Pursuing PV + Storage

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Jon Hawkins
Manager, Advanced Technology and Strategy

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PNM WAS AN EARLY INVESTIGATOR OF PV WITH STORAGE

Project Description

- DOE Smart Grid Storage Demonstration Project – Sept 2011
- Designed to shape PV output both by smoothing PV intermittency as well as shift PV energy for various applications

Equipment

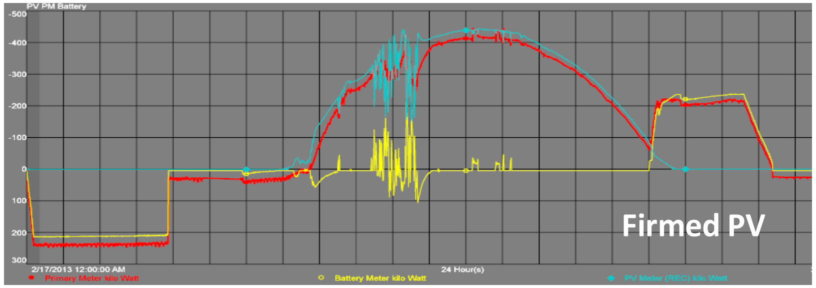
- 500 kW PV (fixed C-Si panels
- Ecoult/East Penn - Advanced Lead Acid Battery system for “shifting” – 1MWh
- Ecoult/East Penn - “Ultra” Battery system for “smoothing - 500kW

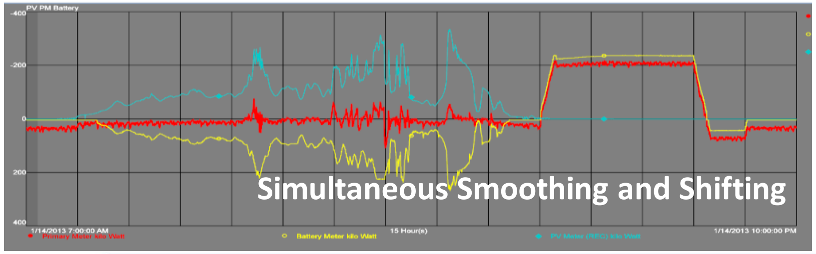
U.S. DEPARTMENT OF ENERGY

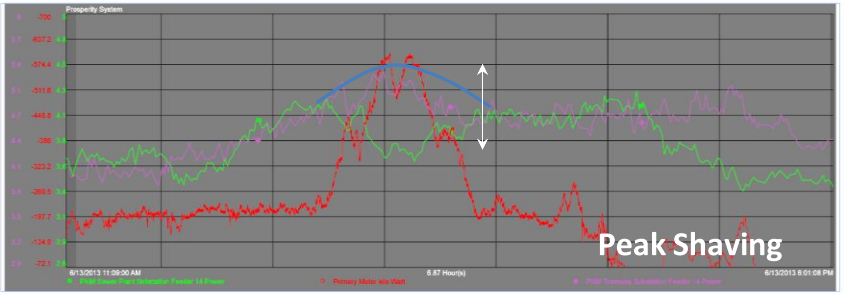
Sandia National Laboratories

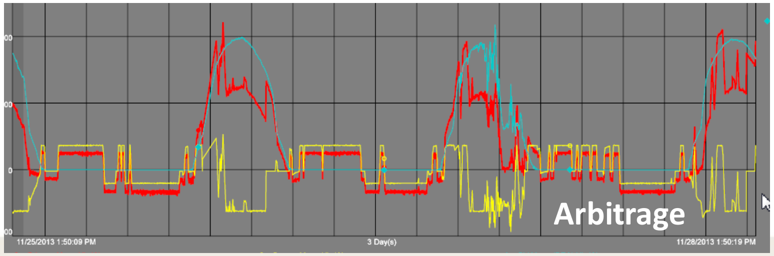
THE UNIVERSITY of NEW MEXICO

SOME PV SHAPING RESULTS







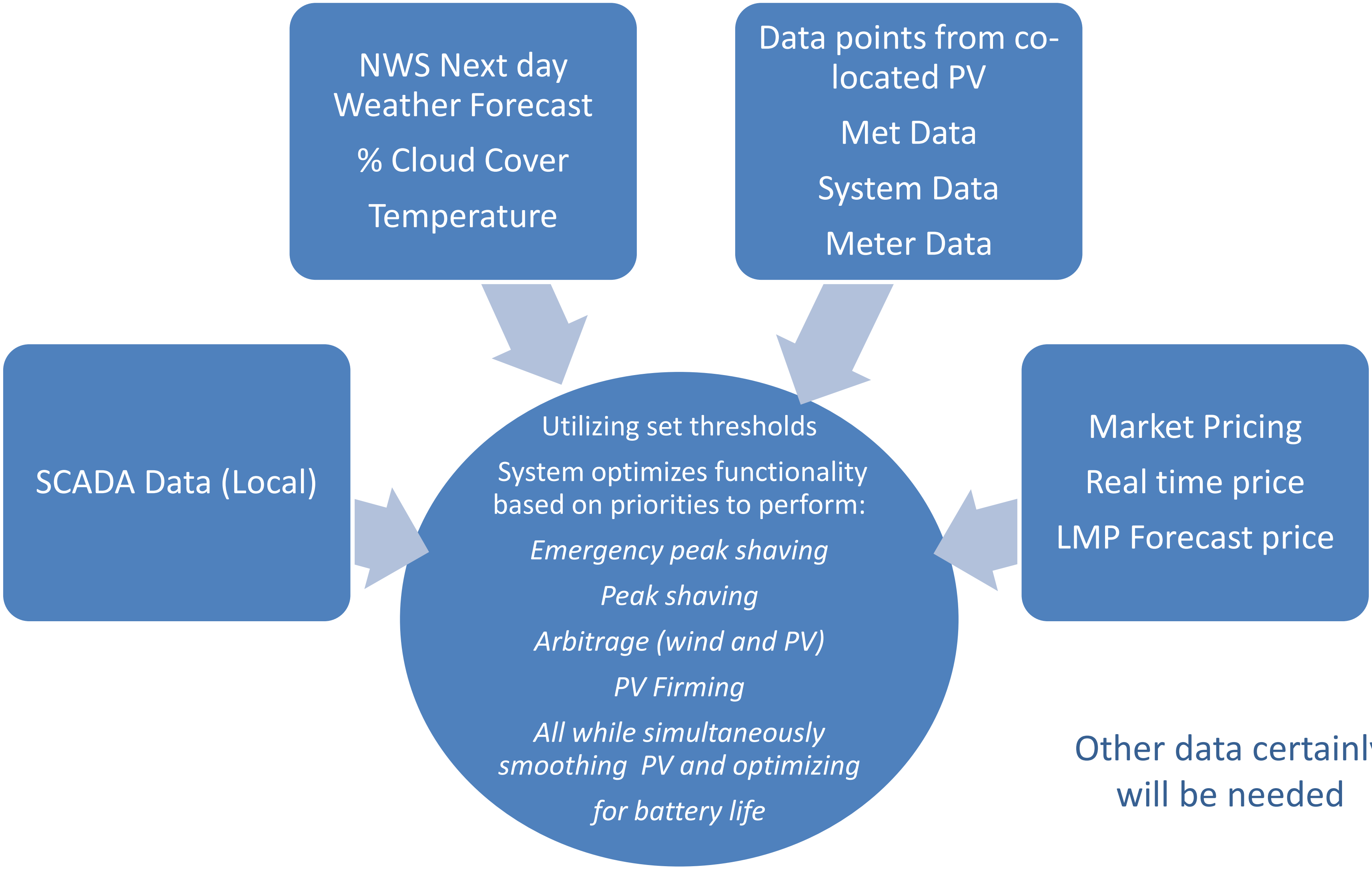


- How might we prioritize functions?
  - Frequency Response
  - Voltage support
  - Peak Shaving (reliability)
  - Firming renewables
  - Supply capacity (could be same as renewable firming)
  - Arbitrage (no market but demonstrated capability)

- Not Demonstrated in this project
  - Spinning Reserve (regulatory review needed)
  - Reactive power support
  - Distribution Upgrade Deferral
  - Transmission Upgrade Deferral

The project attempted to take the technical approach that it could be scaled to any size for battery control and operation. In reality control of the resource(s) may be quite different.

OPTIMIZATION OF ALL CAPABILITIES



Other data certainly will be needed

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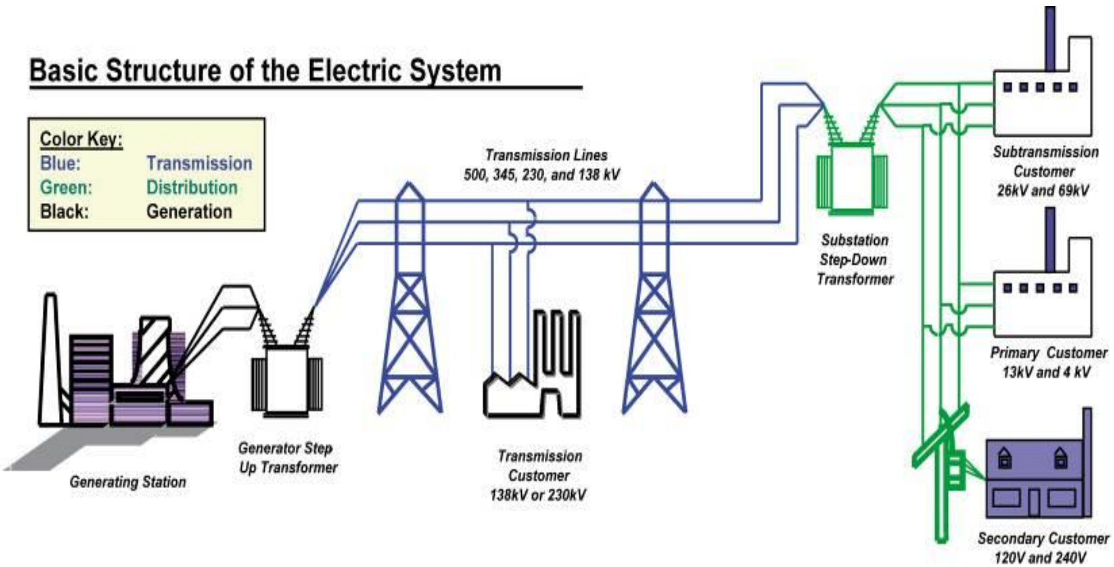
APPROACH TO STORAGE AND CONTROL TODAY DEPENDS ON WHERE IT IS INTERCONNECTED



Transmission

- Possibly a more manual dispatch
- How to take advantage of all benefit streams?
- Market considerations (or lack of)

Distribution/Customer

- More automation needed
- Affect to distribution system
- Customer side complexities

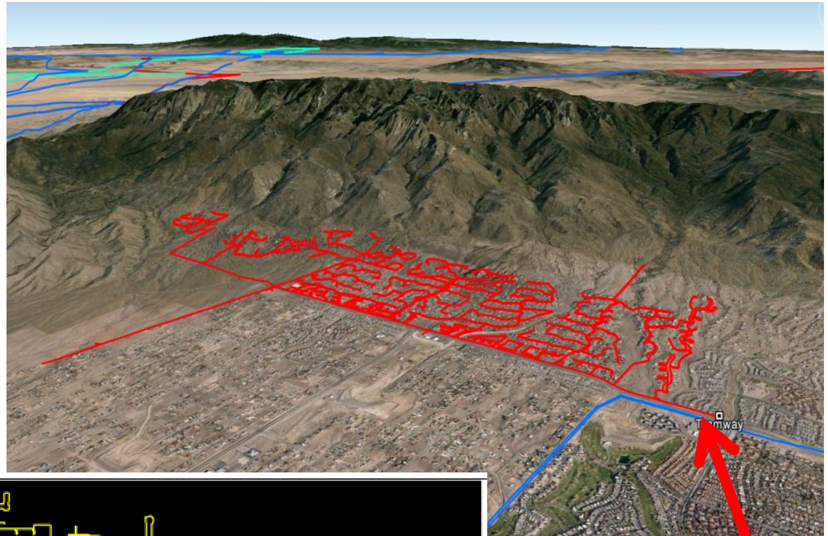
INTERCONNECTION AND OPERATION CONSIDERATIONS

- Transmission (Early thoughts)
  - In the short term, large scale transmission storage (10+ MW scale) may look very similar in dispatch and operation to a gas peaking plant for day ahead market
  - Economics of the market (or lack of in PNM's service territory today) would look to charging based on renewables but natural gas must also be considered. Without incentives and absent reliability drivers, why not just dispatch the PV and wind directly with no need to store them?
  - Economics must consider cost to charge and what if any incentives are outside of a organized market.
  - Is there an arbitrage opportunity or would there be customers or power producers willing to pay premium for renewables in an off peak situation and/or want to sell renewables when sun isn't shining or wind is not blowing
  - Charging costs balance - $ per MMBTU + $ MW (unless fully charged by renewables), whereas today natural gas generation is just $MMBTU outside of an organized market that may provide some incentive
- PNM is interested in possible transmission scale energy storage and issued an RFP (today we do not have Transmission scale energy storage)
- Centralized vs. distributed storage to support future generation resources – when we have no large scale storage the first MWs of centralized are probably low risk, but as generation becomes more distributed, when do we have to consider large scale stranded storage assets.

INTERCONNECTION AND OPERATION CONSIDERATIONS

- Choice of Distribution system initially for PNM for PV resources (and may have some affect on energy storage)
  - PNM has 100 MW of utility owned PV interconnected to distribution and nearly 90 MW of customer owned
  - Cost of interconnection less at distribution
  - Cheap, flat land. (which someday will be harder to come by)
- Distribution storage – what are we using it for and important operational question
  - Distribution upgrade deferral?
  - Balance distributed renewables?
  - How does this affect dispatch of distributed storage to take advantage of possible value streams on a system that bulk system operators or marketers don't typically have visibility of?
  - Need for co-optimization of transmission support vs. distribution power quality

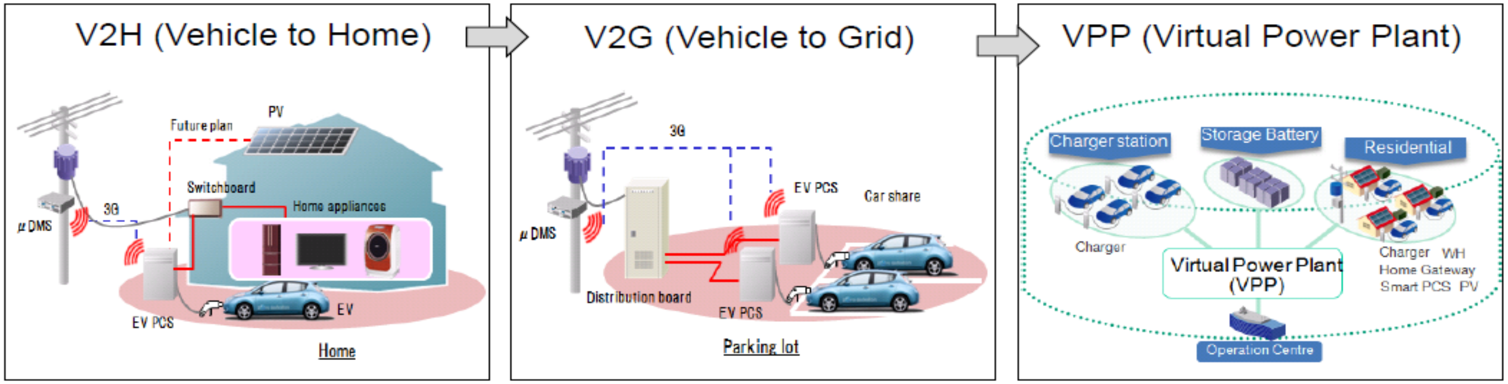
CHALLENGES NOT JUST AT BULK LEVEL- DISTRIBUTION



We know and/or manage the characteristics (Voltage, Current, Power) typically only at this point.

- Wires that feed neighborhoods can be many circuit miles long (example: Far North East heights of ABQ - 75 miles long serving 1888 customers)
- Distributed generation can cause localized Voltage issues
- Resource additions can only be calculated, not measured
- Individual loads must be estimated in PNM’s system today

ELECTRIC VEHICLES AS AN EXAMPLE OF DISTRIBUTION IMPACTS



Source: IRED 2014 Conference – Fumitoshi Emura, Hitachi

- PNM evaluated system impacts of the Albuquerque Rapid Transit Project for their charging needs (200 kW chargers for 26 buses and 80 kW chargers for 34 buses by 2020)
- Initial estimates of approximately $450k in system improvements to support with some system upgrade costs still not determined. Last phases of the project estimated 18 months lead time to add last 2.7 MW of charging.
- This is for a project in the center of a metropolitan area
- How would this contrast against a more rural or suburban application of energy storage with smaller wires, transformers, etc. just in terms of interconnection?

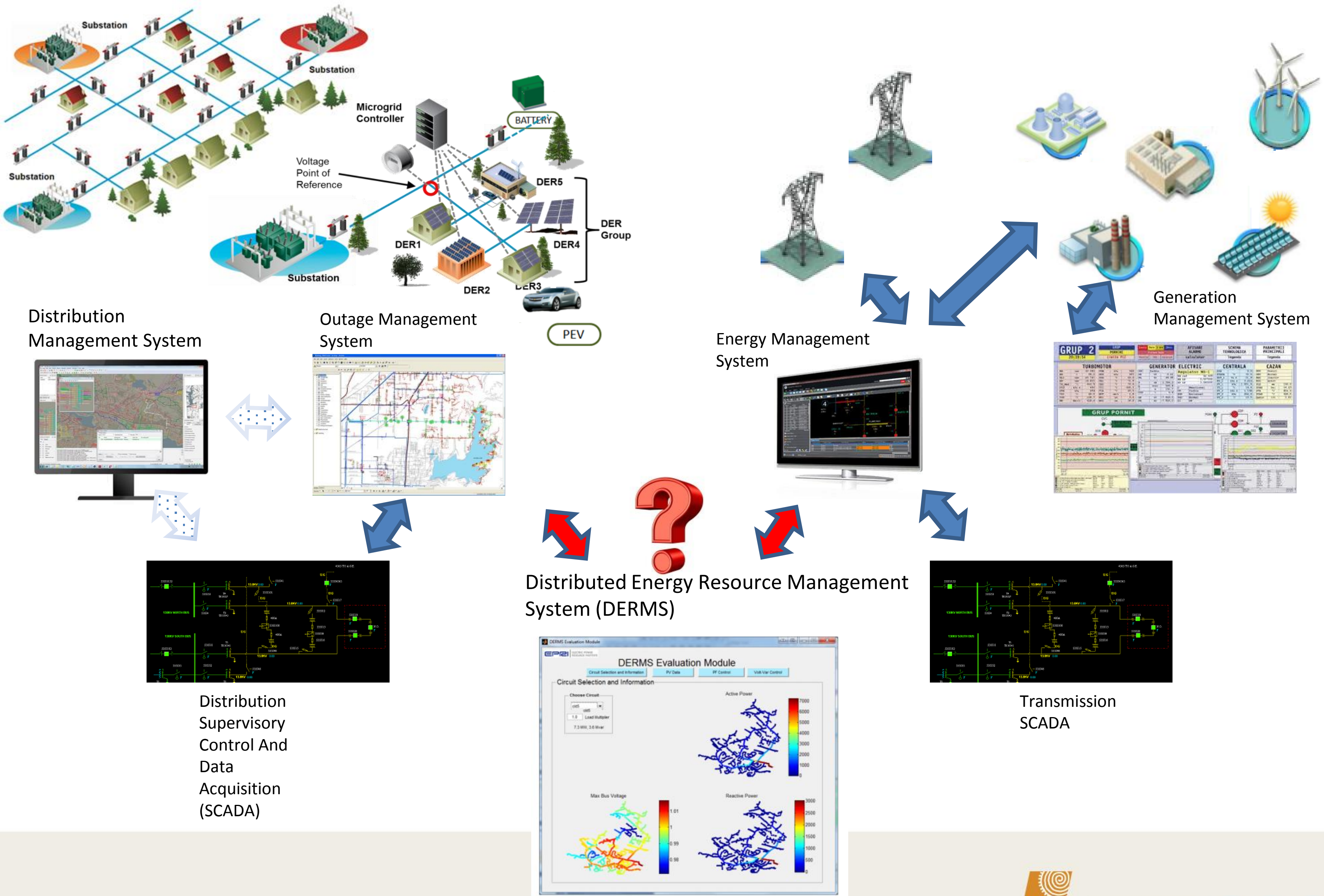
CONTROL OF STORAGE RESOURCES

- Transmission
  - Outside of an organized market – control signals for dispatch and charge are probably integrated into EMS/GMS but done more manually while economics are worked out. In a market there may be more automation if cash flows are more known for a particular service
  - Can be controlled by manual dispatch as there may be fewer installations (similar to gas plant)
  - Day ahead resource scheduling may only allocate a portion of the battery
  - Leave enough energy for 15 minutes at rated capacity for frequency response
  - Charging probably based on renewable generation (although still done manually)
  - How to evaluate other benefits of energy storage and how do they fit if dispatched manually – reliability, reserves, ramping and load following
- Distribution
  - Could be many installations such that manual individual control of each unit would be difficult
  - Probably automated - ADMS/DERMS?
  - Co-optimization problem between providing support for transmission without creating a voltage problem on the distribution level
  - Measurement data to optimization problem analysis

STORAGE – BEHIND THE METER

- Customer side
  - Similar co-optimization problem as seen in distribution, but down as far as possibly the premise transformer
  - Similar measurement data needs (maybe further into the system – premise transformer)
  - Added complexity of incentives (design and regulatory) – why would a customer pay for storage to help the grid when essentially they get energy storage functionality from the grid today.
  - Would need to be automated – ADMS/DERMS? Aggregators? (what is the optimization objective and what data do you need to make it?)
  - Can the utility count on that response?
  - Real and reactive power?
- Communications paths and protocols to control customer side devices
  - Utility – Operational networks (FAN, SCADA, AMI, public Internet)
  - Aggregators – Public internet?, Private network?
  - Security - public internet (at least 3 NERC alerts in the past year and a half that could apply)

CONTROL CENTER SOFTWARE



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FUTURE OF ENERGY STORAGE – A PNMR PERSPECTIVE

- Very bullish on the concept of energy storage as a game changing technology and valuable for integration of renewables
- PNM has issued a bid for energy storage as part of the IRP process
- Costs are still being evaluated/analyzed and working with Sandia National Labs on that evaluation
- Material science on battery chemistries needs continued work
- We need enough critical mass in the industry for:
  - More turn key options for utility scale projects (much like we have today with Combustion Turbines – generator, substation)
  - More integration with utility control center - Generation Management System (GMS), Energy Management System (EMS), Distribution Management System (DMS)/Advanced Distribution Management System (ADMS), Distributed Energy Resource Management System (DERMS)
  - Interoperation of multiple systems above
- Regulatory/Policy treatment of storage
  - Treatment as a resource (e.g. distributed ownership in Texas)
  - How to value storage as a resource
  - Storage with tax credit – can only value one of the benefit streams of storage with tax credit

Questions?

Thank you

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