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The Resource Planning Portal: an online platform for IRP data

Presented by Juan Pablo Carvallo

National Association of Regulatory Utility Commissioners
Center for Partnerships & Innovation Webinar – March 14, 2019

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In this presentation

- The Resource Planning Portal (RPP)
  - Conception
  - Main components
  - Key statistics
- Existing research applications
  - Comparing planning and procurement
  - Trends in market transactions
- Future research
  - Regional resource adequacy assessment

RPP Conception: Wilkerson et al (2014)

- Comprehensive review of Western U.S. 2010-2012 integrated resource plans (90% of sales)

- Evaluate plant retirements; load, DSM, and generation mix forecast; risk categories and assessment techniques.

- Reported inconsistency and lack of clarity in information included in IRP:
  - Nominal vs available capacity
  - Real vs nominal dollars for fuel, carbon, and capital costs
  - Proprietary forecast data for fuels, electricity, or others
  - Absence of DSM data, especially in smaller LSEs

The Resource Planning Portal (RPP)

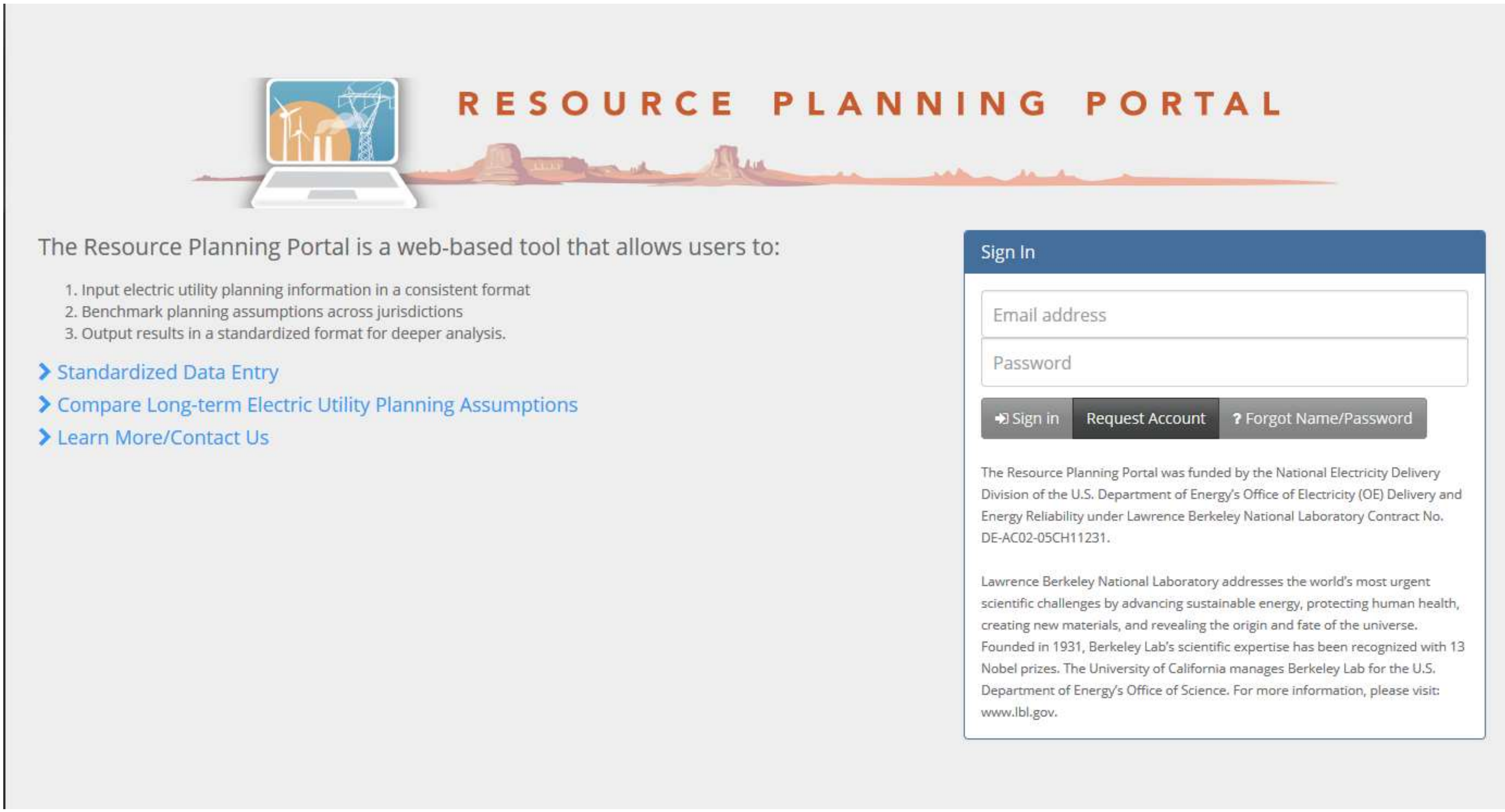
- The Resource Planning Portal is a free, web-based tool that allows users to:

  (1) Input long-term electric utility planning information in a consistent format

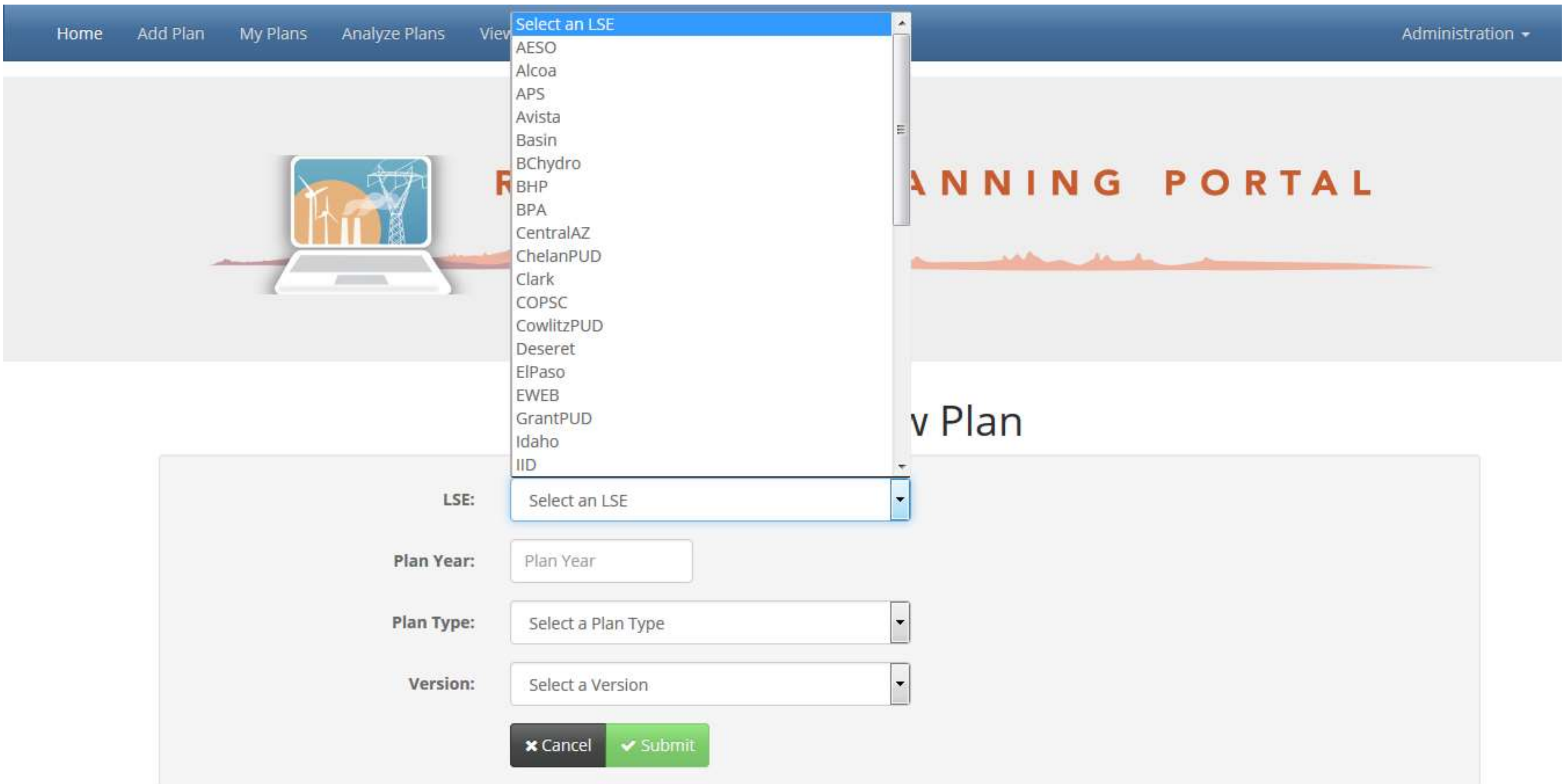
  (2) Benchmark planning assumptions across jurisdictions and load serving entities (LSE) and

  (3) Visualize and output results in a standardized format for deeper analysis.

Landing page: http://resourceplanning.lbl.gov



Entering a new plan



Input plan - Data structure

1. Basic Plan Information
2. Load Forecasts and DSM
   I. Base Case and Load Forecast
   II. Energy Efficiency Program Savings
   III. DR Peak Demand Reduction
3. Power Plants and Contracts
   I. Energy Production Forecasts
   II. Plants
   III. Contracts
4. Transmission, Distribution and Storage
5. Fuel and Environmental Assumptions
   I. Fuel Price Assumptions
   II. Fuel Purchase Agreements
   III. Carbon Price Assumptions
   IV. Other Assumptions
   V. New Generation Capital Costs
6. Loads and Resources
7. Files/Reference

Basic Plan Information

LSE APS

Plan Year 2014

Published Date 04/01/2014

Plan Type Integrated Resource Plan (IRP)

Version Original

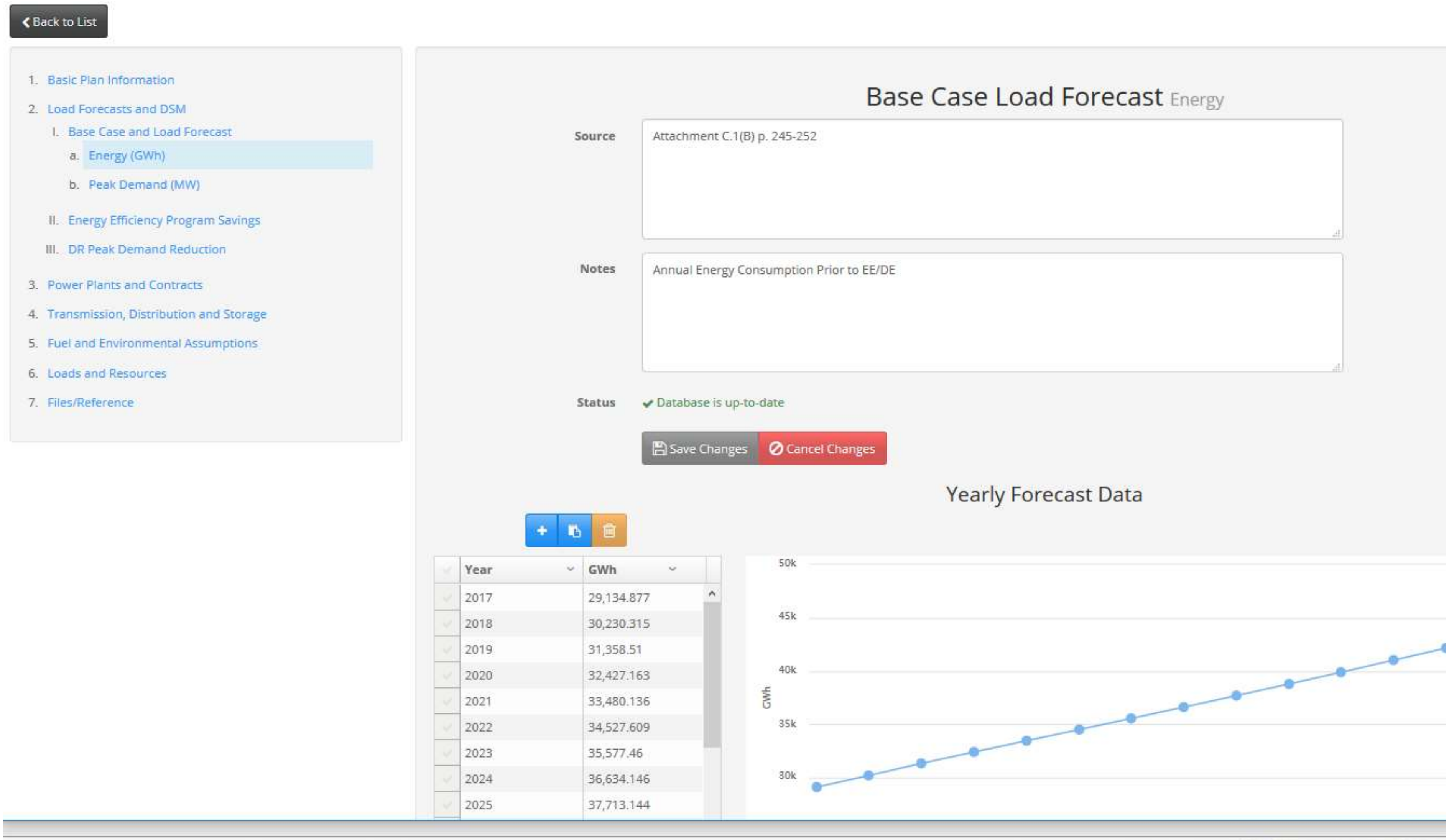
Forecast Horizon 15

General Comments Attachments hold relevant information. They start from p. 198 in the general document.
Analysis ranges from 2014 to 2029

Status ✔ Database is up-to-date

Save Changes | Cancel Changes

Input plan – Load and DSM forecasts



Input plan – Supply side resources

Plant Information

New Plants | Existing Plants | All Plants

Import | New | View/Edit | Remove

Plant Name	In Service Year	Retire Year	Fuel Type	Owned Nameplate Capaci...	Nameplate Capacity
Sexton (Glendale la...	2010	2029	Biogas	2.86	2.86
Small Gen (Tonopah)	2012		Biogas	3	3
SWMP Biomass (Sn...	2008	2023	Biomass	14	14.5
Cholla 1	1962		Coal	116	116
Cholla 2	1978		Coal	260	260
Cholla 3	1980		Coal	271	271
Four Corners 1,2,3	1964	2013	Coal	560	560
Four Corners 4,5	1970		Coal	970	1500
Navajo Generating ...	1975		Coal	315	2250
CC Tolling #1 1A,2A...	2007	2017	Electricity	541	541
CC Tolling #2 1A,2A...	2010	2019	Electricity	579	579
Market Call Option	2008	2015	Electricity	500	500
Salton Sea CE Turb...	2006	2029	Geothermal	10	10

Input plan – Costs and environmental assumptions

1. Basic Plan Information
2. Load Forecasts and DSM
3. Power Plants and Contracts
   - I. Energy Production Forecasts
   - II. Plants
   - III. Contracts
4. Transmission, Distribution and Storage
5. Fuel and Environmental Assumptions
   - I. Fuel Price Assumptions
   - II. Fuel Purchase Agreements
   - III. Carbon Price Assumptions
   - IV. Other Assumptions
   - V. New Generation Capital Costs
6. Loads and Resources
7. Files/Reference

New Generation Capital Costs

+ Ne

Resource	Time Money Value	Capital Cost	Fixed Cost
Geothermal	Real Dollars	4880	83
Solar - DG	Real Dollars	3870	26
Solar - DG	Real Dollars	2696	26
Solar - PV	Real Dollars	2098	25
Wind	Real Dollars	2250	40
CCCT	Real Dollars	965	5.18
SCCT	Real Dollars	1073	5.5

Upload IRP documents

Files/Reference

Upload a File

Download | View | Remove

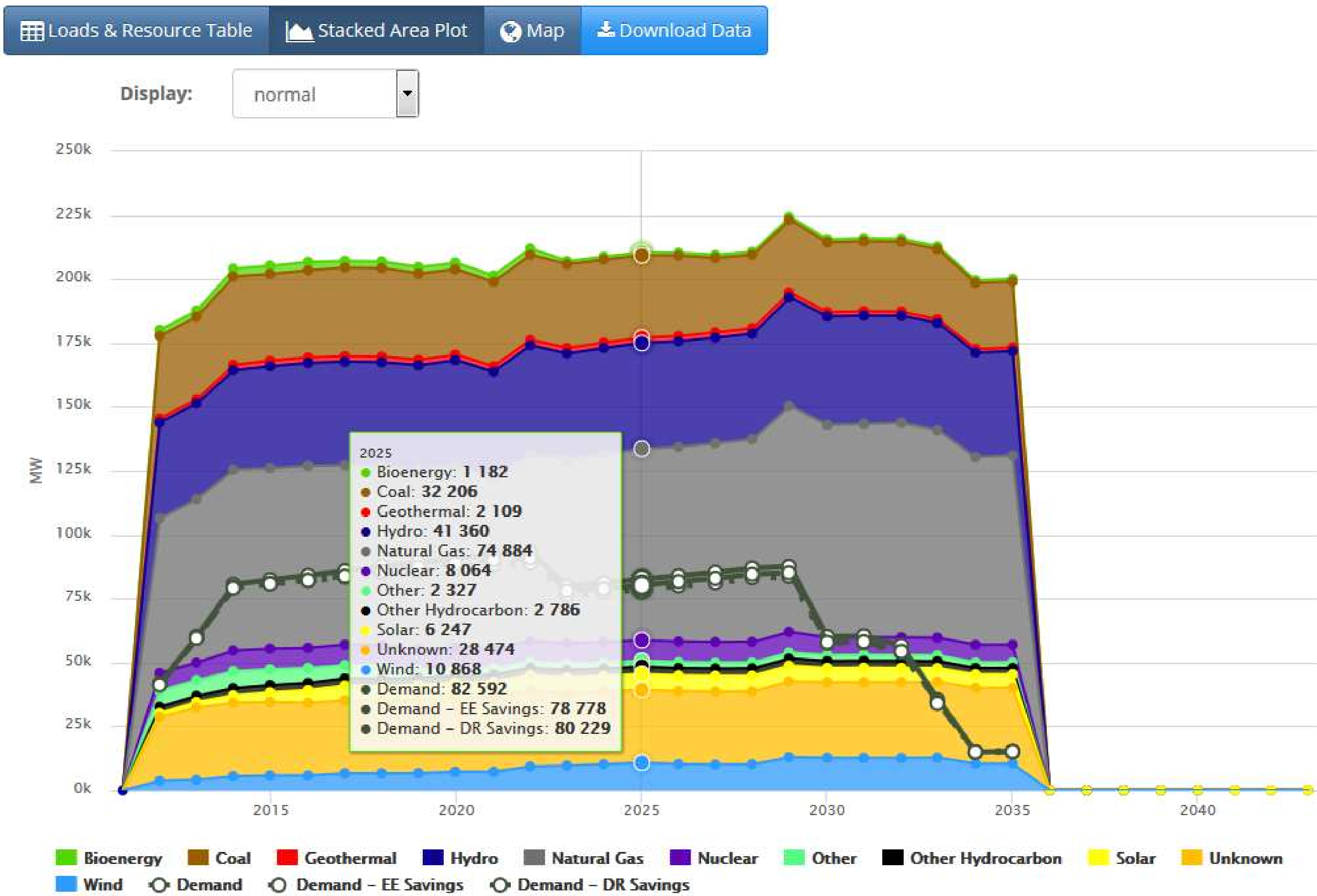
	File Name	Tag	File Description	Upload Date	Status
	2014_IntegratedResource...	Main report		05/06/2015 15:49	✔ OK
	2014_IntegratedResource...	Executive Summary		05/06/2015 15:51	✔ OK
	2014IRPSupplement.pdf	IRP Supplement		05/06/2015 15:52	✔ OK
	Support Calcs.xlsx	Support Calculations	JP's file with extracts from...	05/07/2015 23:49	✔ OK

View/download data—loads and resources (L&R) table

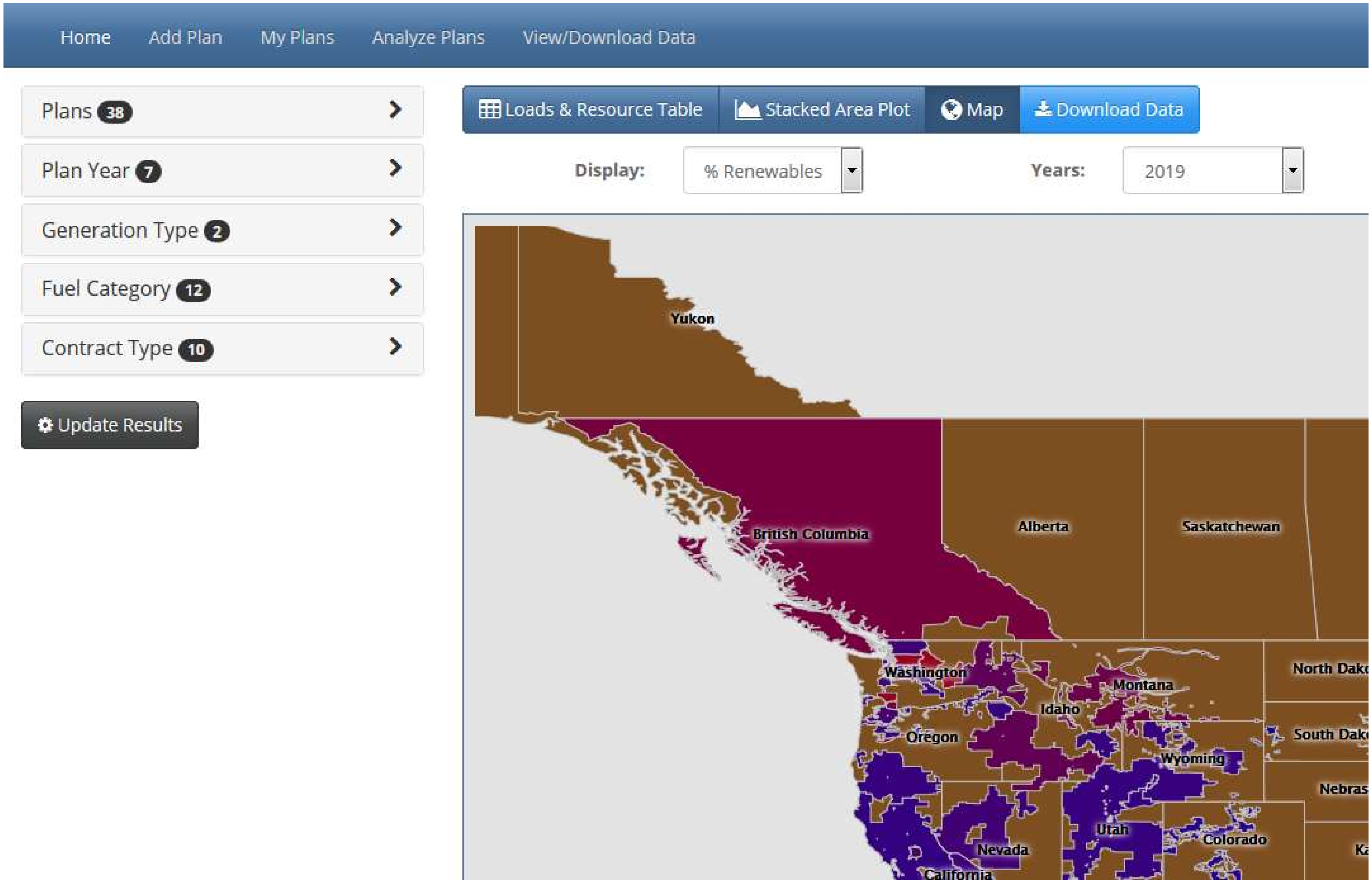
Loads and Resources

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	202
Loads Requirements (MW)	**0**	**0**	**7,146**	**7,292**	**7,573**	**7,881**	**8,180**	**8,481**	**8,772**	**9,071**	**9,373**	**9,671**	**9,965**	**10,260**	**10,558**	**10,8**
Savings (MW)																
Energy Efficiency	0	0	109	267	434	594	738	877	1,008	1,096	1,130	1,174	1,230	1,264	1,307	1,3
Demand Response	0	0	21	21	26	26	26	26	51	76	126	151	176	175	200	2
Total Savings	**0**	**0**	**130**	**288**	**460**	**620**	**764**	**903**	**1,059**	**1,172**	**1,256**	**1,325**	**1,406**	**1,439**	**1,507**	**1,5**
Net Load Requirements	**0**	**0**	**7,016**	**7,004**	**7,113**	**7,261**	**7,416**	**7,578**	**7,713**	**7,899**	**8,117**	**8,346**	**8,559**	**8,821**	**9,051**	**9,2**
Existing Resources																
Bioenergy	0	0	20	20	20	20	20	20	20	20	20	20	20	20	20	
Coal	1,522	962	1,932	1,932	1,932	1,932	1,932	1,932	1,932	1,932	1,932	1,932	1,932	1,932	1,932	1,9
Geothermal	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10	
Natural Gas	480	480	3,327	3,327	3,327	3,327	3,327	3,327	3,327	3,177	3,177	3,177	3,177	3,177	3,177	3,1
Nuclear	0	0	1,146	1,146	1,146	1,146	1,146	1,146	1,146	1,146	1,146	1,146	1,146	1,146	1,146	1,1
Other	1,620	1,620	2,138	1,638	1,638	1,097	1,097	518	518	0	0	0	0	0	0	
Other	0	0	70	70	70	70	70	70	70	70	70	70	70	70	70	

View/download data: charts



View/download data: maps



RPP statistics

- 126 plans uploaded (goal=150)
- Load serving entities:
  - 39 Western
  - 7 Eastern
  - 8 Midwest
- ~1/3 U.S. installed capacity (>340 GW)
- 22% of U.S. electricity retail sales (~820 TWh)
- ~ 200 registered users

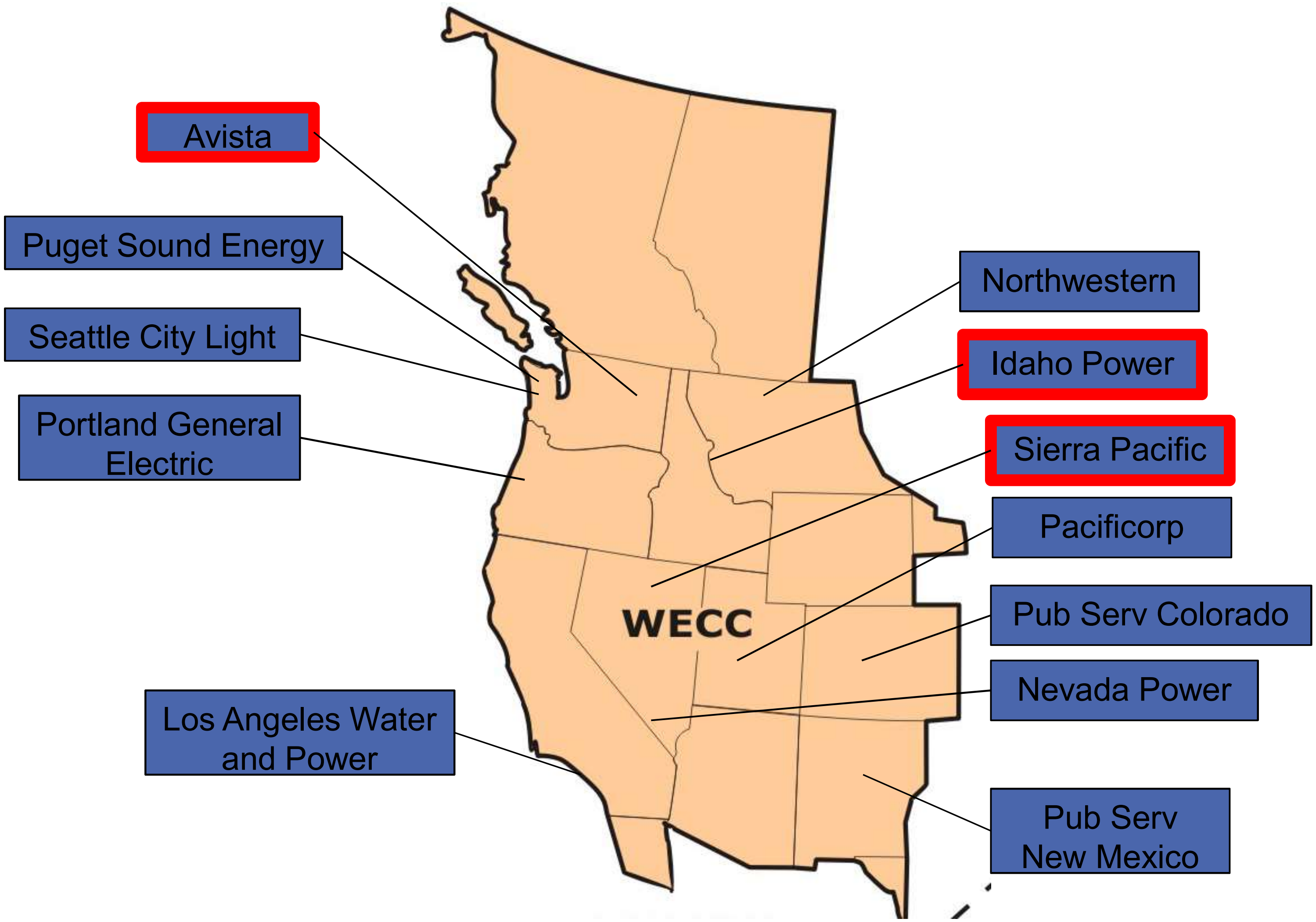
Resource	Capacity (GW)
Coal	79.9
CCCT	68.1
SCCT	65.2
Nuclear	35.3
Hydro	37.3
Wind	14.5
Unknown/Other	9.2
Solar	5.0
Demand Response	8.8

RPP Application: Planning to procurement

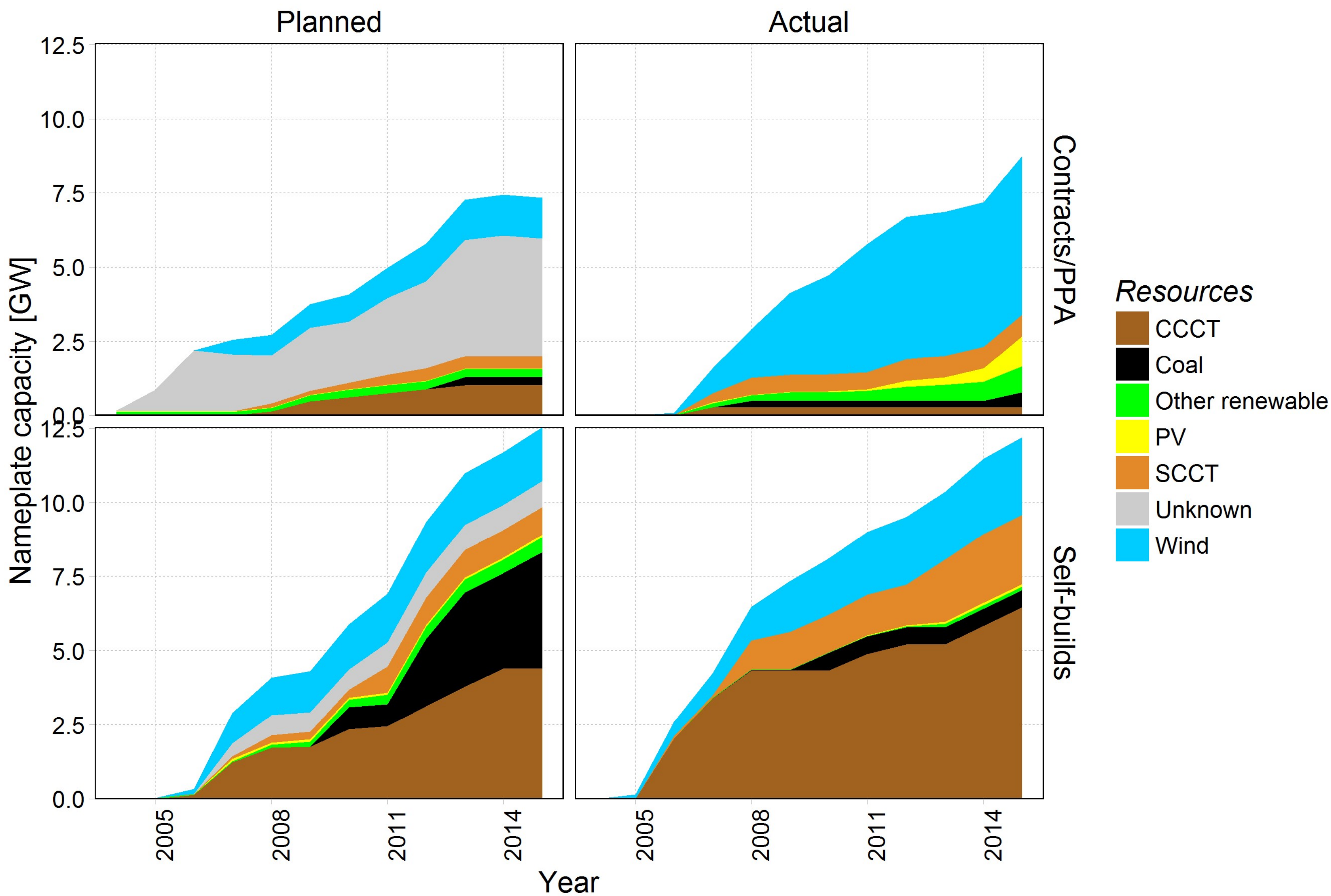
- In principle, IRP should lead to affordable and reliable electricity service through cost-effective and risk-managed resource acquisition
- However, this premise has never been tested

- How do planned acquisitions compare to actual procurement?
- If planned and procured capacities are different,
  - Why do they differ?
  - What is the value of IRP?

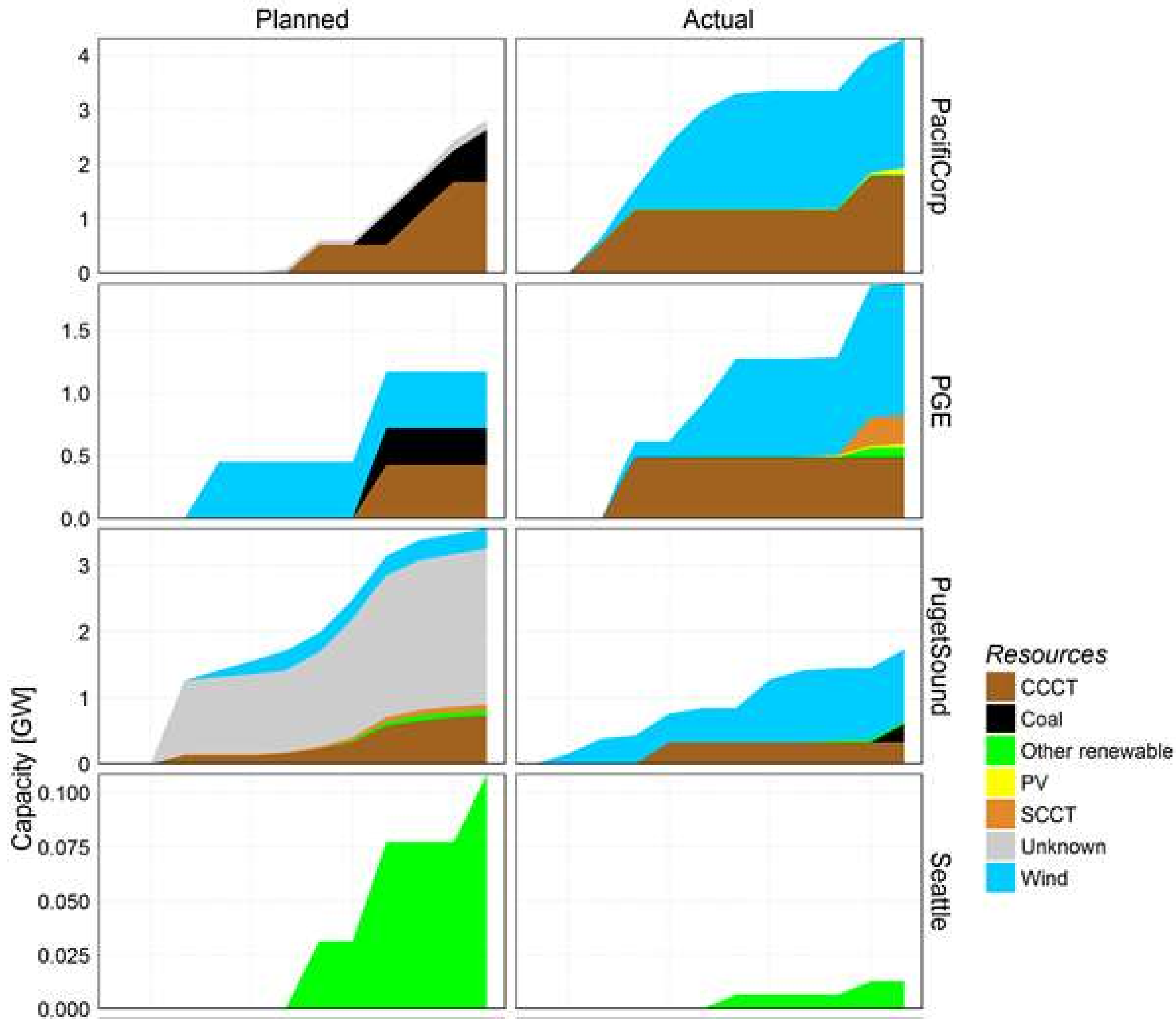
Method, sources, and sample of LSEs



More wind and less coal than originally planned



Larger differences at the LSE level



Differences explained by changing environments

- We find **exogenous** and **endogenous** sources of uncertainty

  - Exogenous: Things generally beyond the control of the LSE
    - Retail choice is a major source of uncertainty for the utility
    - DSM programs performed better than anticipated

  - Endogenous: Things that may be influenced by utility behavior or regulator
    - Timing of procurement influenced by uncertain RFP processes
    - Changes in RPS and DSM requirements explain higher acquisition of renewable resources and reduced load growth

Weak link between planning and procurement

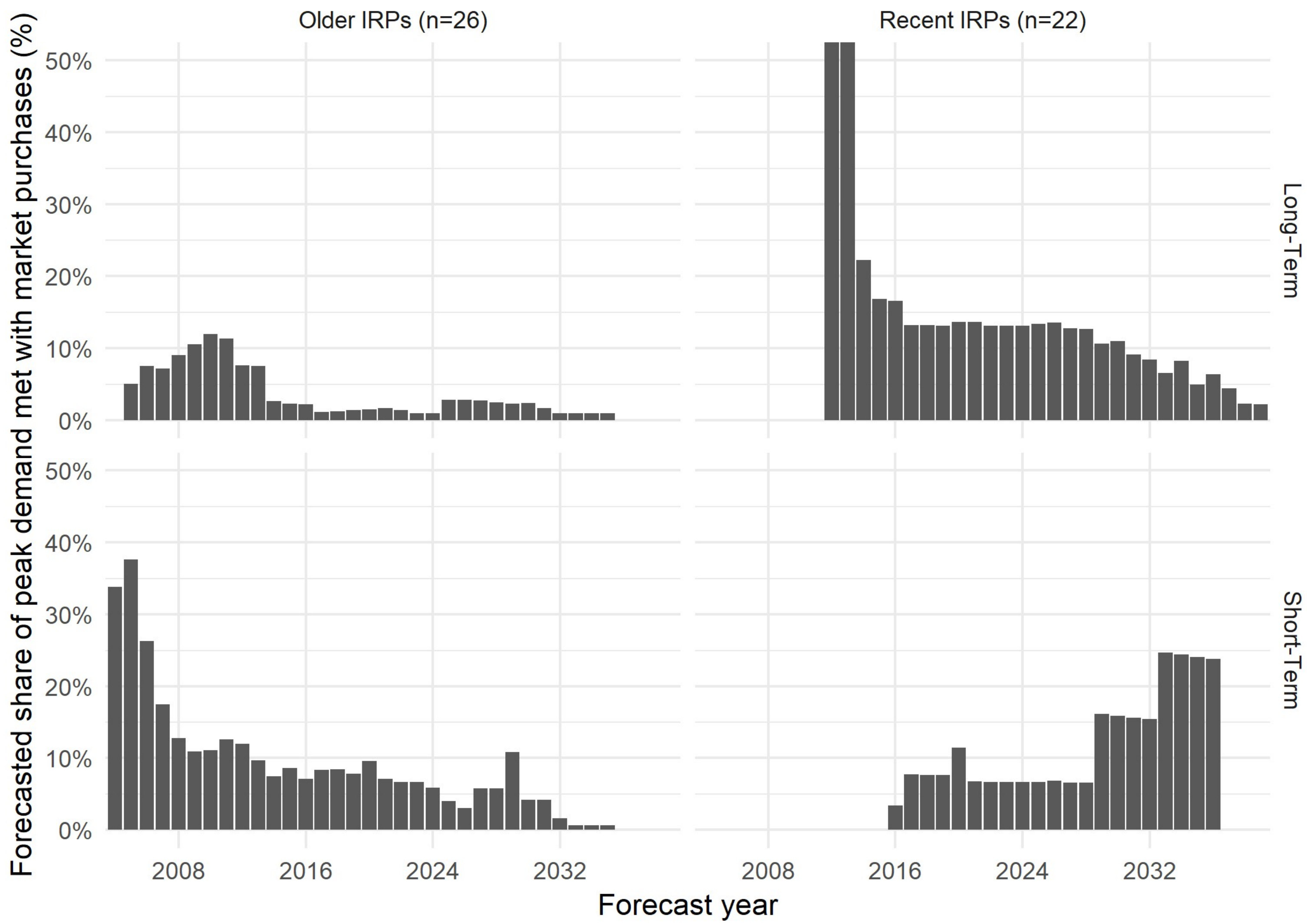
- We find no evidence that risk analysis information developed in selected IRPs was used to inform procurement levels, mix of resources, or buy vs. build decisions

- Value of new information is very high:
  - Simulations/analysis for procurement decisions re-estimated with most recent available information
  - Little or no reference to prior IRP or updated planning results when seeking procurement approval

RPP Application: Market transactions

- Investigate trends in short- and long-term market purchases by (mostly) vertically-integrated utilities
- Paper studies how market purchases are assessed in IRPs and a quantitative analysis of trends in their use
- For a sample of IRPs, we find that:
  - Sophistication of market assessments vary widely, from a simple spot price forecast to a lengthy regional assessment
  - Two thirds of LSEs do not include short-term transactions in their portfolios; half do not even include them as possible resources.

Forecast use of market purchases in IRP



Future work: Resource adequacy (RA) in the West

- Interviewees of market transactions paper commented on the need for a regional RA assessment

- In collaboration with Western Interstate Energy Board (WIEB), study will cover:
  - Surveying existing RA modeling frameworks and tools
  - Adapting the RPP to include all required data to perform RA calculations

- Develop an online resource adequacy assessment tool using the RPP data (possible topic)

For more information

- Resource Planning Portal:
  - https://resourceplanning.lbl.gov/
- Integrated resource planning research
  - Wilkerson, Jordan, Peter Larsen, and Galen Barbose. “Survey of Western U.S. Electric Utility Resource Plans.” Energy Policy 66 (March 2014): 90–103. https://doi.org/10.1016/j.enpol.2013.11.029.
  - Carvallo, Juan Pablo, Peter H. Larsen, Alan H. Sanstad, and Charles A. Goldman. “Long Term Load Forecasting Accuracy in Electric Utility Integrated Resource Planning.” *Energy Policy* 119 (August 1, 2018): 410–22. https://doi.org/10.1016/j.enpol.2018.04.060.
  - Carvallo, Juan Pablo, Alan H. Sanstad, and Peter H. Larsen. “Exploring the Relationship between Planning and Procurement in Western U.S. Electric Utilities,” June 2017.
  - Carvallo, Juan Pablo, Sean P. Murphy, Alan H. Sanstad, and Peter H. Larsen. “The use of market purchases by vertically-integrated U.S. electric utilities”, (forthcoming).
  - Carvallo, Juan Pablo, Sean P. Murphy, Nan Zhang, Benjamin Leibowicz, and Peter H. Larsen. “The economic value of integrating distributed energy resources in electric utility resource planning”, (forthcoming).

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Evolving Approaches to Electricity System Planning

Presented by Lisa Schwartz and Natalie Mims Frick

National Association of Regulatory Utility Commissioners
Center for Partnerships & Innovation Webinar – March 14, 2019

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In this this presentation

- Evolving planning research and technical assistance for states
- Electric grid planning activities
- Distributed energy resources, distribution system planning and integration with other processes
- Integrated resource planning and distributed energy resources
- Resources for more information

Evolving planning research and technical assistance for states

Berkeley Lab's Electricity Markets and Policy Group

- Integrated resource planning (IRP) concepts, modeling – *PUC training*
- Restructuring – *Focus on demand-side management*
- Regional planning and IRP revival – *Resource Planning Portal, impacts of distributed energy resource (DER) policies on transmission needs, load forecasting, plans vs. procurement*
- Distribution system planning – *PUC practices, training and education for states*
- Comprehensive planning – *Support new NARUC-NASEO Task Force*

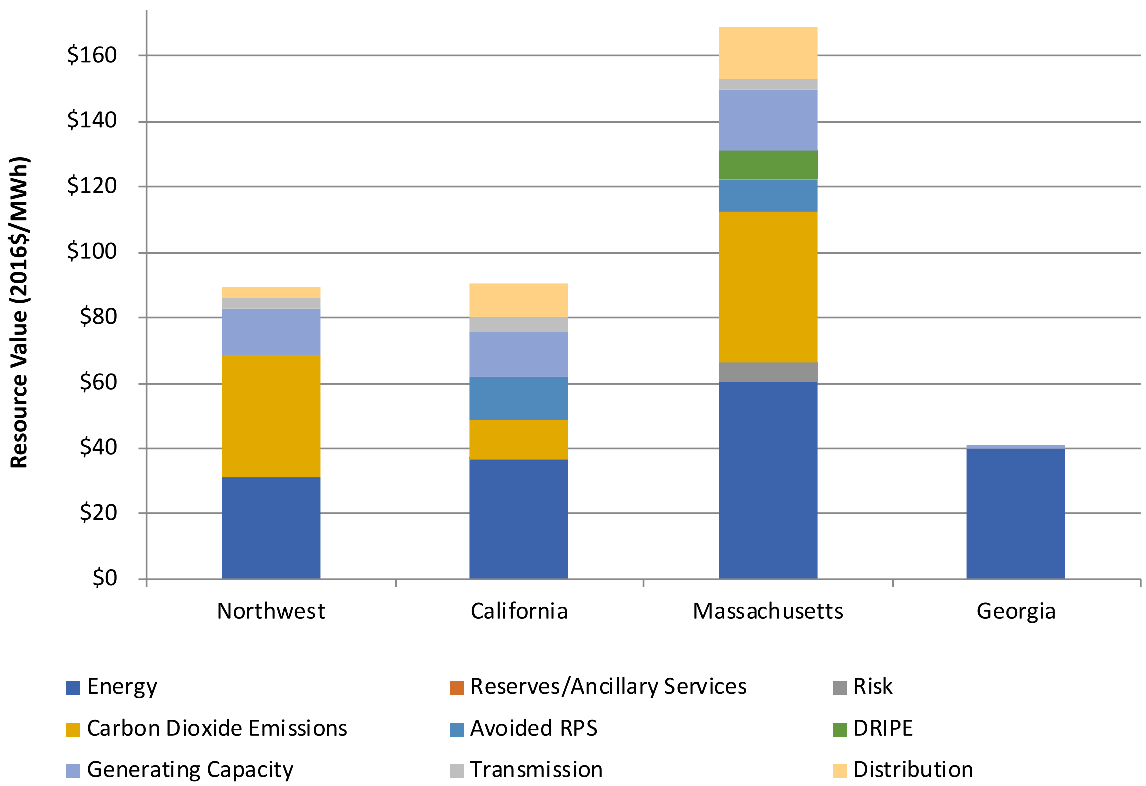
Electric grid planning activities (1)

- ***Distribution planning***
  - Assess needed physical and operational changes to local grid
- ***Integrated resource planning*** (in vertically integrated states)
  - Identify future investments to meet bulk power system reliability and public policy objectives at reasonable cost
- ***Transmission planning***
  - Identify future transmission expansion needs and options for meeting those needs

Electric grid planning activities (2)

- ***Demand-side management (DSM) planning***
  - Identify opportunities to use energy efficiency and demand response to meet future energy and capacity needs

Time-varying value of efficiency



Locational value of efficiency

Energy and grid-related services provided by DERs

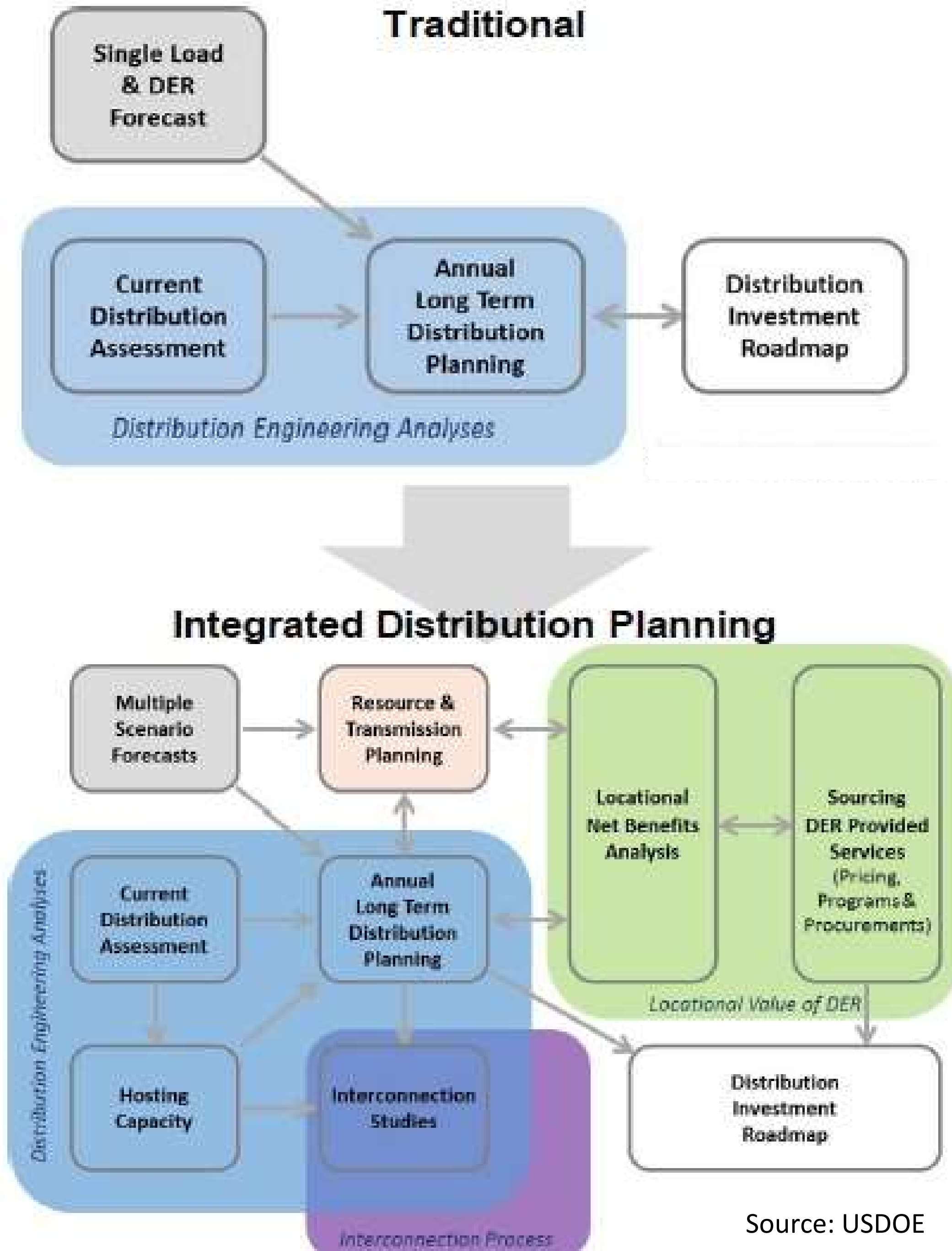
Impact	DER Capability/Service	Key Function
Bulk Level Impact	Energy Production/Load Reduction	Produce electricity
	Generation Capacity	Meet extreme peak
	Frequency Regulation/Load Following/Balancing	Respond rapidly to balance supply and demand
	Spinning Reserve/Non-spinning Reserve	Reliability – provide ability to respond to unforeseen forces outages and/or changes in loads
Locational Impact	Locational Capacity for T&D	Provide or defer need for additional T&D peaking capacity
	Voltage Regulation	Maintain power quality/reduce losses

Adapted by Tom Eckman for Berkeley Lab from Smart Electric Power Alliance. *Beyond the Meter – Addressing the Locational Valuation Challenge for Distributed Energy Resources, Establishing a Common Metric for Locational Value*. September 2016.

Integrated distribution planning

- Assesses **physical** and **operational** changes to the distribution system necessary to enable safe, reliable, and affordable service ***that satisfies customers' changing expectations and use of DERs,*** *generally in* ***coordination with resource and transmission planning***

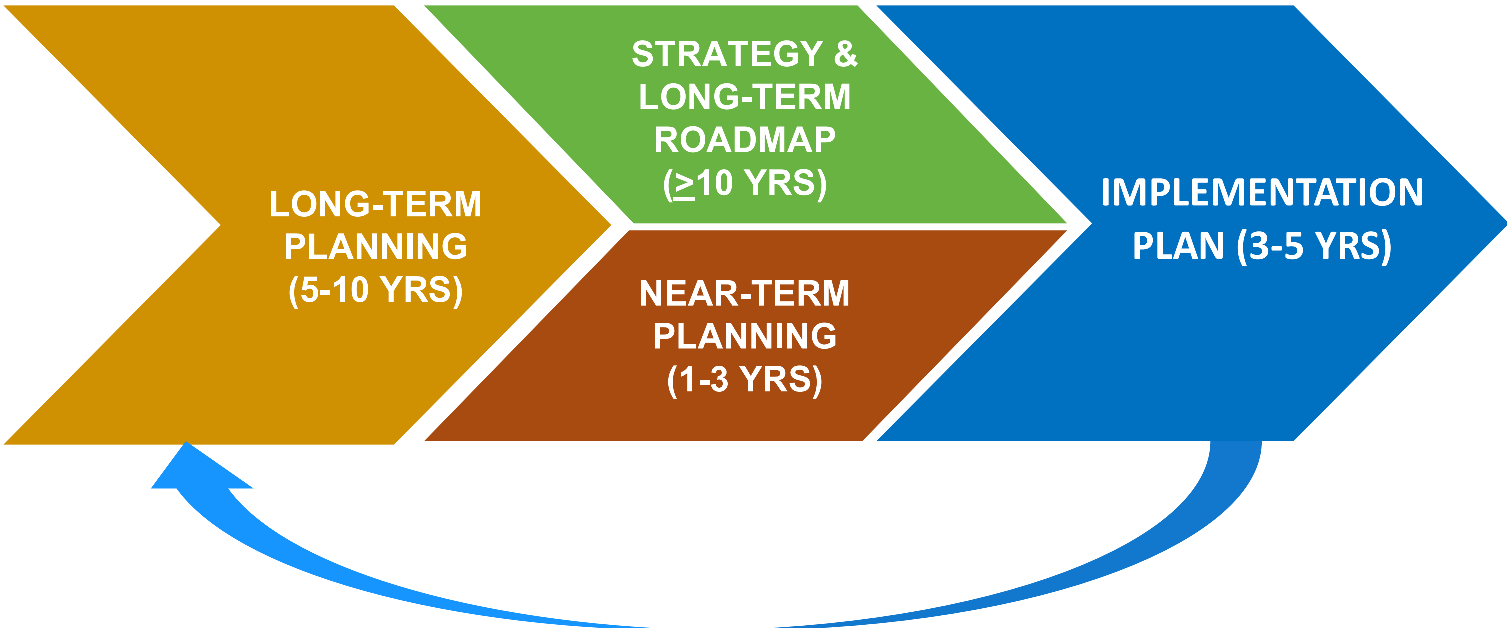
- **Includes stakeholder-informed planning scenarios** to support a reliable, efficient, and robust grid in a changing and uncertain future



Source: USDOE

Integrated planning informs grid modernization strategy

Cyclical integrated distribution planning informs initial grid modernization strategy and updates.



Grid modernization strategy and implementation plans inform subsequent long-term and near-term integrated distribution planning.

Source: USDOE

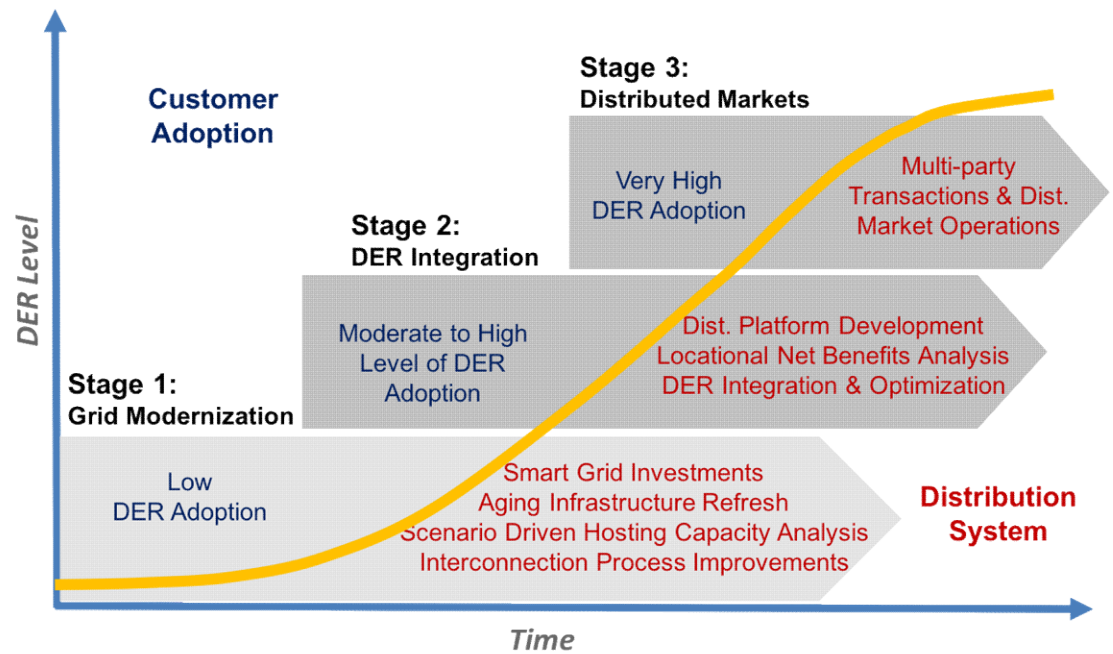
Drivers for improved distribution planning

- More DERs — cost reductions, policies, new business models, consumer interest
- Resilience and reliability
- Aging grid infrastructure and utility proposals for grid investments
- Need for greater grid flexibility in areas with high levels of wind and solar
- Interest in conservation voltage reduction and volt/VAR optimization
- Non-wires alternatives may provide net benefits to customers
- Utility investments: Distribution 29% ($35.7B) of 2017 EEI member investments*

*http://www.eei.org/resourcesandmedia/industrydataanalysis/industryfinancialanalysis/QtrlyFinancialUpdates/Documents/EEI_Industry_Capex_Functional_2018.07.17.pptx

State benefits from improved distribution planning

- Makes transparent utility plans for distribution system investments before showing up individually in rider or rate case
- Provides opportunities for meaningful PUC and stakeholder engagement
  - Can improve outcomes
- Considers uncertainties under a range of possible futures
- Considers all solutions for least cost/risk
- Motivates utility to choose least cost/risk solutions
- Enables consumers and service providers to propose grid solutions and participate in providing grid services



Graph from De Martini and Kristov for Berkeley Lab, 2015

Emerging distribution planning elements

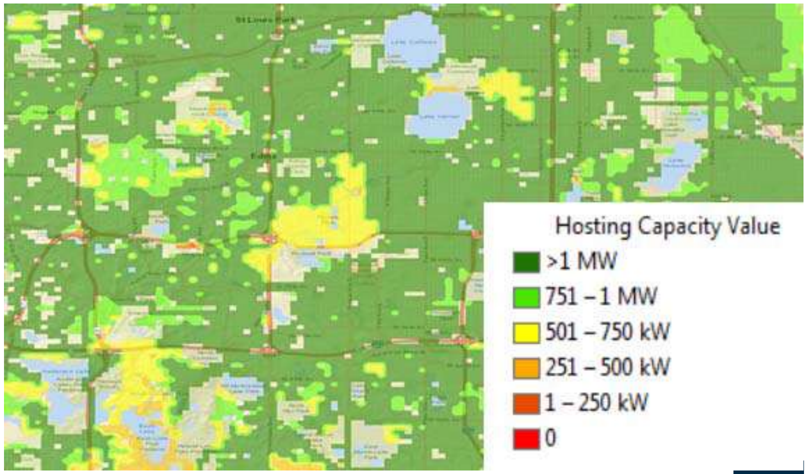
- Projecting loads and DERs in a more granular way
- Analyzing hosting capacity — amount of DERs that can be interconnected without adversely impacting power quality or reliability under existing control and protection systems and without infrastructure upgrades
- Assessing locational value of DERs
- Analyzing non-wires alternatives to traditional investments
  - Investments in energy efficiency, demand response, distributed generation and storage that provide specific services at specific locations to defer, mitigate or eliminate need for traditional distribution infrastructure
- Increasing visibility into distribution system
- Better representing distribution system in models for planning and operations
- Engaging stakeholders

Examples: States advancing distribution system planning

- Requirements for utilities to file distribution system or grid modernization plans (CA, HI, IN, MA, MD, MI, MN, NV, NY)
  - *Integrated* distribution planning is nascent.
- Consideration of cost-effective non-wires alternatives (CA, HI, MI, MN, NV, NY, RI)
- Requirements for hosting capacity analysis (CA, HI, IL, MN, NV, NY)
- Locational net benefits analysis for DERs (CA, HI, NV, NY)
- Storm hardening, undergrounding (MD, FL)
- Requirements for utilities to report on poor-performing circuits and improvement plans (many states)

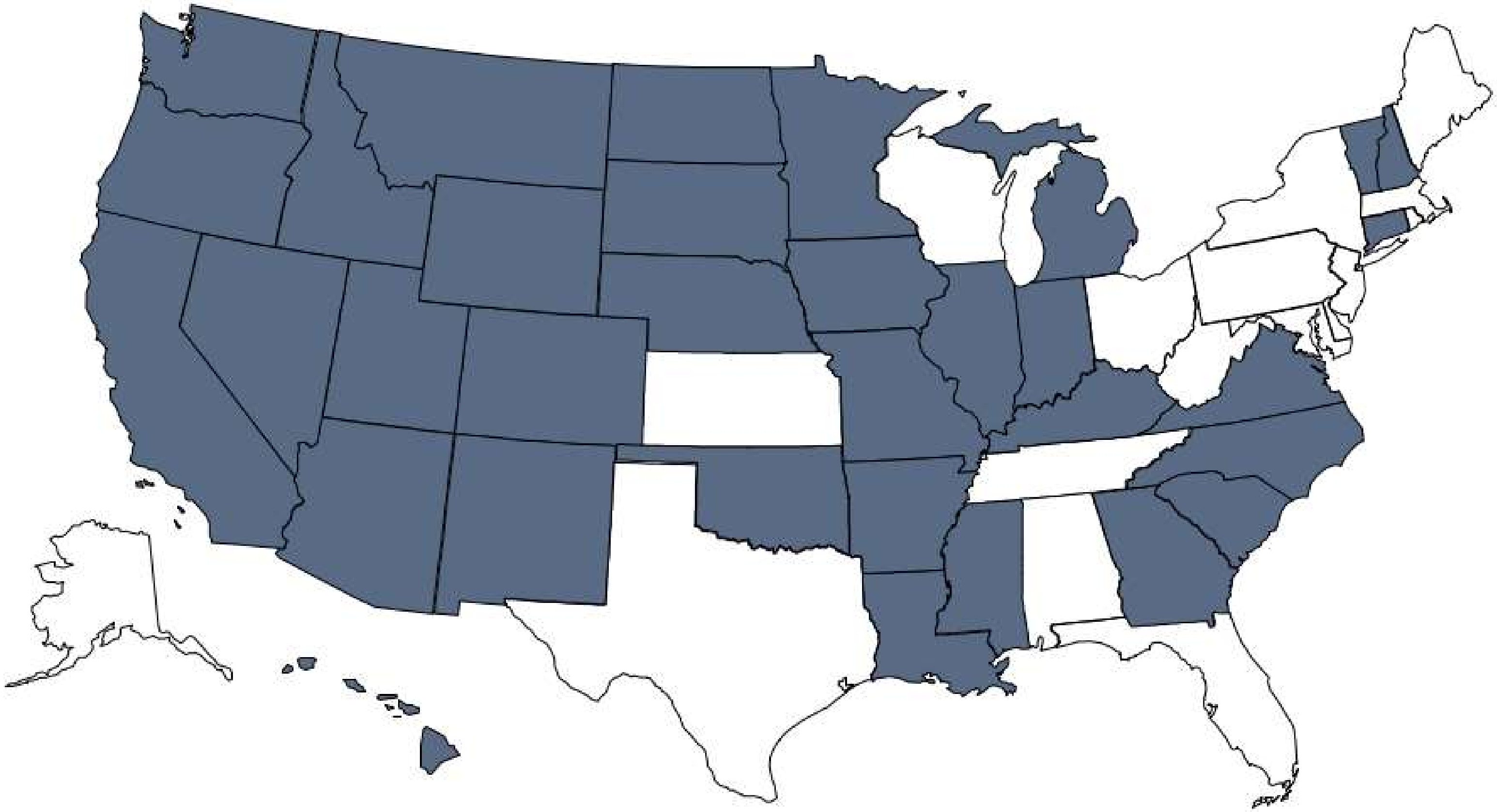
Example: Minnesota

- Commission set Integrated Distribution Planning requirements for Xcel Energy in Docket No. 18-251 and also set requirements for smaller regulated utilities
- Most requirements are the same across utilities:
  - 10-year Distribution System Modernization and Infrastructure Investment Plan
    - Including 5-year action plan based on internal business plans and DER future scenarios: base case, medium and high
  - Coordination with integrated resource planning
  - Stakeholder engagement: one utility meeting before filing; PUC staff can convene a meeting during public comment period
  - Data specified for filing: baseline distribution system, financial data, DER deployment
  - For projects >$2M, analyze how non-wires alternatives compare in viability, price and long-term value
    - Specify project types (load relief or reliability), timelines and cost thresholds
- For smaller utilities:
  - Biennial filing (instead of annual)
  - Simpler hosting capacity analysis



Xcel Energy, Hosting Capacity Study, 11/1/18

Integrated resource planning is required in most states



Source: Adapted from Synapse Consulting.
Notes: IRP requirements vary by state. Florida requires utilities to file a 10-year site plan. In Tennessee, the Tennessee Valley Authority conducts an IRP, and in Alabama, Alabama Power conducts an IRP.

DERs in integrated resource planning

- Some regulators explicitly require utilities to consider at least one type of DER in IRP or other long-term planning. For example:
  - Washington requires utilities to use identified DERs as inputs to IRP.
  - Oregon electric companies must evaluate DERs on a par with supply-side resources in IRPs and consider, and quantify where possible, additional benefits (Order 07-002). The PUC's order on Portland General Electric's 2016 IRP required the utility to "work with Staff and other parties to advance distributed energy resource forecasting and distributed energy resource representation in the IRP process." PUC staff's February 2019 white paper proposes a holistic, robust structure for distribution planning, including planning for DERs.
  - New Orleans requires Entergy New Orleans to consider storage and other DERs as potential supply-side resources in IRP.
  - New Mexico requires energy storage to be considered with other resource options in IRP.
  - Massachusetts issued an order that clarified the objective of including DERs to "facilitate the interconnection of distributed energy resources and to integrate these resources into the Companies' planning and operations processes."
  - California, Georgia, Iowa, Indiana, Kentucky, Michigan, Nebraska, Nevada, New Mexico and Oregon require consideration of combined heat and power in IRP.

Source: A Framework for Integrated Analysis of Distributed Energy Resources: Guide for States

DER data resolution varies depending on purpose - Efficiency example

- Cost-benefit analysis in energy efficiency planning
  - Hourly time-varying demand and energy value
  - Hourly time-varying economic value
- Distribution system planning
  - Sub-hourly time-varying energy, demand and economic value for specific levels of the system — e.g., distribution substation or a specific distribution feeder or line section
- Resource planning
  - Depends on approach used to incorporate energy efficiency into planning process
    - Load decrement – seasonal or on- and off-peak time-varying demand or energy value of efficiency
    - Input to the resource planning optimization model – efficiency is treated like other resources
      - Various efficiency measures are grouped by price
      - Energy efficiency shape of each bundle is available for model to choose

High Resolution

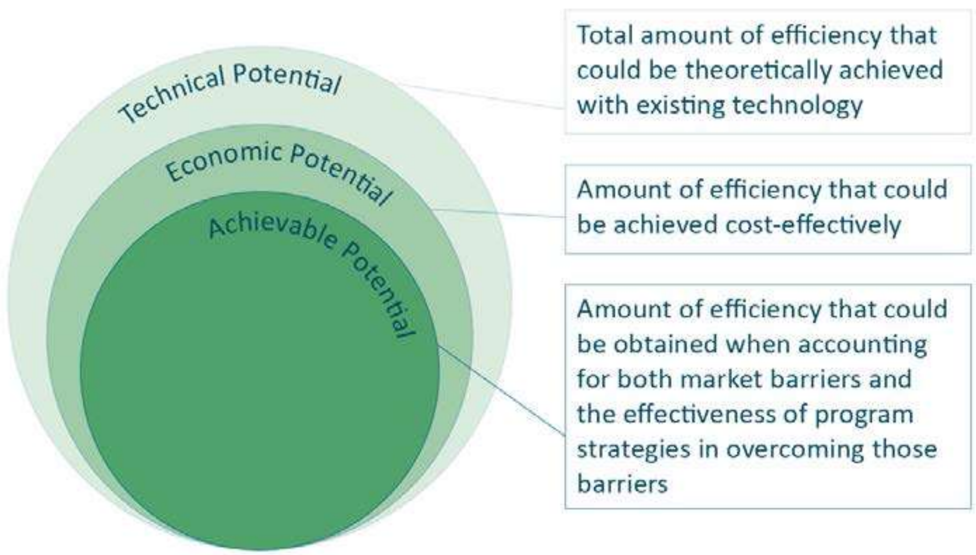
- Sub-hourly (e.g., 15-minute interval data)
- Hourly annual (8,760) data
- Peak day/off-peak day
- Monthly data with weekday vs. weekend/holiday
- Seasonal data with weekday vs. weekend/holiday
- Monthly data
- Seasonal (e.g., quarterly) data
- Annual energy savings by measure, program or portfolio

Low Resolution

Source (also for next few slides): Mims Frick and Schwartz (forthcoming), *Using Time-Varying Value of Efficiency for Planning and Programs in the Electricity Sector*

Accounting for DERs in IRP – Efficiency example

- Energy efficiency is generally addressed in one of two ways:
  1. Assumed amount of energy efficiency savings subtracted from load forecast
     - The utility may identify the amount of savings through an energy efficiency potential assessment, preset standard or target, or another planning exercise.
     - If the utility chooses to use a preset standard or target, it also may consider scenarios with higher amounts of efficiency.
  2. Resource option selected by an optimization model
     - Capacity expansion models simulate economic dispatch of existing and potential future power systems to allow efficiency to compete directly with other resource options
     - Use reliability criteria and economic decision rules ("optimization logic") to determine type, amount, and schedule for new resource development to meet forecasted future need for energy and capacity
     - Can also determine whether retirements of existing resources (or power purchase contracts) would be economic



Case Study #1: Public Service of New Mexico

- Public Service of New Mexico's 2017 IRP includes efficiency in the load forecast.
- Both existing and future efficiency are included as a decrement to the load forecast.
- Utilities are required to invest 3% of retail sales revenues in efficiency and load management programs.

Table 4. 2017 IRP Low-Load Forecasts

Forecasts	2017	2022	2036
Demand (MW)			
PNM Forecasted Load Total	1,906	1,963	2,261
EE (incremental)	(23)	(91)	(145)
PV-DG (incremental)	(18)	(45)	(62)
Net System Total	**1,865**	**1,827**	**2,055**
Energy (GWh)			
PNM Forecasted Load Total	8,998	9,460	9,352
EE (incremental)	(197)	(706)	(1,042)
PV-DG (incremental)	(47)	(210)	(251)
Net System Total	**8,754**	**8,544**	**8,059**

Table 5. 2017 IRP Mid-Load Forecasts

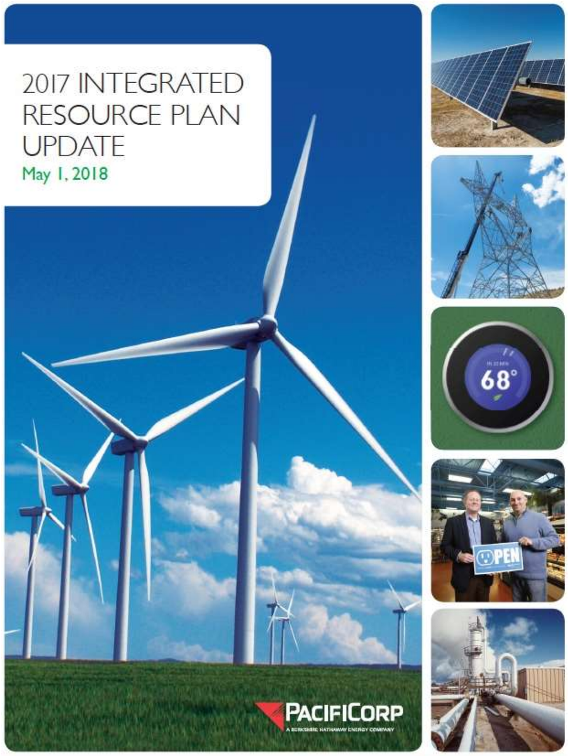
Forecasts	2017	2022	2036
Demand (MW)			
PNM Forecasted Load Total	1,911	2,163	2,650
EE (incremental)	(23)	(89)	(122)
PV-DG (incremental)	(18)	(33)	(48)
Net System Total	**1,871**	**2,041**	**2,480**
Energy (GWh)			
PNM Forecasted Load Total	9,040	10,475	11,671
EE (incremental)	(197)	(695)	(881)
PV-DG (incremental)	(47)	(153)	(194)
Net System Total	**8,796**	**9,627**	**10,597**

Table 6. 2017 IRP High-Load Forecasts

Forecasts	2017	2022	2036
Demand (MW)			
PNM Forecasted Load Total	1,915	2,361	3,076
EE (incremental)	(23)	(85)	(100)
PV-DG (incremental)	(18)	(20)	(34)
Net System Total	**1,875**	**2,257**	**2,943**
Energy (GWh)			
PNM Forecasted Load Total	9,088	11,339	13,924
EE (incremental)	(195)	(660)	(726)
PV-DG (incremental)	(47)	(96)	(137)
Net System Total	**8,847**	**10,583**	**13,061**

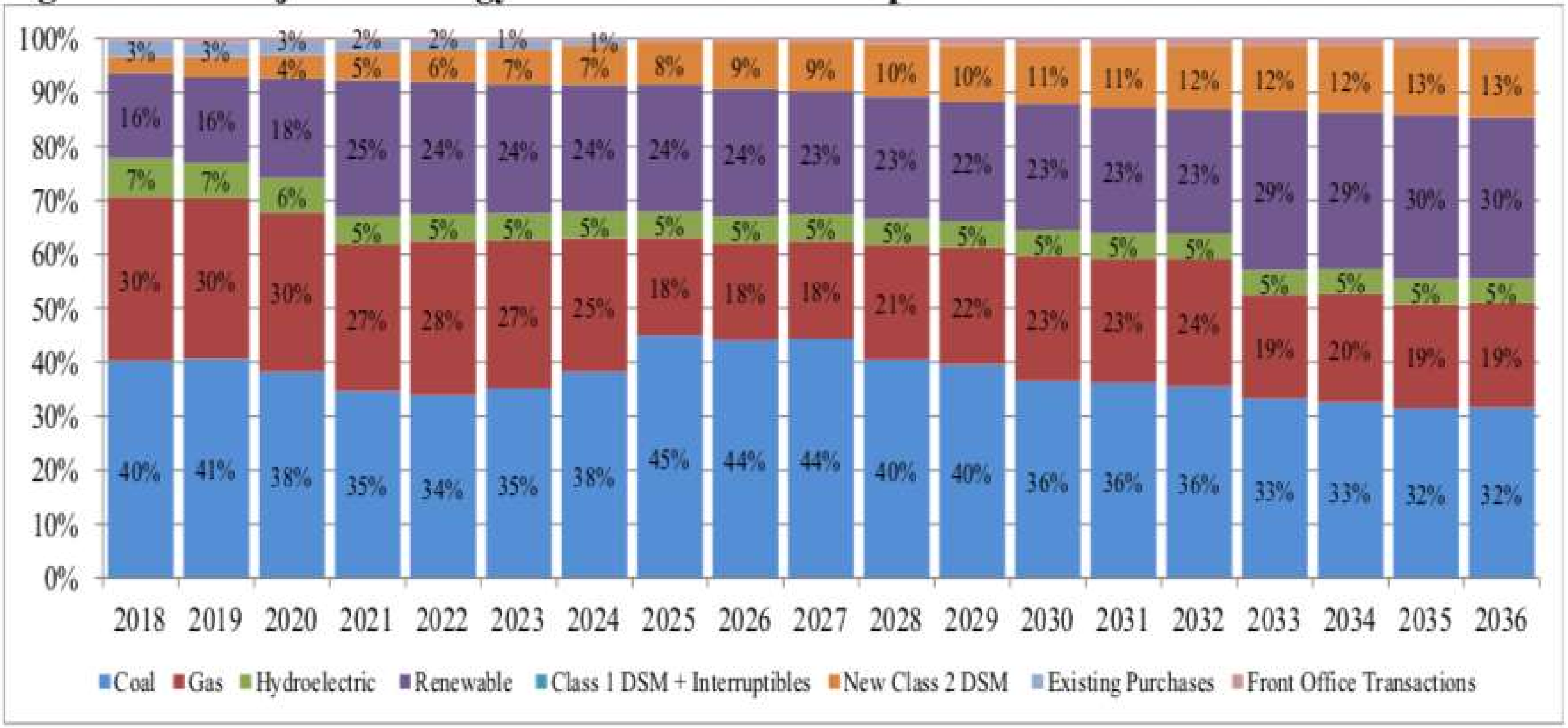
Case Study #2: PacifiCorp

- PacifiCorp's IRP covers six states (Utah, Oregon, Wyoming, Washington, Idaho, California).
- PacifiCorp conducts IRP to determine how to meet its forecasted electricity system energy and capacity needs at the lowest cost.
- Energy efficiency is modeled as a resource through the use of efficiency supply curves which are inputs to the capacity expansion model, along with all other resources.
- The utility modeled supply curves for nine types of demand response in its 2017 IRP update.

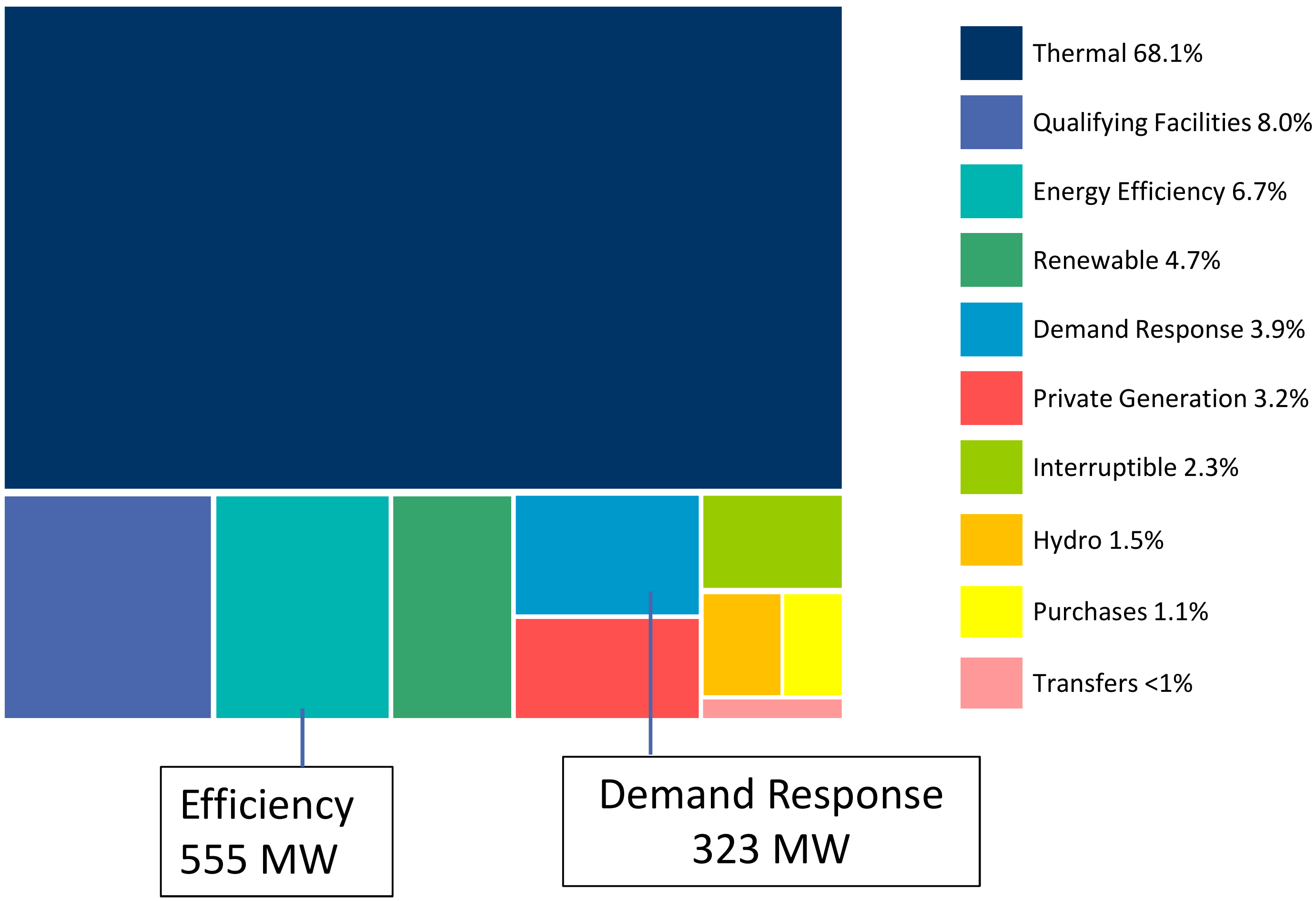


PacifiCorp 2017 IRP Update: Projected Energy Mix

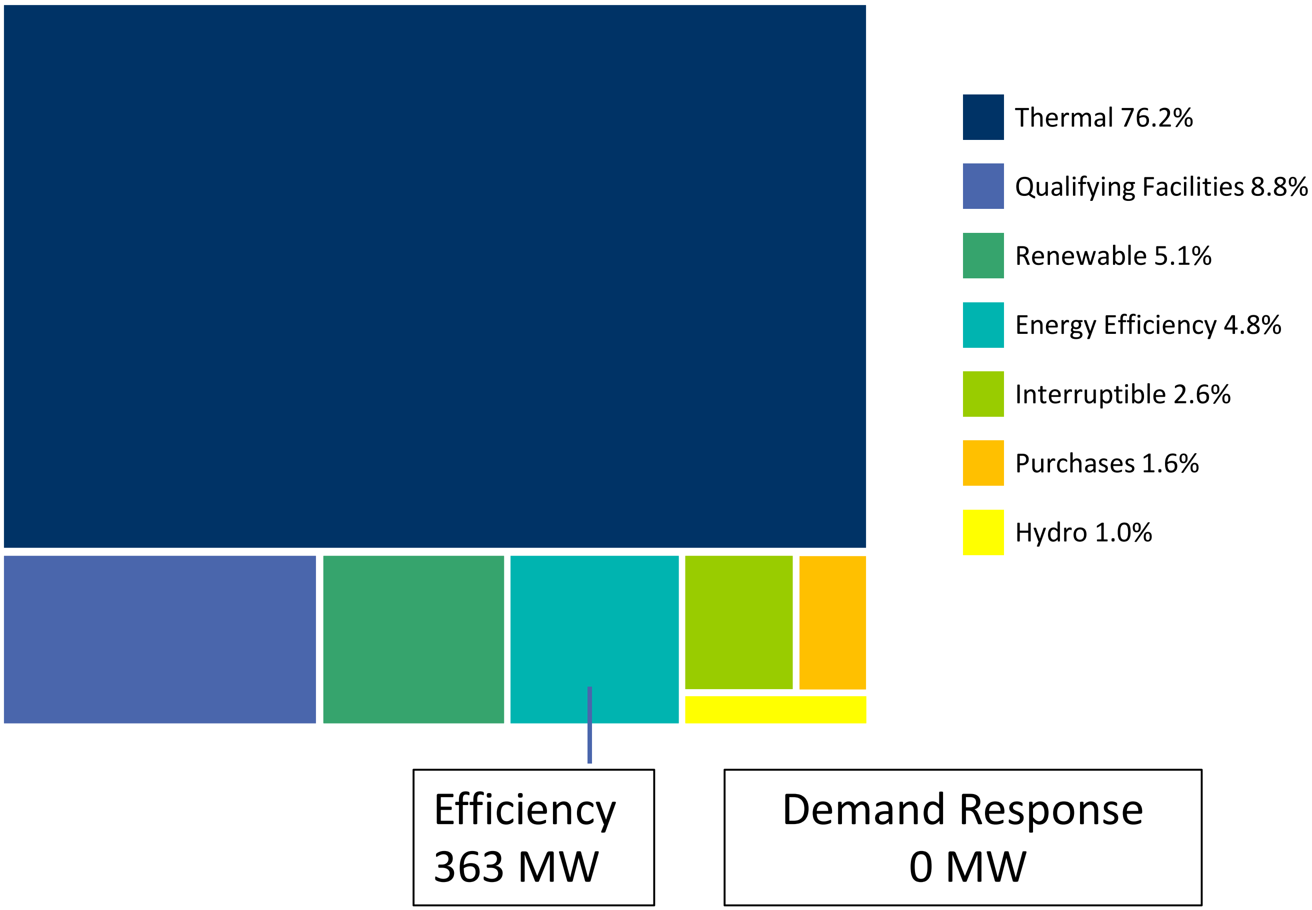
Figure 8.3 – Projected Energy Mix with 2017 IRP Update Preferred Portfolio Resources



Rocky Mountain Power (UT, WY, ID) Summer 2027 Capacity Mix



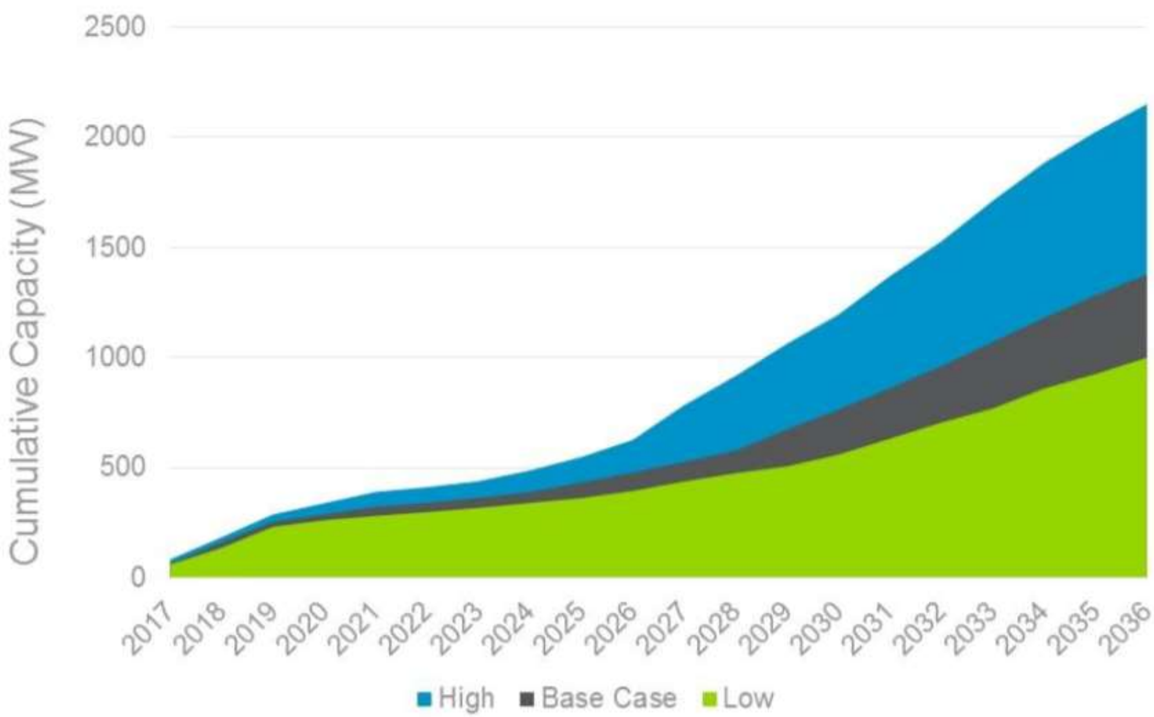
Rocky Mountain Power (UT, WY, ID) Winter 2027 Capacity Mix



PacifiCorp 2017 IRP private generation forecast (1)

- PacifiCorp studied privately owned distributed generation to forecast high, base and low adoption scenarios for its 2017 IRP.
- PacifiCorp segmented the base adoption scenario by resource and state (next slides).

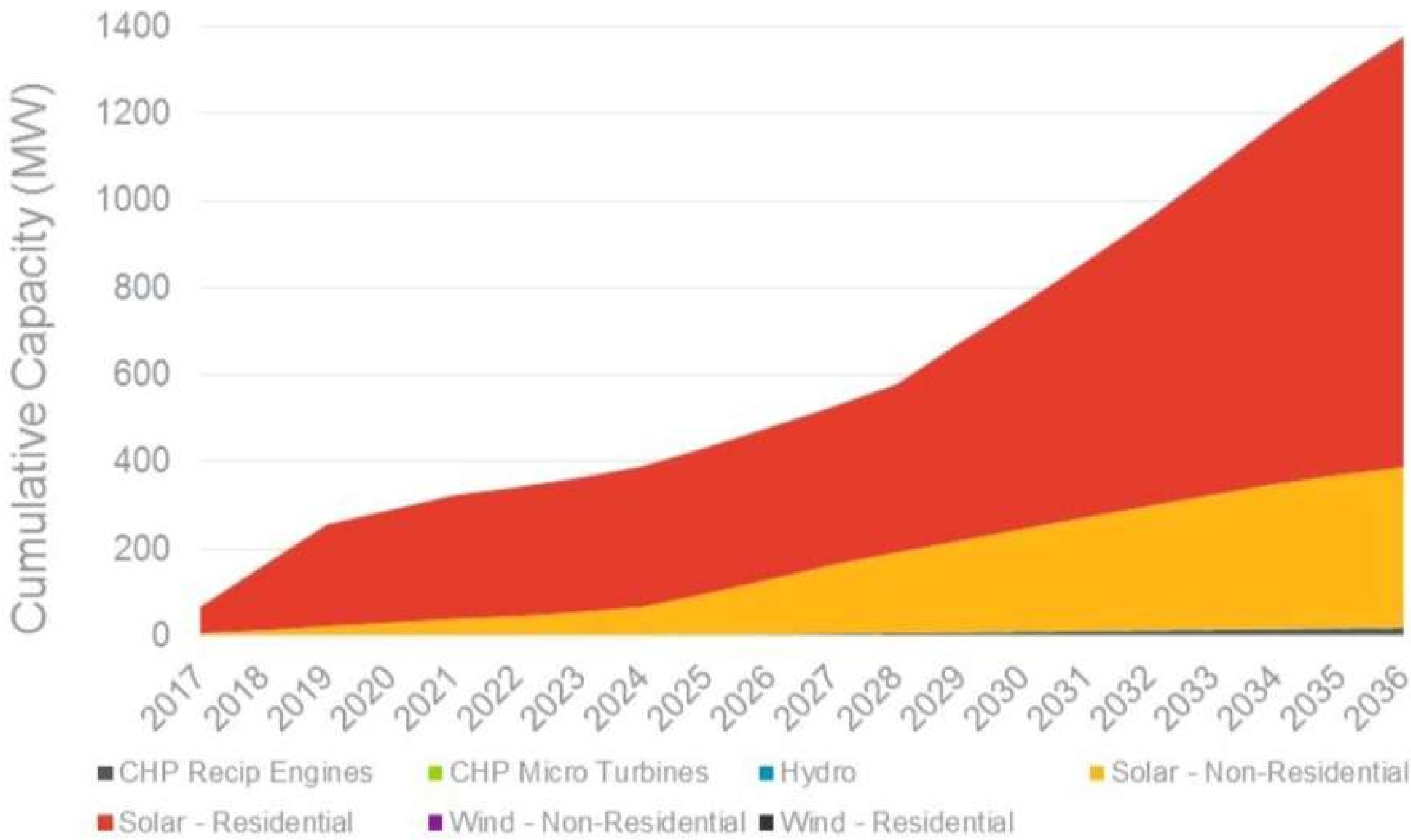
Figure 2 Cumulative Market Penetration Results (MW AC), 2017 – 2036



http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Integrated_Resource_Plan/2017_IRP/PacifiCorp_IRP_DG_Resource_Assessment_Final.pdf

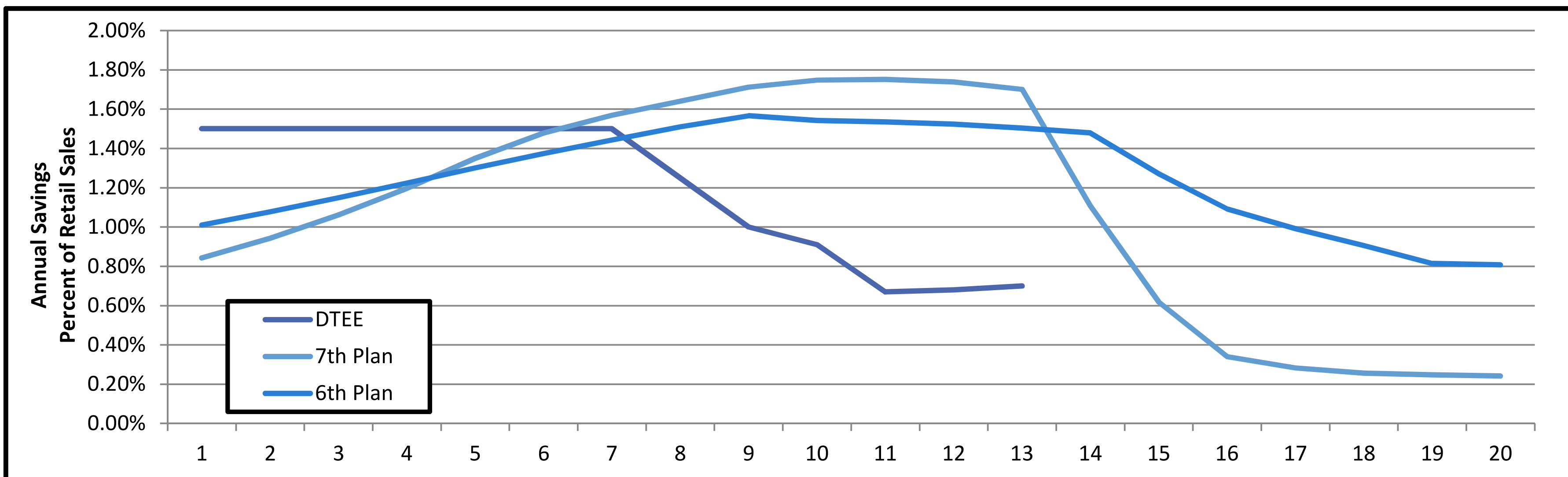
PacifiCorp 2017 IRP private generation forecast (2)

Figure 4 Cumulative Market Penetration Results by Technology (MW AC), 2017 – 2036, Base Case



Energy efficiency as a resource in electric system planning

- Forthcoming Berkeley Lab report on efficiency in electric system planning
- Review spectrum of modeling techniques to incorporate efficiency into electric system planning, identify key planning practices for estimating efficiency potential and costs, and examine inputs on savings and costs suitable for capacity expansion models used in electric system planning
  - Key planning practices: load forecasting, potential assessments, capacity expansion model inputs and modeling, and risk analysis
- Develop case studies describing how selected utilities, ISO/RTOs, and agencies address key planning practices that treat efficiency as a resource in electric system planning
  - Northwest Power and Conservation Council, NE-ISO and PJM, American Electric Power and PacifiCorp
  - Case studies cover 30 states



For more information (1)

- U.S. Department of Energy's (DOE) Modern Distribution Grid initiative (www.doe-dspx.org)
- Distribution system planning training — e.g., see https://emp.lbl.gov/publications/mid-atlantic-distribution-systems-and
- Alan Cooke, Juliet Homer, Lisa Schwartz, *Distribution System Planning – State Examples by Topic*. Pacific Northwest National Laboratory and Berkeley Lab, May 2018
- Juliet Homer, Alan Cooke, Lisa Schwartz, Greg Leventis, Francisco Flores-Espino and Michael Coddington, *State Engagement in Electric Distribution Planning*, Pacific Northwest National Laboratory, Berkeley Lab and National Renewable Energy Laboratory, December 2017
- *Summary of Electric Distribution System Analyses with a Focus on DERs*, by Y. Tang, J.S. Homer, T.E. McDermott, M. Coddington, B. Sigrin, B. Mather, Pacific Northwest National Laboratory and National Renewable Energy Laboratory, 2017
- J.S. Homer, Y. Tang, J.D. Taft, D. Lew, D. Narang, M. Coddington, M. Ingram, A. Hoke. *Electric Distribution System Planning with DER and Grid Modernization - Tools and Methods* (forthcoming)
- Natalie Mims Frick, Lisa Schwartz, Alyse Taylor-Anyikire, *A Framework for Integrated Analysis of Distributed Energy Resources: Guide for States*, Berkeley Lab, 2018
- Berkeley Lab's Future Electric Utility Regulation report series — in particular:
  - *Distribution Systems in a High Distributed Energy Resources Future: Planning, Market Design, Operation and Oversight*, by Paul De Martini (Cal Tech) and Lorenzo Kristov (CAISO)
  - *The Future of Electricity Resource Planning*, by E3 and Andrew Mills, Berkeley Lab)
  - *Value-Added Electricity Services: New Roles for Utilities and Third-Party Providers*, by Institute for Electric Innovation, Advanced Energy Economy and National Association of State Utility Consumer Advocates
  - *The Future of Transportation Electrification: Utility, Industry and Consumer Perspectives*, by Alliance for Transportation Electrification, EVgo and National Consumer Law Center

For more information (2)

- Berkeley Lab's Electricity Markets and Policy (EMP) Group research on integrated resource planning
- End-Use Load Profiles for the U.S. Building Stock
  - Building Technologies Office-funded project — a multi-lab collaboration to create end-use load profiles for residential and commercial sectors across the United States
- EMP Group energy efficiency research
- EMP Group time- and locational-varying value of efficiency research
  - Time-varying value of electric energy efficiency (2017)
  - Time-varying value of energy efficiency in Michigan (2018)
  - No time to lose: Recent research on the time-sensitive value of efficiency
  - Using time-varying value of efficiency for planning and programs in the electricity sector (forthcoming)
- Collecting and Analyzing Peak Demand Impacts from Electricity Efficiency Programs (forthcoming)
- Energy Efficiency in Electricity Resource Planning (forthcoming)

These are examples and are not meant to be a comprehensive list of related research.

Technical assistance for states

- **Berkeley Lab's Electricity Markets and Policy Group** provides independent and unbiased technical assistance to state utility regulatory commissions, state energy offices, tribes and regional entities in these areas:
  - Energy efficiency (e.g., policy frameworks, implementation strategies, resource planning approaches, utility cost recovery, and evaluation)
  - Demand response (e.g., time-varying pricing)
  - Renewable energy resources
  - Utility regulation (e.g., rate design and ratemaking, utility incentives and disincentives, financial impacts of distributed energy resources)
  - Distribution and transmission planning
  - Grid modernization and broader issues on electricity system decision-making

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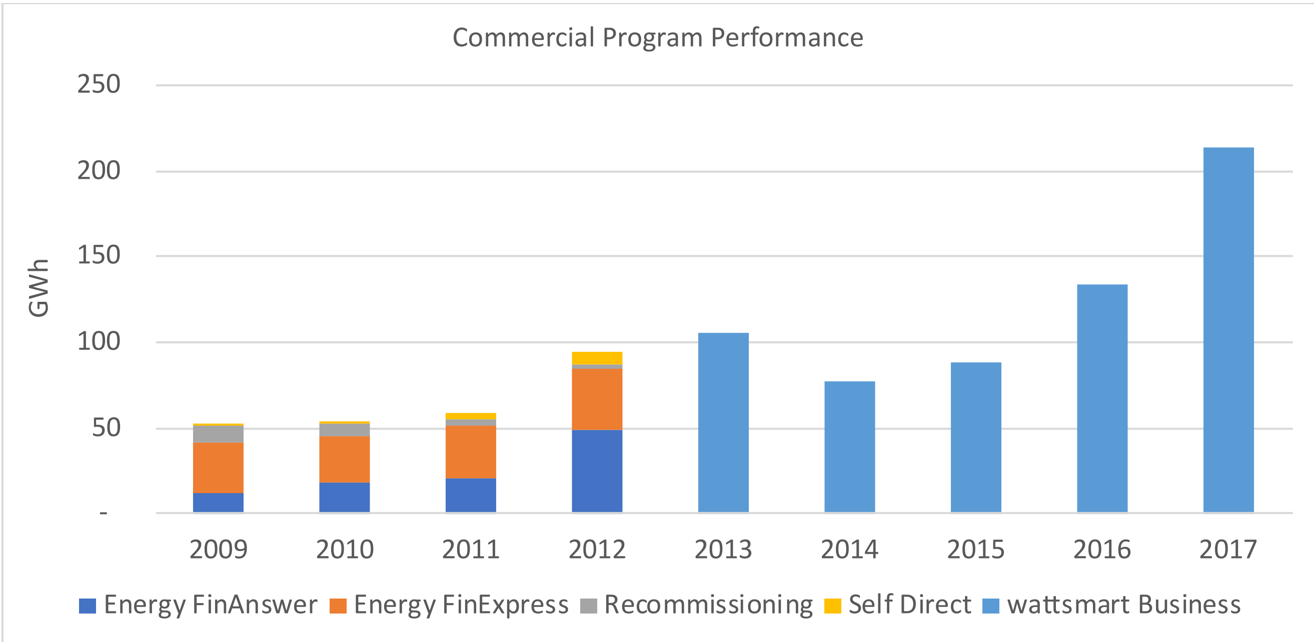
Click here to join the Berkeley Lab Electricity Markets and Policy Group mailing list and stay up to date on our publications, webinars and other events. Follow the Electricity Markets and Policy Group on Twitter @BerkeleyLabEMP

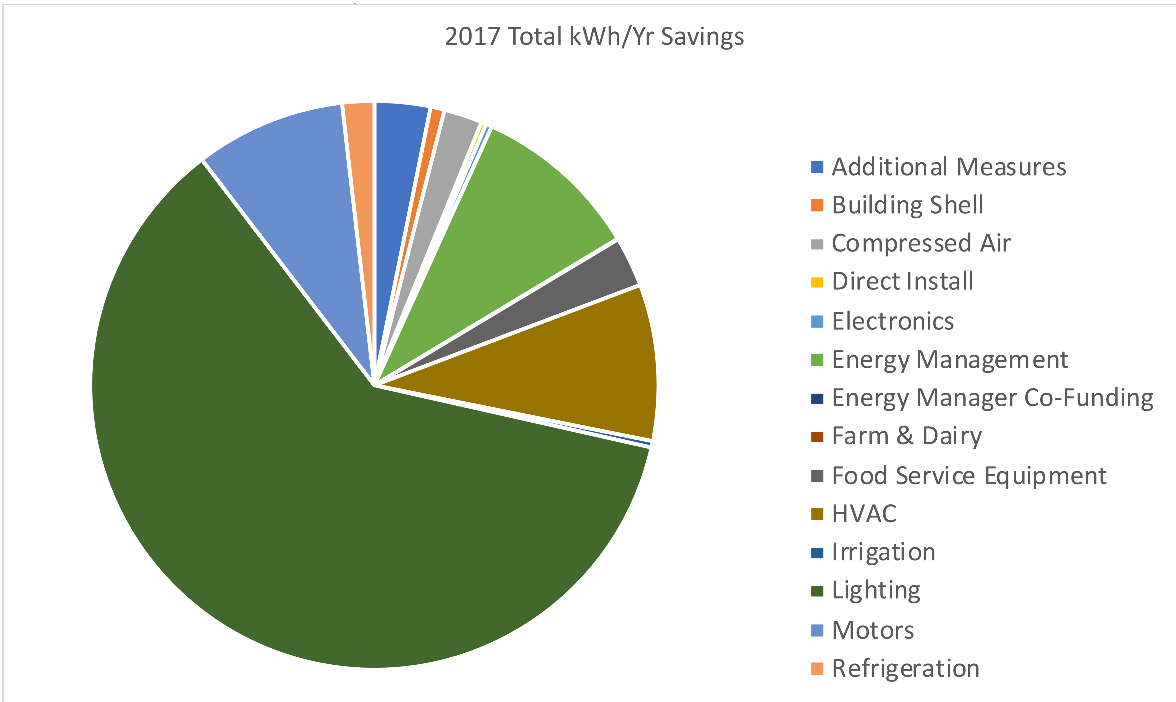
EXTRAS

Utah commercial energy efficiency programs (1)



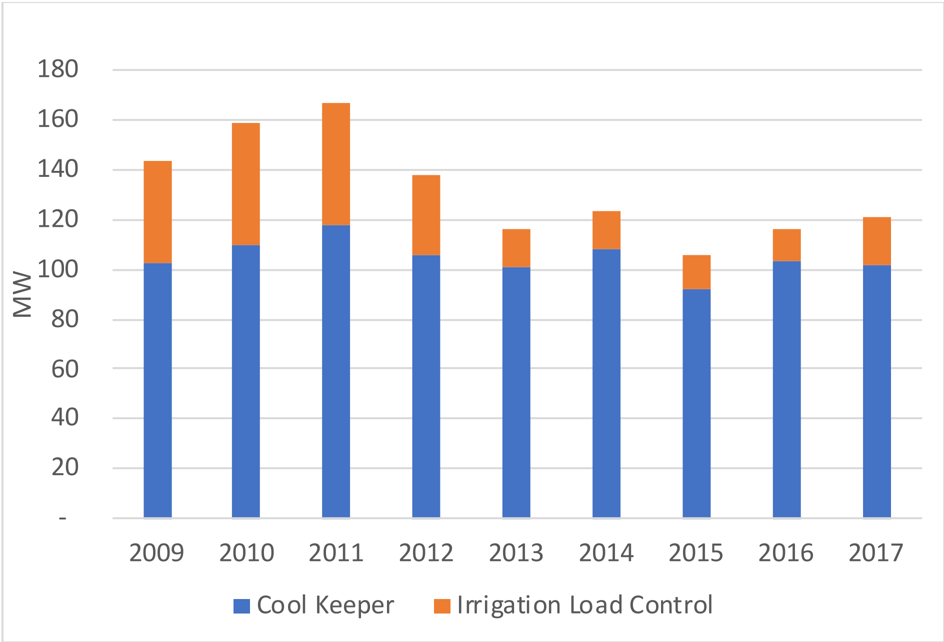
Utah commercial energy efficiency programs (2)

2017 commercial energy efficiency savings by



See "Additional Slides" for programs for residential customers

Utah demand response programs



Program	Description
Cool Keeper	Residential A/C two-way direct load control program that cycles compressor on and off for periods in each hour. Administered by GoodCents and Eaton.
Irrigation Load Control	12 pm – 8 pm M-F, two-way dispatchable load control system administered by EnerNoc. Pay-for-performance structure with limited number of opt-outs of events.

PacifiCorp 2017 IRP private generation forecast - by state

Figure 3 Cumulative Market Penetration Results by State (MW AC), 2017 – 2036, Base Case