Modeling the Future of Energy

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EMF Snowmass Workshop:
Rapid System Transitions Towards Low GHG Futures

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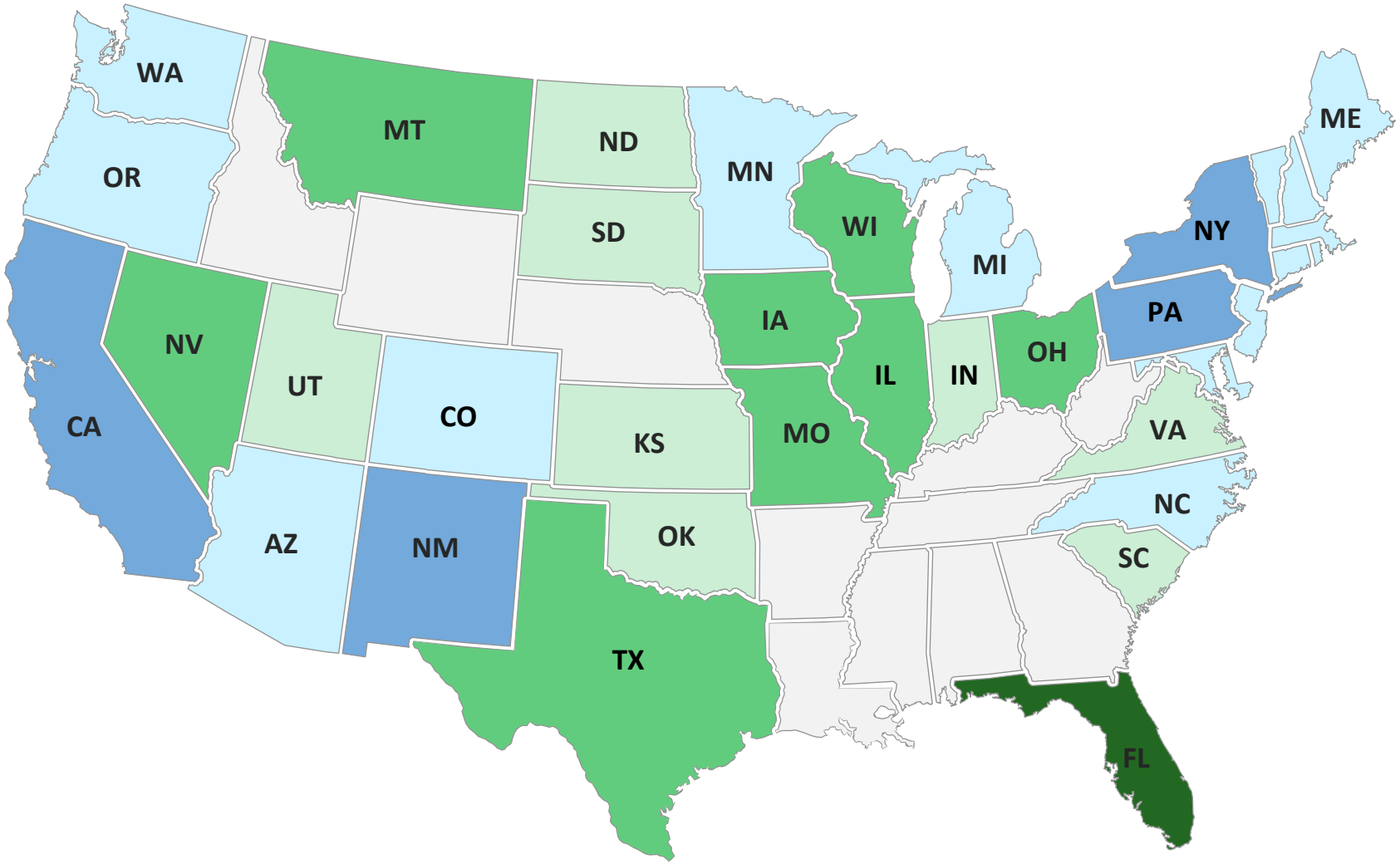
Subnational Modeling: Existing State RPS, Clean Energy & GHG Targets

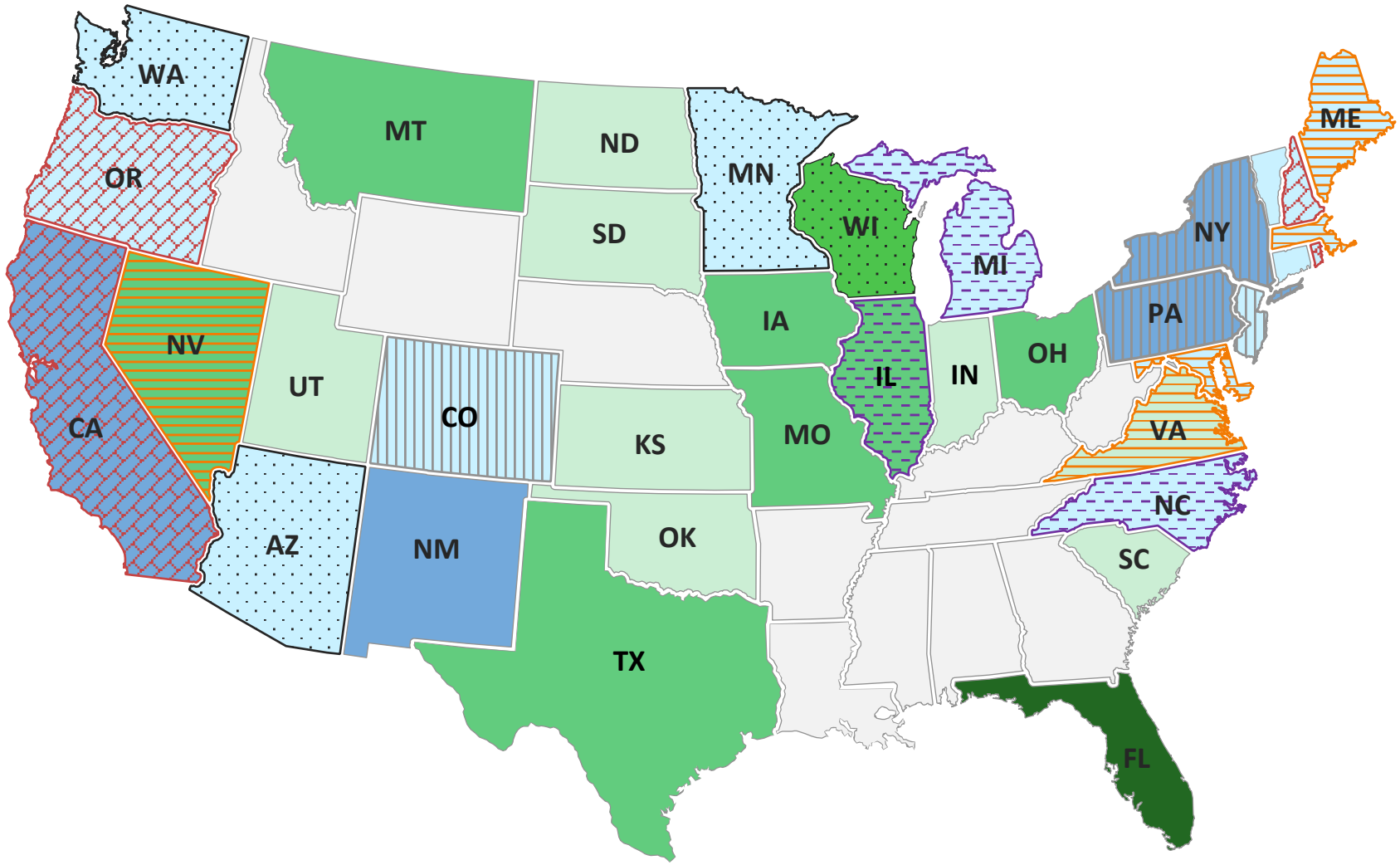


Existing

- Renewable Portfolio Goal Only
- Renewable Portfolio Standard Only
- GHG Target Only
- RPS & GHG Targets
- Clean Energy & GHG Targets
- Clean Energy Target Only
- N/A

Update: April 25, 2019

Proposed / Pending State RPS, Clean Energy & GHG Targets



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Summary – Planning for Electric Sector Investment

Electric sector investment is long-lived; investors want/need a clear view of revenue … but electric sector is undergoing dramatic change

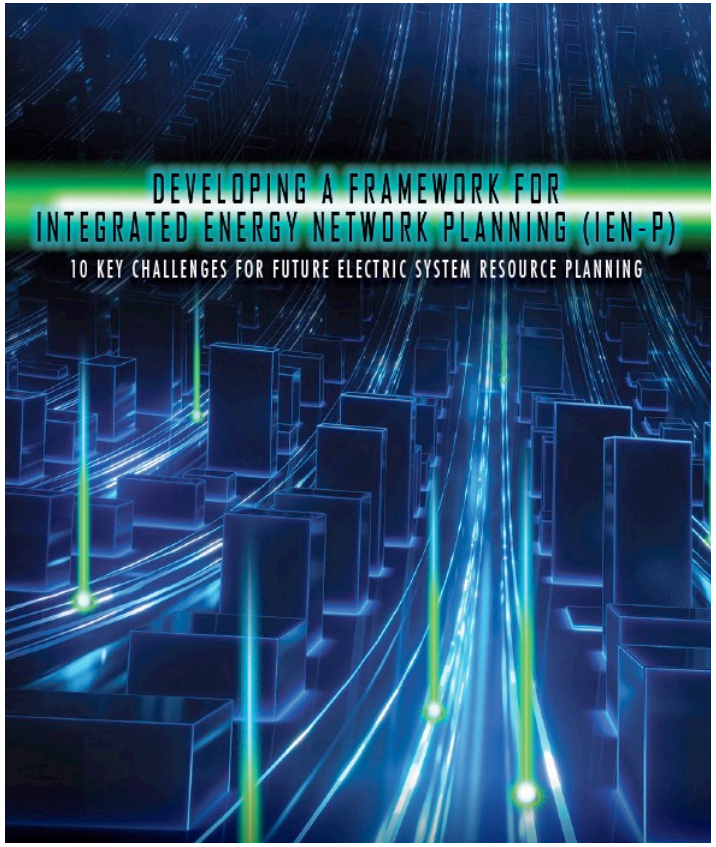
- Electricity generation: Wholesale markets driven by marginal cost … but new generation options have no/low marginal cost.
- End-use:
  - There is someone with a brain/smart phone/both behind the meter. Broad new opportunities to alter energy use, generate or store energy.
  - New electric technologies … transport, heat, industrial … and infrastructure buildout
- Delivery: Many views emerging on electric and gas infrastructures.
- Storage: No standard models for compensation or real-time, daily and seasonal storage.
- Integration of energy: Emerging integration of energy and natural resources – electricity, gas, water, heat.

Robust Modeling Insights Needed

Electric Sector Planning Drives (or Supports) Investment

…

What are the Key Planning Challenges?



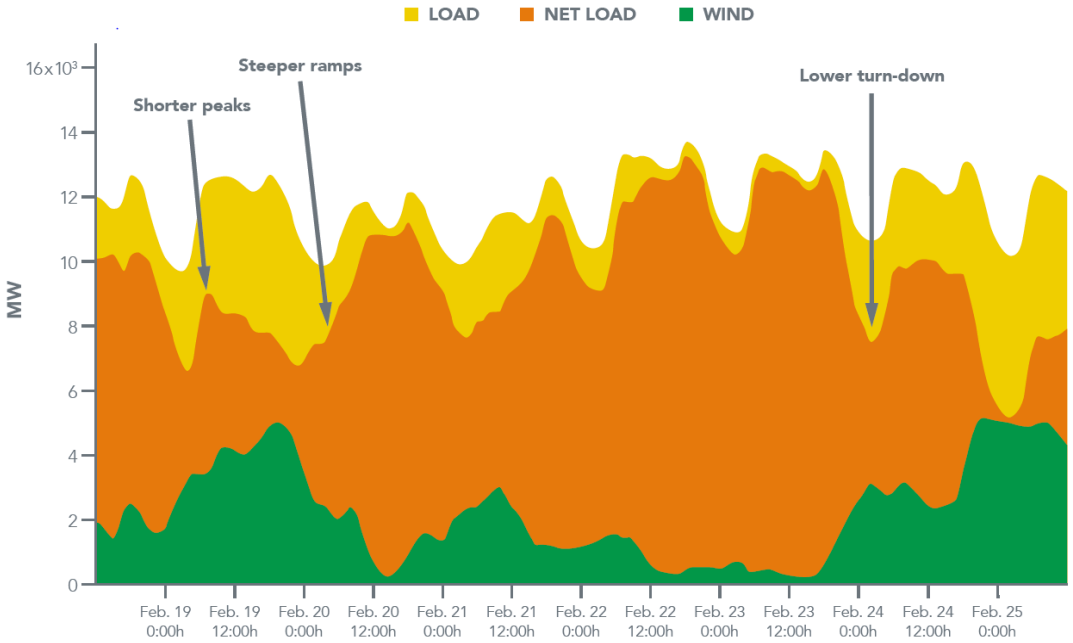
See: http://integratedenergynetwork.com/

Integrated Energy Network: Resource Planning Challenges

Category	Key IEN Planning Challenge
Modeling the Changing Power System	1. Incorporating operational detail 2. Increasing modeling granularity 3. Integrating generation, transmission & distribution planning 4. Expanding analysis boundaries and interfaces 5. Addressing uncertainty and managing risk
Integrating Forecasts	6. Improving forecasting 7. Improving modeling of customer behavior and interaction
Expanding Planning Objectives	8. Incorporating new planning objectives and constraints 9. Integrating wholesale power markets 10. Supporting expanded stakeholder engagement

1. Incorporating Operational Detail

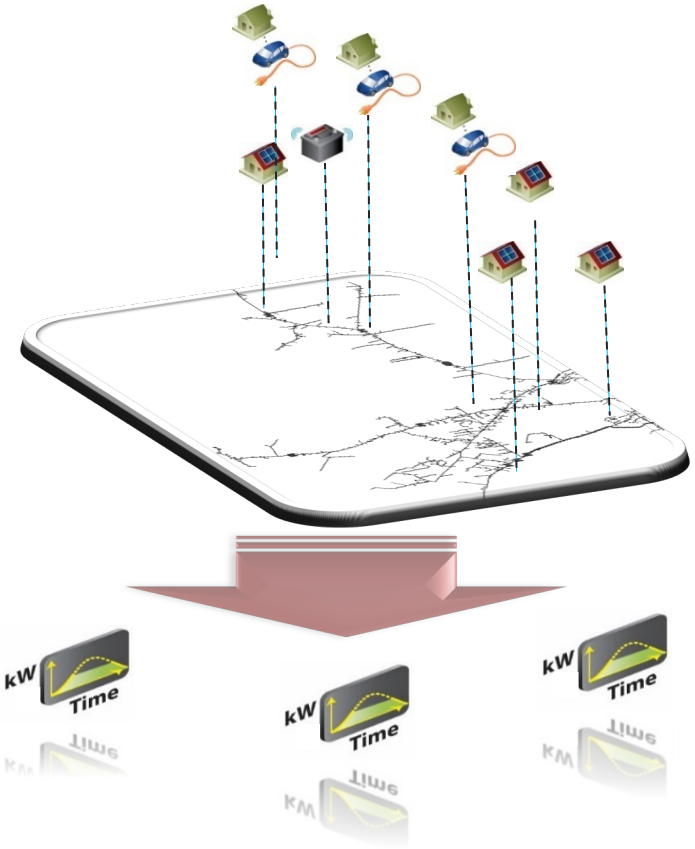
- Evaluate and address potential reliability impacts (e.g., frequency response, voltage stability and short circuit considerations) associated with the changing resource mix.
- It is becoming more important to incorporate operational reliability capabilities (e.g., ramping rates, minimum generation levels), and adverse interactions (e.g., variability, uncertainty, active and reactive control capabilities) into resource planning.
- Existing resource adequacy metrics (e.g., LOLE) may not be the "best" or only metric to use to measure electric reliability.



Wind and Solar Generation Can Increase Power System Flexibility Needs.
Source: Flexibility in 21st Century Power Systems, 21st Century Power Partnership.

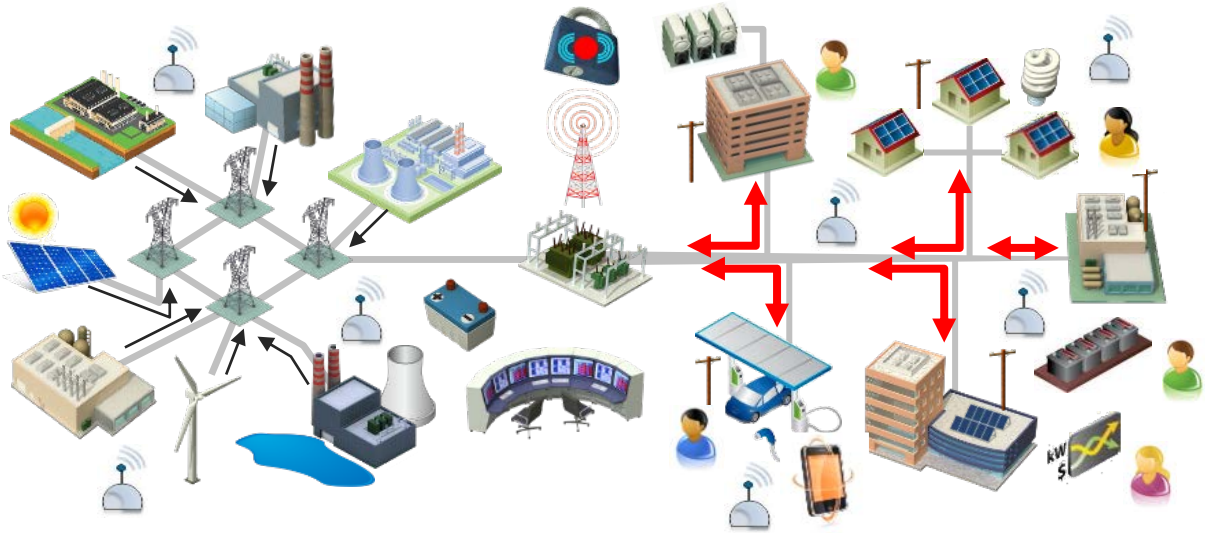
2. Increasing Modeling Granularity

- *Temporal* Resolution
  - Hourly / sub-hourly time steps and multiple timeframes
  - Evaluation of energy storage systems and variable renewable resources require inter-temporal constraints and opportunities to be more fully recognized.
  - Understand potential net load impacts from utility renewable generation, customer choice, storage, DER deployment, and increased electrification.



- *Geographic* Resolution
  - "Birds of a feather flock together" – EVs and rooftop PV typically are adopted in neighborhoods, so disproportionally impact circuits. Traditional deterministic and stochastic modeling do not capture the geographic nature of customer preferences.
  - DER targeting and location have a direct impact on transmission and generation investment decisions and depend on customer preferences.

3. Integrating G, T, and D Planning



- TSO/DSO interaction increasingly is important, particularly as the distribution system provides more services
- Allows for evaluation of “non-wires alternatives” (NWA) to new G, T and/or D investments
- DER valuation and targeting, including locational attributes
- Improve communications and “hand shakes” between planning functions
- Connections to other critical infrastructure (e.g., natural gas, H_2O, electric vehicle charging)

4. Expanding Analysis Boundaries

- Interactions with other sectors of the economy to achieve least-cost GHG emissions reductions (e.g., CA SB-350)
- "Gas-electric" coordination to better optimize planning and operations of natural gas fuels with electric operations
- Energy-water nexus – Planning to address both consumption and use of water in power generation and potential impacts of power generation on water resources is becoming more prominent.
- Multi-jurisdictional planning – Some companies are now facing conducting resource planning across multiple jurisdictions in an integrated manner. Examples include PacifiCorp in the western US and Duke in the eastern U.S.

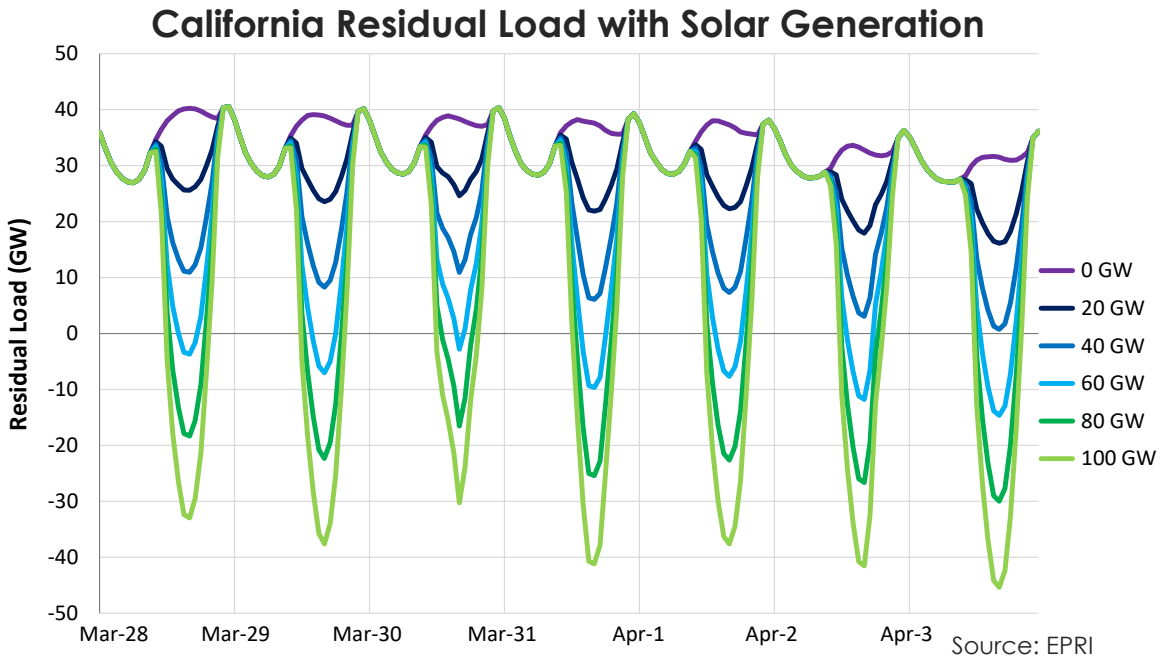
5. Addressing Uncertainty and Managing Risk

- **Risk**
  - Deterministic v. stochastic modeling – Deterministic modeling and scenario analysis may not be adequate. Planners may need to do more stochastic modeling to capture the inherent uncertainty in the electric system.
  - Non-market risks – Growing need to develop methods and approaches to evaluate "non-market" risks, such as a perceived lack of "fuel diversity," and the ability to respond to changes in the external operating, policy and regulatory environments.

- **Uncertainty** – Becoming increasingly important to incorporate forecast uncertainty and variability in future loads, VER production, and DER adoption and use.
  - Production profiles for VERs are uncertain over time horizons from minutes to years, with each different time horizon causing their own challenges
  - Capacity values for variable generation are uncertain
  - VERs can increase variability and volatility of energy prices
  - Increasing DR capabilities may make it more difficult to forecast load

6. Improving/Integrating Forecasting

- Key areas of forecasting are critical for robust long-term resource planning.
  - Electric load
  - DER adoption
  - Natural gas prices
  - Weather



Source: EPRI

- Need to better characterize natural uncertainty inherent in these key factors, and gain insights using computationally tractable methods.

- The ability to analyze "big data" related to DER, customer behavior, operations and other aspects of the future electric system may require new analysis capabilities and computational power.

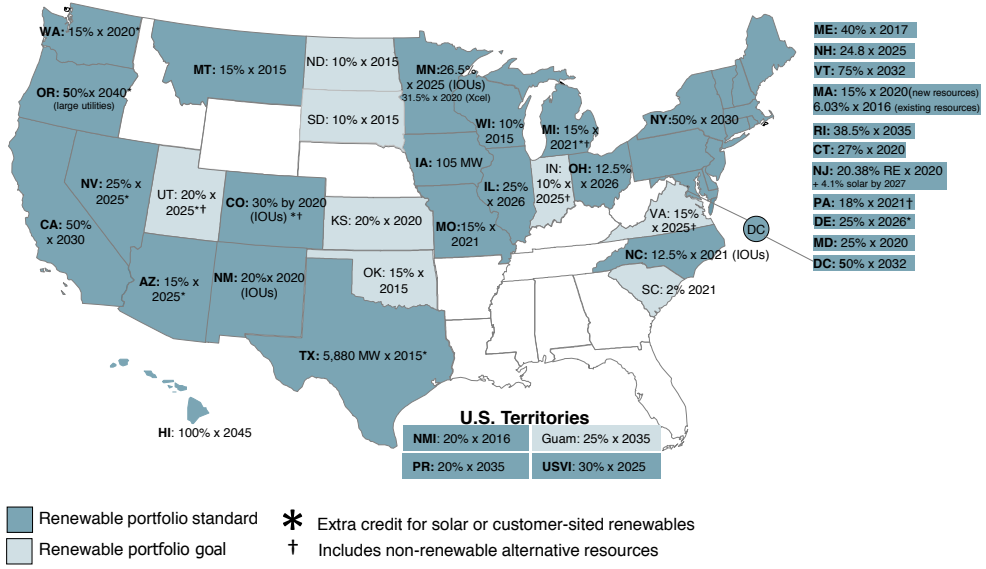
7. Customer Behavior and Interaction

- Customer behavior is expected to have a direct and tangible impact on resource planning in the future.
- Some ways customer behavior and resource planning may interact include:
  - Behind the meter generation (e.g., solar PV)
  - DER approaches, such as EE and DR
  - Electric transportation, electrification, and smart devices
  - Electric rates and rate structures may impact consumer behavior, electric demand, and planning

8. New Planning Objectives and Constraints

- GHG emissions and RPS – CA requires IRPs to achieve least-cost GHG emissions reductions and aggressive RPS targets.

- Water resources – Some electric companies are being asked to consider impacts on local water resources.

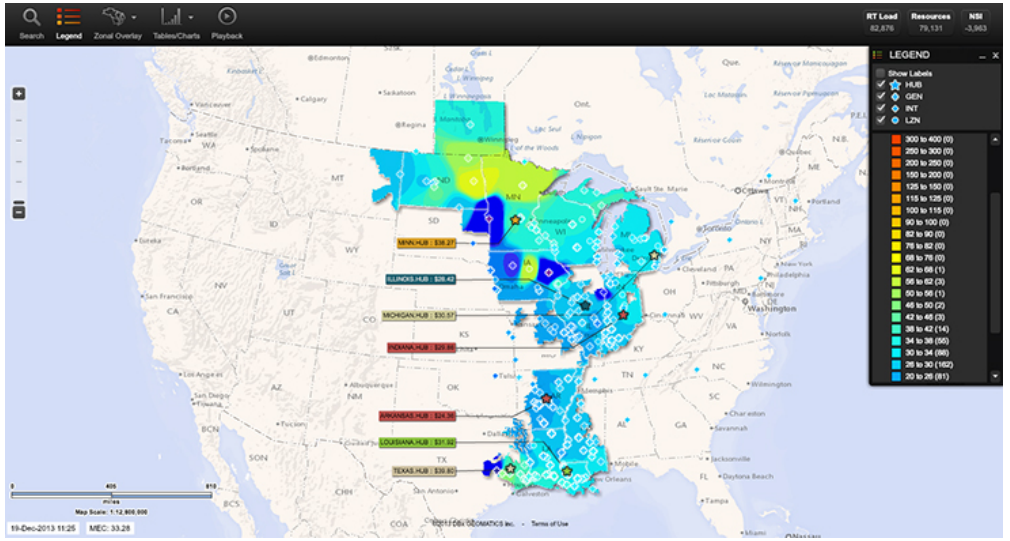


29 States + Washington DC + 3 territories have a Renewable Portfolio Standard
Source: www.dsireusa.org / February 2017

- Resiliency – Electric companies are being asked to more fully address system resiliency in resource planning. This includes two facets:
  - *Physical* – Protect the system from extreme weather events and restore it
  - *Cyber* – Protect the electric system from cybersecurity threats and restore it

9. Wholesale Power Market Interactions

- Interactions between companies and ISO/RTOs markets are starting to create new challenges for resource planners.
- Planners are challenged by considering buying and selling energy, capacity, and ancillary services (A/S) rather than building new resources or procuring “own” resources.



- Growing need to project uncertain potential future wholesale power prices, and incorporate them into modeling tools.
- Growing need to better understand how A/S and capacity markets may evolve, and impacts on future value of power resources.
- Planning methods will have to consider how ISOs/RTO markets will value different resource capabilities in the future.

10. Expanding External Stakeholder Engagement

- The primary audience for company IRPs traditionally has been state PUCs and other regulators. Additional important audiences have included business associations, environmental and consumer advocates, and local non-governmental organizations (NGOs).
- In recent years, public expectations regarding involvement in company resource planning have changed dramatically
  - New stakeholders are engaged and participating in the planning process
  - Stakeholders want to address a broader array of issues than have been addressed in company resource planning in the past (e.g., rate design, rate setting, others…)
  - Stakeholders are becoming engaged in the entire resource planning process
- More companies now are engaged in designing and managing extensive stakeholder engagement processes related to resource planning activities.

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Together…Shaping the Future of Electricity

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