Operating Flexibility Metrics and Standards Project

– a California Energy Systems for the 21st Century (CES-21) Program

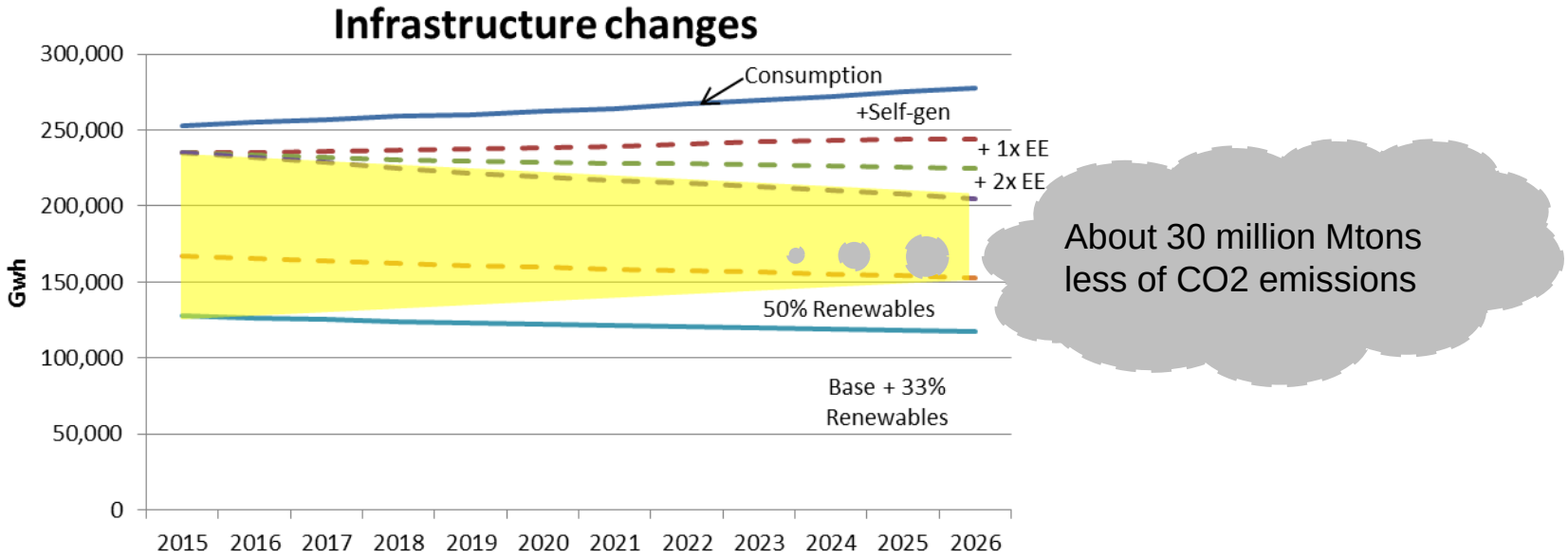
2016 Workshop on
Strategies for Energy Trends & Industry Sustainability
PG&E, March 31, 2016

Key messages

- California's electric infrastructure is changing to provide cleaner, and affordable, reliable service to customers
- These changes create challenges and opportunities about the system's operating flexibility
- On-going research provides early indications about where challenges and opportunities exist
- Operating flexibility challenges/opportunities are primarily an economic (not a reliability) issue

California's electric infrastructure is changing

1. Flat or negative load growth in part due to self-gen
2. Large amounts of intermittent renewable generation
3. Double incremental energy efficiency (EE) if cost effective



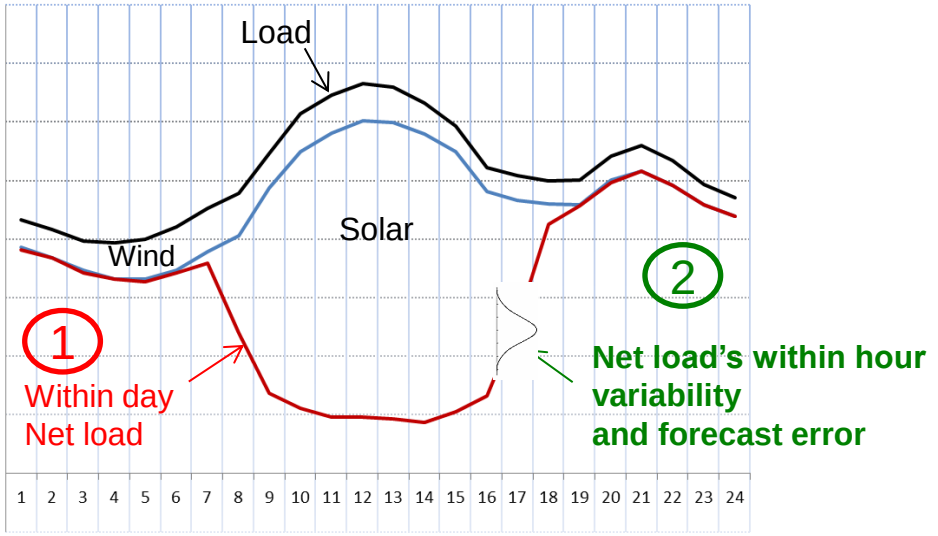
Why? To squeeze about 30 million MTons of CO2 emissions
Question: What's the least cost solution to reduce emissions, and maintain reliability by continually balancing loads and resources

Changes create operating flexibility challenges

To maintain reliability, system operators continually balance loads and resources

1. **Within day**: Forecasted load and resources must be balanced.
2. **Within hour**: During the operating day/hour, deviations from forecast must be balanced too (load, wind/solar forecast error and variability, outages)

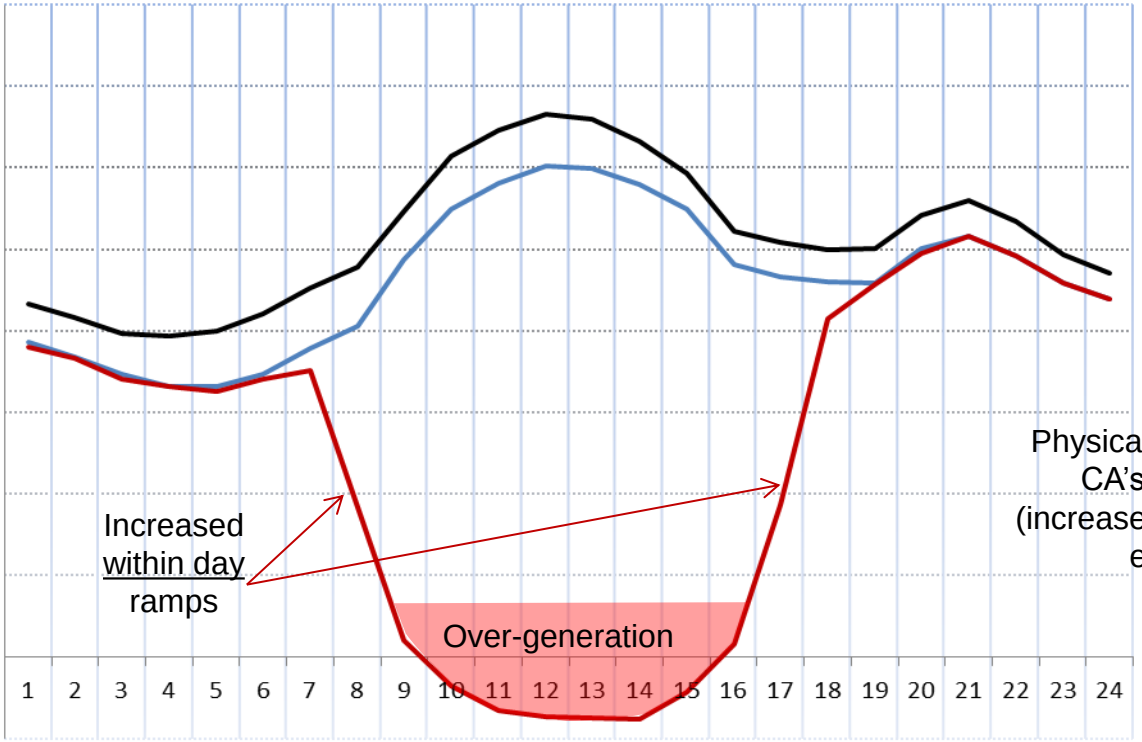
Net load in a day
(Net load = load - wind – solar)



Research question: Should planning standards change to ensure sufficient operating flexibility is available to the system?
Preliminary finding: The system is reliable and has flexibility if it is able to curtail excess solar and vary imports/exports -- more work to test system with higher levels of renewables

More on operating flexibility challenges

The bulk of the flexibility need is day-ahead or within the day (10,000+ MW higher ramps)

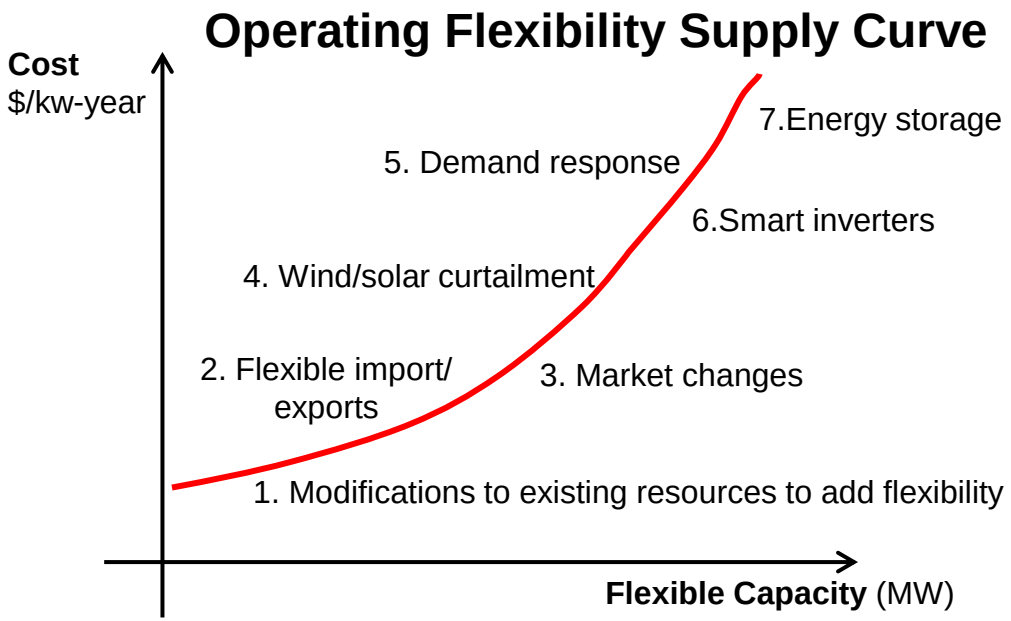


Physical and financial stress on CA's gas fired resources (increased starts/cycling, reduced energy revenues)

Additional reserves to manage the intermittency within the hour (1000+ MW)

Opportunities

1. Efficient and flexible powerplants
2. Flexible imports and exports
3. Market changes
4. Renewable curtailments
5. Demand response
6. Smart inverters to curtail surplus solar or manage intermittency
7. More storage when cost-effective



Summary

- Looking forward to a cleaner although somewhat more expensive future
- This is not a reliability problem, but an economic optimization
  - We're adding more resources than load growth; however, more operating flexibility is needed to balance loads and resources
  - Many alternatives are available to provided needed flexibility
  - We can make this a reliability problem if we manage the transition poorly and disable or exclude alternatives unnecessarily
- Operating flexibility standards could be a useful guidepost to ensure a minimum flexibility is available to maintain reliability