Integrating Renewables Into Daily Grid Operations

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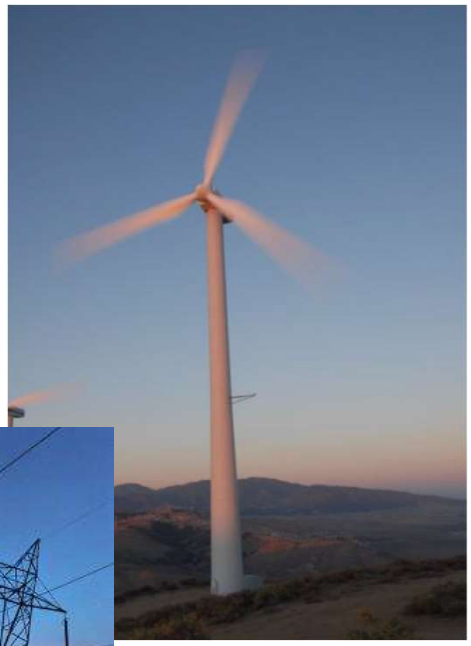
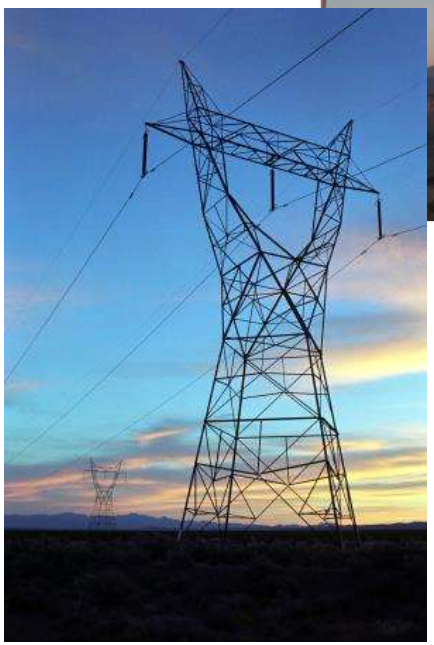
Introduction

Integrating Renewables into Daily Grid Operations

- Purpose is to identify challenges resulting from integrating renewables into daily operations
- Offer a few possible responses to challenges
- Not a presentation of study results



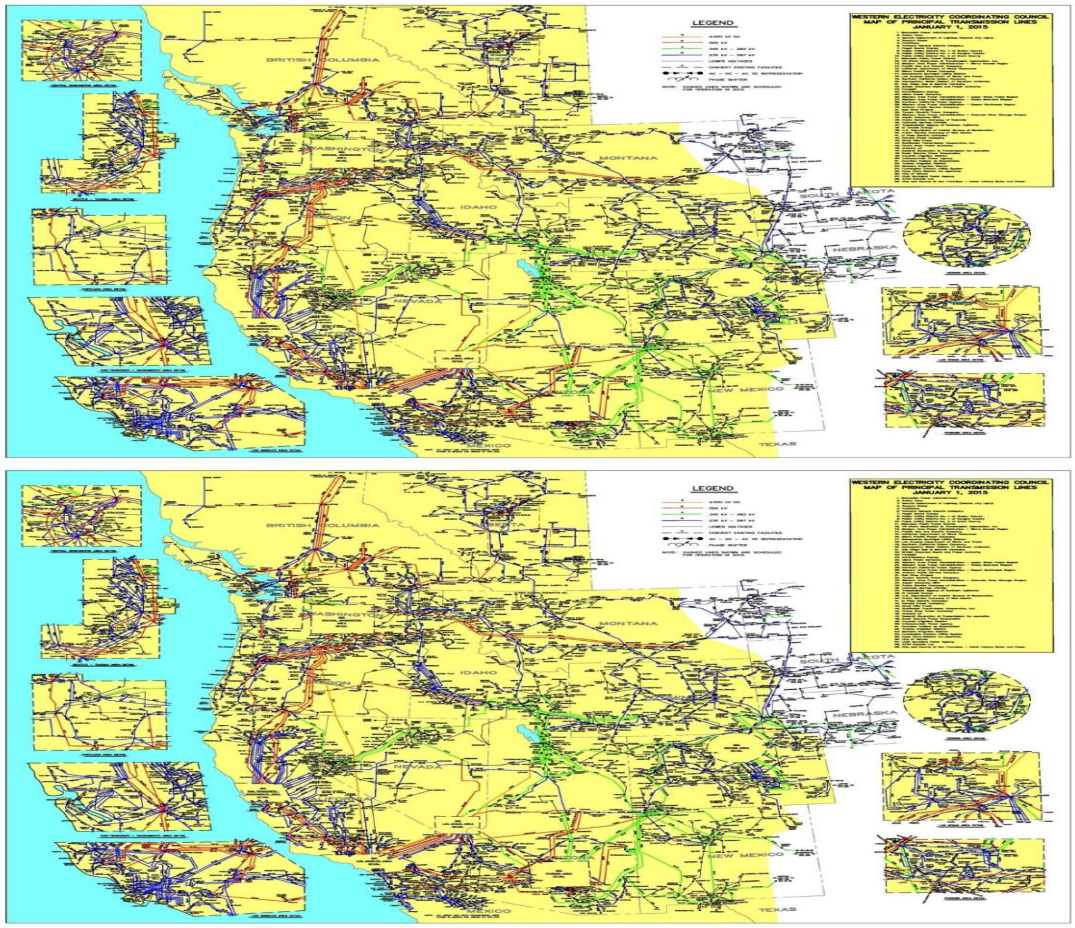


Agenda

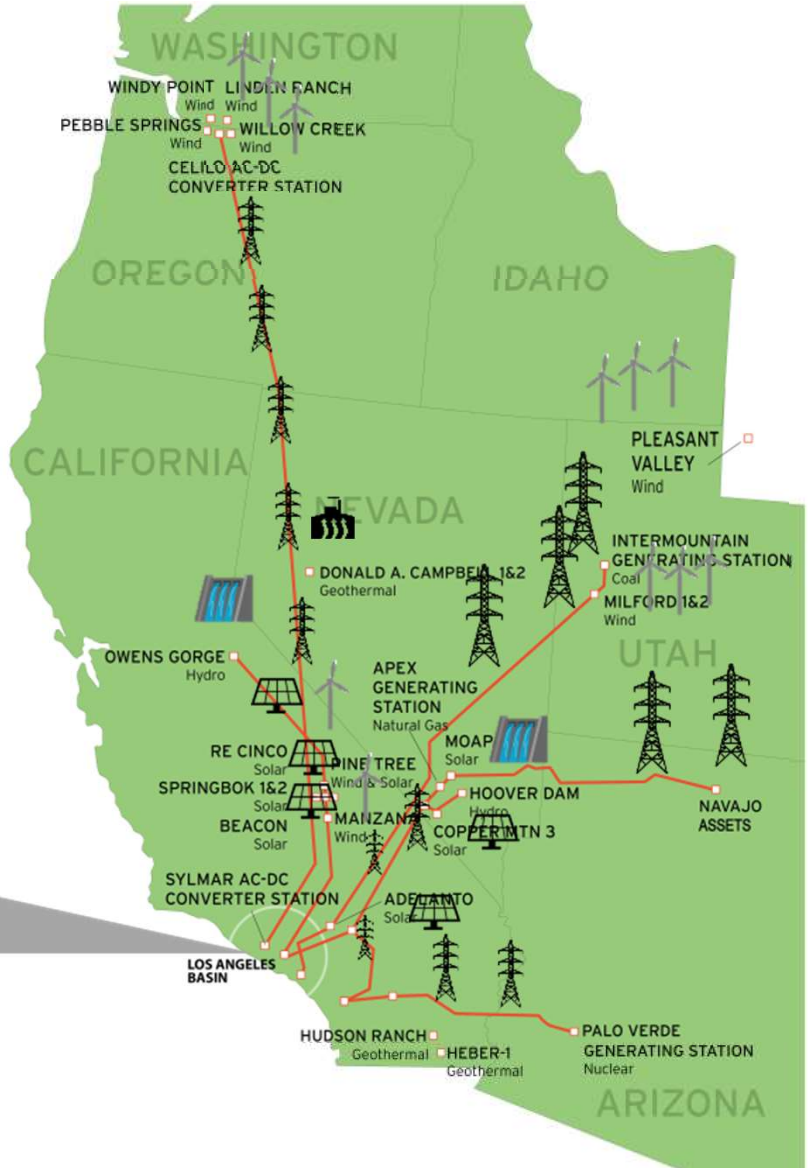
Integrating Renewables into Daily Grid Operations

- What is the ‘Grid’
- NERC Standards
- Operations without Renewables (wind, solar)
- Operations with Renewables
- Challenges that Renewables Bring
- Dealing with the Challenges

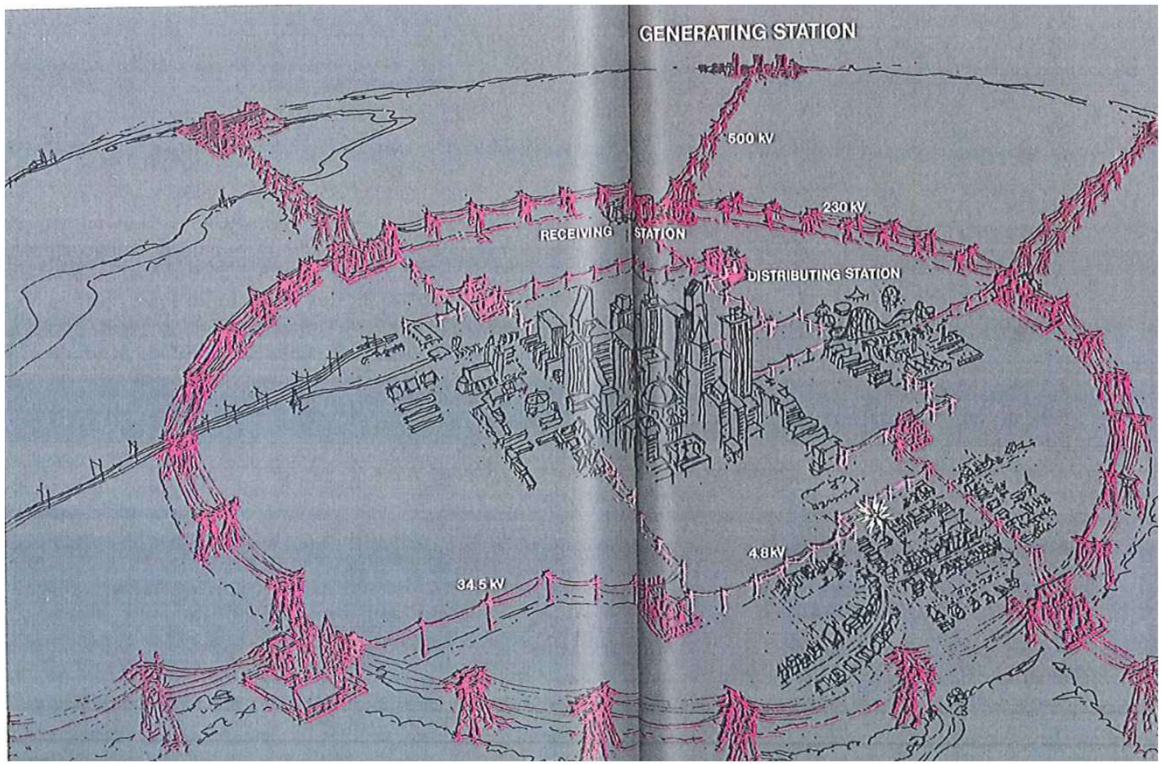
Current Power Grid



Los Angeles Power System



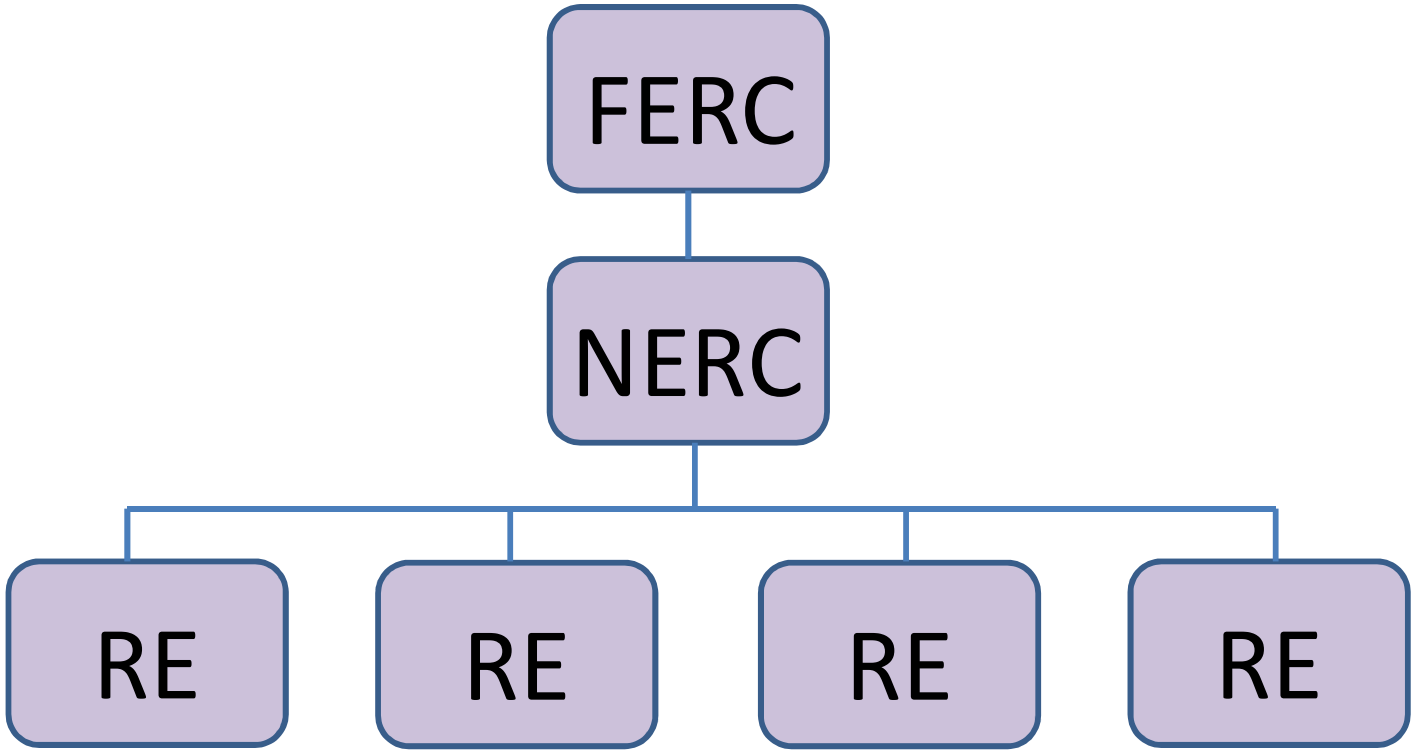
What is the “Grid”?



NERC Standards

- What is FERC?
- Federal Energy Regulatory Commission
- What is NERC?
- North American Electric Reliability Corporation
- FERC is federal agency over NERC
- NERC is over WECC

NERC Standards



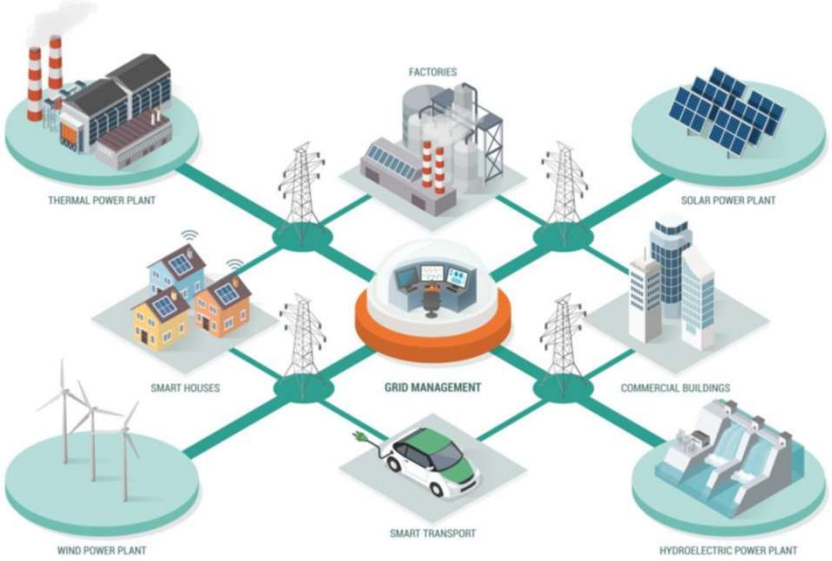
Overview of Operations

WECC is divided into many Balancing Authorities (BA):

- Main responsibility of BA:
  - Balance supply with demand (BAL-001-1)
  - California BA's: CAISO, LADWP, IID, BANC (SMUD, WAPA,TID, and others.

Power Balancing

- In the Industry, Demand = Load
- Supply = Generation
- ‘Load Curve’ show instantaneous demand over time



Real Power Balancing Control Performance

Standard BAL-001-1 — Real Power Balancing Control Performance

A. Introduction

1. **Title:** **Real Power Balancing Control Performance**
2. **Number:** BAL-001-1
3. **Purpose:** To maintain Interconnection steady-state frequency within defined limits by balancing real power demand and supply in real-time.
4. **Applicability:**

   4.1. Balancing Authorities
5. **Effective Date:** The WECC Regional Variance to NERC Reliability Standard BAL-001-1 is to be effective on the first day of the second quarter, after regulatory approval.

B. Requirements

R1. Each Balancing Authority shall operate such that, on a rolling 12-month basis, the average of the clock-minute averages of the Balancing Authority's Area Control Error (ACE) divided by 10B (B is the clock-minute average of the Balancing Authority Area's Frequency Bias) times the corresponding clock-minute averages of the Interconnection's Frequency Error is less than a specific limit. This limit ε_1^2 is a constant derived from a targeted frequency bound (separately calculated for each Interconnection) that is reviewed and set as necessary by the NERC Operating Committee.

$$AVG_{Period}\left[\left(\frac{ACE_i}{-10B_i}\right)_1 * \Delta F_1\right] \le \in_1^2 \quad or \quad \frac{AVG_{Period}\left[\left(\frac{ACE_i}{-10B_i}\right)_1 * \Delta F_1\right]}{\in_1^2} \le 1$$

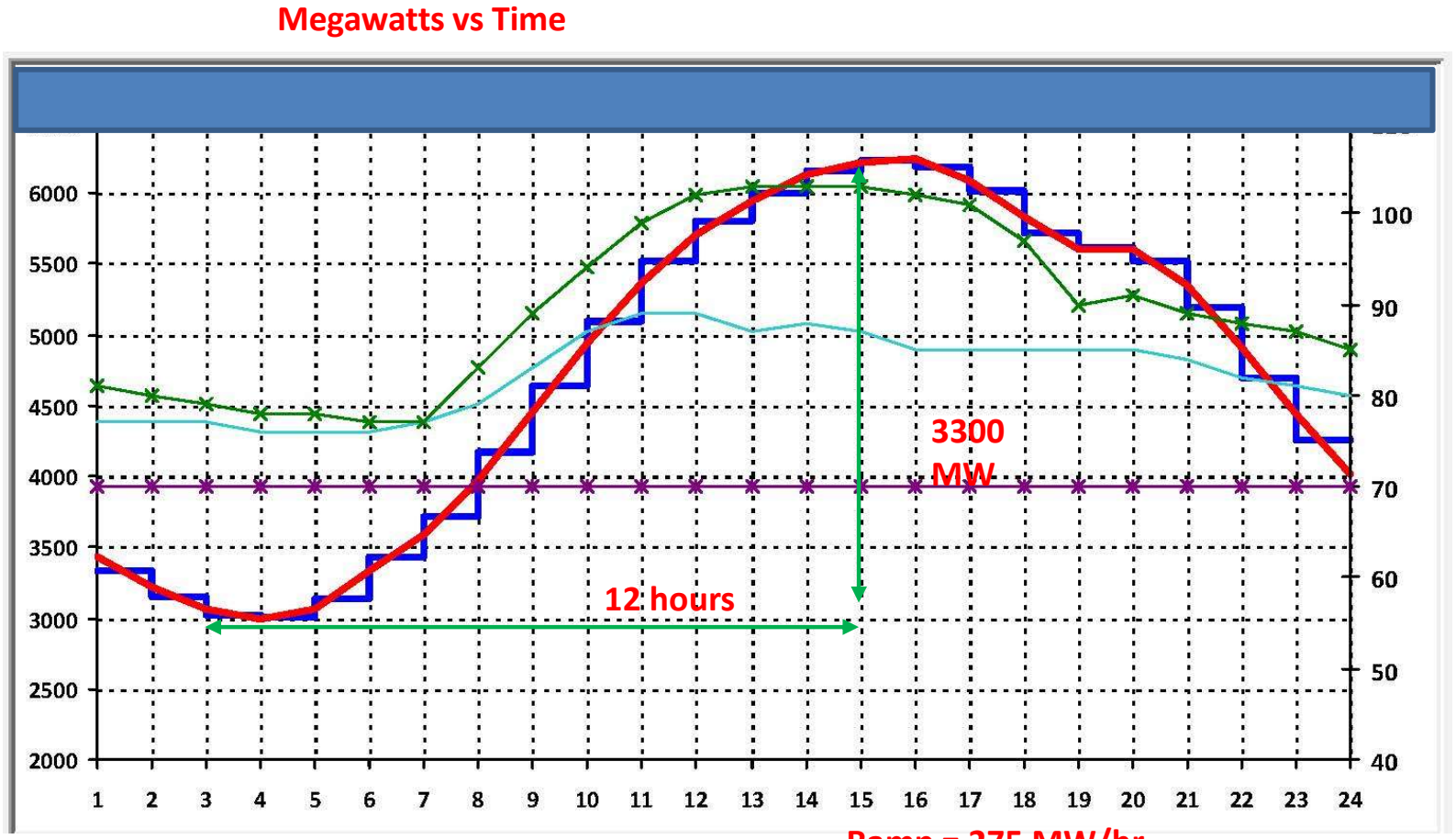
The equation for ACE is:

$$ACE = (NI_A - NI_S) - 10B\,(F_A - F_S) - I_{ME}$$

where:

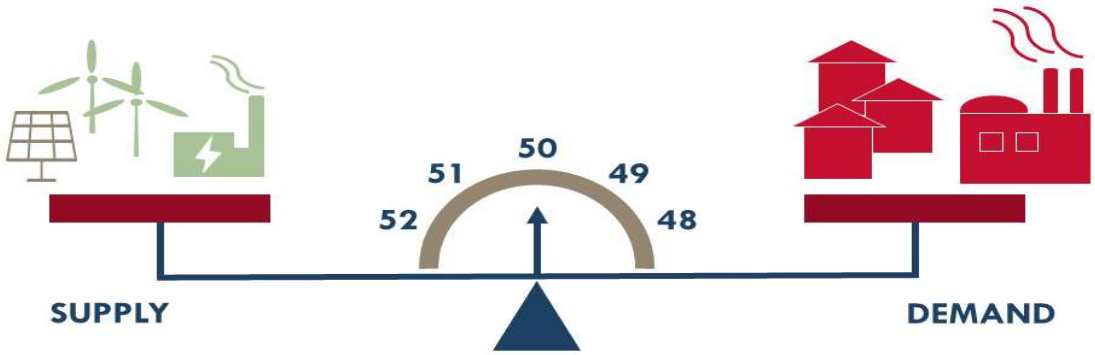
- NI_A is the algebraic sum of actual flows on all tie lines.
- NI_S is the algebraic sum of scheduled flows on all tie lines.

Load Curve for a Hot Day

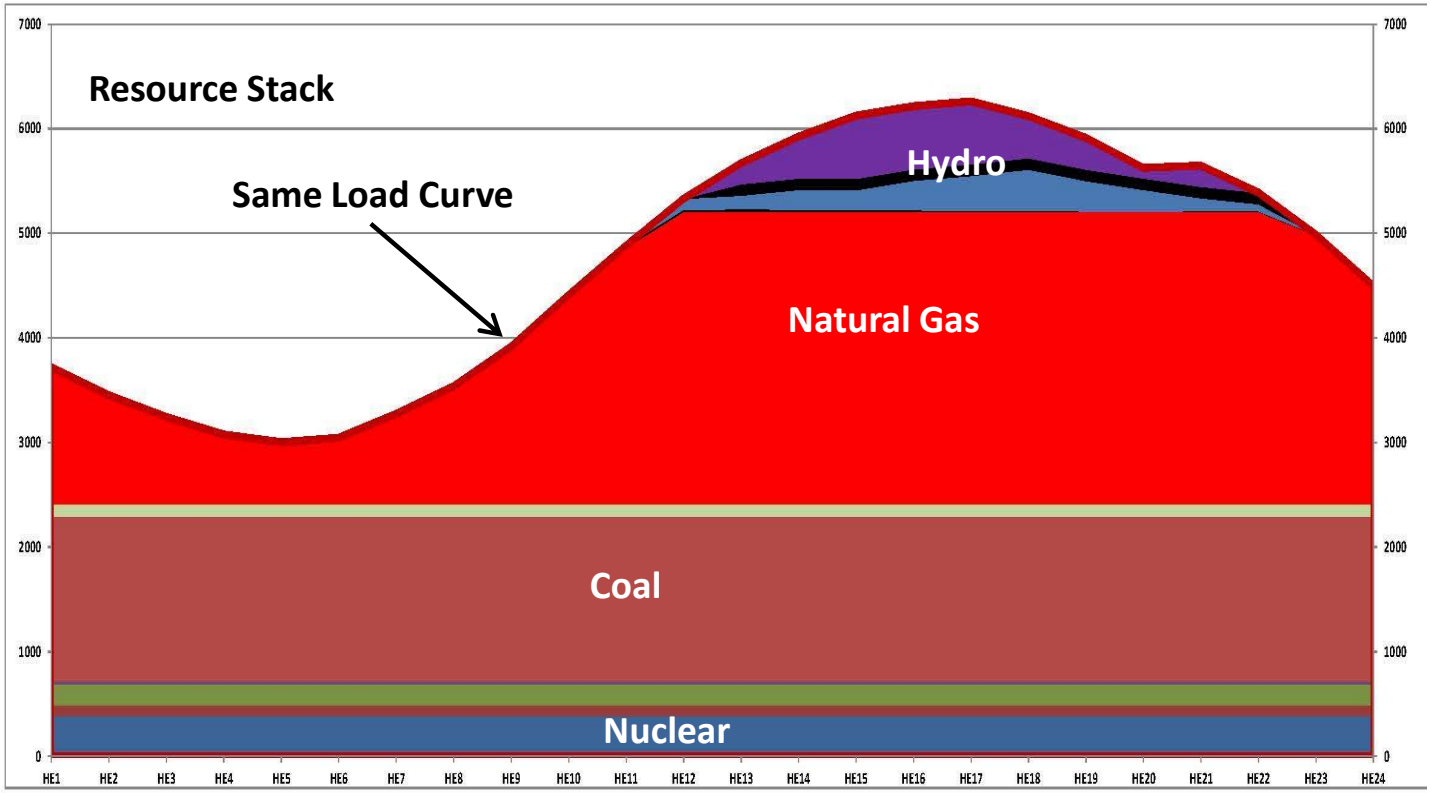


Power Balancing

- How do we balance generation and load?
  - As the load varies, Load Dispatchers or System Operators ‘dispatch’ generation to meet the load using computer tools (AGC, Econ Dispatch)
- Conventional power generation capable of being dispatched:
  - Coal, Nuclear, Natural Gas, and Hydro
  - Nuclear is base load



Balancing Operations without Renewables



Renewables

- Law recently signed by Governor Brown in 2018 (Senate Bill 100)
- Renewable energy targets:
  - 33% by end of 2020 (LADWP is on track for 39.6% in 2020)
  - 55% by 2025 (LA Green New Deal Plan)
  - at least 60% by 2030 (Senate Bill 100)
  - 80% by 2036 (LA Green New Deal Plan)
  - 100% by 2045 (LA Green New Deal Plan)
  - No coal by July 1, 2025
  - Once-through cooling natural gas phase out by December 31, 2029

Renewables

- Utility-scale solar
- Very large installations, 250 MW AC
- 1400 acres, 2 square miles
- One million 250 W modules (!)
- On clear day, output looks like this

Pine Tree
Wind & Solar

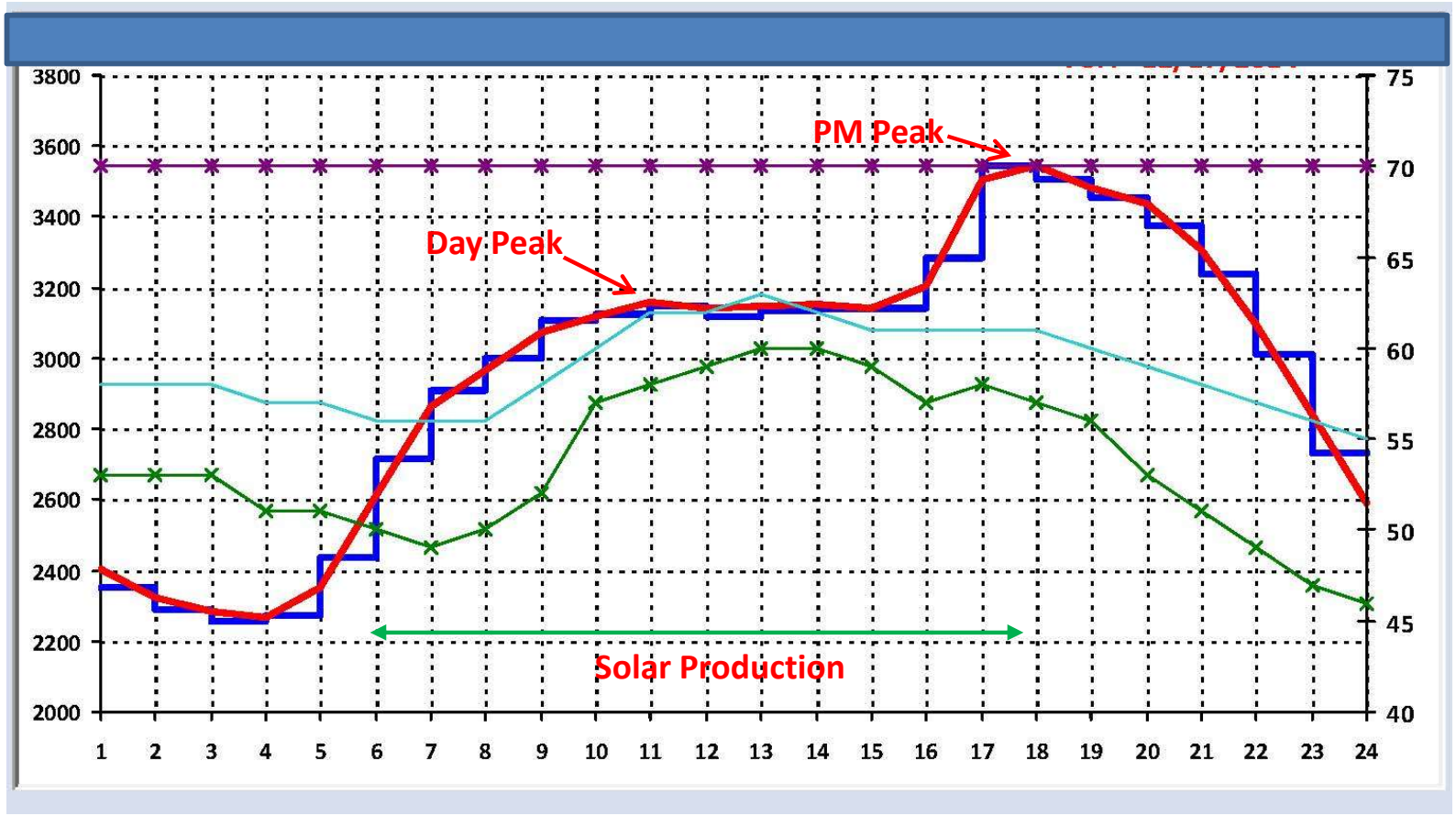
Barren Ridge Transmission

Renewables

How do we make room for smooth solar in resource stack?

Typical Winter Day

Not the Hot Day Curve



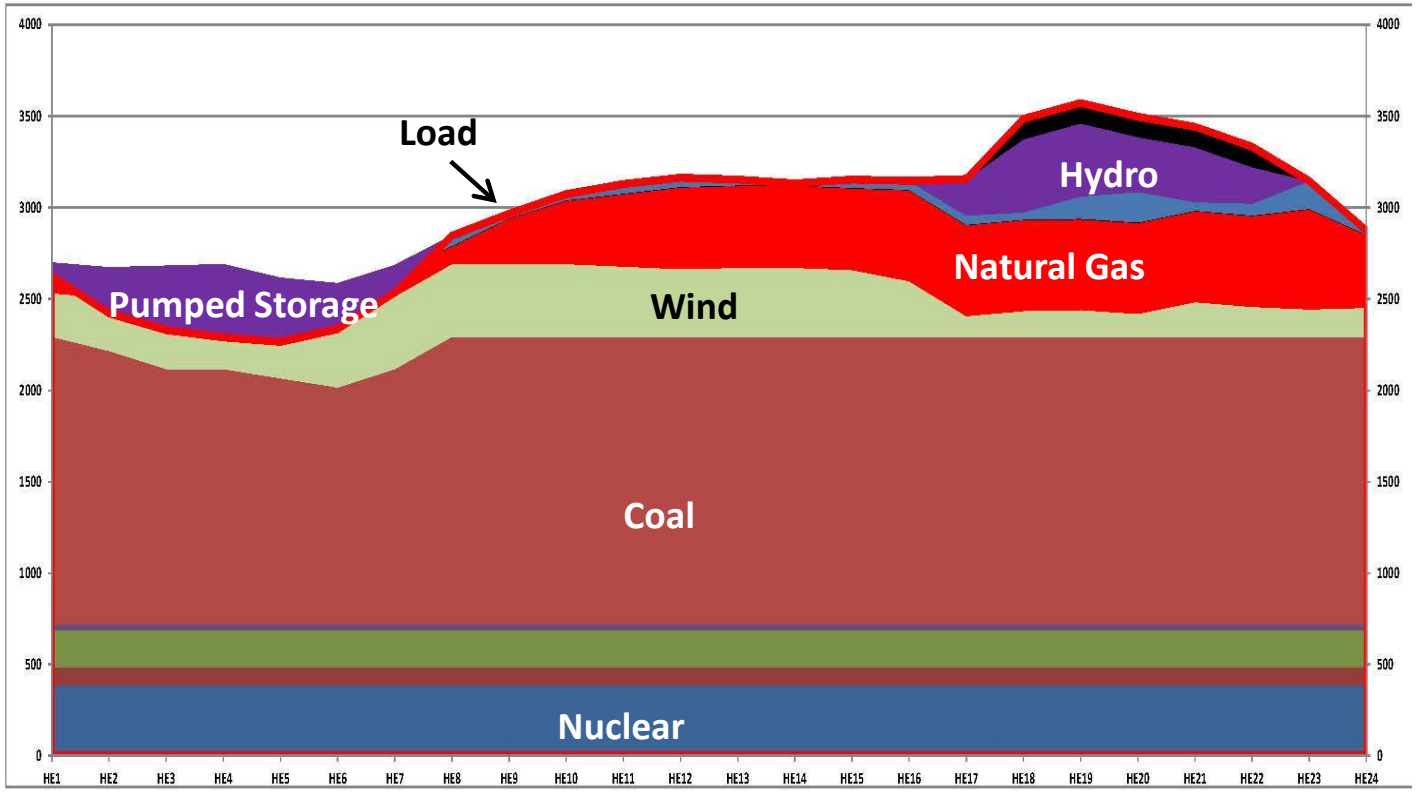
Legend

Load

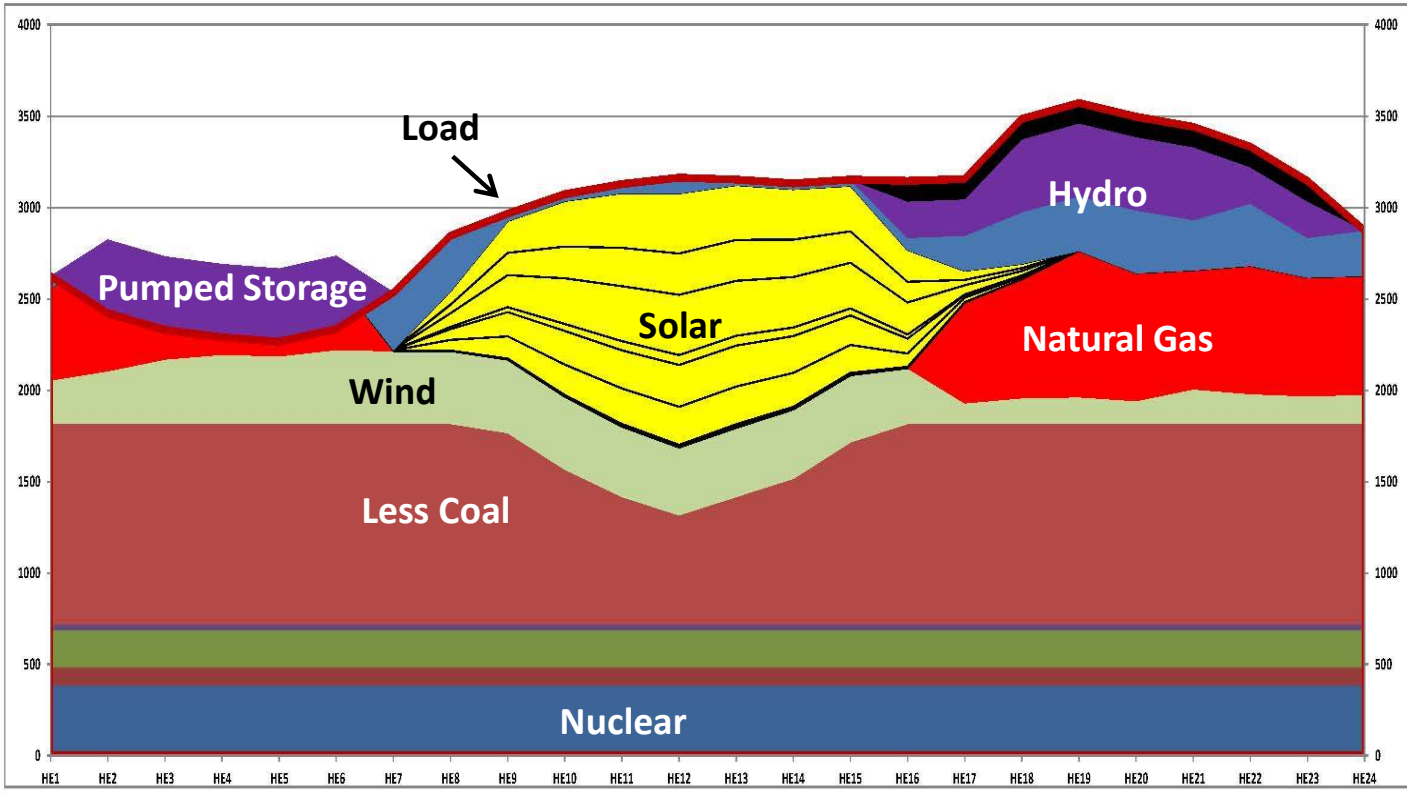
Forecast

Solar Power

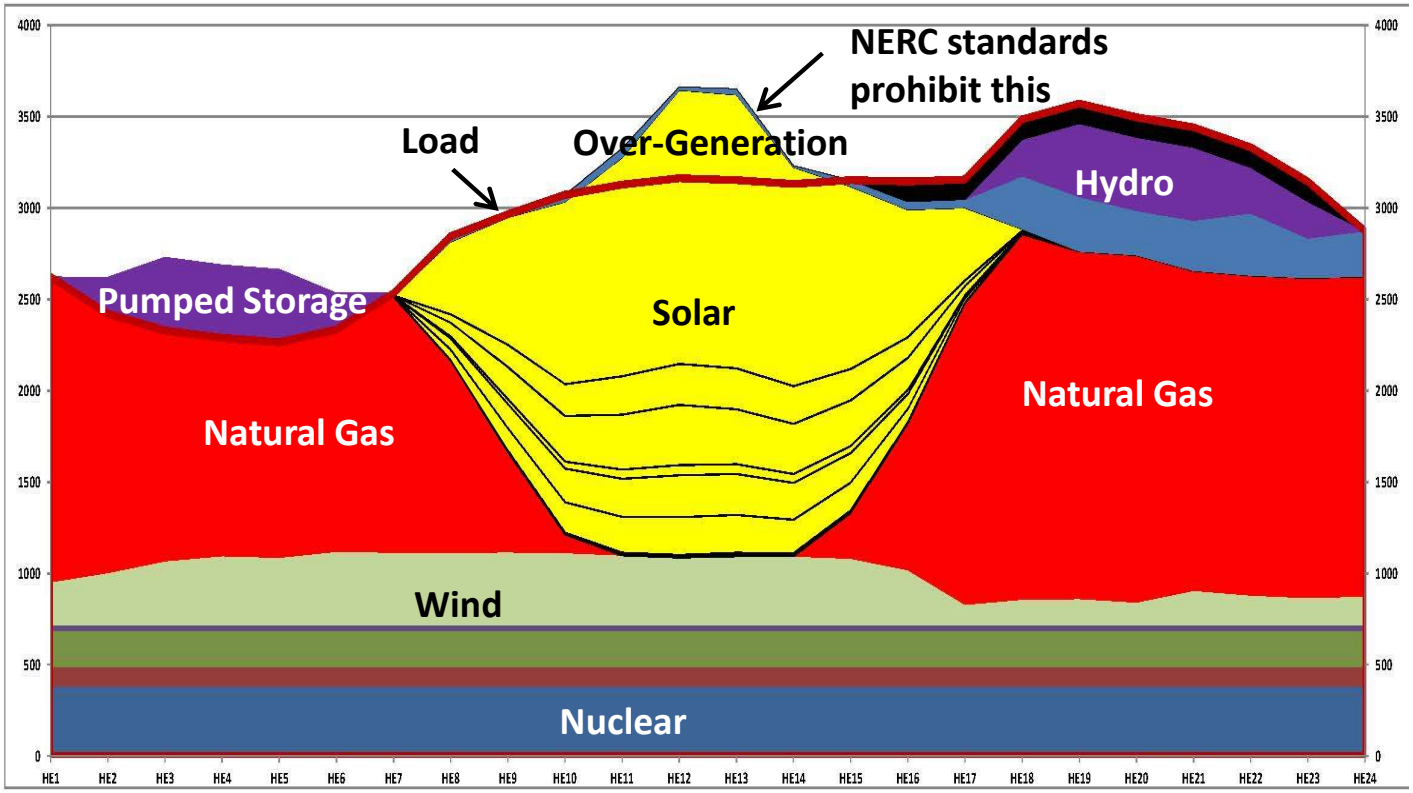
2015 Resource Stack



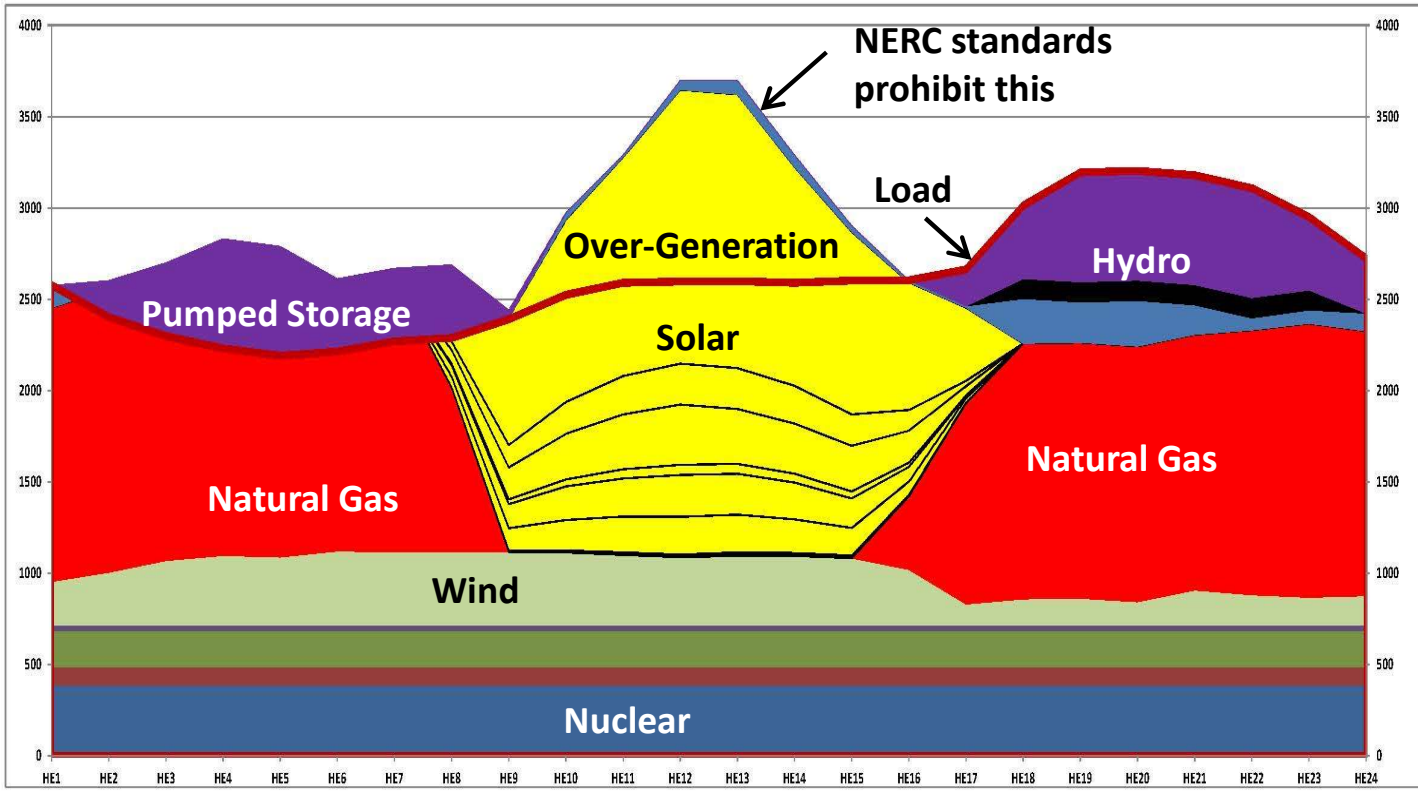
Late 2016 Resource Stack



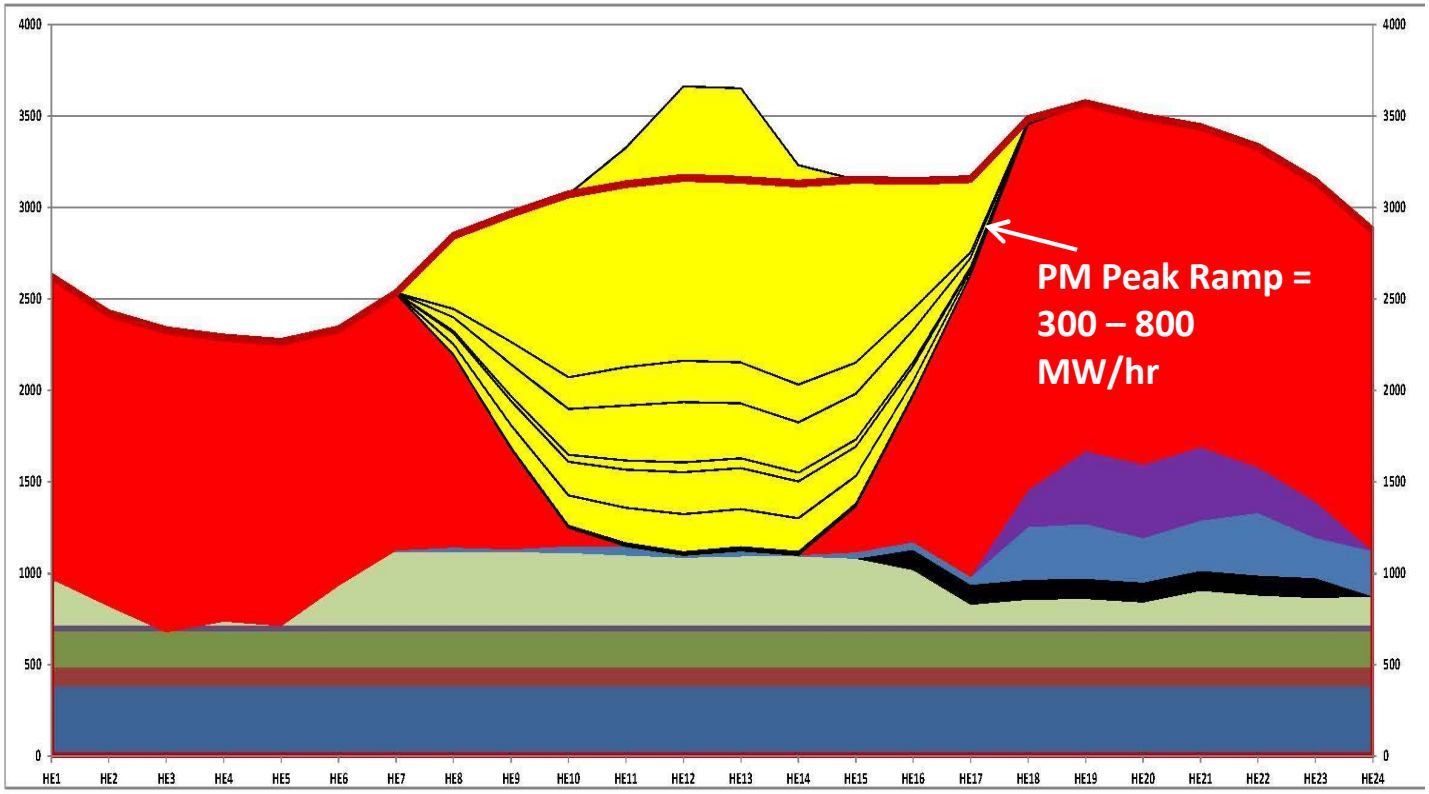
2027 Resource Stack



2027 Resource Stack (Sunday)



Ramp of Gas Fired Generation



Challenges with Renewables

- Over-Generation
- Wear on equipment
- PM ramp

Solutions for Renewables

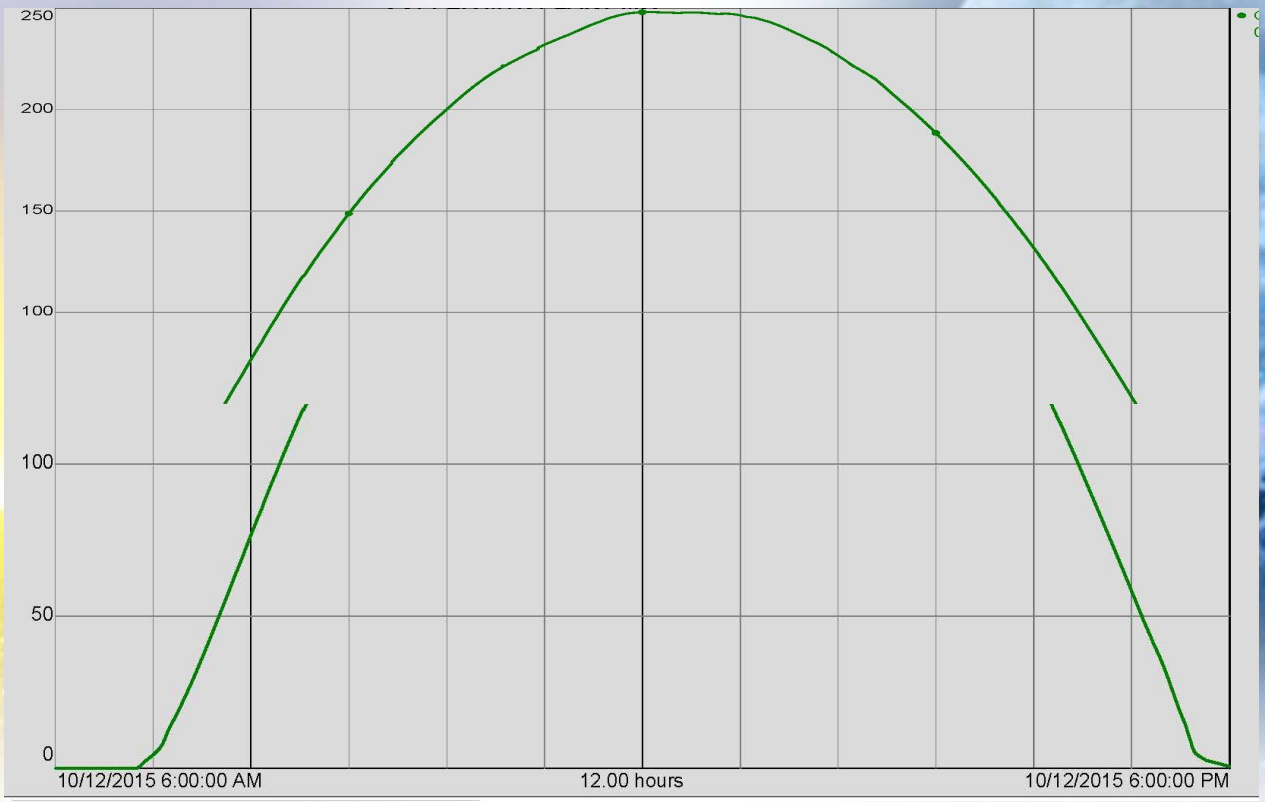
Over-Generation

- Marketplace
- Sell to others
- Energy storage
- Pumped Storage
- Curtail renewable production

PM Ramp

- Modern CT generation (quick start)
- Energy storage
- Pumped Storage
- Demand Response to reduce PM Peak
- Purchase additional energy for ramping from the market

Solar Production



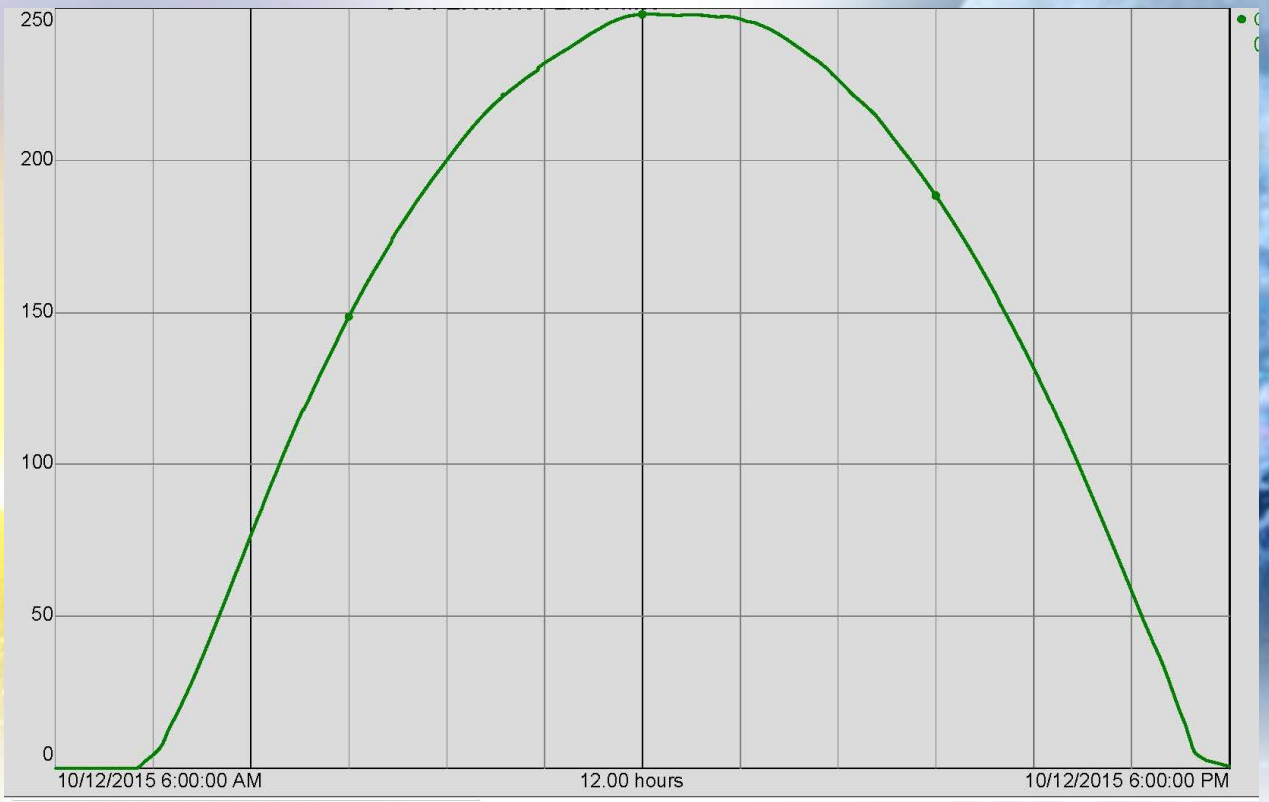
Solar Variability

- Solar does not always follow the smooth curve
- Solar and wind are variable energy resources
- Some evidence of variability

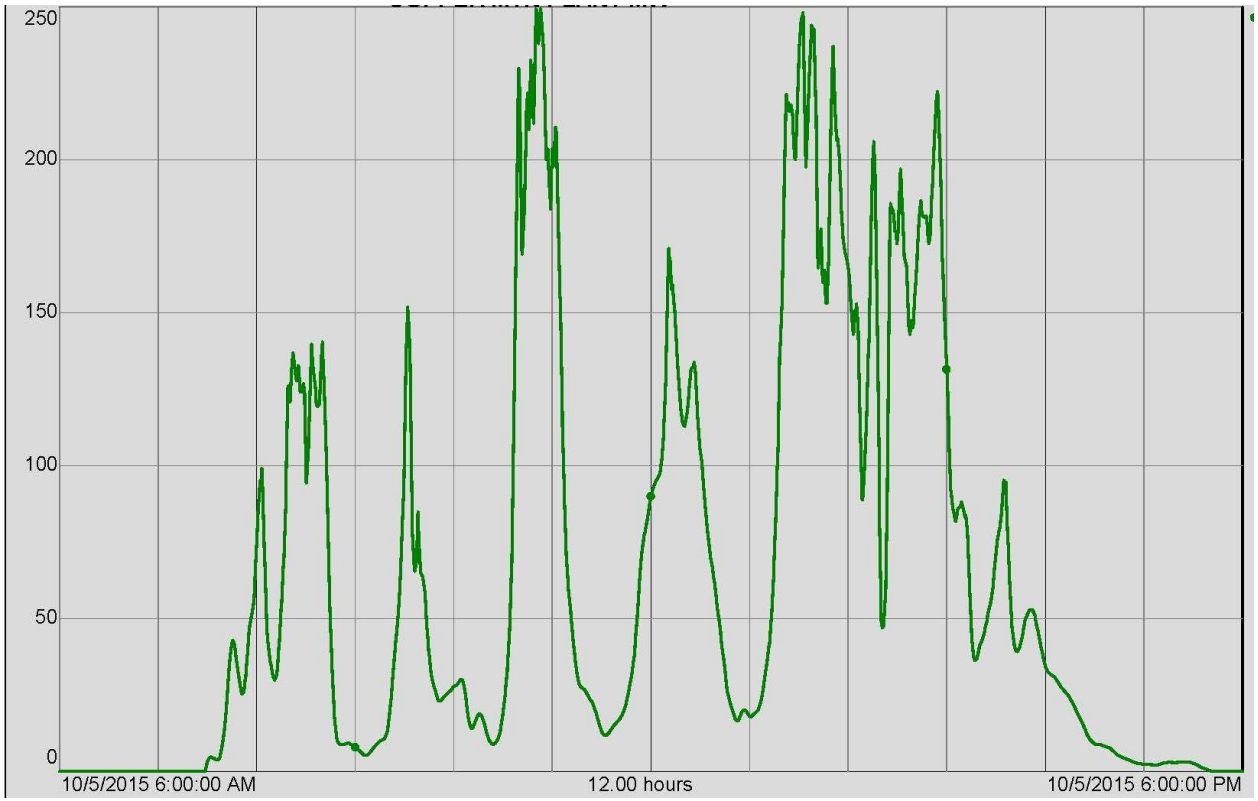
Solar Variability

- 60% of days are smooth
- 40% of days are very variable

Solar Production



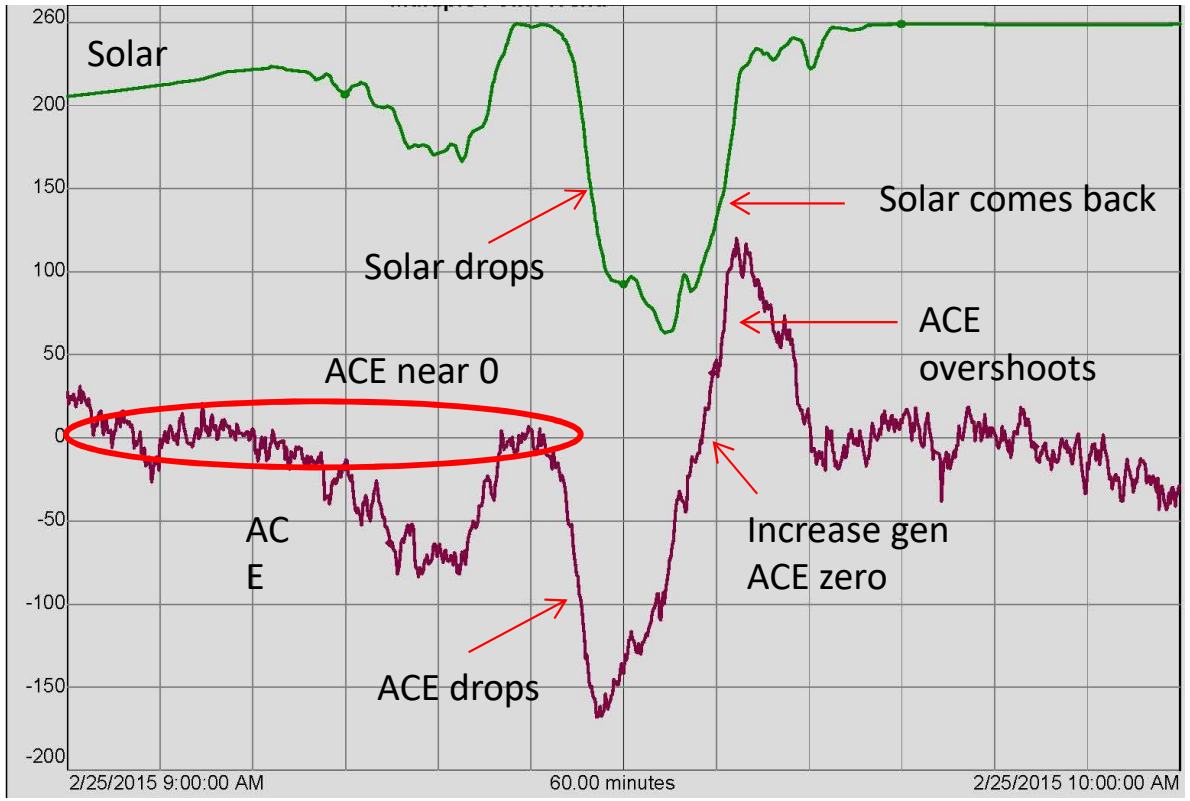
Solar Variability



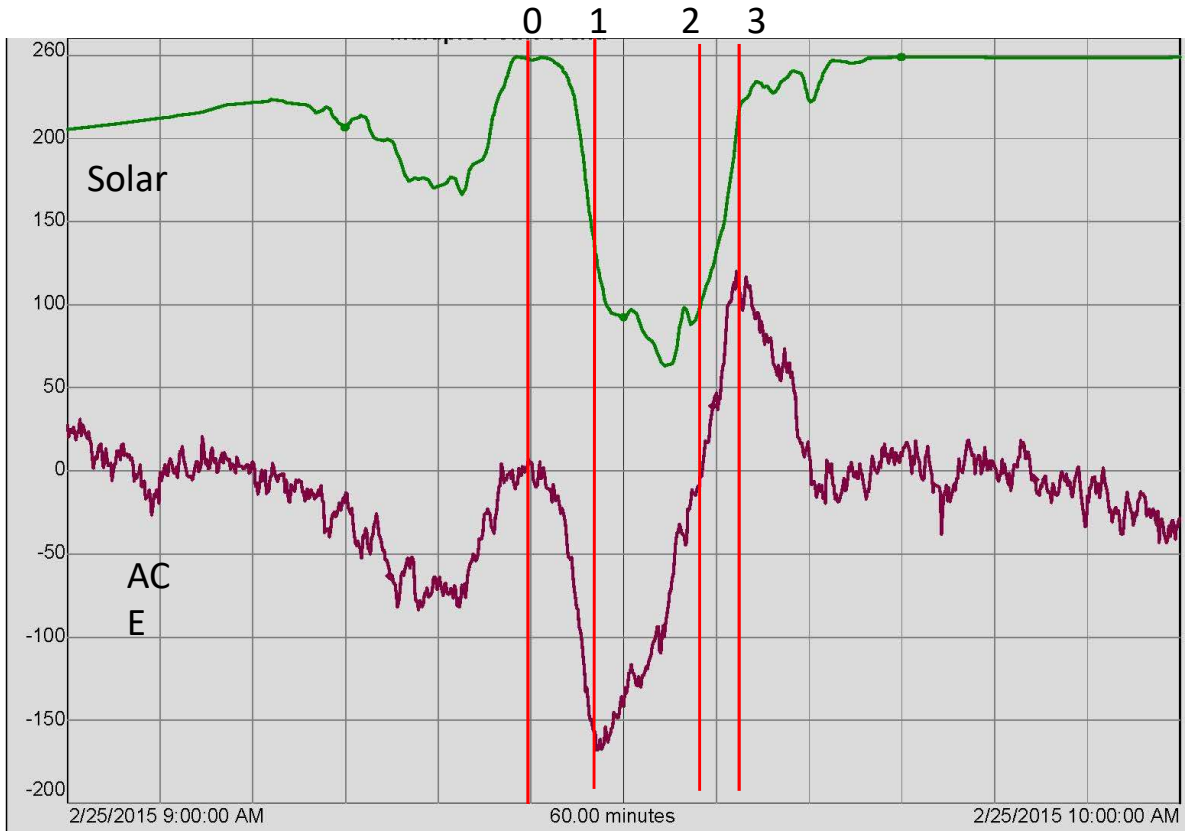
Solar Variability

- Variability of utility-scale solar shows up as variable generation
- Variability of roof-top solar shows up as variable load
- Variability of both load and generation
- Either way, when solar goes down, ACE goes negative

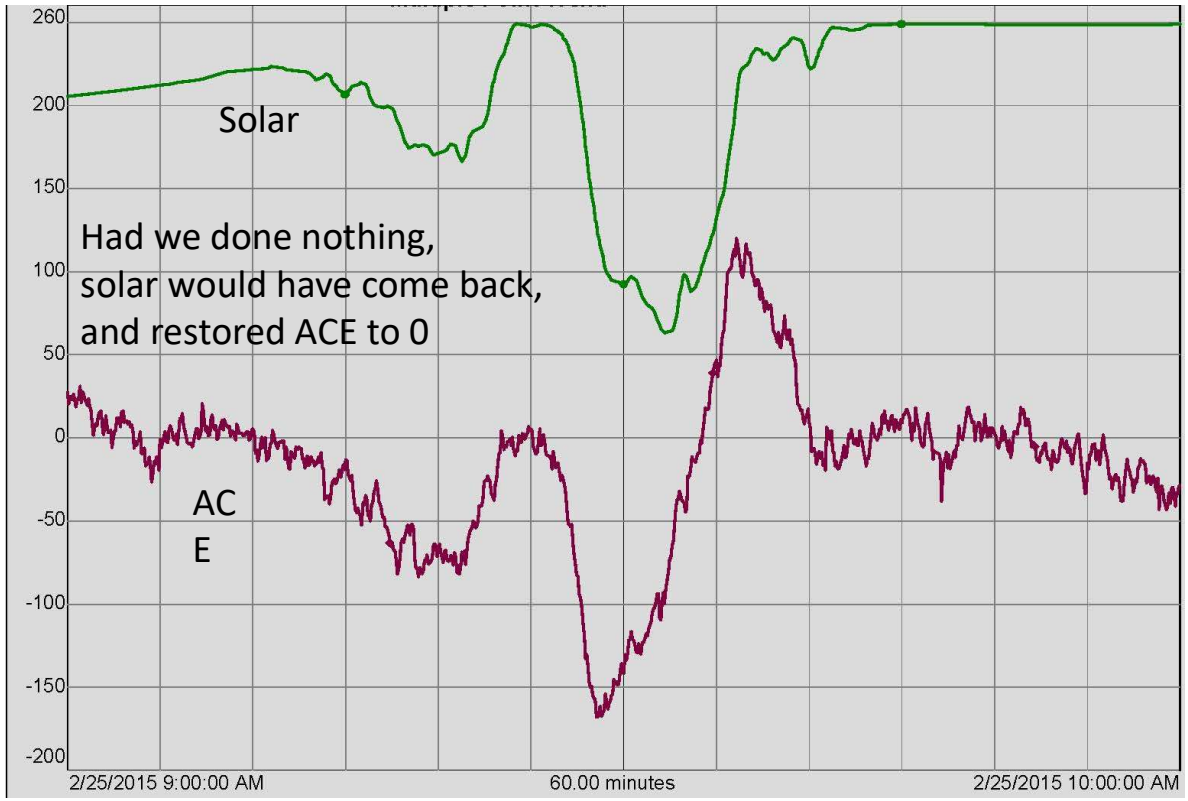
Solar Variability and ACE



Solar Variability and ACE



Solar Variability and ACE



Variability

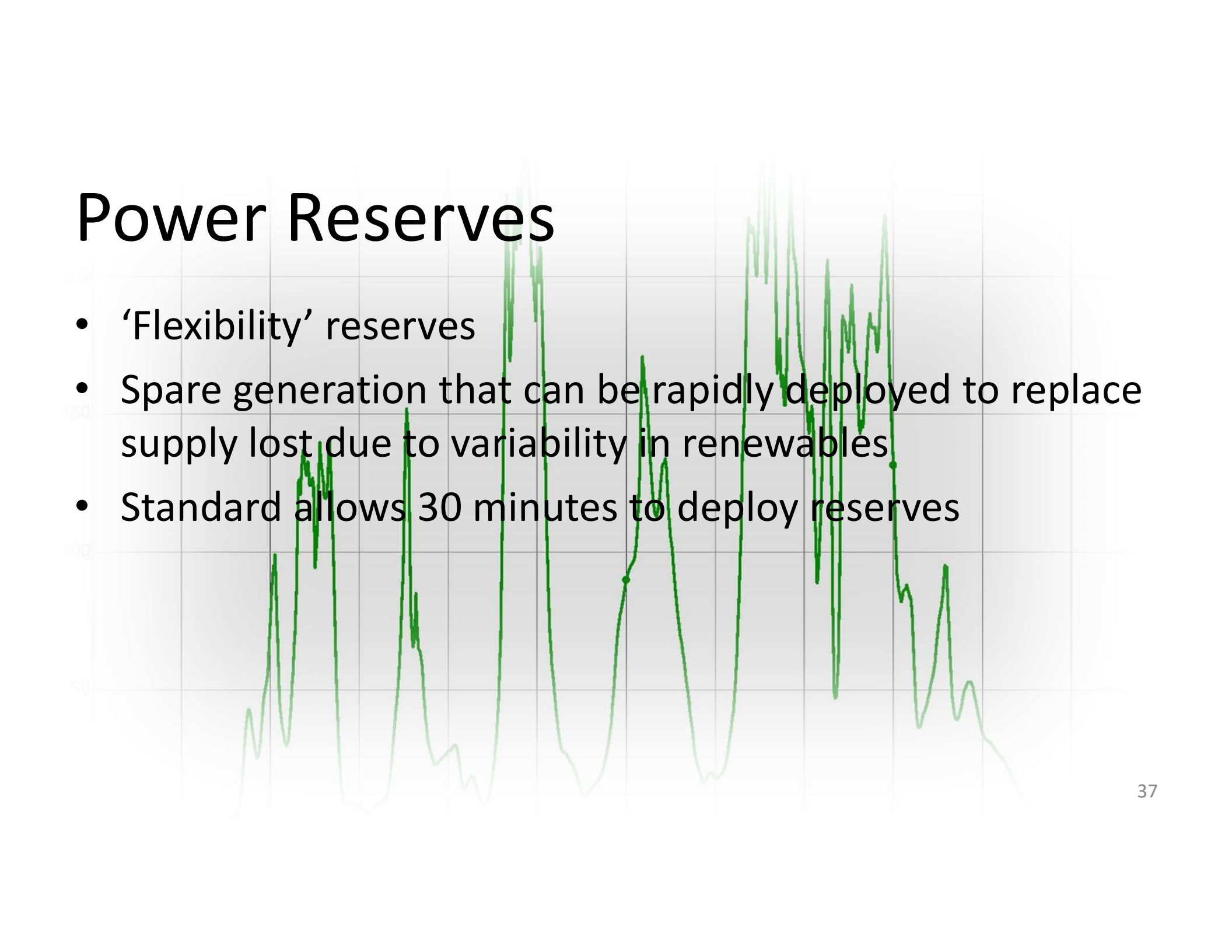
- Responses to the challenge
- Short-term (15 minute) renewable forecasts
- Energy Imbalance Market
- “Flexibility Reserves”

Power Reserves

- Conventional generators can ‘trip’ for many reasons
- Unexpected loss of generator called a ‘Contingency’
- ‘Contingency Reserves’: spare generation that can be rapidly deployed to replace generation lost to a Contingency
- Within 15 minutes

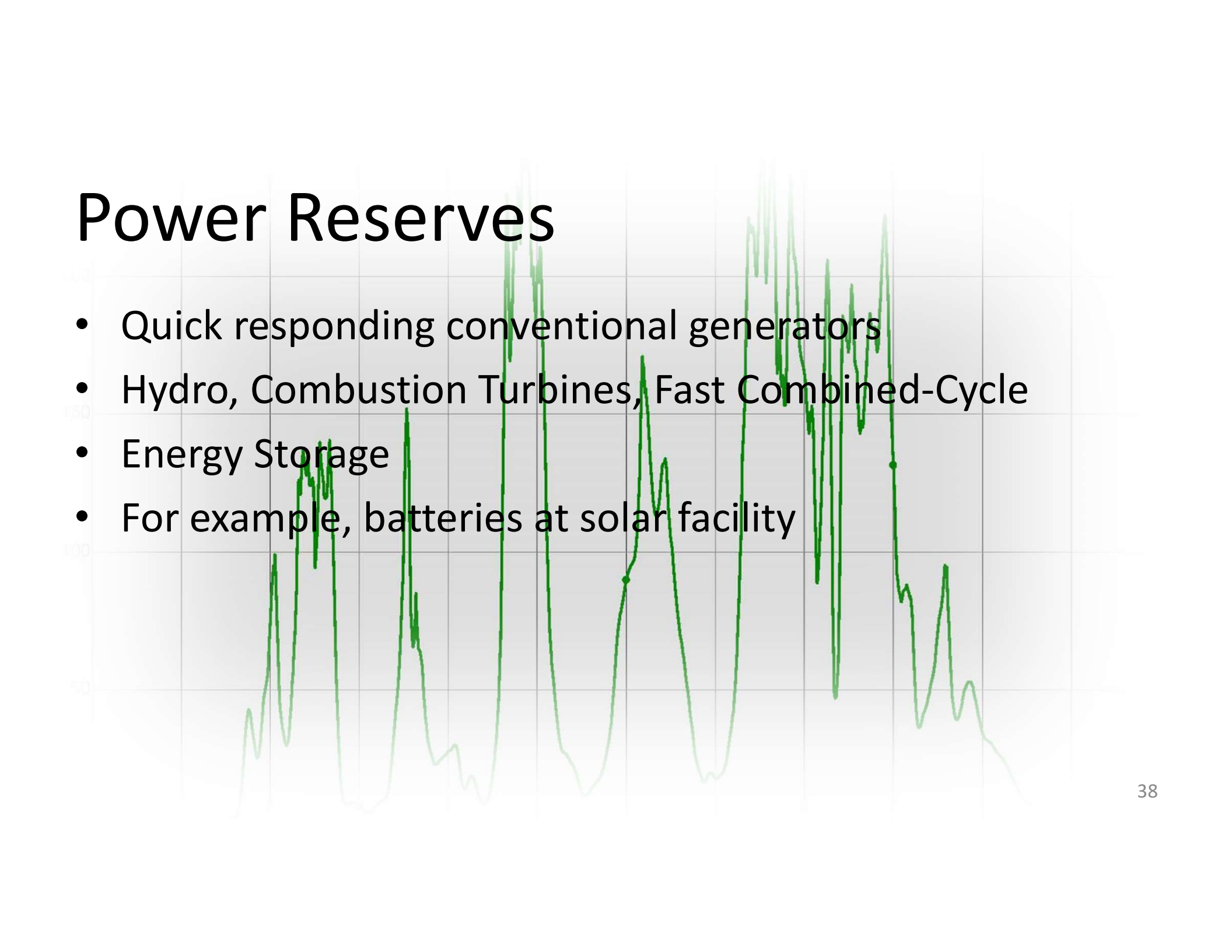
Power Reserves

- ‘Flexibility’ reserves
- Spare generation that can be rapidly deployed to replace supply lost due to variability in renewables
- Standard allows 30 minutes to deploy reserves



Power Reserves

- Quick responding conventional generators
- Hydro, Combustion Turbines, Fast Combined-Cycle
- Energy Storage
- For example, batteries at solar facility



Reserves

- Quick responding conventional generators
- Hydro, Combustion Turbines, Fast Combined-Cycle
- Energy Storage
- For example, batteries at solar facility
- Last resort is curtail renewables

Summary

Integrating renewables into daily operations present challenges:

- Over-generation
- Wear and tear on conventional generators
- Meeting the PM ramp
- Keeping ACE within limits during variability

Summary

Ways to meet challenges

- Energy Storage
- Pumped Storage
- Hydro Generation
- Short-term renewable forecasting
- Energy Imbalance Market; sales and purchase
- Incentivize on/off-peak consumption
- Curtail Renewables

QUESTIONS?