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Value of "DER" to "D":
The role of distributed energy resources in local electric distribution system reliability

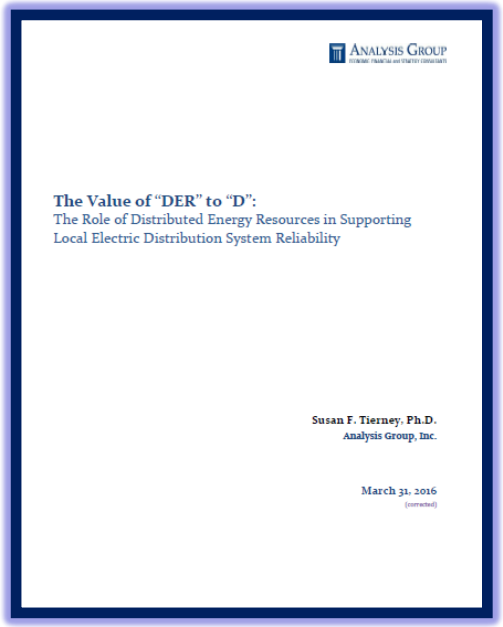
Sue Tierney

Presentation to CPUC "Thought Leaders" Forum

April 21, 2016

Overview

- Context
- Core questions explored in this presentation
- Approach: literature review and case studies
- General findings
- Case studies: SCE and Con Edison
- Results of EPRI analysis of those two systems
- Conclusions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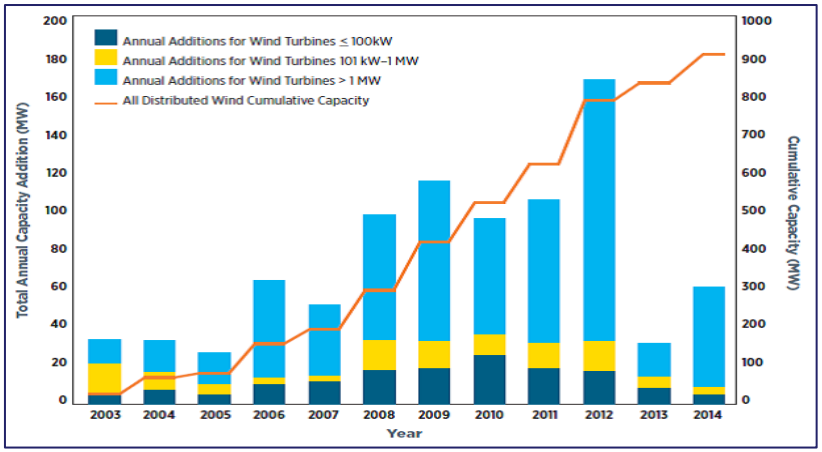
The Value of "DER" to "D":
The Role of Distributed Energy Resources in Supporting Local Electric Distribution System Reliability

Susan F. Tierney, Ph.D.
Analysis Group, Inc.

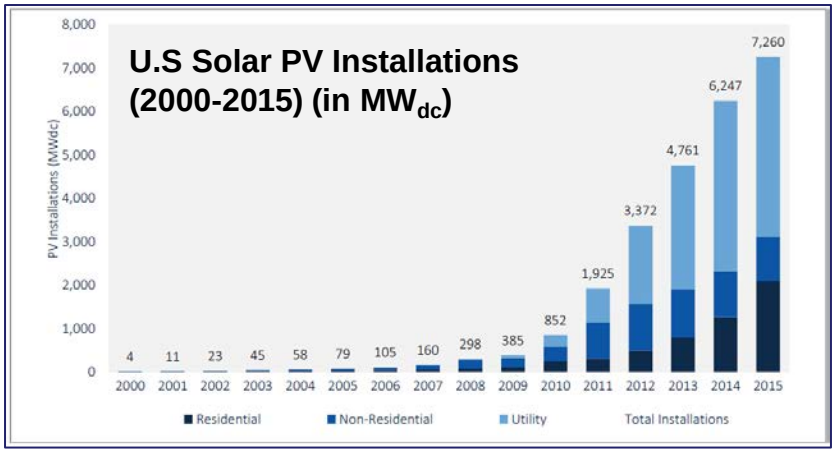
March 31, 2016
(corrected)

Context:
Distributed energy resources are proliferating rapidly

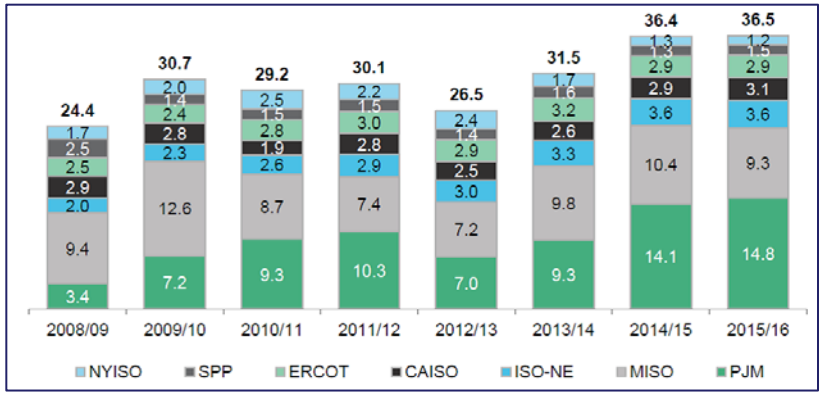
In response to policy support, technology change, customer interest



Distributed Wind Capacity Additions: Annual and Cumulative (2003-2014)



Incentive-Based Demand Response (DR) Capacity By U.S. ISO/RTO by Delivery Year (GW)



GTM Research/SEIA, U.S. Solar Market Insight: Executive Summary, 2015 Year-in-Review, March, 2016; A. Orrell & N. Foster, "2014 Distributed Wind Market Report," PNNL, August 2015; BNEF Finance, 2016 Sustainable Energy in America Factbook

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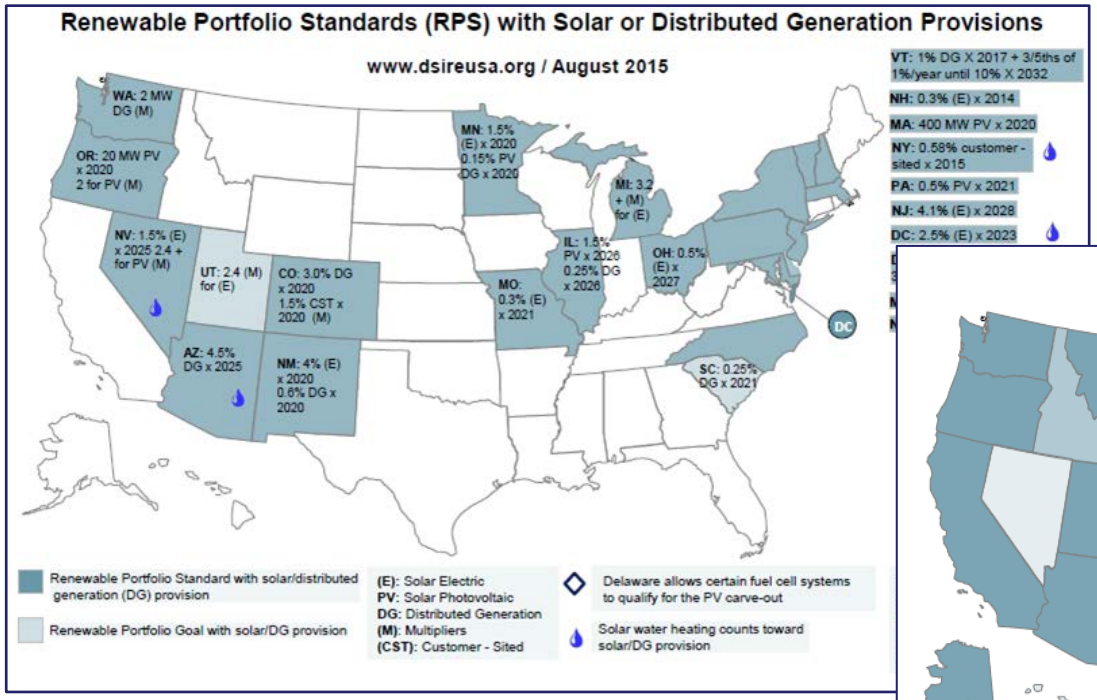
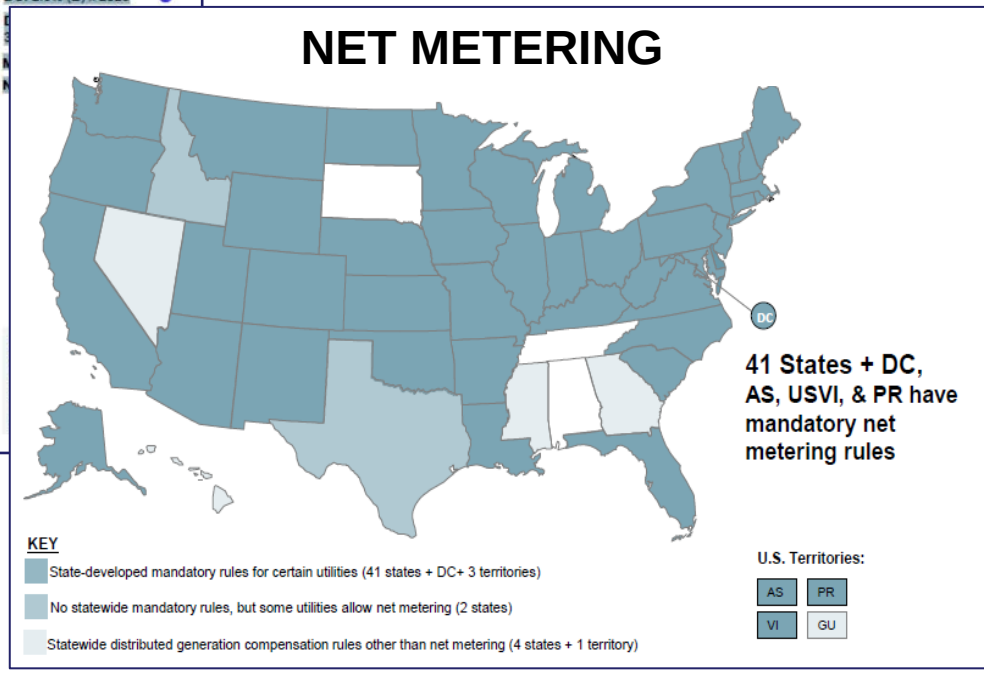
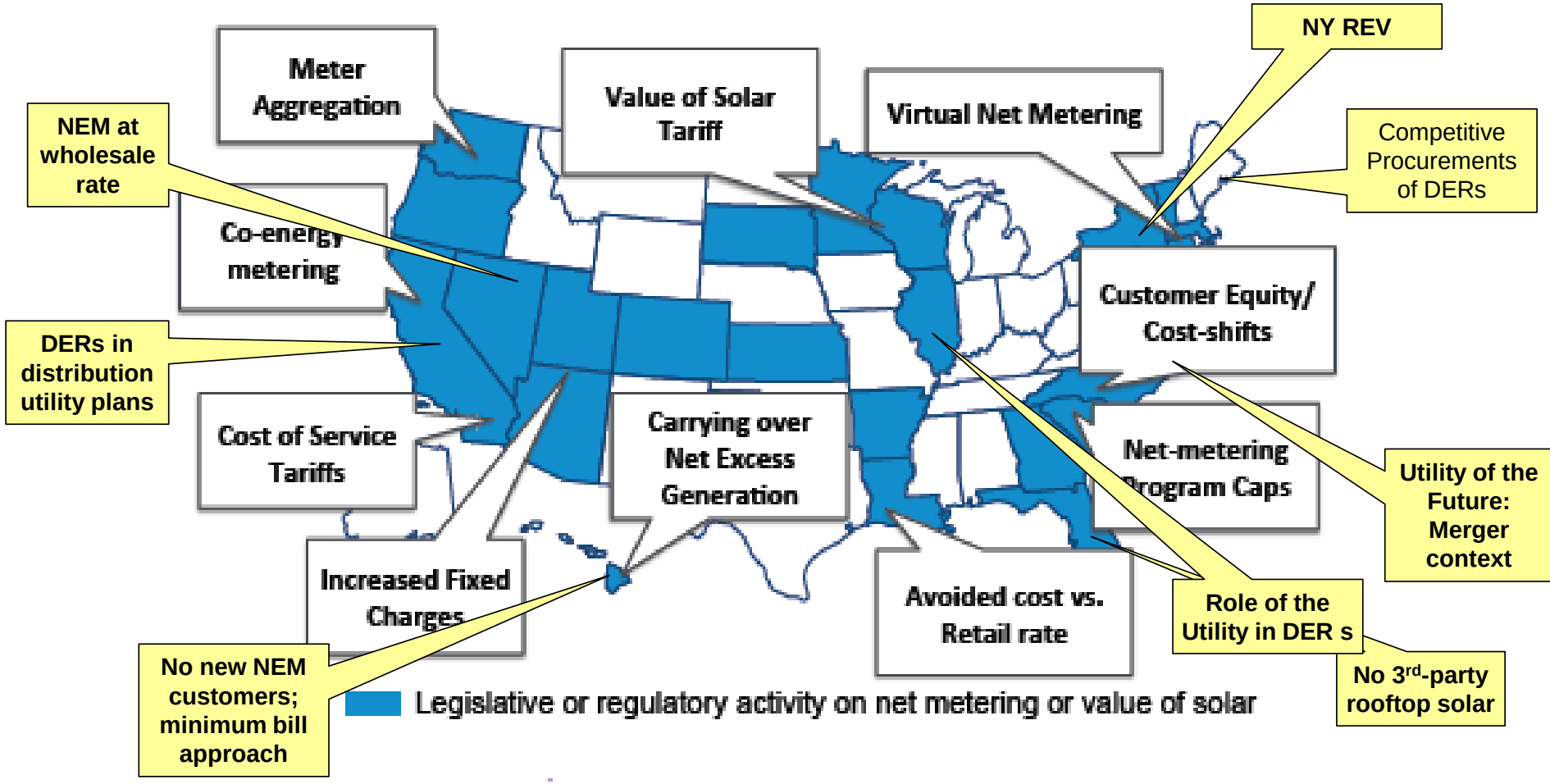


RPS WITH SOLAR CARVE-OUT



Database of State Incentives for Renewables & Efficiency

Context:
Myriad regulatory, legislative, stakeholder discussions



Original Figure from Carl Linvill, "Utility Solar Business Models in a Time of Transition," Utah Governor's Energy Development Summit, June 4, 2014, with updated information by Tierney

Context: Multiple Lenses on the Value of DERs: Value to whom and for what?

Retail Electricity Customer with DERs

Electric Distribution Utility

Utility-Scale Power Supply and Transmission

Society: External Impacts

The focus of this discussion (and Tierney white paper)

Core questions to regulators relating to DERs for D:

- **How to think about the value of DER to *the distribution system* ("The Value of DER to D")?**
  - **In light of differences among DERs' characteristics**
  - **In light of differences across utility system configurations**
- **Given interactions of DERs and the local distribution system, what are implications for the following?**
  - **Distribution-system planning**
  - **DER procurements as alternatives to traditional distribution investments**
  - **Compensation to DER providers for the values they provide to the local distribution system**

Literature review and case studies

Review of what we know/don't know about interactions of DERs and the local grid:

- Characteristics of DERs
- Analyzing DER benefits and costs
- Compensation approaches
- DERs and distribution planning
- Impacts of DER at the grid edge
- Markets for DERs

Review of results of new EPRI modeling of DER scenarios in two utility contexts:

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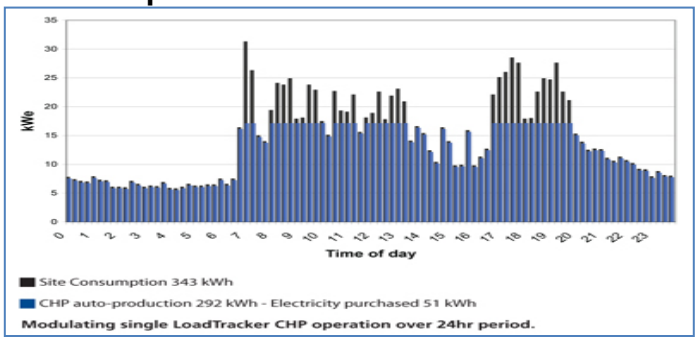
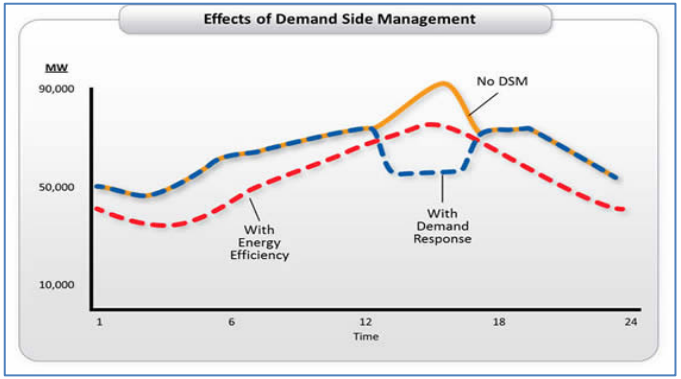
Findings:

Different DER technologies have different attributes and different impacts on and contributions to the electric system

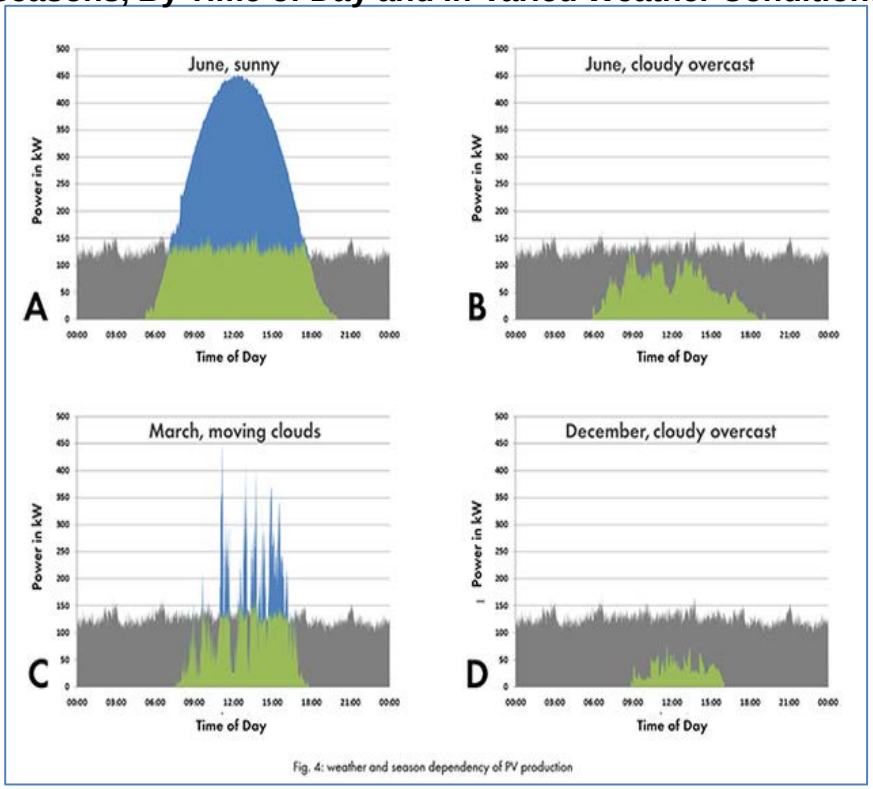
CHP Output in Relation to On-Site Demand



Effects of Demand Response on Customers' Loads



Solar PV Output on a Building During Several Seasons, By Time of Day and In Varied Weather Conditions



http://www.sma.de/en/partners/knowledgebase/commercial-self-consumption-of-solar-power.html; http://www.theenergycollective.com/david-k-thorpe/244046/demand-side-response-revolution-british-energy-policy; http://www.sav-systems.com/newsletter/issue-33-sav-loadtracker

Findings:

The value of DERs to D depends on:

- **Their location on the distribution grid**
- **Their having attributes that provide the needed characteristics of availability, dependability, and durability (sustainable supply)**

EPRI is currently performing detailed technical analyses to explore this issue on two different distribution systems:

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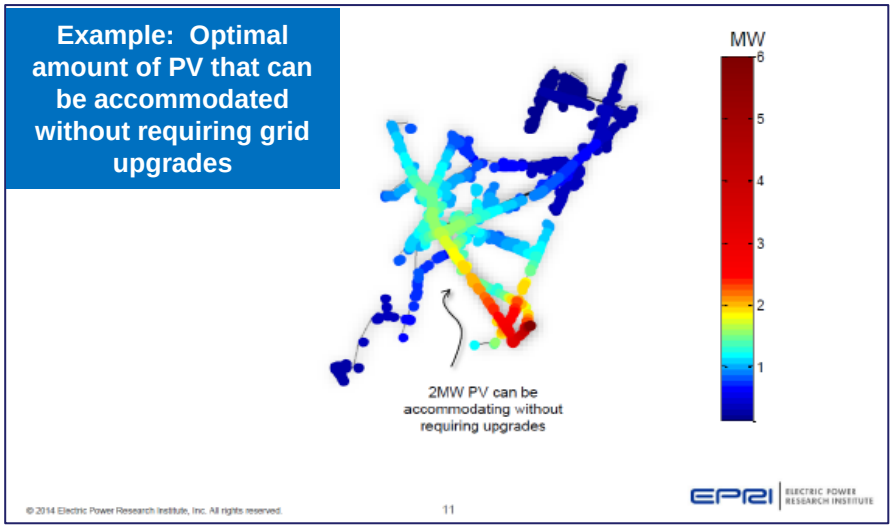


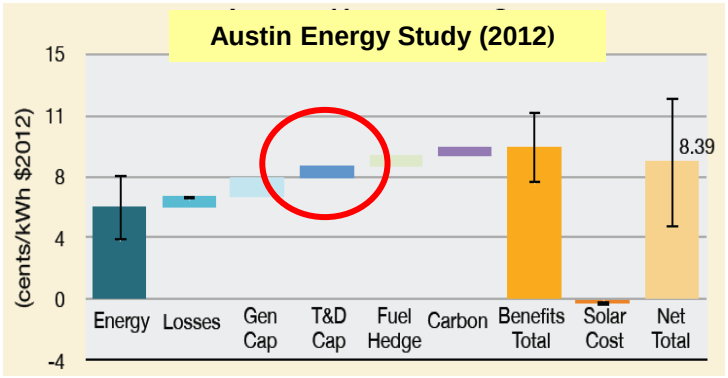
Illustrative Solar PV Hosting Capacity Map

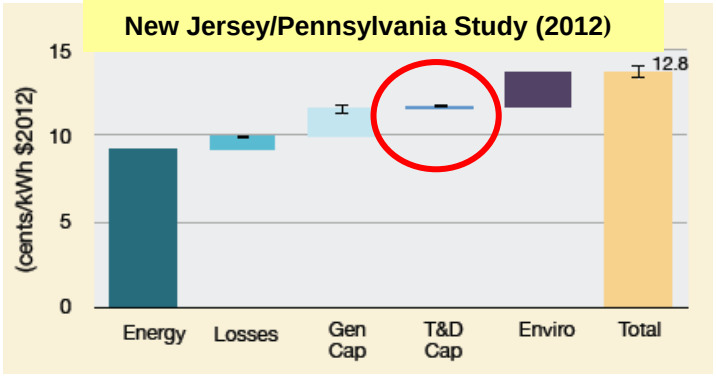
EPRI map, presented in Greentech Leadership Group and CalTech Resnick Institute, "More Than Smart: Overview of Discussions Q3 2014 thru Q1 2015," Volume 2 of 2, March 31, 2015, page 42.

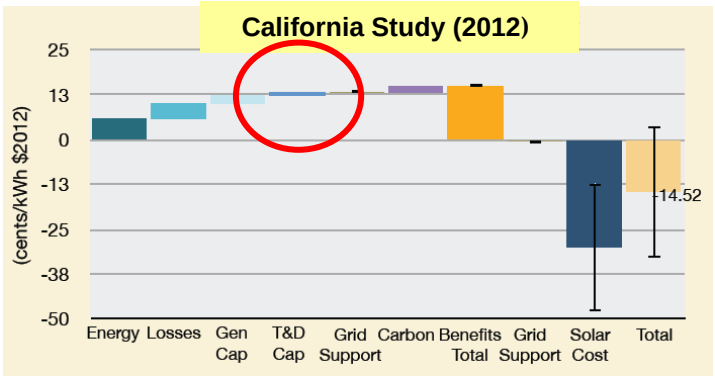
Findings:

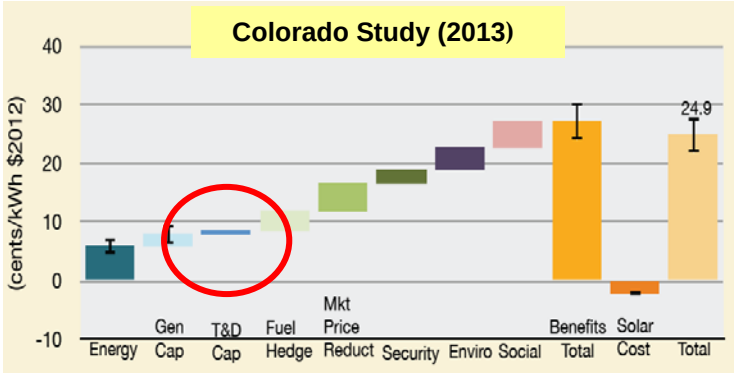
Studies indicate the Value of DER to D is typically small relative to the Value of DER to Generation (G), Transmission (T), or Society (S)

Average Avoided-Cost Values Identified in Selected Studies









Rocky Mountain Institute, e-Lab, "A Review of Solar PV Benefit & Cost Studies," Rocky Mountain Institute, September 2013

Findings:

Most potentially avoidable distribution-related costs are tied to deferred capital investments

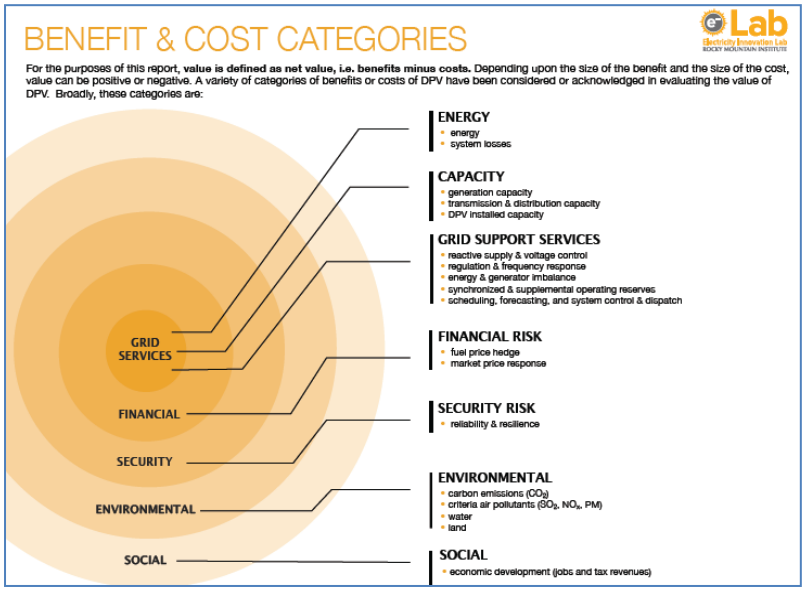
- **Other potential avoided distribution costs are distribution losses and distribution operations and maintenance**

http://www.visualdictionaryonline.com/energy/hydroelectricity/electricity-transmission/overhead-connection.php; http://www.science.smith.edu/~jcardell/Courses/EGR220/ElecPwr_HSW.html

Findings:

Conceptual frameworks for valuing DERs only go part of the way in identifying which DERs actually contribute value to D

- **Determining the value of a particular DER technologies/ applications in specific distribution-system contexts will be difficult to execute because of location-specific impacts of DERs with different attributes**
- **The industry should nonetheless attempt to develop/apply more evidence-based valuation approaches**

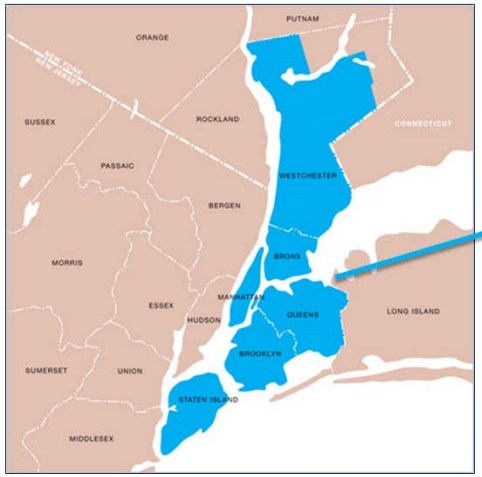


Source of figure: e-Lab, "A Review of Solar PV Benefit & Cost Studies," Rocky Mountain Institute, September 2013

Case studies:

Two distribution utilities engaged EPRI to analyze the goodness-of-fit of DERs to cost-effectively defer traditional distribution investment

ConEdison Electric Service Territory



NYISO Zones

CAISO Zones

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Case studies:

Con Edison and SCE have commonalities and key differences

- **Large utilities providing mainly delivery service**
- **Experience integrating diverse DERs onto its system**
- **In a state with active customer and regulatory interest in DERs**
- **Very different physical systems (allowing the case studies to represent the bookends of distribution-system design)**
- **Working together with EPRI to perform detailed technical analyses to better understand how the locational, temporal, and performance characteristics of DERs interact with distribution systems**

Case studies:

The two utilities' distribution-system configurations are very different

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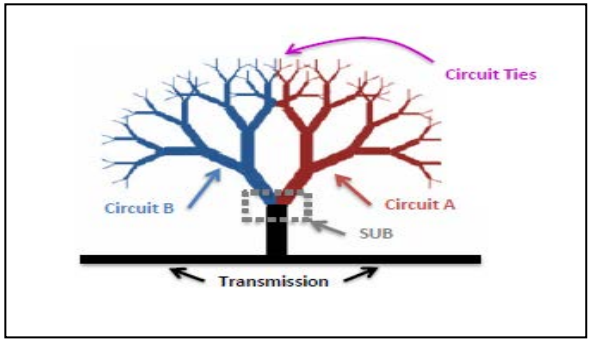
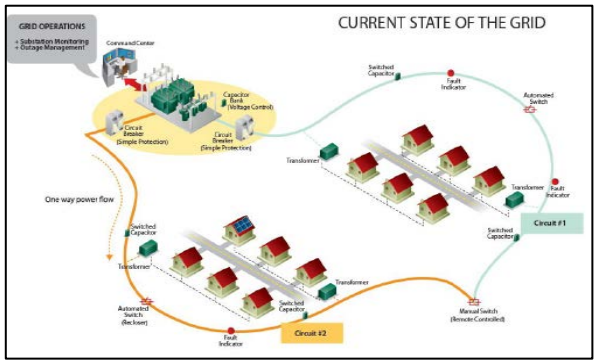
Its Radial Distribution System Resembles a Tree



Customers are Served Off of the System's Branches



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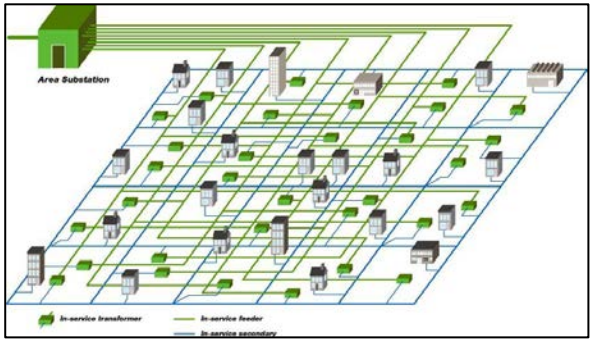
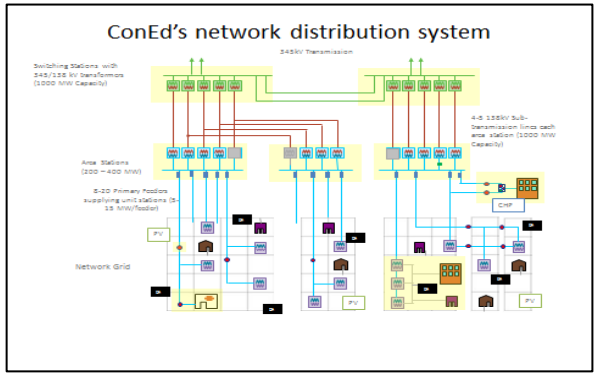
Its Network Distribution System Resembles a Mesh



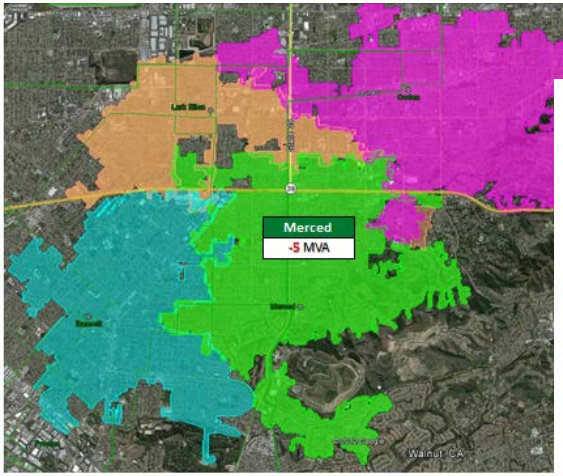
Customers are Served Off of Interconnected Wires



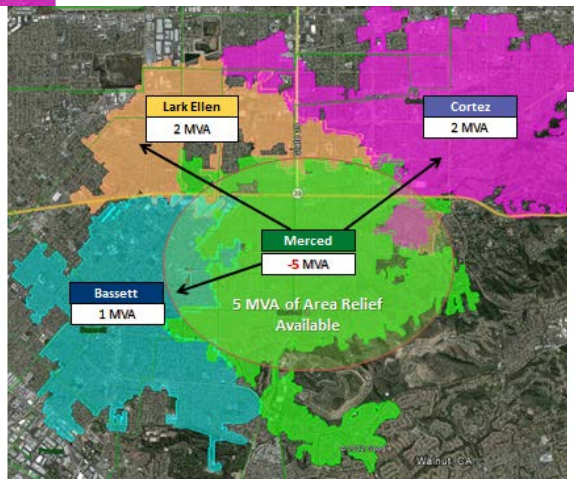
Case studies:

Distribution-system planning uses many tools to address anticipated local reliability issues and avoid new investment

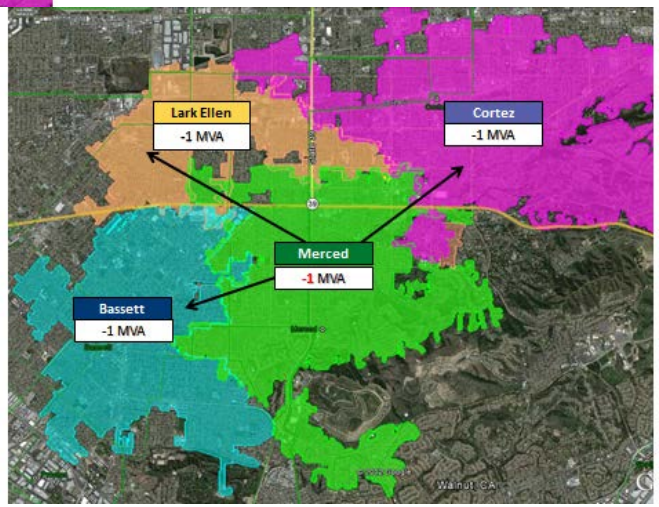
- **Example: SCE's load-growth planning in a radial system, using "load rebalancing" to defer new capital investment**



Problem Identification



Operational Planning



Future Need

Source of illustrative diagrams: Erik Takayesu, SCE

Case studies:

EPRI used its "Integrated Grid" framework to develop book-end scenarios to analyze: a first case to explore the potential for DERs to meet load growth; and a second case where PV occurs randomly.

- **In the load-growth case, to consider DER portfolio capability and cost to defer/ avoid traditional investment**
- **In random PV placement scenario, to consider the impacts to the local grid and the cost to enable increasing penetration of PVs**

Time and Locational Value of DER - Applying the EPRI Integrated Grid Framework

FORTHCOMING EPRI STUDY:
EPRI, "Time and Locational Value of Distributed Energy Resources (DER): Methods and Applications" (*EPRI # 3002008410)*

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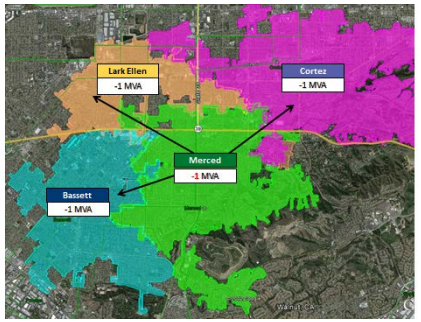
Case studies: EPRI's preliminary results

EPRI's results vary across the two utility systems and across scenarios

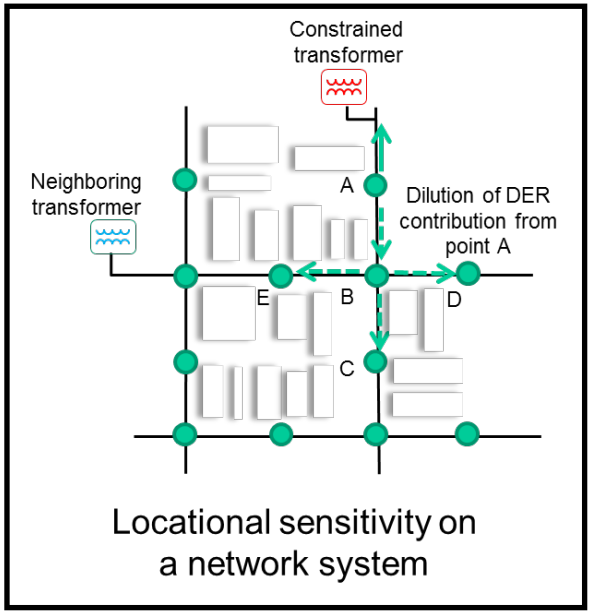
- **For the SCE case, the study examined the potential of a portfolio of strategically placed DERs to avoid a new distribution feeder:**
  - **The analysis (which is still underway and quantitative results are still preliminary) illustrates the complexity of dealing with the trade-offs of different types of DERs in different locations. Current analysis indicates:**
    - Solar PV alone may not eliminate the need for the feeder because it contributes less late in a day when many feeders' peak occurs.
    - A large, more varied portfolio (PV, energy efficiency, DR, storage) may be required to provide sufficient hours of relief to eliminate the need.
    - Storage, as well as DR (at lower cost than storage), can be paired with PV to mitigate violations on peak.
    - Better local data will help more robust benefit/ cost analyses.



Case studies: EPRI's preliminary results

EPRI's results vary across the two utility systems and across scenarios

- **In Con Edison's network system: the placement of the DERs matters significantly in terms of their ability to mitigate a local problem (e.g., an overloaded transformer).**



Locational sensitivity on a network system

- If all the DERs could be positioned at the site of the overloaded transformer, they would have the biggest impact in mitigating the problem. The farther away are the DERs, the less impact a MW of DER has on solving the problem.
- The less targeted the DERs, the more DER MWs are needed to remedy the violation and the more additional equipment (e.g., new SCADA systems) are needed to address power flows.
- The amount of DER that can be physically located at any single node or load point on the network is affected by practical real-world constraints in the built environment near that actual node.

Case studies: EPRI's preliminary analysis and results

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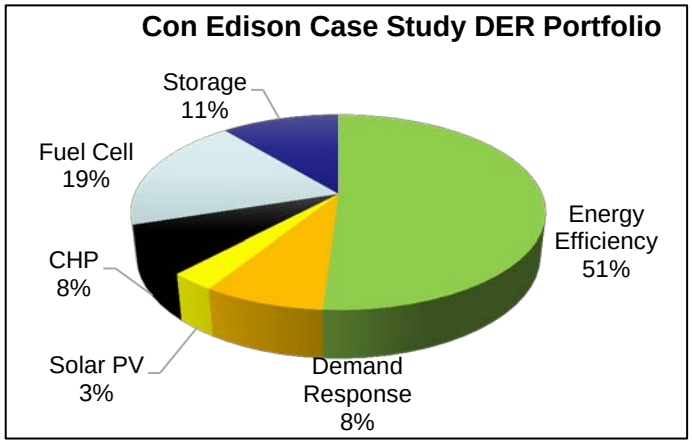

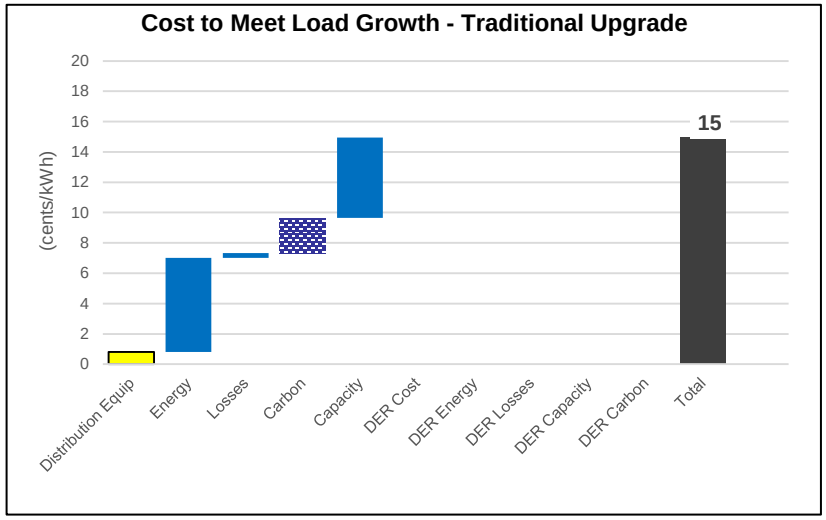

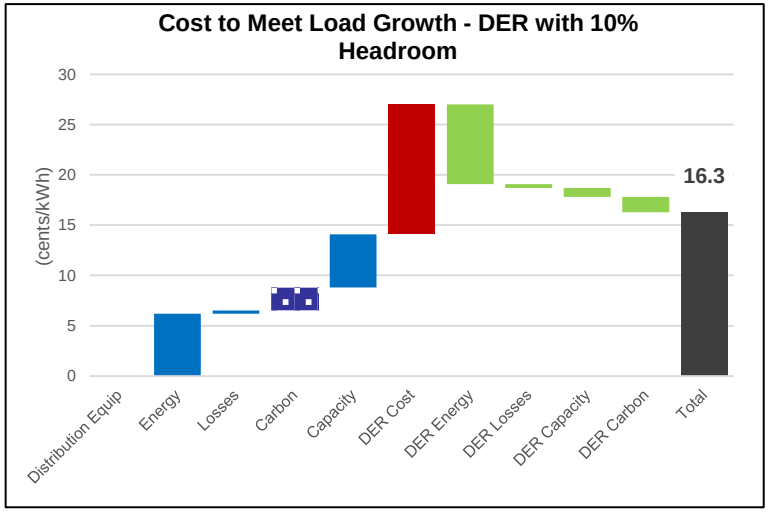

Case studies: EPRI's preliminary results

More broadly, here are general insights from EPRI's forthcoming study:

- **Individual DERs (and portfolios of different DER technologies) have different and complex interactions with the electric system.**
- **To effectively defer/replace traditional distribution solutions, DERs need to have equivalent availability, dependability and durability.**
- **DER impacts can be either beneficial or adverse, depending on a wide variety of contextual circumstances. This makes it difficult to generalize.**
- **Benefits and costs need to be characterized at the local and bulk power system levels to estimate their full value, in order to understand the sources of value and character of localized benefits and costs.**

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Insights:
Integrating DERs into distribution planning

Utilities should integrate DERs into distribution planning to consider the potential for DERs to substitute for traditional utility investments

- **DERs need to fit within the long-lead times for most traditional fixes.**
- **In the early phases of distribution planning, the scale of a required DER portfolio (and its location, timing and other attributes) should be considered to defer a traditional alternative.**
- **Until there is more experience with DERs, utilities should consider building in sufficient margins to assure reliability.**

Insights:
Evolve compensation for DERs to D to be more value-based

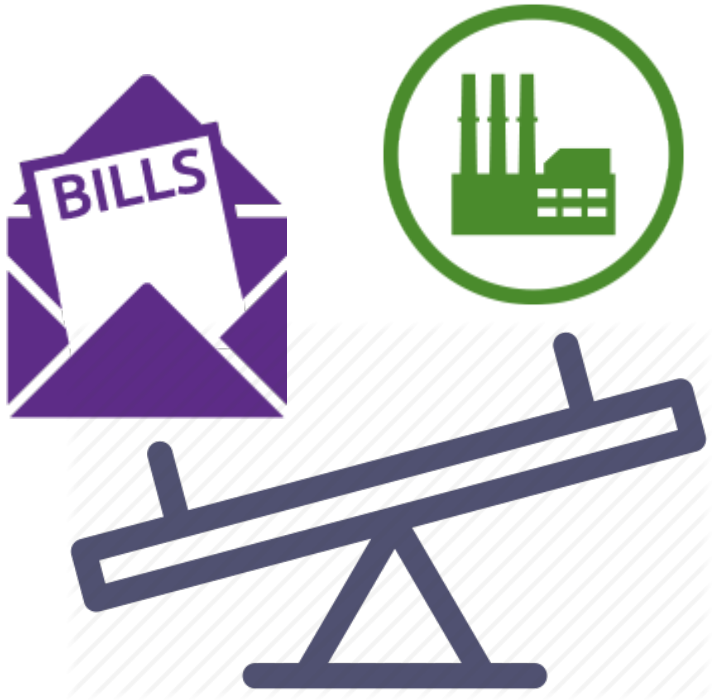
New methods for valuing DERs for D should be built on the timeless regulatory principles in order for DERs to be incorporated in ways that create value for all customers on the local systems.

- **Efficiency & fairness principles should be core to efforts attempting to create value for all customers on the distribution system.**

Insights:
Lessons from PURPA can inform the evolution

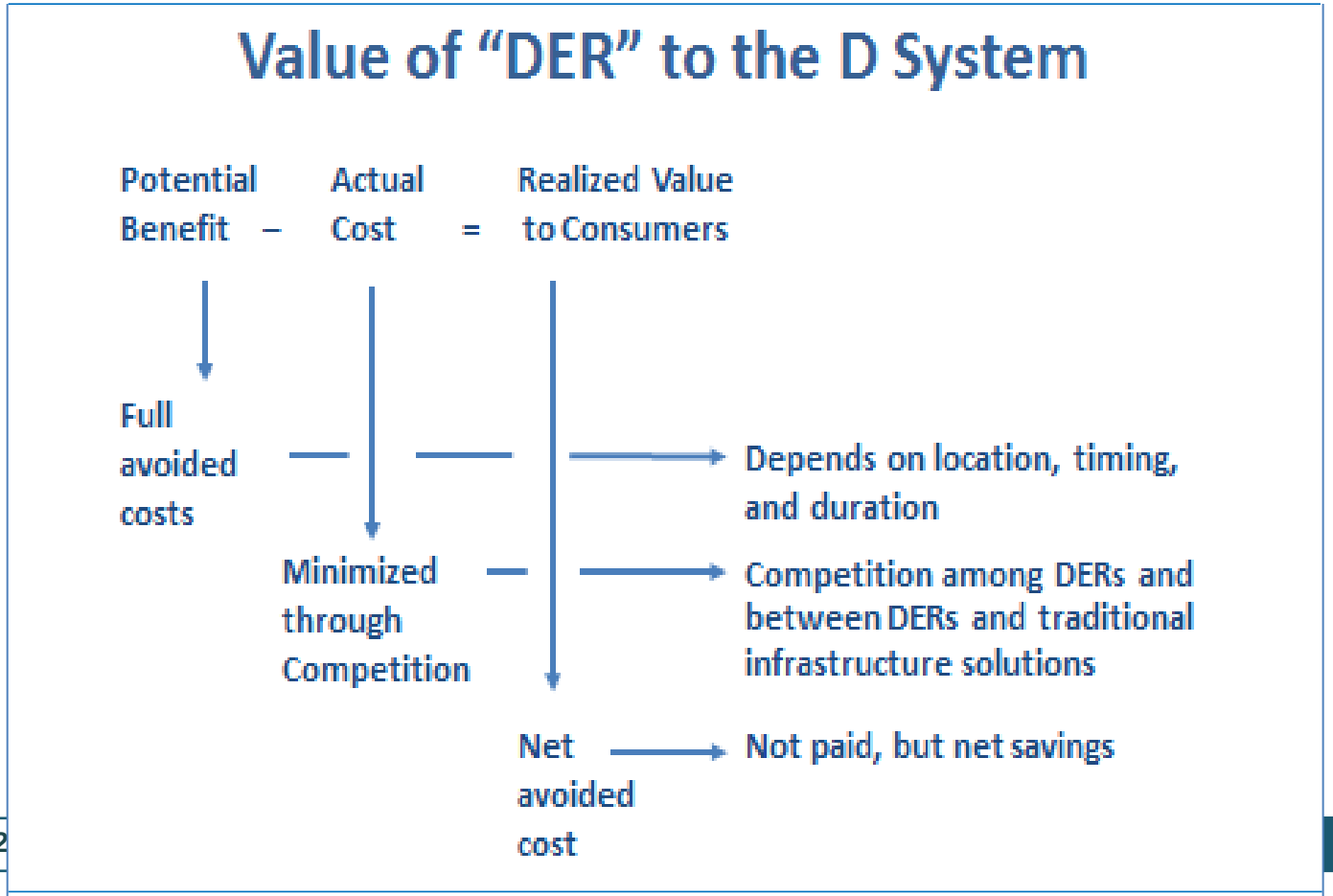
Prior PURPA experience teaches that market-based mechanisms led to greater value to customers:

- **Early PURPA implementation (with standard offers, administratively determined prices) helped start the small-power-producer market, but with later costs associated with above-market contracts**
- **Subsequent PURPA implementation evolved to competitive solicitations to reveal the portfolio of contracts consistent with the utility's needs and at market-based prices**



Insights:
Competition will create value to consumers

Integrating DERs into local reliability planning and operations allows the opportunity for cost-effective local reliability solutions



Insights:
Sequence the competitive markets for DERs for D

Forward contracting for DER capacity should be the focus of early-stage market developments related to DER for D.

- **Focus initial market-design attention on procuring DERs for their capacity value to the local grid, with performance incentives**
- **In the future, other shorter-term/operational sources of value of DER to D may be tapped, with shorter-term/ transactional markets to compensate DERs for other services provided to D**
- **This sequencing of "DER-for-D" market elements fits with economic principles about the conditions that enable robust, successful markets to exist**

Insights:
Consider the 'missing money' and incentives issues

For wires companies:

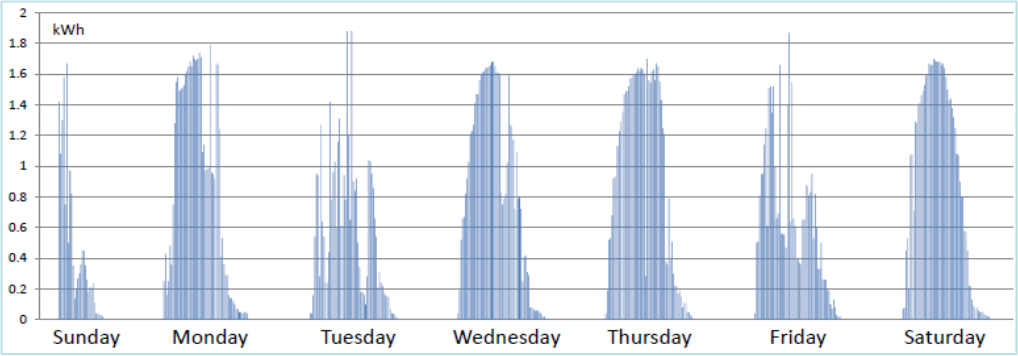
- **To align utilities' incentives with the creation of value for customers, regulators should put in place mechanisms to compensate utilities for incorporating cost-effective and competitively priced DERs into their plans and operations**
- **To the extent that primarily wires-only distribution companies select DERs as cost-beneficial in frameworks, regulators will need to address 'missing money' issues because the lion's share of net benefits is likely attributable to generation and societal impacts**
- **Transparency in rate design would reflect cost-recovery mechanisms that are different than the utility's distribution charges**
- **Pilot programs and ratemaking approaches could be a useful way to test out new concepts**

Conclusions:
Insights for further consideration of the Value of DERs to D

- Rely on time-tested ratemaking principles of efficiency and fairness
- Pay attention to the differences among DER technologies and their contributions to the local grid in calculating their potential value to D
- Move beyond conceptual valuation frameworks that identify potential net benefits of DERs to D
- Transition distribution-system planning to incorporate DERs
- Build upon PURPA experience that market-based mechanisms provide value to customers compared to administratively determined avoided costs
- Start with forward contracting for DER capacity before focusing on operational/transactional DER markets
- Affirmatively address financial incentives and missing money issues

Thank you

Energy Produced from the Solar PV Panels on Tierney Roof In 15-minute Intervals (kWh) During All Hours in a 7-day period (Sunday-Saturday) in July 2015



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