Ensuring Grid Reliability

with

Increased Distributed Energy Resources

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Electric Power Research Institute (EPRI)

Energypath 2018 Conference
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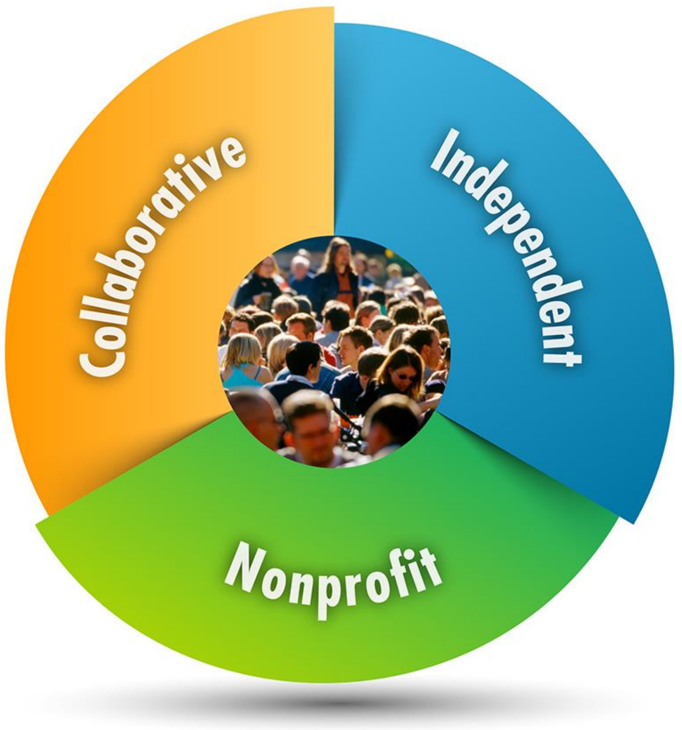
EPRI: Born in a Blackout

Founded in 1972 as an independent, nonprofit center for public interest energy and environmental research

New York City, The Great Northeast Blackout, 1965

Three Key Aspects of EPRI



Independent

Objective, scientifically based results address reliability, efficiency, affordability, health, safety, and the environment

Nonprofit

Chartered to serve the public benefit

Collaborative

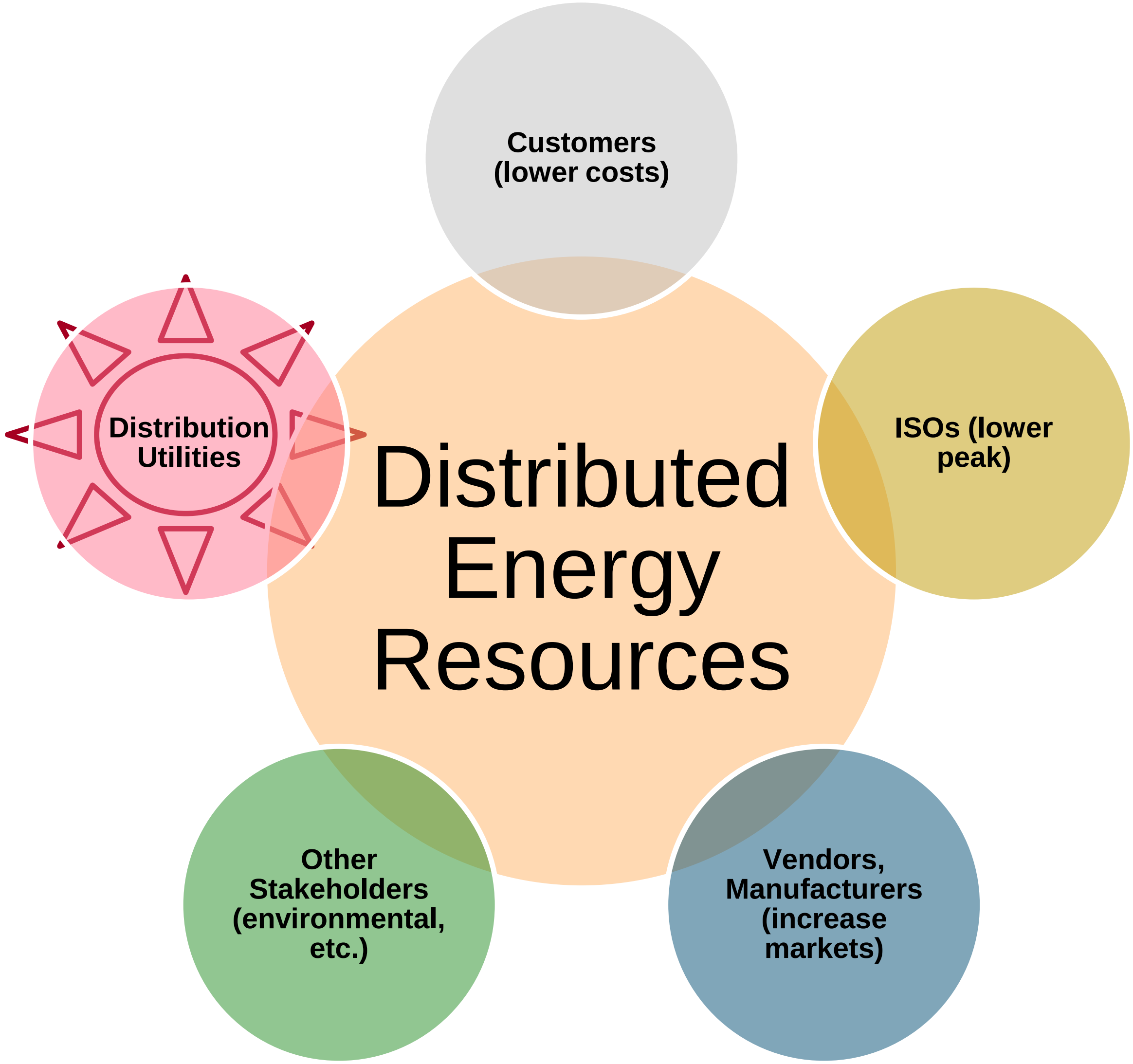
Bring together scientists, engineers, academic researchers, and industry experts

Our Members…

- 450+ participants in more than 30 countries
- EPRI members generate approximately 90% of the electricity in the United States
- International funding – nearly 25% of EPRI’s research, development, and demonstrations

About Our Research

Distributed Energy Resources…Who has Interest?

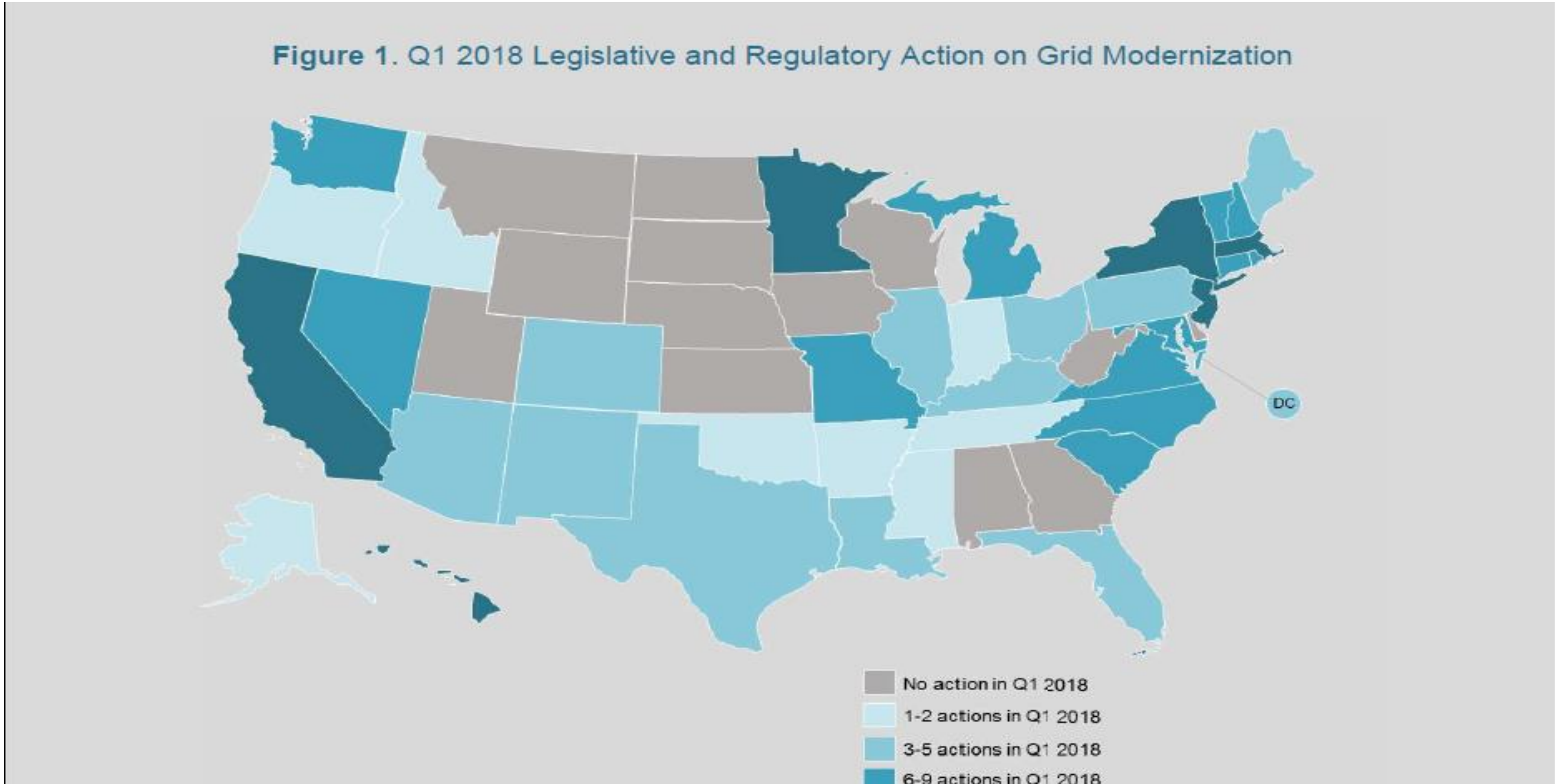


Ensuring Grid Reliability…Who is Responsible?

The Distribution Utility

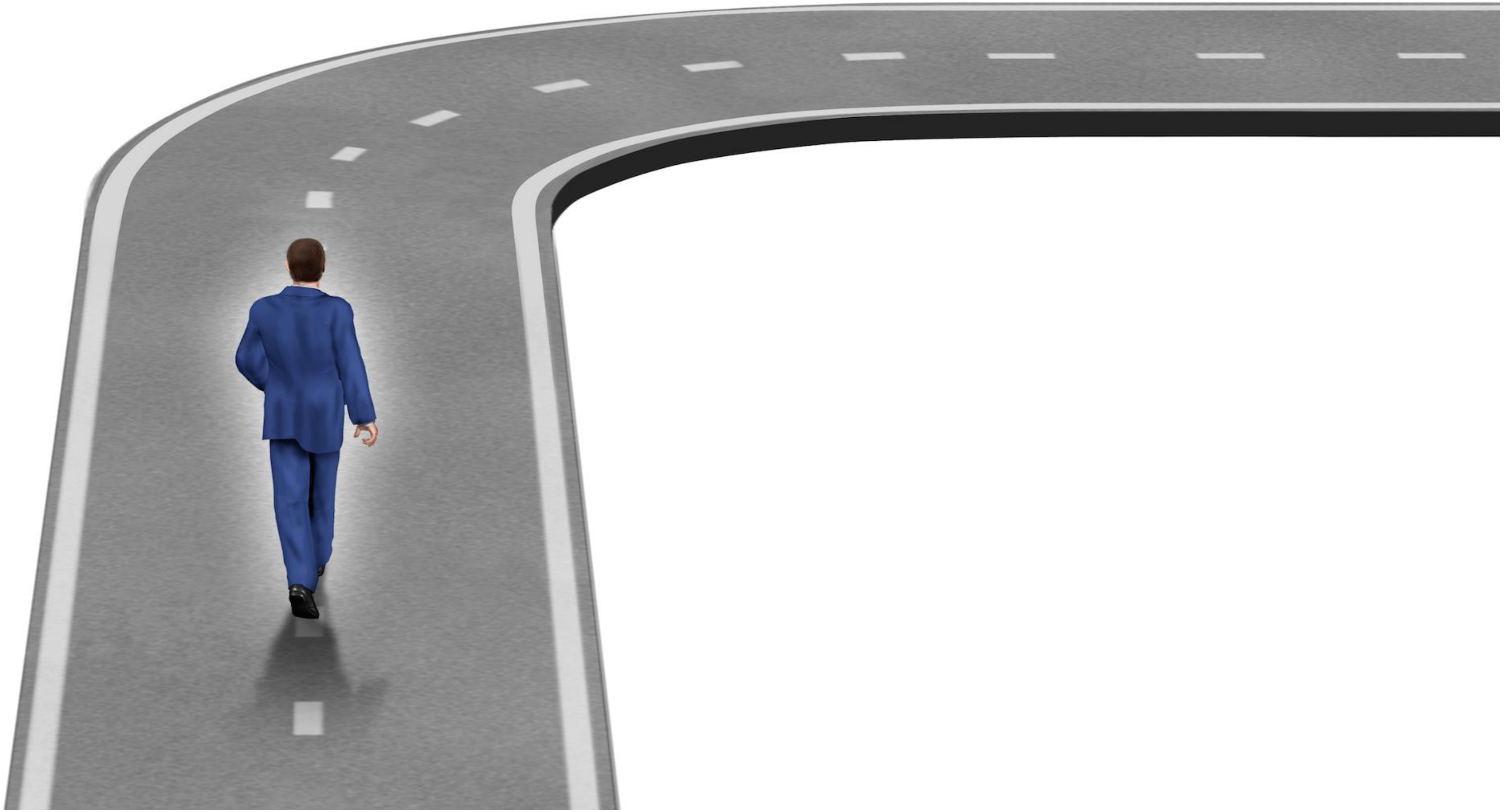
"Utilities are responsible for reliability, and the functions needed to enable distributed markets are integrally bound to the functions needed to ensure reliability. " *NYPSC Order for Reforming the Energy Vision issued 2015*

Industry is starting embrace the change…

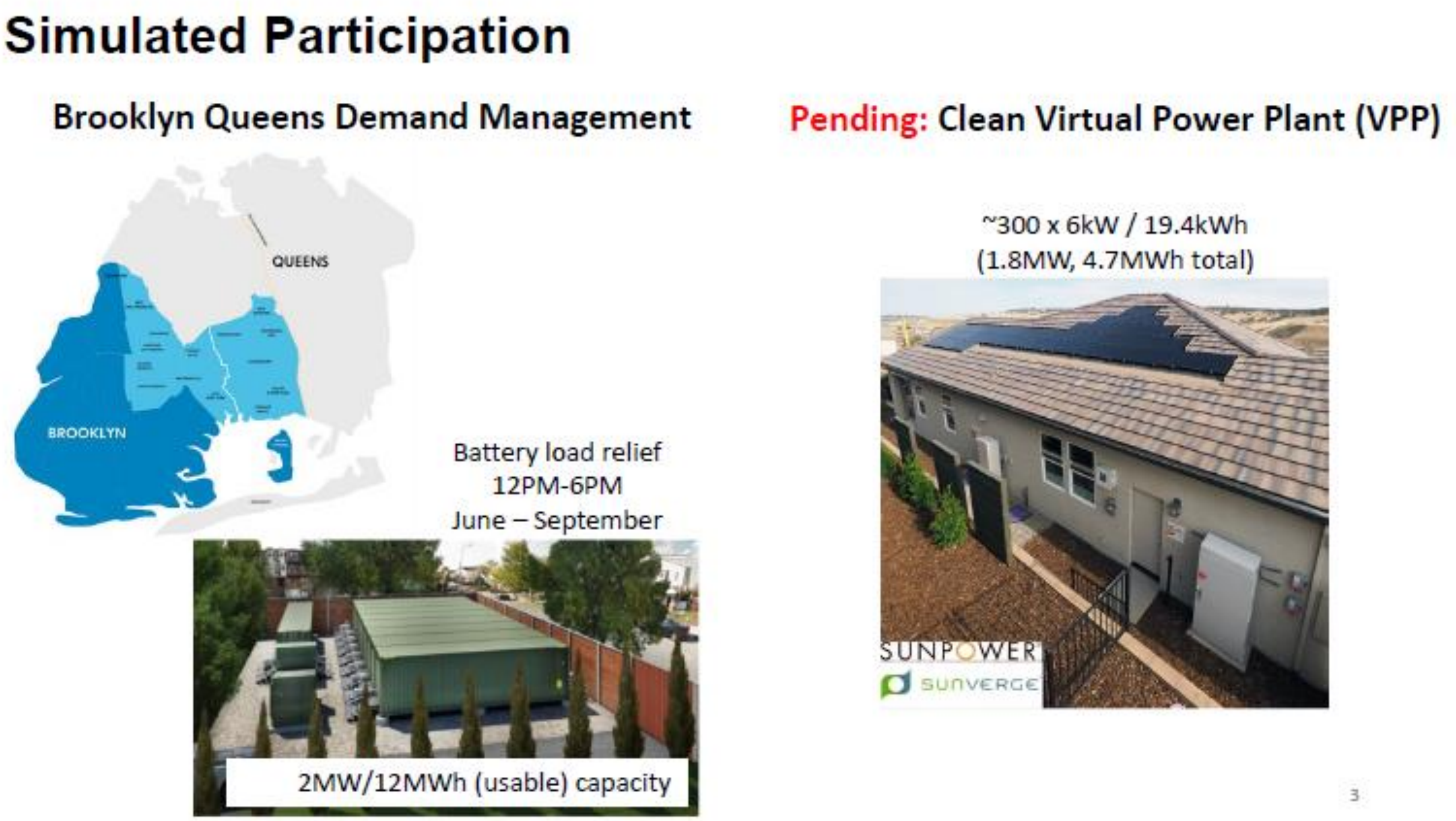


Courtesy NC Clean Energy Technology Center
50 States of Grid Modernization Q1 2018 Quarterly Report

Utilities turning a corner….but not a U-turn



Non Wires Alternatives (NWAs)



Research Questions

- Where can DER be located for the greatest benefit?
- How to ensure that DER will be available to support the larger grid when necessary?
- What are the gaps between theory and practical implementation?

Integrated Energy Network

Customers at the center

Flexible central generation, storage, new loads, active customers and better forecasts balance variable generation

Physical connections augmented by secure data and communications

Energy and Natural Resource Systems are Integrated to Provide Reliable, Safe, Affordable, Cleaner Energy and Expanded Customer Choice

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EPRI/Industry Conducting Research to Optimize DER

Some Grid Considerations:

- *Location of DER*
- *DER Technology(ies) and Incorporation of Energy Storage*
  - *Sizing*
  - *Integration*
- *Smart Inverters to Optimize the DER*
- *Duration of Reliability*
- *Cost Benefit Analysis*

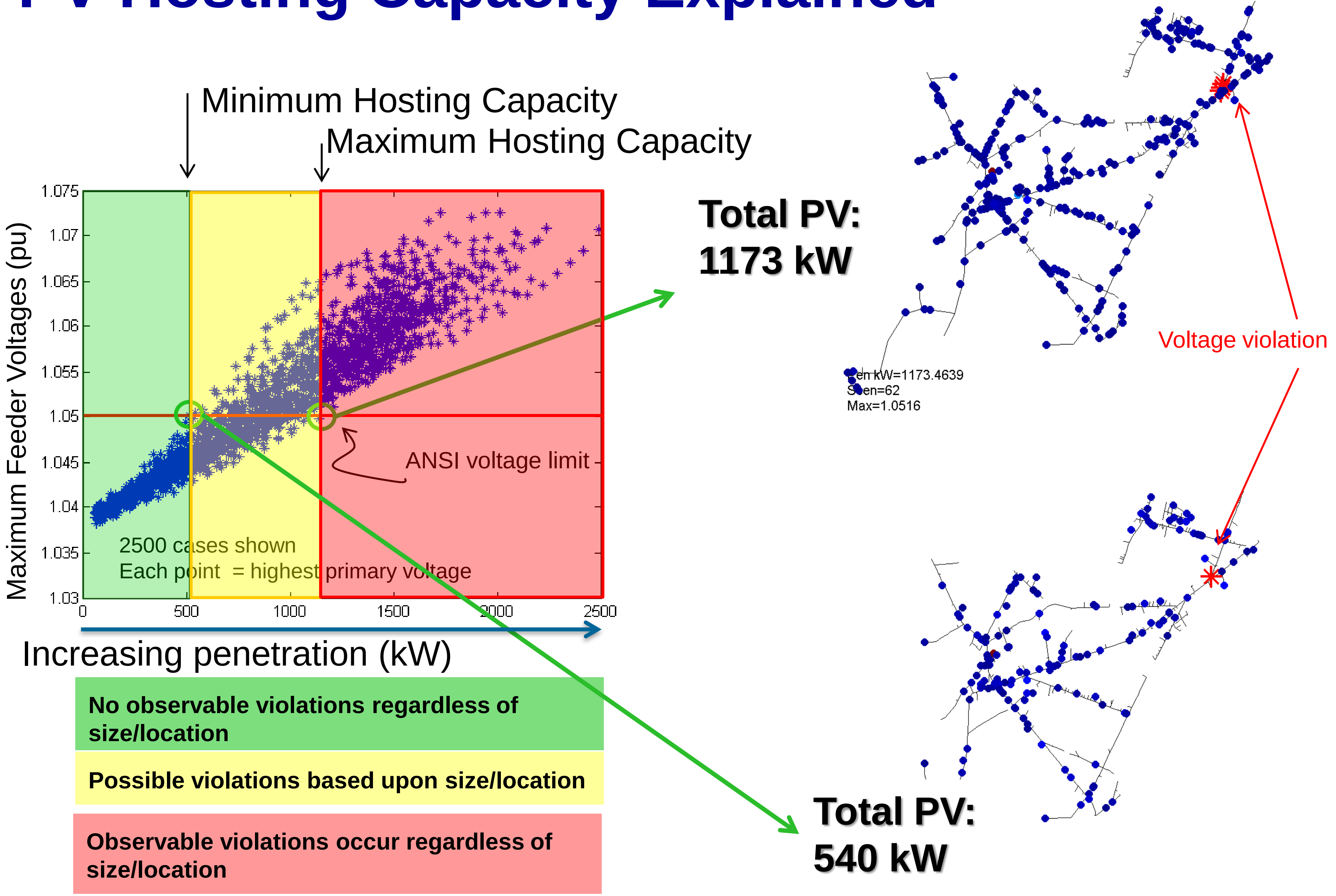
Location

Hosting Capacity: What is it?

The amount of Solar PV or other (Distributed Energy Resources) that can be accommodated without impacting power quality or reliability under existing control and infrastructure configurations.

The impact from DER is dependent on the unique feeder and DER characteristics

PV Hosting Capacity Explained



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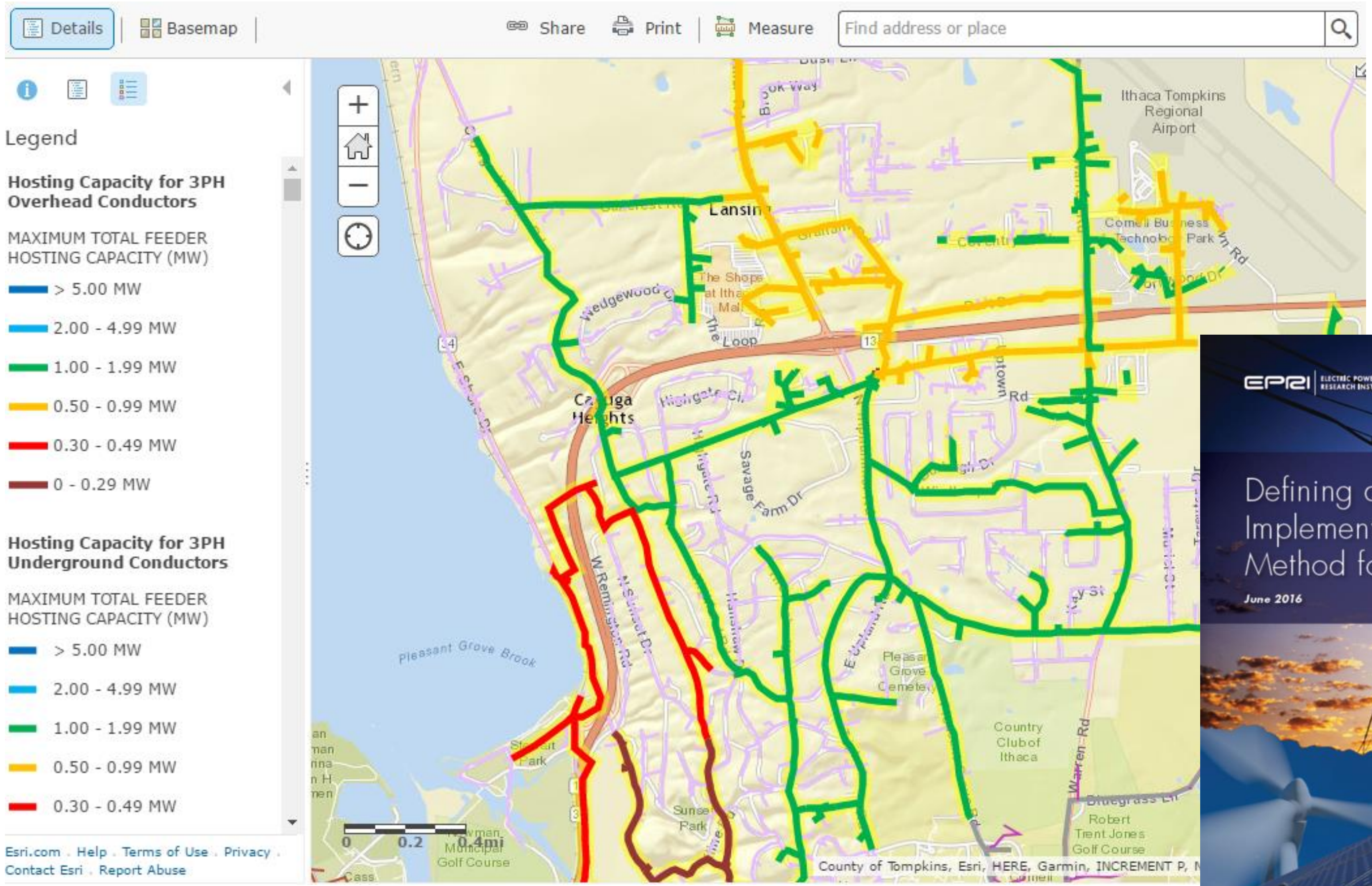
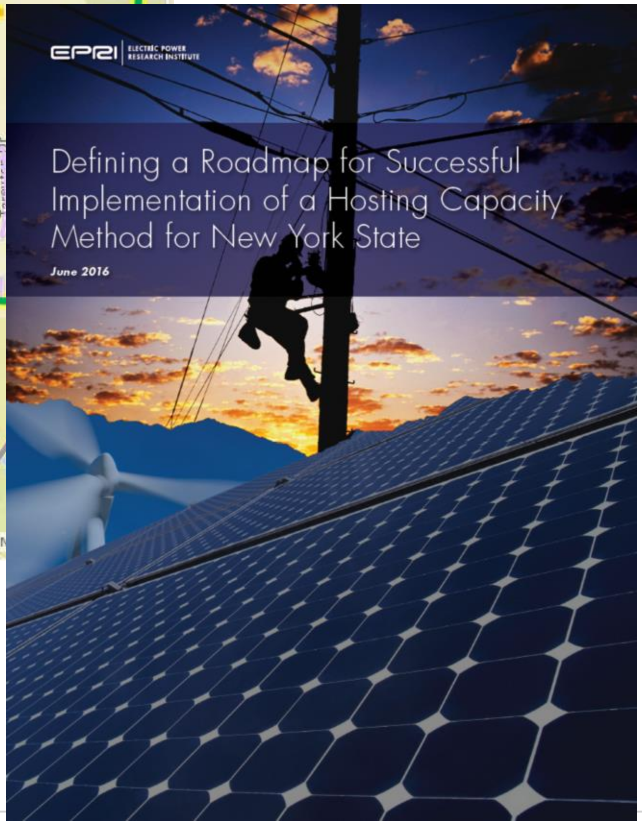
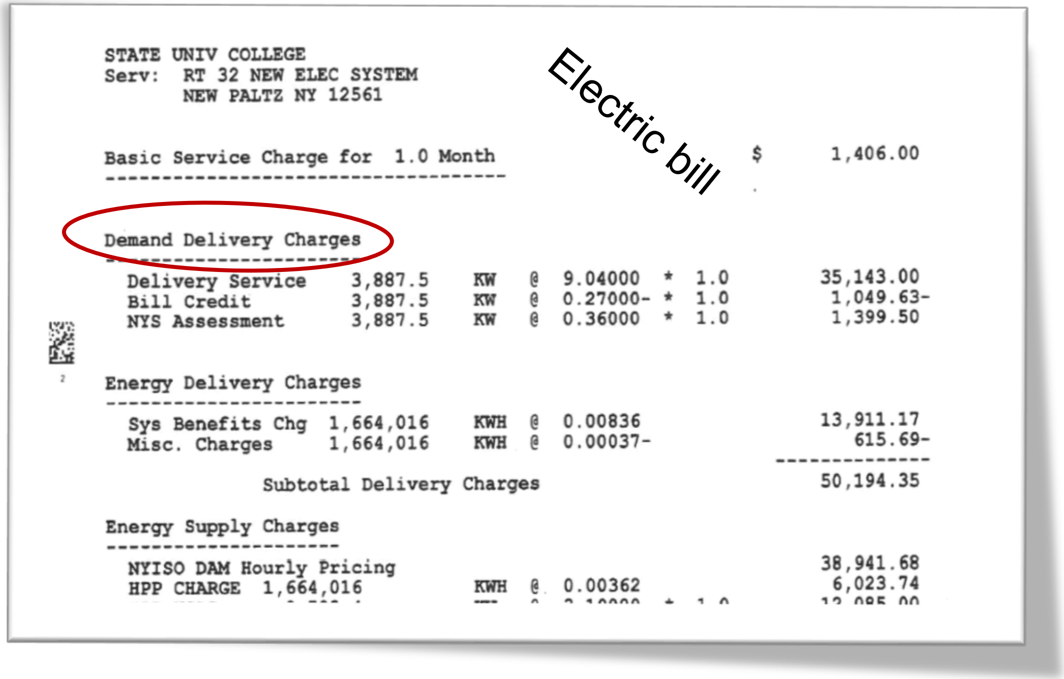
Hosting Capacity Maps Inform DER Developers



Hosting Capacity Maps courtesy of NYSEG/RGE

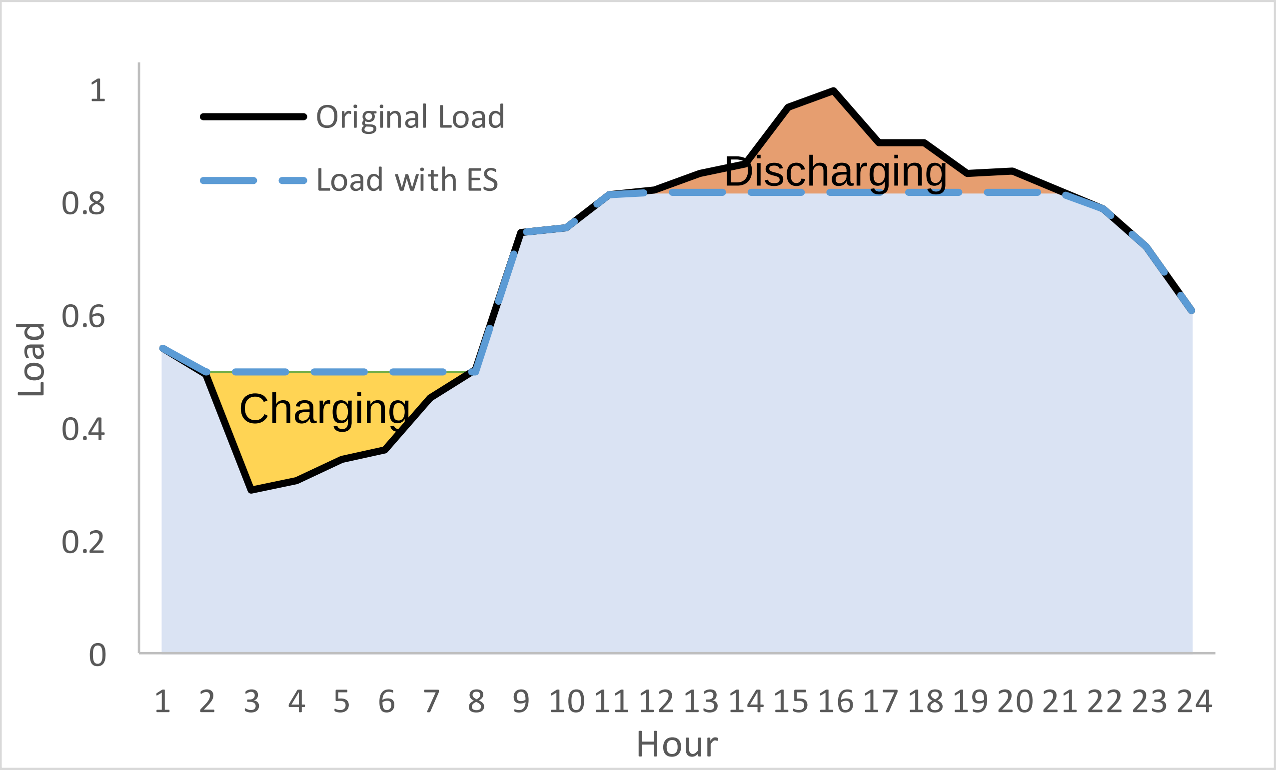


Load Peak Shaving: Example of Storage Only



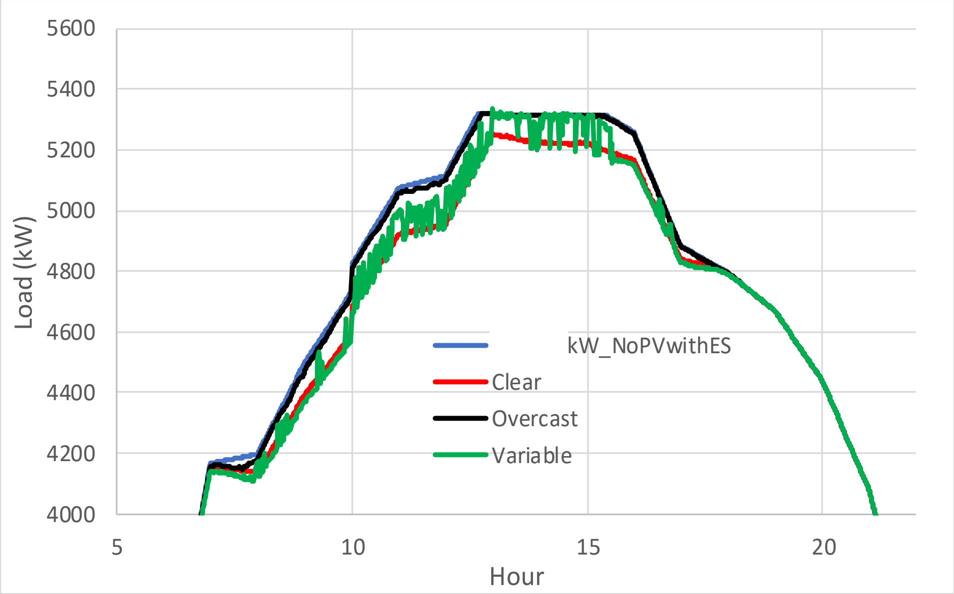
STATE UNIV COLLEGE
Serv: RT 32 NEW ELEC SYSTEM
NEW PALTZ NY 12561

Basic Service Charge for 1.0 Month					$ 1,406.00
Demand Delivery Charges					
Delivery Service	3,887.5	KW	@ 9.04000	* 1.0	35,143.00
Bill Credit	3,887.5	KW	@ 0.27000-	* 1.0	1,049.63-
NYS Assessment	3,887.5	KW	@ 0.36000	* 1.0	1,399.50
Energy Delivery Charges					
Sys Benefits Chg	1,664,016	KWH	@ 0.00836		13,911.17
Misc. Charges	1,664,016	KWH	@ 0.00037-		615.69-
Subtotal Delivery Charges					50,194.35
Energy Supply Charges					
NYISO DAM Hourly Pricing					38,941.68
HPP CHARGE	1,664,016	KWH	@ 0.00362		6,023.74

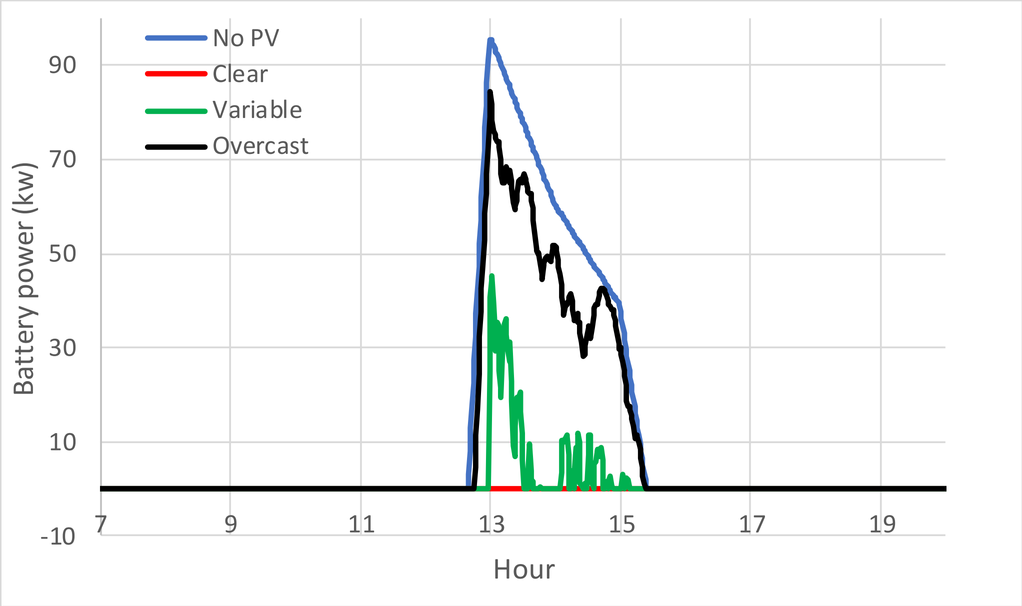


- Load peak shaving lowers the electric bill by reducing the peak demand based charge.
- Battery is charged during light load hours and discharges in peak load hours when the load is above the peak shaving target.

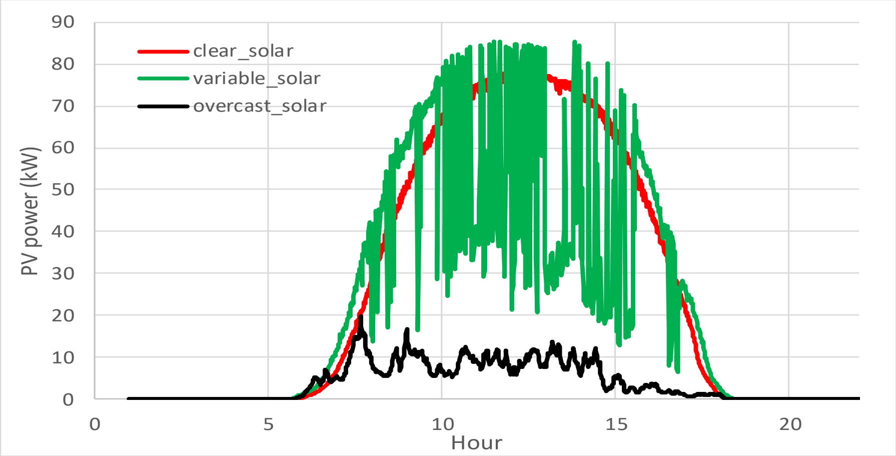
Peak Shaving with Different PV Generation



Demand



Battery discharging power



PV generation

- PV generation reduces the peak demand and as a result, less or no power is needed from battery to keep the peak demand below the target.
- Battery mitigates the load variations above the target in highly variable solar day.

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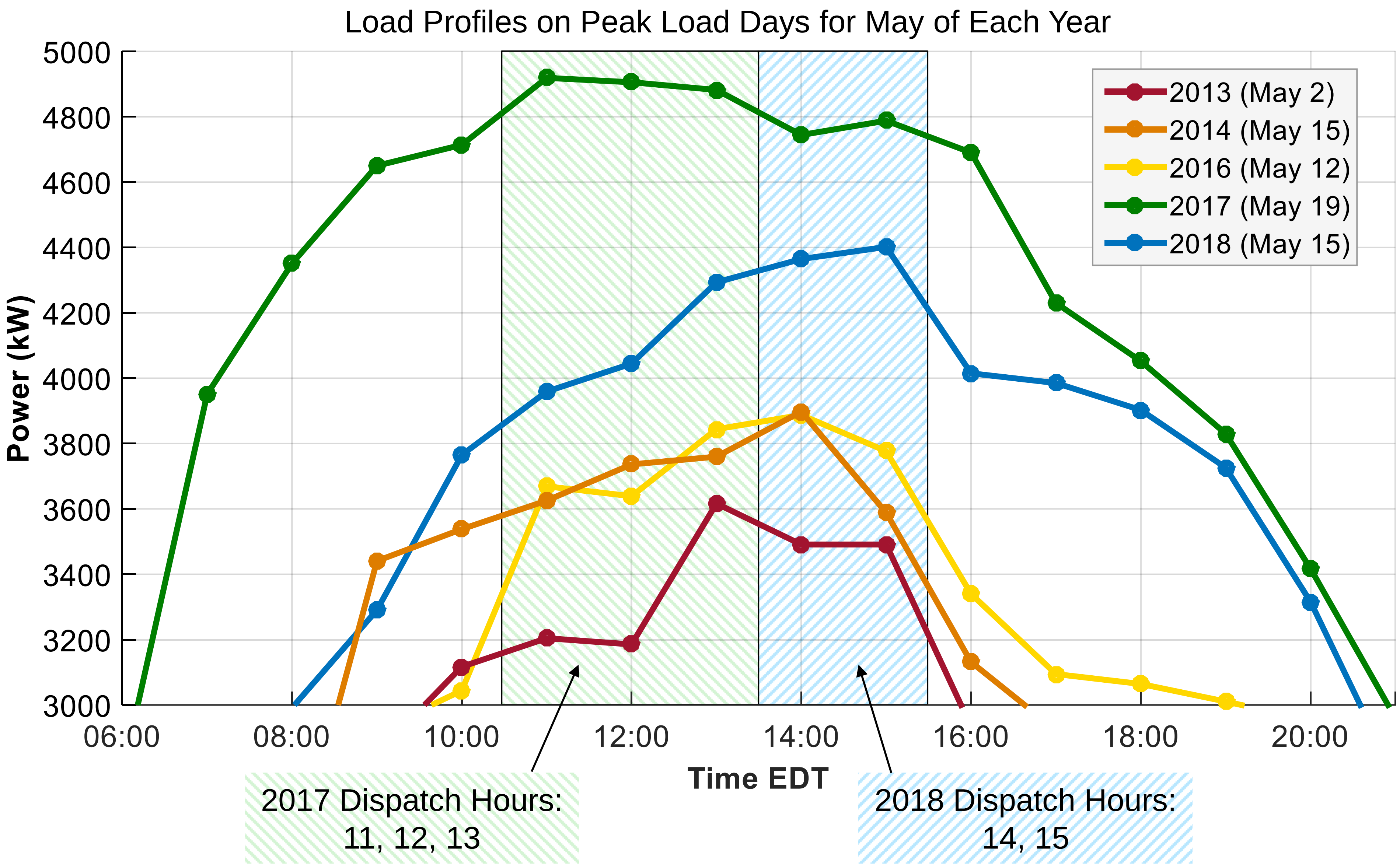
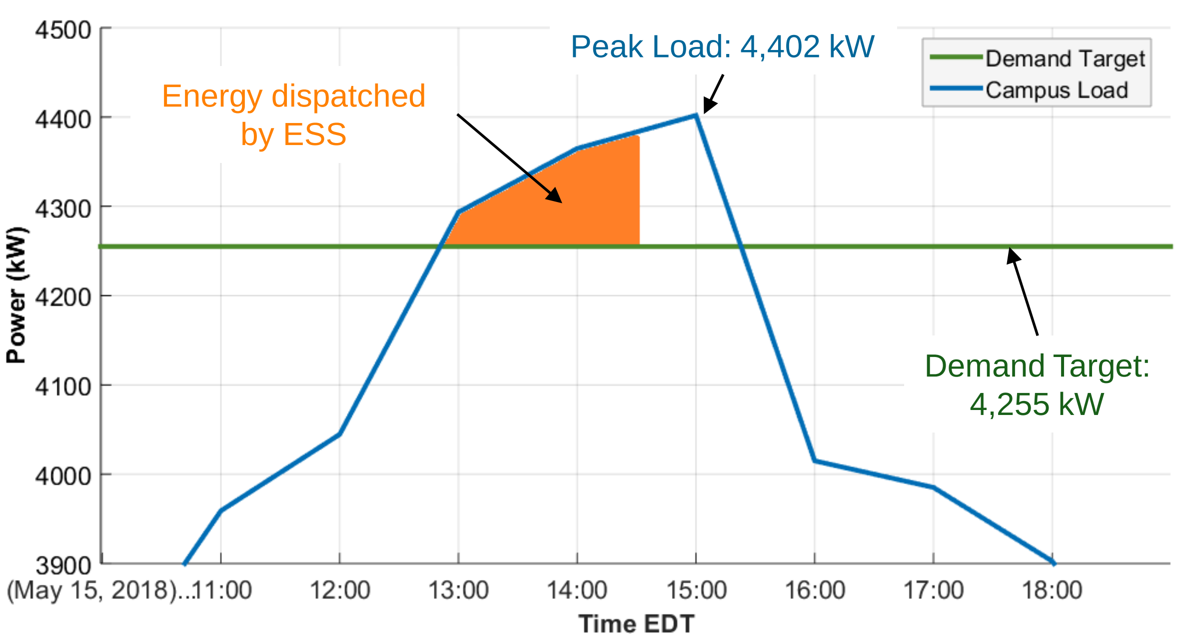
Dispatch Hours Can Vary from Year to Year



ESS Will Not Reduce Peak Load if Demand Target is Too High or Low

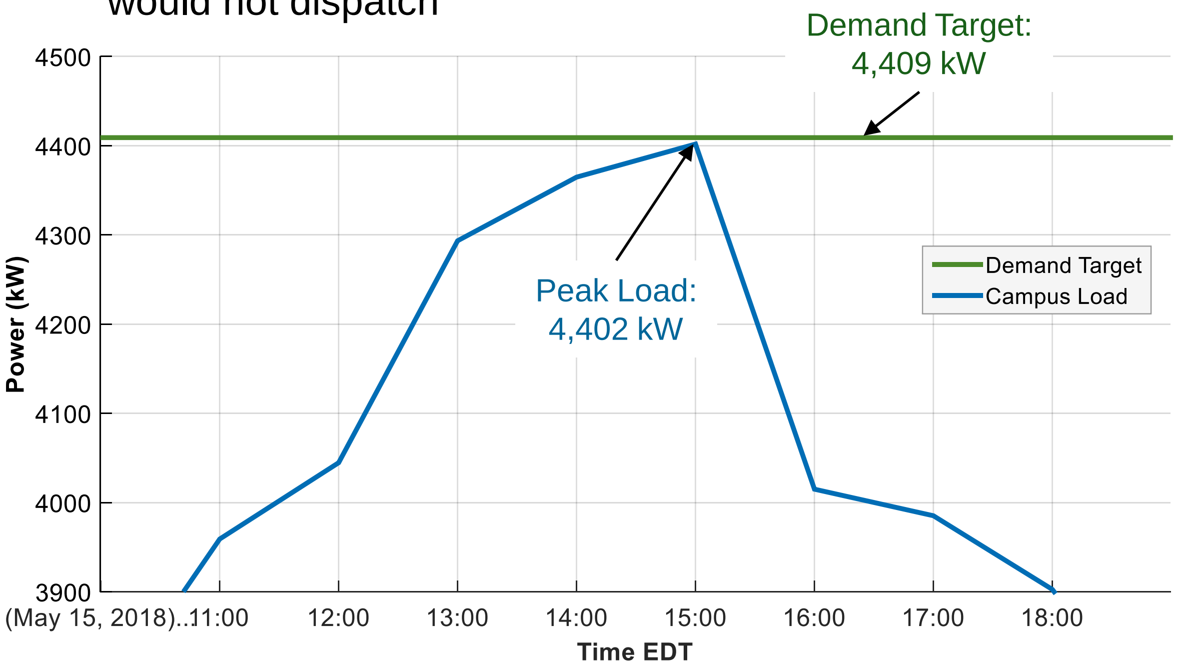
If demand target is set too low:

- ESS dispatches its capacity before peak demand occurs
- From prior example:
  - Ideal demand target 5/18/18 was 4,309 kW
  - If demand target set 54 kW lower at 4,255 kW, ESS would have dispatched its capacity before the peak load at 15:00



If demand target is set too high:

- ESS does not dispatch because demand target is not reached
- From prior example:
  - Ideal demand target 5/18/18 was 4,309 kW
  - If demand target set 100 kW higher at 4,409 kW, ESS would not dispatch

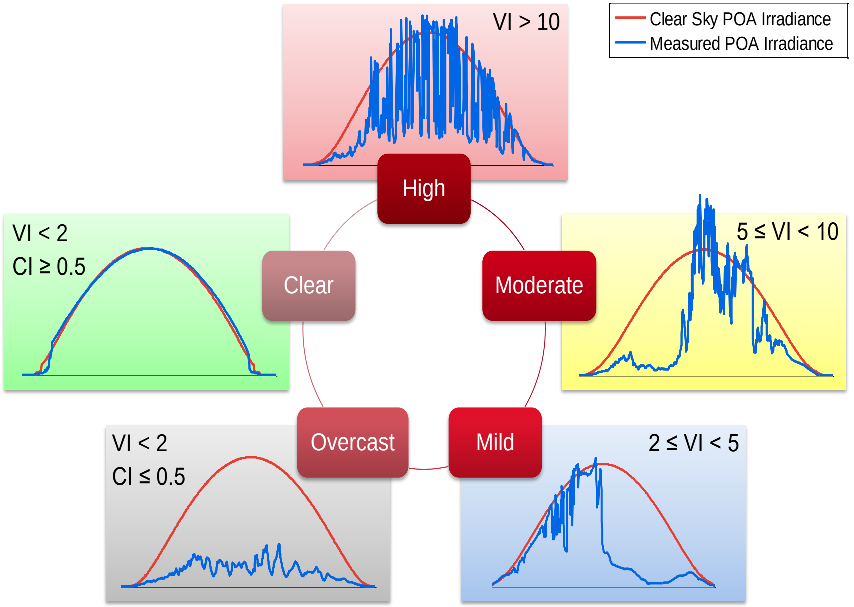


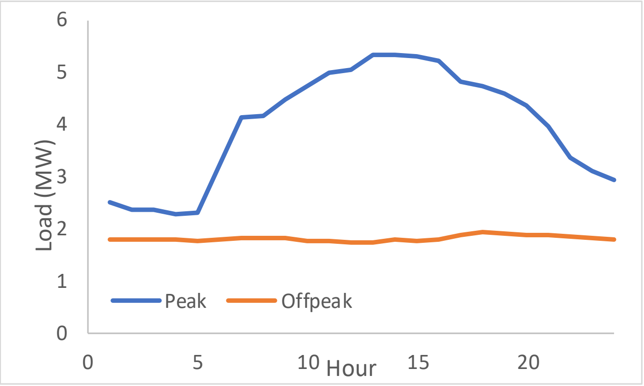
Determining Smart Inverter Setting based on Feeder Performance

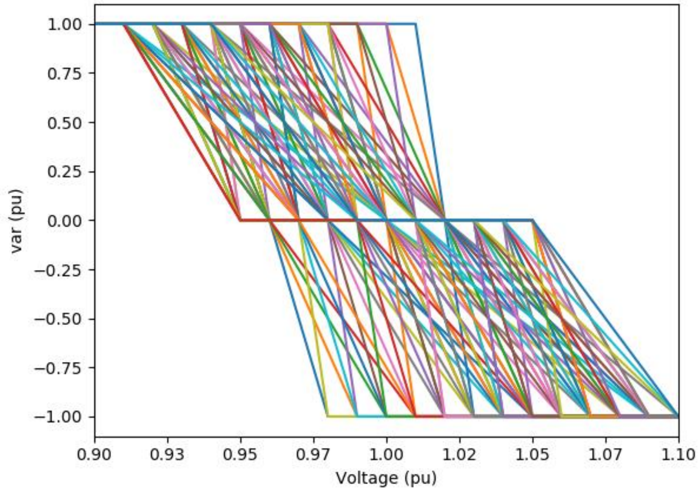
Analysis method:

- Solar variability conditions
  - Clear day
  - Overcast day
  - Highly variable day
- Load variability conditions
  - Peak load day
  - Minimum load day
- Smart inverter settings
  - Volt-var

    Multiple volt-var curves with varying slope, varying deadband and varying mid point in a band that covers (V_{min} ,V_{max}) are analyzed.
  - Off-nominal power factor (0.9 – 0.99 absorbing)
- Select the best setting by ranking the feeder performance







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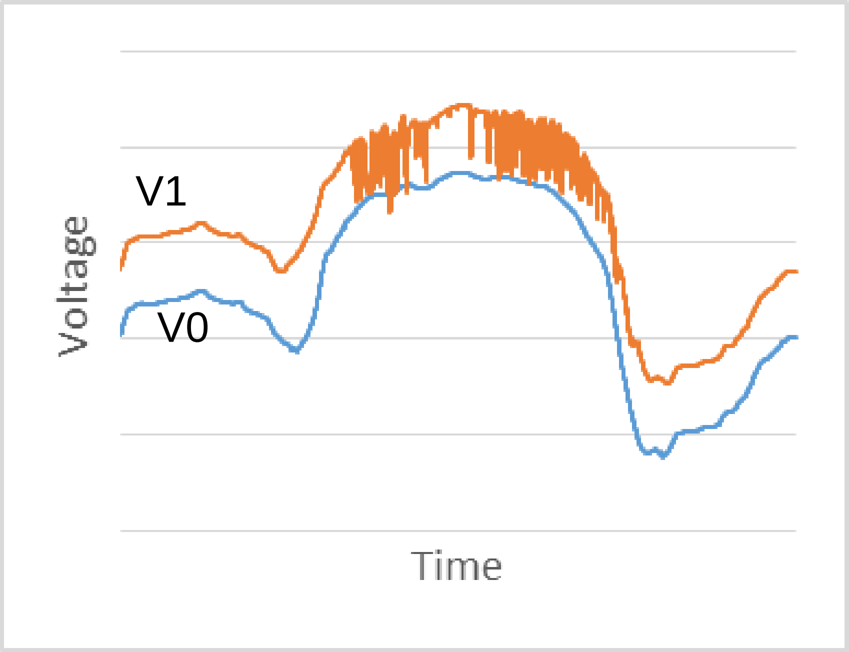
Smart Inverter Settings – Reducing Voltage Variability

- Voltage variability index

$$VI = \frac{\sum_{k=2}^{n} \sqrt{(V1_k - V1_{k-1})^2 + \Delta t^2}}{\sum_{k=2}^{n} \sqrt{(V0_k - V0_{k-1})^2 + \Delta t^2}}$$

V1 is the voltage curve being evaluated and the V0 is the reference voltage, which is normally the voltage without PV.

Voltage variations add additional “length” to the voltage curve and larger voltage variability index indicates more variations.



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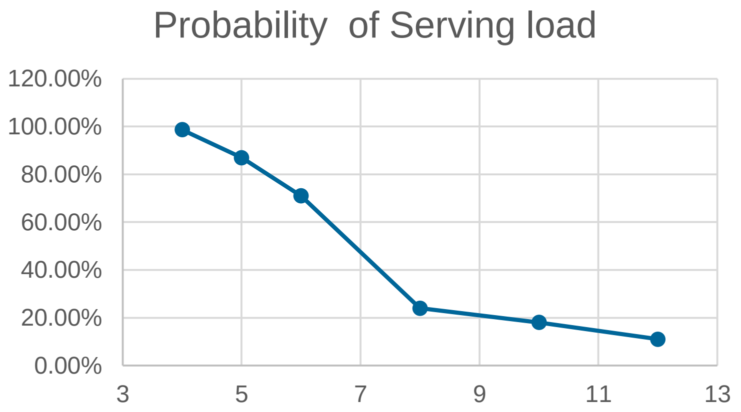
Duration

Operation without Diesel generator

- The microgrid site has a 100 kW 2 hours battery and 101 kW of PV capacity
- Assuming a PV+ES microgrid only, the islanding duration that the microgrid allows is very short

Islanding (hours)	Probability of Serving load
4	98.7%
5	87%
6	71%
8	24%
10	18%
12	11%

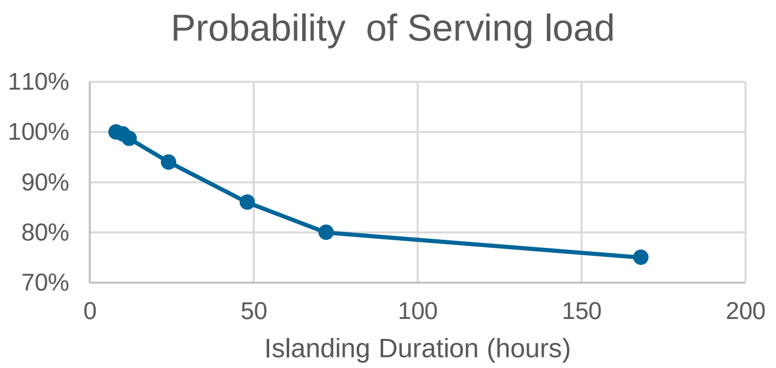


Duration

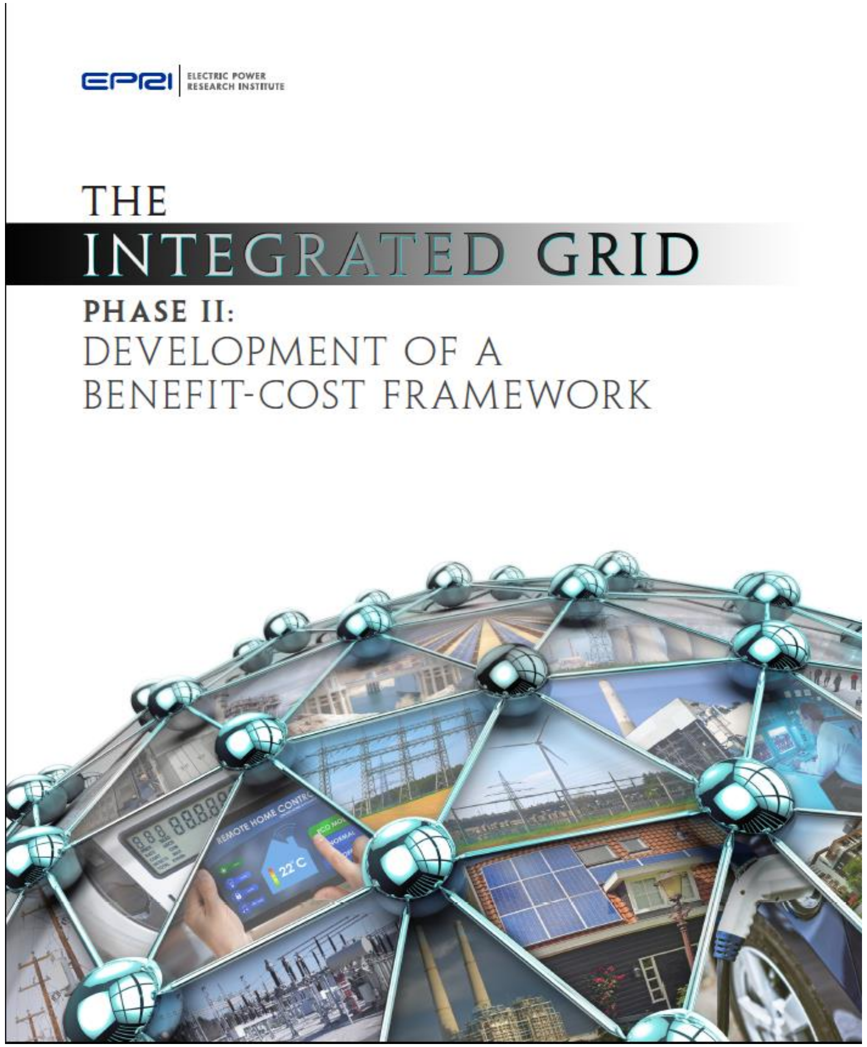
Operation including Diesel generator

- The microgrid considered for the site includes a 30 kW Diesel generator
- Allowing the Diesel generator to operate at full capacity during islanding, yields a very high probability of serving an outage
- After three days, probability of serving loads diminishes to less than 80%

Islanding (hours)	Probability of Serving load
8	100%
10	99.6%
12	98.7%
24	94%
48	86%
72	80%
168	75%



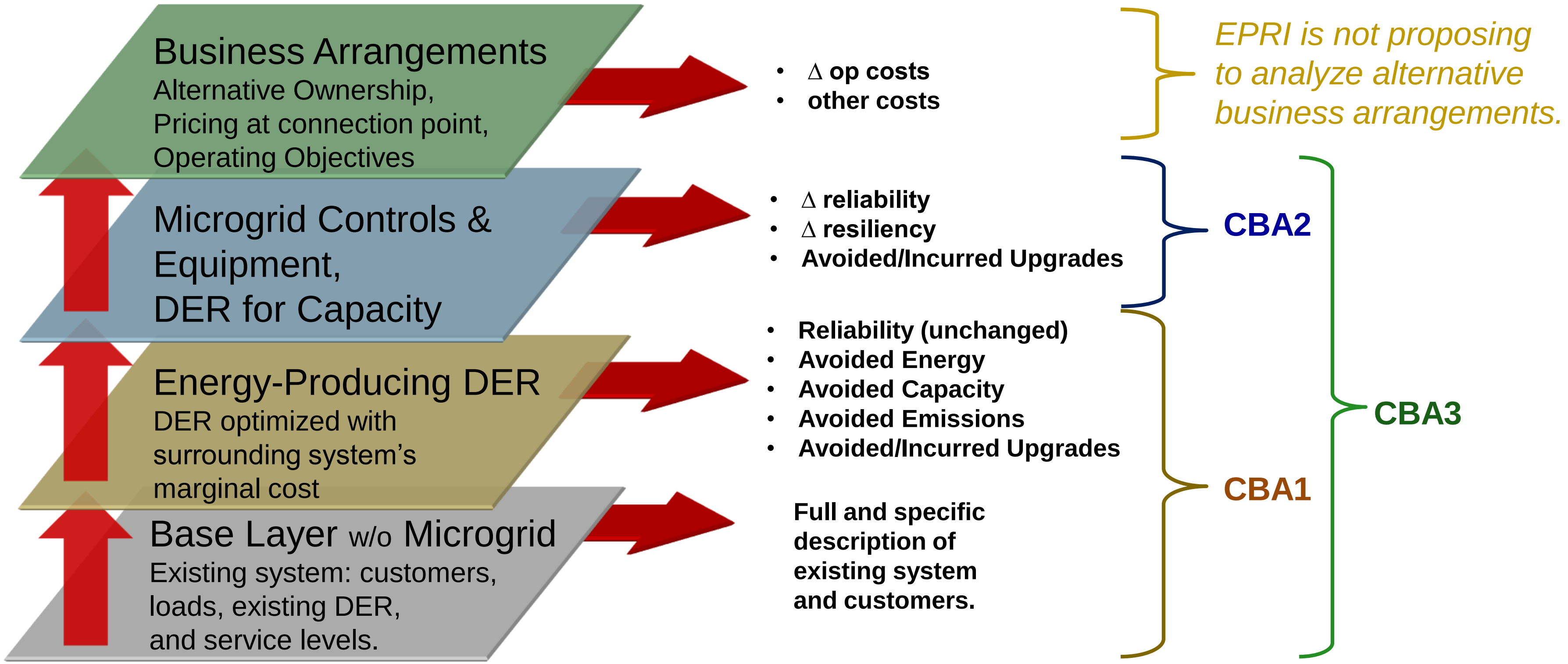
EPRI's Benefit-Cost Framework



Commendation by the National Association of Regulatory Utility Commissioners

Integrated Grid Cost-Benefit Framework

"Stacking Order" for DER and Microgrids



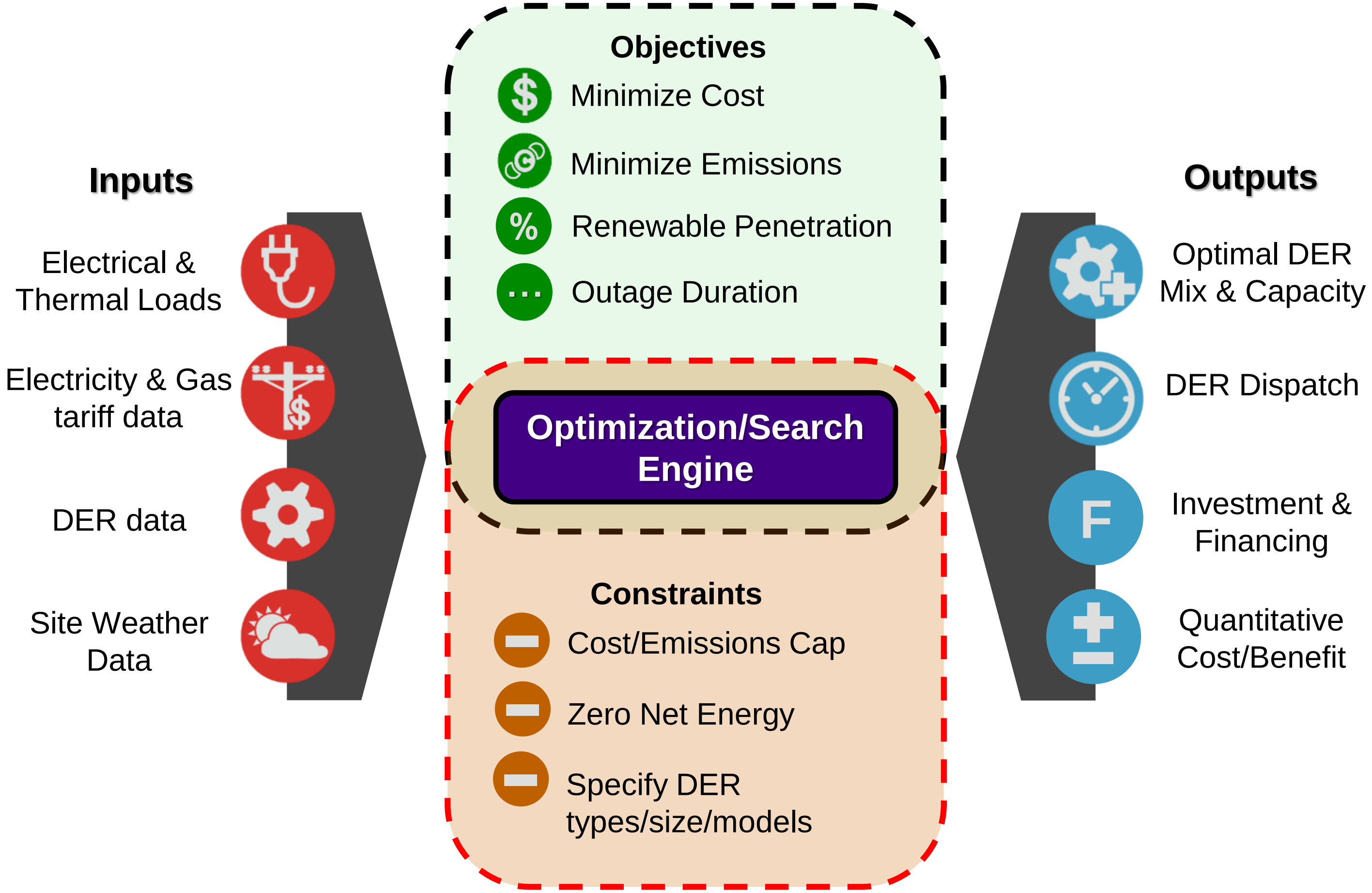
CBA 1: What is the net value of the energy-producing DER?

CBA 2: Does the value of incremental reliability/ resiliency outweigh the incremental cost?

CBA 3: Does the total value of the DER outweigh its cost?

Modeling & Tools

DER-CAM Modeling Overview



Questions?

Together…Shaping the Future of Electricity