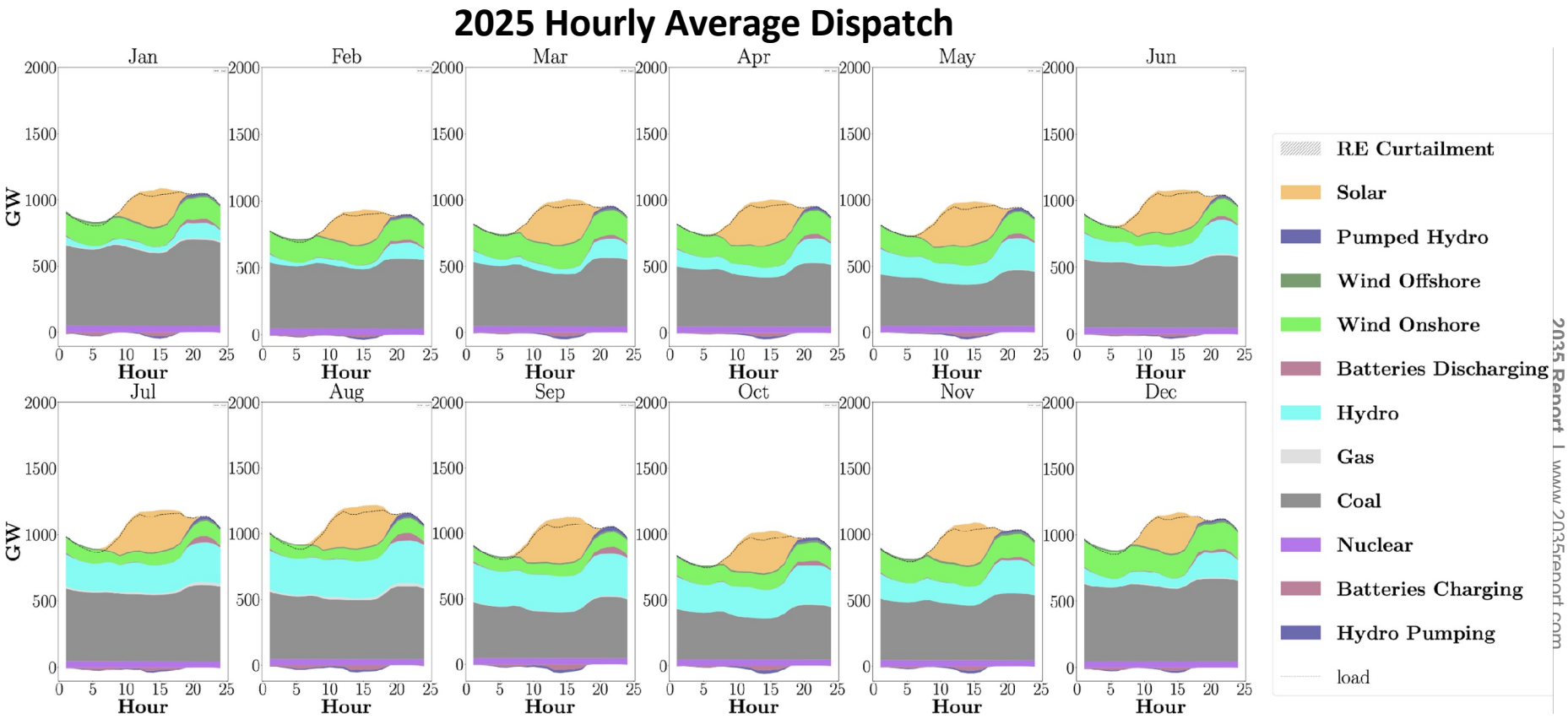
CUMULATIVE NEW INVESTMENT



TOTAL GENERATION WHOLESALE COST



DEPENDABLE POWER IN ALL SEASONS, WITHOUT NEW COAL CAPACITY IN 2025



Weather Day Capacity Factor Variation