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Determining Flexible Capacity Needs for the CAISO Area

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Introduction

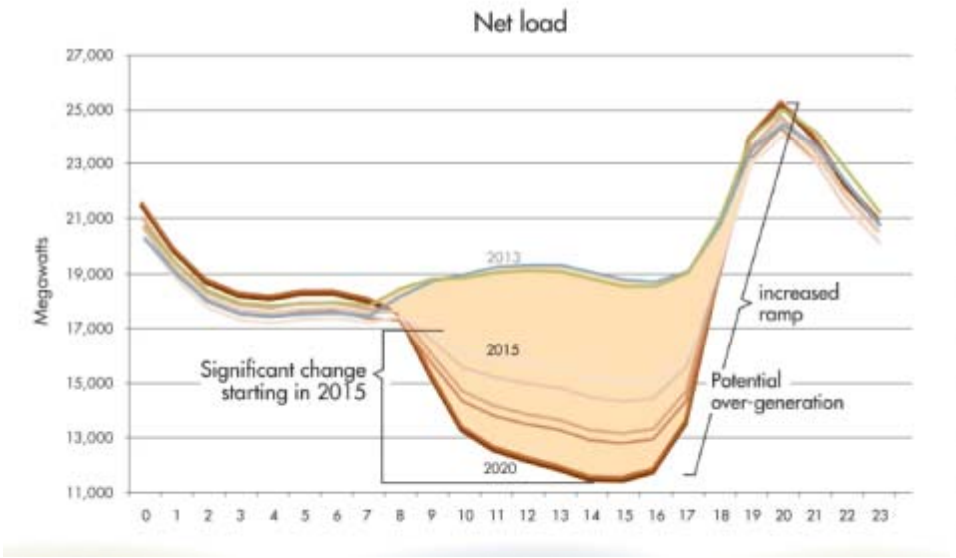
- **Wind and solar are both variable and uncertain, creating a need for power system flexibility**
- **E3 has been working with the CAISO to identify the need for flexible resources to meet 33% RPS in 2022**
- **E3 has developed the Renewable Energy Flexibility Model (REFLEX) to calculate the need for power system flexibility and evaluate alternative strategies for meeting identified needs:**
  - New flexible resources: CTs, ICEs, energy storage
  - Operating strategies: scheduled renewable curtailment, optimal reserve scheduling
  - Structural improvements: within-hour scheduling, Energy Imbalance Market, forecasting improvements
- **REFLEX is available on PLEXOS and ProMaxLT platforms**

Existing Tools are Unable to Address Flexibility Needs

- **Previous studies have focused exclusively on characterizing the operating issues**
  - Deterministic production simulation model runs at various timesteps (5 minutes, 10 minutes, hourly)
  - Stochastic representation of day-ahead forecast errors and sub-timestep flexibility needs
  - Typically select a conservative operating policy, e.g., meet 95% of sub-timestep ramping needs
- **Current models do not adequately address the important planning questions:**
  - How much flexible capacity is needed to accommodate a given quantity of wind and solar?
  - How much wind and solar can be added to a given system before more flexible resources are required?

Defining the Problem

- **Introduction of variable renewables has shifted the capacity planning paradigm**
- **The new planning problem consists of two related questions:**

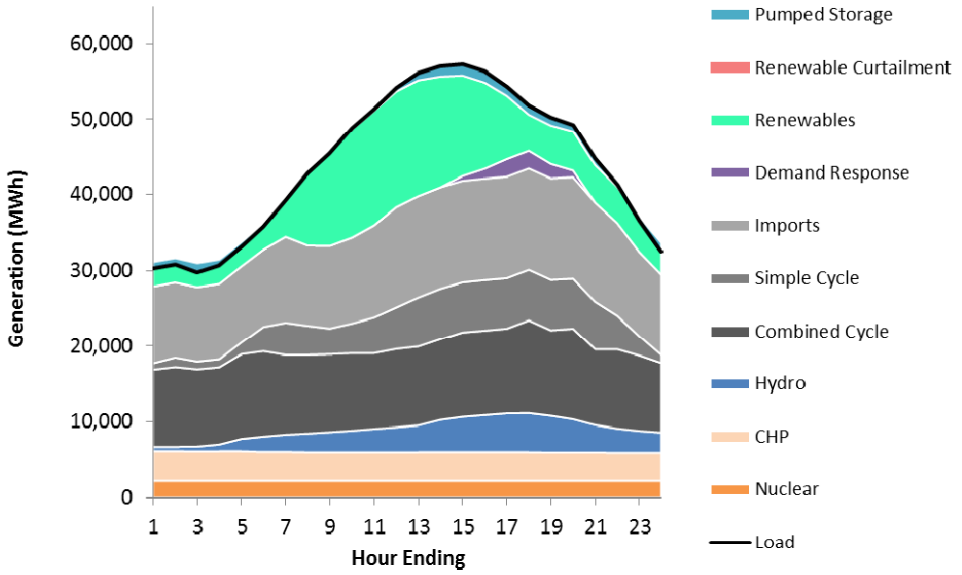


1. How many MW of dispatchable resources are needed to (a) meet load, and (b) meet flexibility requirements on various time scales?
2. What is the optimal mix of new resources, given the characteristics of the existing fleet of conventional and renewable resources?

REFLEX Modeling Approach

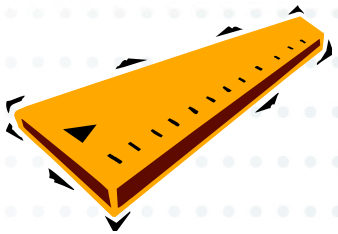
+ Robust, stochastic production simulation modeling

- 24 hours of time-sequential operations to capture unit commitment, forecast errors and ramping requirements
  - Day-ahead, hour-ahead and five-minute timesteps
- Optimal unit commitment and dispatch over 24-hour period
- Draw from a large sample of load, wind, solar, hydro conditions
- Calculates the likelihood, magnitude, duration and cost of flexibility violations to inform potential solutions



What is the Standard for Flexible Generation Capacity?

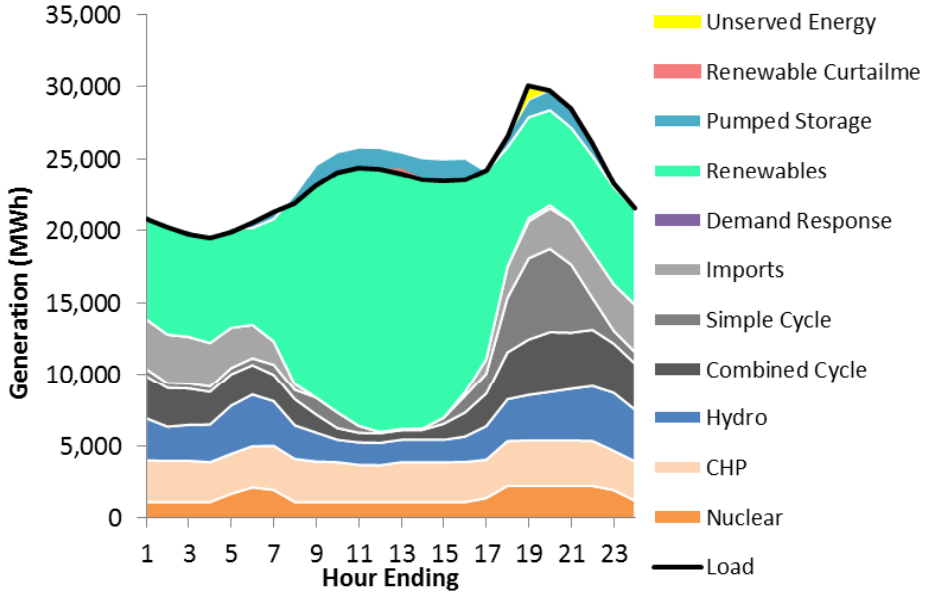
- **Conventional Capacity Planning:**
  - Build system to achieve 1 loss of load event in 10 years

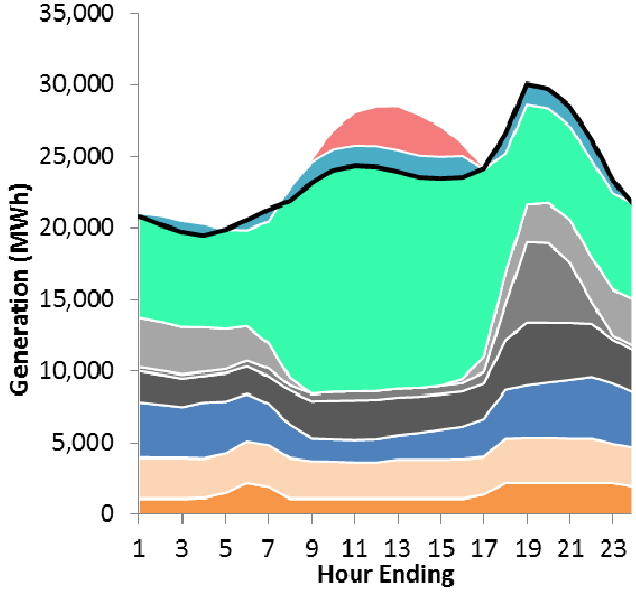


- **Flexibility Planning:**
  - No standard exists!!!
- **REFLEX casts the "build" decision as an economic tradeoff**
  - Compares the cost of constructing new resources against the value of avoiding flexibility violations

System Operator May Need to Choose Between Violation Types

- **Cycling off thermal resources to make space for renewables can create upward ramping challenges when renewables production drops**
  - Unserved energy shown in example day
- **Limited renewable curtailment allows slow-start thermal resources to remain online to meet subsequent ramps**
- **Strategy for meeting flexibility needs must be informed by cost tradeoffs**





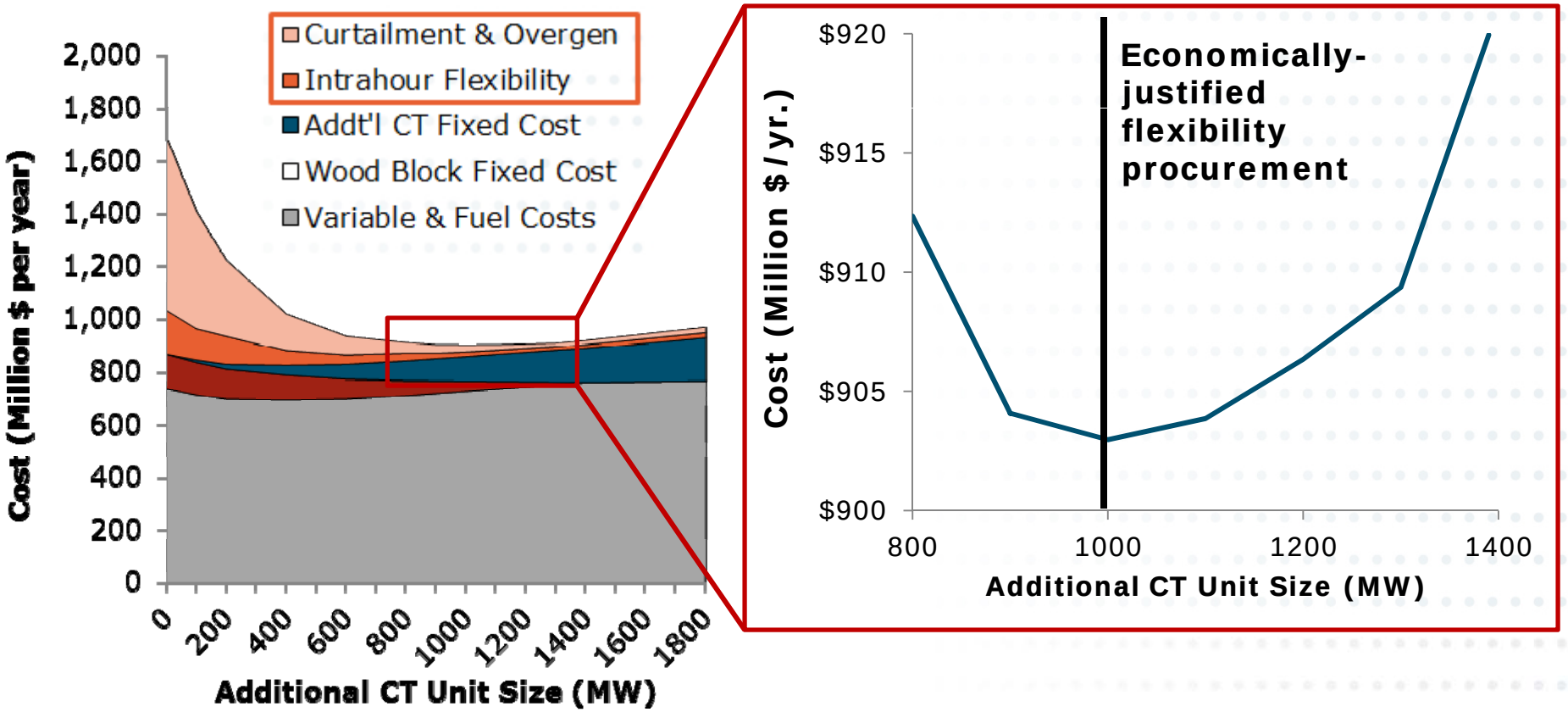
Flexibility Cost Penalties

- Relative cost penalties impose flexibility mitigation strategy "loading order"
- Costs will depend on specific system and applicable policies
- Assuming that all renewables must be delivered is equivalent to placing an infinite penalty on curtailment and overgeneration

Operating Strategy	Example Cost
Overgeneration/Scheduled Curtailment	$200/MWh
Sub-hourly Downward Flexibility Shortage	$250/MWh
Sub-hourly Upward Flexibility Shortage	$1,000/MWh
Unserved Energy	$40,000/MWh

Optimal Flexibility Investment

- **REFLEX provides an economic framework for determining optimal flexible capacity investments by trading off the cost of new resources against the value of avoided flexibility violations**



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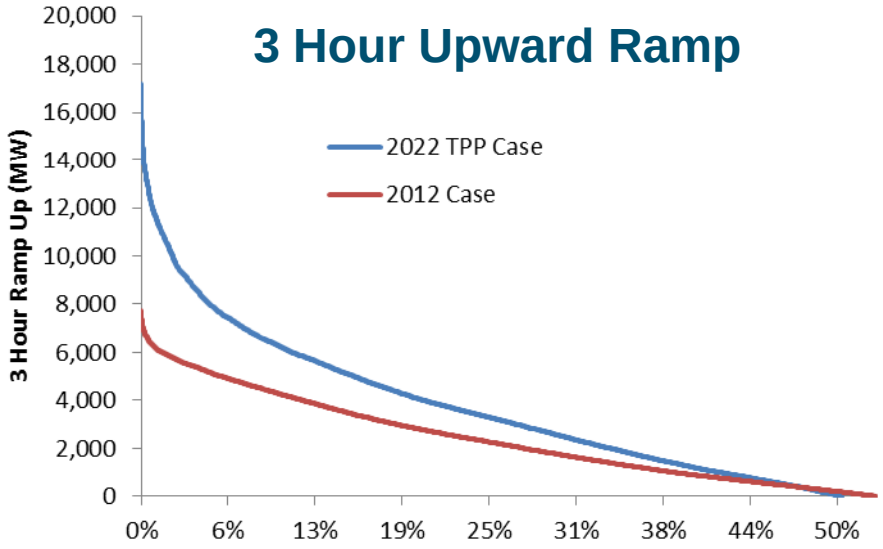
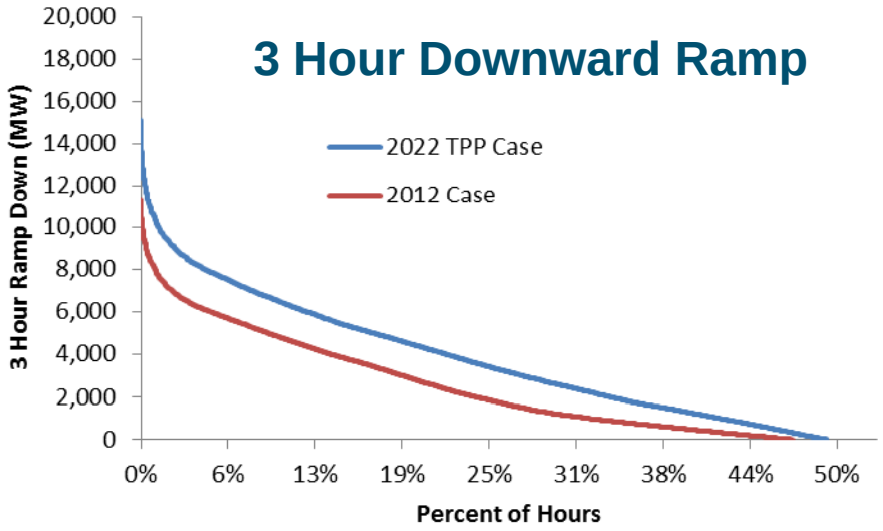
CALIFORNIA ISO TEST CASE

Significant Increases in Ramping Needs

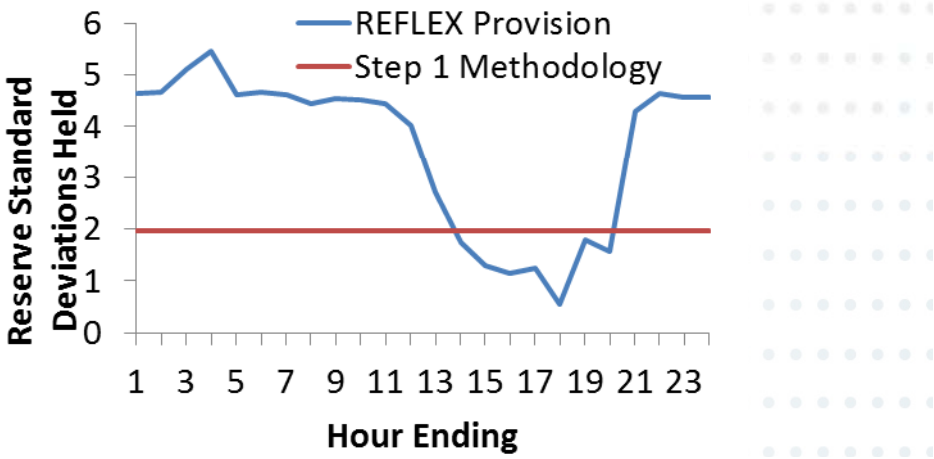
- **Maximum upward 3 hour ramp doubles between 2012 and 2022**
  - Many more hours with higher ramps
- **Capability of system declines between 2012 and 2022**
  - Retirement of 15,000 MW of coastal generators using once-through cooling

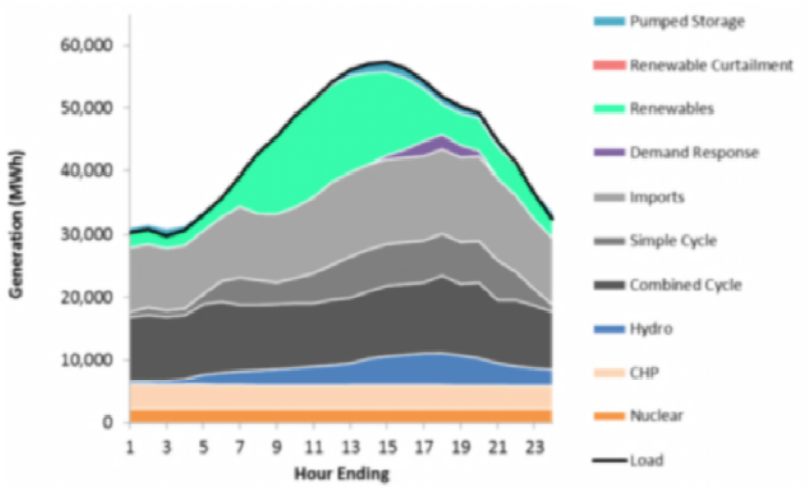


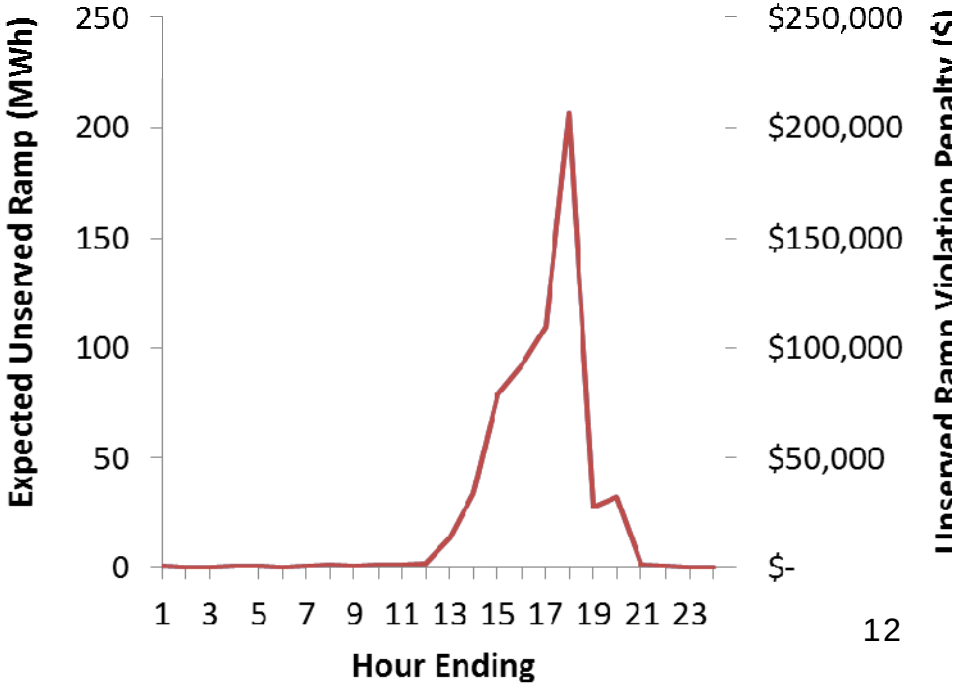


Highest net load day

- All resources are turned on to meet peak net load
- 608 MWh of upward flexibility reserve shortage, penalized at $608,000



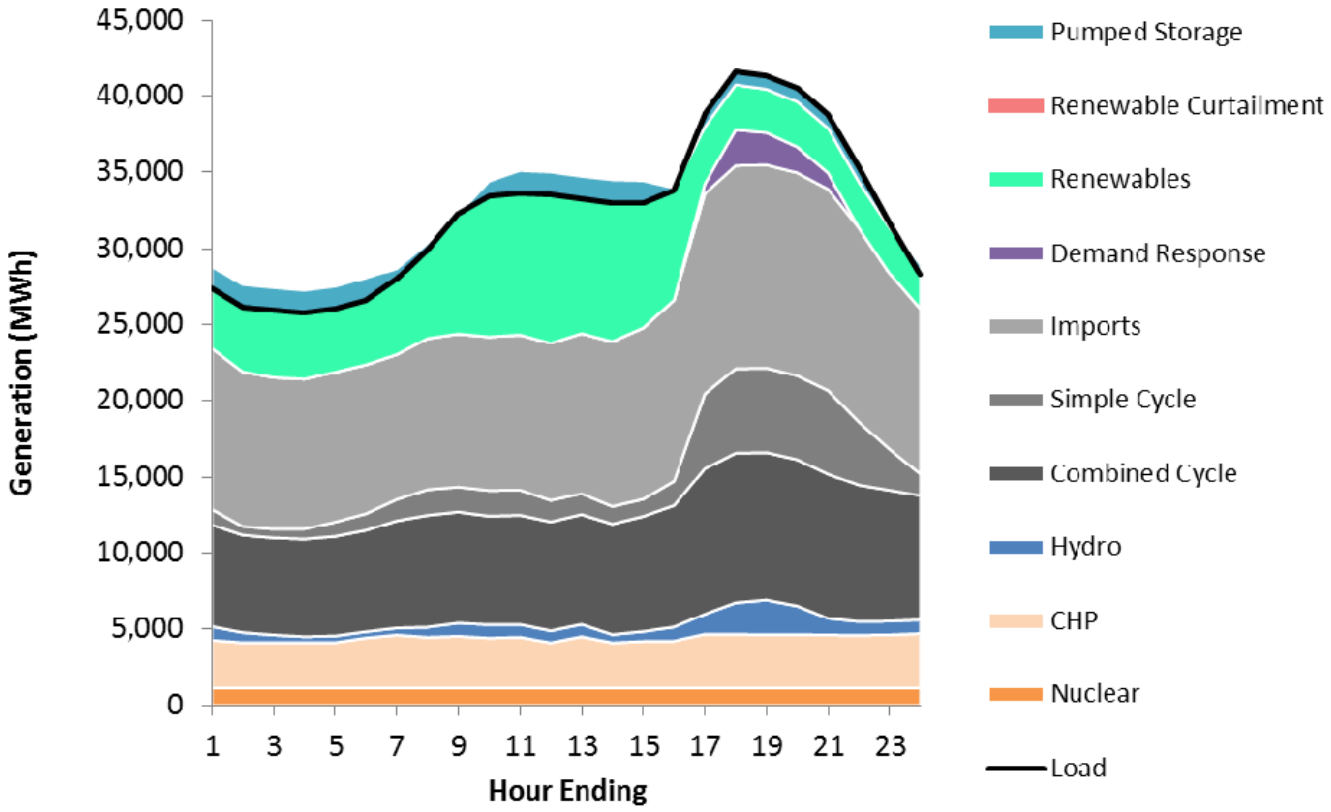




Day with the largest net load ramp

+ December, weekend, high-load and solar draw

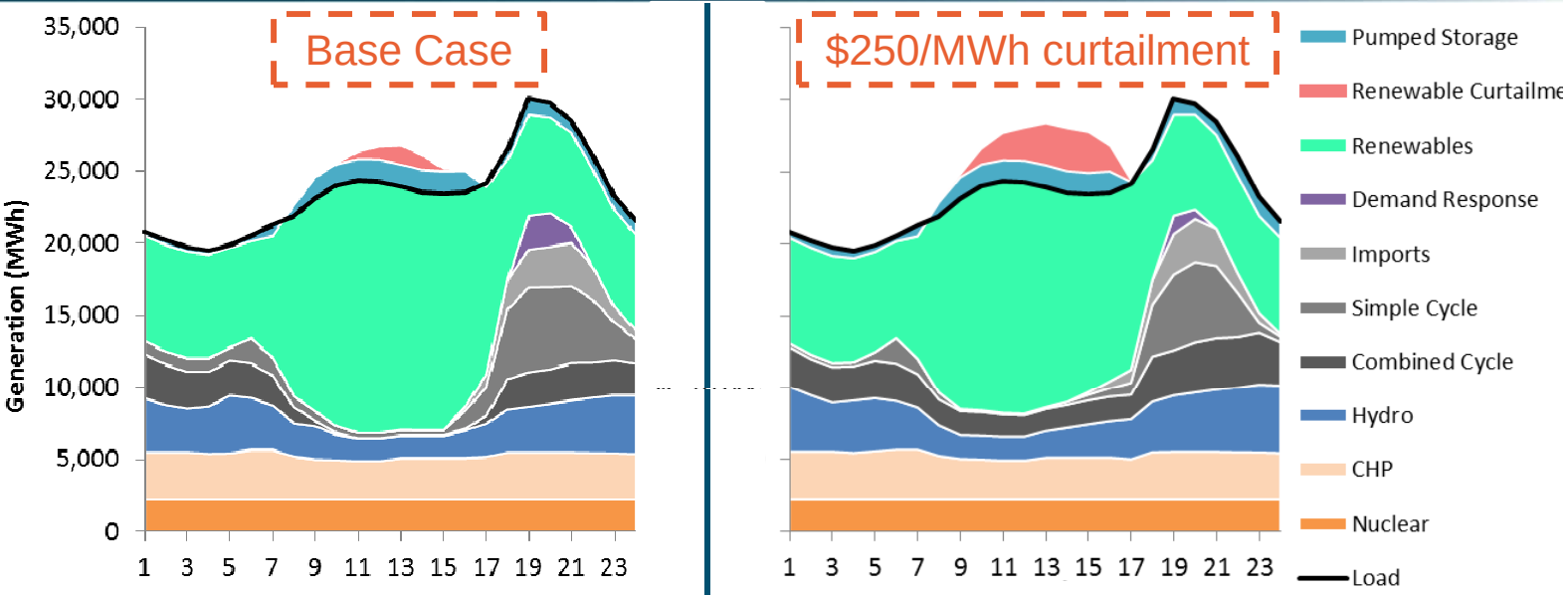
- Single largest 1 hour net load ramp of the year
- Upward flexibility reserve shortages recorded at HE 18-20



Low-load, high hydro, high solar draws

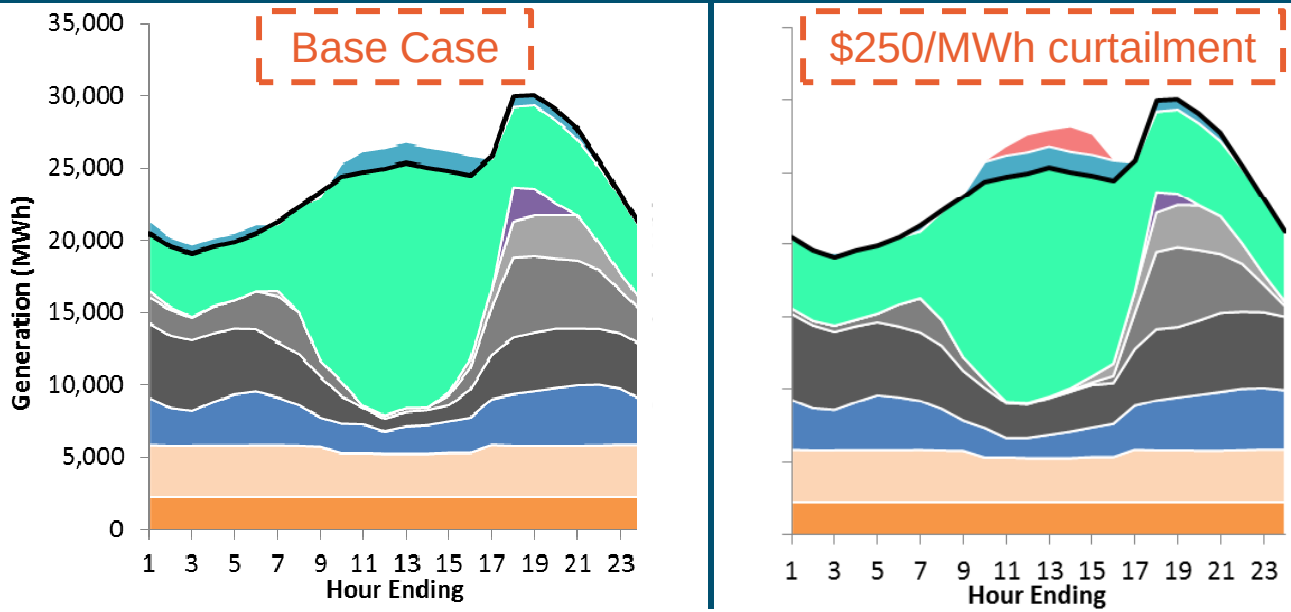
+ April
+ Weekend
+ Low-load
+ High hydro
+ High solar

Draw 279



+ February
+ Weekend
+ Low-load
+ High hydro
+ High solar

Draw 262



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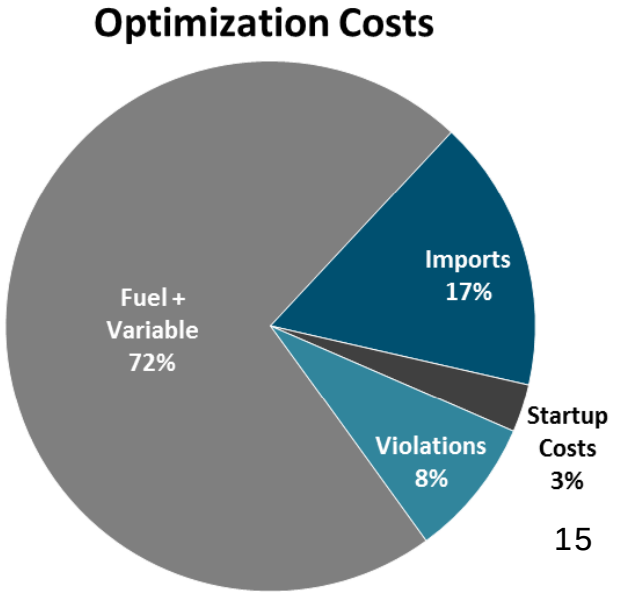
Very preliminary results

- No unserved energy
- Annual production cost of $5,100 MM/year
- Annual flexibility violation costs of $475 MM/year
- Next step: test effect of new flexible resources

Violation costs shown for illustrative purposes and are extremely sensitive to cost parameters

Violation Type	Expected Violations (MWh/yr)
Regulation Up	2,255
Regulation Down	4,767
Spinning Reserves	0
Upward flexibility	420,100
Downward flexibility	228,780
Curtailment	4,906
Total	660,807



Conclusions

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- **Integration challenges are significant at 33% RPS**
- **Too early to say whether the benefits of additional flexible capacity would outweigh the costs**
  - E3 working with the CAISO within the CPUC's Long-Term Procurement Planning proceeding
  - Next step: add flexible resources and measure change in total cost
- **Overgeneration is likely to be a significant issue**
  - Will need mechanisms for managing renewable curtailment
    - Market mechanisms, modifications to contracts, payment provisions
  - California may be looking to export energy during spring and early summer when loads are low and wind, solar and hydro are all high
- **Regional coordination helps reduce burdens for all**

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Thank You!

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