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High Level Overview: Managing Renewables

Understanding Terms

- Firm capacity, non-firm capacity
- Fully dispatchable, semi-dispatchable, non-dispatchable
- Intermittent, variable, stochastic, uncertain
- Predictable, forecast
- Deterministic, probabilistic

Conventional Power Plans versus Renewable Resources

Conventional Bulk	Renewables
Firm capacity	Non-firm or semi-firm
Fully dispatchable, controllable	Non-dispatchable to semi-dispatchable
Inertia	Inertia-less
Unlikely discrete failures taking entire plant out	Frequent minor – moderate changes
Unlikely correlation with other outages and conditions	Weather dependent with correlation with other weather dependent resources and demand
Single, large plant	Many smaller units (e.g., wind turbines or solar panels in a “farm”)

Break

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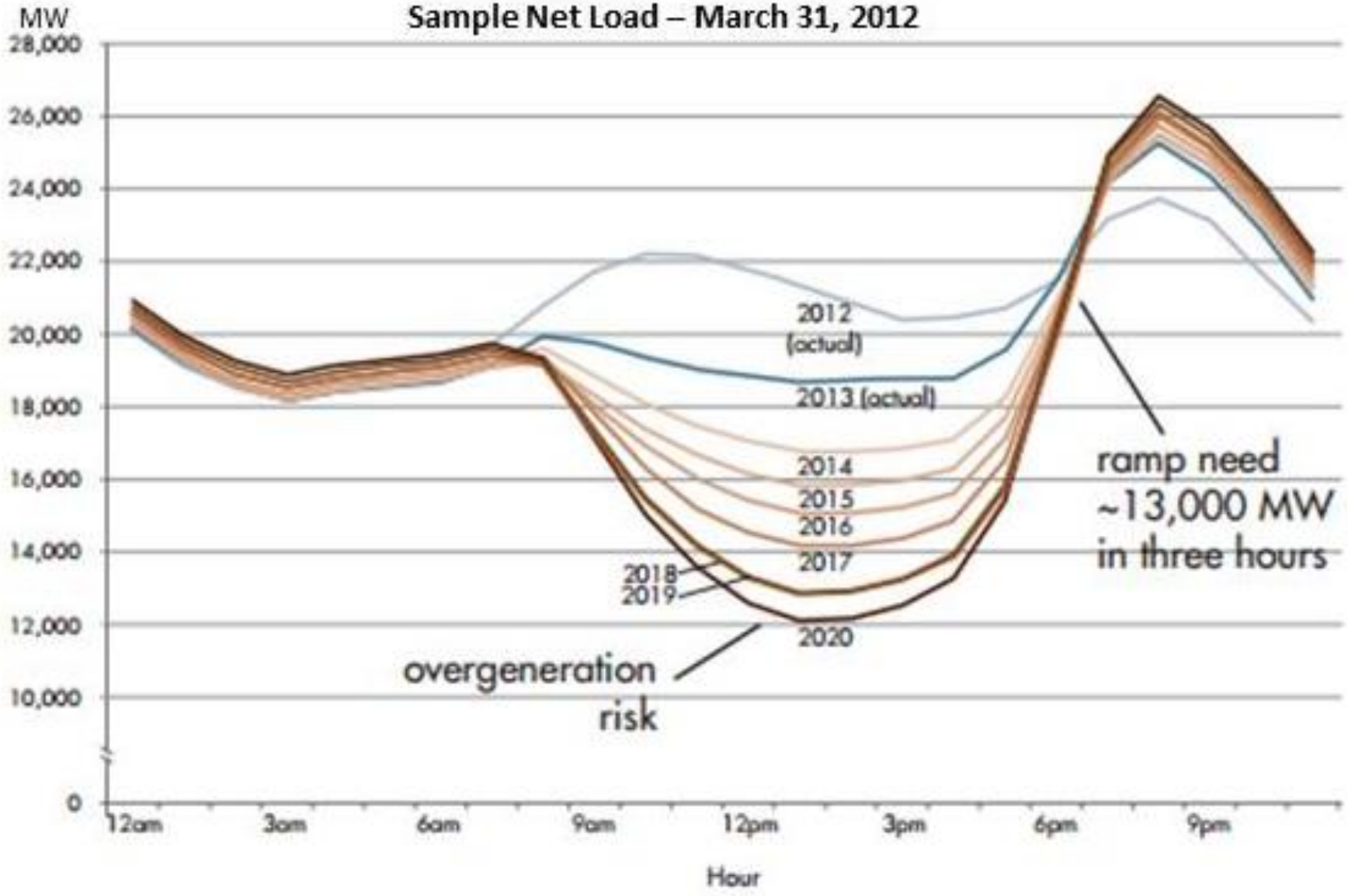
High Level Overview: Managing Renewables

CAISO

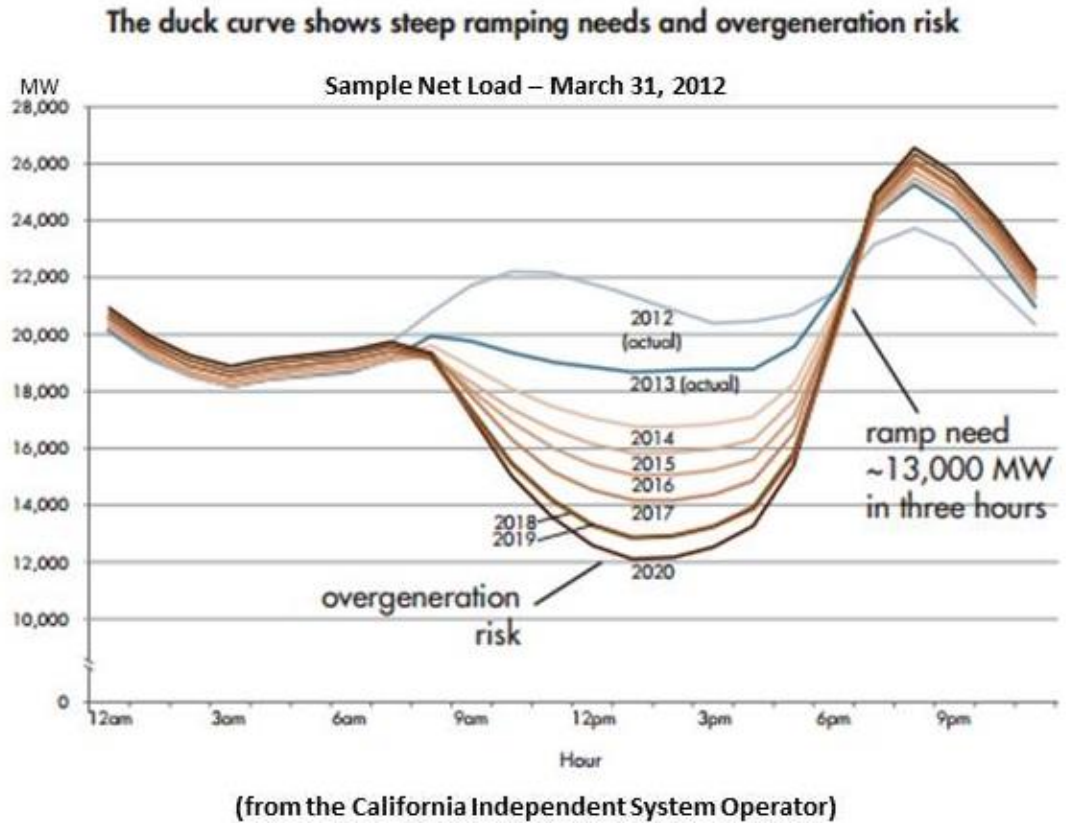
The duck curve shows steep ramping needs and overgeneration risk



(from the California Independent System Operator)

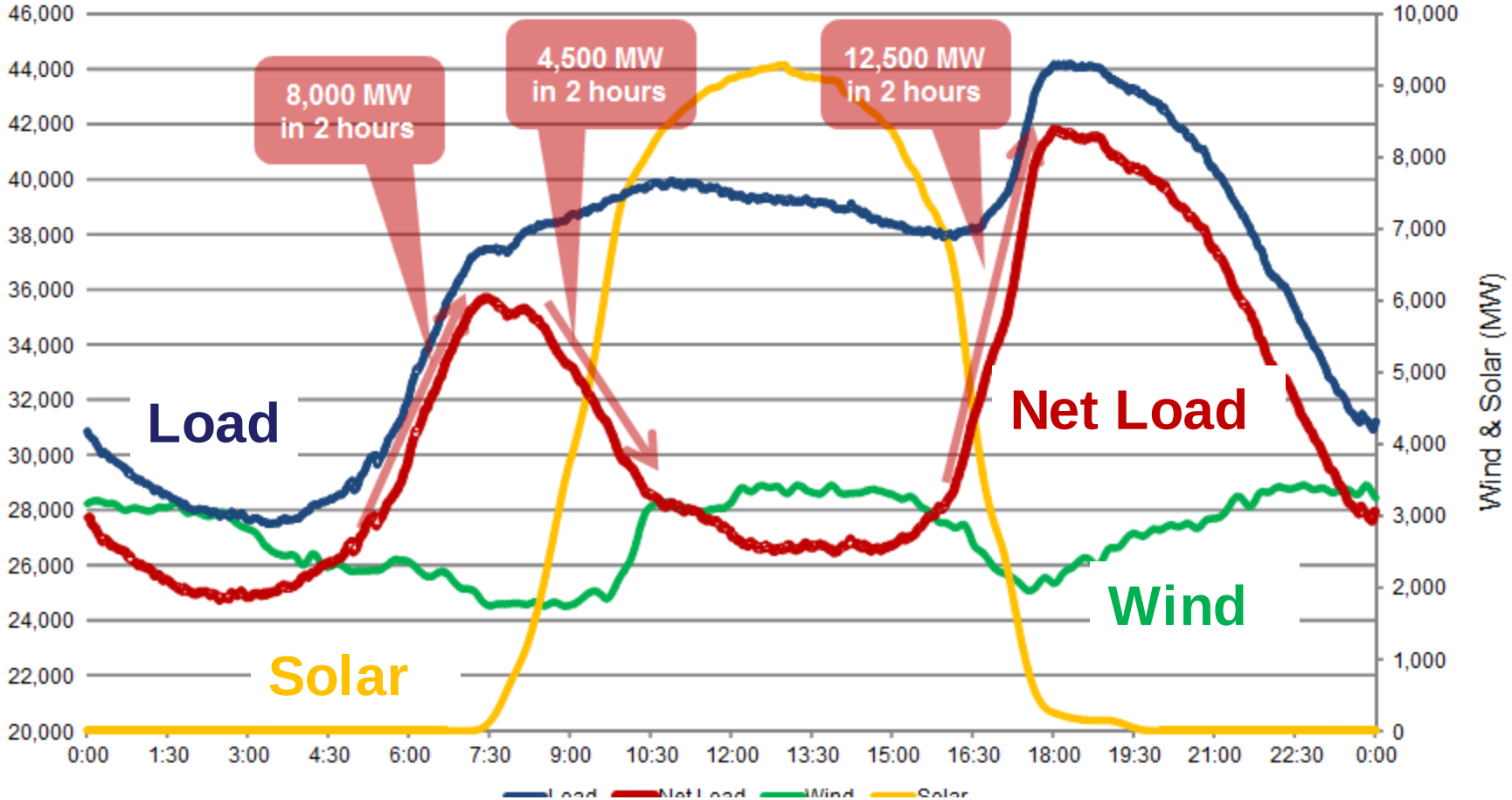
Challenges Due to Renewable Resources

CAISO's Duck Curve



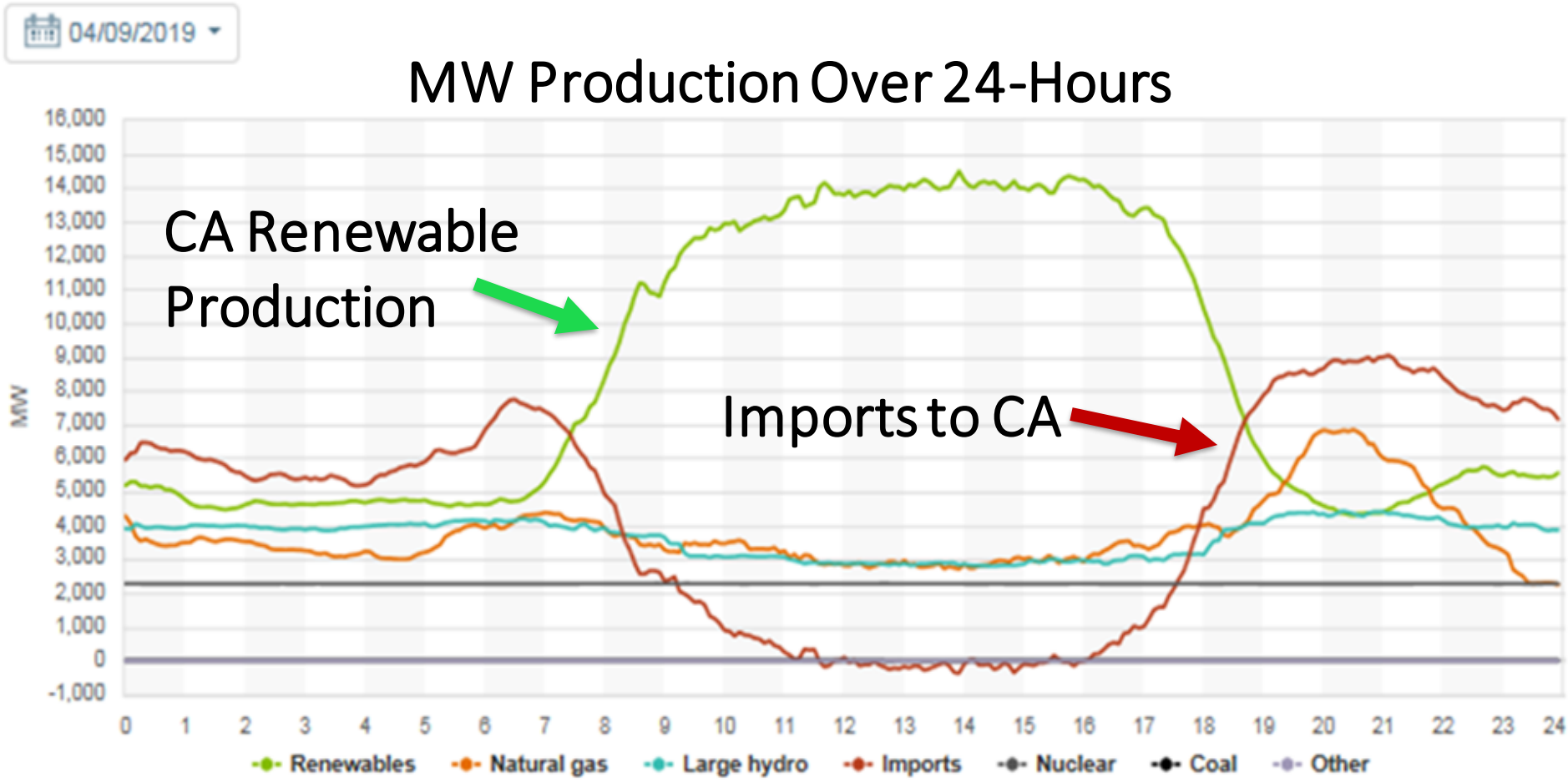
I am guessing you have all heard of this – we are going to hear about more challenges than just the Duck Curve

Massive Ramping Required California - 2020



Such ramping requirements alone are a challenge, let alone the locational requirements

California: April 9, 2019
Net Imports: Providing Most of the Flexibility



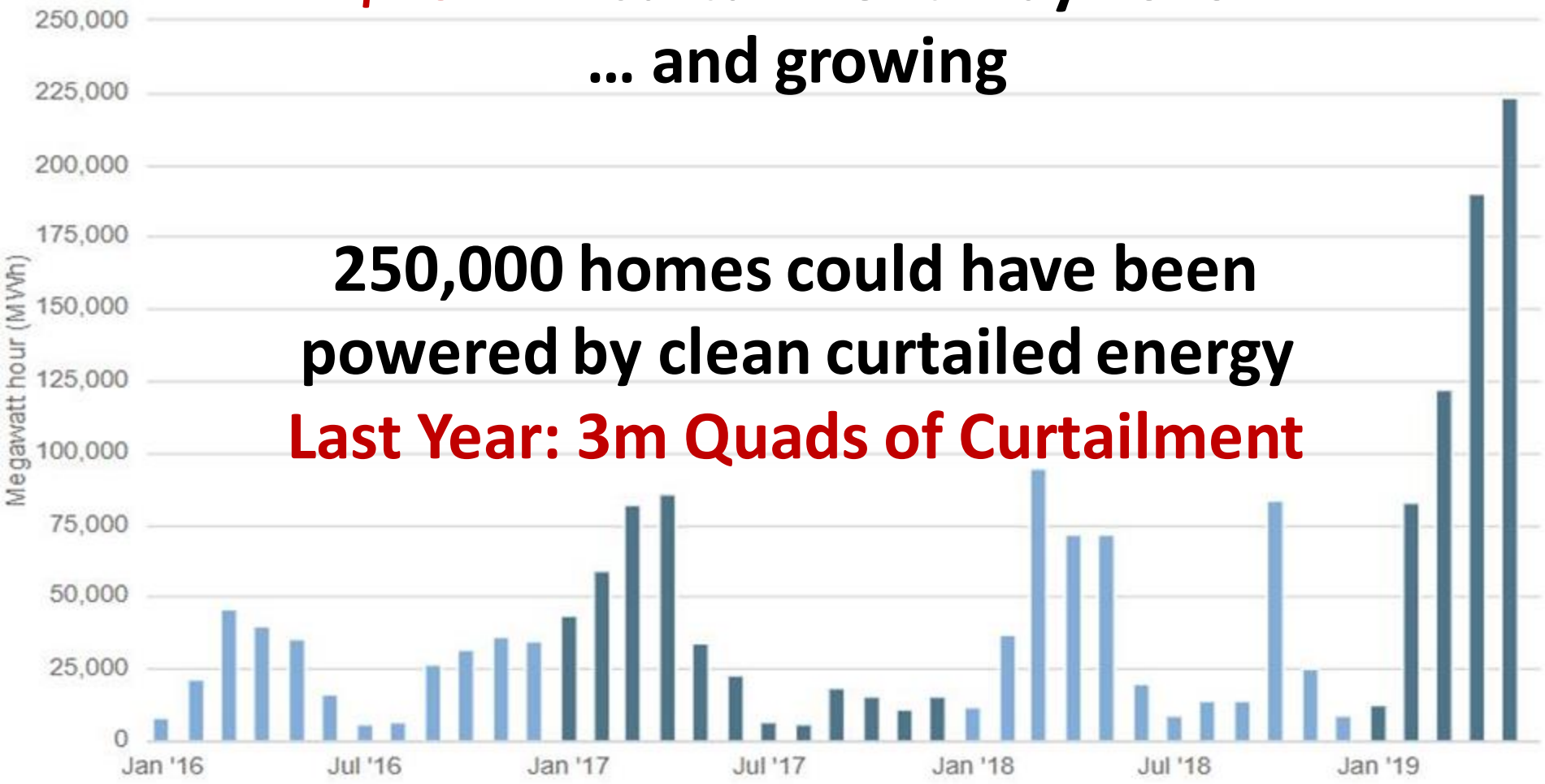
California: 2015-2019
Monthly Wind and Solar Curtailment

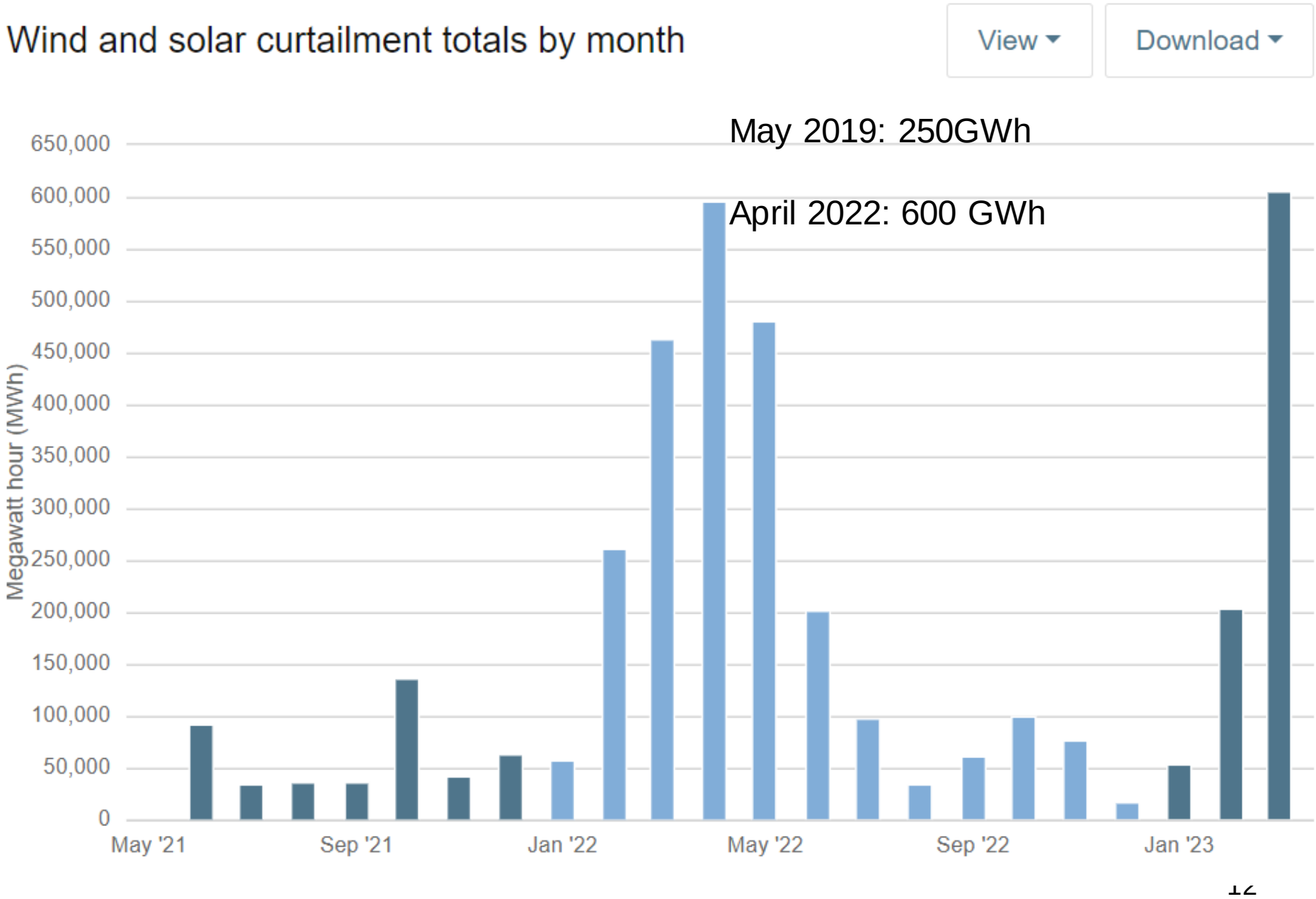
$10M in curtailment May 2019

… and growing

250,000 homes could have been powered by clean curtailed energy

Last Year: 3m Quads of Curtailment




Wind and solar curtailment totals by month
View
Download
May 2019: 250GWh
April 2022: 600 GWh
650,000
600,000
550,000
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
Megawatt hour (MWh)
May '21
Sep '21
Jan '22
May '22
Sep '22
Jan '23

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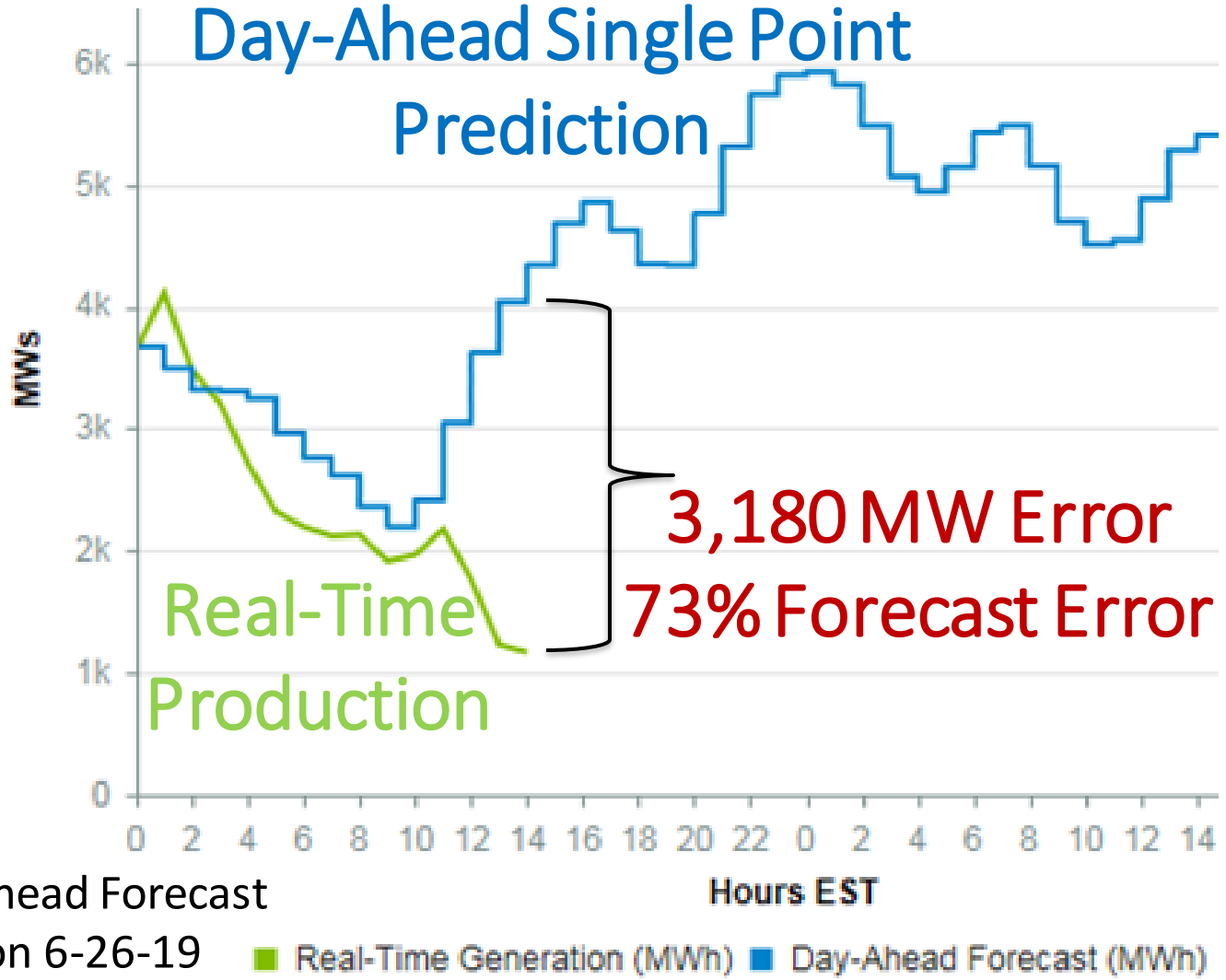
High Level Overview: Managing Renewables

MISO

Challenges Due to Renewable Resources: MISO Forecast Error

TODAY:
- Reliance on conventional generators
- Single point predictions



MISO Renewable Day-Ahead Forecast and Real-Time Production 6-26-19

Challenges Due to Renewable Resources: MISO Wind Events

- **July 29, 2018: 1MW** renewable power produce for one operational state
- **July 28, 2018: 128MW** renewable power produce over an hour
- 2018 MISO renewable capacity: **18GW!**
- MISO, "MISO 2018 Summer Assessment Report," pp. 4, Sept. 2018. Online. Available: https://cdn.misoenergy.org/2018%20Summer%20Assessment%20Report283263.pdf

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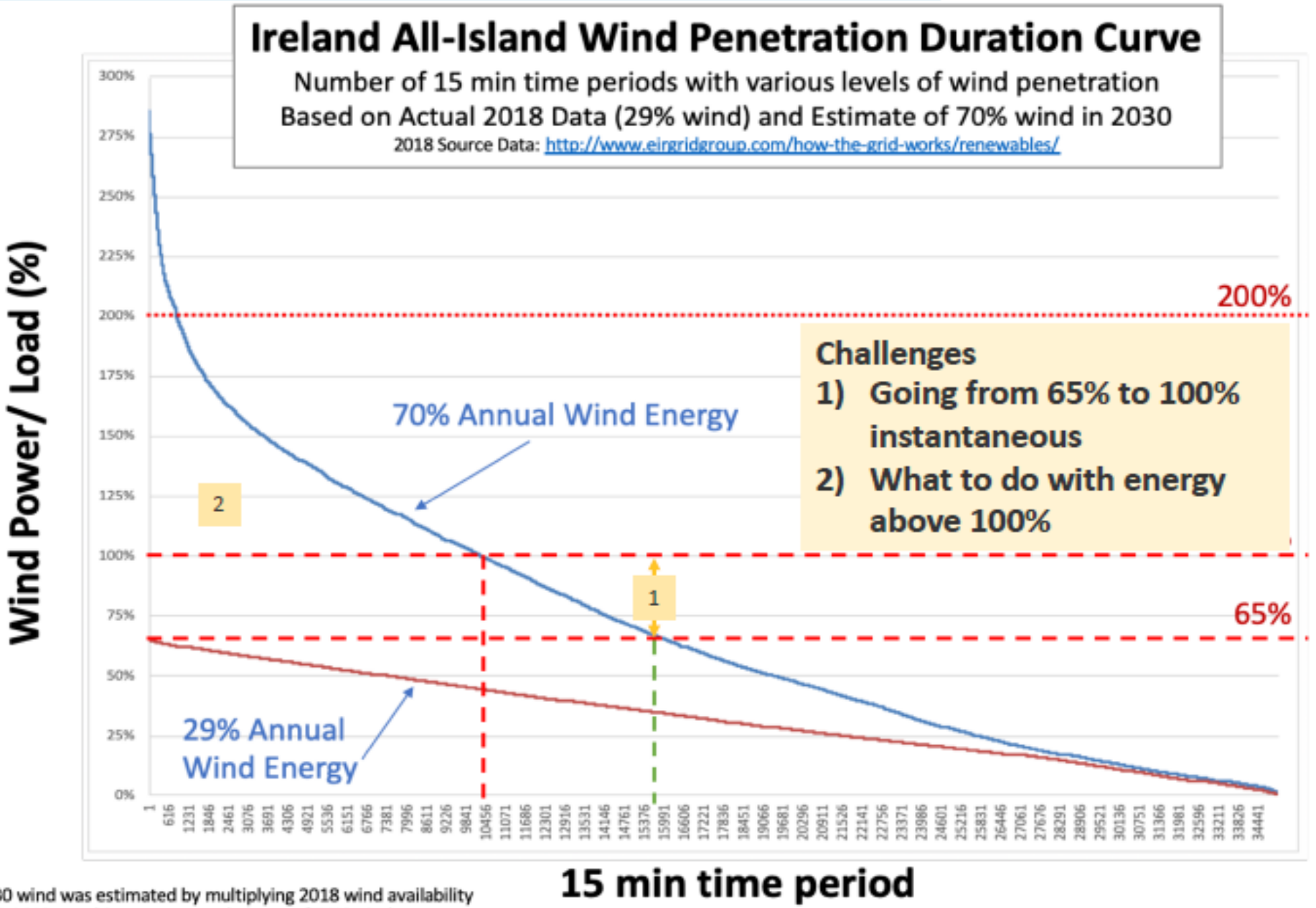
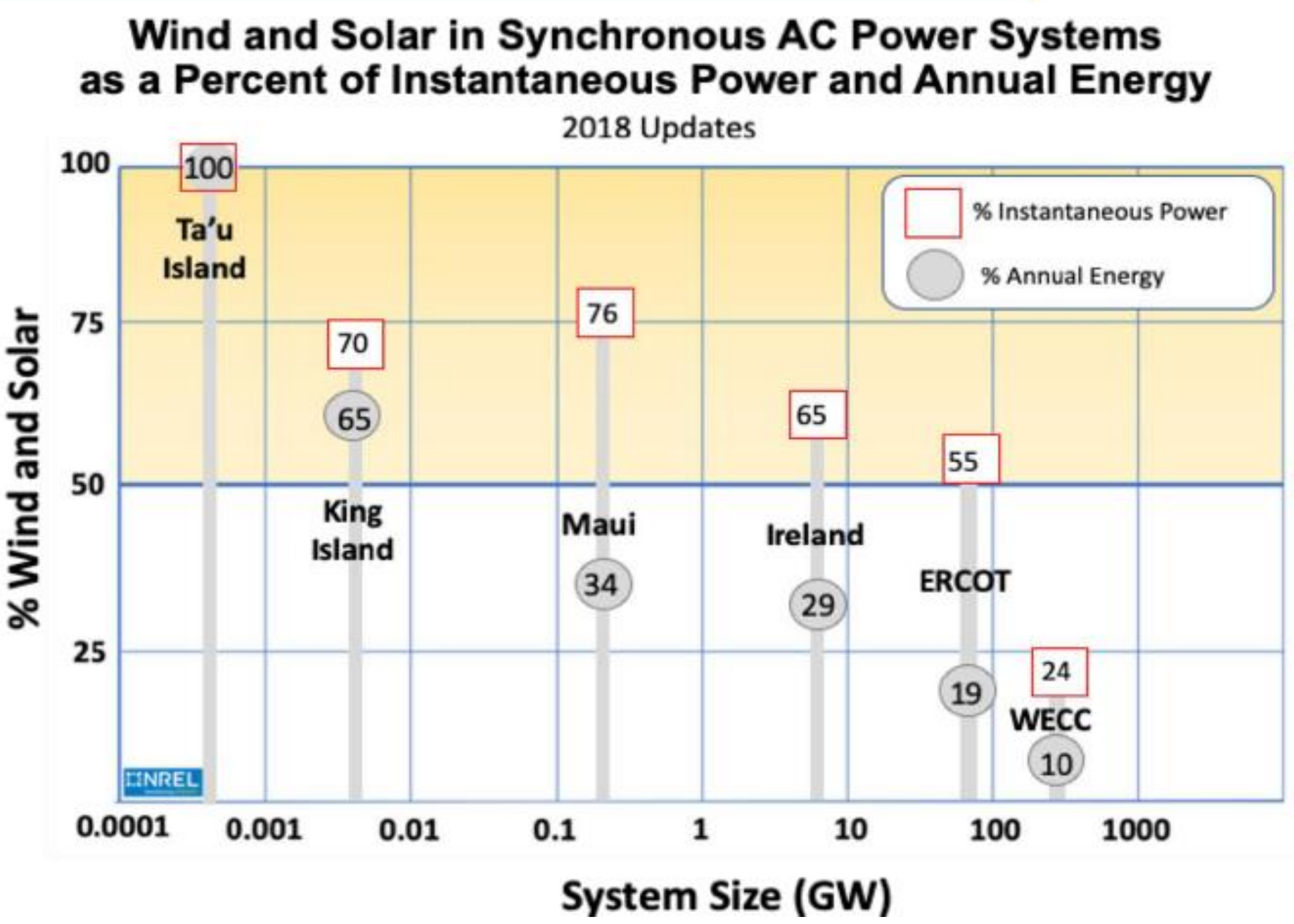
Ireland and the World

A closer look at 70% in Ireland



2030 wind was estimated by multiplying 2018 wind availability by 2.1612 to achieve an energy balance of 70% wind.

Towards higher levels of power-electronic based, variable generation



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High Level Overview: Managing Renewables

Reserves

CAISO Operating Reserve Rule

- Let's evaluate how CAISO ensures sufficient reserve
  (from before their high renewable production days)
- Consider the following operating reserve rule from CAISO (for N-1 contingencies and net load deviations)
- Operating Reserve: >=

  5% of Load met by Hydro

  + 7% of Load met by non-Hydro

  + 100% interruptible imports
  (or largest contingency)

  https://www.caiso.com/Documents/SpinningReserveandNonSpinningReserve.pdf
- Question: What does this signify?

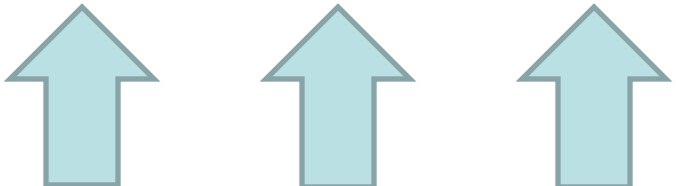
CAISO Operating Reserve Rule

- Operating Reserve: >=
  - 5% of Load met by Hydro
  - + 7% of Load met by non-Hydro
  - + 100% interruptible imports (or largest contingency)

https://www.caiso.com/Documents/SpinningReserveandNonSpinningReserve.pdf

- Question: What does this signify?
- Hydro is more likely to deliver as expected?
- Question: what about other resources or individual hydro units?
- Good question
- Question: where does 5% and 7% come from?
- I have no idea (and how do we know these are the right numbers?)
- I previously spoke to CAISO… this exists from long ago… and was roughly chosen

- We need to expand our understanding of and ability to quantify, in a transparent manner, asset performance risk
- Room for improvement… even for conventional assets and N-1



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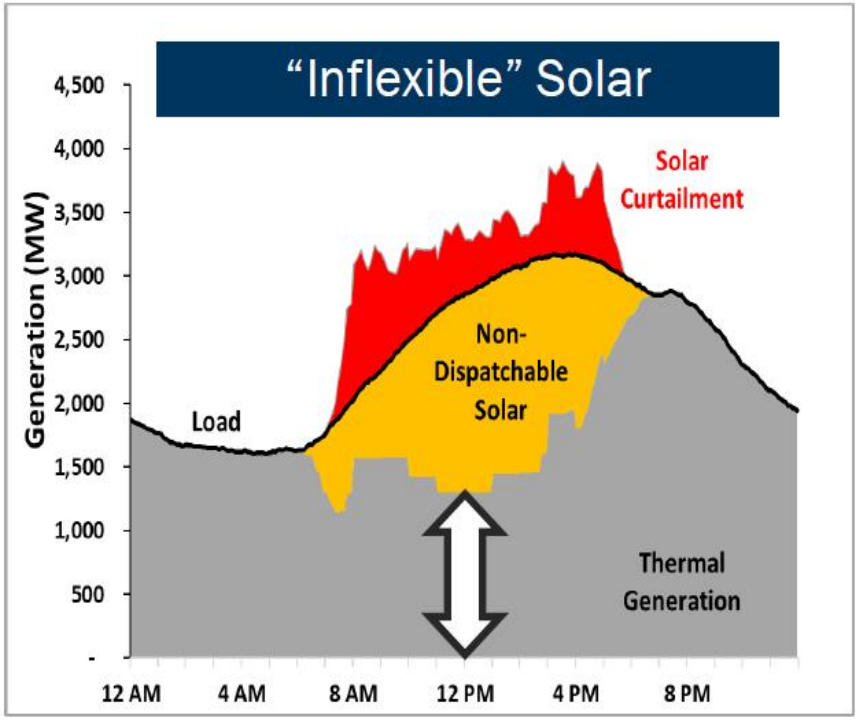
High Level Overview: Managing Renewables

Opportunities

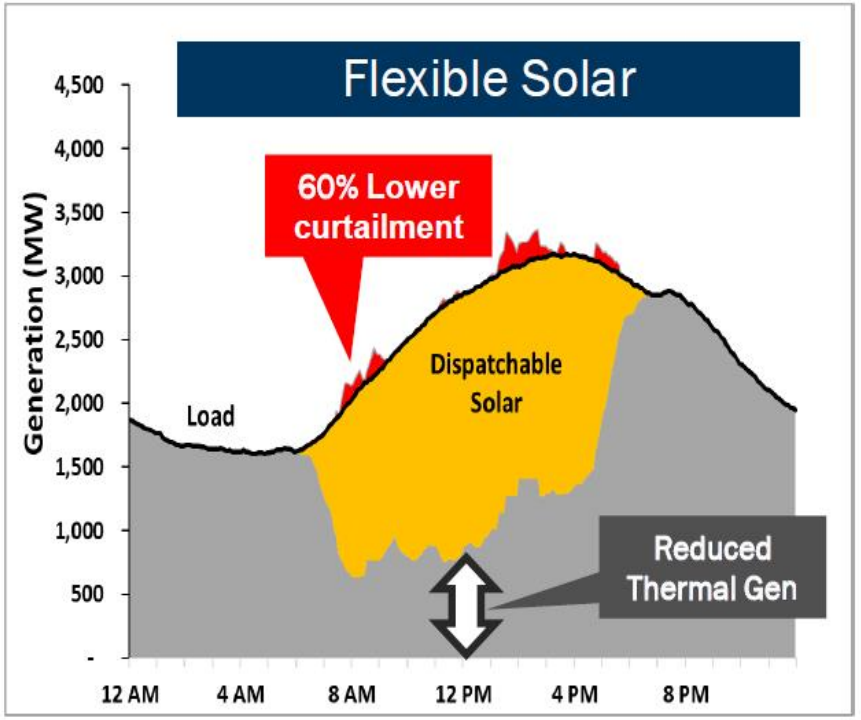
First Solar Study

Opportunities…

Flexible Solar Reduces Curtailment – An Illustration (2,400 MW Solar)



Solar Provides No Regulation Reserves



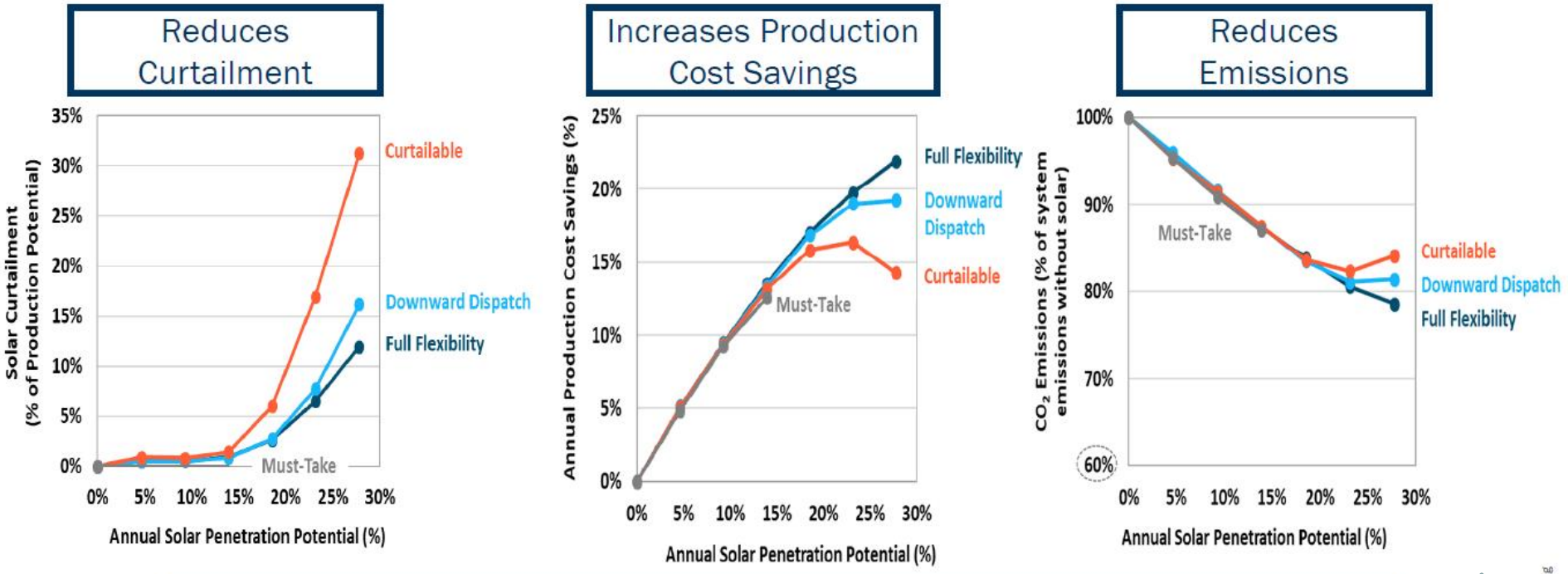
Flexible Solar: Provides regulation reserves

Source: E3,TECO, First Solar Report "Investigating the Economic Value of Flexible Solar Power Plant Operation", https://www.ethree.com/wp-content/uploads/2018/10/Investigating-the-Economic-Value-of-Flexible-Solar-Power-Plant-Operation.pdf

Must transition to flexible renewables: mindset must change

Dispatchable Solar Saves System Costs

First Solar Study



Flexible dispatch for utility-scale solar resources reduces solar curtailment, fuel consumption & emissions

From First Solar

Key Messages

- Utility-scale Solar is now able to provide *grid flexibility & essential reliability services*
- Leveraging this innovative resource leads to a more efficient power system with *lower system costs and reduced emissions*
- However, *Grid Management Innovations* are needed to leverage solar flexibility given its inherent variability and uncertainty

What can we already learn?

- Renewables have distinct characteristics
- Existing paradigm designed for resources with different characteristics… itself is far from perfect for conventional resources
  - To this day, we still do not optimize over all N-1 and yet N-1 reliability has existed for how long? … the same for AC nonlinearities…
- There are challenges…
  … and opportunities