EPRI Intelligrid / Smart Grid Demonstration Joint Advisory Meeting
March 3, 2010

Community Energy Storage
Presentation & Simulation Results

AEP AMERICAN® ELECTRIC POWER

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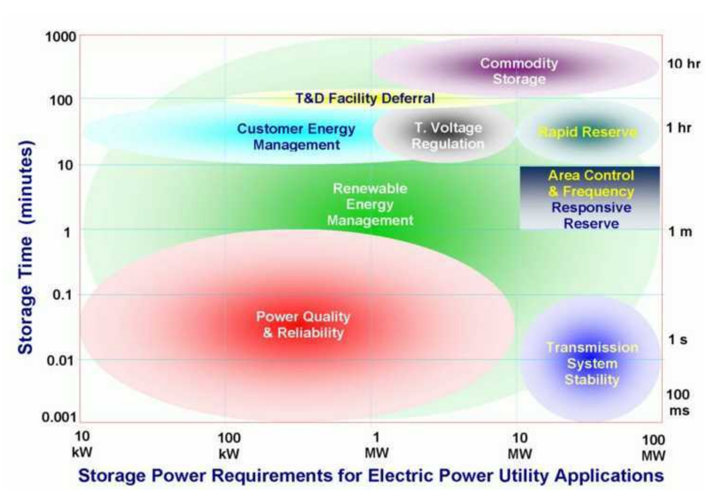
Energy Storage Applications in Utilities

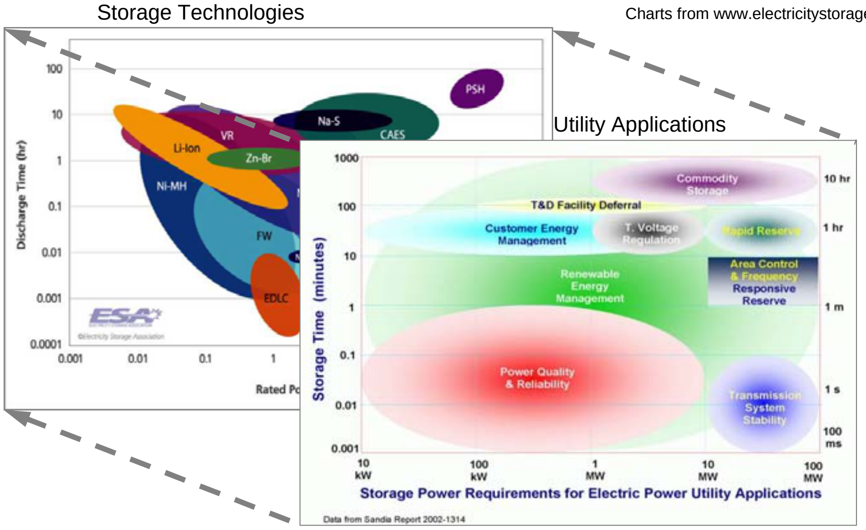


Data from Sandia Report 2002-1314

Matching Storage Options to Utility Needs

Storage Technologies

Charts from www.electricitystorage.org



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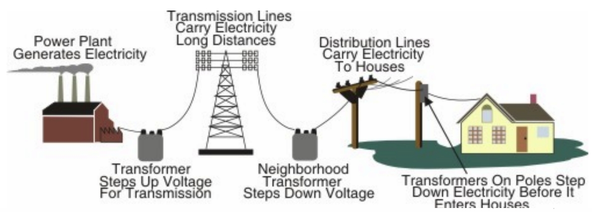
The Evolution of the Electric Utility System

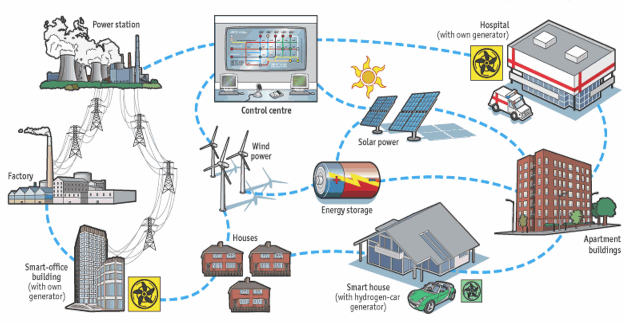
Before Smart Grid:

One-way power flow, simple interactions



After Smart Grid:

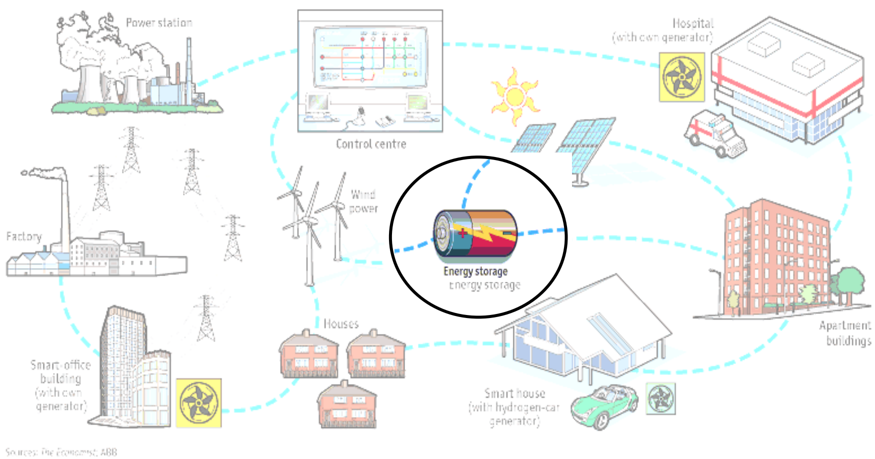
Two-way power flow, multi-stakeholder interactions



Adapted from EPRI Presentation by Joe Hughes
NIST Standards Workshop
April 28, 2008

Smart Grid Enables Energy Storage

But where is the best location/size for the storage ?



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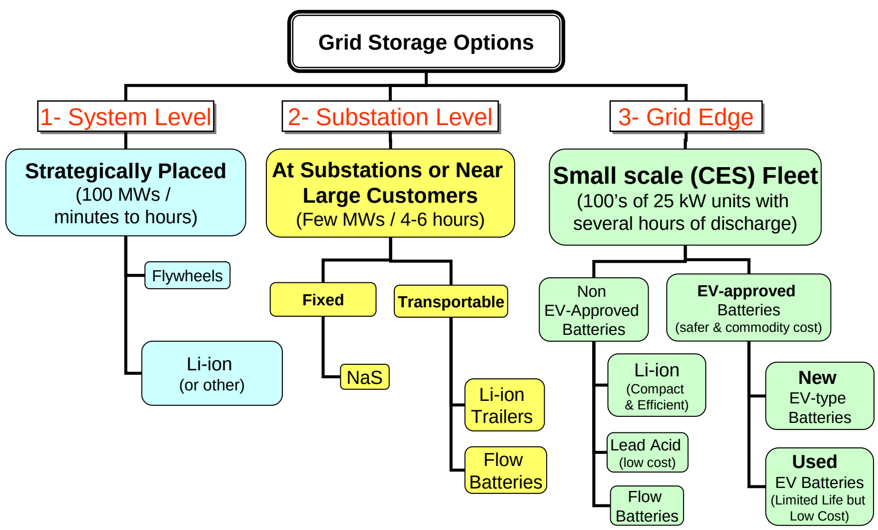
Energy Storage Options



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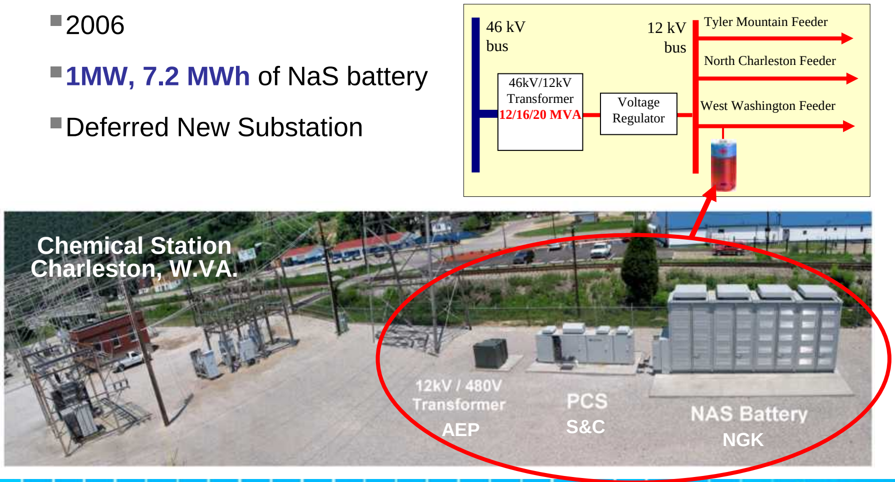
AEP's 1ST Substation Battery

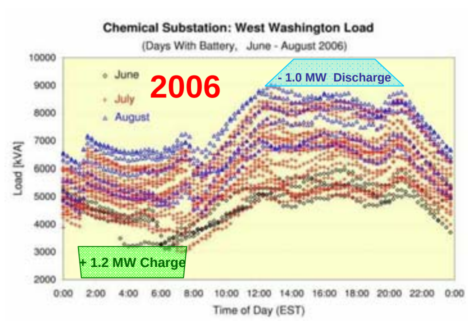
This First Utility-Scale NAS Project was Partially Funded by DOE/Sandia

- 2006
- **1MW, 7.2 MWh** of NaS battery
- Deferred New Substation

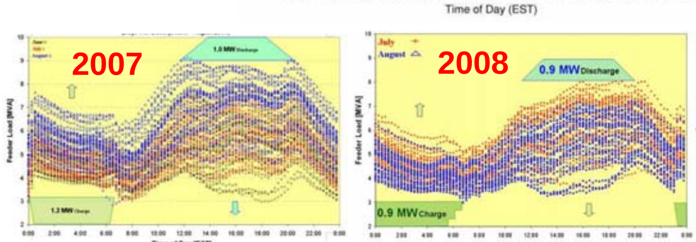


AEP 2006 Project – Peak Shaving

- Scheduled trapezoidal Charge & Discharge profiles
- Improved the feeder load factor by 5% (from 75% to 80%)
- Reduced the oil temperature of the 20MVA supply transformer by about 4 degrees C



Three Successful Years of Peak Shaving



AEP Storage 2010 – 11MW, 75MWh

1 MW, 7.2 MWh installed in 2006

- Deferred substation upgrades

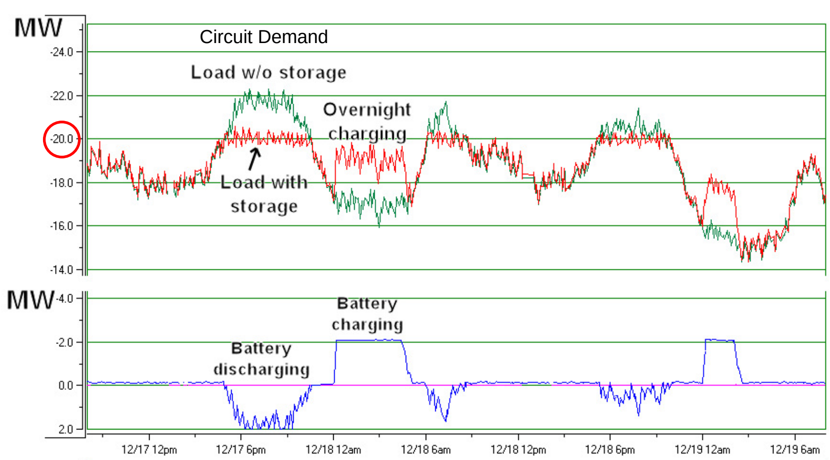
3 - 2MW,14.4 MWH Commissioned in 2009

- Implemented **“Load Following”**
- Demonstrated **“Islanding”**

4MW, 25MWh substation will be on-line in March 2010

The New “Islanding” feature is Partially Funded by DOE/Sandia

Load Following Peak Shaving



Performance of Balls Gap's 2MW Battery from 12/17 to 12/19/2008

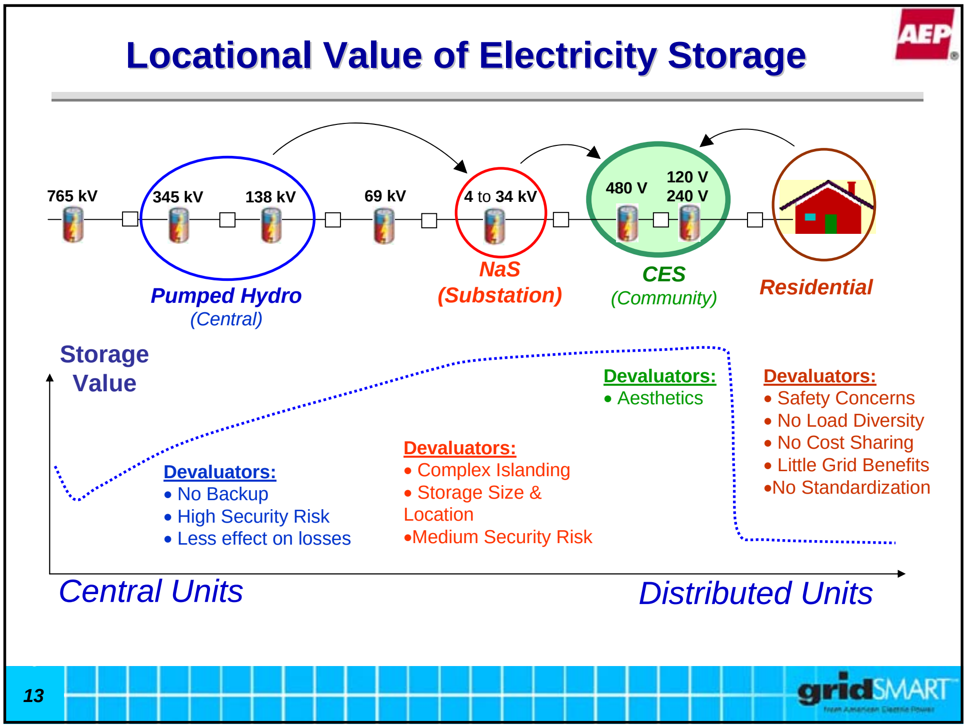
Live Islanding Experience

- **NaS Storage Site :** Balls Gap, Milton, WV
- **Outage Date:** Dec 18, 2009
- **Outage Cause:** Heavy snow
- **Island Size:** 25 Customers (small area)
- **Time to island customers:** 2 min.
- **Power Outage Duration**: 2 Days
- **Time to Exit Island:** 6 sec. (not Synchronized)
- **Average Island Load:** 167 kW

To Optimize Storage

Need an energy storage system with the following FOUR key features:

1. Very Close to Customers
   - Backup Power,
   - Buffer Customer Renewables
2. Grid-Connected
   - Load Leveling,
   - Volt / VAR support
3. Utility-Operated
   - Load Diversity (multiple customers on one storage)
   - Improved Safety
   - Optimizing Grid Performance
4. Utility-Owned
   - Standardization & Commodity Pricing
   - Socializing the Cost


Locational Value of Electricity Storage
AEP
765 kV
345 kV
138 kV
69 kV
4 to 34 kV
480 V
120 V
240 V
Pumped Hydro
(Central)
NaS
(Substation)
CES
(Community)
Residential
Storage Value
Devaluators:
• No Backup
• High Security Risk
• Less effect on losses
Devaluators:
• Complex Islanding
• Storage Size & Location
•Medium Security Risk
Devaluators:
• Aesthetics
Devaluators:
• Safety Concerns
• No Load Diversity
• No Cost Sharing
• Little Grid Benefits
•No Standardization
Central Units
Distributed Units
13
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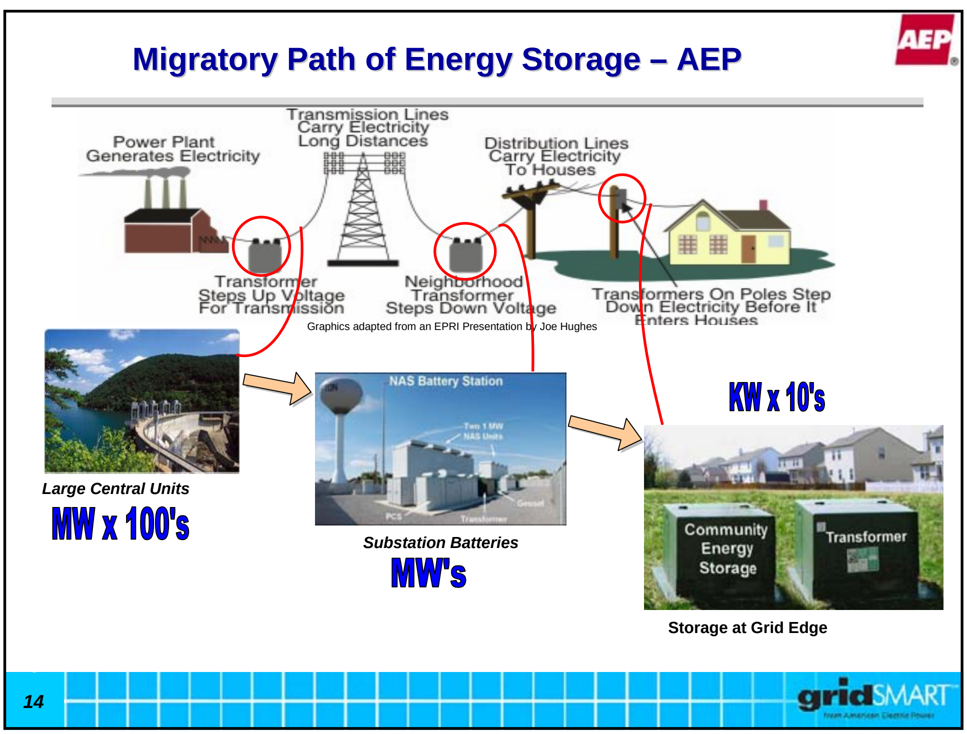
Migratory Path of Energy Storage – AEP
AEP
Power Plant Generates Electricity
Transmission Lines Carry Electricity Long Distances
Distribution Lines Carry Electricity To Houses
Transformer Steps Up Voltage For Transmission
Neighborhood Transformer Steps Down Voltage
Transformers On Poles Step Down Electricity Before It Enters Houses
Graphics adapted from an EPRI Presentation by Joe Hughes
Large Central Units
MW x 100's
NAS Battery Station
Substation Batteries
MW's
KW x 10's
Community Energy Storage
Transformer
Storage at Grid Edge
14
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Community Energy Storage (CES)

CES is a fleet of small distributed energy storage units connected to the secondary of transformers serving a few houses controlled together to provide feeder level benefits.

Key Parameters	Value
Power	25 kW
Energy	75 kWh
Voltage - Secondary	240 / 120V
Battery - PHEV	Li-Ion
Round Trip AC Energy Efficiency	> 85%

Functional Specifications for CES are "OPEN SOURCE"
In 2009 EPRI hosted open webcasts to solicit industry wide input.

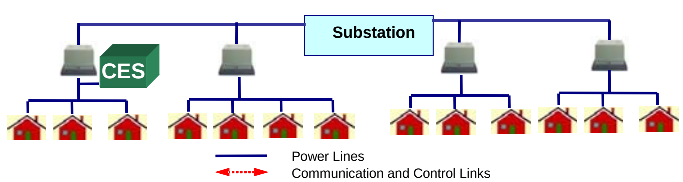
www.aeptechcenter.com/ces

CES – A Virtual Substation Battery

CES is Operated as a Fleet offering a Multi-MW, Multi-hour Storage

Local Benefits:

1) **Backup power**
2) **Voltage correction**
3) **Renewable Integration**



CES – A Virtual Substation Battery

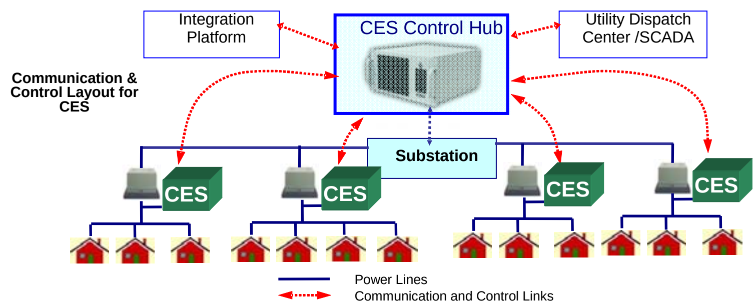
CES is Operated as a Fleet offering a Multi-MW, Multi-hour Storage

Local Benefits:

1) Backup power
2) Voltage correction
3) Renewable Integration

Grid Benefits:

4) Load Leveling at substation
5) Power Factor Correction
6) Ancillary services



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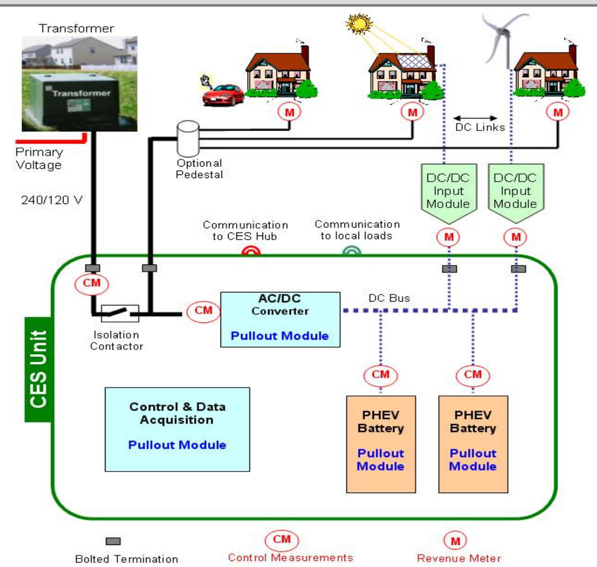
CES Layout



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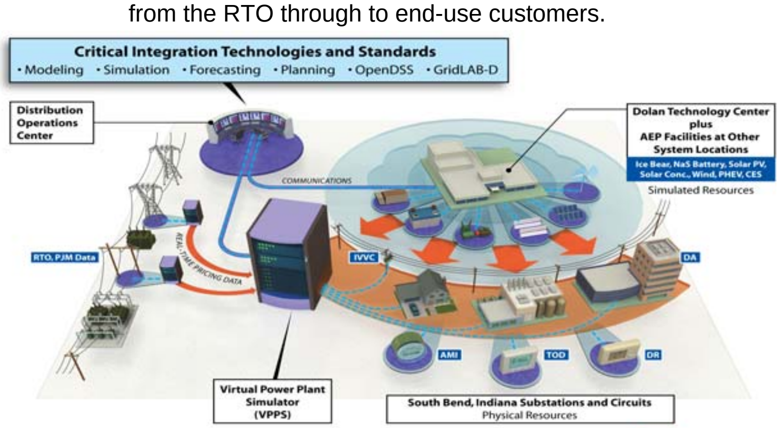
Benefits of CES

While CES is, Functionally, a Multi-MW, Multi-hour Substation Battery, It has Inherent Advantages over Larger Batteries located in Substations:

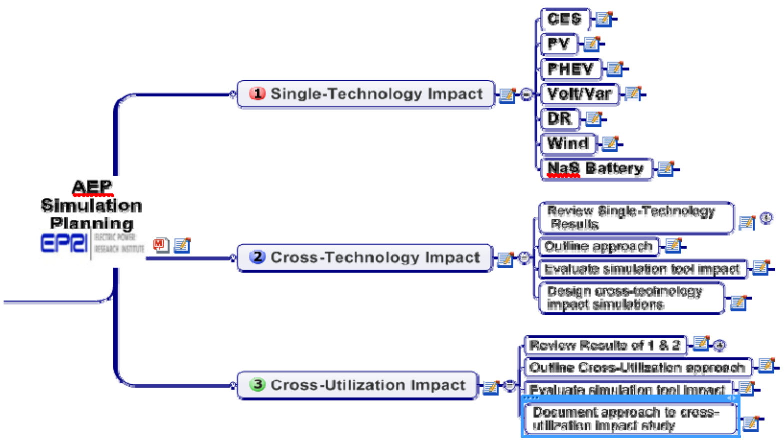
1. More **reliable** Backup Power to customers (closer)
2. More **scalable**, flexible implementation (many small units)
3. More **efficient** in buffering customer **renewable** sources
4. More synergy with **Electric Vehicle** batteries (competition)
5. Easier installation and **maintenance** (240 V)
6. Unit outage is less critical to the grid (smaller)

AEP-EPRI SMART GRID DEMO

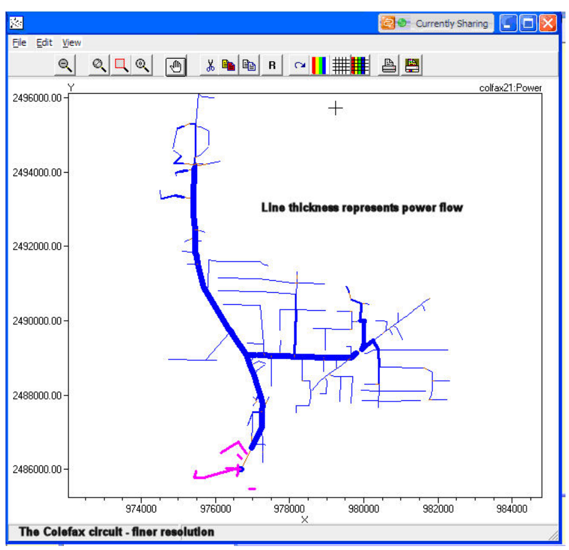
Performance of a fully integrated and robust smart grid from the RTO through to end-use customers.



AEP Approach to SG Technology Simulations

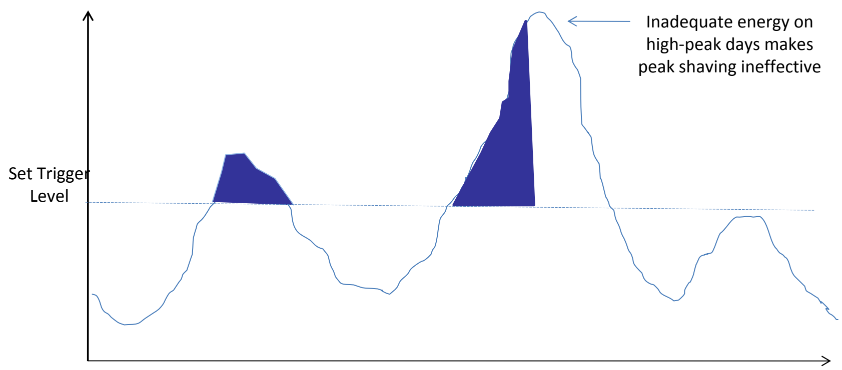


AEP Simulation – South Bend



Challenge: Need for Peak Shaving.

Ideal and simple if stored energy is sufficient. However, there is no assurance that stored energy would be adequate and , therefore, peak shaving could be completely ineffective.



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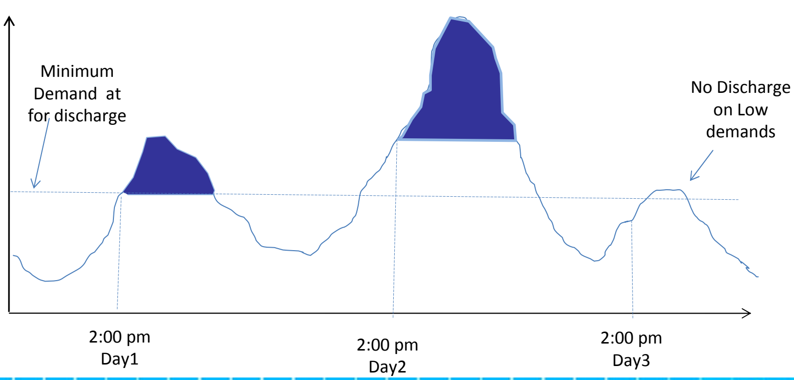
Time Triggered Discharge Parameters

- Set Points:
  - Start Time (same for all days)
  - Minimum Demand below which no energy should be discharged



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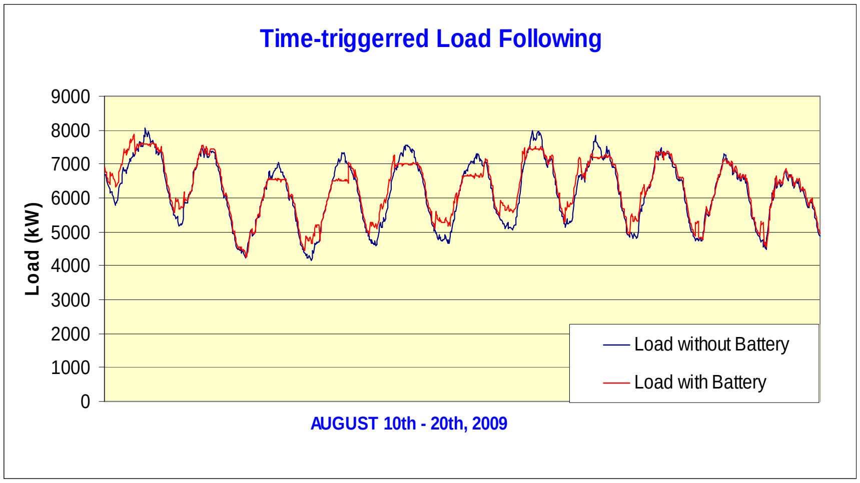
Time Triggered Load Following Simulation Results



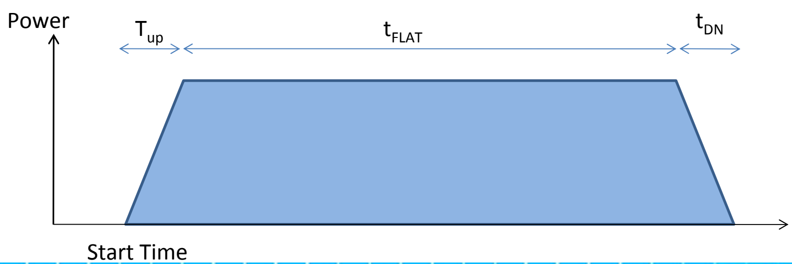
Scheduled Discharge (or Charge)

Simple but discharges a fixed amount of energy, even on the low peak days

Scheduled Discharge Parameters

- Set Points:
  - Start Time
  - Ramp Up duration (min) - T_{up}
  - Flat Duration (hours) - t_{FLAT}
  - Ramp Down Duration (min) t_{DN}

- Dynamic Inputs:
  - Unit Available Energy
  - Status (Manual, etc.)
  - Unit output (kW, kVAR)
  - Voltage



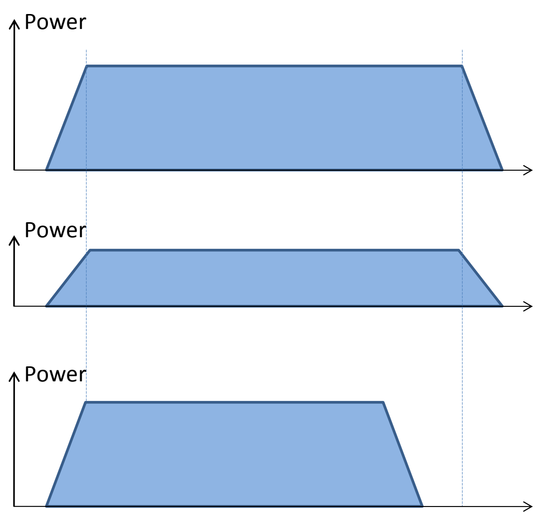
CES Unit Power & Energy

Case 1 – Reported Available energy is sufficient

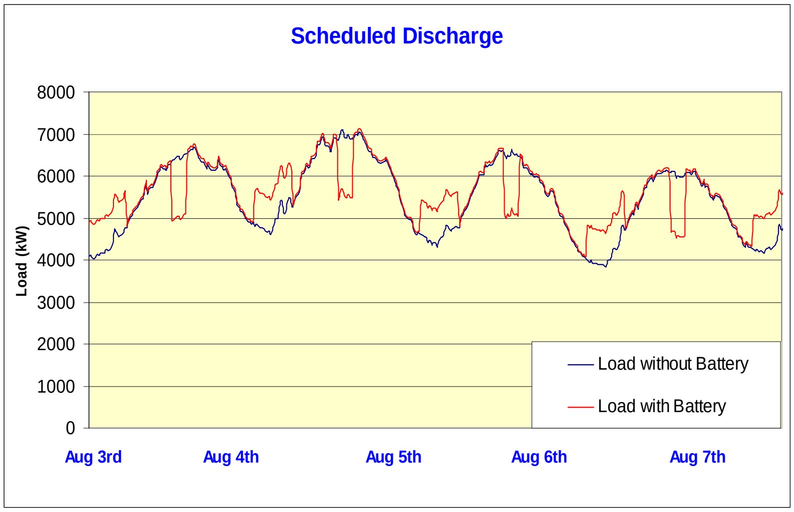
Case 2 – Available energy is not sufficient

1. Planner Option (Keep Duration, reduce Power)

2. Dispatcher Option (Keep Power, reduce duration)



Scheduled Discharge Simulation Result



Lessons Learned & Going Forward….

- Adequate storage capacity (energy) is needed to meet peak shaving (power) requirements with variable load behavior.
- Adaptive storage dispatch will permit optimal utilization of storage.
- Performance for pf correction will be analyzed.
- Cross-technology: CES will provide flexible integration into other DER schemes like VVC.

Conclusions

- **AEP** plans to deploy **Community Energy Storage (CES)** as part of its **gridSMART^{SM}** initiatives.
- **Virtual Power Plant Simulator** enables the utility to analyze the performance of a fully integrated and robust smart grid from the RTO through to end-use customer appliances.

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