RPS Collaborative Webinar

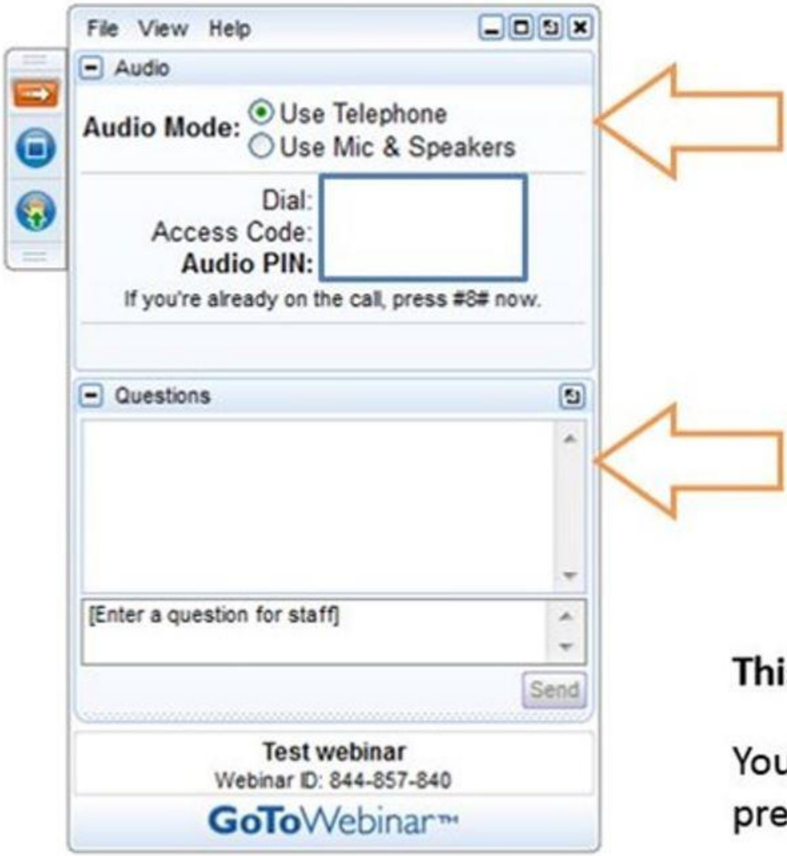
Grid Modernization and Renewable Portfolio Standards

Hosted by
Warren Leon, Executive Director, CESA

October 11, 2016

Clean Energy States Alliance

Housekeeping



All participants are in "Listen-Only" mode. Select "Use Mic & Speakers" to avoid toll charges and use your computer's VOIP capabilities. Or select "Use Telephone" and enter your PIN onto your phone key pad.

Submit your questions at any time by typing in the Question Box and hitting Send.

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RPS Collaborative

- With funding from the Energy Foundation and the US Department of Energy, CESA facilitates the **Collaborative**.
- Includes **state RPS administrators**, **federal agency representatives**, and other stakeholders.
- Advances dialogue and learning about RPS programs by **examining the challenges and potential solutions** for successful implementation of state RPS programs, including **identification of best practices**.
- To sign up for the Collaborative listserv to get the **monthly newsletter** and announcements of **upcoming events**, see: www.cesa.org/projects/state-federal-rps-collaborative

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CleanEnergy States Alliance

Today's Guest Speakers

- **Lisa Schwartz**, Energy Efficiency Team Leader in the Electricity Markets and Policy Group, Lawrence Berkeley National Laboratory

- **Lori Bird**, Principal Analyst in the Market and Policy Impact Analysis Group, National Renewable Energy Laboratory

Lawrence Berkeley National Laboratory

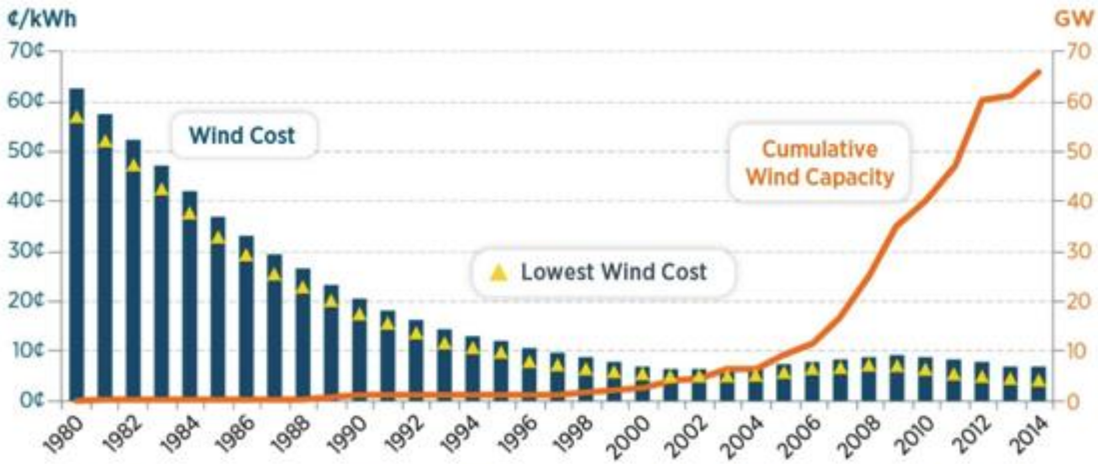
NREL NATIONAL RENEWABLE ENERGY LABORATORY

National Energy Lab Research and State Technical Assistance Under DOE's Grid Modernization Initiative

RPS Collaborative Webinar
Oct. 11, 2016

Lisa Schwartz, Berkeley Lab, Electricity Markets and Policy Group

Land-Based Wind Power

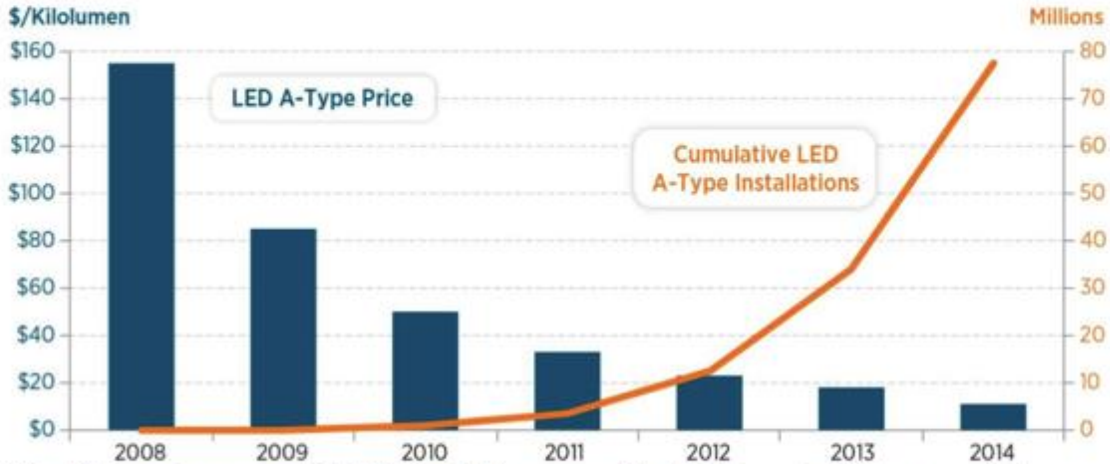


Notes: 1 gigawatt (GW) = 1,000 megawatts (MW). All costs shown are inflation adjusted to dollar year 2014 and exclude the production tax credit (PTC). Wind capacity as reported by market reports.[2] "Wind Cost" represents estimated levelized cost of energy from a representative wind site, and "Lowest Wind Cost" represents costs derived from power purchase agreements from good to excellent wind resource sites in the interior of the country.[3]

Solar PV: Distributed Generation

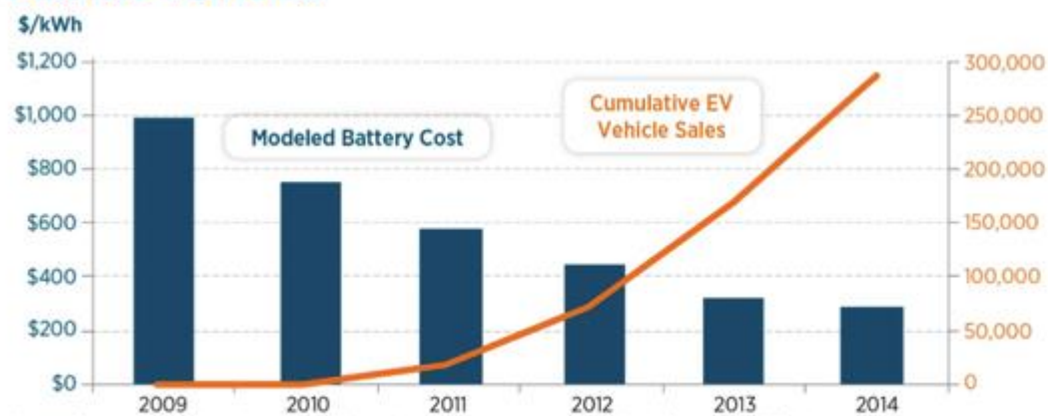
Notes: All prices are in $/W$_{DC}$ and inflation adjusted to dollar year 2014. 1 gigawatt (GW) = 1,000 megawatts (MW). Capacity weighted average as reported by market report for residential systems only.[32] Non-residential systems are typically larger and have lower reported prices. Capacity is cumulative distributed residential and non-residential capacity, in GW$_{DC}$.[33]

LED Lighting



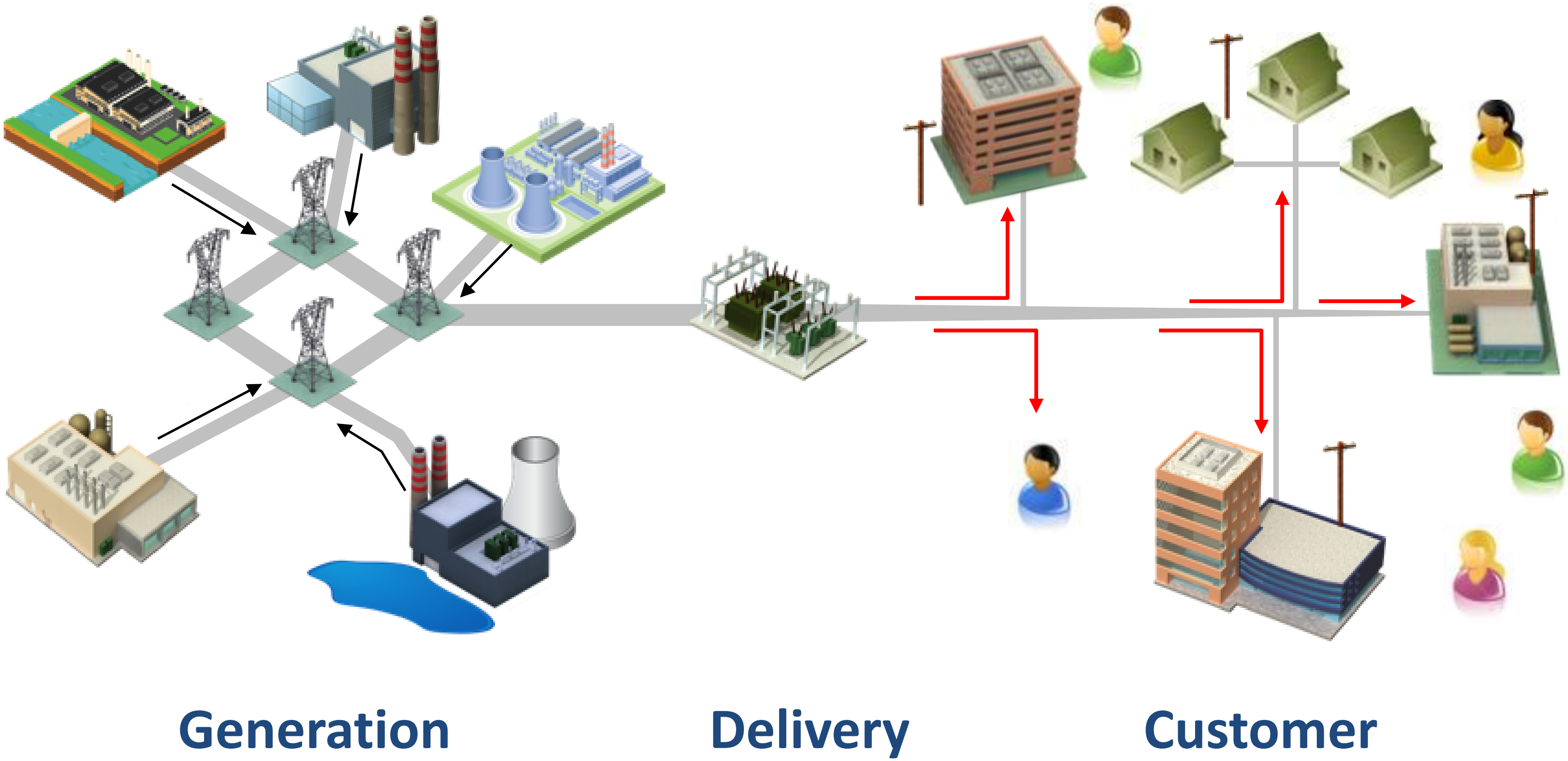
Notes: Kilolumen is a measure of visible light output by a source. Price data is in nominal dollars as reported in internal tracking report.[42] Cumulative LED A-type bulb installations as reported in market report.[43]

Electric Vehicles



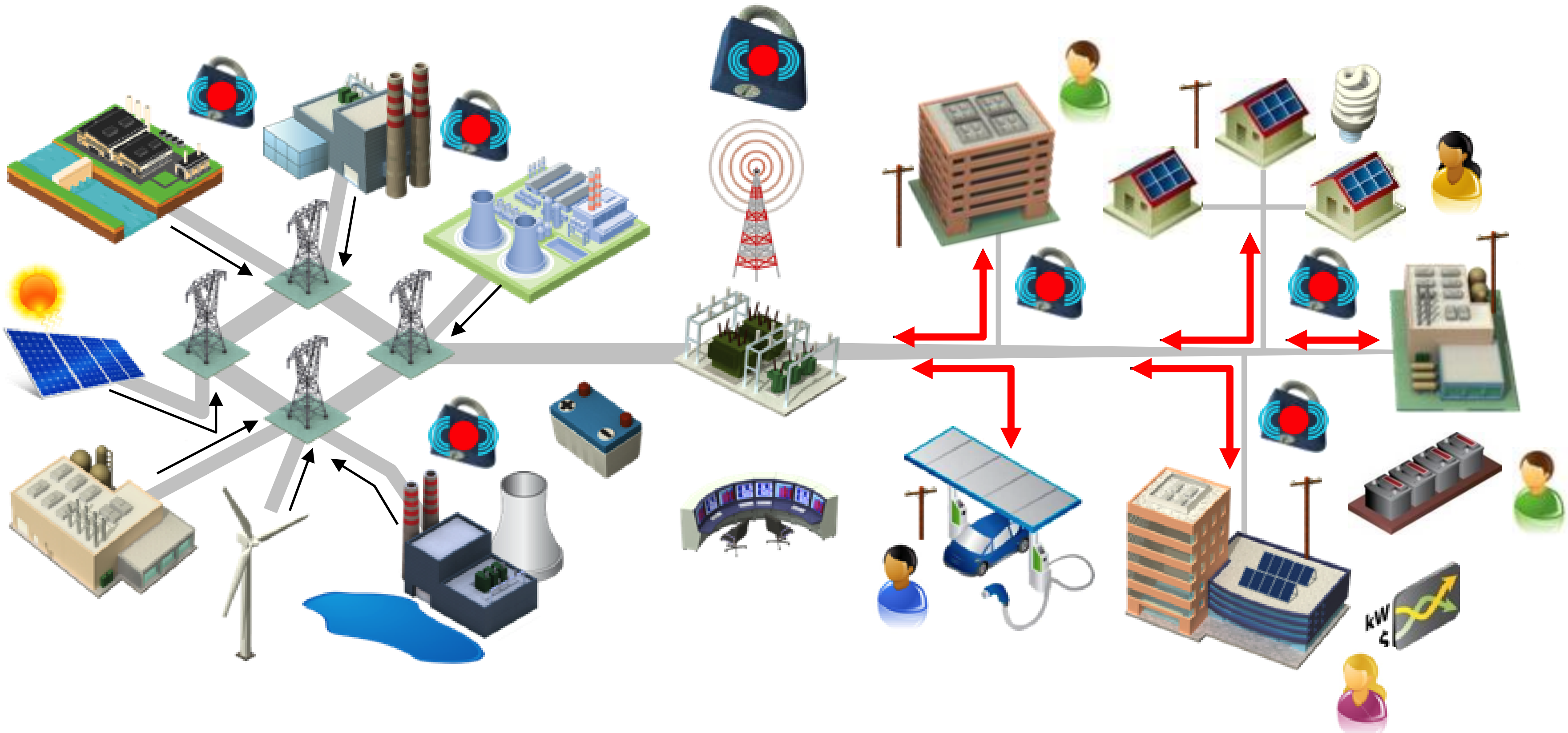
Notes: Costs are modeled costs for high-volume battery systems, derived from DOE/UIS Advanced Battery Consortium PHEV Battery development projects and are representative of nominal dollars. Sales as reported by market tracker, here "EVs" include all plug-in hybrid and battery plug-in vehicles.[52]

The Grid of the Past



Source: EPRI, 2009

The Grid of the Future



Generation **Delivery** **Prosumer**

Source: EPRI, 2009

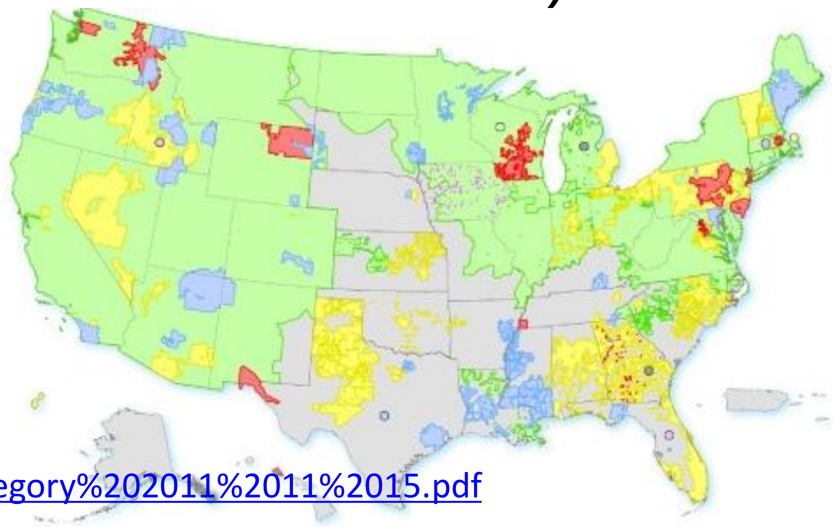
What is grid modernization?

- A modern grid must have:*
  - greater resilience to hazards of all type
  - improved reliability for everyday operations
  - enhanced security from an increasing and evolving number of threats
  - additional affordability to maintain our economic prosperity
  - superior flexibility to respond to variability and uncertainty
  - increased sustainability through additional clean energy and energy-efficient resources

*Adapted from U.S. Department of Energy's Grid Modernization Multi-Year Program Plan (MYPP): http://energy.gov/sites/prod/files/2016/01/f28/Grid%20Modernization%20Multi-Year%20Program%20Plan.pdf

Earlier grid modernization efforts

- DOE's Smart Grid Investment Grant Program under the Recovery Act of 2009 provided funds for a variety of grid modernization projects (examples):
  - Advanced metering infrastructure
  - Customer systems (communications, demand response)
  - Distribution systems (automation, mgt., monitoring)
  - Transmission systems (phasor measurement units)
  - Equipment manufacturing (smart appliances)
  - Integrated/cross-cutting systems (AMI + distribution automation + load control)



http://energy.gov/sites/prod/files/SGIG%20Awards%20by%20Category%202011%2011%2015.pdf

DOE's grid modernization vision today

The future grid will solve the challenges of seamlessly integrating conventional and renewable sources, storage, and central and distributed generation. It will provide a critical platform for U.S. prosperity, competitiveness, and innovation in a global clean energy economy. It will deliver resilient, reliable, flexible, secure, sustainable, and affordable electricity to consumers where they want it, when they want it, how they want it.

Enhance the Security of the Nation

- Extreme weather
- Cyber threats
- Physical attacks
- Natural disasters
- Fuel and supply diversity
- Aging infrastructure

Sustain Economic Growth and Innovation

- New energy products and services
- Efficient markets
- Reduce barriers for new technologies
- Clean energy jobs

Achieve Public Policy Objectives

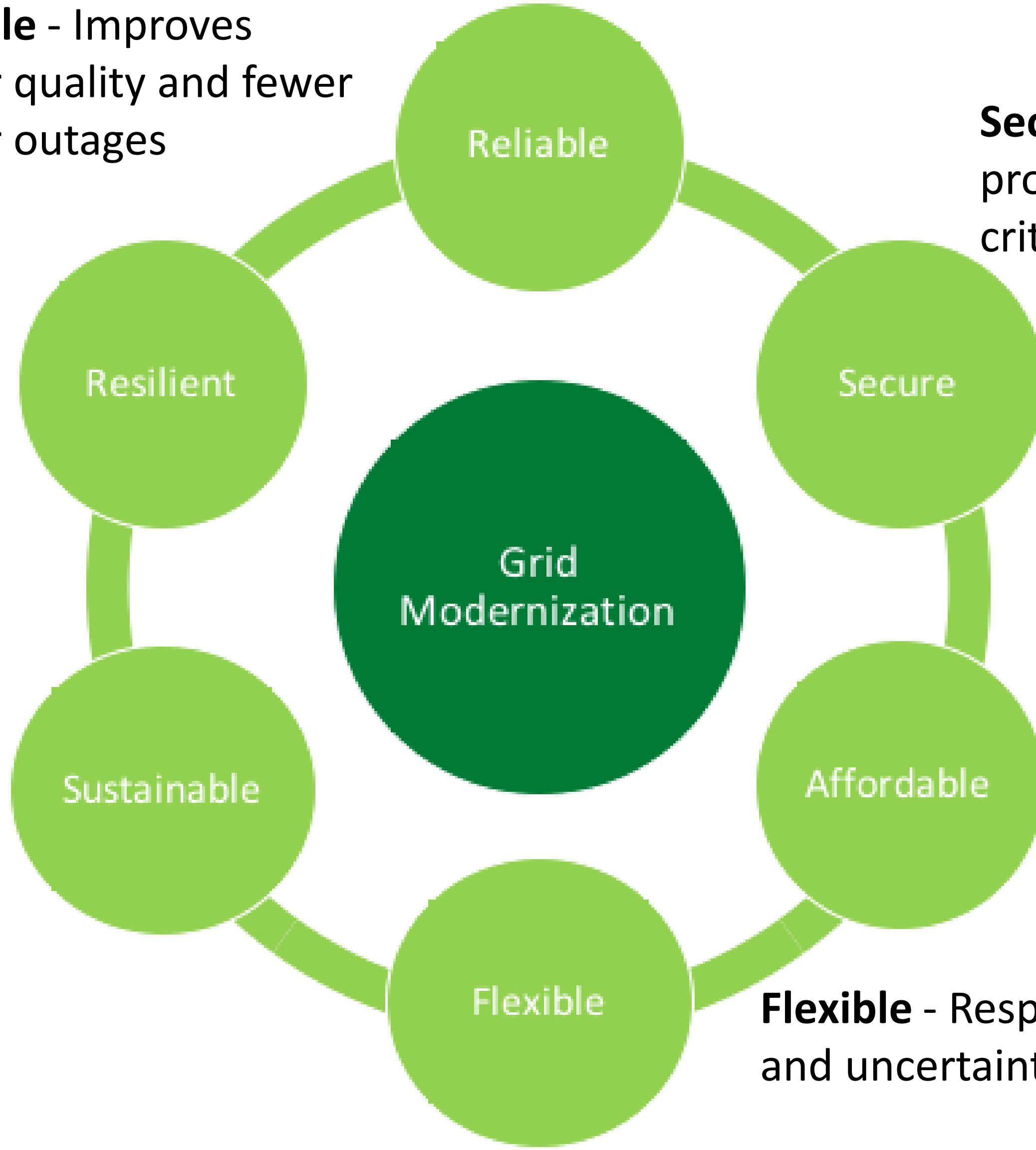
- 80% clean electricity by 2035
- State RPS and EEPS mandates
- Access to reliable, affordable electricity
- Climate adaptation and resilience

Key future grid attributes

Reliable - Improves power quality and fewer power outages

Secure - Increases protection to our critical infrastructure

Resilient - Quick recovery from any situation or power outage



Affordable - Maintains reasonable costs to consumers

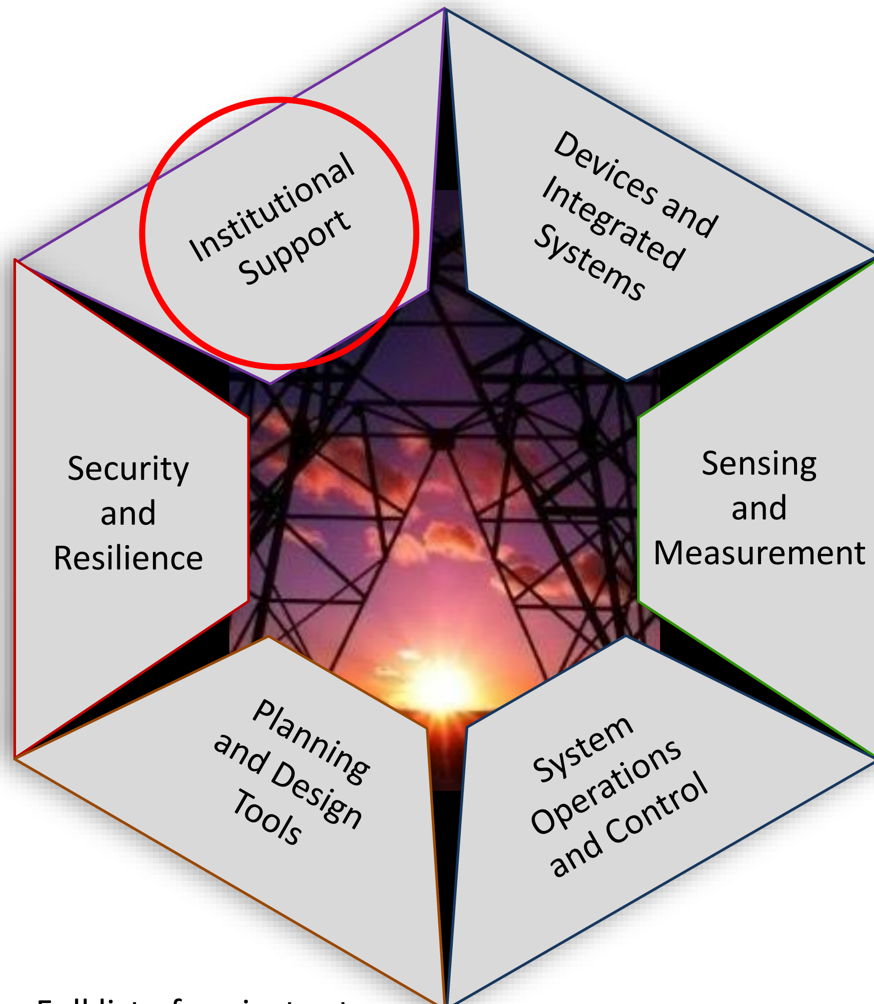
Sustainable - Facilitates broader deployment of clean generation and efficient end use technologies

Flexible - Responds to the variability and uncertainty of conditions

DOE's Grid Modernization Initiative

- An aggressive five-year grid modernization strategy that includes:
  - Alignment of the existing base activities among DOE Offices
  - An integrated Multi-Year Program Plan (MYPP)
  - New activities to fill major gaps in existing base
  - Laboratory consortium with core scientific abilities and regional outreach
- Scope
  - Developing **new architectural concepts, tools and technologies** that measure, analyze, predict, protect and control the grid of the future
  - **Enabling the institutional conditions that allow for more rapid development and widespread adoption of these tools and technologies**
- Grid Modernization Lab Consortium
  - A multi-year collaboration among 14 DOE National Laboratories and regional networks that will help develop and implement the MYPP

Foundational R&D Activities



Full list of projects at
http://energy.gov/under-secretary-science-and-energy/doe-grid-modernization-laboratory-consortium-gmlc-awards

Institutional support projects

Four main institutional support activities under DOE's Multi-year Program Plan:

1. Provide technical assistance to states and tribal governments
2. Support regional planning and reliability organizations
3. Develop methods and resources for assessing grid modernization: Emerging technologies, valuation and markets
4. Conduct research on future electric utility regulations

Each activity has specific goals and target achievements to be completed by 2020.

Institutional Support

Activity 1:
Provide Technical Assistance to States and Tribal Governments

- Provide technical assistance to states and tribes to inform their decision making for electricity policy, accelerating policy innovation in at least seven states
- Provide technical analyses to at least 10 states, including guidance on how to consider new technologies such as distributed energy resources and establish formal processes to review utility distribution system plans

Institutional Support

Activity 2:
Support Regional Planning and Reliability Organizations

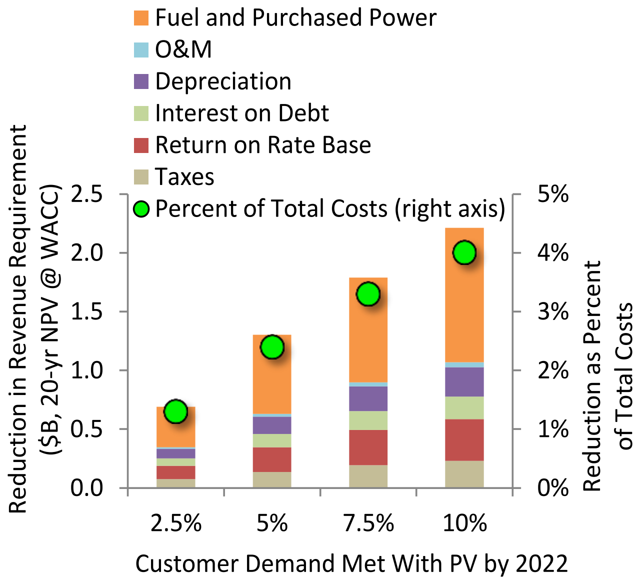
- Support regional planning and reliability organizations in developing institutional frameworks, standards, and protocols for integrating new grid-related technologies
- Coordinate a regional long-term planning process that uses standardized planning assumptions and publicly available databases of transmission topology and regional resource data
- Facilitate long-term regional planning in each U.S. interconnection

Institutional Support

Activity 3:
Develop Methods and Resources for Assessing Grid Modernization: Emerging Technologies, Valuation, and Markets

- Develop new methods for valuing distributed energy resources and services
- Develop analysis tools and methods that facilitate states' and tribes' integration of emerging grid technologies into their decision making, planning and technology deployment
- Track grid modernization progress in states and tribes through standardized data collection methods and performance and impact metrics

Activity 4:
Conduct Research and Technical Assistance on Future Electric Utility Regulations



See "Future Electric Utility Regulation" slides

6 Institutional Support Projects

Regional Projects

- New York: Technical Support to the Reforming Energy Vision (REV) Initiative*
- California: Distributed Energy Resources (DER) Siting and Optimization Tool to enable large scale deployment of DER*

Foundational Projects

- Foundational Analysis: Metrics*
- Grid Services and Technologies Valuation Framework*
- Future Electric Utility Regulation
- Distribution System Planning: Decision Support Tools

**See "Additional Slides"*

Future Electric Utility Regulation

Goals:

- States will have improved capability to consider alternative regulatory and ratemaking approaches to enable grid modernization investments, including financial incentives for utilities and impacts on consumers and markets
- Approaches will better tie utility earnings to consumer value, economic efficiency, pollution reduction and other public policy goals

Tasks:

1. Use improved financial analysis tools to help states make better-informed decisions
2. Provide direct technical assistance to state public utility commissions considering incremental changes to cost of service regulation (e.g., decoupling or rate design changes) or more fundamental changes (e.g., performance-based regulation)
3. Continue Future Electric Utility Regulation series of reports

Participants:

- LBNL (lead – Lisa Schwartz), NREL (Lori Bird), PNNL, SNL, LANL, NETL

Future Electric Utility Regulation Series

- A new series of reports from Lawrence Berkeley National Laboratory taps leading thinkers to grapple with complex regulatory issues for electricity
- Unique point-counterpoint approach highlights different views on the future of electric utility regulation and business models and achieving a reliable, affordable and flexible power system
- Expert advisory group provides guidance and review
- Primary funder of initial reports: DOE Office of Electricity Delivery and Energy Reliability - Electricity Policy Technical Assistance Program
    1. *Distributed Energy Resources (DERs), Industry Structure and Regulatory Responses*
    2. *Distribution Systems in a High DER Future: Planning, Market Design, Operation and Oversight*
    3. *Performance-Based Regulation in a High DER Future*
    4. *Distribution System Pricing With DERs*
    5. *Recovery of Utility Fixed Costs: Utility, Consumer, Environmental and Economist Perspectives*
    6. *The Future of Electricity Resource Planning*
- DOE Office of Energy Efficiency and Renewable Energy is co-funding new reports

feur.lbl.gov

FUTURE ELECTRIC
Utility Regulation

Next 3 Future Electric Utility Regulation reports under DOE's Grid Modernization Initiative

- **What is the future of wholesale electricity markets?**
  - Market impacts of integrating increasingly higher levels of renewable resources with zero marginal cost
  - Market impacts of environmental regulations further constraining the deployment of fossil fuel resources
  - Adequacy of today's market designs to acquire the flexible resources needed to integrate increasing levels of variable energy resources at least cost
  - Adequacy of today's market designs to accommodate state public policy goals and potential design changes to further enable deployment of resources that achieve goals
- **What incentives and disincentives do utilities have for investing in electricity infrastructure** (e.g., information and communication technologies, conservation voltage reduction on distribution systems, visualization and automation technologies for transmission systems) **in the face of rapid changes in the electric industry?**
- **How can state utility regulators foster competition for value-added electricity products and services while allowing utilities to play new roles?**

Distribution System Decision Support Tool

Goal:

- A widely accepted process for advanced electric distribution planning (EDP)

Tasks:

1. Conduct outreach and workshops on EDP processes and gaps
2. Provide education for state regulators (leverage NARUC) and utilities on EDP
3. Develop a formal approach to review grid components and systems and identify and modify tools for utilities for next-generation EDP processes
4. Provide TA to utilities (modeling tools and best practice, leverage APPA and NRECA) and state regulators (including a process for reviewing a utility's proposed distribution system plan)
5. Develop lessons learned toolkit (models, resources, best practices)

Participants:

- NREL (lead – Mike Coddington), LBNL (Lisa Schwartz), PNNL (Juliet Homer)

Additional Slides

1.1 Foundational Analysis for GMLC Establishment of a Framework of Metrics

Goals:

To develop a comprehensive framework of metrics and supporting data collection, processing, analysis and reporting, along with underlying data, *tools*, methods and *systems* to assess the evolving state of the grid and the impact that specific grid modernization investments are expected to achieve and actually deliver

The six "ilities:"

- *Reliability*
- *Resilience*
- *Flexibility*
- *Sustainability*
- *Affordability*
- *Security*

Tasks:

1. Establish initial metrics/baseline
2. Refine/implement
3. Multi-dimensional analysis
4. Stakeholder engagement

1.2.4 Grid Services and Technologies Valuation Framework

Goals:

- Provide a widely accepted, well-tested framework for evaluating the collection of value streams (net benefits) that can be provided by different grid-related services and technologies.

Tasks:

1. Stakeholder Advisory Group and communications
2. Listing and definition of services, technologies, values, and beneficiaries
3. Review methodologies for gaps and commonalities
4. Develop full framework
5. Conduct table-top and pilot demonstrations

1.3.22 Technical Support to the New York State Reforming the Energy Vision (REV) Initiative

Goals:

- Continue and expand DOE support to the New York Reforming the Energy Vision initiative in the form of TA to New York Public Service Commission and New York State Energy Research and Development Authority (NYSERDA)

Tasks:

1. Project Coordination and Oversight
2. Needs Assessment
3. Deliver Technical Assistance
4. Assessment of Distribution Planning Methods
5. Evaluation of REV Demonstration Projects
6. Analysis of Implementation Models
7. Support to New York Prize (microgrid competition)

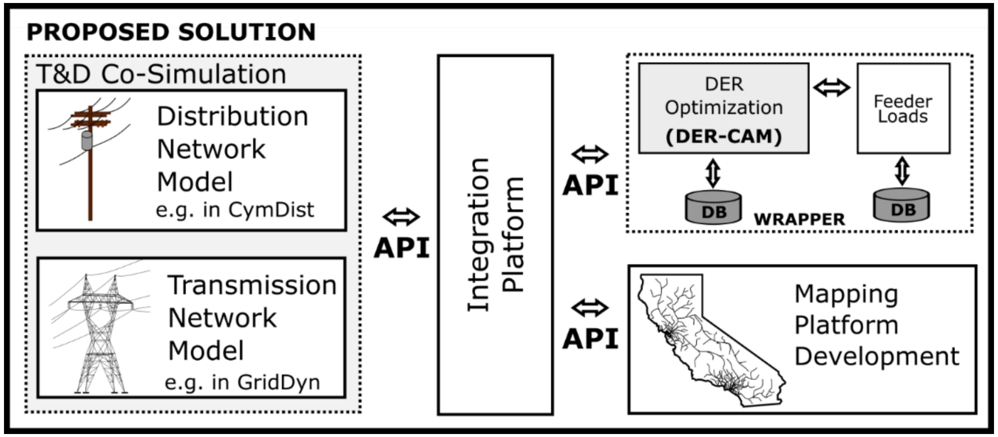
1.3.5 DER Siting and Optimization Tool to enable large scale deployment of DER in California

Goals:

- Deliver an online, open-access integrated distributed resource planning tool to promote DER penetration taking into account system-wide impacts

Tasks:

1. Develop CA T&D co-simulation models and data visualization
2. Find meaningful behind-the-meter DER adoption patterns and DER operational strategies
3. Identify favorable DER and microgrid sites considering policy incentives and DER grid services
4. Consider network constraints for DER location
5. Evaluate and mitigate impacts of DER in bulk electric system



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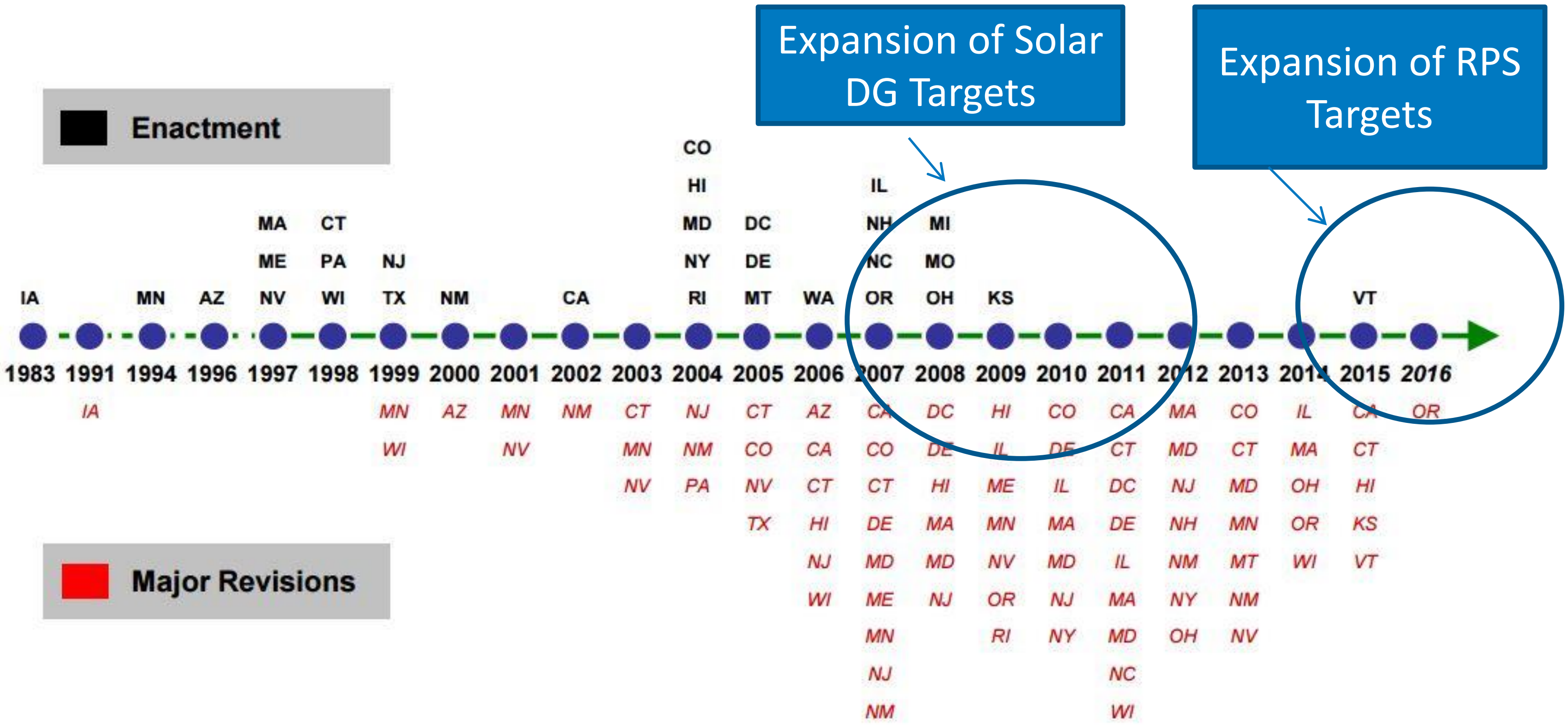
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Implications of Grid Modernization for Renewable Portfolio Standard (RPS) Goals and Implementation

Lori Bird

October 11, 2016

Evolution of Renewable Portfolio Standards (RPS)



- While initial RPS targets were often 15-20% renewables, over time, many states have increased targets (several at 50%+ RE)
- Solar and DG carve-outs in many states (18) are leading to substantial amounts of distributed generation

Source: Barbose LBNL, U.S. Renewables Portfolio Standards 2016 Annual Status Report

How Much Renewable Energy Can the Grid Handle?

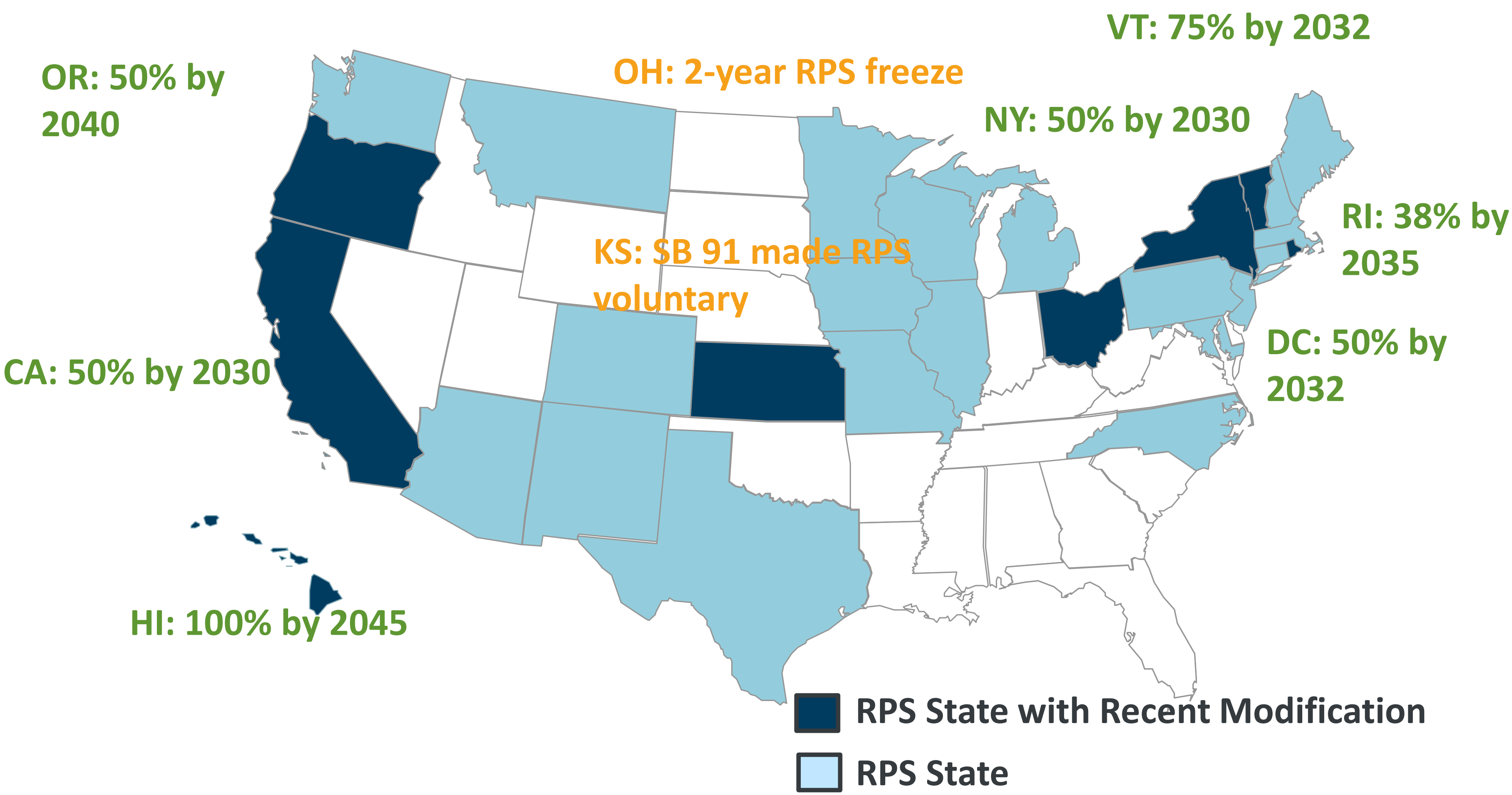
NREL has conducted a series of modeling studies to examine grid impacts of Increasing penetrations of renewable energy

20% → **30%** → **80%**

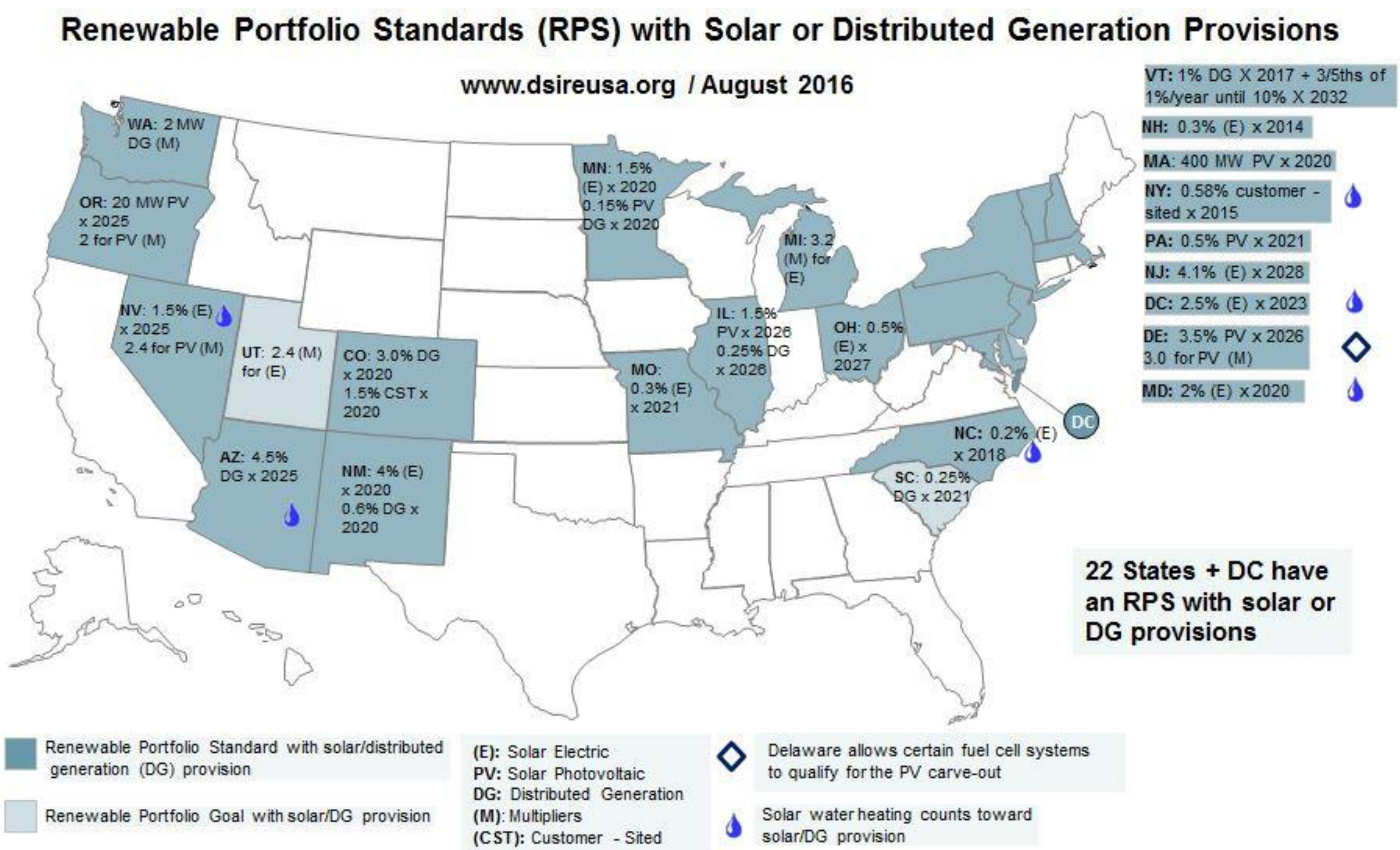
http://www.nrel.gov/grid/power-systems-design-studies.html

Recent Changes in State RPS Targets

6 states recently increased RPS targets to 50% RE or greater



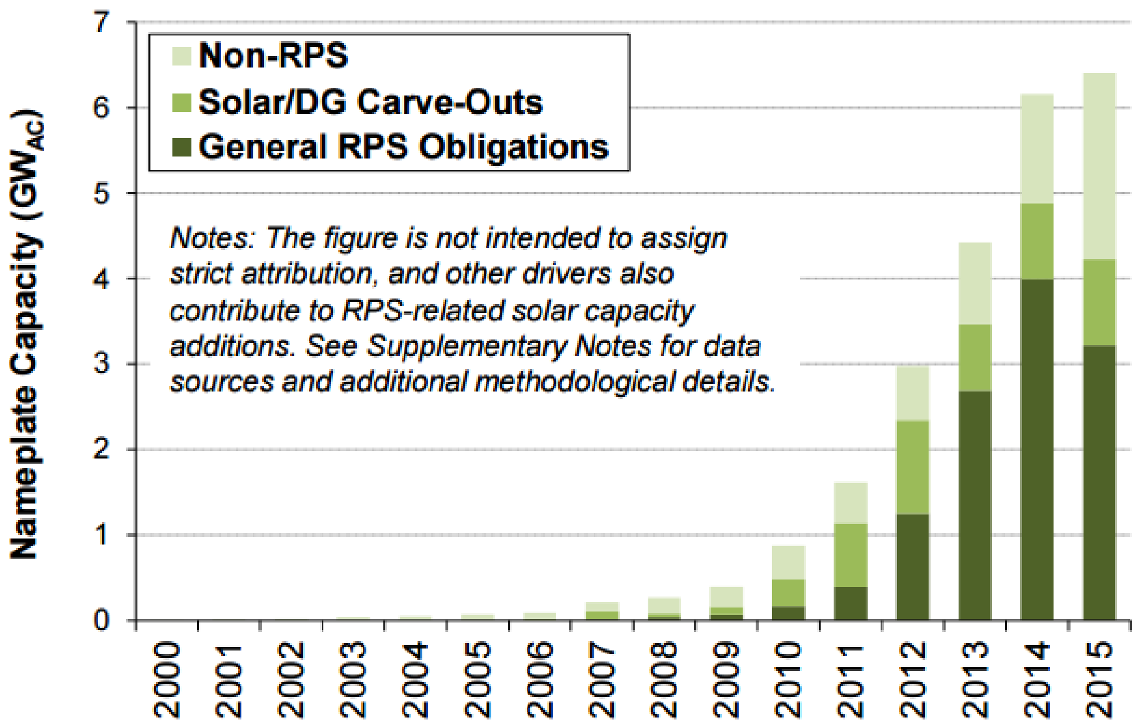
State Solar and Distributed Generation Carve Outs



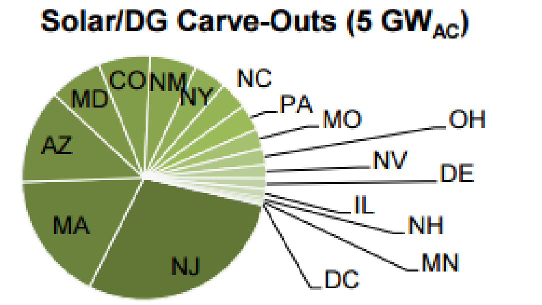
Source: DSIRE database http://www.dsireusa.org

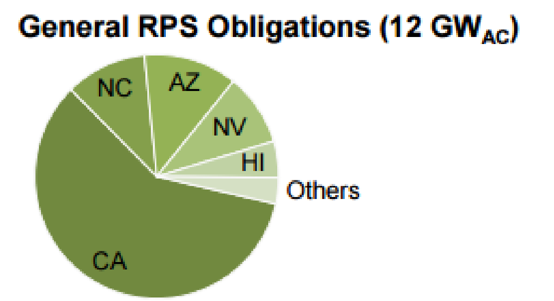
RPS Solar Carve-outs Driving Distributed Solar

Annual U.S. Solar Capacity Additions



Cumulative RPS Solar Capacity Additions

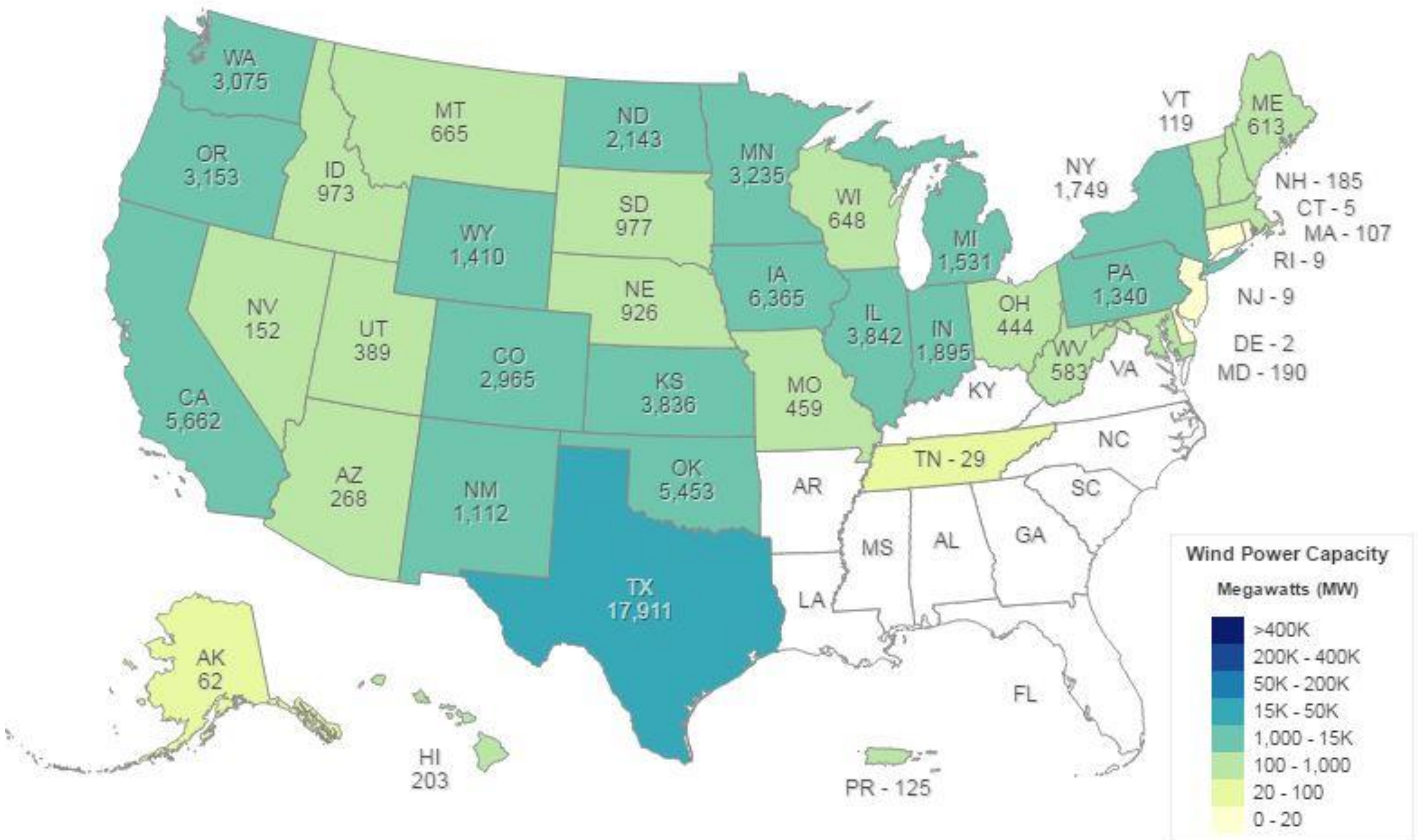




Notes: A portion of the solar capacity shown for AZ and NV serves RPS obligations in CA

Source: Barbose, LBNL, U.S. Renewables Portfolio Standards 2016 Annual Status Report

Wind Energy Installations by State



Total Installed Wind Capacity: 74,819 MW

Source: American Wind Energy Association Q2 2016 Market Report

Renewables are One Driver for Grid Modernization

Grid modernization addresses a variety of trends, new technologies, and new demands on electric energy infrastructure in the coming years

- A changing mix of types and characteristics of electric generation
- Growing demands for a more resilient and reliable grid
- Growing supply- and demand-side opportunities for customers to participate in electricity markets
- The emergence of interconnected electricity information and control systems
- An aging infrastructure

DOE Grid Modernization Initiative Objectives

Objective: to help shape the future of our nation's grid and solve the challenges of:

- integrating conventional and renewable sources with energy storage and smart buildings,
- while ensuring that the grid is resilient and secure to withstand growing cybersecurity and climate challenges.

Goals:

- 10% reduction in the societal costs of power outages
- 33% decrease in cost of reserve margins while maintaining reliability
- 50% cut in the costs of wind and solar and other DG integration

Grid Evolution to Adapt to Changing Resource Mix

New Generation/Use Characteristics

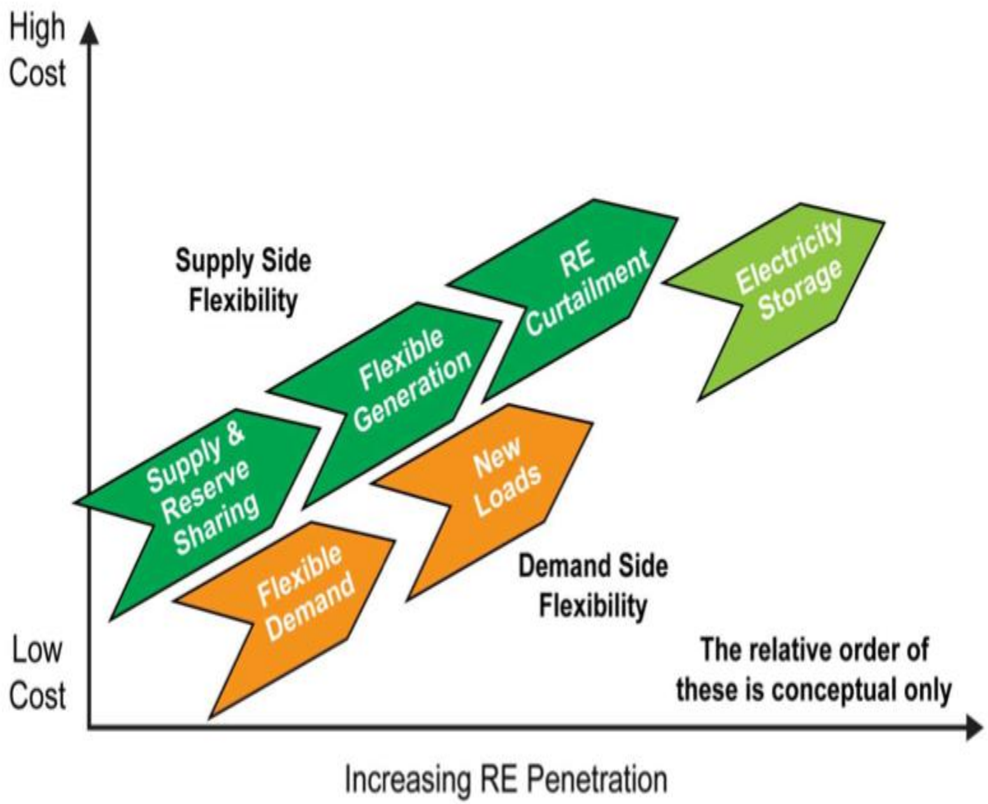
- Increased variability and uncertainty of generation (wind/solar)
- Time of renewable generation may not correspond with loads
- More prosumers –more on-site consumption and grid exports
- Shifting system peaks with solar consumption (duck curve)
- Rapid growth of distributed generation on feeders, clustering of DG in some cases

Grid Needs and Impacts

- Need for additional grid flexibility to address variability
- Ability to address greater consumer interaction (e.g., advanced metering, smart inverters)
- Improved sensing and measurement
- Address distribution system impacts (e.g., voltage) of more DERs and clustering
- Changing needs for distribution system planning
- More demand response to add system flexibility

Grid Flexibility is Needed to Manage Higher Amounts of RE

Can manage higher penetrations of renewables on the grid through both supply-side and demand side mechanisms

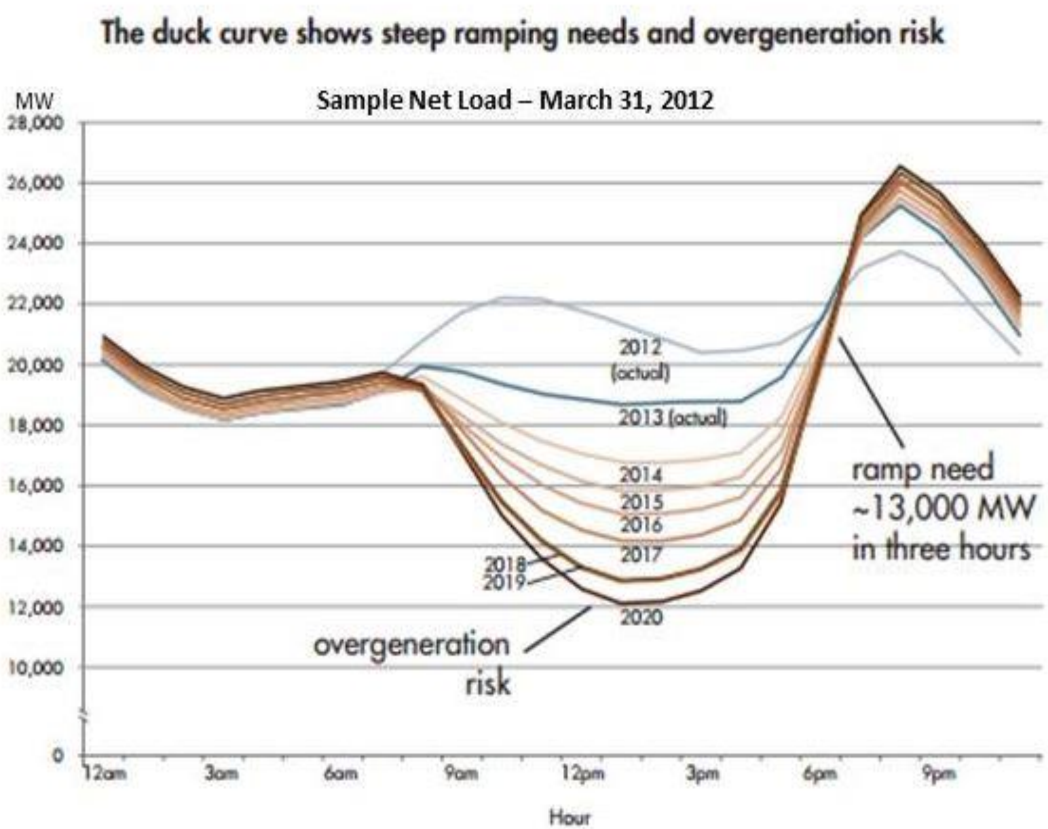


Both **supply and demand side** flexibility can help address grid challenges

Demand side flexibility can be achieved through various means:

- Demand response/time of use rates
- Storage
- New loads (e.g., EVs)

Example: Grid Modernization Solutions for Solar



(from the California Independent System Operator)

- California concerned about large solar energy consumption mid-day – duck curve
- Potential solutions include increased demand response, storage
- Moving to Time-of-use (TOU) rates to encourage customer load shifting
- Grid must be capable of the consumer interaction (e.g., advanced metering needed, customer needs automatic load controls)

DOE Grid Modernization Efforts

Devices and Integrated Systems	• Connected testing methods and facilities (Labs, academia, industry) • Open source library of generic device models
Sensing and Measurement	• Low-cost easily installed sensor technologies • Nationwide grid sensing network for system visibility
System Operations and Power Flow	• Stochastic, predictive EMS for real-time operations • Active power flow control technologies
Design and Planning Tools	• Integrated grid modeling framework (ISO <-> devices) • Desktop distribution system planning tool
Security and Resilience	• Device-level "day 0 attack" detection and protection • Distributed control for self-healing grids
Institutional Support	• Standards for interoperability and interconnection • Market transformation analysis tools and resources

NREL Tools

Future Electric Regulation Project – Technical Assistance

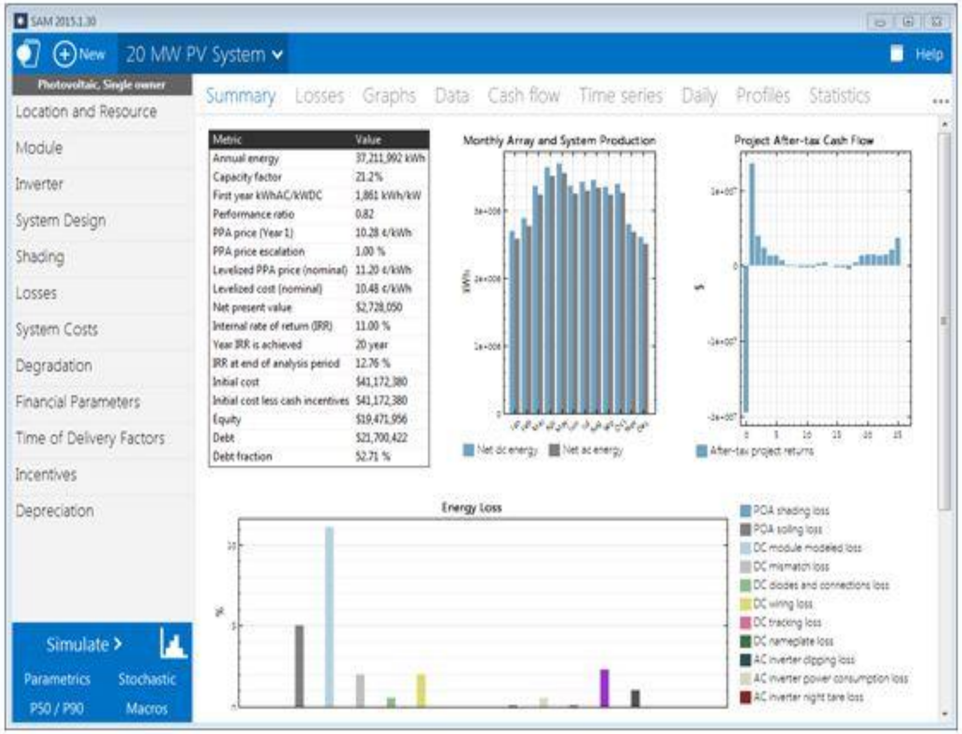
- Grid Modernization Future of Electric Utility Regulation Project includes state technical assistance (TA)
- NREL can provide TA to evaluate rate or regulatory changes to address the changing generation mix and grid issues, such as:
    - New rate designs to address grid issues (e.g., TOU rates)
    - Distributed generation adoption under rate designs
    - Distribution system impacts of DER loads and consumer interaction
- Some of NREL tools:
    - System Advisor Model (SAM)
    - Distributed Generation Market Demand Model (dGen)
    - Integrated Energy Systems Model (IESM)

System Advisor Model (SAM)

SAM is a financial and performance model for renewable energy technologies

Simulates RE system production for specific locations based on weather files

- **Can evaluate system payback under various rate structures**
- **Can evaluate commercial and residential financing models**

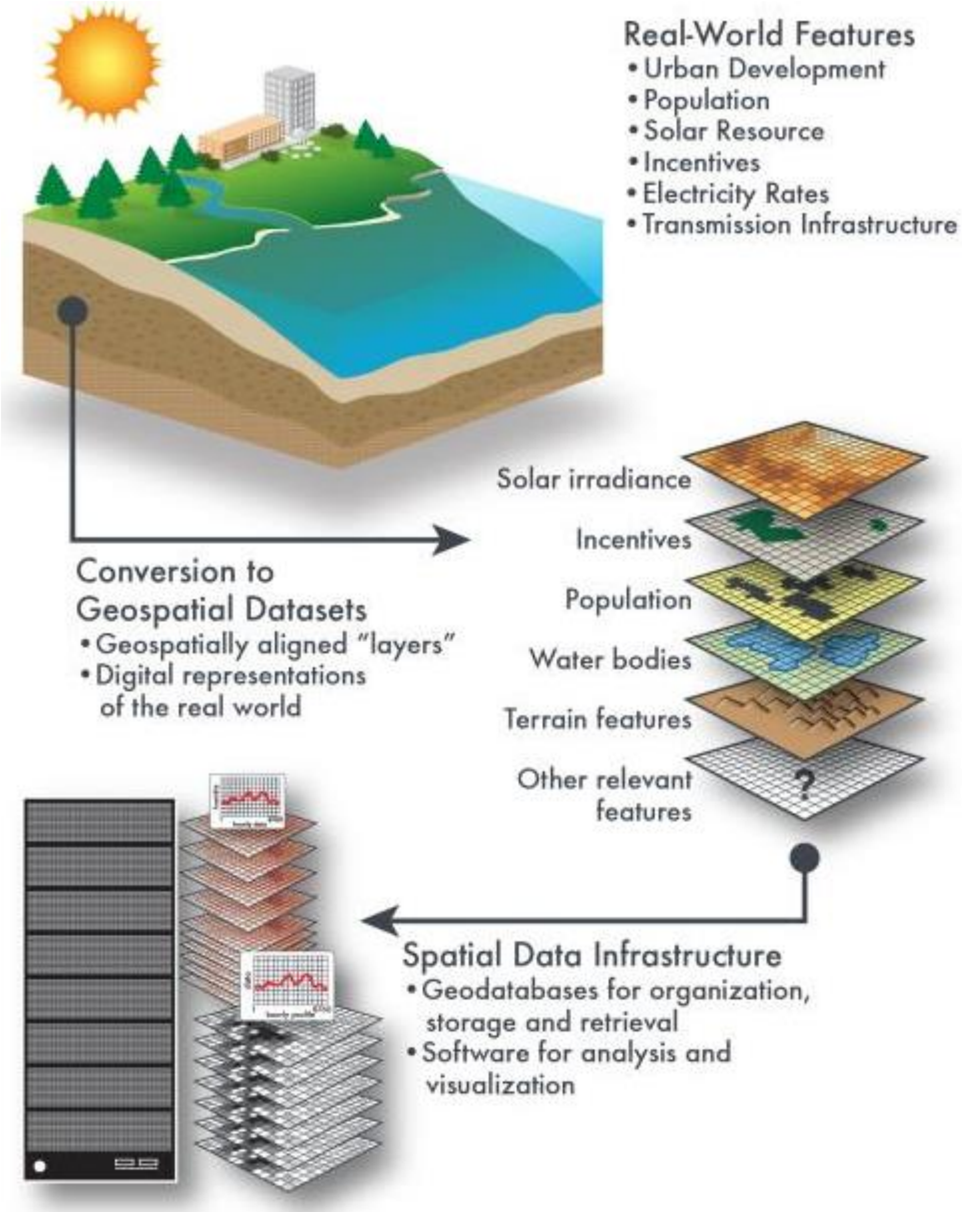


SAM https://sam.nrel.gov/

Distributed Generation Market Demand Model (dGen)

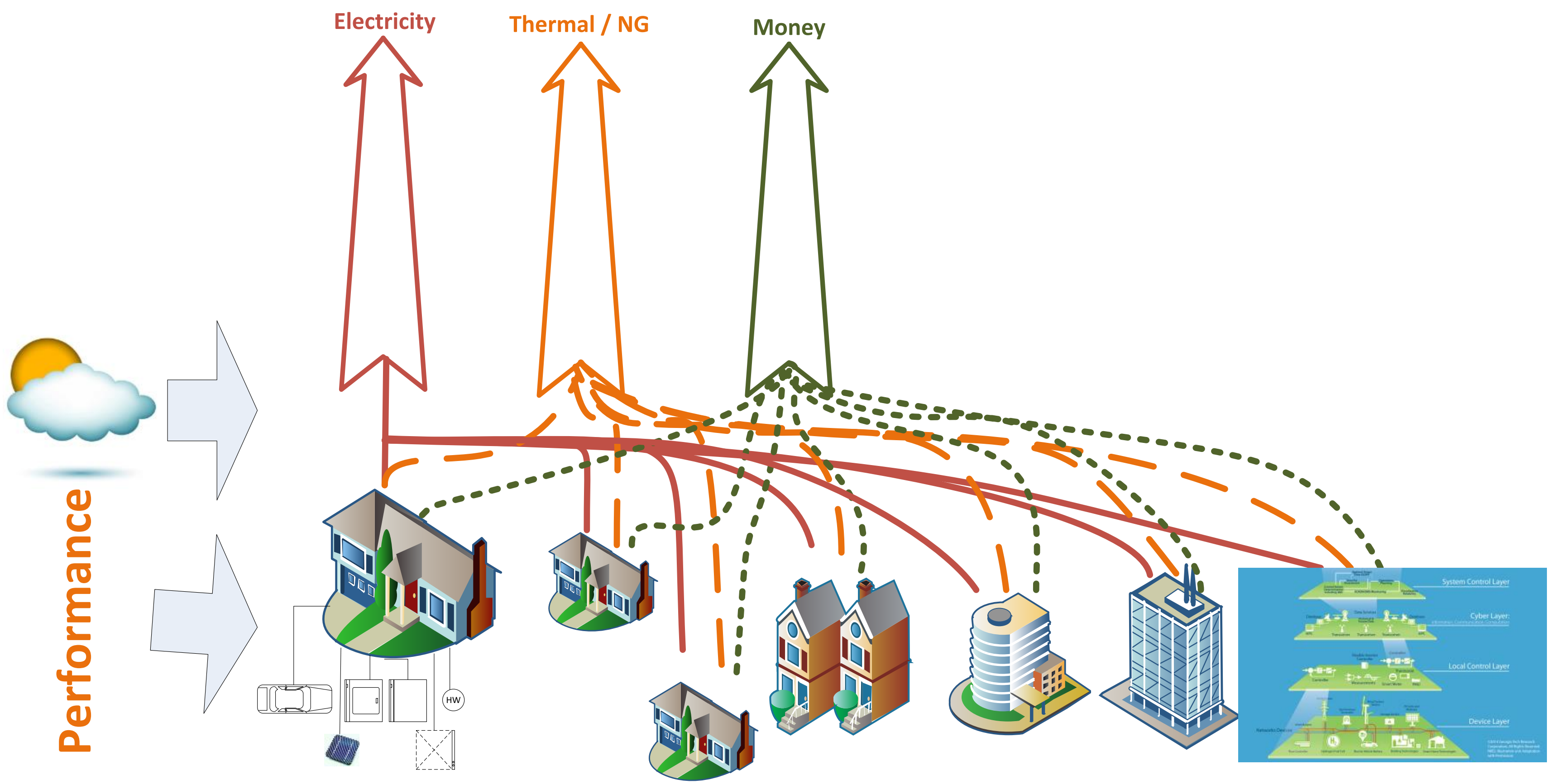
Model Overview:

- The dGen family of models forecasts customer adoption of distributed generation technologies for residential, commercial, and industrial entities in the contiguous United States through 2050.
- dSolar is the distributed PV module within the dGen family
- High geographic resolution enables state, utility, or city-specific analysis with overlay of multiple spatial layers.
- Major Studies: SunShot Vision, Renewable Electricity Futures, Impact of Federal Tax Credit Extensions on Renewable Deployment
- dGen model documentation: Sigrin et. al., 2016



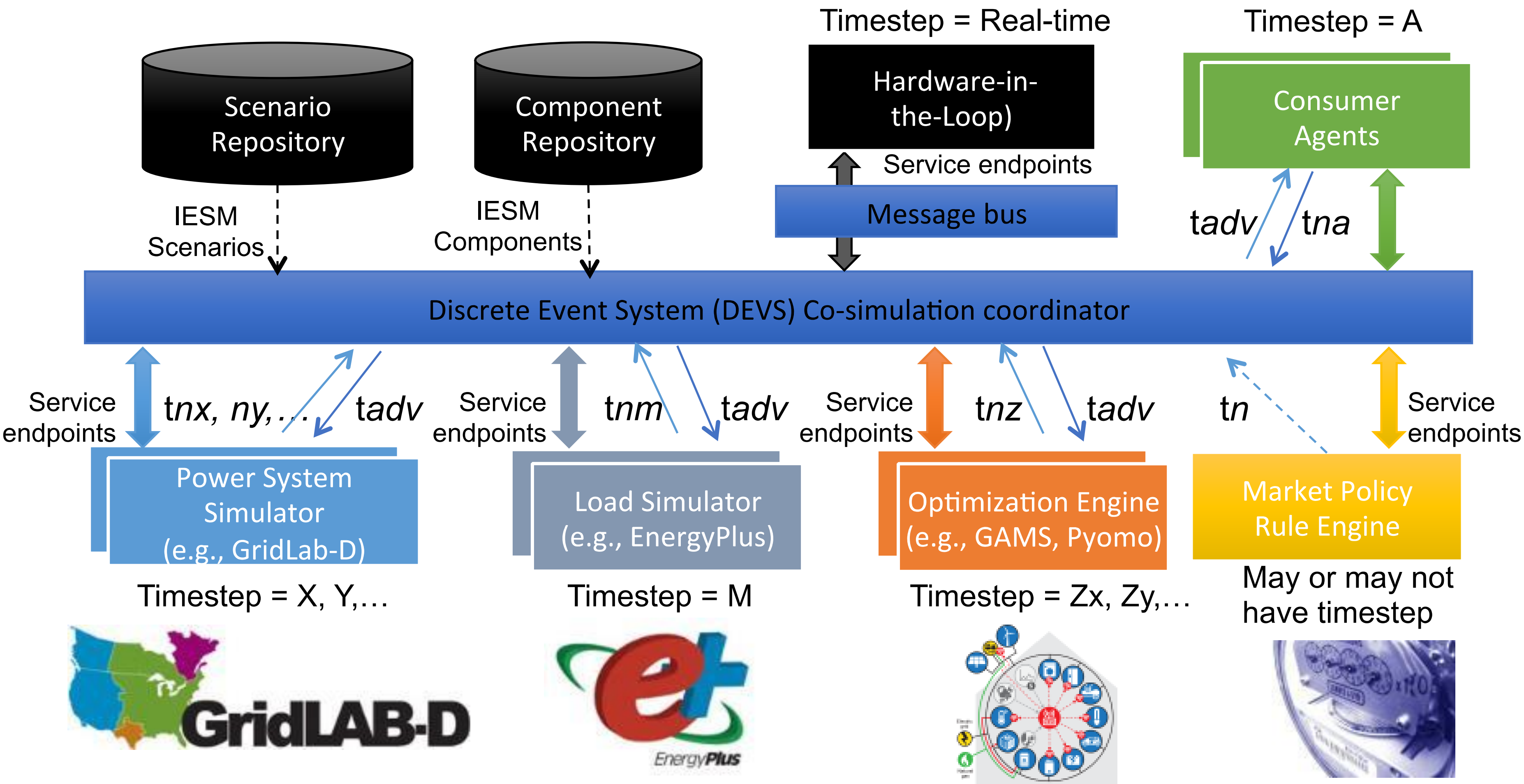
Integrated Energy System Model (IESM) Simulation Tool

- Examines physics-based performance of technologies and buildings
- Enables evaluation of multiple retail markets and tariff structures
- Provides market layer input to market-to-device testing



Co-Simulation Platform

- The Integrated Energy System Model (IESM) co-simulation platform enables simulation of the impact of emerging technologies and tariffs on the electric distribution system



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Thank you for attending our webinar

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