American Electric Power's

Energy Storage Deployments

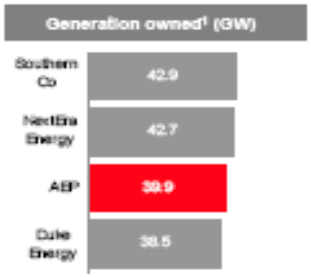
AEP AMERICAN® ELECTRIC POWER

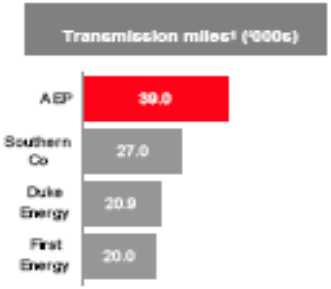
American Electric Power : Company Profile

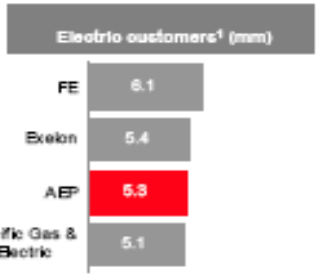
One of the largest U.S. electricity generators

The largest U.S. electricity transmitter

One of the largest U.S. electricity distributors

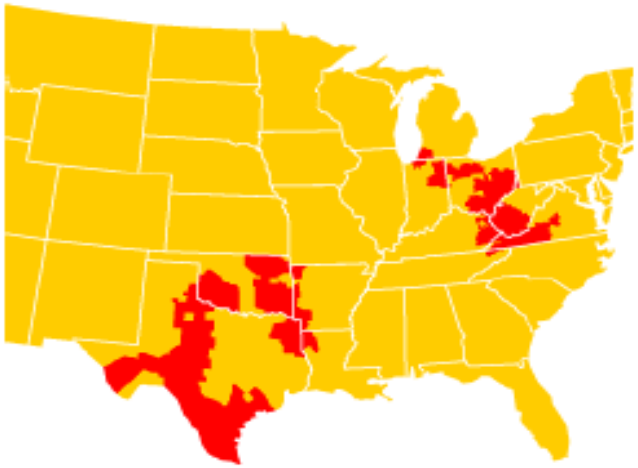






[1] : Company Filings

Serving electric customers in 11 states



AEP Fast Facts

$14.4B Revenues *
$1.2B Net Income *
10.75% System ROE *

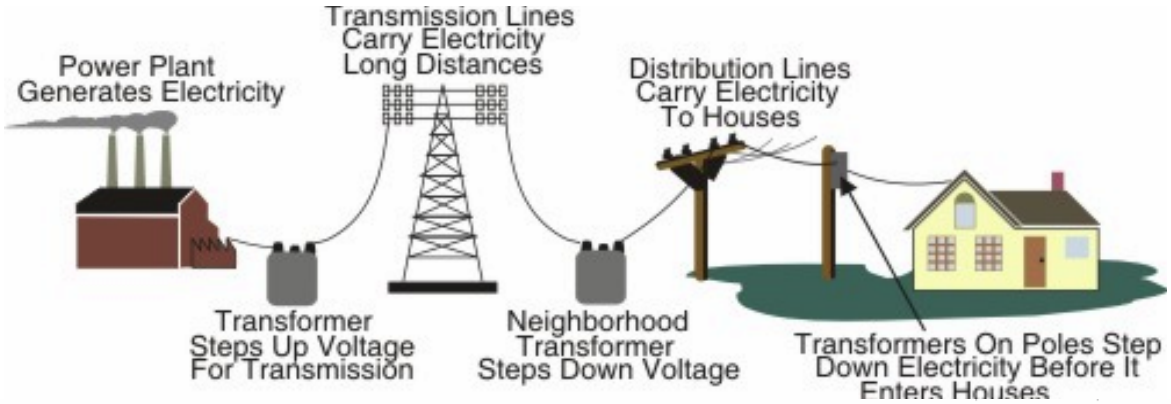
$17B Market Capitalization
BBB/Baa2/BBB credit rating

* - represents results for 2010

The Evolution of the Electric Utility System

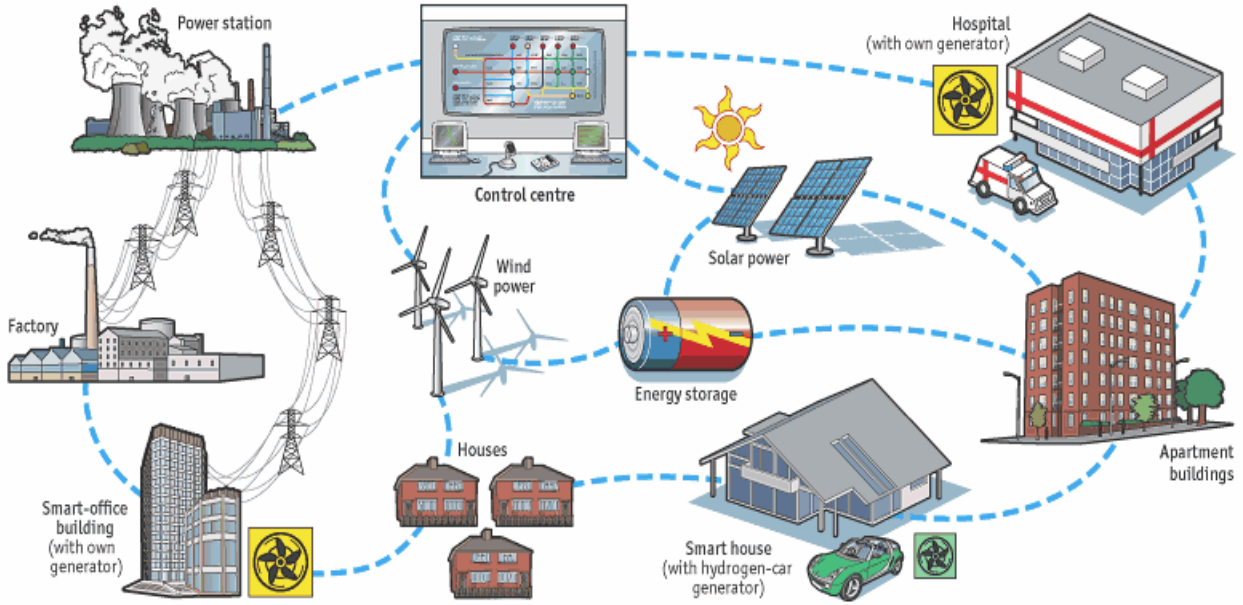
Before Smart Grid:

One-way power flow, simple interactions, limited sources of renewable generation



After Smart Grid:

Two-way power flow, multi-stakeholder interactions, increased penetration of renewable generation

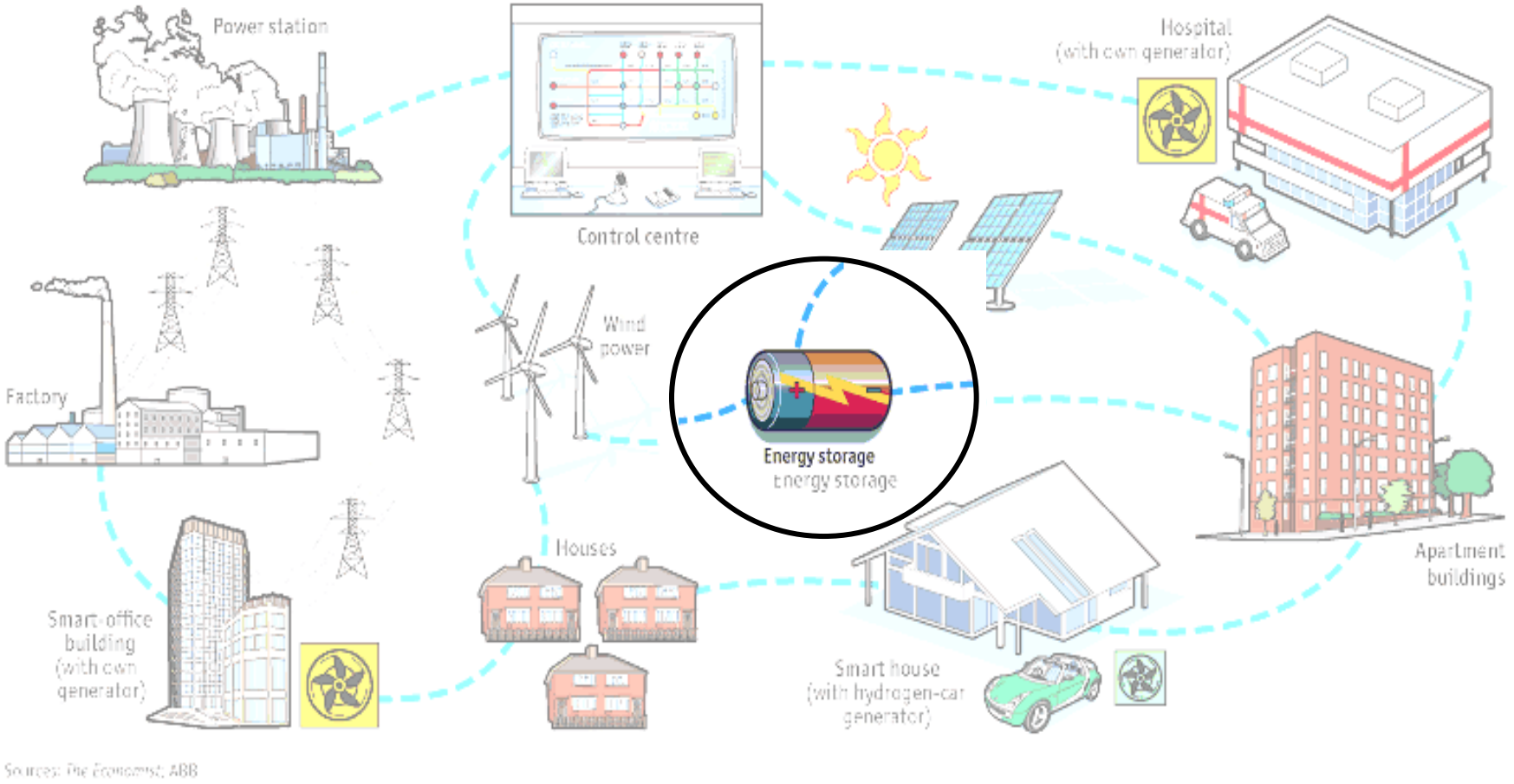


Sources: *The Economist*; ABB

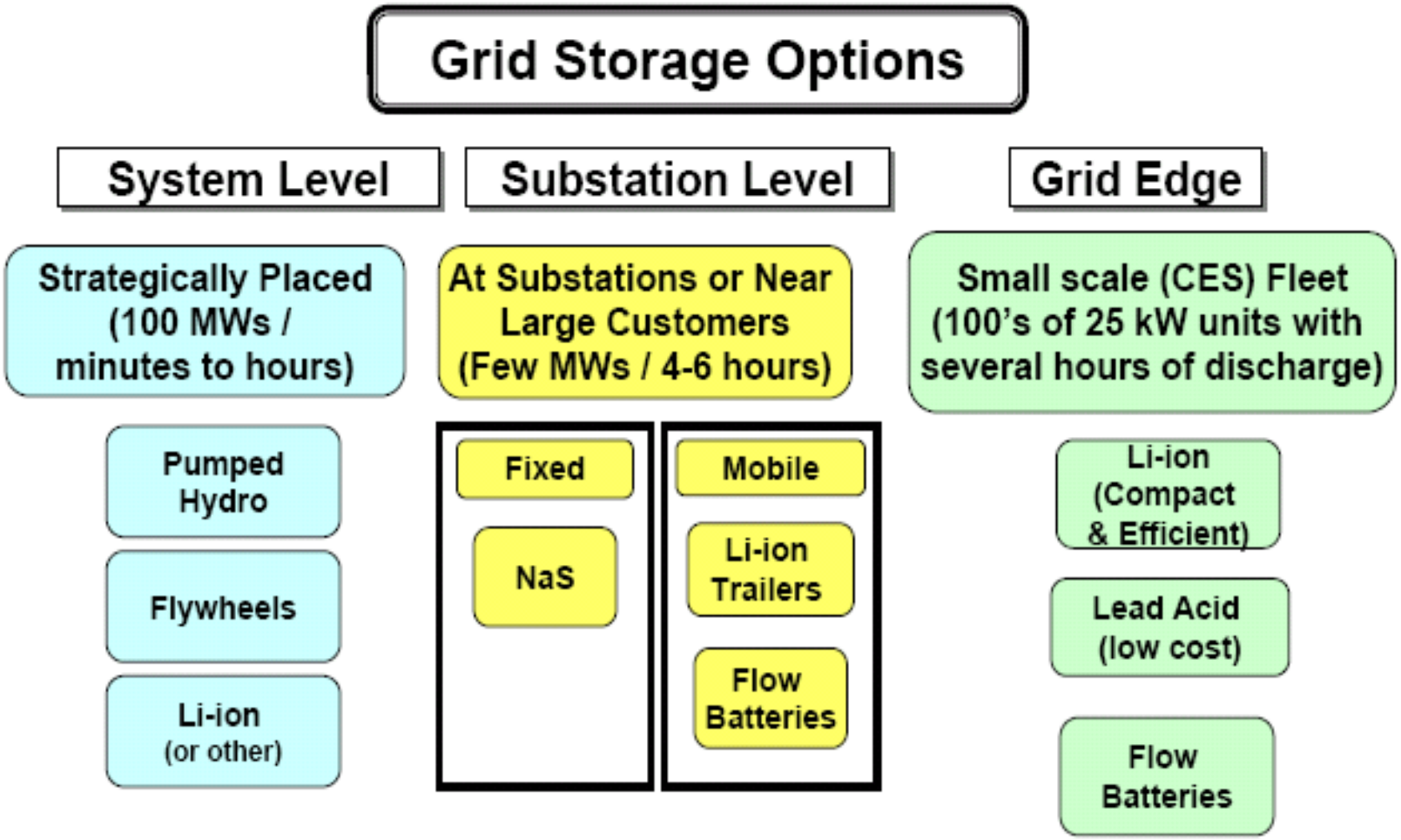
Adapted from EPRI Presentation by Joe Hughes
NIST Standards Workshop
April 28, 2008

Smart Grid Enables Energy Storage

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



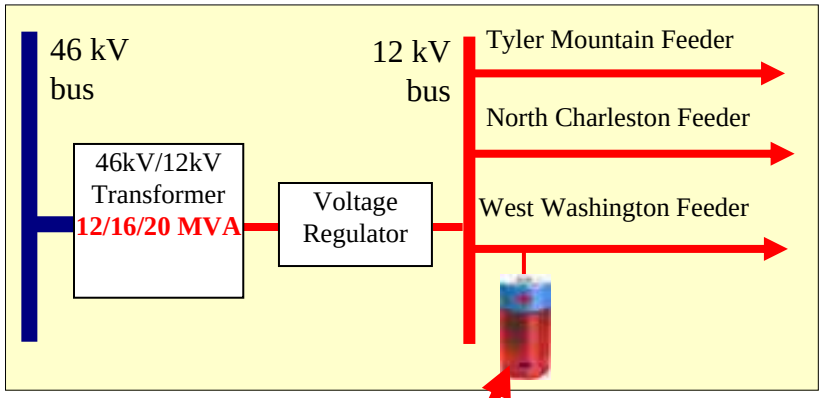
Energy Storage Options

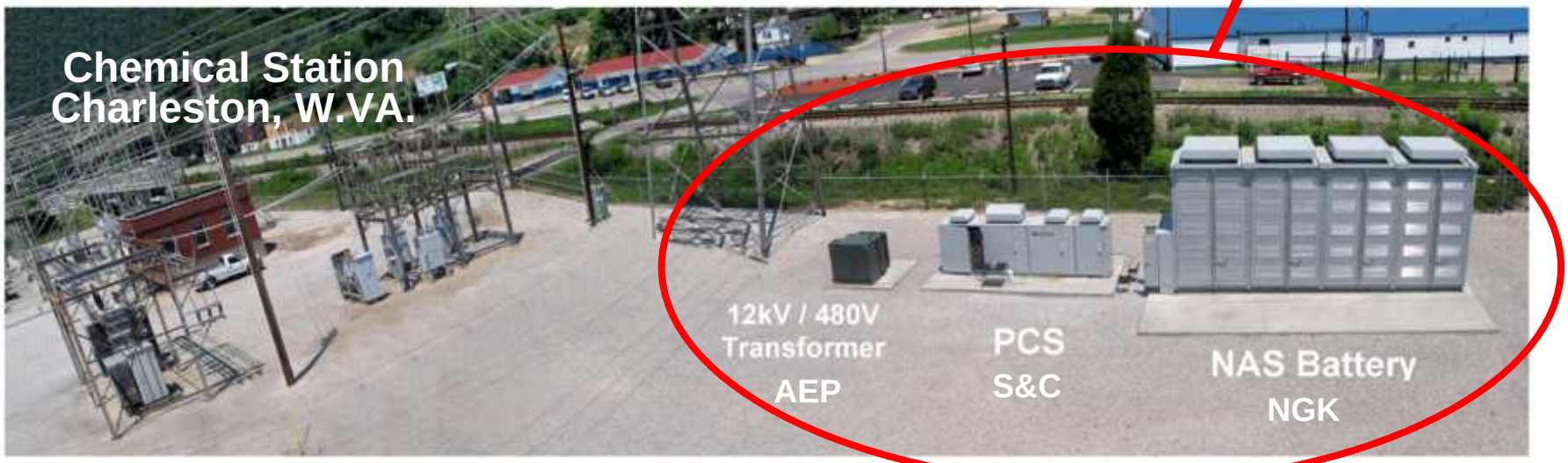


AEP's 1ST Substation Battery

This First Utility-Scale NAS Project in the U.S. was Partially Funded by DOE/Sandia

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

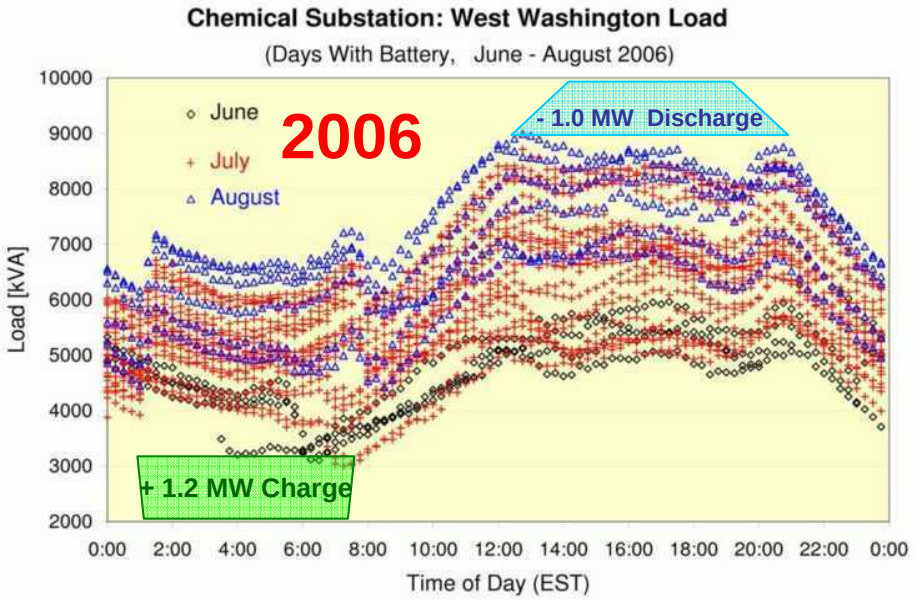




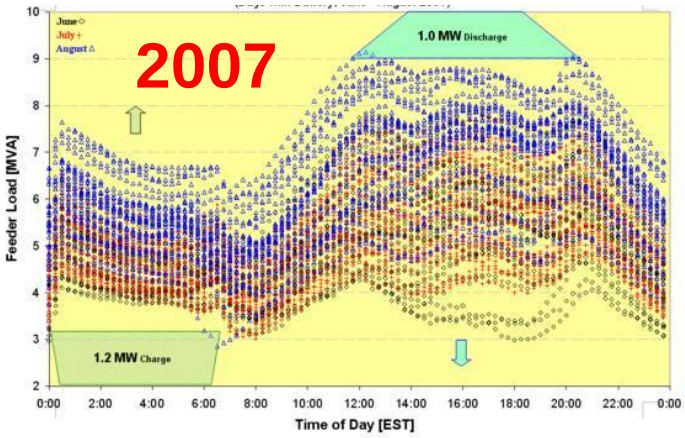
gridSMART from American Electric Power

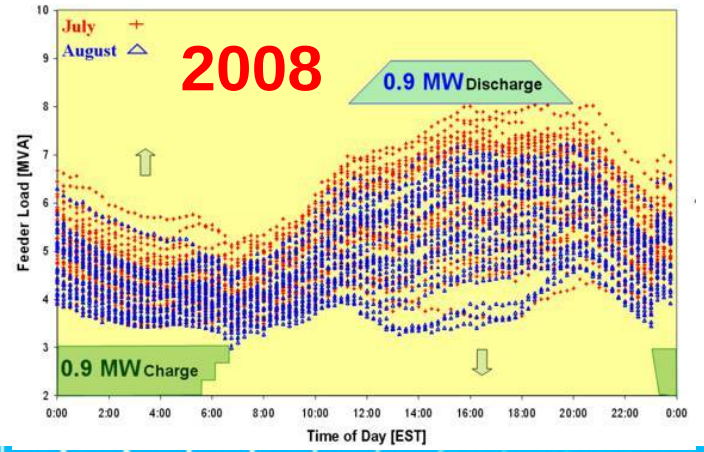
AEP 2006 Project – Peak Shaving

- Scheduled trapezoidal Charge & Discharge profiles
- Summer Month Peak Days
- Improved the feeder load factor by 5% (from 75% to 80%)



Three Successful Years of Peak Shaving





gridSMART from American Electric Power

AEP Storage 2010 – 11MW, 75MWh

1 MW, 7.2 MWh installed in 2006

- Deferred substation upgrades

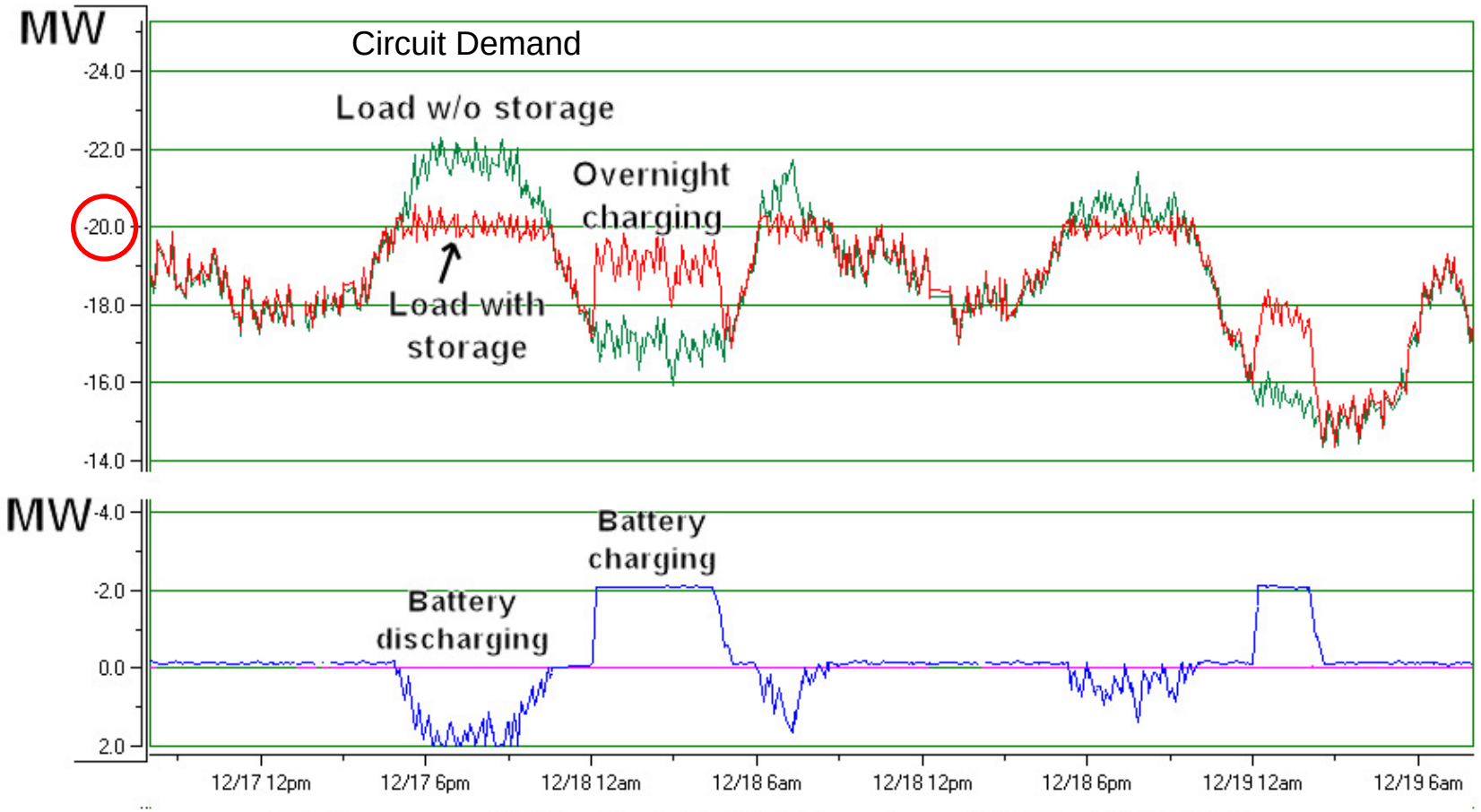
3 - 2MW,14.4 MWH Commissioned in 2009

- Implemented **"Load Following"**
- Demonstrated **"Islanding (Backup Power)"**

4MW, 25MWh substation on-line in 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

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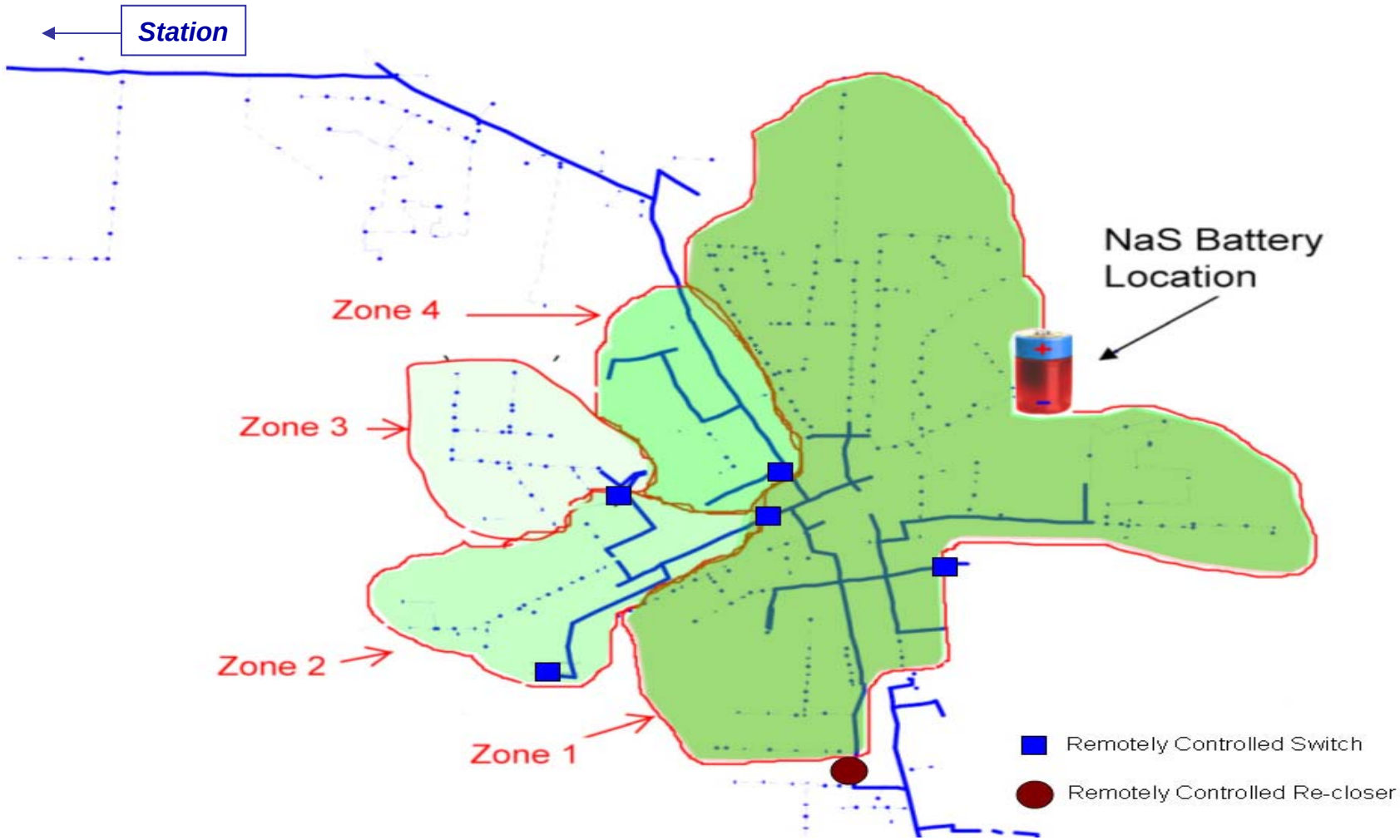
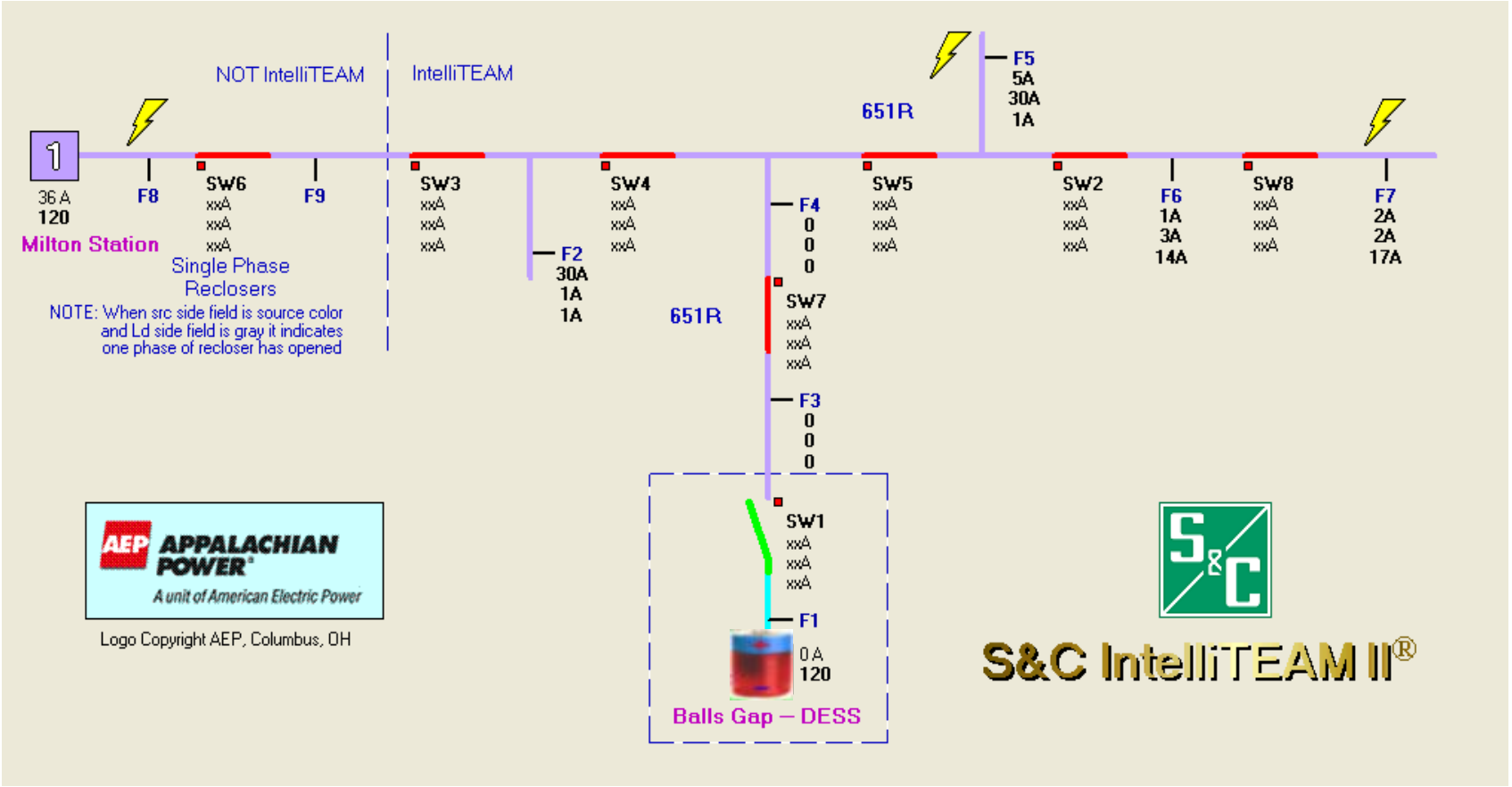
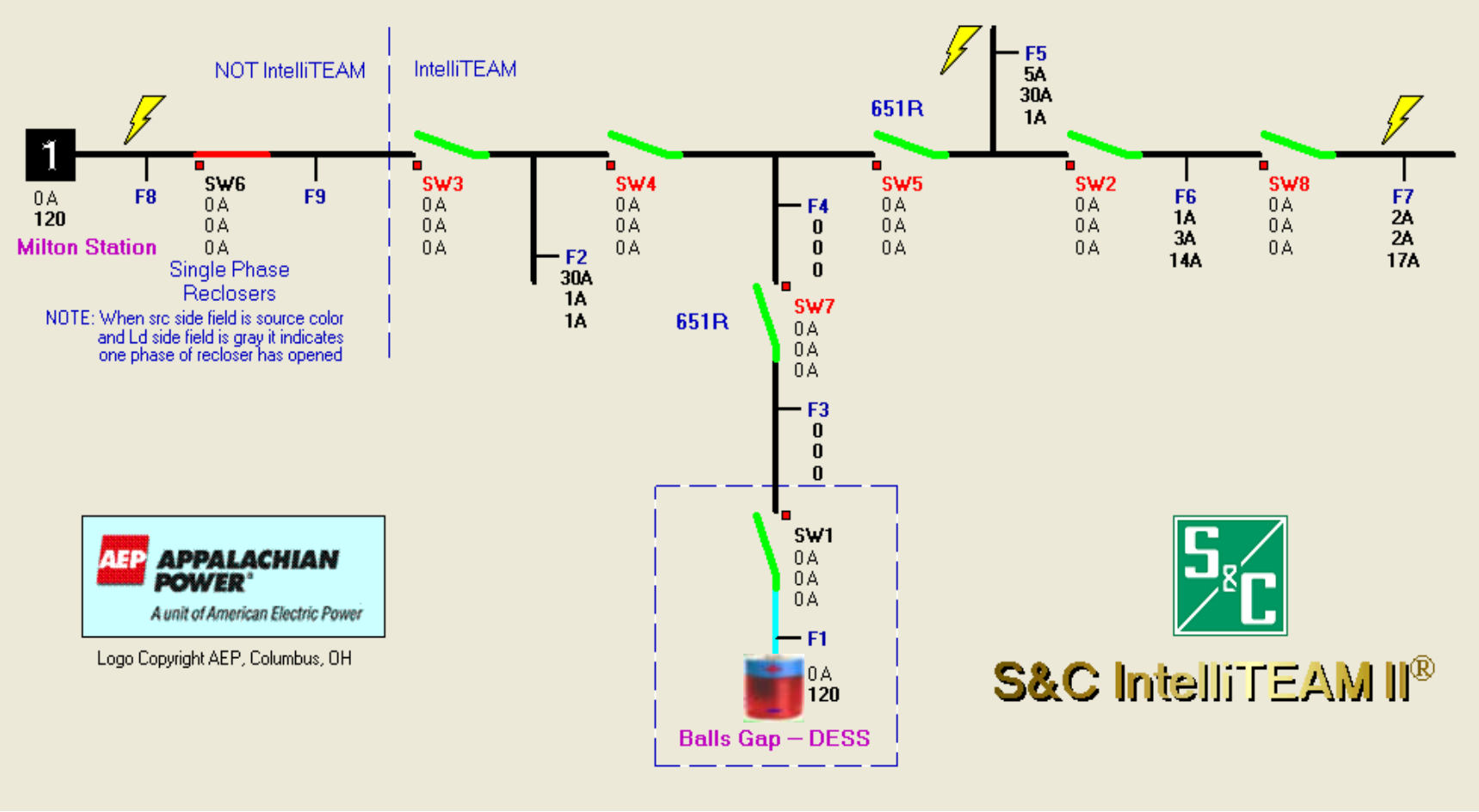
Churubusco, IN:
Battery Islanding Zones.



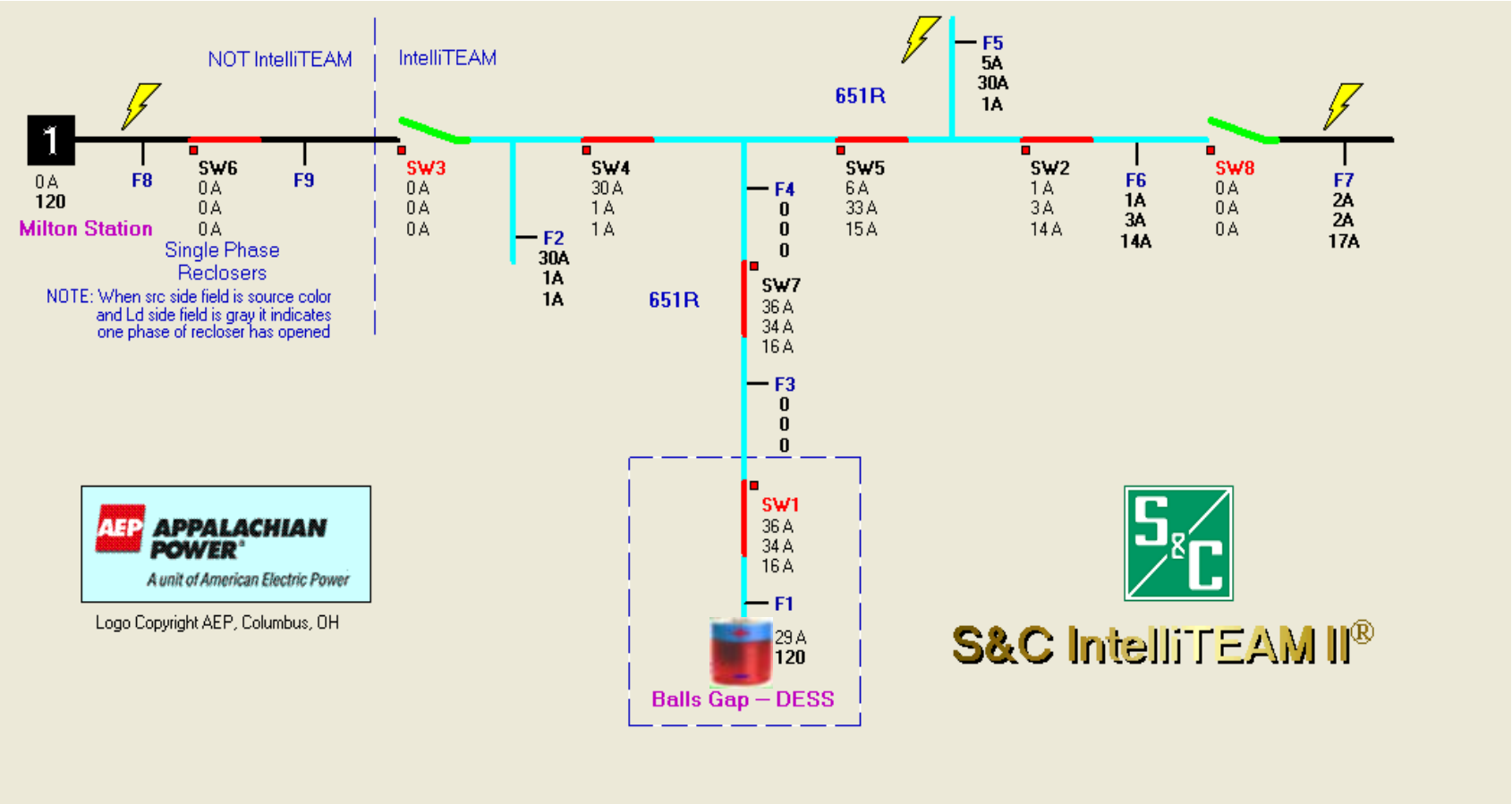
System Normal :
Grid connected. Battery disconnected.



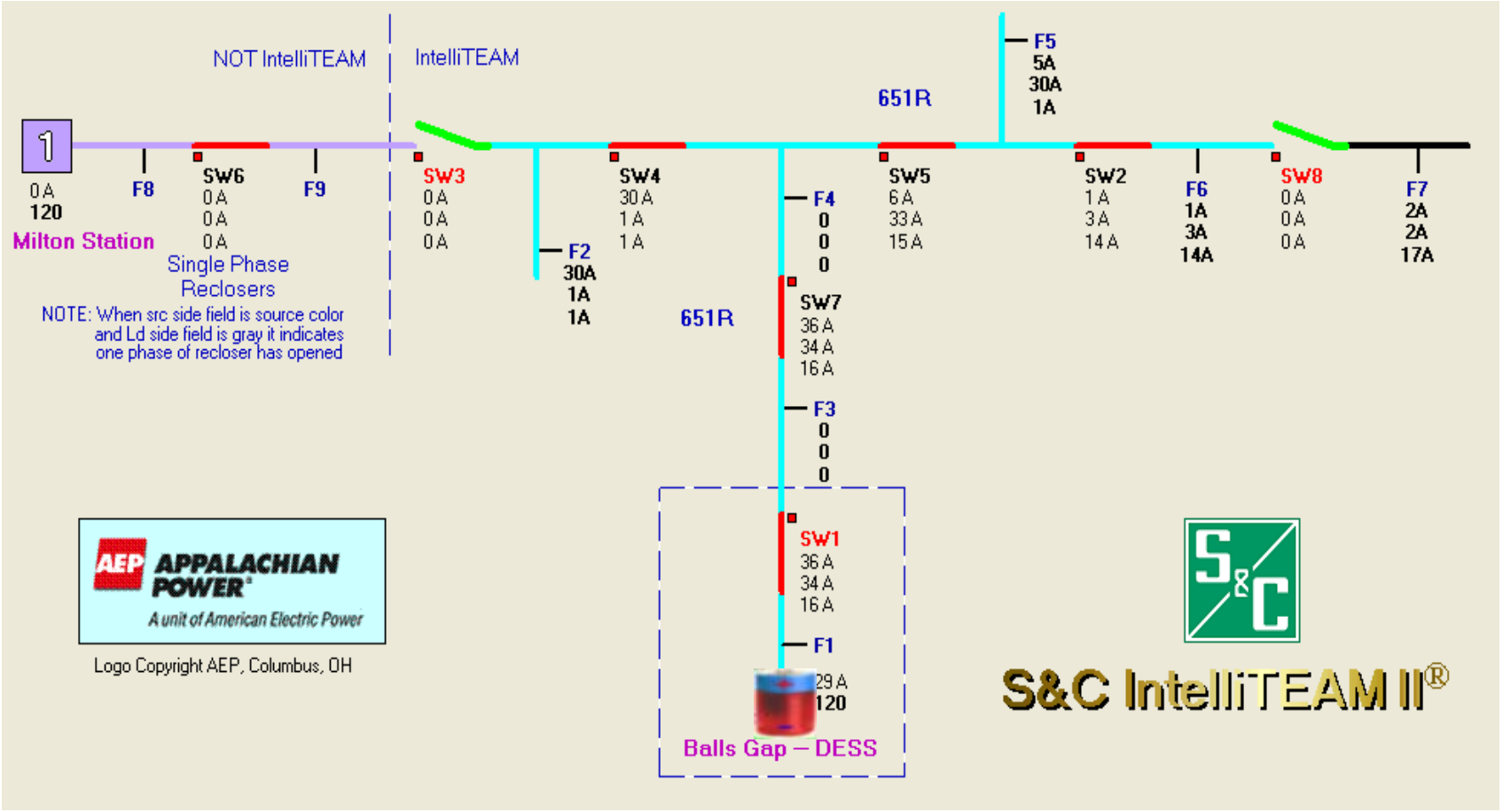
Fault at F8; loss of grid power. All reclosers and switches in the island open.



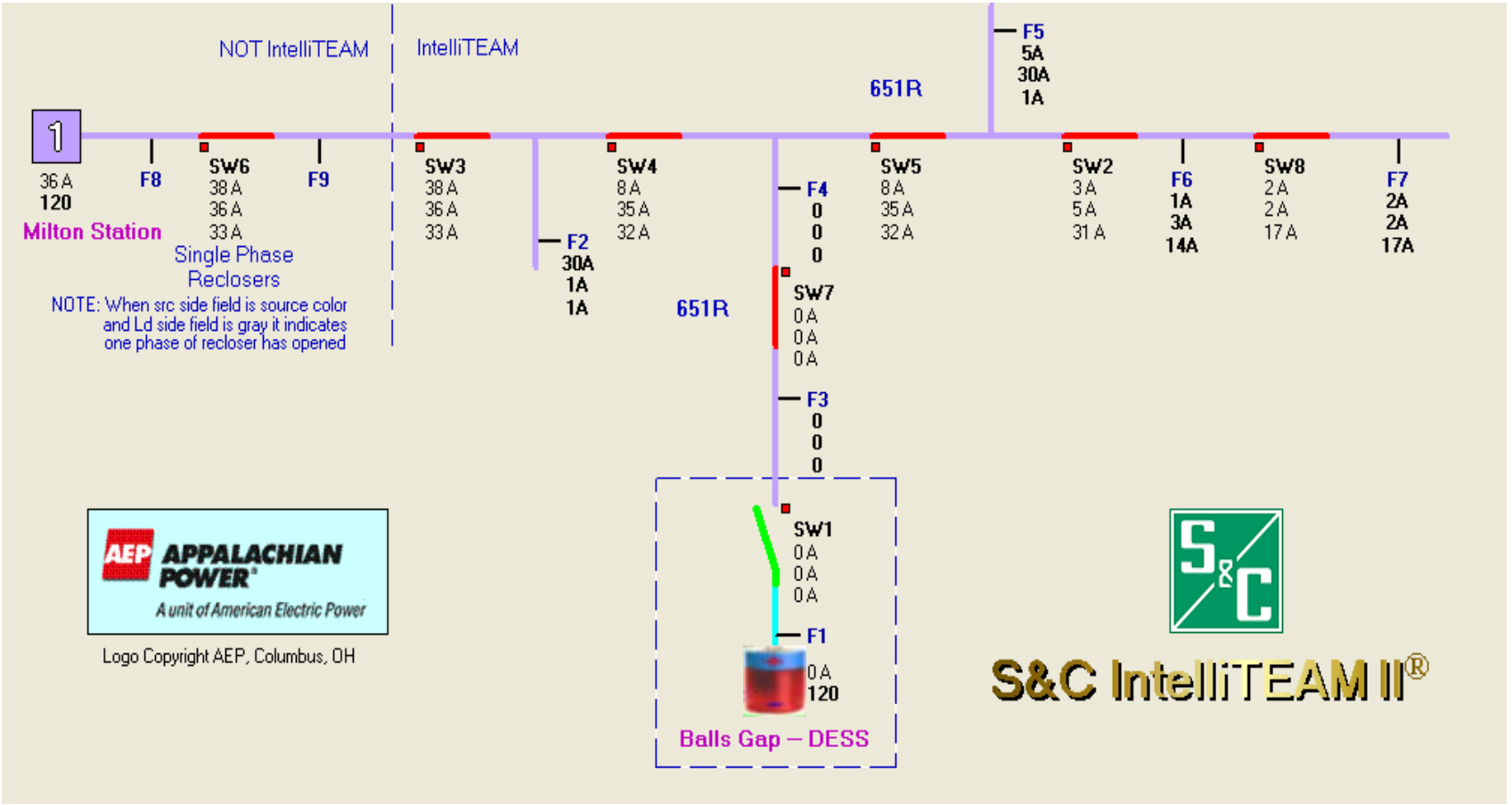
Battery picks up island based on last load information.



Grid power restored.



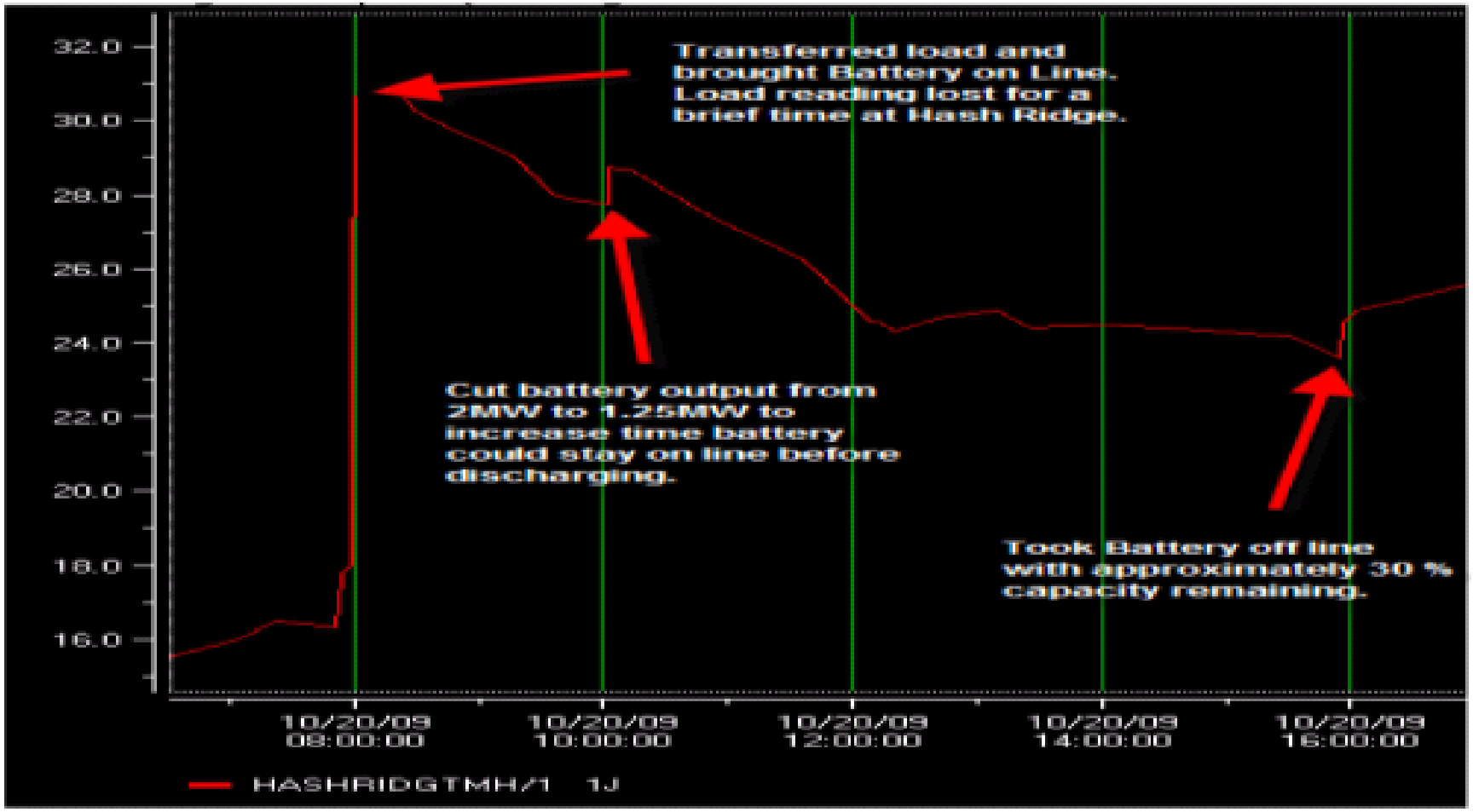
Battery disconnected. Load connected back to the grid.



Islanding (Backup Power) Events

	Event 1	Event 2	Event 3
Location	Milton, WV	Milton, WV	Milton, WV
Customers on Backup Power	25	700	700
Duration on Backup Power	48 hours	1hr 17 mins	10 hours
Cause of Outage	Ice Storm	Vehicle Accident	Electrical Fault
Date	Dec 2009	Nov 2010	Mar 2011

Battery used for Voltage Support



gridSMART from American Electric Power

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	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.

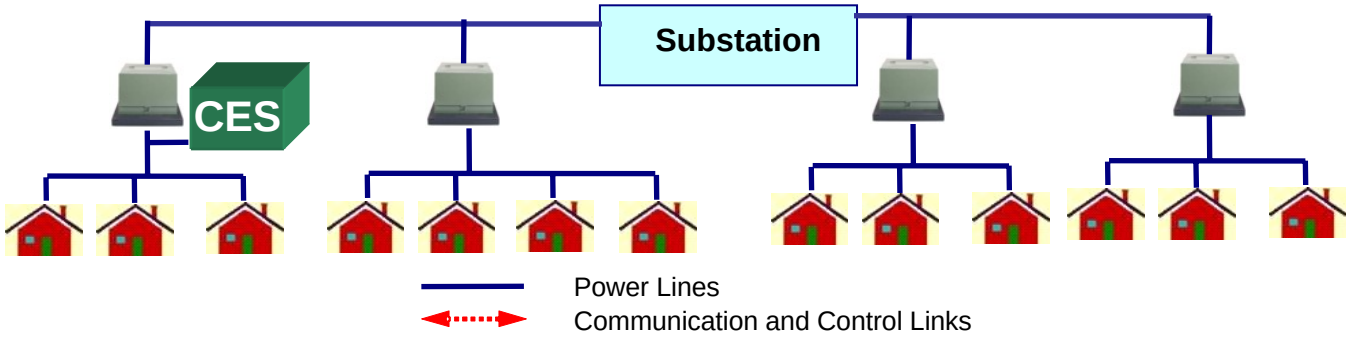
www.dolantechcenter.com/Focus/DistributedEnergy/EnergyStorage.aspx

CES – Benefits to the Customer

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

Local Benefits:

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



CES – A Virtual Substation Battery

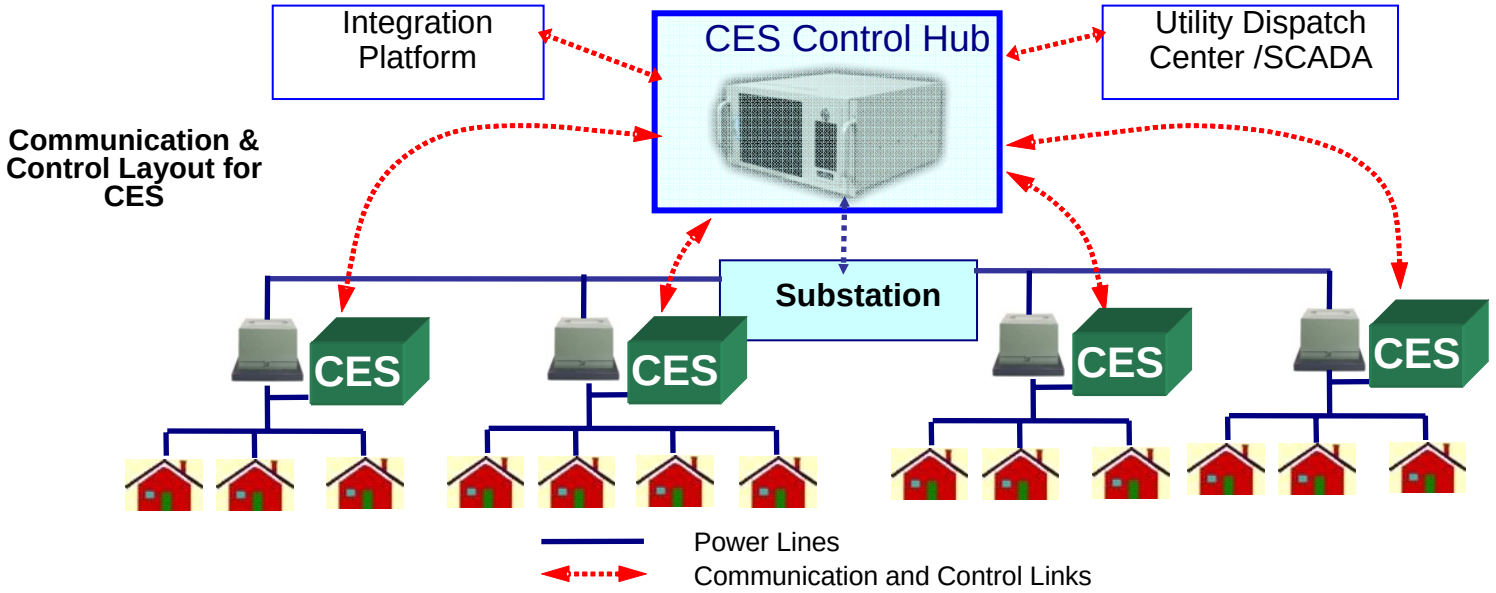
CES is Operated as a Fleet offering a Multi-MW, Multi-hour Storage

Local Benefits:

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

Grid Benefits:

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



CES – NE Columbus Project Benefits.

Community Energy Storage

gridSMART℠ From AEP OHIO

80 units, 25kW (2 MW/2 MWh)

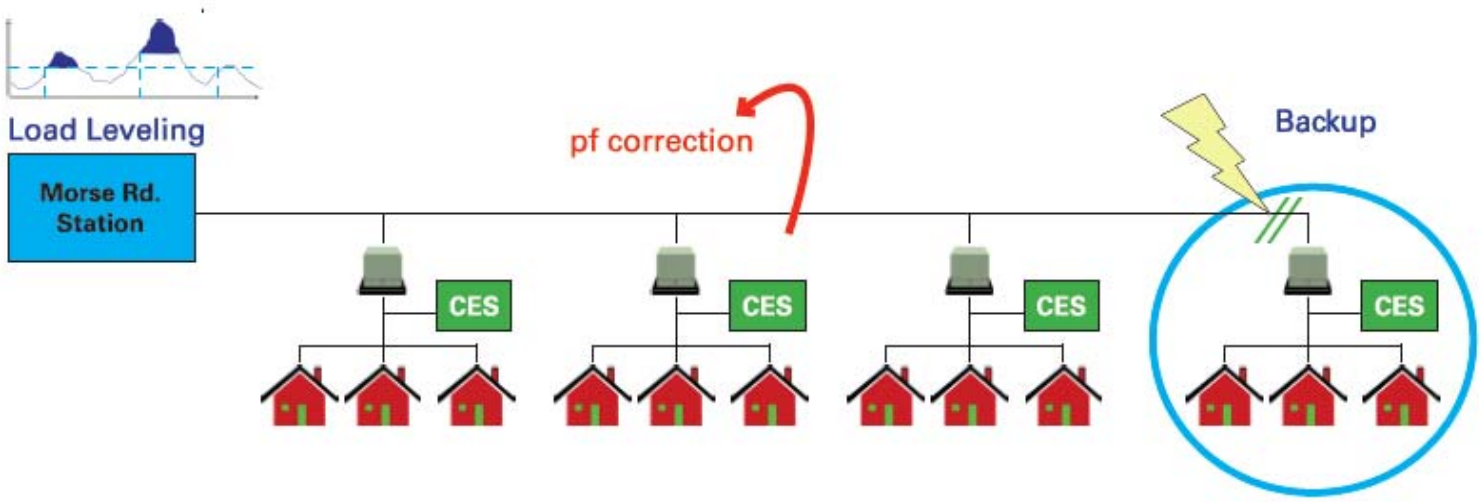
Control hub at Morse Rd Station (northern Columbus)

Circuit F5801

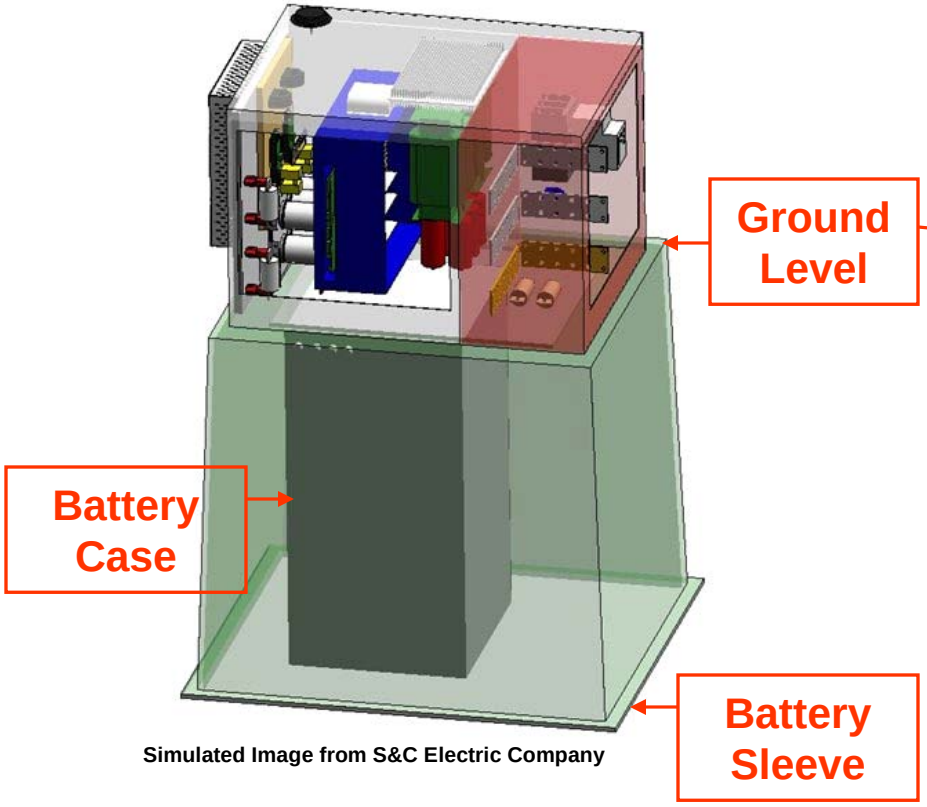
13kV, 6.3 MV peak load

1,742 customers

System will cover approximately 20% of customers



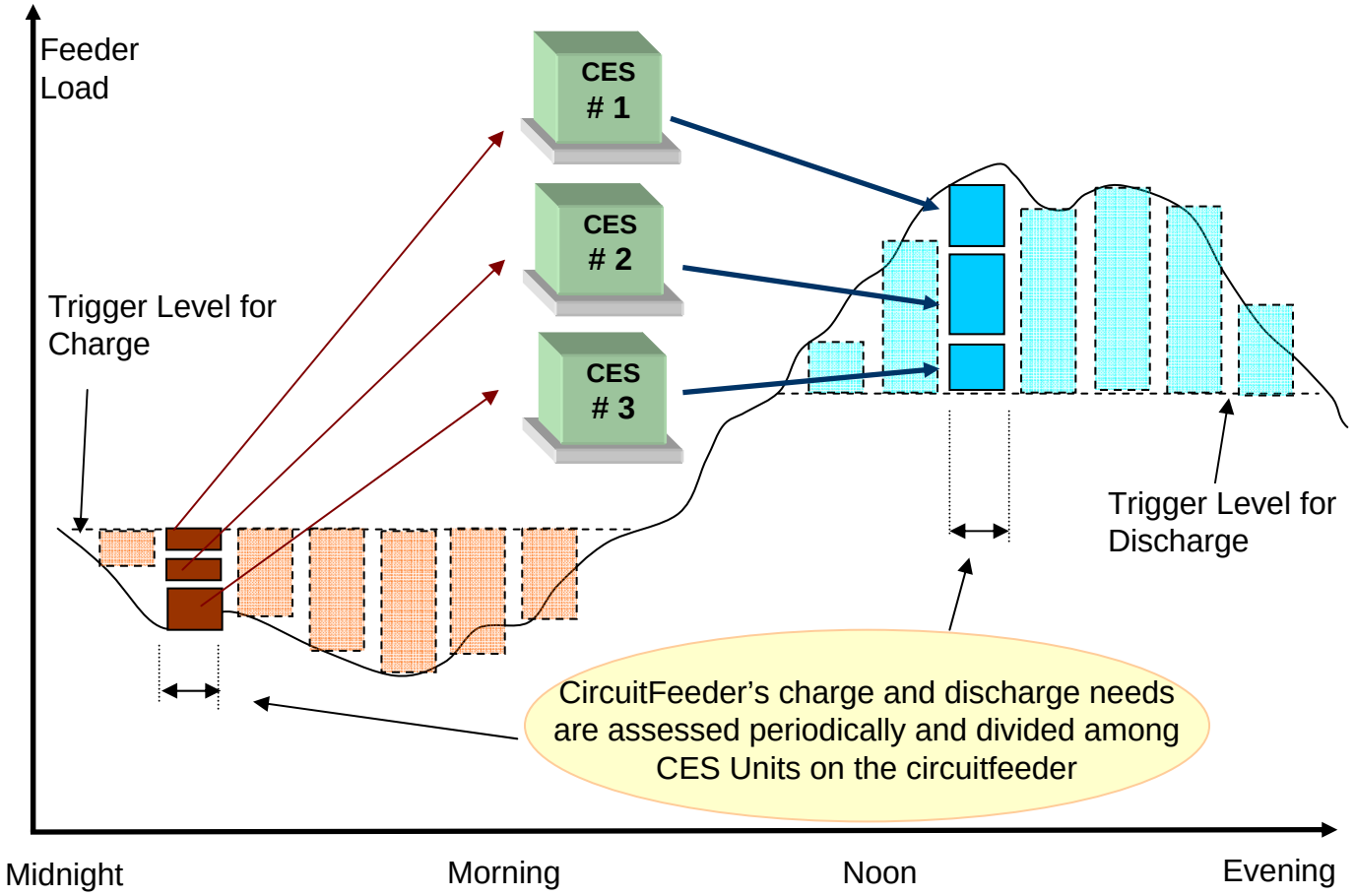
First CES Deployment



Simulated Image from S&C Electric Company

First Deployment of CES in Columbus, Ohio

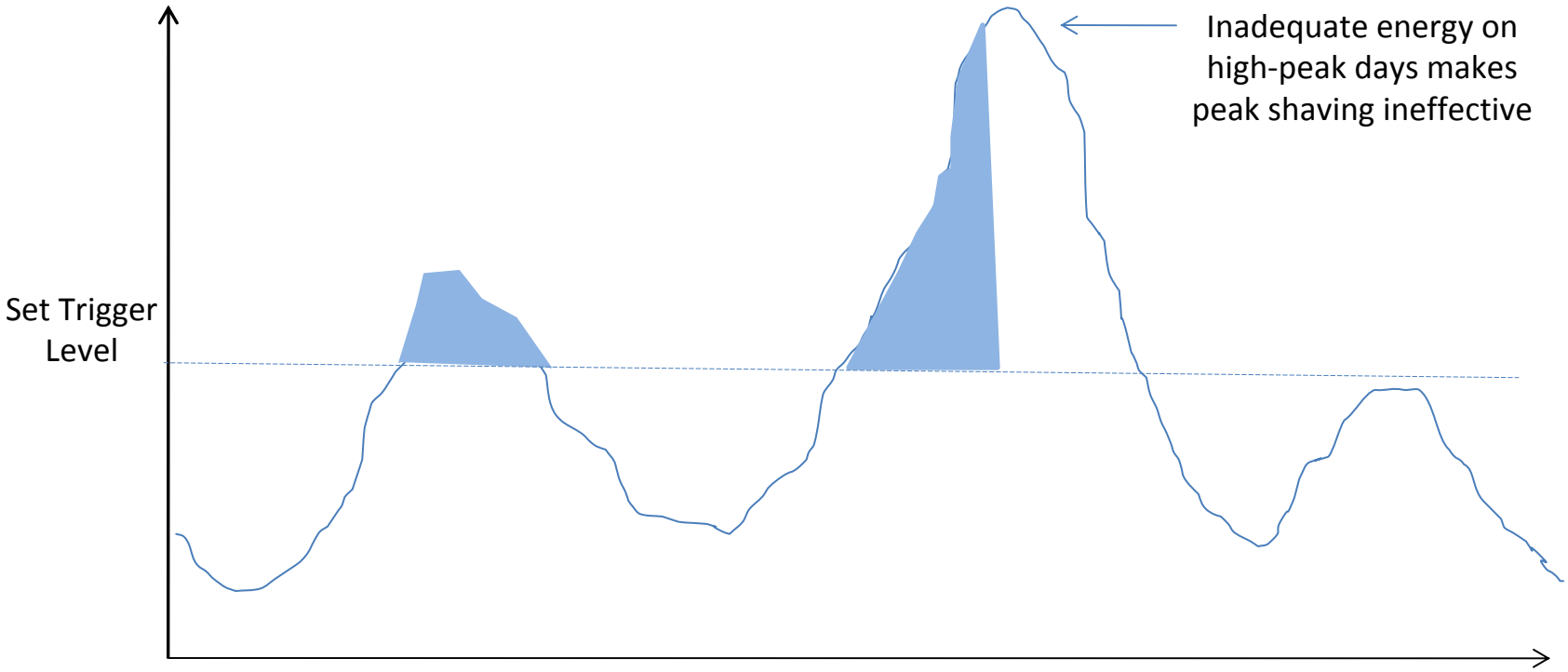
Load Leveling – Spread Across the CES Fleet



Feeder level demand profile showing CES Unit charge and discharge

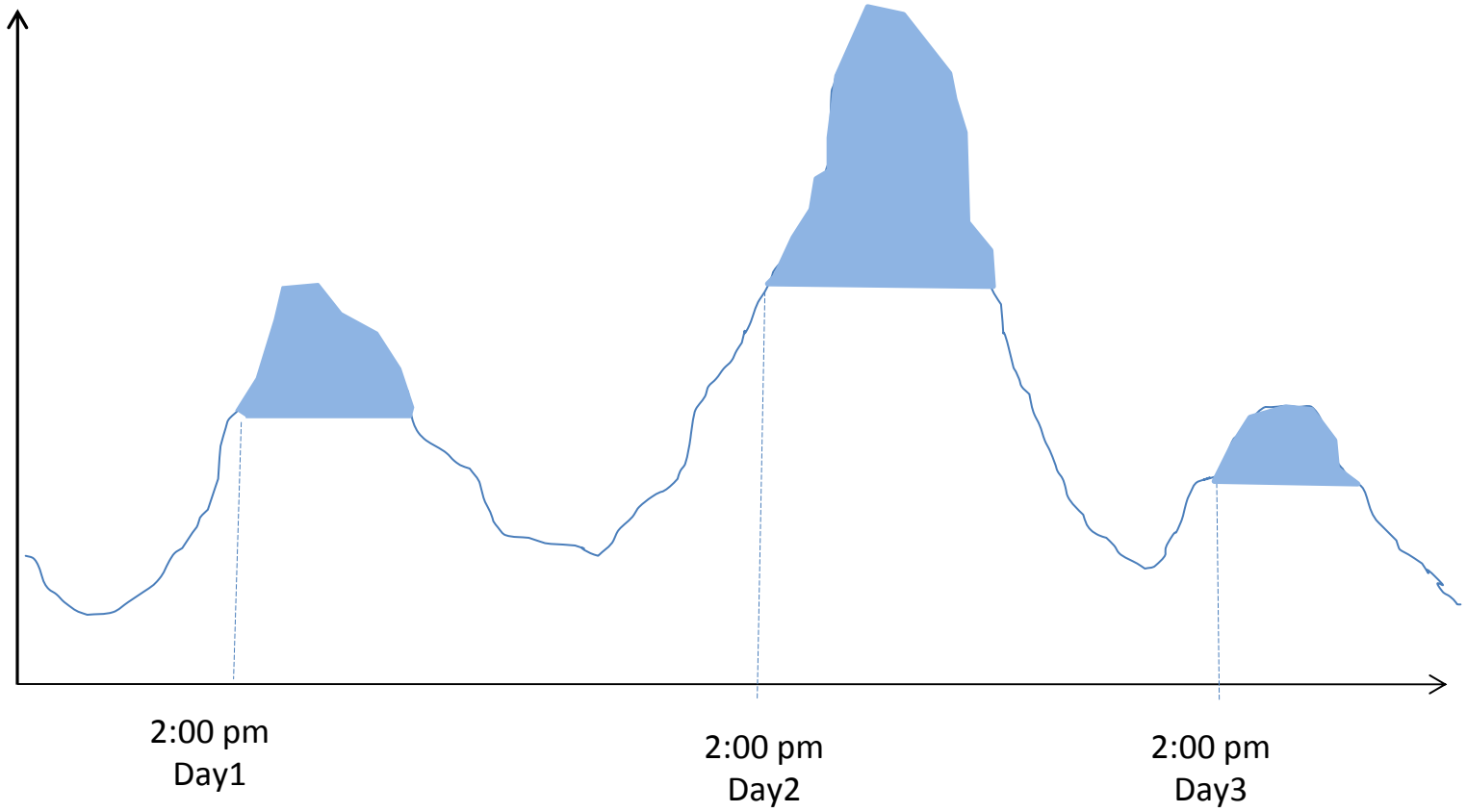
Demand Triggered Load Following

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.



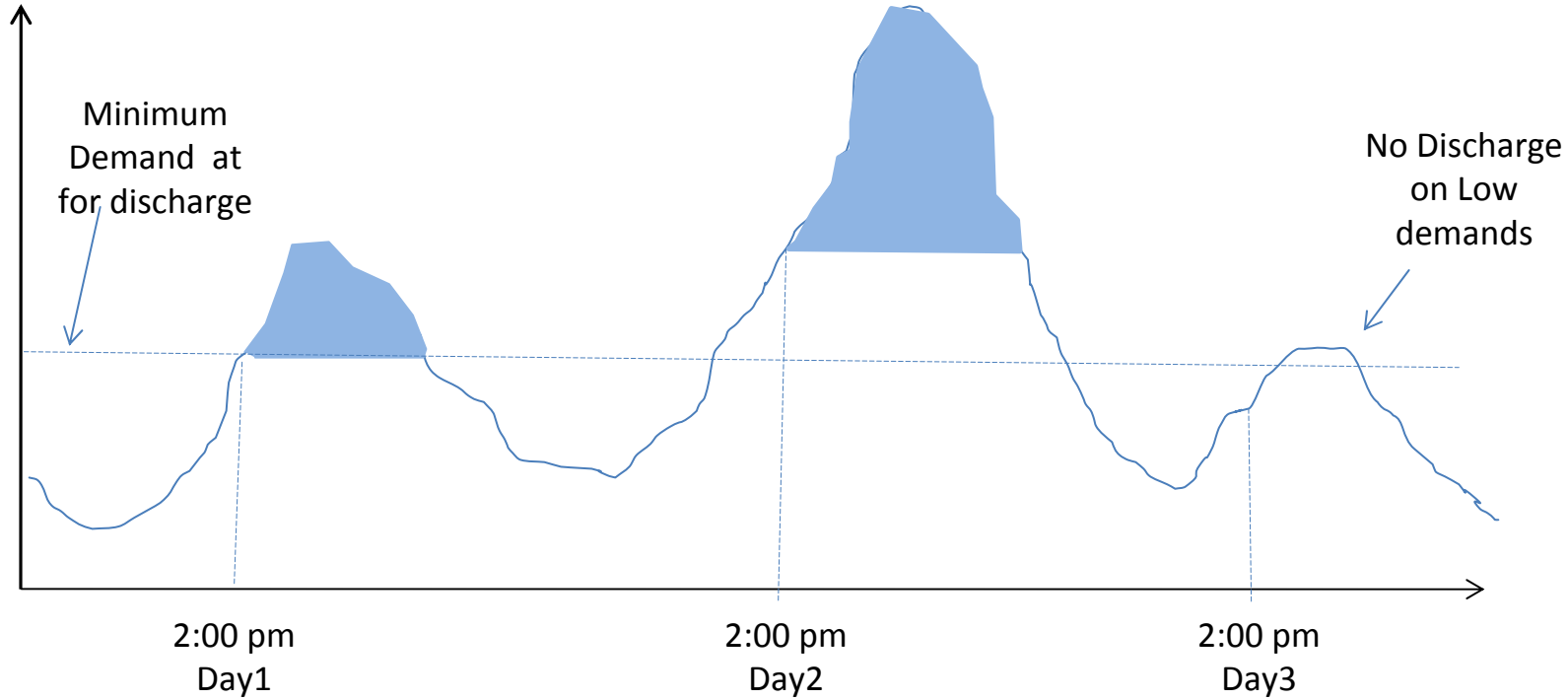
Time Triggered Load Following

Simple and the amount of energy is somewhat proportional to the peak load but there is no assurance that stored energy would be adequate



Time Triggered Discharge Parameters

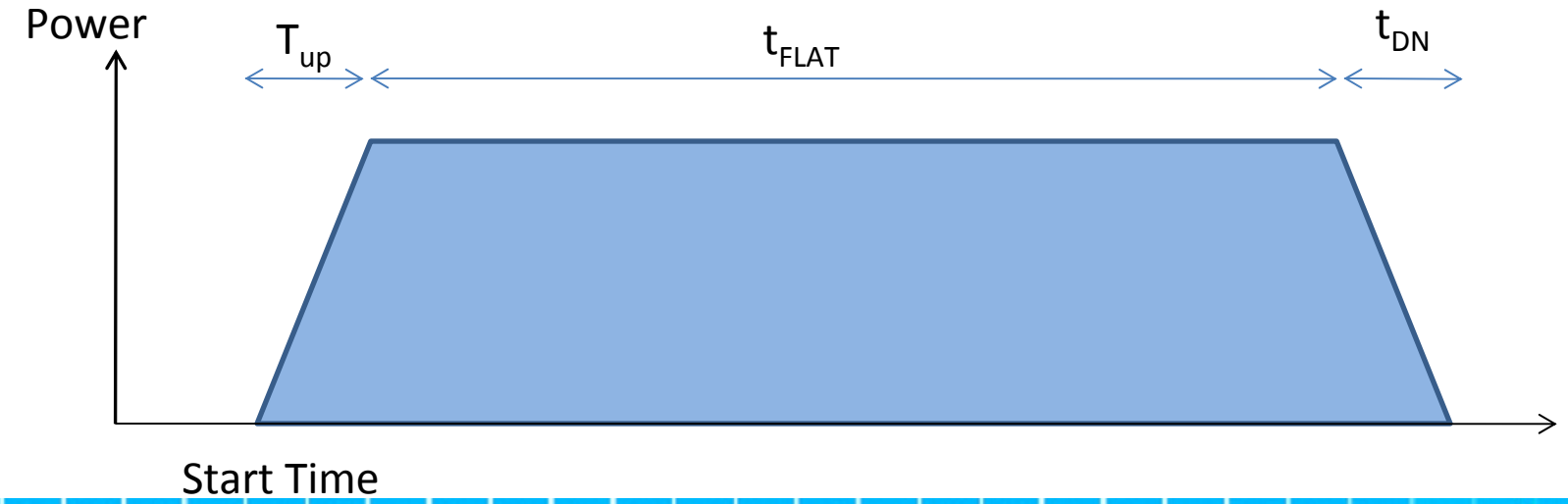
- Set Points:
  - Start Time (same for all days)
  - Minimum Demand below which no energy should be discharged



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



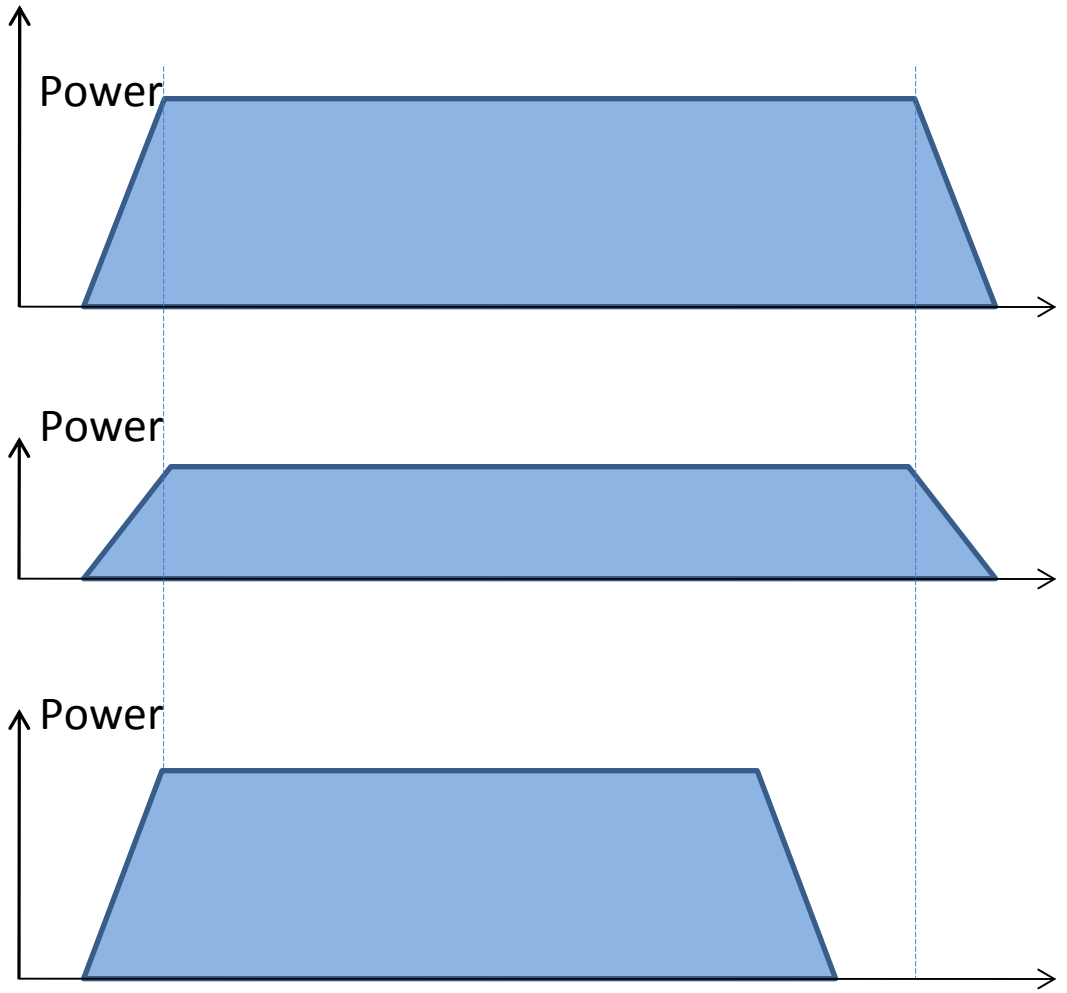
Scheduled Discharge Options

Case 1 – Reported Available energy is sufficient

Case 2 – Available energy is not sufficient

1.Planner Option (Keep Duration, reduce Power)

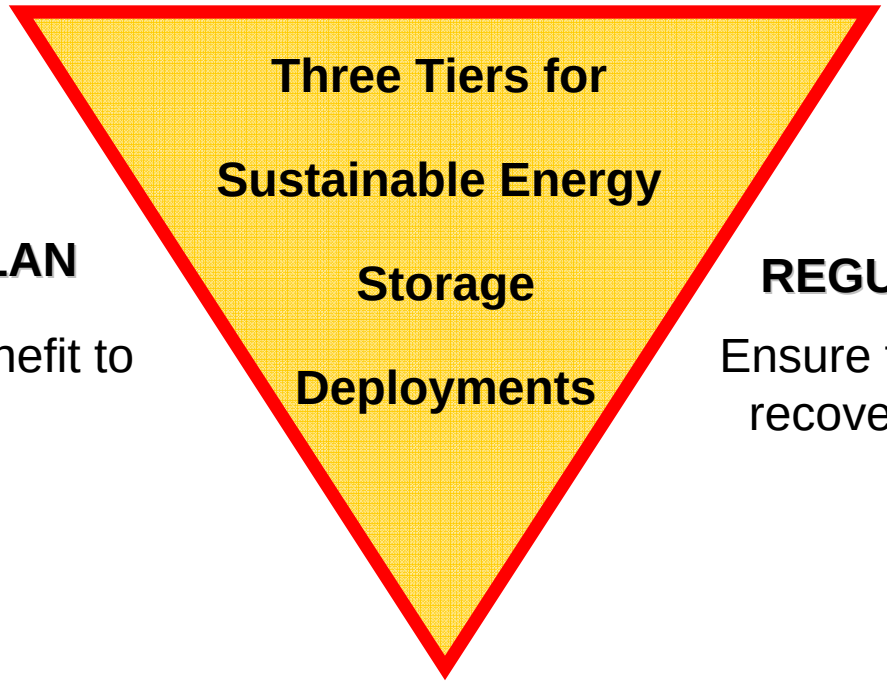
2.Dispatcher Option (Keep Power, reduce duration)



Sustainable Future Deployments

TECHNOLOGY

Validate energy storage technology can meet grid requirements



BUSINESS PLAN

Credible financial benefit to customers

REGULATORY

Ensure favorable rate recovery treatment

Conclusion

- Successful deployment of Energy Storage Systems
- AEP's current Energy Storage strategy is focused primarily on Community Energy Storage.
- Energy Storage System Cost must reduce significantly to become economically justifiable for utility deployment.
- Market predictions indicate that near-term costs for energy storage may broaden deployment opportunities.