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CEC's Long-Term Planning and Geothermal Resources

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CERRO Modeling Goals

- Support the state's effort to meet climate goals, which requires reliability analysis of different scenarios of clean energy development:
  - Evaluate the risks and uncertainties that could shape how the clean energy transition unfolds.
  - Estimate the types of resources most impactful to that transition, the volume of resources required, and the risk associated with each type of resource.
  - Understand how different assumptions could impact California's electric system reliability through 2045:
    - Resource costs and availability
    - Policy and tax incentives enabling resource development
    - Land use constraints limiting resource availability

Long-term System Scenarios

Feasibility Scenarios

- **Base:** Allowed to build all emerging resources at their default prices.
- **No CCS**: Removes the availability of Carbon Capture & Storage (CCS) retrofits from the portfolio.
- **No Emerging Resources:** Removes the availability of emerging resources from the portfolio.

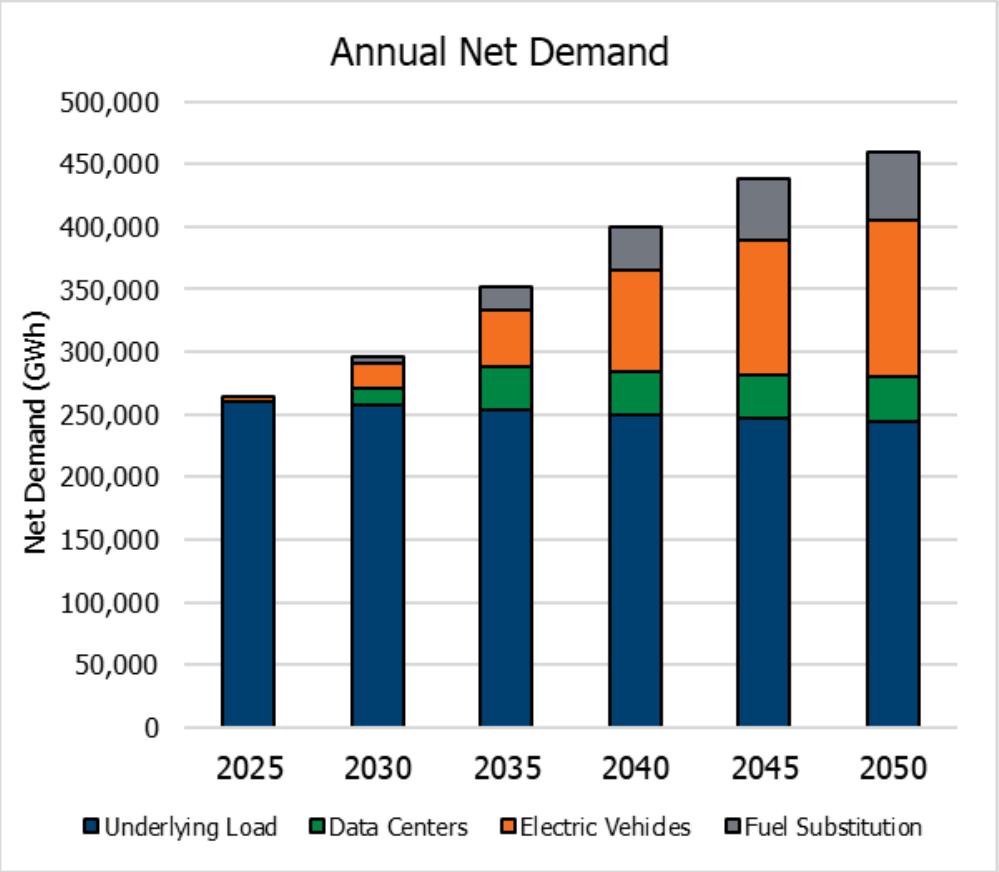
Cost Reduction Scenarios

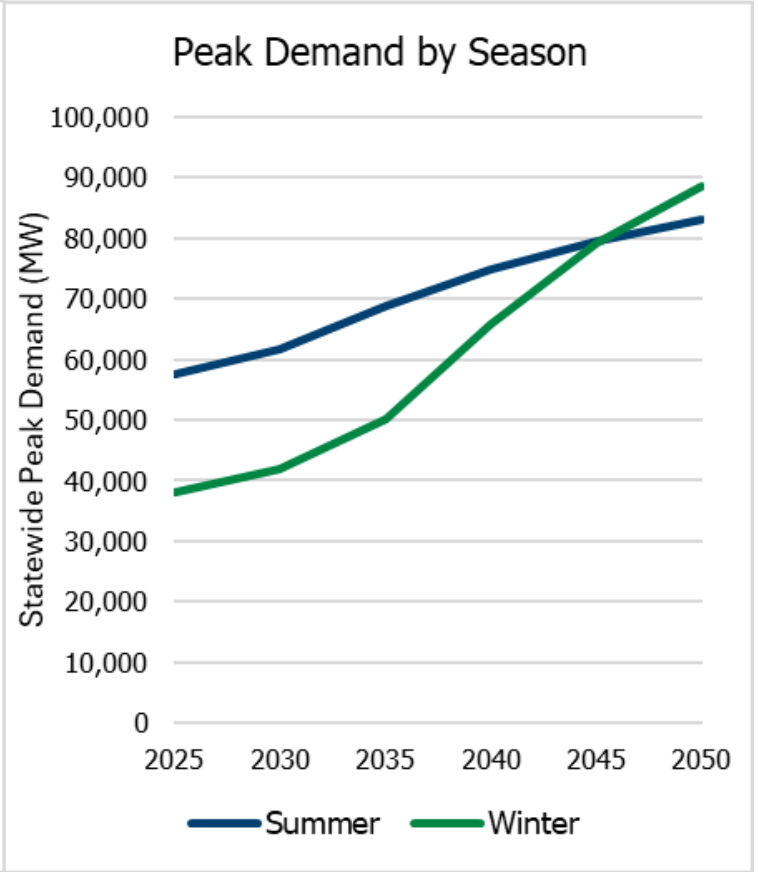
- **Tax Credits Extension:** Maintains the tax credit regime from Inflation Reduction Act.
- **Low-Cost LDES**: Models 70% cost reduction for Long Duration Energy Storage (LDES).
- **No CCS – Low-Cost OSW:** Models the Advanced cost for Offshore Wind (OSW) from NLR's ATB.

Land Use Scenarios

- **No Emerging – High Wind Potential**: Adds 35 GW of low-quality in-state wind as a candidate resource.
- **No Emerging – TCR Land Use Screen**: Reduced wind and solar potentials due to Terrestrial Climate Resilience (TCR) higher conservation land use screen.

Demand Assumptions

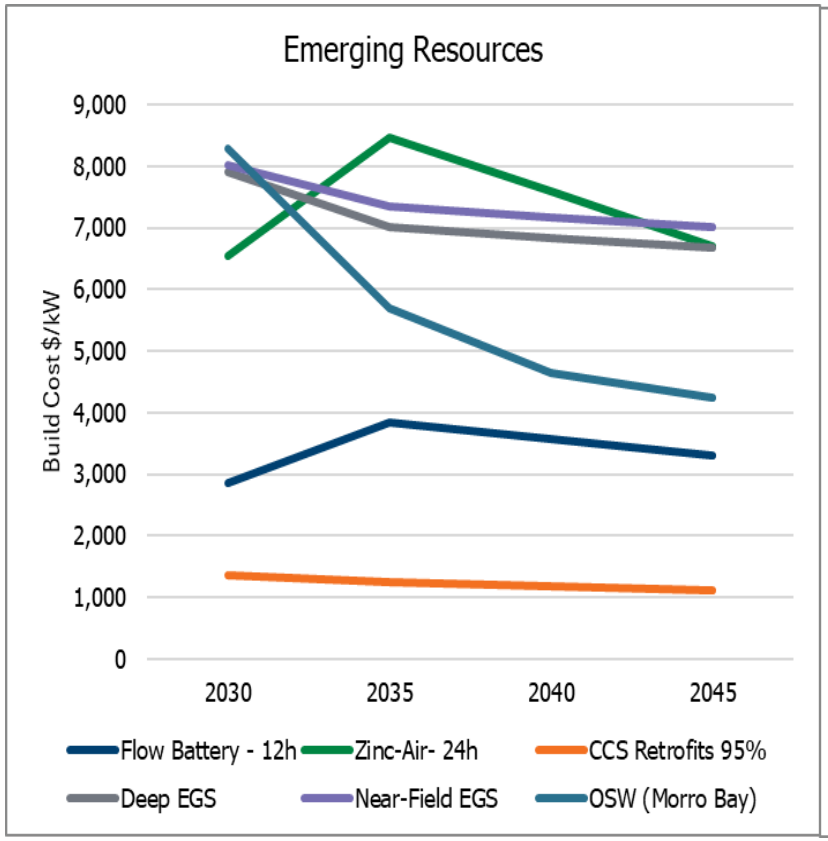


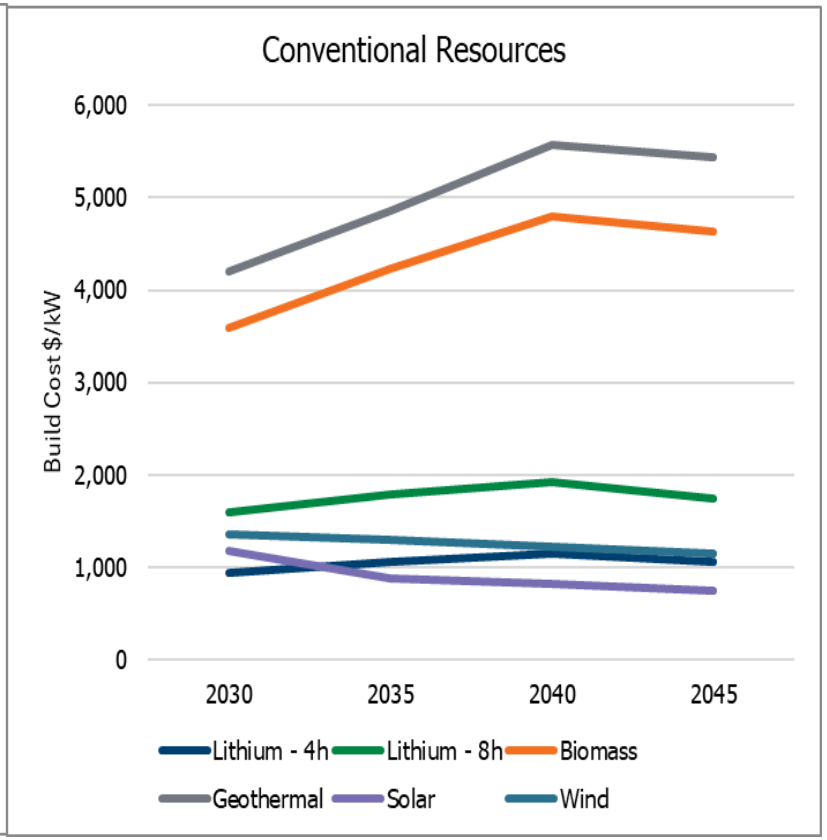


- 2025 IEPR Demand Forecast – Planning
- Lower electrification assumptions than SB100 or 2024 IEPR Forecast, due to slower adoption following federal actions in 2025.
- 70% increase in total demand by 2045.
- Winter peaking by 2045.

Source: CEC Staff

Build Costs for Candidate Resources





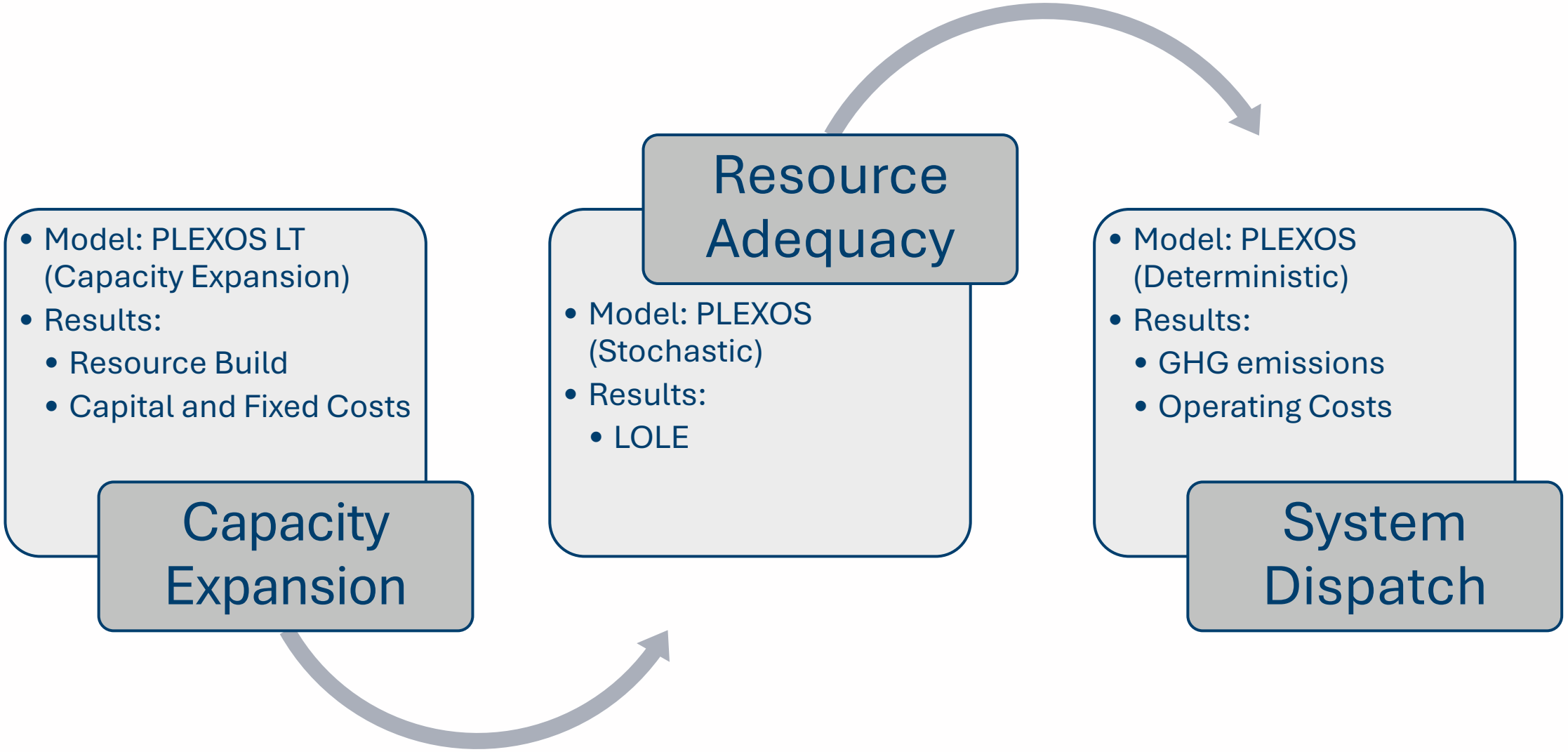
Source: CEC Staff, based on data from NLR ATB 2024

CEC is seeking stakeholder feedback on build costs and resource availability

- Costs sourced from National Laboratory of the Rockies Advanced Technology Baseline (ATB) 2024 (most recent).
- Wind, solar, lithium batteries, and CCS retrofits are the lowest-cost resources.
- CCS costs include estimates for cost of carbon transport and storage.*
- Investment Tax Credit expires in 2035 for energy storage, geothermal, and biomass.

*Sourced from "Geospatial Modeling of Geologic Carbon Dioxide Storage Potential" by Electric Power Research Institute

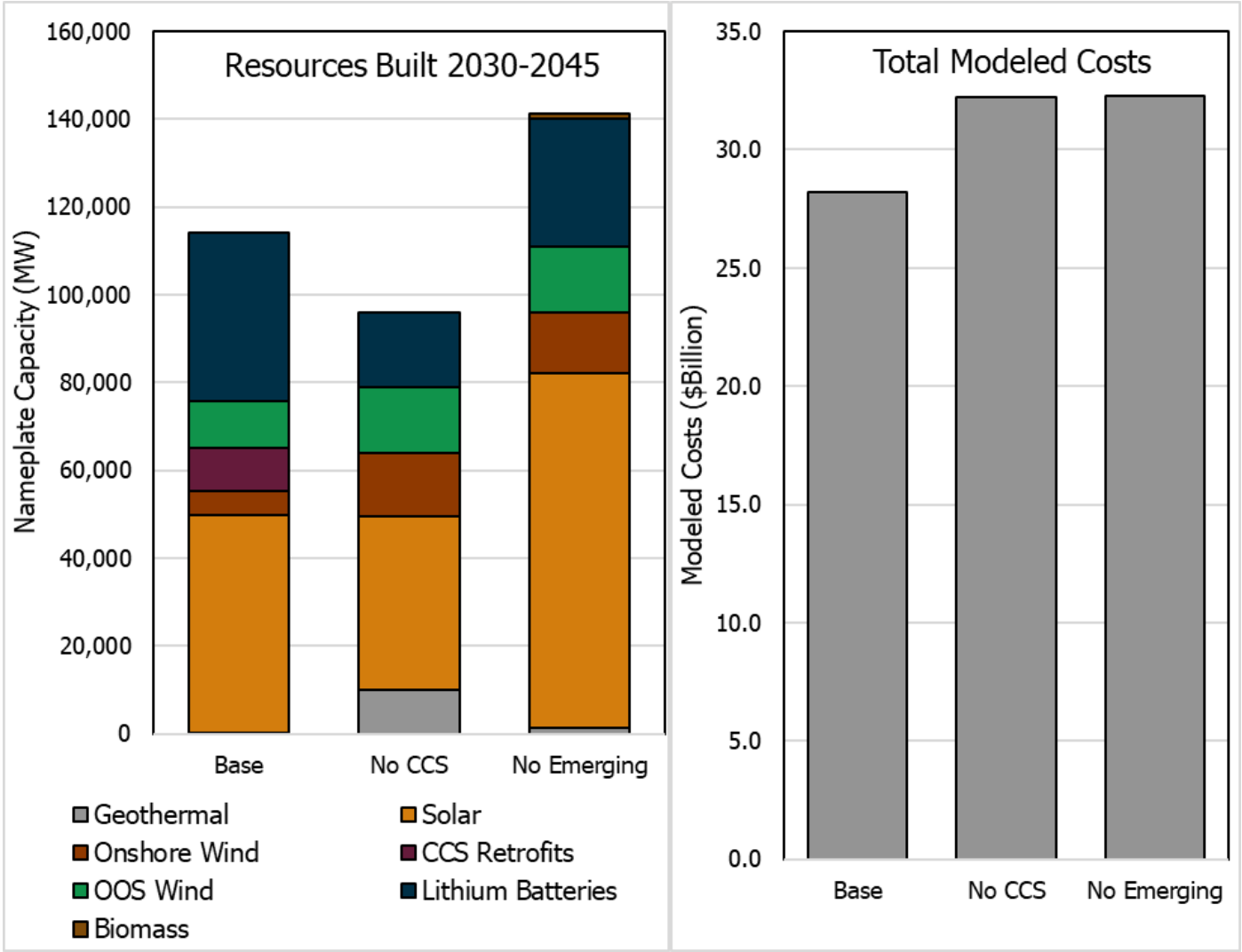
Modeling Process



Modeling Results 2045

Feasibility Scenarios - Meeting Demand Long-term Reliant on Clean Firm Resources

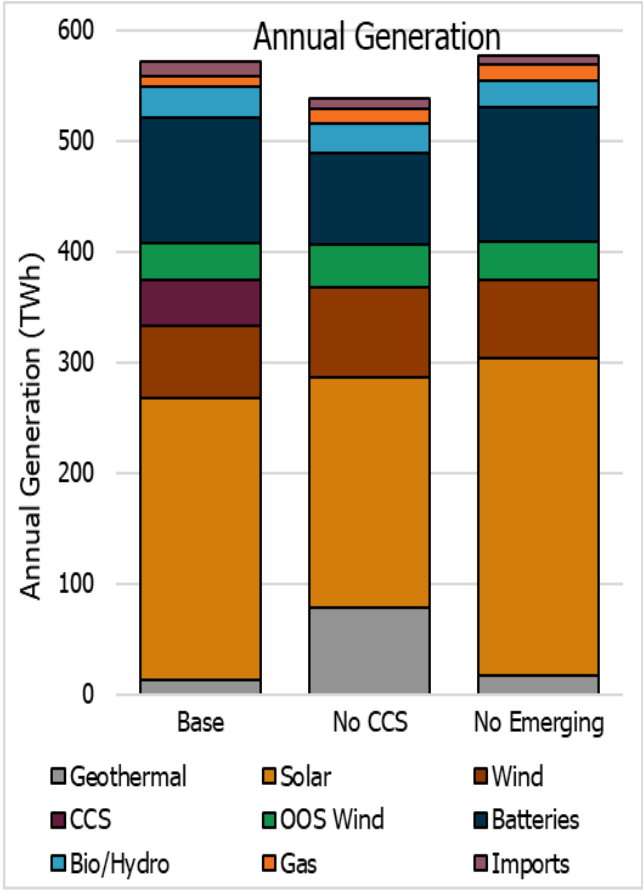
- Low-GHG firm resources selected in all scenarios, demonstrating need and cost-competitiveness even at high costs per kW:
  - 10 GW of CCS in Base
  - 10 GW of EGS in No CCS
  - 3 GW of geothermal and biomass in No Emerging
- Removing CCS raises modeled costs by 15% with current assumptions.
- EGS costs 10x solar per kW but generates power in winter when it is most needed.

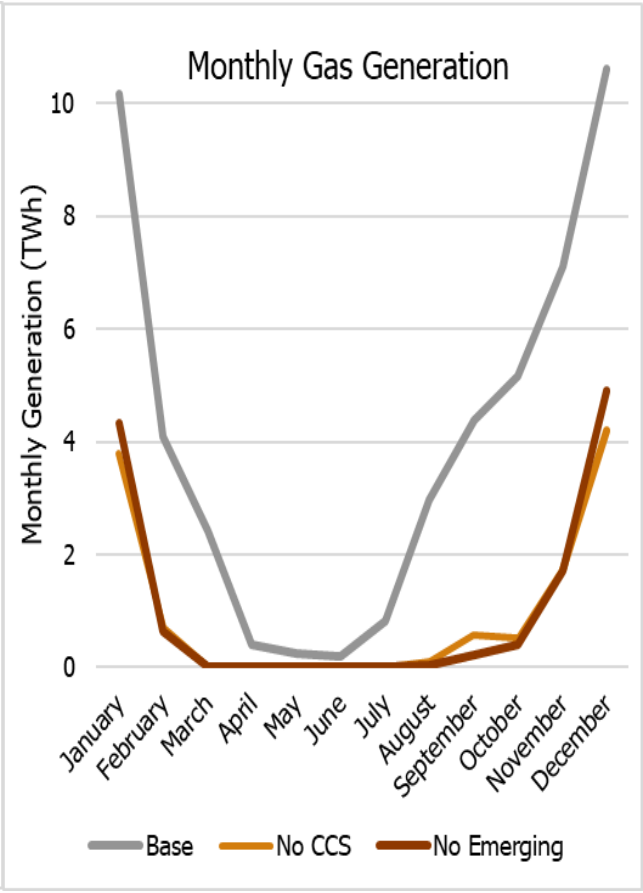


Source: CEC Staff

Feasibility Scenarios - Gas Generation Maintained in Winter to Meet Demand

- Emerging resources contribute significantly to overall generation mix:
  - 11% from CCS in Base Scenario
  - 15% from Geothermal in No CCS Scenario
- Fossil gas from unretrofitted plants must decline from levels seen today:
  - Less than 3% of total generation from 34%
  - Highly concentrated in specific winter days
- Seasonal variations:
  - Most gas use in winter
  - Little to no gas use in spring/summer without CCS
  - Need to evaluate implications, feasibility and requirements of no gas generation for multiple months

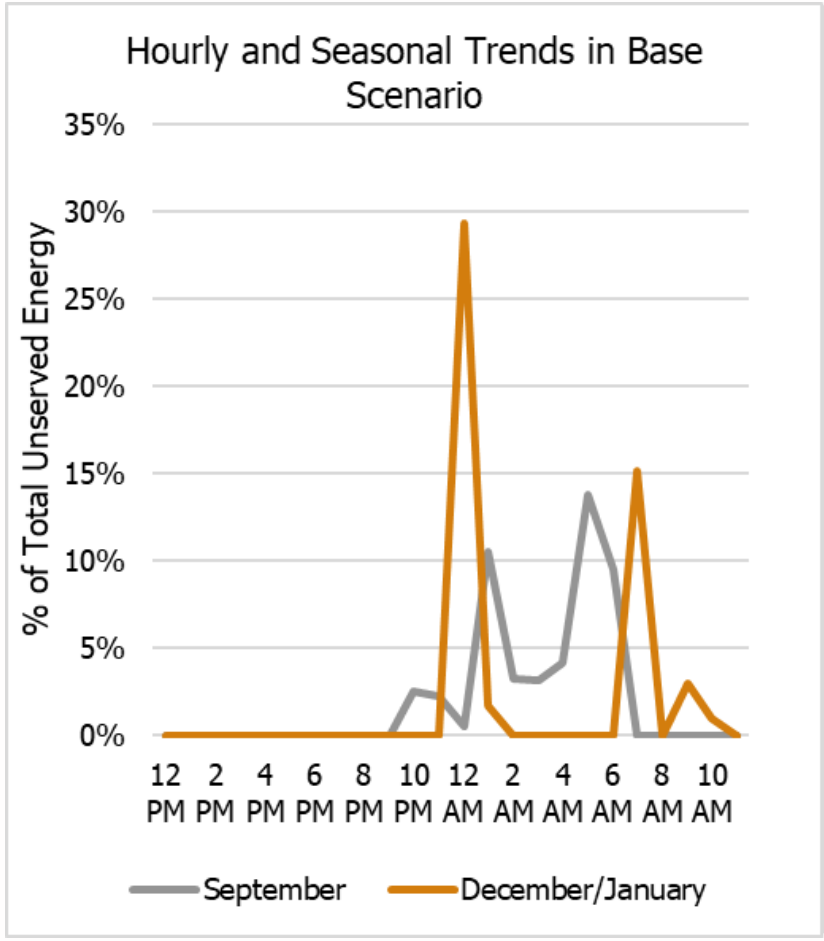


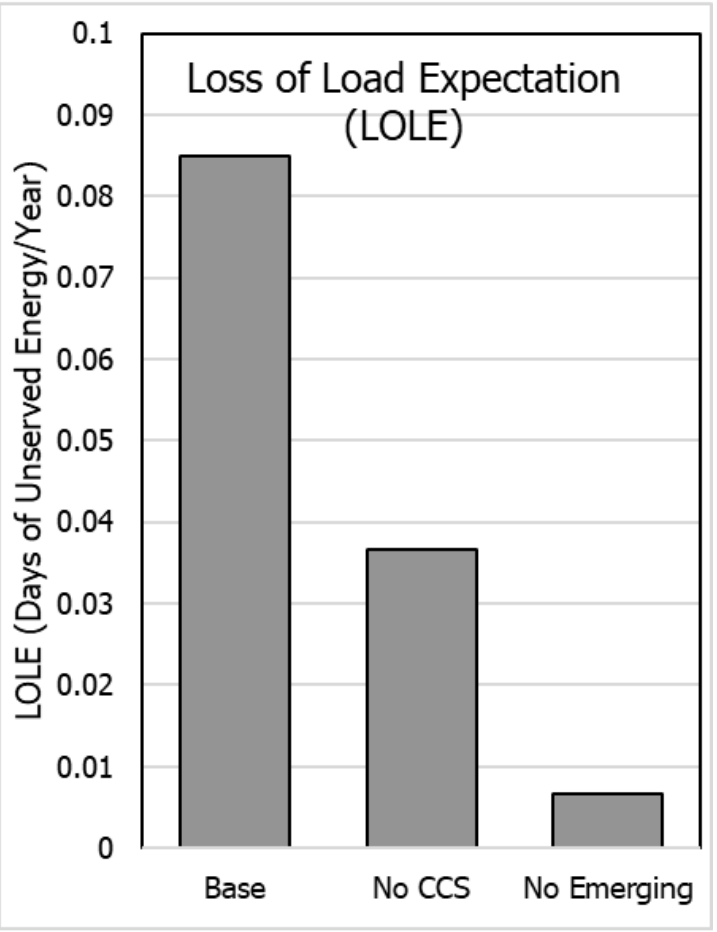


Source: CEC Staff

Feasibility Scenarios - Reliability Requirements add Summer Peak and Winter Resource Needs

- CCS Retrofits add low GHG energy but not new capacity.
- Reliability constraints lead to adding ~30GW of solar + storage to Base scenario.
- Load growth to 2045 will require 150+ GW of new generation capacity to meet reliability targets, not just clean energy targets.
- In 2045, unserved energy occurs at night during energy-constrained events in summer and winter.



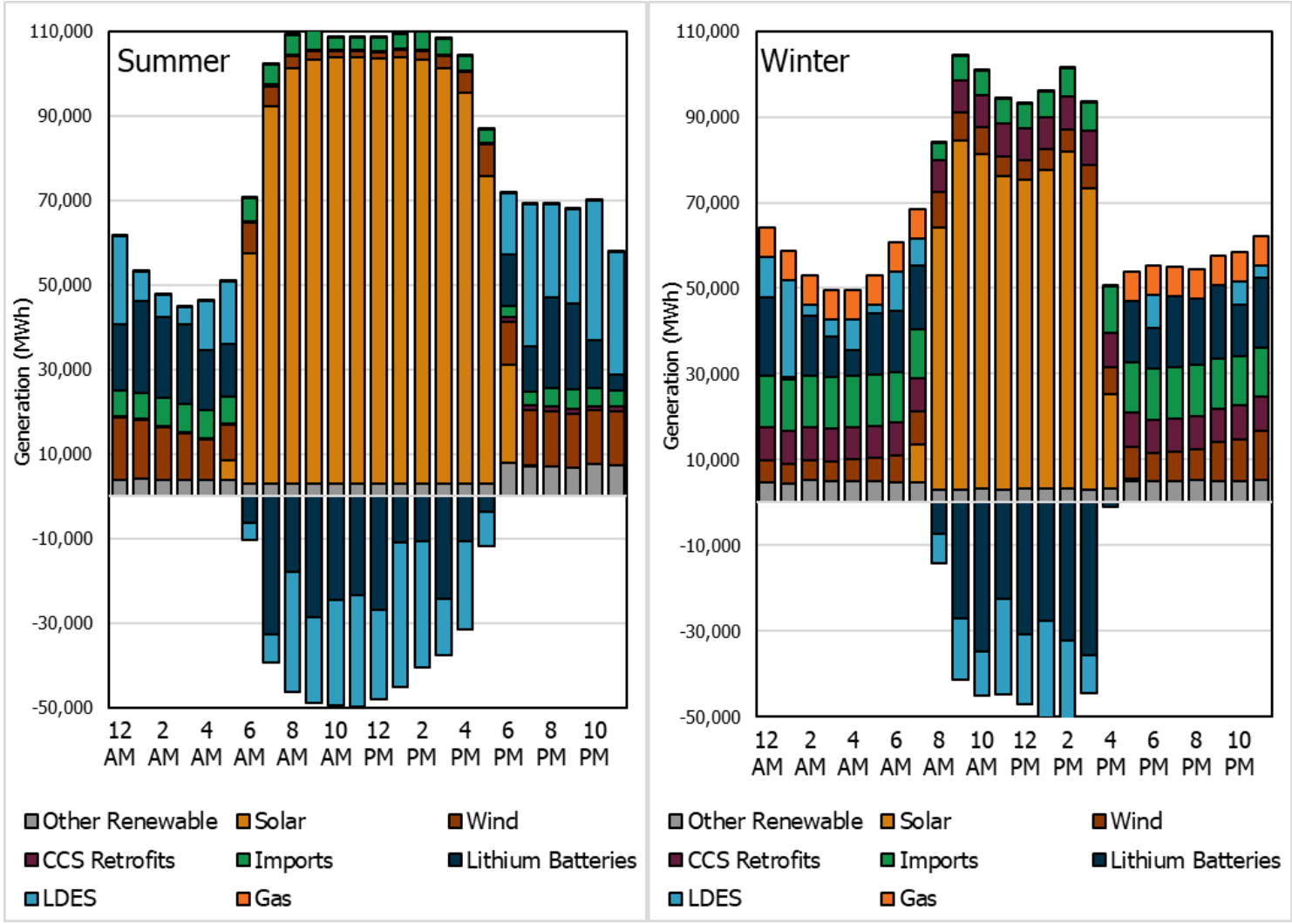


Source: CEC Staff

Clean Firm Capacity Needed to Enable Reliability

Capacity and generation on low-solar days

- Low-solar days see high gas burn. They tend to be cloudy, windy days
- Resource diversity is very impactful for winter loads, even from intermittent sources like wind
- Zero-carbon firm resources valuable to the model even at relatively high cost



Conclusions

Maintaining Reliability While Meeting Climate Goals Under Future Uncertainty

- Meeting GHG goals will require significant increase in electric demand and consequent deployment of clean energy resources.
  - Build rates of 7-10 GW/year every year until 2045
  - Critical summer peak and winter night capacity needs
- High demands and low renewable output in winter means firm technologies/resource diversity is strongly valued to meet reliability even at current cost projections.
  - EGS built at $7,000/kW
  - CCS reduces portfolio costs by 15%
  - 32 GW of marginal wind deployed without clean firm resource available
  - OOS Wind selected in all scenarios
- IRA repeal will raise overall costs, making clean firm technologies more cost-competitive relative to large renewable and storage builds to meet reliability.
  - Modeled cost increases of 15-20%
  - Higher CCS uptake in base scenario.