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

Summary

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Agenda

- Purpose, approach and scope of project
- Role of technical advisory group and members
- DER definition and uses for report
- Frameworks under consideration
- Discussion questions

Purpose of Research

- Potential studies for distributed energy resources (DERs) typically do not consider all DER types or account for how they interact with one another to affect potential estimates or forecasts of electricity system impacts and benefits.
- The Second Installment of the Quadrennial Energy Review includes a recommendation to prepare a national DERs potential study to more effectively value and integrate DERs.
- This project includes two tasks stemming from this recommendation.
  - The task 1 deliverable was a memo to the U.S. Department of Energy (DOE) on the identification and documentation of user needs for an integrated DER (IDER) potential study. It was completed in September 2017.
  - The task 2 deliverable is a guide for states with frameworks on how to conducted integrated analysis of DERs.

Approach – Task 1

- Task 1 - Identification and documentation of user needs
  - Interviewed state public utility commissions, electric utilities, independent system operators (ISOs), a regional planning organization, and consultants about the state of the art of potential studies for DERs, and the potential value of and uses for integrated DER potential studies
  - Complied a list of potential studies that address more than one type of DER (though not often in an integrated fashion)

Task 1 Key Findings

- State policy makers and public utility commissioners and commission staff will benefit most from an IDER potential study.
- All interviewees stated that an IDER potential study would be useful to inform policies, regulations, and programs.
- Interviewees identified the following as valuable components of an IDER potential study:
  - Definitions of resource options to assess in IDER potential study
  - Data requirements for an IDER potential study
  - Methods for evaluating IDER potential
  - Identification of resources that are nationally available and how states can use them to conduct their own IDER potential study
  - Methods for estimating adoption rates of IDERs
  - Establish an advisory group to assist with making decisions about data and methodologies to use

Approach – Task 2

- *Frameworks for Integrated Analysis of Distributed Energy Resources: A Guide for States* will provide frameworks for states to consider in developing an integrated approach to assessing potential of and planning for DERs. The frameworks use top-down approaches in order to use more readily available data included in integrated resource plans (IRPs), demand-side management (DSM) plans, and potential studies for various types of DERs.
- The guide will include:
  - High level summary of the range of existing DER potential studies (see Appendix slides 28-40 for examples)
  - Data sources, data gaps and resource-specific considerations for each DER type
  - Options for methodologies and analytical approaches (frameworks)
  - Discussion of tradeoffs between framework approaches with respect to granularity, cost, accuracy and data requirements
  - Cost estimate ranges for one or two approaches for performing an integrated DER analysis
  - Implementation steps for the frameworks

Scope of Project

- The guide seeks to provide states — with diverse starting points — a path forward to analyze DERs in an integrated way.
- The guide is NOT a:
  - Detailed explanation or comprehensive overview of DER potential studies, DSM plans, IRPs or distribution system planning
  - Comprehensive documentation of all DER-related literature
  - Review of models that are available to conduct integrated DER analysis

Technical Advisory Group

- The technical advisory group is comprised of a range of experts – state utility commission and energy office representatives, regional energy efficiency organizations, utility representatives, academics and consultants.
- The technical advisory group will:
  - Provide input on this call
    - Provide follow-up input through email by Jan. 22 on discussion questions in this presentation
  - Serve as peer reviewers for the draft report
    - Report review will occur March 30 – April 20.
    - We plan to publish the report in June.

Technical Advisory Group Members

Brendon	Baatz	American Council for an Energy Efficient Economy
Josh	Gould	Con Edison
Lorenzo	Kristov	Consultant
Steve	Schiller	Consultant
Tom	Eckman	Consultant
Fredrich (Fritz)	Kahrl	E3
Jamie	Barber	Georgia Public Service Commission
Jennie	Potter	Hawaii Natural Energy Institute
David	Parsons	Hawaii Public Utilities Commission
Meegan	Kelly	ICF
Julia	Friedman	Midwest Energy Efficiency Alliance
Jessica	Burdette	Minnesota Department of Commerce
Danielle	Byrnett	National Association of Regulatory Utility Commissioners
Rodney	Sobin	National Association of State Energy Offices
Tom	Stanton	National Regulatory Research Institute
Greg	Wikler	Navigant
Paul	De Martini	Newport Consulting
Jay	Lucas	North Carolina Utilities Commission
John	Ollis	Northwest Power and Conservation Council
Mark	Martinez	Southern California Edison
Howard	Gellar	Southwest Energy Efficiency Project
Tim	Woolf	Synapse
Gary	Brinkworth	Tennessee Valley Authority
Damon	Lane	Vermont Energy Investment Corporation

Defining DERs and Uses for the Guide

- For the guide, DERs are defined as energy efficiency, demand response, distributed generation (as represented by CHP and solar PV) and storage. The report also will address electric vehicles.
- The target audiences for the guide are state policymakers, public utility commissions and state energy offices. Other stakeholders include investor-owned, municipal and rural electric cooperative utilities, consumer representatives, and DER product and service providers.
- Uses for the guide:
  - Advance identification of least-cost, best-fit resource plans and strategies
  - Inform grid modernization efforts
  - Support achievement of state energy goals
  - Serve as practical guidance at the state level or for utility service areas within a state

Limited *Integrated* DER Analysis

- There is very limited information available in the literature about the critical assumptions that must be made, or the order in which the assumptions should be made, to integrate individual DERs into a cumulative impact.
- Distribution planning that identifies a system constraint and combines DERs to defer that need is an example of considering DERs in an integrated way. However, it does not identify the potential of IDER for longer-term planning or policy-making purposes.
- There is very little information in the literature on the additional cost of considering resources in an integrated way.
- There is a small — but growing — body of literature on the value of integrated DER analysis. Generally, there are cost savings associated with implementation of DERs together.
- Given the lack of literature on how to conduct an integrated analysis of DERs, we are proposing two frameworks to guide states.

Framework 1: Prioritization of Specific DER(s)

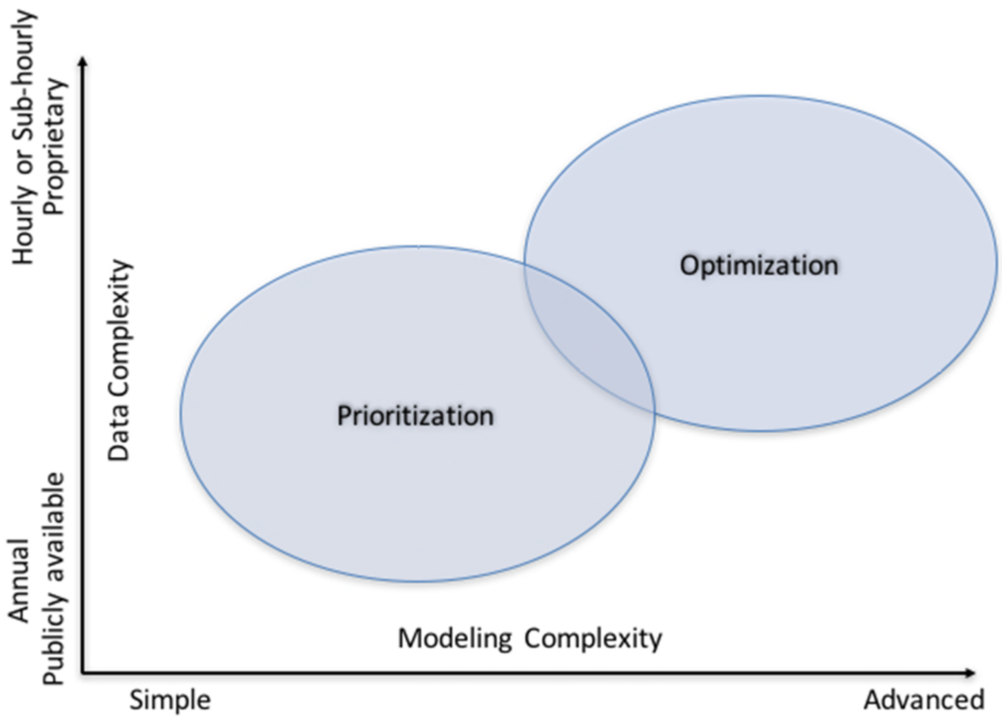
- Proposed approach:
  - Identify DER prioritization based on state energy policies, regulations or other ranking basis.
  - Estimate in isolation the technical, economic, and achievable potential of the DERs being used in the analysis.
  - Analyze the impacts of the DER potentials starting with the top-priority resource. As each additional DER type is layered on, account for how it impacts the availability or operation of all or some of the other DERs.
- Example:
  - One DER could be compared to other resources that are already optimized.
    - Compare the impact of one DER on a preferred IRP portfolio.
    - Compare the impact of increasing energy efficiency on demand response in a DSM portfolio.

Framework 2: DER Optimization

- Proposed approach:
  - Define the geographic region (e.g., entire state or utility service area).
  - Define the resources and baseline (e.g., the preferred plan from a utility IRP).
  - Model many alternative combinations of DERs to solve for an identified state goal (e.g., minimizing cost and risk) and compare defined metrics for resulting resource portfolios.
- Example:
  - The Pacific Northwest Power and Conservation Council uses scenarios and sensitivities to determine which resource strategies exhibit low cost and risk.
  - "Scenarios combined elements of the future that the region controls, such as the type, amount and timing of resource development, with factors the region does not control, such as natural gas and wholesale electricity market prices. Sensitivity studies alter one parameter in a scenario to test how the least cost strategy is affected by that input assumption." (7th Power Plan, p. 3-7)

Spectrum of Frameworks

- There is a range of complexity for both of the frameworks.
- As with any forecasting exercise, the assumptions and data used when implementing the frameworks will define the robustness of the results.
- The analysis can be iterative for both frameworks (e.g., they can be used over time to repeatedly update a planning process and adapt to new goals).



Trade-offs Between the Frameworks

- The guide will include a discussion of the trade-offs between the two frameworks and will cover the strengths and weaknesses of each, including:
  - Granularity of data
  - Cost
  - Time
  - Accuracy
  - Data requirements
  - Ability to use framework iteratively or to reassess existing policies

Implementation of DER Frameworks

- To provide states guidance on implementing the DER frameworks, the report may include:
  - Discussion of the application of the DER Prioritization and Optimization frameworks in IRP, DSM planning and distribution system planning. (See Appendix, slide 22).
  - Examples or case studies of integrated analysis of DERs in IRPs, DSM planning and distribution system planning. (See Appendix, slides 23 – 25).
  - Resources (e.g., reports, utility filings, legislation and regulatory orders on including DERs in IRP, DSM planning and distribution planning). (See Appendix, slides 26 – 27).

Framework Categories

- A valuable feature of guidance documents is categorization of options.
- How to categorize the Prioritization and Optimization Frameworks?
  - Example of Prioritization Framework category: For efficiency, there are at least three policy approaches: loading order, energy efficiency resource standard, and requirement to acquire all cost-effective efficiency.
  - Example of Prioritization Framework category: For solar there are many policy approaches. One approach is a solar carve-out as part of a renewable energy portfolio standards.
  - Example of Prioritization or Optimization Framework category: Using either approach, a baseline is required. One option is to use the preferred plan from an IRP.

Discussion Questions

- What are the strengths and weaknesses of the two proposed frameworks (DER Prioritization and Optimization)? (see slides 12-14)
- Are there additional frameworks that should be discussed in the state guide?
- Are there comparative analysis examples that would aid in shaping the discussion of trade-offs between each framework? (see slide 15)
- What resources are there to guide how to categorize the Optimization and Prioritization Frameworks? (see slide 17)
- What other case studies, examples and resources exist that consider DERs in an integrated manner? (see slide 16 and appendix 23-27)
- What guidance is there on the treatment of DERs in DSM, IRP or distribution planning that is relevant to integrated DER analysis? (see slide 16 and appendix 23-27)

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Appendix

Examples of DER Prioritization and Optimization

- Examples of how the Prioritization Framework could be implemented, using efficiency as the priority resource:
  - California and Maine have "loading orders" that require efficiency be acquired first, before other resources.
  - 26 states have energy efficiency resource standards
  - Several states have requirements that all cost-effective energy be acquired (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, Washington)
- Example of how the Optimization framework could be implemented:
  - PacifiCorp "develops a range of different resource portfolios" that are evaluated for risk (e.g., natural gas price scenarios and carbon dioxide emissions limits assumptions).
  - The resource portfolios model efficiency, demand response, energy storage and private generation (residential PV, small-scale wind, small-scale hydro and CHP). The amount of resources available are based on a potential studies.
  - PacifiCorp also developed 16 sensitivity cases to look at impact of of specific planning assumptions, including a low and high private generation sensitivity.

Examples of DERs in DSM planning

- Efficiency and demand response are the most common DERs used in DSM planning.
- Energy efficiency and demand response potential studies often provide the data used in DSM planning.
- Report examples:
  - DOE Energy Efficiency Potential Study Catalog
  - 2025 California Demand Response Potential Study (March 2017)
  - PacifiCorp Demand-Side Resource Potential Assessment for 2017-2036 (February 2017)
  - Minnesota Demand Side Management Potential Study (ongoing)

Report examples of DERs in IRP or long-term load forecasting

- PacifiCorp IRP Distributed Generation Resource Assessment (July 2016)
- Planning for a Distributed Disruption: Innovative Practices for Incorporating Distributed Solar into Utility Planning (August 2016)
- ISO-NE Distributed Generation Forecast Working Group forecasts long-term incremental distributed generation growth in the region (date)
- Northwest Power and Conservation Council plans to forecast the load impact of rooftop solar plus batteries in the 8th Power Plan.
- Con Edison's Distribution System Implementation Plan (June 2016)

Report examples: DERs in distribution planning

- LBNL regional training for public utility commissions on distribution systems and planning contains overview of distribution planning and information on DERs and distribution planning
- State Engagement in Electric Distribution System Planning (December 2017)
- Beyond the Meter: Planning the Distributed Energy Future. Volume II: A Case Study of Integrated DER Planning by SMUD (May 2017)
- Distribution Systems in a High Distributed Energy Resources Future (October 2015)
- Summary of Electric Distribution System Analyses with a Focus on DERS (April 2017)
- The Future of Electricity Resource Planning (September 2016)

Policy examples of DERs in IRP

- Washington UTC Report and policy statement on treatment of energy storage technologies in integrated resource planning and resource acquisition
- California requires that utility IRPs address procurement of efficiency, demand response, energy storage, and transportation electrification.
- New Orleans City Council 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.

Policy examples: DERs in distribution planning

- California's Distributed Energy Resource Action Plan Aligning Vision and Action (May 2017)
- Distributed Energy Resources Roadmap for New York's Wholesale Electricity Markets (January 2017)
- California AB 327 (2013) requires reform of distribution planning to advance time and location variant pricing and incentives and support DERs
- New York requires that utilities file Distribution System Implementation Plans (DSIP), and incorporate DERs (EE, DR, DG and EV) into the utility planning process.

Potential studies: Demand response

- PacifiCorp Demand-Side Resource Potential Assessment for 2017-2036 (Volume 5) considers DR and rate structures in an integrated potential assessment.
  - "The first step in conducting an integrated assessment of Class 1 and Class 3 DSM resources is to define a hierarchy of options, according to which eligibility criteria are established. This is necessary to account for the interactive effects between Class1 and Class 3 DSM resources, and to avoid double counting of impacts."

- "Compared to the standalone analysis results, total Class 1 DSM potential is lower by 3% because of the stacking and interactive effects. Class 3 DSM, however, is decreased by 30%. This is due to the fact that Class 3 resources are lower in the hierarchy and encounter more competing, alternate resource options."

Table F-1 Participation Hierarchy in Class 1 and 3 DSM Options by Customer Class

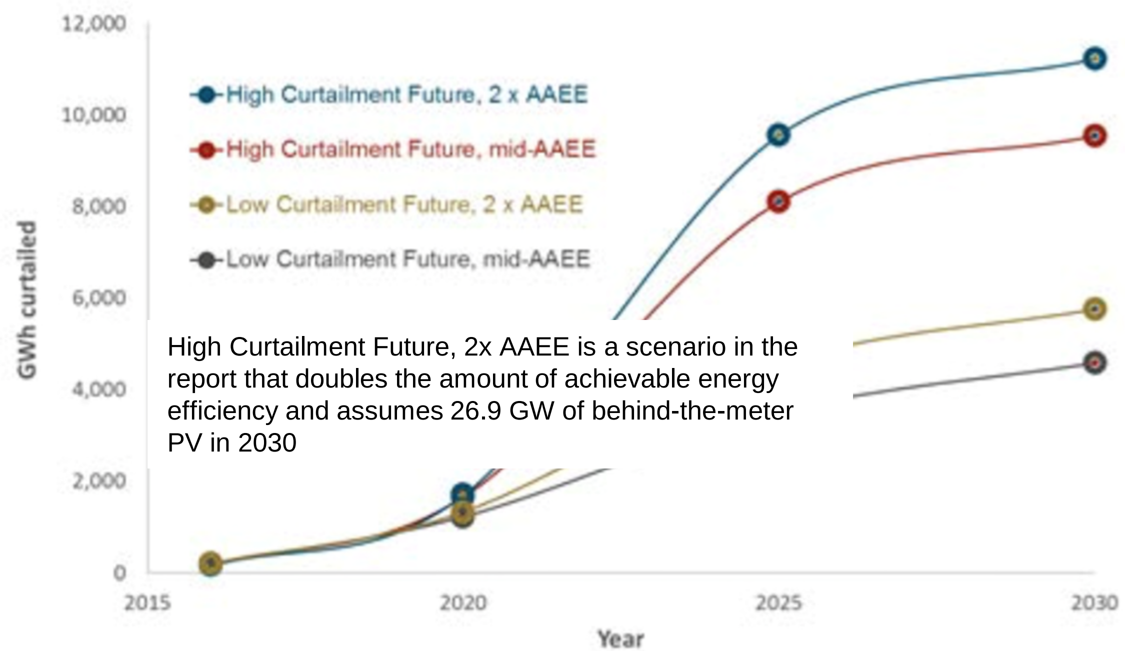
	Program Option	Resource Class	Residential	Small C&I	Medium C&I	Large C&I	Extra Large C&I	Irrigation
Loaded First	DLC Central AC	Class 1	x	x	x			
	DLC Space Heating	Class 1	x	x	x			
	DLC Water Heating	Class 1	x	x	x			
	DLC Smart Thermostats	Class 1	x					
	DLC Smart Appliances	Class 1	x					
	DLC Room AC	Class 1	x					
	DLC Irrigation	Class 1						x
	Ice Energy Storage	Class 1		x	x			
	Curtail Agreements	Class 1				x	x	
	TOU Demand Rate	Class 3	x					
	TOU Demand Rate w EV	Class 3	x					
	Time-Of-Use	Class 3	x	x	x	x	x	x
	Critical Peak Pricing	Class 3	x	x	x	x	x	x
	Real Time Pricing	Class 3				x	x	
Loaded Last	DLC Elec Vehicle Charging	Class 1	x					

Potential studies: EE+DR

- California Demand Response Potential Study considered the impact of EE adoption on DR potential.
  - "There is an ongoing discussion around interactive effects of energy efficiency and demand response, and the bifurcation of DR into load-modifying and supply resources facilitates a new way of viewing these effects. Once could broadly consider energy efficiency as a load modifying DR measure, whereby the net load is decreased by an efficiency investment."
  - "Improved efficiency for an end use that also participates as supply DR reduces the availability of baseline load to actively shed. It is an important point, however, that the net sum of the DR resource is unchanged in general, and could be increased through EE investment."
  - The study also identifies "co-benefits of DR and energy efficiency (e.g., bill savings from DR-device induced energy efficiency or from a third party offering incentives to reduce the upfront cost of DR."

Potential studies: EE+DR (cont'd)

- [California Demand Response Potential Study] also found that "doubling energy efficiency also increases curtailment by approximately 1,500 – 2,000 GWh. This is because lower loads in hours of high solar overgeneration increases curtailment, and this effect more than offsets any reduction in renewable energy procurement needed to meet the lower RPS requirement caused by lower load."

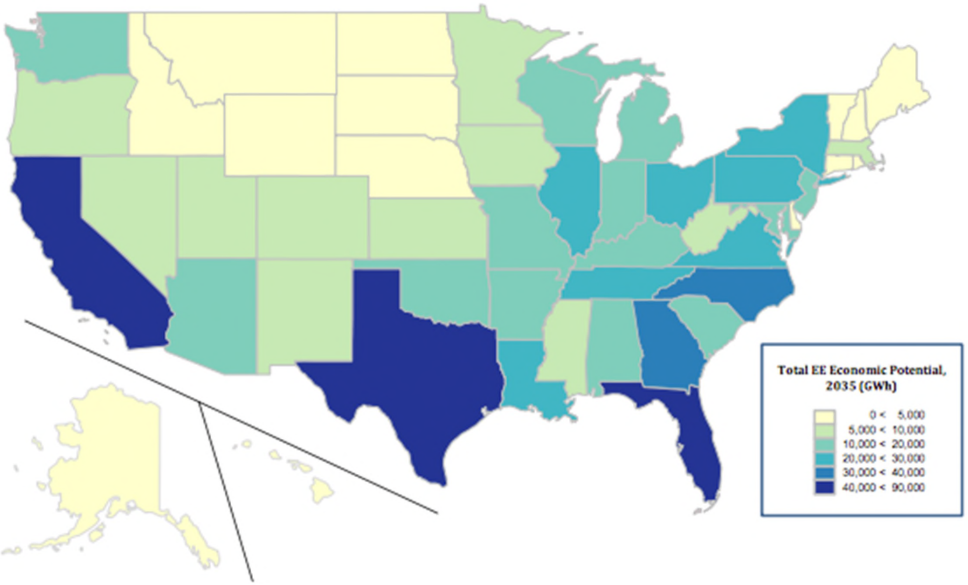


High Curtailment Future, 2x AAEE is a scenario in the report that doubles the amount of achievable energy efficiency and assumes 26.9 GW of behind-the-meter PV in 2030

AAEE = Additional achievable energy efficiency

Potential studies: Energy efficiency

- There are many publicly available energy efficiency potential studies for utilities, states, and regions of the U.S.
- The Electric Power Research Institute, for DOE, conducted a national energy efficiency potential assessment in May 2017.
- The national potential was used to determine state level potential.
- Economic potential was estimated using avoided cost based on the Annual Energy Outlook 2016 fuel costs projections.
- The potential does not reflect changes to technology since 2014 (when last report was released)
- EPRI anticipates publishing an updated analysis at the end of 2017 or early 2018.



State economic potential in 2035 (GWH)

Potential studies: Energy efficiency

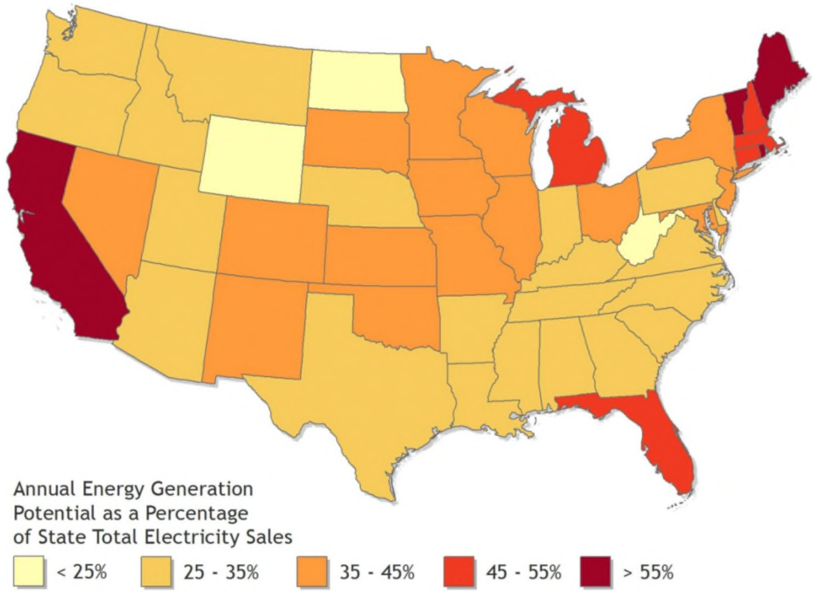
- There are many publicly available energy efficiency potential studies for utilities, states, and regions of the U.S.
- Northwest Power and Conservation Council is a leader in the U.S. in assessing energy efficiency potential
- In the 7th Power Plan, the Council developed conservation supply curves based on the amount and shape of efficiency available at a variety of cost bins, by year.
- It is common for energy efficiency potential assessments to have technical, economic and achievable potential.
  - The logic of moving from economic to achievable potential is often opaque and occurs in a model.
  - The Council assumes that, over a 20 year planning period, 85% of technically potential can be achieved.
- The Council found that efficiency could cost-effectively meet all load growth in 90% of the future conditions evaluated.
- In 8th Plan, the Council will be looking at the reliability of capacity saving estimates of EE, among other refinements.

Potential studies: Solar

- NREL published a rooftop solar technical potential assessment for the U.S. in 2016.
- The report provides the potential at the national, state, and ZIP-code level based on light detection and ranging data, GIS and solar generation modeling.

There are three primary methods used for PV potential:constant-value methods, manual selection and GIS based methods.

- Technical potential is provided by building class (small, medium, large) and by state



Potential studies: PV + Storage

- NREL "conducted an initial techno-economic assessment of PV and storage feasibility" at 5 universities.
- The assessment compared a business as usual case with an alternate scenario where PV and batteries would be installed.
- NREL found that in the scenario with PV and batteries "total energy savings decreased slightly due to losses in the round trip efficiency of the battery," but increased demand savings by $157,000 per year.

Table 2. Technology Comparison for Luther College

Technologies Evaluated	Business as Usual	Add PV	Add PV and Battery Storage
Additional PV Size	n/a	3 MW	3 MW
Battery Size	n/a	n/a	0.58 MW:3.2 MWh
Total Cost	n/a	$5.6 million	$7.8 million
Annual Energy Costs	$487,000	$269,000 ($218,000 savings)	$292,000 ($195,000 savings)
Annual Demand Costs	$679,000	$652,000 ($28,000 savings)	$522,000 ($157,000 savings)
Life Cycle Cost	$29.0 million	$27.1 million	$25.6 million
Net Present Value	**n/a**	**$1.9 million**	**$3.4 million**

Solar + storage

- Xcel solar+storage and wind+storage bids
  - https://assets.documentcloud.org/documents/4340162/Xcel-Solicitation-Report.pdf
- NextEra Tucson Electric solar+storage bids

Potential studies: Storage

- Identifying the potential for storage is less prescriptive than other IDERs as technical potential is unlimited.
- NREL recently published the first publicly available "comprehensive survey of the magnitude of demand charges for commercial customers across the United States."
- Assumption of study is that demand charges may be a key predictor of the potential adoption of storage.
- Finding is that there are nearly ~5 million commercial customers in the United States who can subscribe to retail electricity tariffs that have demand charges in excess of $15 per kilowatt (kW), over a quarter of the 18 million commercial customers in total in the United States.

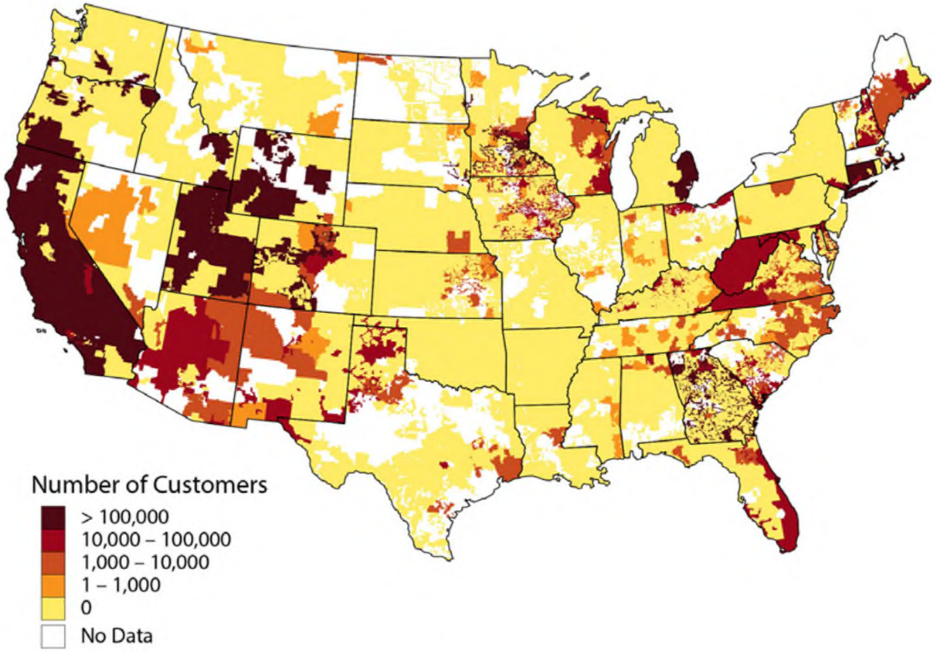
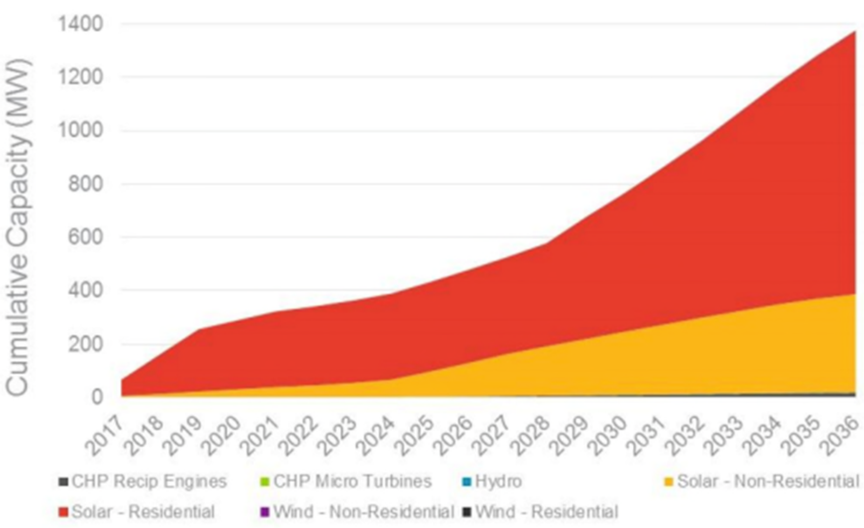


Figure 1. Number of commercial electricity customers who can subscribe to tariffs with demand charges in excess of $15/kW.

Potential studies: Storage (cont'd)

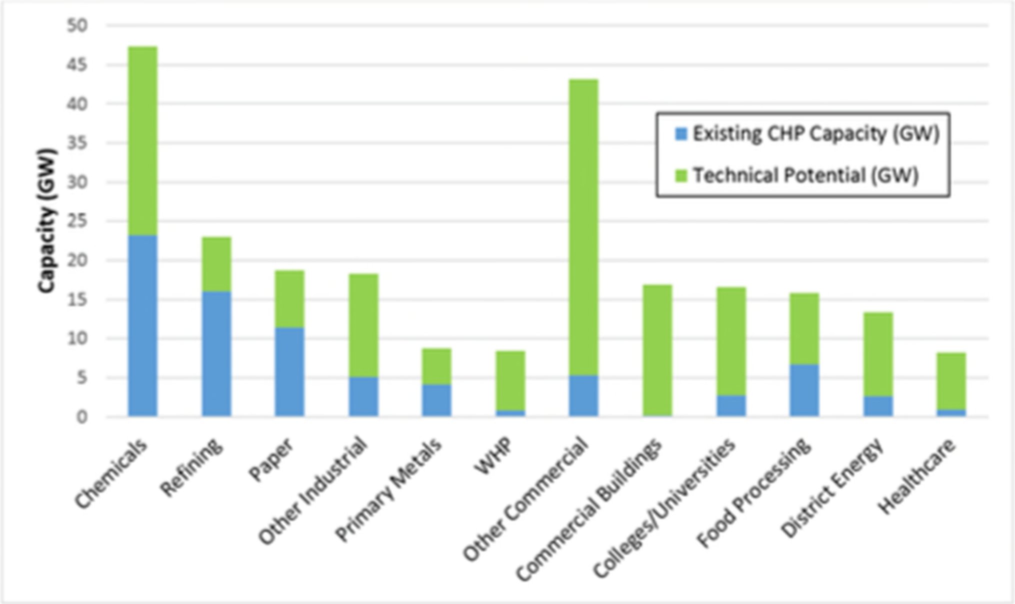
- In 2016, Navigant evaluated the potential for storage in PacifiCorp's six state territory as part of their 2017 Integrated Resource Plan.
- The report examined drivers and challenges to the energy storage market in PacifiCorp's territory, but did not provide potential energy or capacity values from using storage.
- The evaluation qualitatively considered current and future applications of paired resources: non-residential solar, residential solar, wind, hydro, and CHP, each combined with storage.
- The report also assessed the technical and market potential for solar, small wind and hydro, CHP with reciprocating engines and CHP with micro turbines.



Cumulative market penetration results by technology MW AC, 2017-2036; Base Case

- The majority of the market penetration was in residential solar, as shown in the figure to the left.
- Resources were not considered in an integrated fashion.
- Navigant used simple payback as a key indicator for customer uptake.
- Adoption was considered under multiple scenarios (base, high and low cases).

Potential studies: Combined heat and power (CHP)



U.S. DOE CHP Deployment Program, 2016.

- DOE published report in 2016 on the technical potential of CHP
- DOE calculated the technical potential for CHP on a state by state basis for three types of CHP markets
  - Topping cycle
  - Waste heat to power
  - District energy

- Study found that "a significant portion of the remaining technical potential for on-site CHP in the U.S. is located in commercial facilities."
- Report provides detailed CHP potential for each state including: amount of existing CHP installed, types of industries with CHP, potential by industry and capacity size and number of sites.
- Report does not consider any other DERs, but could be used as a resource by states to understand technical potential
- Additional assumptions would be necessary to calculate achievable or economic potential.

Potential studies: CHP (cont'd)

- ICF conducted a CHP assessment in 2013, and calculated an economic potential based on state electricity and natural gas prices.
- ICF estimated there is 6,355 MW of CHP that is available with a payback of less than five years.
- The economic potential is dated, but ICF report does provide a methodology that could be applied on a state basis to the 2016 DOE CHP technical potential (referenced on prior slide).
- States may need to refine approach and use industry specific prices instead of average electric and gas prices, and consider state financial incentives for CHP.
- ICF considered the impact of capital cost reductions, increases in electricity costs and decreases in natural gas price on CHP economic potential.

Other studies: Evolved Energy

- EPSA is working with Evolved Energy to study how energy efficiency measures interact with flexible load (DR) measures. Specifically:
  - How does this interaction change by technology?
  - How does the interaction vary by region?
- Energy efficiency and flexible load supply curves are created and integrated to estimate the amount of technical potential and the cost of saving both resources.
- The final product is forthcoming and the summary findings will be included in LBNL's guide for states on IDER potential studies.

Other studies: DER cost and planning guidance

- There are a variety of studies that examine the value of DERs together in an integrated way, but do not discuss the potential of those resources to be deployed:
  - NREL, RMI and DOE published research in early 2017 on the cost of pairing solar with a large (5kW) or small (3 kW) battery.
  - LBNL published research in 2017 showing that commercial demand charges can be reduced by pairing solar and storage together
  - DOE published a paper in 2016 on the value of integrating demand response and storage
- Other studies provide directional guidance on integrating resources
  - CAISO, CEC and CPUC released a roadmap for advance and maximizing storage value in California in 2014
  - LBNL published scoping study in 2011 on how DG and DR could be deployed together