RAP®

December 13, 2019

The Electricity Sector of the Past, Present, and Future

South Carolina Public Service Commission

“Utility of the Future” Workshop

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Today’s Agenda

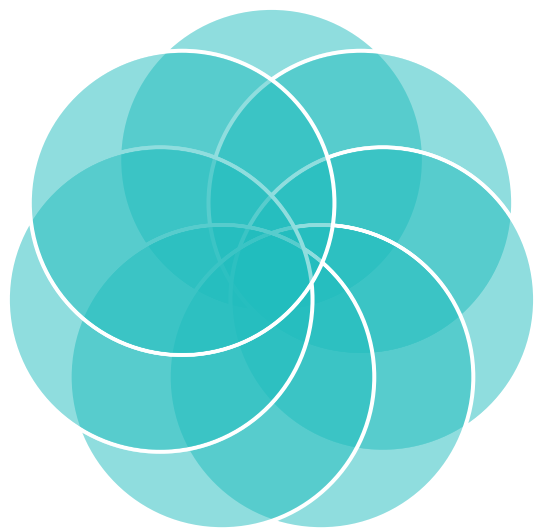
1. History, Trends, and Challenges facing Regulation and Markets
2. **Distributed Resource Capabilities and Value, and Implications for Compensation, Rate Design, and Planning**
3. Best Practices in Resource Planning
4. Approaches to Dealing with Misalignments in Traditional Regulation and Markets
5. Process Options for Moving Change Forward

Outline

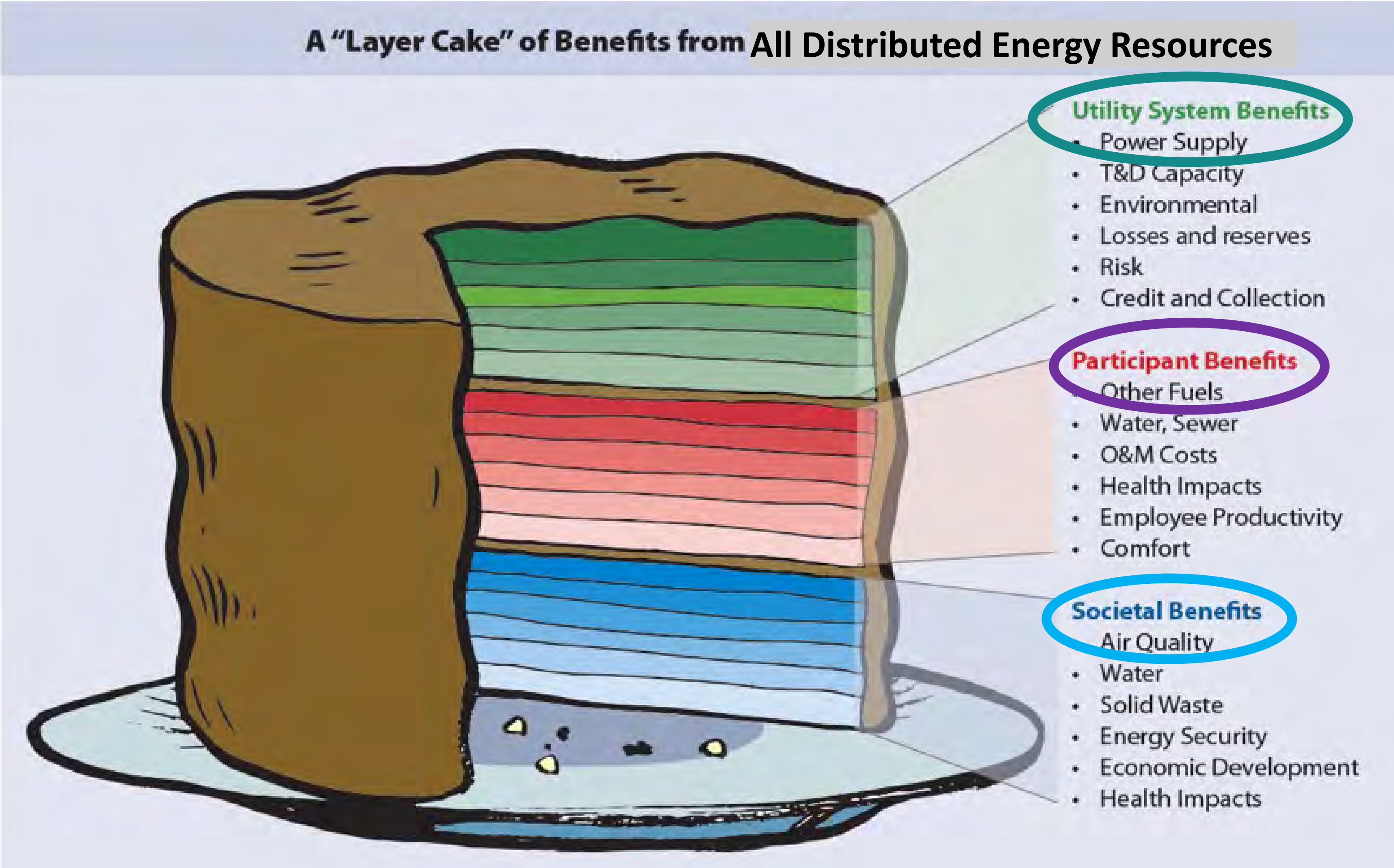
- Distributed Resource Capabilities and Value
- DERs and Implications for Compensation and Rate Design
  - Distributed Generation
  - Storage
  - Electric Vehicles
- Implications for Planning Needs

1 Distributed Energy Resources: Capabilities and Value

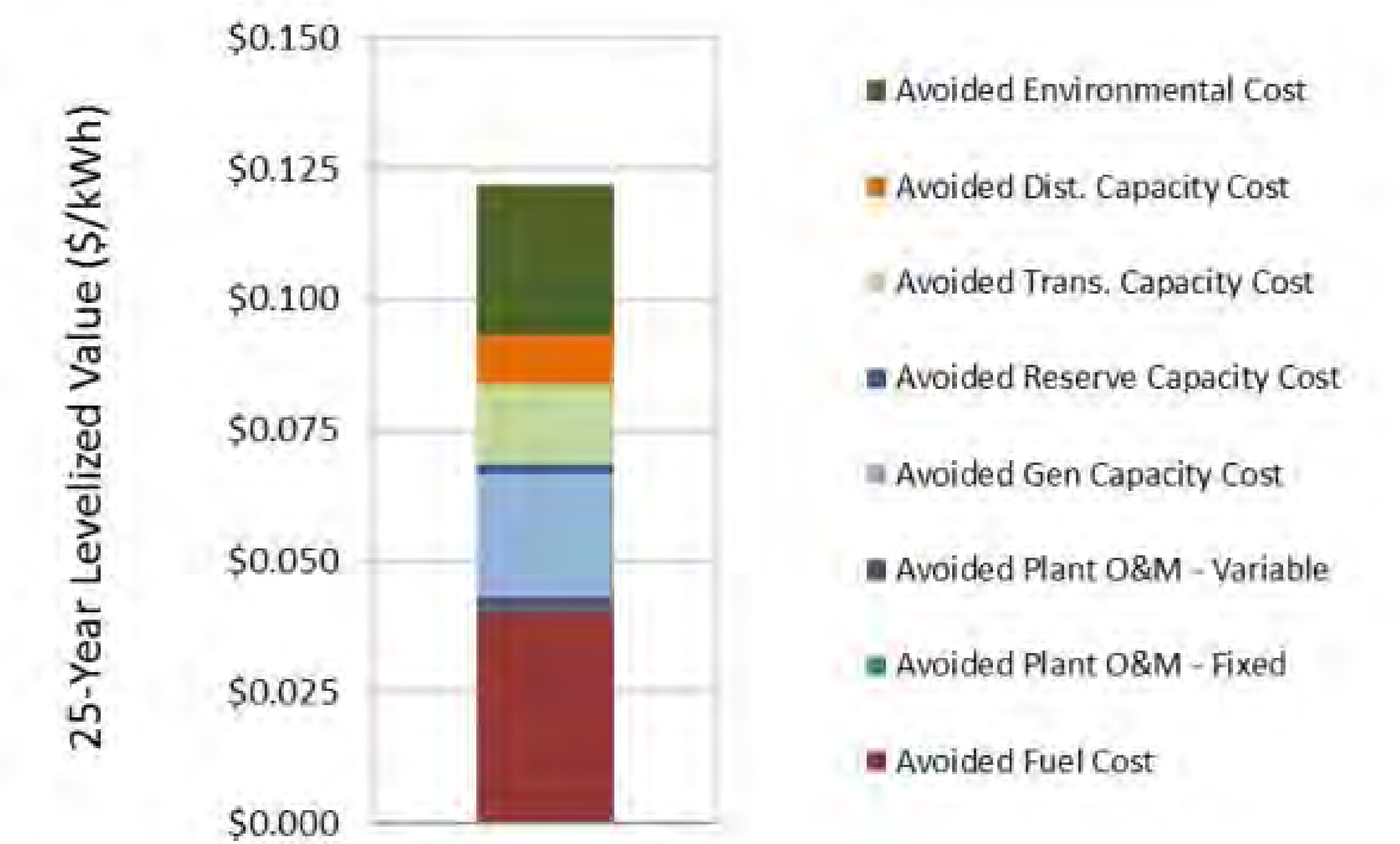
What resources are we talking about?



Energy Efficiency Benefits



Examples of DER Value Streams



Source: Minnesota PUC Briefing Papers, 2014.

Supply Side: Inverter-Based Technologies Provide Important System Benefits

Taking Notice at NARUC

The Electricity Committee and Energy Resources and Environment Committee have acknowledged the importance of flexible resources.

(1) Utilities and utility commissions should be well educated about the different types of quantitative models that exist today …

(2) Planning frameworks and modeling tools that are publicly and commercially available should model the full spectrum of services that energy storage and flexible resources are capable of providing …

Resolution on Modeling Energy Storage and Other Flexible Resources, NARUC Resolution EL-4/ERE-1 ***November 2018***

Ultimately, any question about the value of an electricity service must consider “value to whom”?

Cost-Effectiveness Tests are Designed to Answer that Question

Though these tests were developed to evaluate ***energy efficiency*** *programs, they are sometimes used to evaluate other DERs.*

Test Name	Question Answered	Summary of Approach
Participant Test (PT)	Will costs decrease for the person or business participating in the program?	Only considers the costs and benefits experienced by program participants
Ratepayer Impact Measure (RIM)	Will utility rates decrease?	Considers the costs and benefits that affect utility rates, including program administrator costs and benefits and utility lost revenues
Program Administrator Cost Test (PAC)[4]	Will the utility's total costs decrease?	Considers the costs and benefits experienced by the utility or program administrator
Total Resource Cost Test (TRC)	Will the sum of the utility's total costs and the participant's total costs (or energy-related costs) decrease?	Considers the costs and benefits experienced by all utility customers
Resource Value Test (RVT)	Will utility system costs be reduced while achieving applicable policy goals?	Considers the utility system costs and benefits plus those costs and benefits associated with achieving energy policy goals
Societal Cost Test (SCT)[5]	Will net costs to society decrease?	Considers all costs and benefits experienced by all members of society

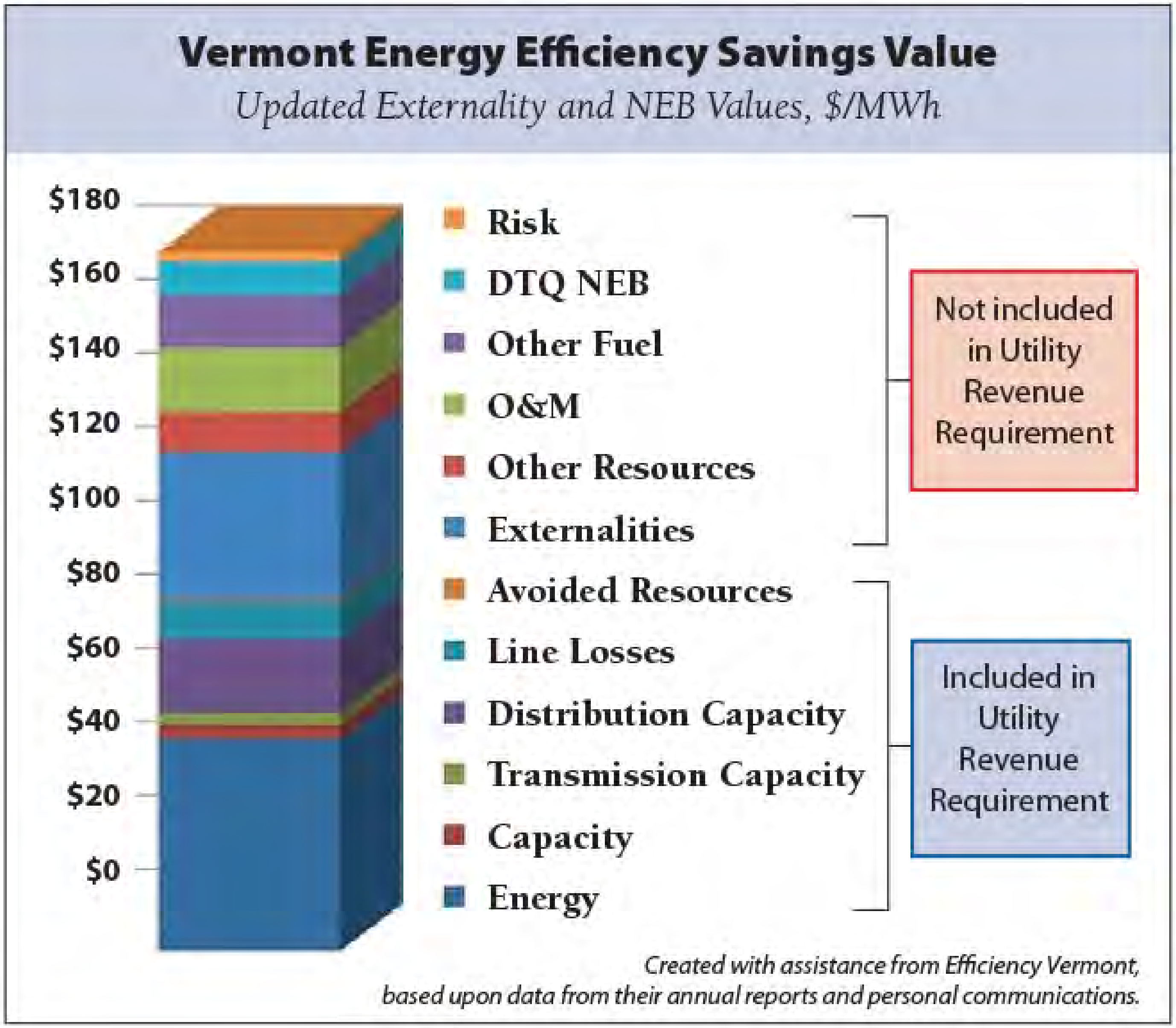
Cost-Effectiveness Tests are Designed to Answer that Question

Though these tests were developed to evaluate ***energy efficiency*** *programs, they are sometimes used to evaluate other DERs.*

Test Name	Purpose
Participant Test	Focus on the customer
Ratepayer Impact Measures (RIM)	Focus on rates
Program Administrator Cost Test (PAC)	Focus on utility costs
Total Resource Cost Test (TRC)	Focus on customer and utility costs
Resource Value Test (RVT)	Focus on priorities of state, including relevant costs and benefits
Societal Cost Test (SCT)	Focus on costs and benefits to society as a whole

Value of Service ≠ Compensation

- Cost effectiveness tests do not establish DER ***compensation***
- DER compensation should be sufficient to induce customers to invest in resources that provide benefits to all customers


Vermont Energy Efficiency Savings Value
Updated Externality and NEB Values, $/MWh
$180
$160
$140
$120
$100
$80
$60
$40
$20
$0
Risk
DTQ NEB
Other Fuel
O&M
Other Resources
Externalities
Avoided Resources
Line Losses
Distribution Capacity
Transmission Capacity
Capacity
Energy
Not included in Utility Revenue Requirement
Included in Utility Revenue Requirement
Created with assistance from Efficiency Vermont,
based upon data from their annual reports and personal communications.

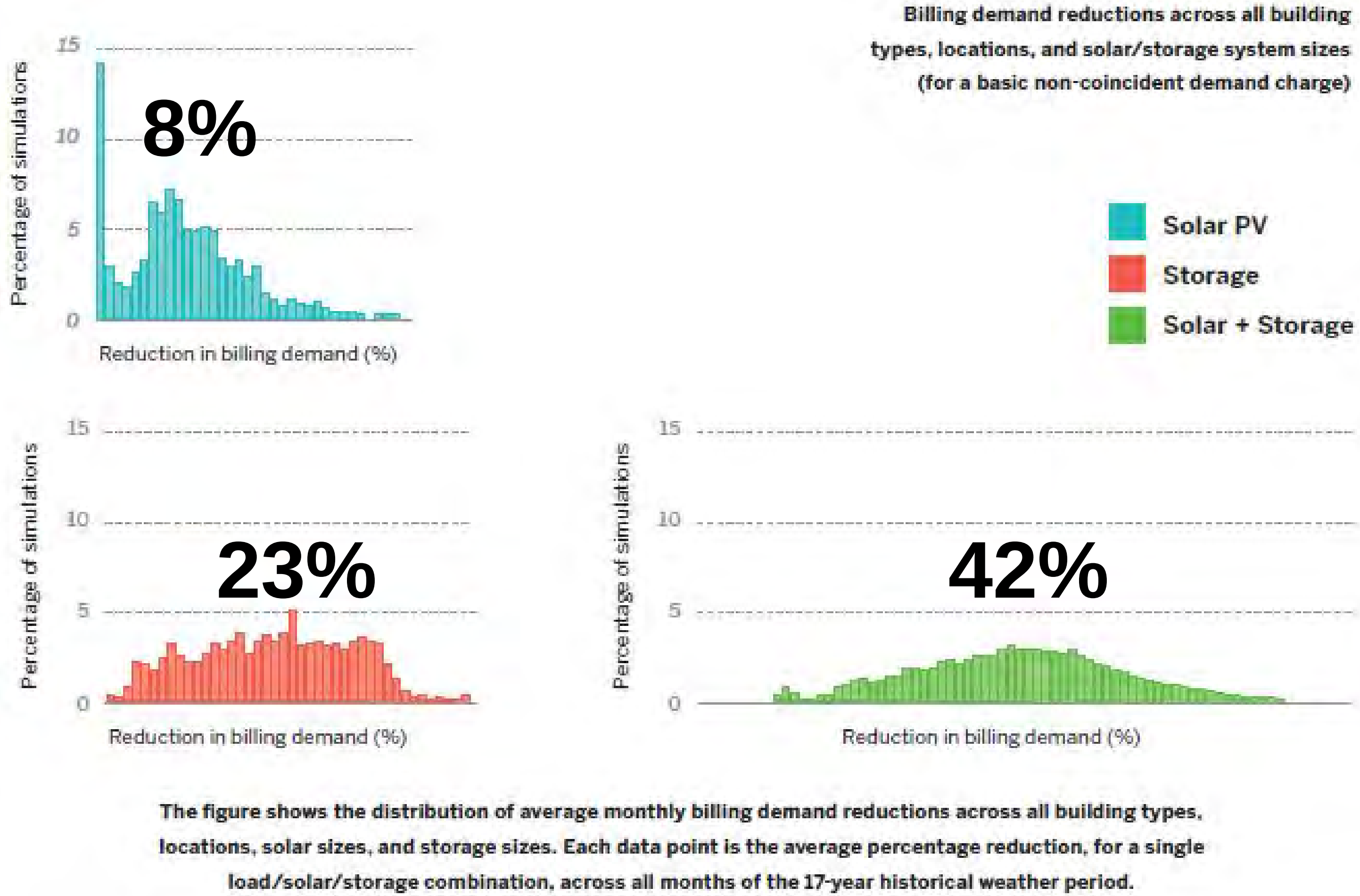
2 The Potential Value of Combinations of DERs

Synergies in Value: *PV + EV*

≥

+

Synergies in Value: *PV + Storage*



Source: Gagnon et al. (2017). *Solar + Storage Synergies for Managing Commercial-Customer Demand Charges*. Lawrence Berkeley National Laboratory.

Synergies in Value: *PV + DR*

- Combining PV and DR can create value for all ratepayers in the form of avoided energy, capacity, or ancillary service costs
- Flexible loads, like electric water heaters, can shift to take advantage of excess generation from a customer's PV system
  - Especially valuable to the customer if they don't receive full retail rate net metering
- Flexible loads can also "shape and shimmy" to help integrate variable PV generation

Combining DERs for Customer and Utility Value: Sunna Case Study

- Steele-Waseca Cooperative Electric
  - Owatonna, Minnesota
- Built community solar garden on headquarters, encourages controllable electric water heating

Photo credit of Steele-Waseca Cooperative Electric https://swce.coop/swce-field-services/renewables/

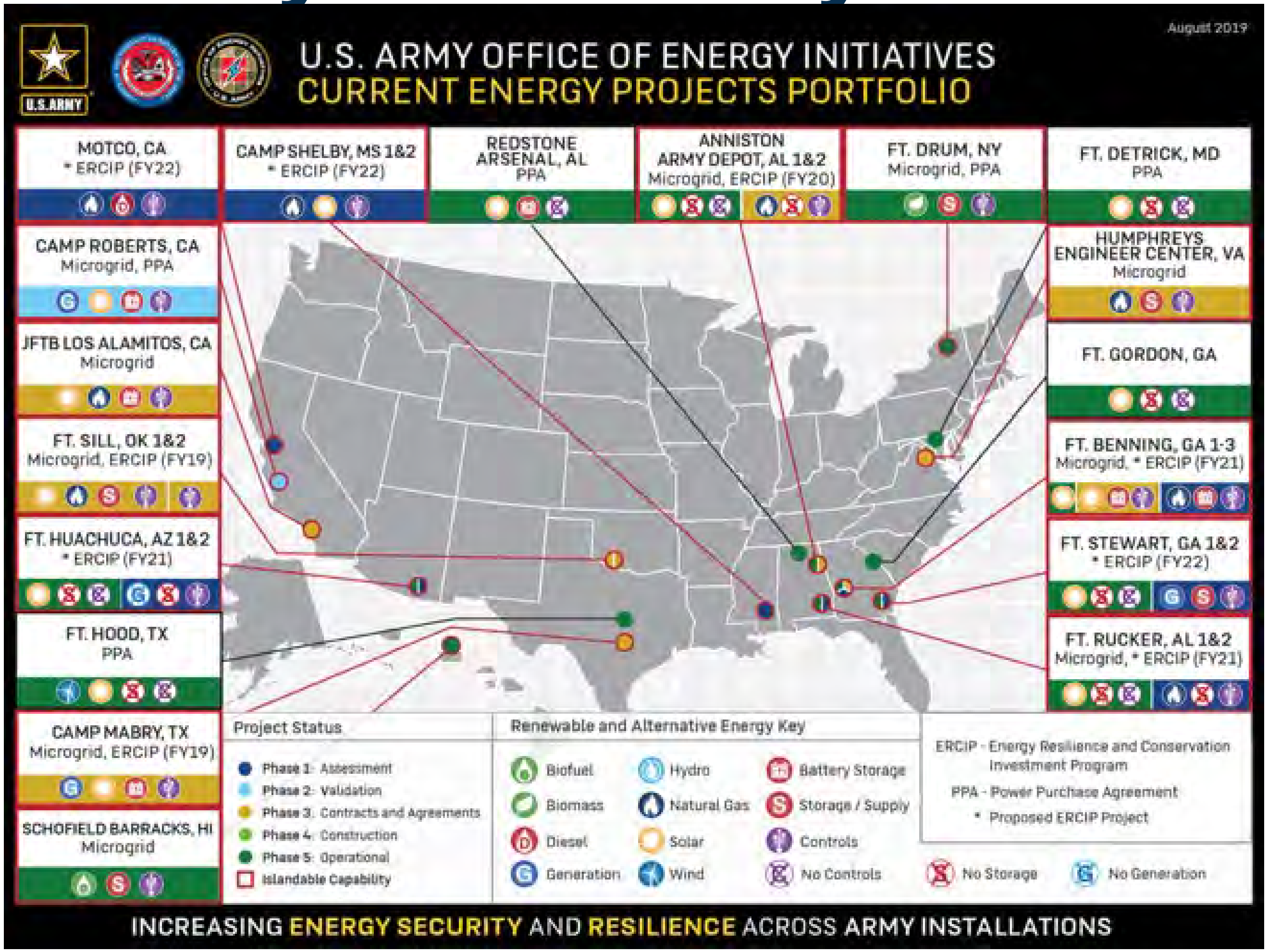
The Sunna Project

- $1,225 for one panel

OR

- $170 for one panel + a free electric water heater if the customer subscribes to the grid-integrated water heater program

Combining DERs for Resilience: US Army Case Study



Source: US Army Office of Energy Initiatives

Example of a US Army Project

Army proposed outgrant of 115 acres at JFTB Los Alamitos

- Developer would construct, own, operate and maintain 16 MWs of solar power, energy storage, and microgrid components
- During normal ops, the developer sells power to the grid
- During contingency ops, the developer would provide islandable power for critical loads for min 7 – max 30 days

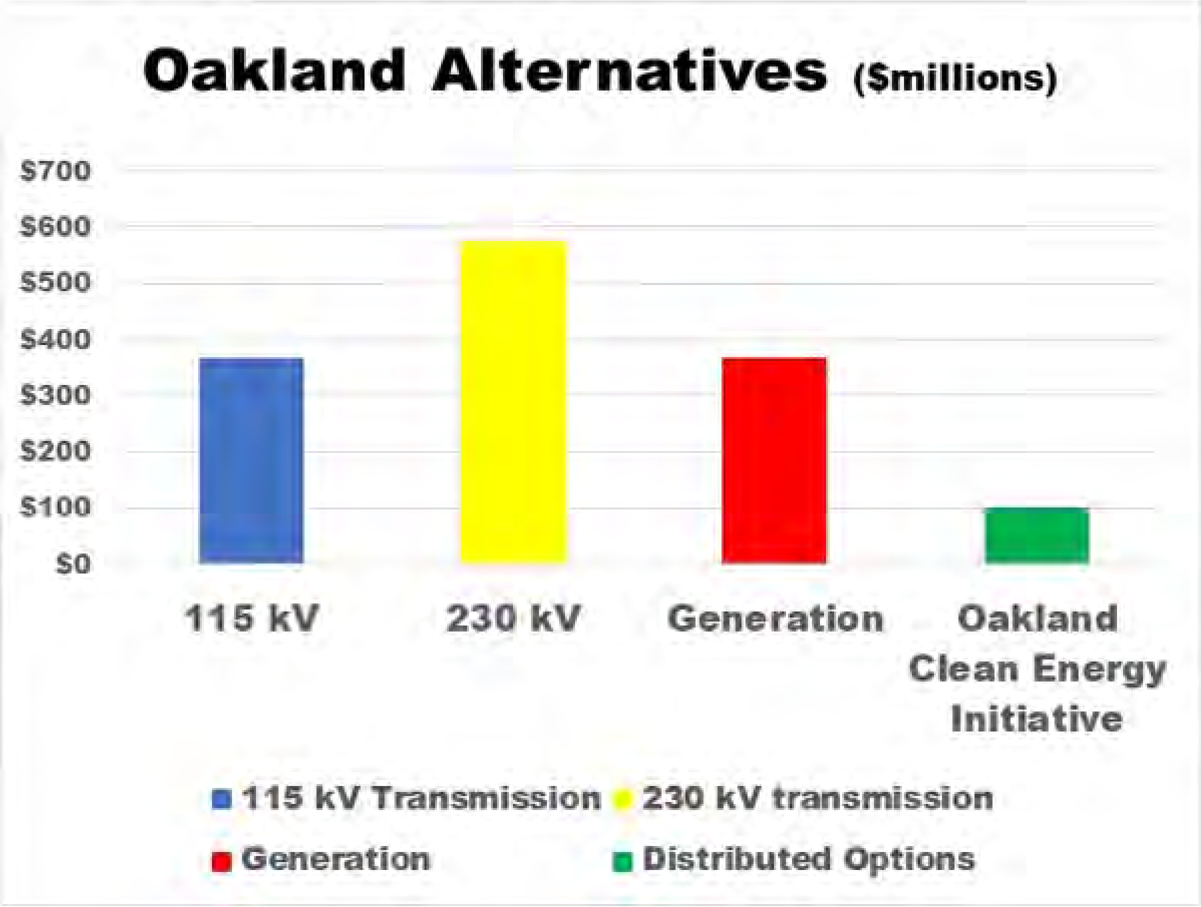
Notional Army Microgrid

Project Development Concept

Combining DERs in a Non-Wires Solution: Oakland Case Study

- PG&E and East Bay Clean Energy project, Oakland Clean Energy Initiative (OCEI)
- Replaces a retiring 165 MW Dynegy gas peaker, obviates need for 115 kV and 230 kV transmission
- Combination of resources includes:
  - 25-40 MW combination of EE, DR, PVDG (minimum 19 MW of load reducing response)
  - 10 MW/40 MWh storage
  - Substation upgrades and line re-ratings

Saves Ratepayers Money, Reduces Emissions



Implications for Implementation

- What are the priorities of the state of SC as interpreted by the PSC that will determine how utilities will decide on resources?
- What information is needed to assess the value of distributed resources?
- And combinations of those resources?

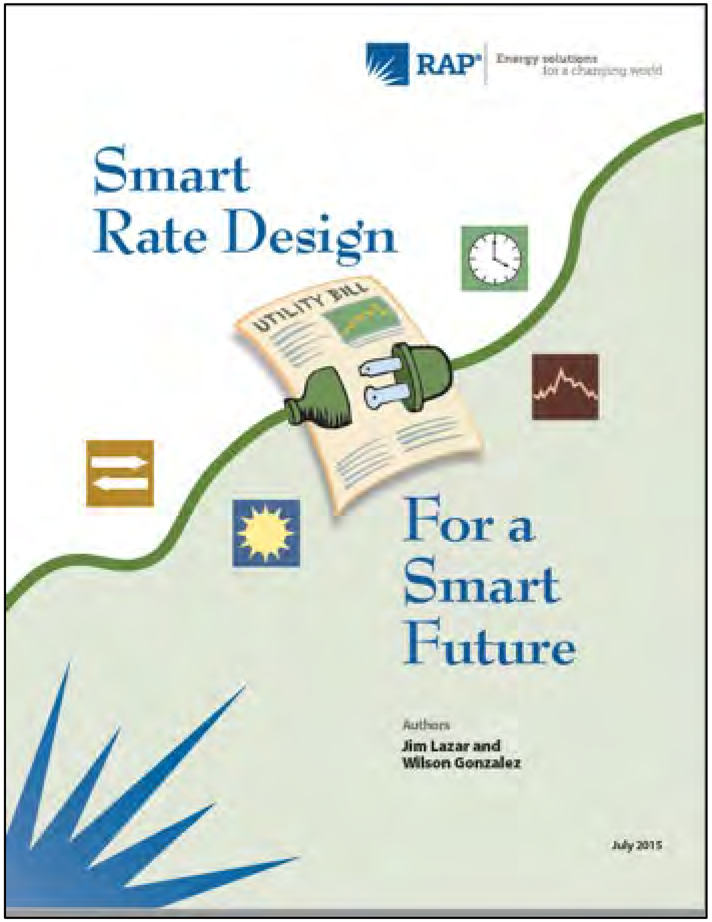
3 Implications for Compensation and Rate Design

Quantifying Value is Difficult but Precision is Not Necessary

- Economics of many value streams can be:
  - Time-dependent
  - Location-dependent
  - Interdependent
- Values can be estimated by:
  - Using market prices as proxies
  - Administrative determination

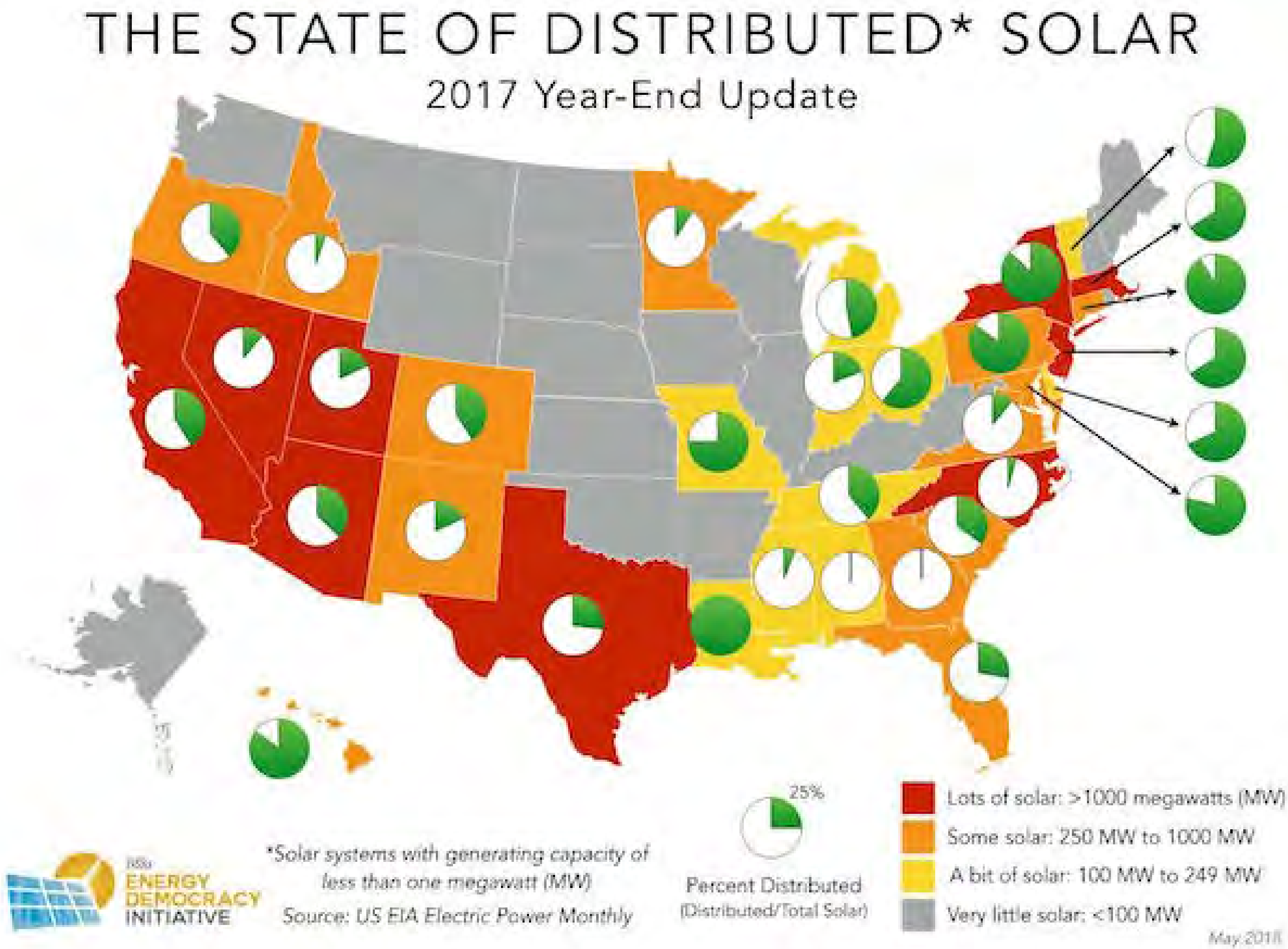
Smart Rates are Essential to Fair Compensation

- Poor rate design can induce private investment for private benefit that *fails to provide public benefit*
- Smart rate design aligns customer investment and operation of DERs with system value



Rate design should make the choices the customer makes to optimize their own bill consistent with the choices they would make to minimize system costs.

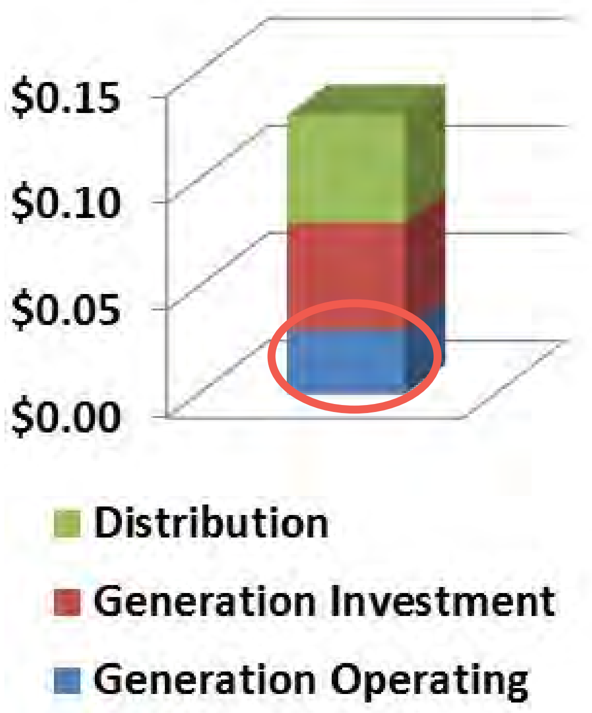
Distributed Generation


THE STATE OF DISTRIBUTED* SOLAR
2017 Year-End Update
25%
Percent Distributed
(Distributed/Total Solar)
Lots of solar: >1000 megawatts (MW)
Some solar: 250 MW to 1000 MW
A bit of solar: 100 MW to 249 MW
Very little solar: <100 MW
*Solar systems with generating capacity of less than one megawatt (MW)
Source: US EIA Electric Power Monthly
ENERGY DEMOCRACY INITIATIVE
May 2018

Two Views of Cost Recovery

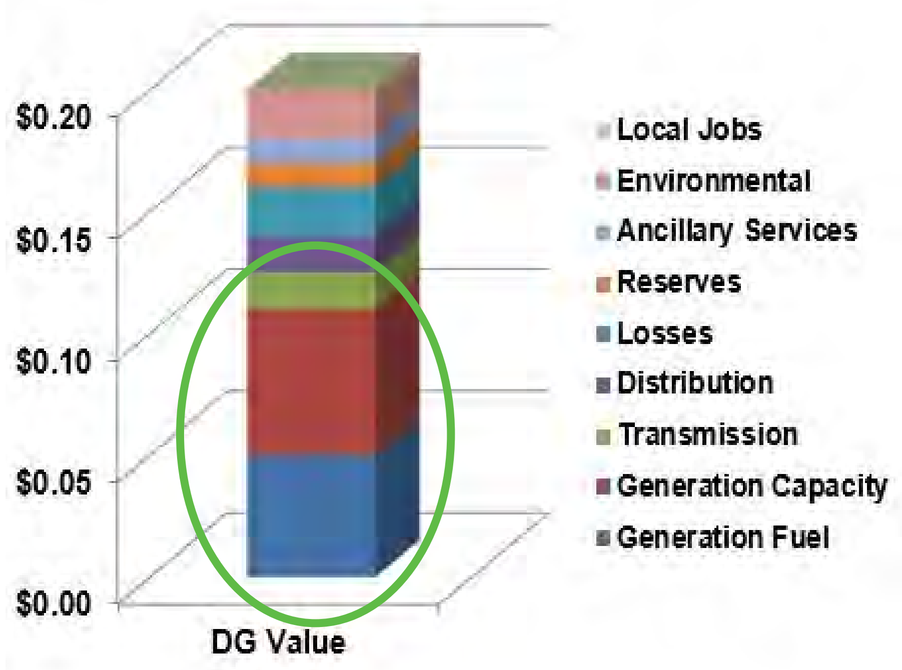
Traditional Utility View

DG customer "uses" the grid and should pay for it;

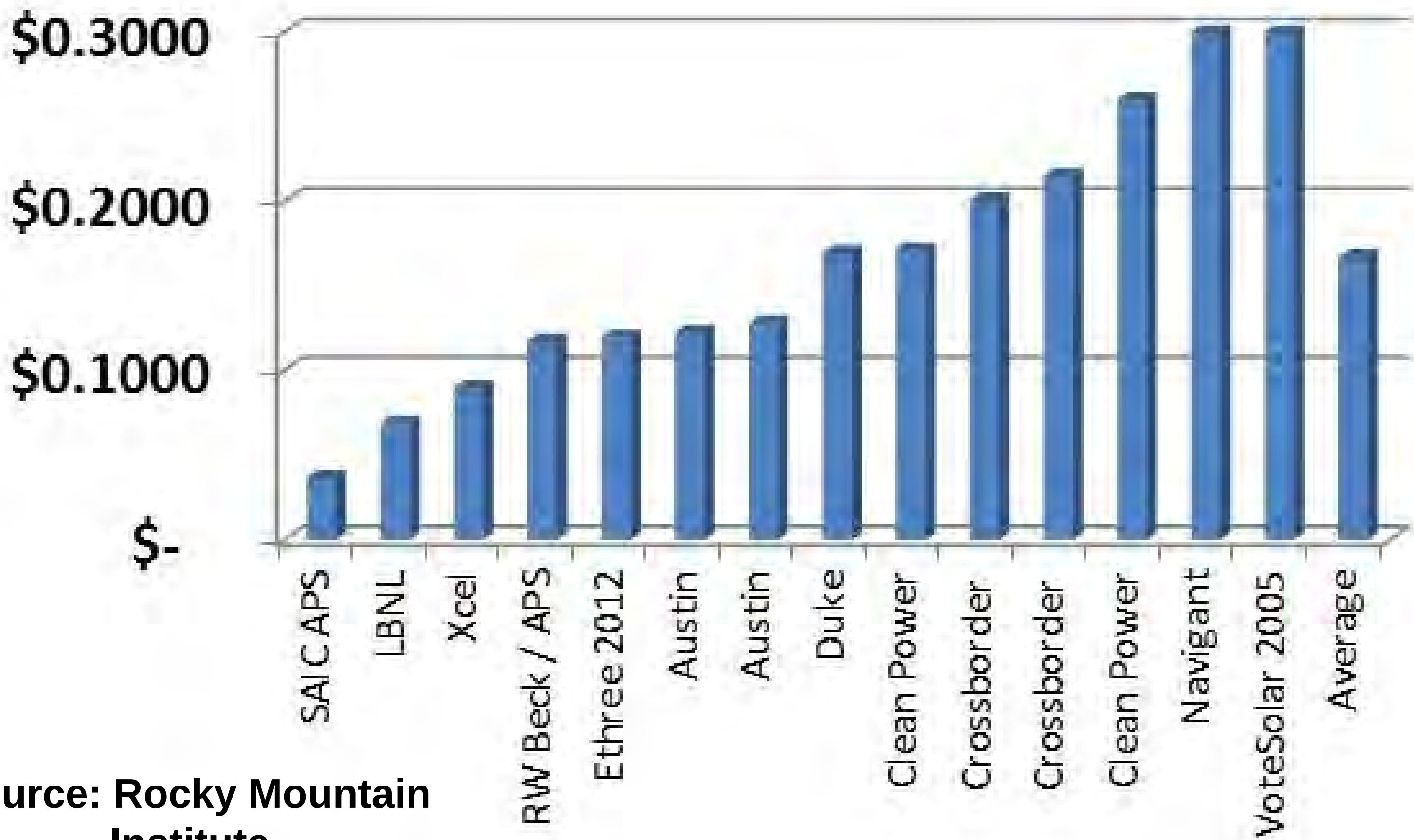


Solar Advocate View

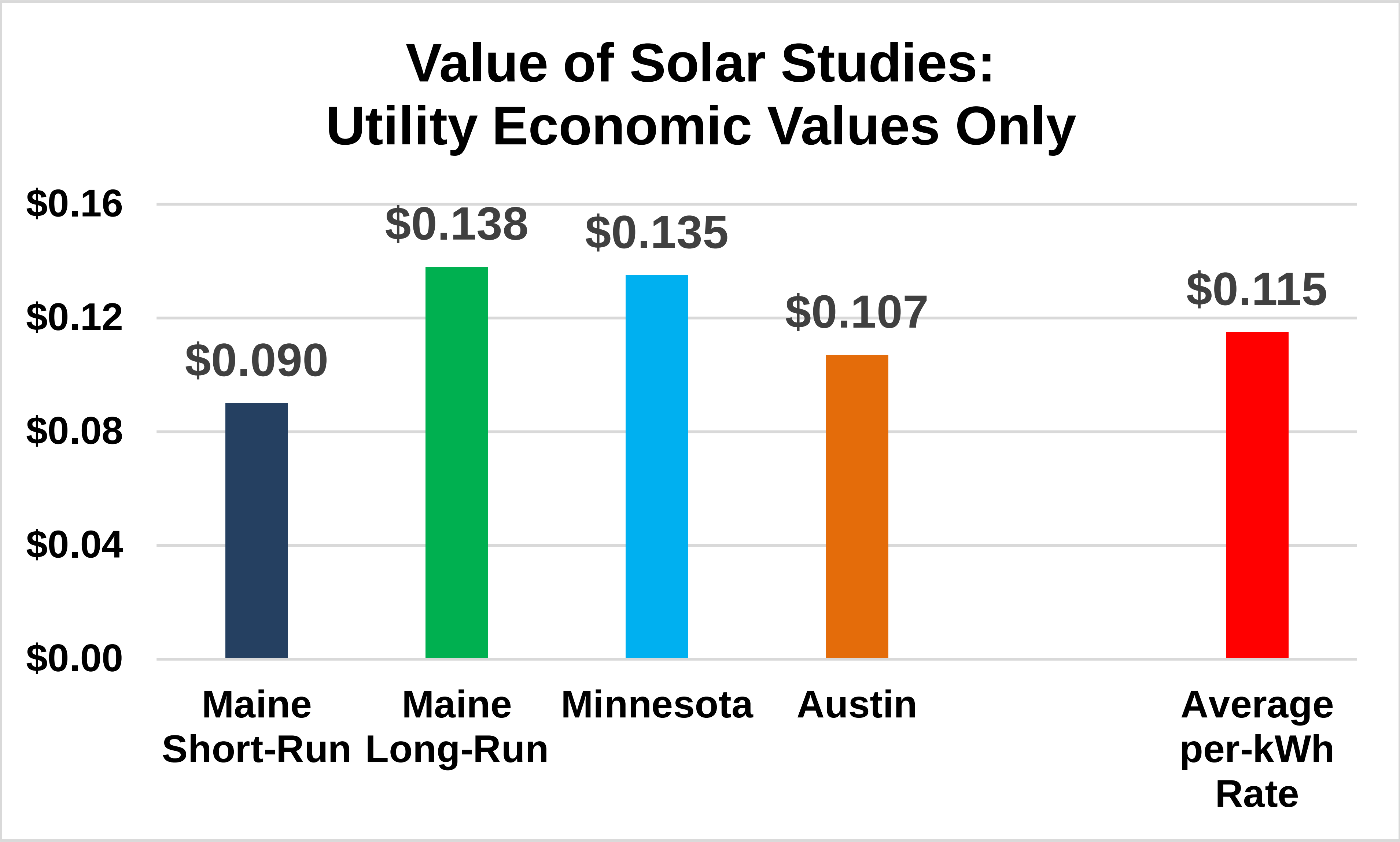
Value of distributed resource is greater than the than retail rate;



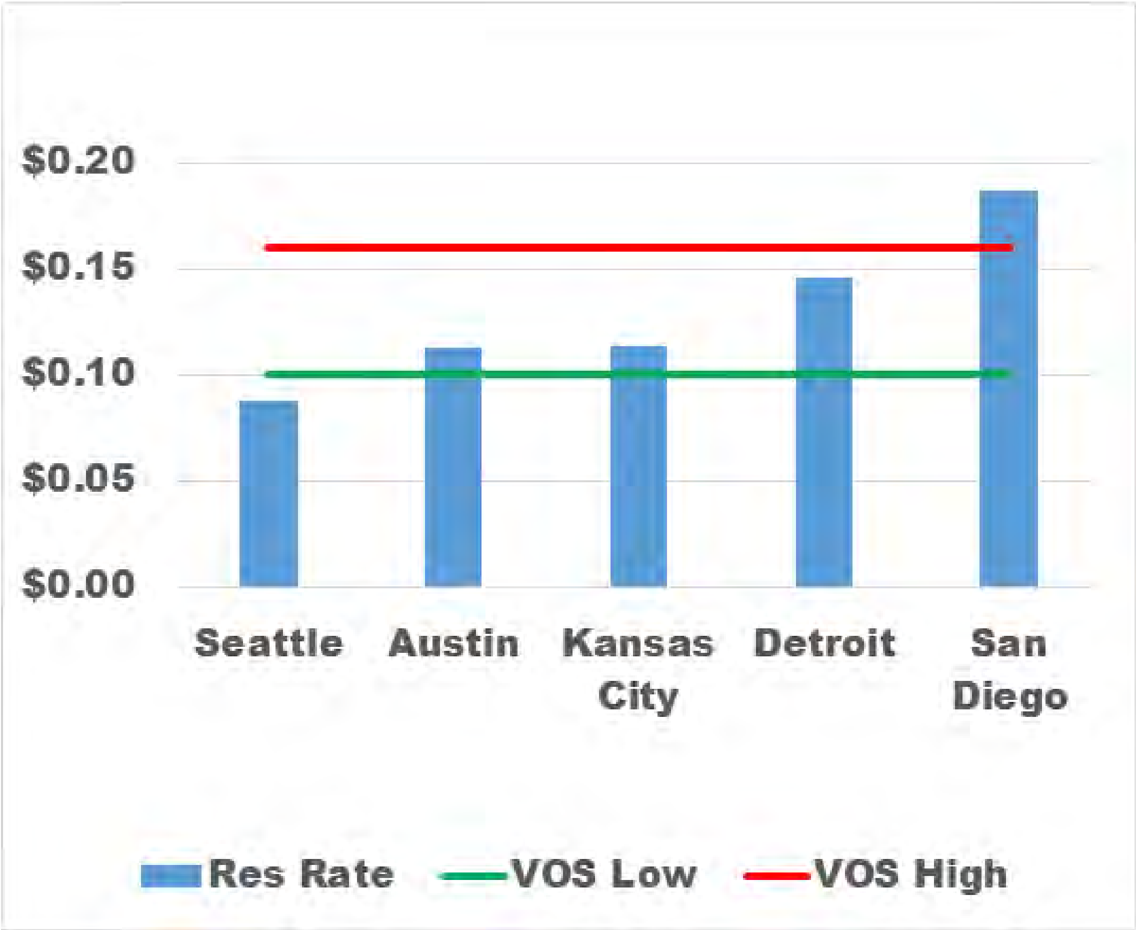
2014 Survey Of Multiple Value of Solar Studies: Average: $0.1672/kWh



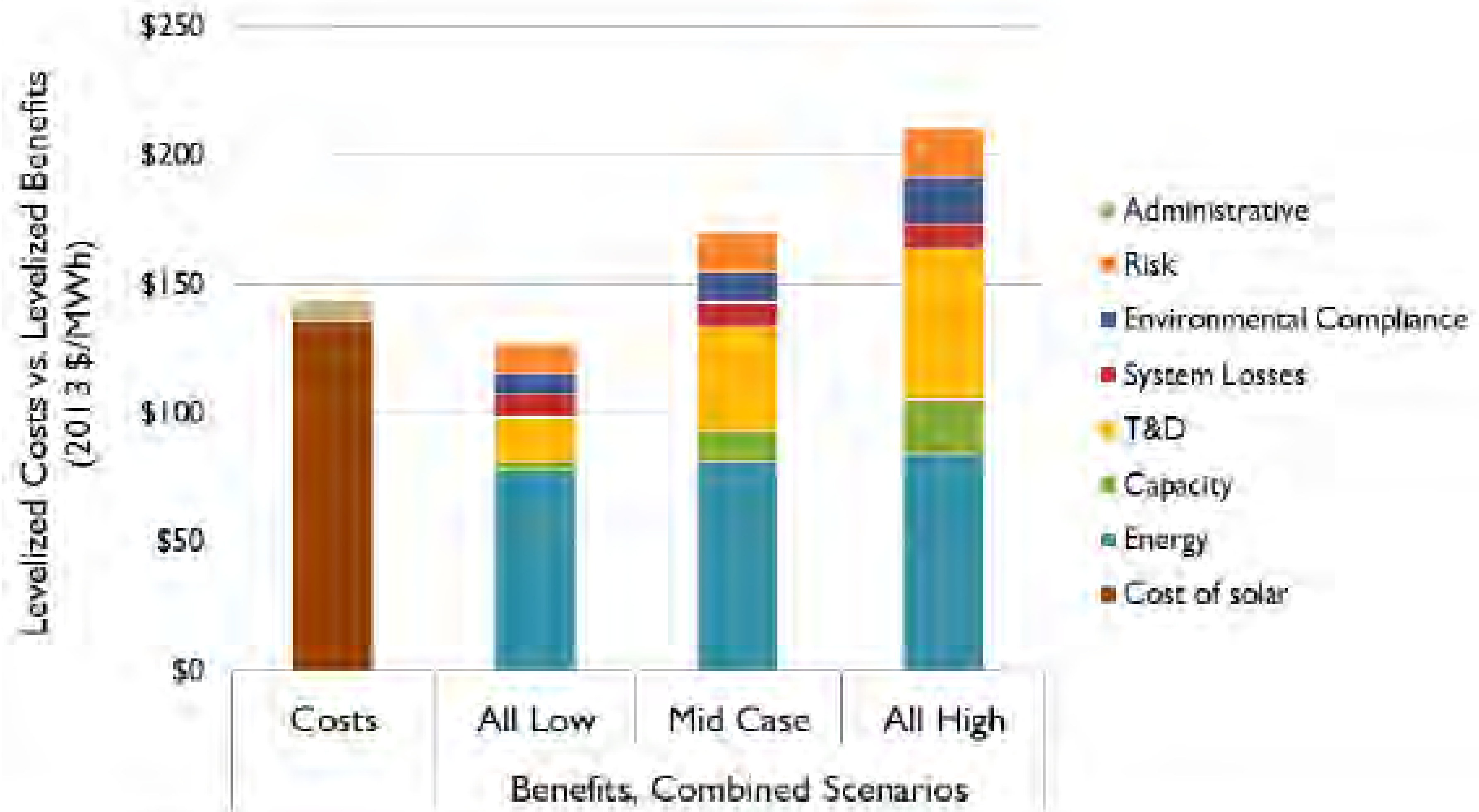
Source: Rocky Mountain Institute


Value of Solar Studies:
Utility Economic Values Only
$0.16
$0.12
$0.08
$0.04
$0.00
$0.090
$0.138
$0.135
$0.107
$0.115
Maine Short-Run
Maine Long-Run
Minnesota
Austin
Average per-kWh Rate

High-Cost vs. Low-Cost Utilities



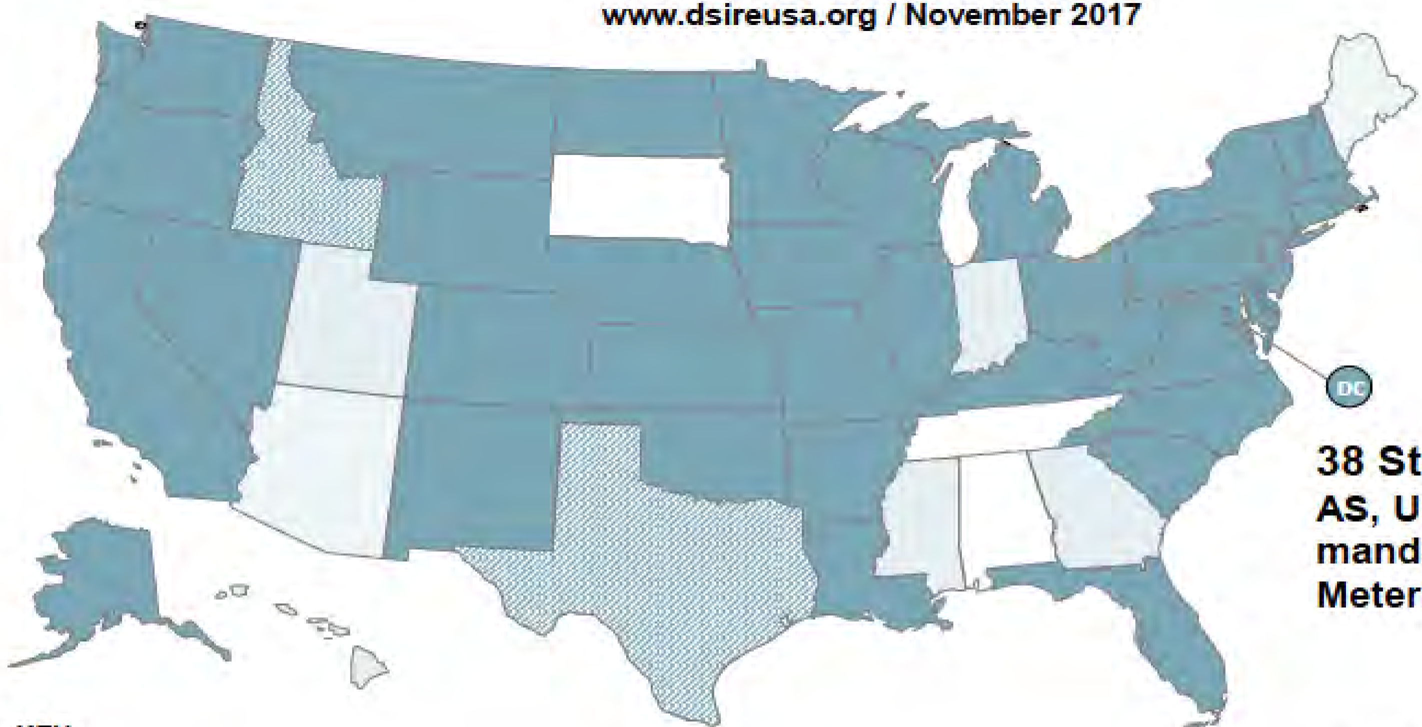
Mississippi Value of Solar Study



DSIRE® | NC CLEAN ENERGY TECHNOLOGY CENTER | U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Net Metering

www.dsireusa.org / November 2017



38 States + DC, AS, USVI, & PR have mandatory Net Metering rules

KEY

- State-developed mandatory rules for certain utilities (38 states + DC+ 3 territories)
- No statewide mandatory rules, but some utilities allow net metering (2 states)
- Statewide distributed generation compensation rules other than net metering (7 states + 1 territory)

U.S. Territories:

AS	PR
VI	GU

Net-Metering: Tool to incentivize investment?

- Railroads
- Airlines
- Semiconductors

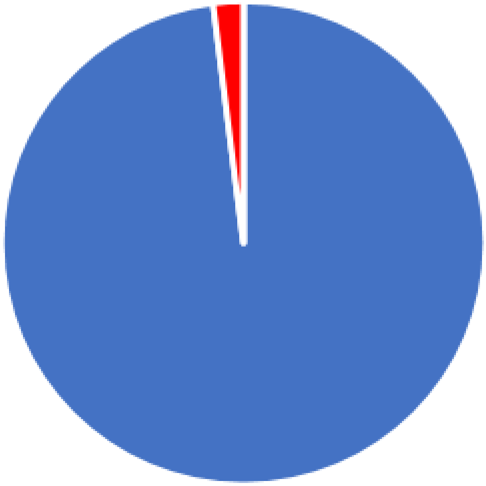
Transition to Mature Industry

- Supply chains
- Educated customers

- More important to reflect grid value in compensation

How big is the impact if:
5% of customers install solar over 5 years?

- Assume:
  - Distribution is 40% of the bill
  - No Distribution Cost Savings
  - Average Power Supply Cost = Marginal Power Supply Cost
- Then:
  - Impact on other consumers is 2%



System Cost Impacts

Low levels of saturation: 0% - 5%

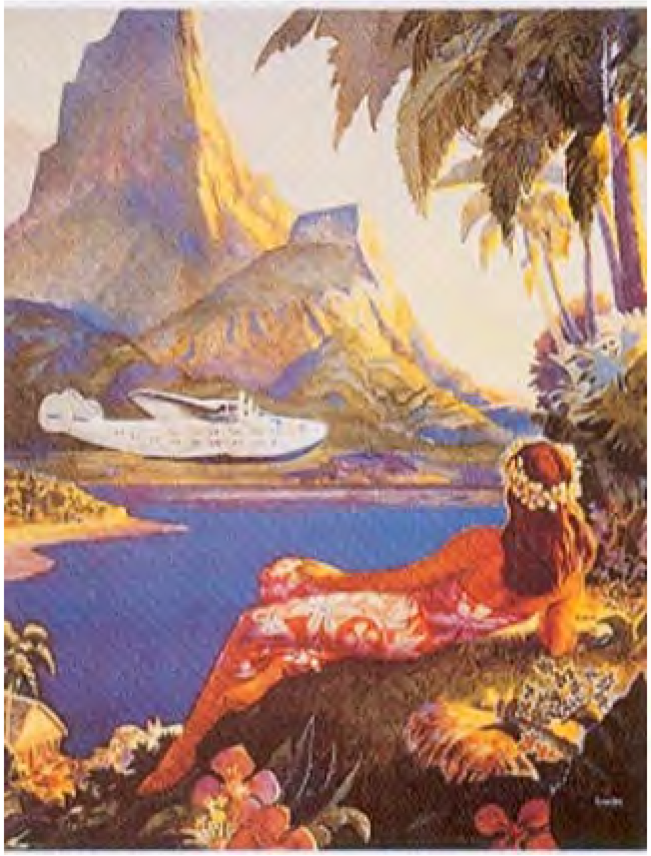
Moderate levels of saturation 5% - 10%

- Voltage Regulation

High levels of saturation Over 10% of Customers

- Generation and Transmission Impacts

System Cost Impacts

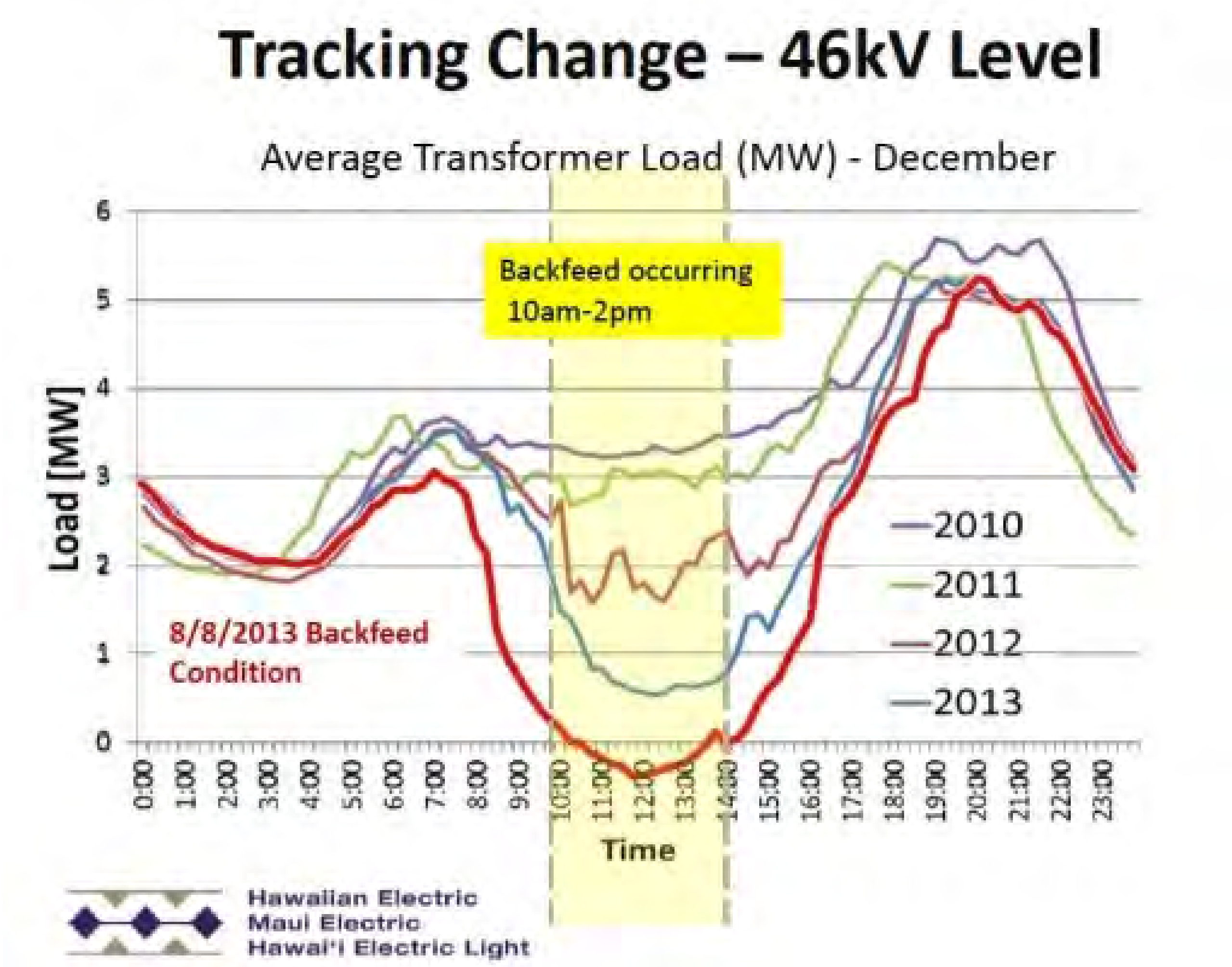


Half of System Peak in Maui

Table 3. HECO Companies' Net Energy Metering Program Capacity and Enrollment

Capacity (MW)	**HECO**	**HELCO**	**MECO**
Installed or Approved	327.9	73.3	88.8
In the Queue	17.3	5.1	11.9
Total	**345.2**	**78.4**	**100.7**
Total NEM Customers	51,680	11,549	12,893
System Peak Load (MW)	1,165	188	191
NEM % of All Customers	17%	14%	18%
NEM % of System Peak	**30%**	**42%**	**53%**

Circuits and Substations “Running Backwards”



Peak Load Benefits May Reach A Limit

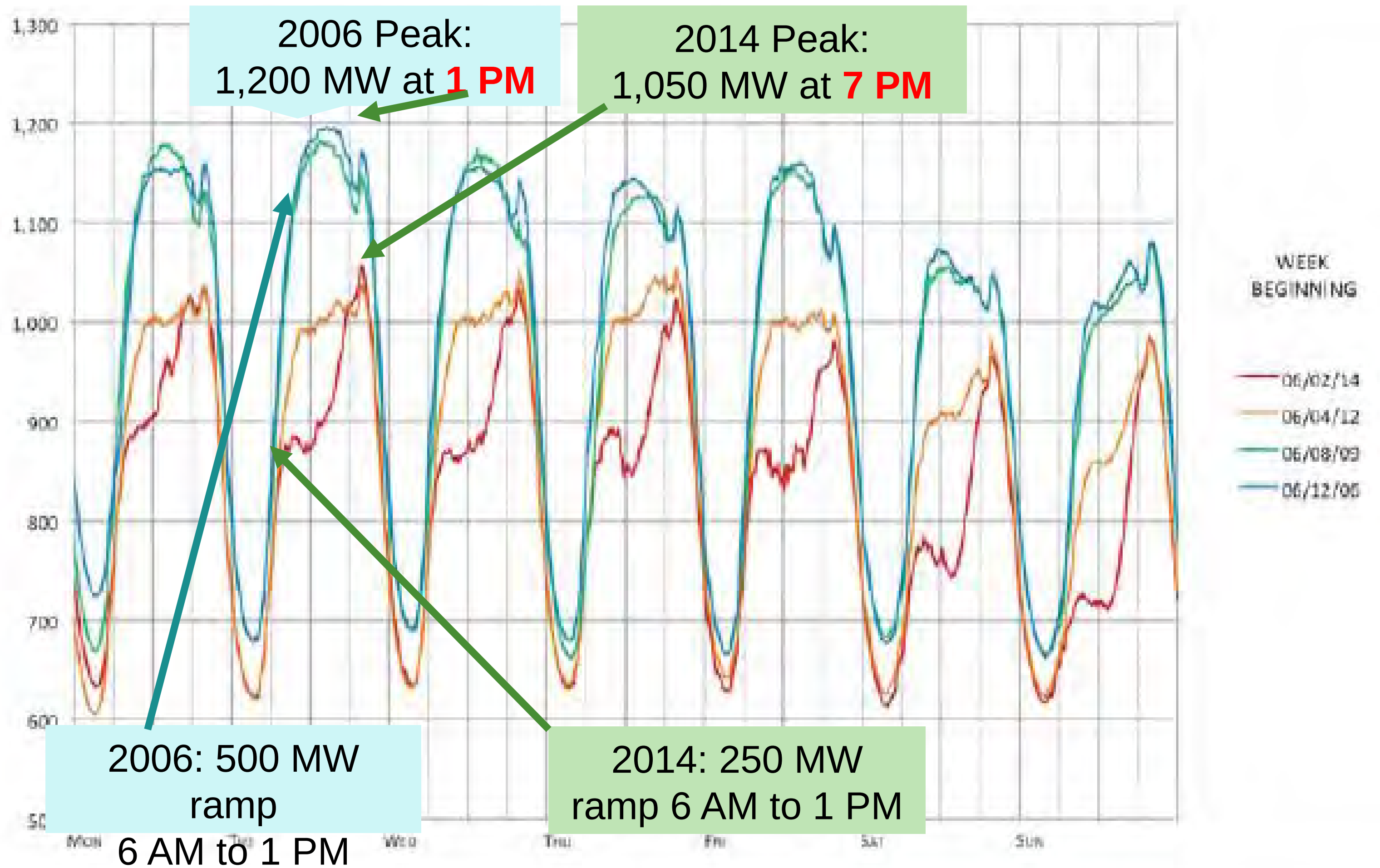


Figure 1-7. O'ahu System Load Profiles, 2006–2014

Source: Hawaiian Electric Co

Examples of Net Metering Successor Tariffs

- Hawaii
- California
- Austin Energy, Texas
- Nevada

Hawaii

- Ended net metering in 2015 due to high distributed generation penetrations – 30% and 53% of 2 utilities peak load
- Transition successor tariffs to net metering
- Smart Export Tariff – Solar + Storage
  - Customers charge batteries during day 9-16:00
  - Use power from batteries in evening
  - Credit for power exported during evening, overnight, or early morning hours

California

- 913,481 net-metered solar projects, totaling 7.6 GW of installed capacity, as of November 2018
- California plans to increase this total - 16 GW of behind-the-meter solar by 2030 estimated (peak load ~ 46GW)
- Net metering 1.0: full retail compensation; 1 MW system size cap; tariff available until utility reached a 5% cap- utilities were approaching
- Net metering 2.0 – preserves full retail rate compensation; interconnection fee; customers on TOU rate; no cap on system size, demand or similar charges disallowed
- CPUC now looking at alternatives to net metering

Austin Energy, Texas

Standard Rates

This is the default rate option under this schedule.

	Inside City Limits	Outside City Limits
Basic Charges ($/month)		
Customer	$10.00	$10.00
Delivery	$0.00	$0.00
Energy Charges ($/kWh)		
0 – 500 kWh	$0.02801	$0.03700
501 – 1,000 kWh	$0.05832	$0.05600
1,001 – 1,500 kWh	$0.07814	$0.07868
1,501 – 2,500 kWh	$0.09314	$0.07868
Over 2,500 kWh	$0.10814	$0.07868

Value of Solar	Value-of-Solar Rate ($/kWh)
Residential Customers	$0.09700

Nevada

- In 2015, Nevada PUC implemented a new net metering program
  - Increased fixed service charge- tripled
  - Decreased the energy charge for excess energy from DG – were to fall 2 cents per kWh
- Market for DG slowed dramatically, major solar firms left the state and over 2,600 jobs lost
- As a result, legislature passed bill to reinstate NEM, 95% retail compensation, to decline with each 80 MW of solar installed to a floor of 75%
- Solar rebounded

Other Approaches to DG Compensation

Net Energy Metering is Not the Only Method

- Value of Solar Tariff (VOST)
- Power Cost Only
  - Long-run marginal cost
  - Short-run avoided fuel and purchased power
- High Fixed Charges
- Demand Charges

Power Cost Only: Pedernales Electric Cooperative

- Fixed Charge: $22.50/month
- Transmission Charge: $.01256/kWh
- Delivery Charge: $.02712/kWh
- Energy Charge: $.0605/kWh

Customer avoids $.10 for power used on-site, and receives $.06 for power fed to grid.

Straight Fixed/Variable Rate: Franklin Public Utility District

Fixed Charge: $34.00

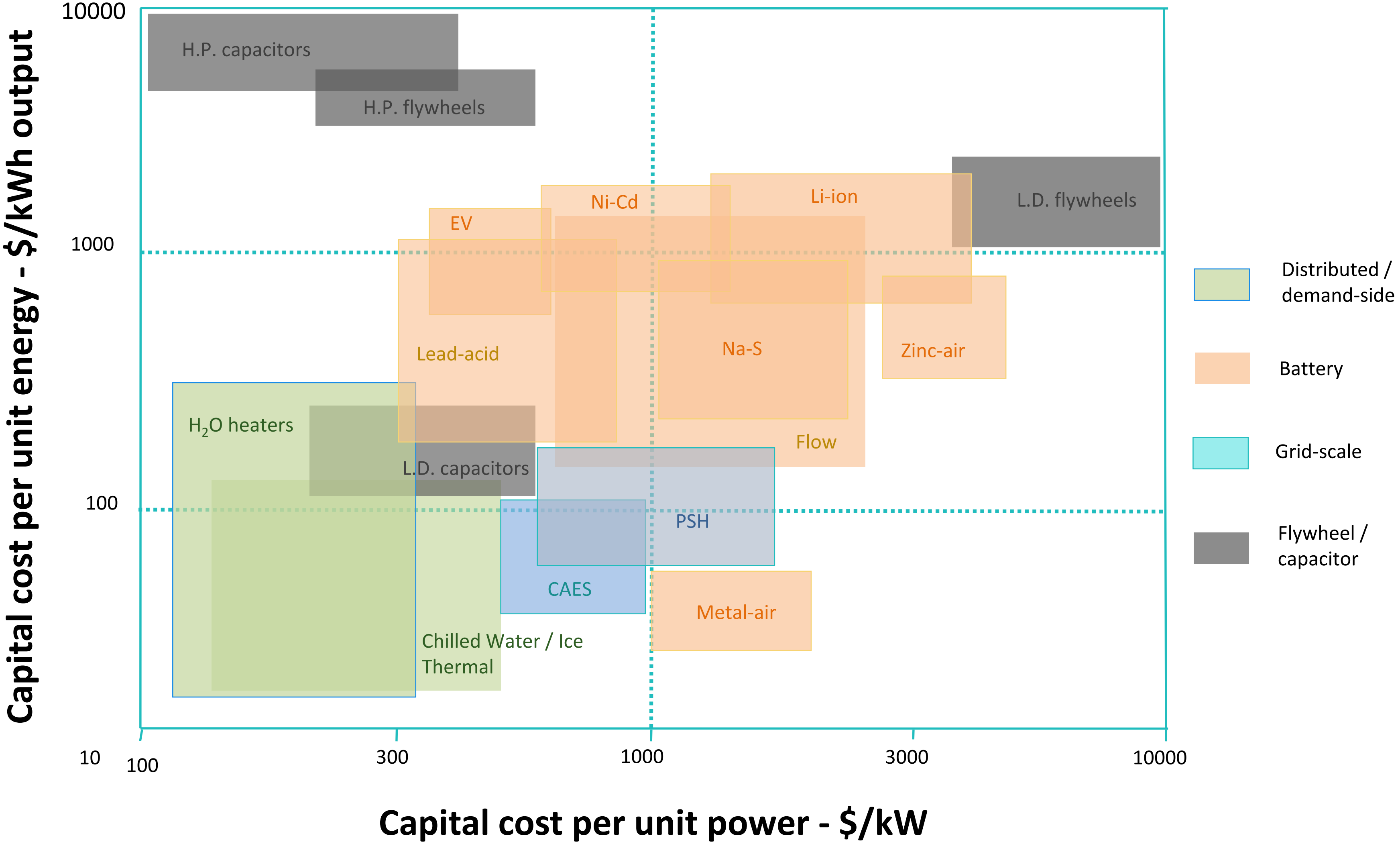
Energy Charge: $.0673/kWh

Implications

- What level of market maturity should trigger the regulator to reassess net metering as a way to compensate solar PV? (is it a number, or some qualitative market standard reflecting choices of supplier, depth of supply chain, installation cost comparison with other states?)
- What level of solar penetration creates system effects that indicate a need to reassess net metering?

Storage

There Are Many Kinds of Storage



Storage is More Than Batteries

Photo: © Gunther Intelmann for Cook+Fox Architects

Ice Storage For Residential Air Conditioning

Ice-Energy "Ice Cub"

- 2.5 ton capacity
- 18 SEER compressor
- 3 hours storage, to get through high-cost hours

Water Heaters Are Probably the Cheapest Source of Storage

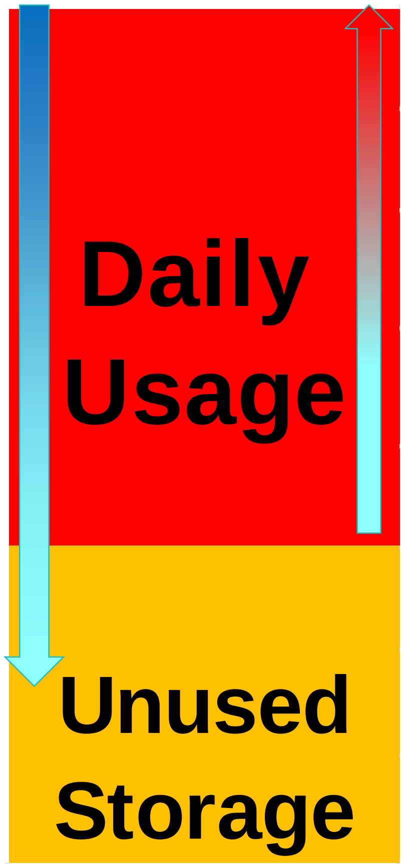
- High concentration in multi-family
- Unlikely to run out of hot water
- Can provide ancillary services to grid
- Water heater controls widely used in France, Australia, and in rural Minnesota

How Many Electric Water Heaters in the Southeast?

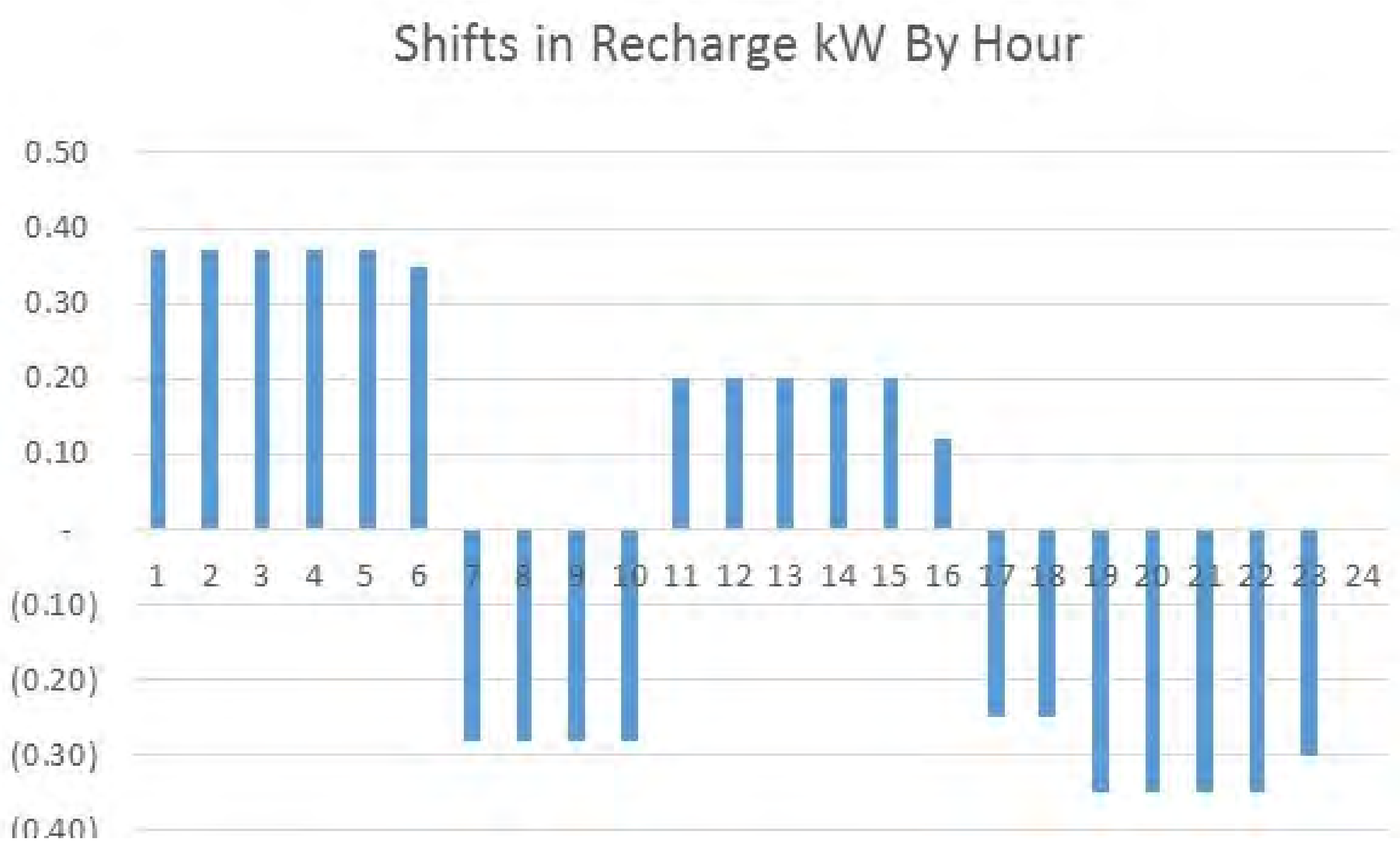
Region	Millions of Electric Water Heaters	Total Residences	% Electric
VA	1.8	3	60%
GA	1.8	3.5	51%
FL	6.2	7	89%
NC SC	4.2	5.4	78%
TN	1.8	2.4	75%
AL, KY MS	3.1	4.6	67%
Total	18.9	25.9	73%

Multi-Family Daily Use is Within Capacity of a 52 Gallon Tank

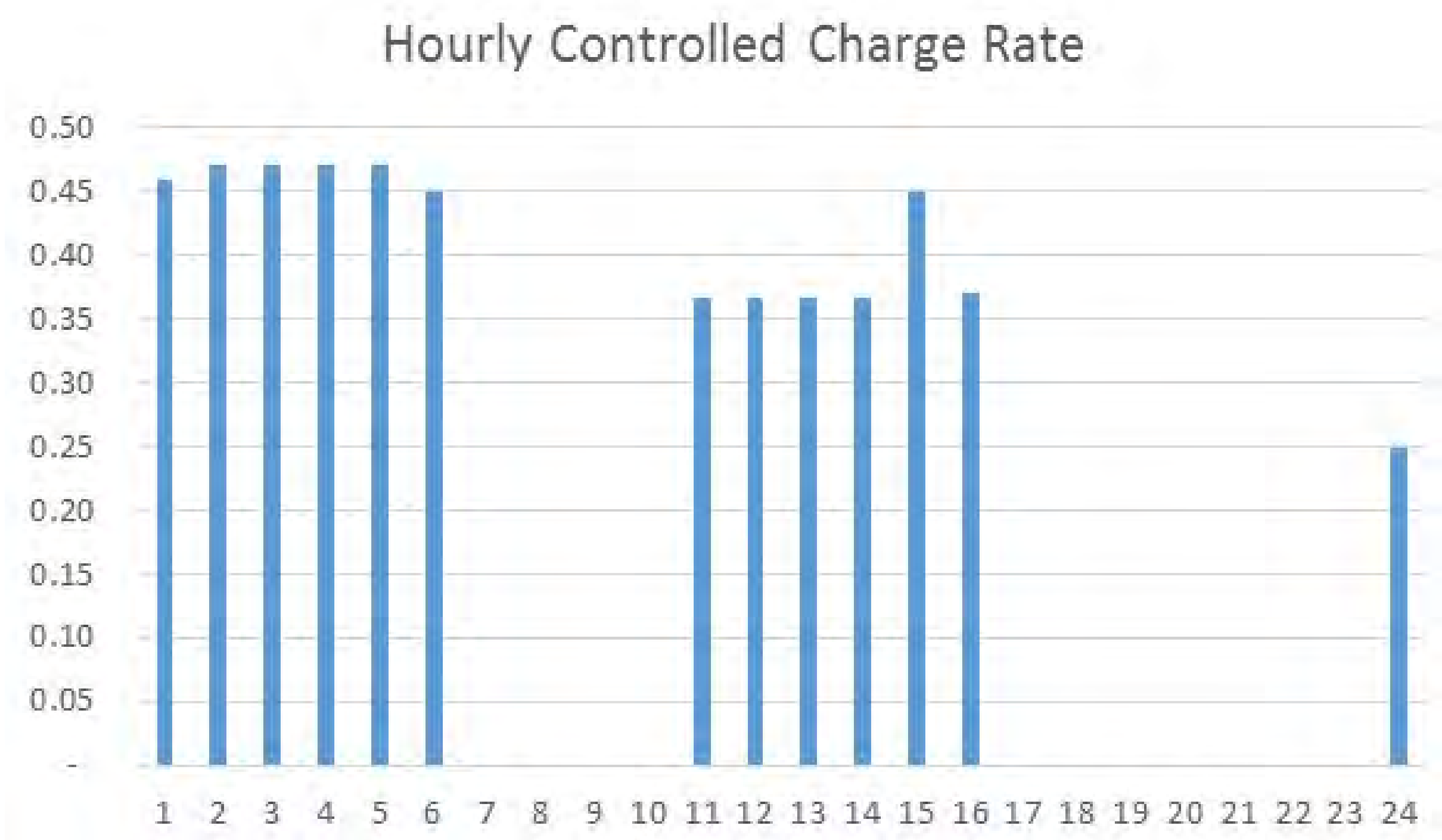
- Daily Usage: 5.33 kWh
- 52 Gallon Tank Capacity:
  7.92 kWh
  @ 140° Max &
  75° inlet water temp.



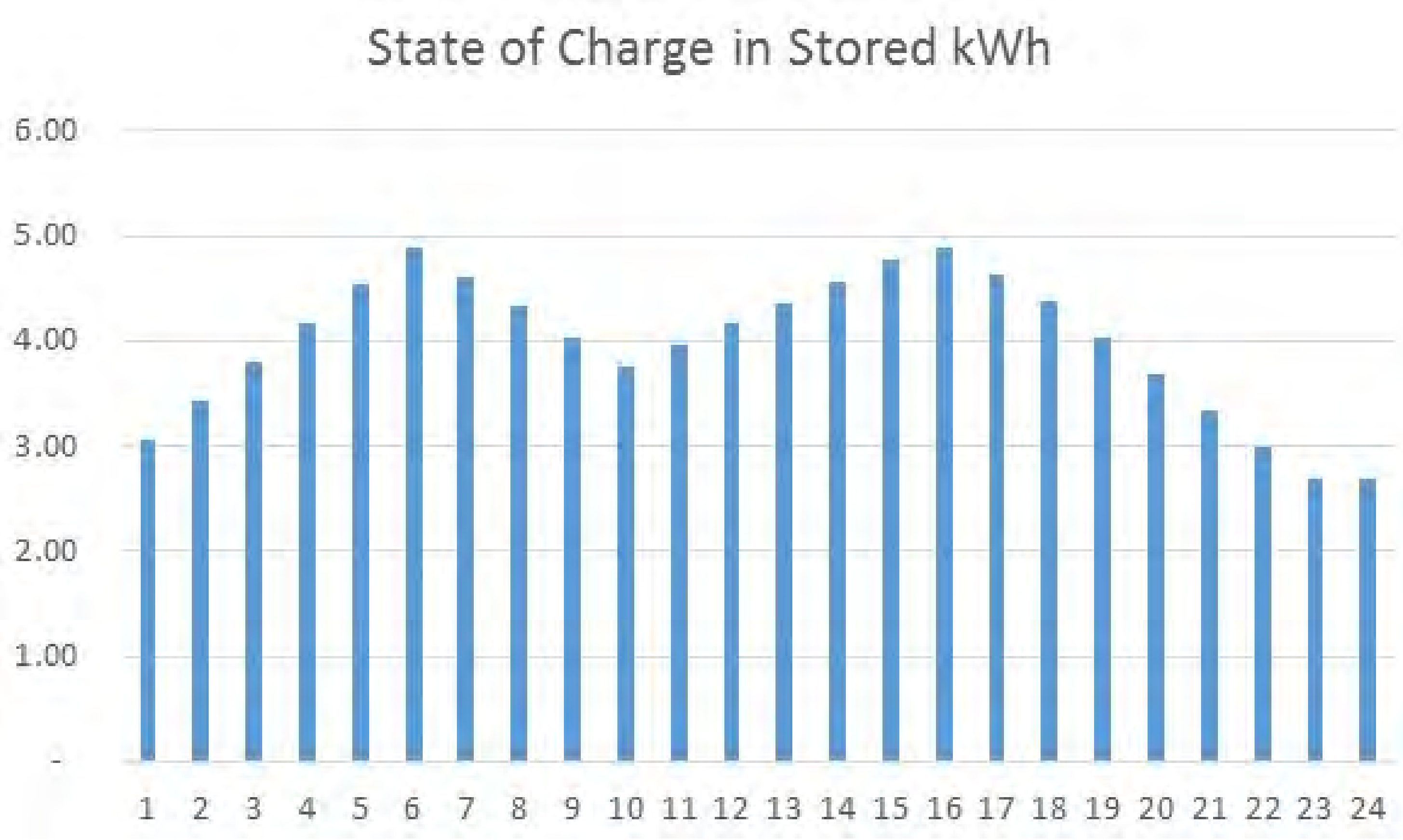
Reduce Charging: 6–10 AM; 4-10 PM Increase Charging at Other Hours



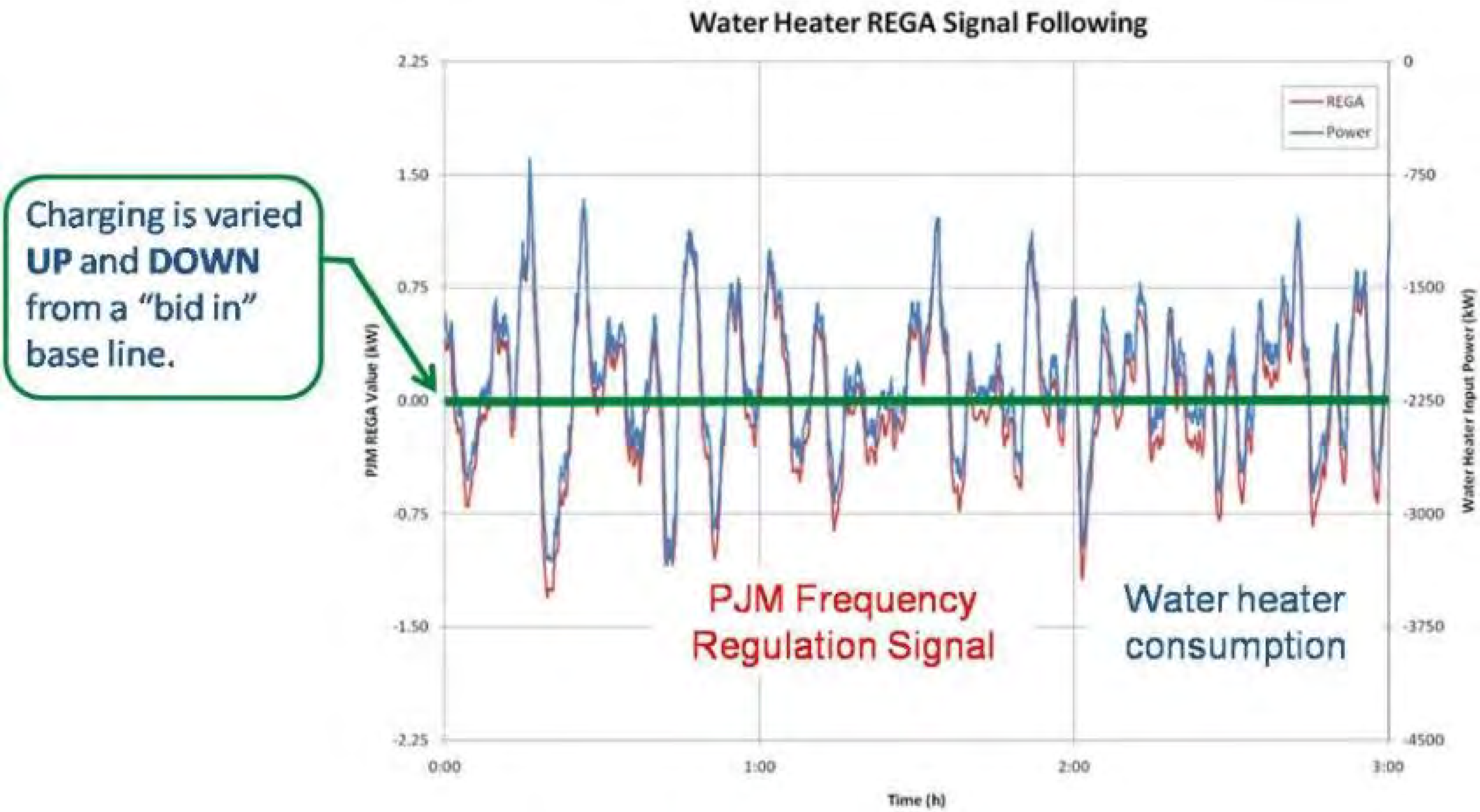
Charging Occurs Mid-Day and Mid-Night



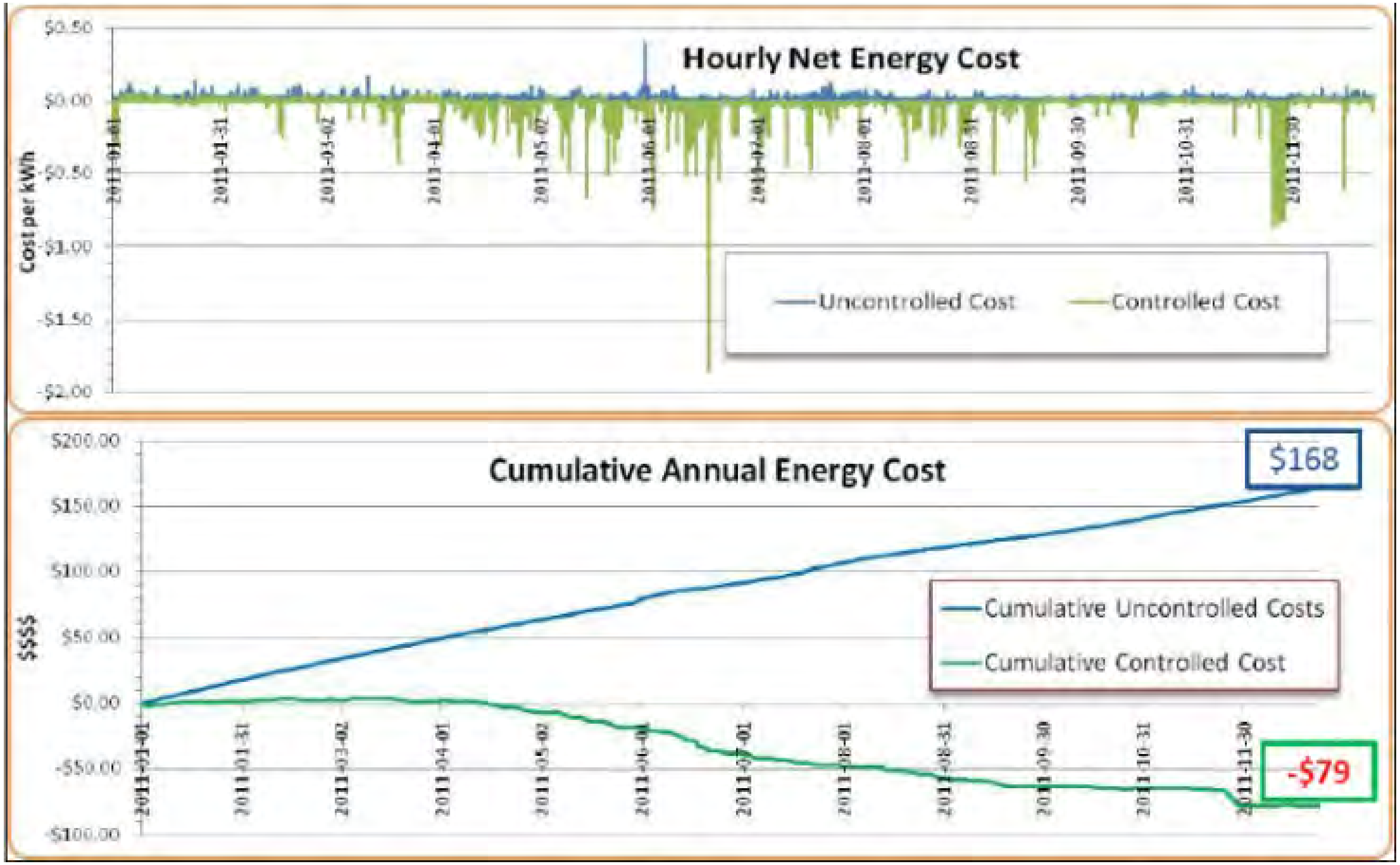
We Only Use Half the Available Storage



Grid-Integrated Water Heating also Provides Ancillary Services



Ancillary Service Value May Exceed Water Heating Energy Cost

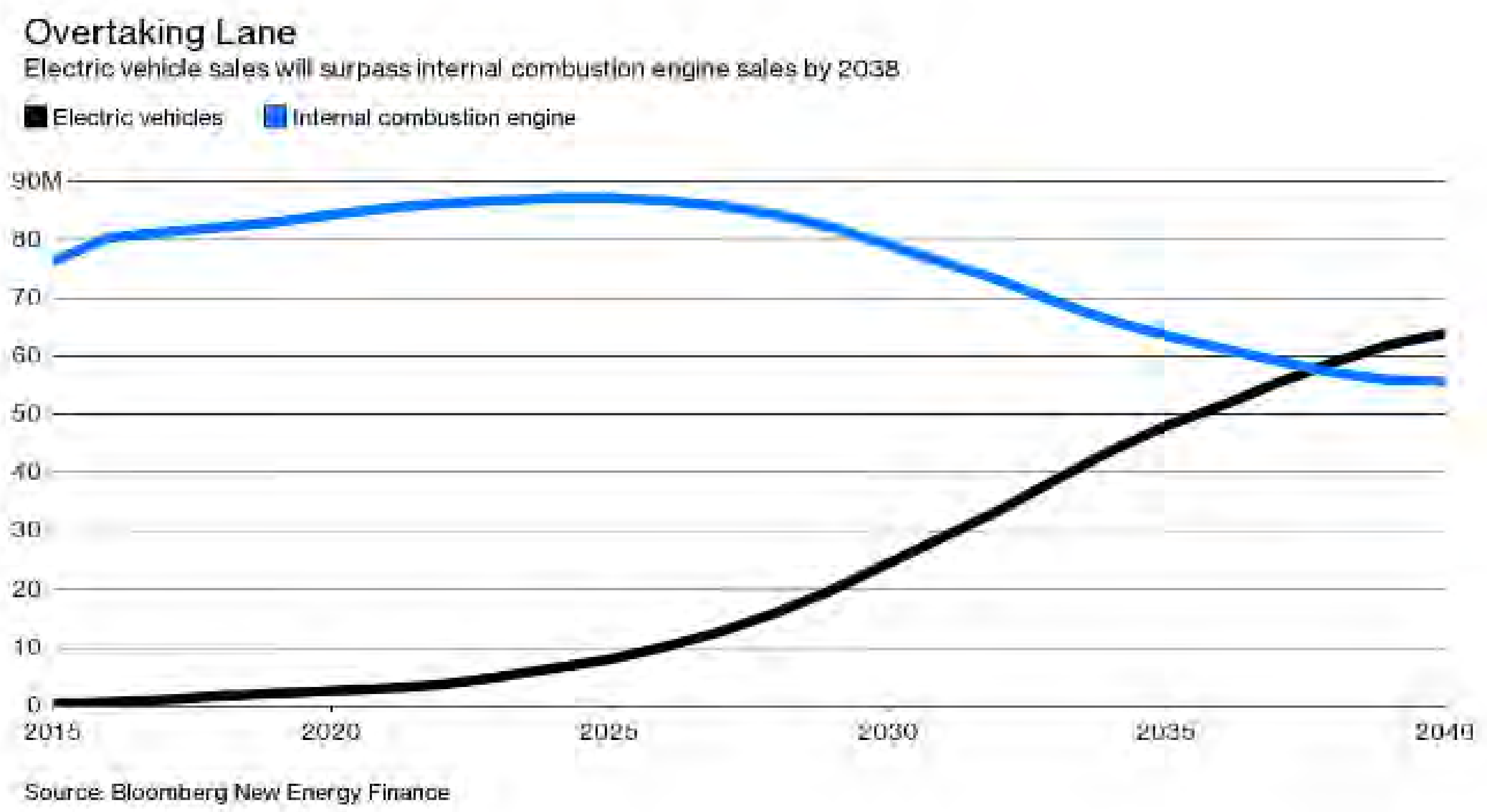


Green Mountain Power Tesla Battery Tariff

- Customer Ownership Option: Direct Purchase
- "Shared Access" Option: $1.25/day
  - Utility: Diurnal Storage, Ancillary Services
  - Customer: Emergency backup power

Electric Vehicles (EVs)

Electric Vehicles

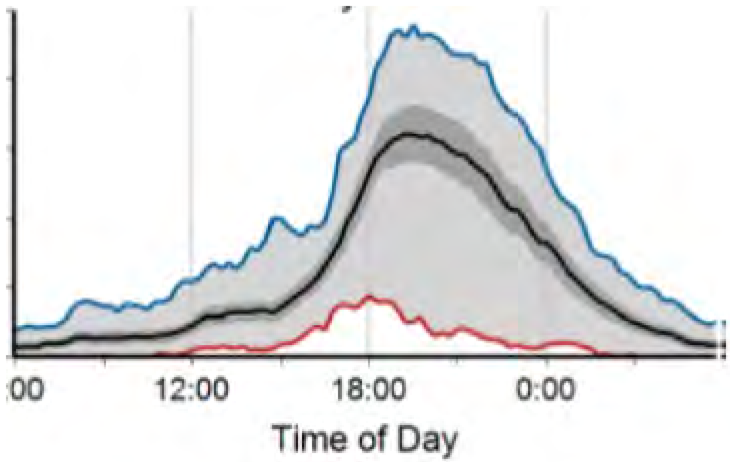


How much power does an EV use?

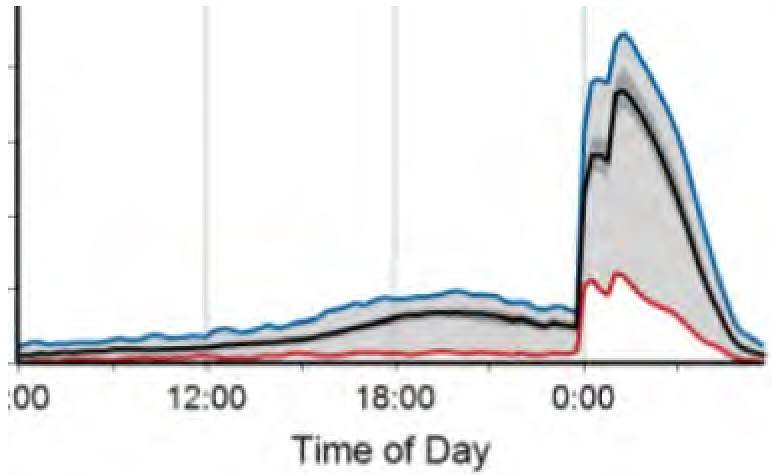
- Nissan Leaf: 4 miles/kWh
- Tesla S: 3 miles/kWh
- Energy: 1,000 miles/month = 250 – 333 kWh/month
- Demand: Level 2 Charging: 3.3 kW – 6.6 kW
- Two-thirds of a water heater

Upgrade a Water Heater: Fuel Your EV with the Savings

Price Can Influence When EVs Are Charged



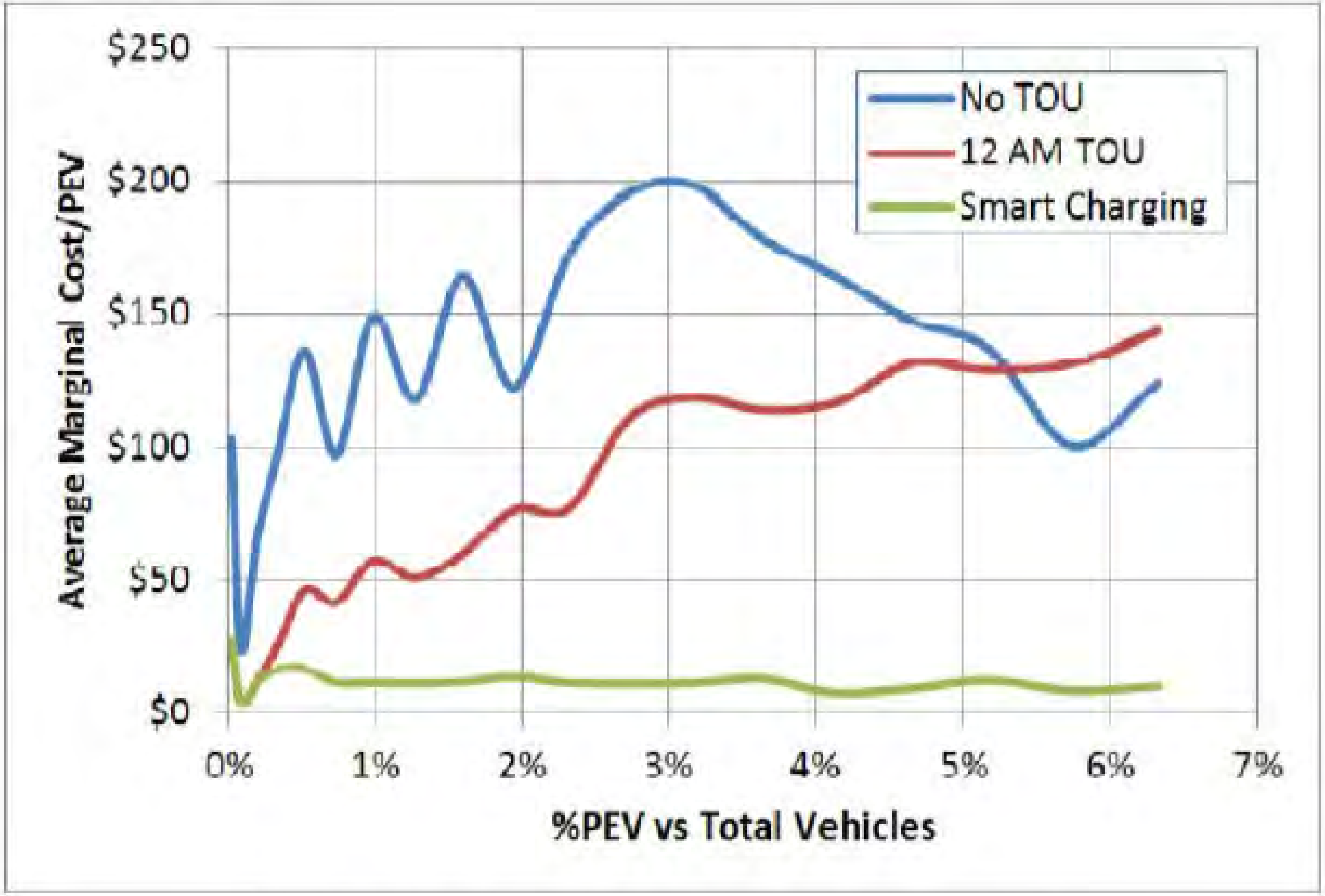
Dallas/Ft Worth
(standard rates)



San Diego
(time-of-use rates)

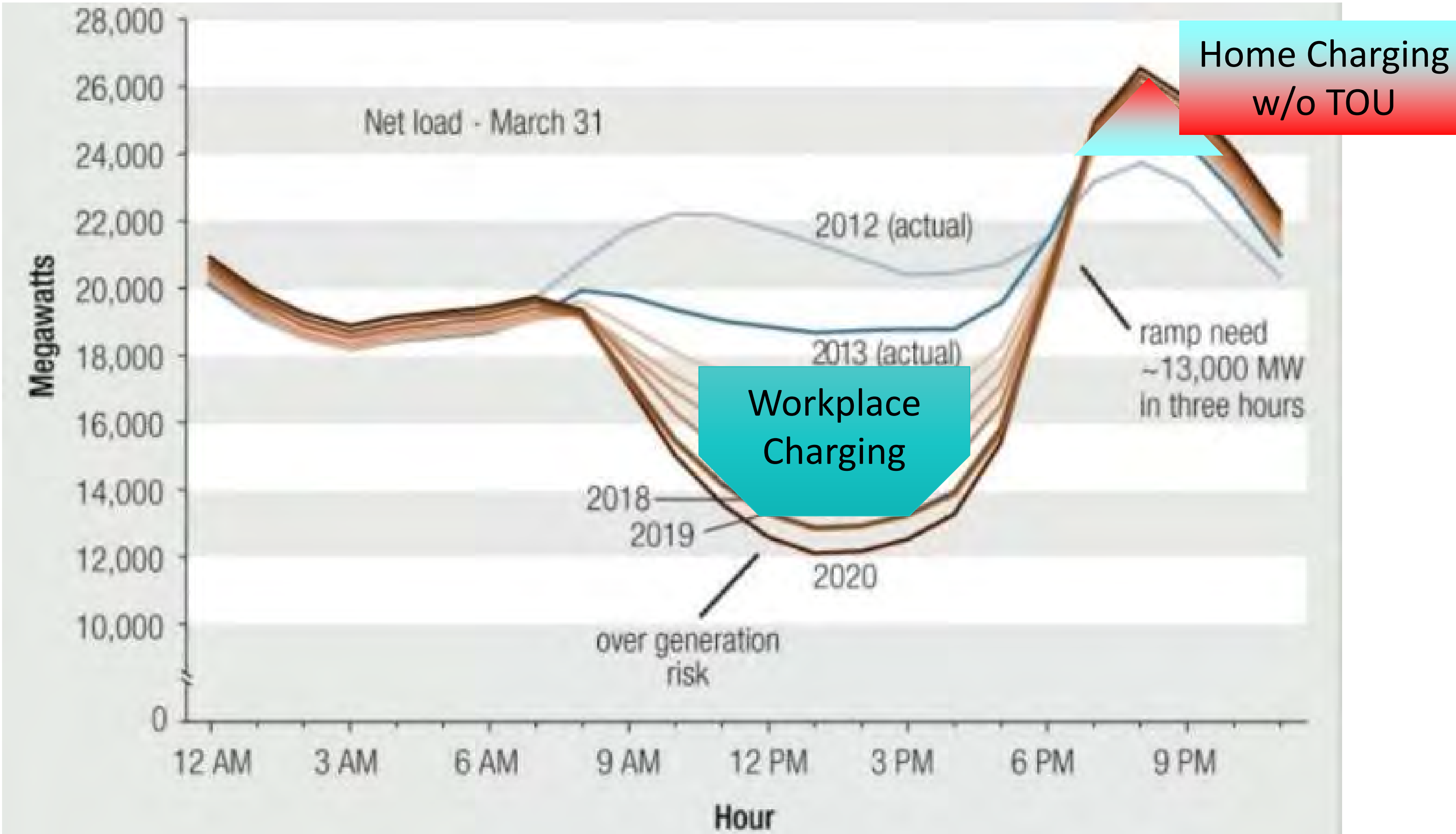
Copied from: M.J. Bradley, 2017

Potential Grid Savings Are Huge



SOURCE: Berkheimer et al SAE Paper, 2014

Workplace Charging and the Duck Curve



Comparison of Three Rates: Consequences for Commercial EV Adoption

	Antiquated Rate	Coincident Peak Demand Charge	Smart Rate
Demand Charge	$10/kW	$10/kW	$2/kW
Demand Measurement	NCP	4 PM - 8 PM	Site Infrastructure
Energy	$0.12/kWh	$0.12/kWh	$.05 - $.75/kWh
Energy Measurement	No TOU	No TOU	TOU

Smart Rate => Workplace EV Charging

	Antiquated Rate	Coincident Peak Demand Charge	Smart Rate
Demand Charge	$10/kW	$10/kW	$2/kW
Demand Measurement	NCP	4 PM - 8 PM	Site Infrastructure
Energy	$0.12/kWh	$0.12/kWh	$.05 - $.75/kWh
Energy Measurement	No TOU	No TOU	TOU

Electric Vehicle Charging Cost Per Month 6.6 kW 250 kWh

NCP Demand	$ 66.00		$ 13.20
CP Demand		$ -	
Energy	$ 30.00	$ 30.00	$ 12.50
Total	$ 96.00	$ 30.00	$ 25.70
Average $/kWh	$ 0.384	$ 0.120	$ 0.103