A Review of 2009 Energy Storage Projects in American Electric Power

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Electric utilities have become increasingly aware of the benefits of energy storage systems. This has been influenced by the need to buffer the increasing impact of higher penetrations of intermittent renewable energy resources and advancements in energy storage technologies. Many recent deployments of solar energy systems are at residential and commercial customer sites. In AEP's service territory, the number and cumulative size of the total installed customer solar energy has doubled each year over the last decade and is expected to accelerate in the future. This trend and the increasing demand for better electric service, is persuading utilities to deploy energy storage systems closer to its customers.

A look at the historical deployment of energy storage systems at electric utilities indicate a migratory pattern from large central storage units to broadly distributed smaller systems closer to customers (Figure 1 & Figure 2). For many decades, electric utilities have installed large *central* pumped hydro facilities (100's of MW) as a means to store their excess generation and use it when demand is high. With greater availability of advanced battery technologies over the last two decades, utilities have been able to deploy more distributed *substation* batteries (several MW) to improve electric grid performance. The migration of energy storage systems is progressing and utilities have begun the process to deploy much smaller energy storage units (10's of kW) broadly distributed at the *edge of the grid*, close to customers. The key driver behind this move is the need to buffer rapidly growing customer-owned renewable resources that central and substation batteries cannot offer at the customer level. In addition to offering this benefit, when aggregated customer-level storage systems can offer additional values like capital deferral, peak shaving and removal of transmission congestion.

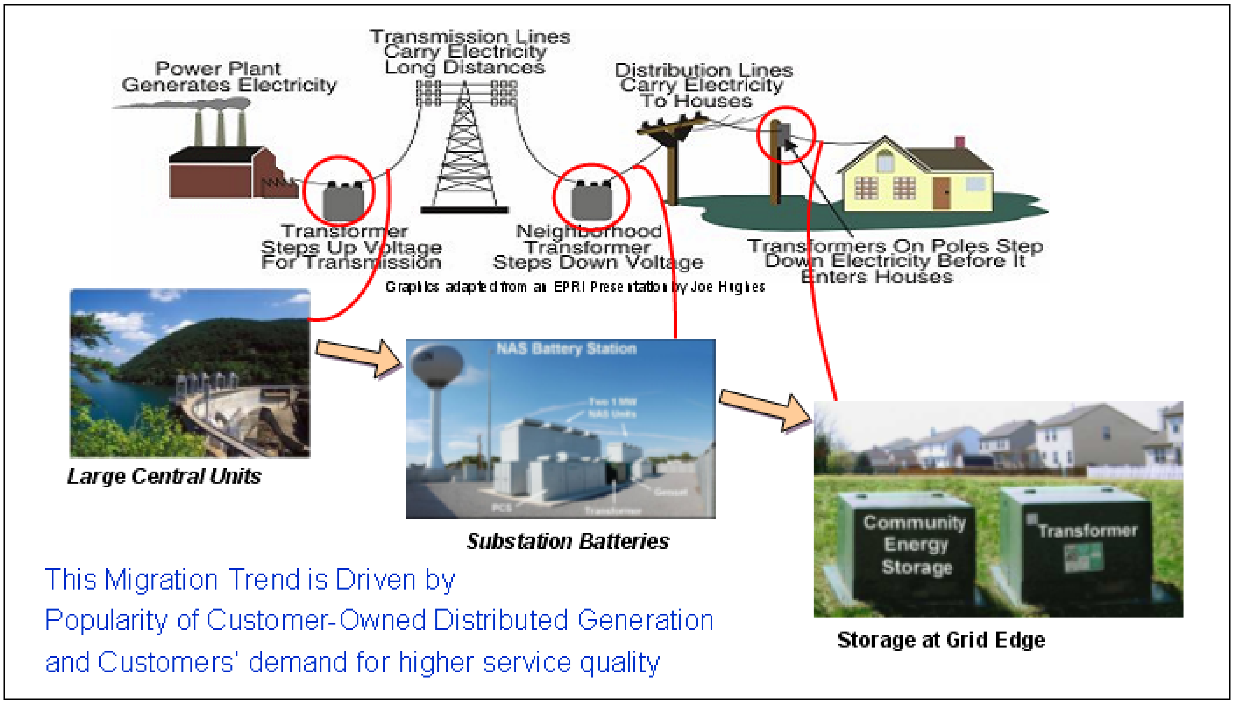

Figure 1: Migratory trend of energy storage systems across utilities.

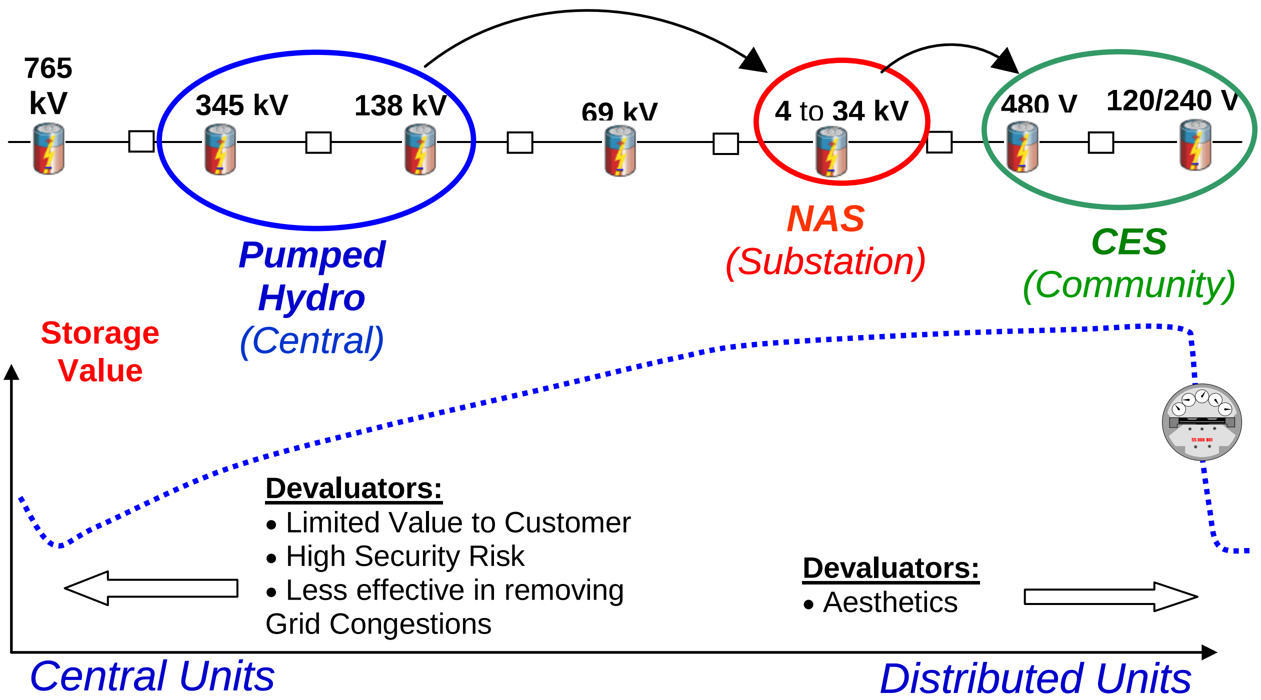

Figure 2: Value associated with storage locations on the grid.

AEP installed a 600MW pumped hydro energy storage in 1965 which has been beneficial in system level peak shaving. Recent deployments of energy storage systems have been to distributed NaS batteries in 1 MW and 2 MW-sized installations at four different substations (see Table I).. A 4 MW NaS battery unit will be deployed by January 2010 (the ratio of energy to rated power of NaS batteries is about 7 hours). Besides basic load leveling which is the main function of the large central pumped hydro units, AEP decided to install "**Dynamic Islanding**" on three of its NaS batteries to enable these battery systems serve as a backup unit for customers in the absence of electric grid power. This new feature was designed and developed by S&C electric using their IntelliTeam devices with partial support from DOE/Sandia.

Table I - NaS substation battery deployment at AEP (2008-9)

AEP NaS Substation Battery Deployment 2008-9			
	Indiana	Ohio	W. Virginia
Deployment Date	Jan 2009	Sep 2008	Dec 2008
In-service date (Islanding)	May 2009	May 2009	July 2009
Live Islanding Test			July 8, 2009

During an outage from the main feed of the transformer, power electronic and communication devices will allow certain portions of the circuit to be disconnected from the electric grid and be energized by the battery (Figure 3).

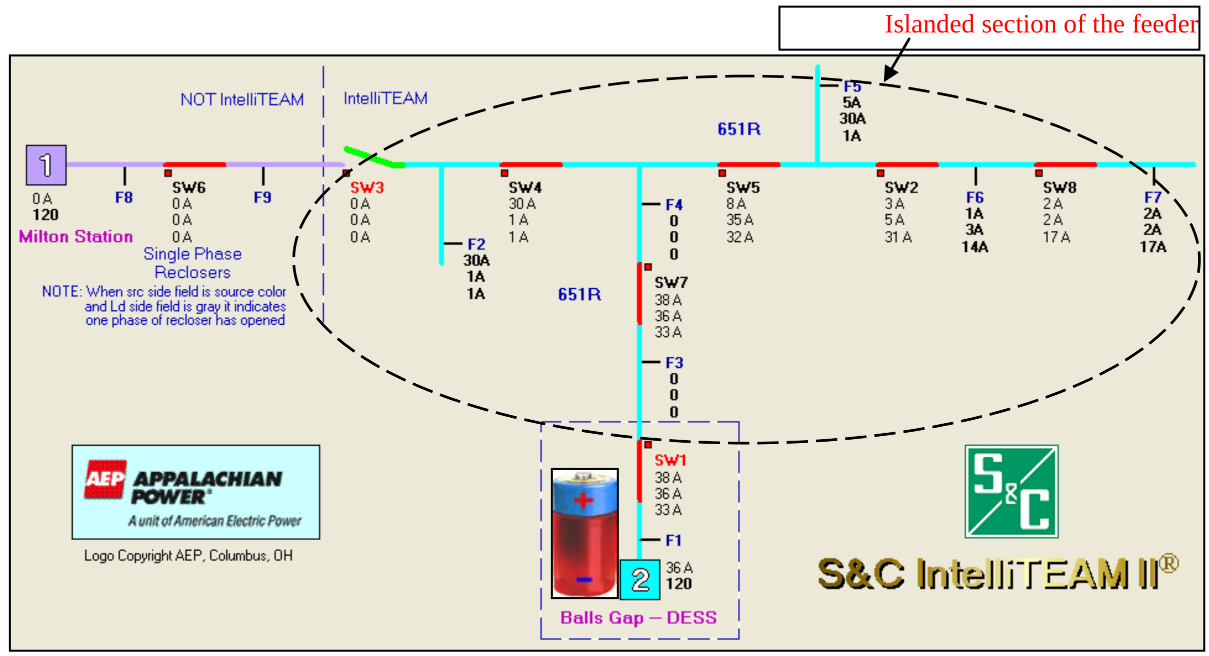

Figure 3: Screenshot of the simulation program showing islanded portion of feeder.

A live islanding test at the Milton, WV battery location was performed in July 2009. During a simulated loss of grid power, the 2-MW battery energized 700 customers for approximately 30 minutes before grid power was restored and the customers were returned to the electric grid (Figure 3).Those customers could have been sustained for several hours. This successful demonstration was the first application of islanding with NaS batteries.

Advancing the migratory trend of locating energy storage closer to customers, AEP, with the help of EPRI and a collaboration of over twenty utilities, vendors and manufacturers, has developed a detailed set of functional specifications to implement a new strategy in the deployment of energy storage called Community Energy Storage (CES). The specifications are open source and available from www.aeptechcenter.com/ces. While CES can be deployed for single family houses, multi family apartments or small businesses, AEP prefers to initiate this strategy with single family houses where a single CES unit, connected to the secondary of a transformer, can serve 4-5 houses that are connected on the same transformer (Figure 4).

CES is designed to leverage the electric transportation market and its fierce global competition by using new or used electric car batteries. As shown in Figure 5, CES units are charged, discharged and controlled as a fleet and, collectively, act as a multi-MW substation battery. While CES is a virtual substation battery, it has distinct advantages over a substation battery including but not limited to:

1. More reliable Backup Power to customers (closer)
2. More Effective in providing Voltage Support (distributed)
3. More likely to be a standardized commodity (low cost)
4. More Efficient in buffering customer renewable sources
5. More synergy with Electric Vehicle batteries (huge market, safe, reliable & low cost)
6. Easier installation and maintenance (240 V)
7. Unit outage is less critical to the grid (smaller)
8. Lower resistive loss in wires (closer to customer)
9. A better fit into the Smart Grid.

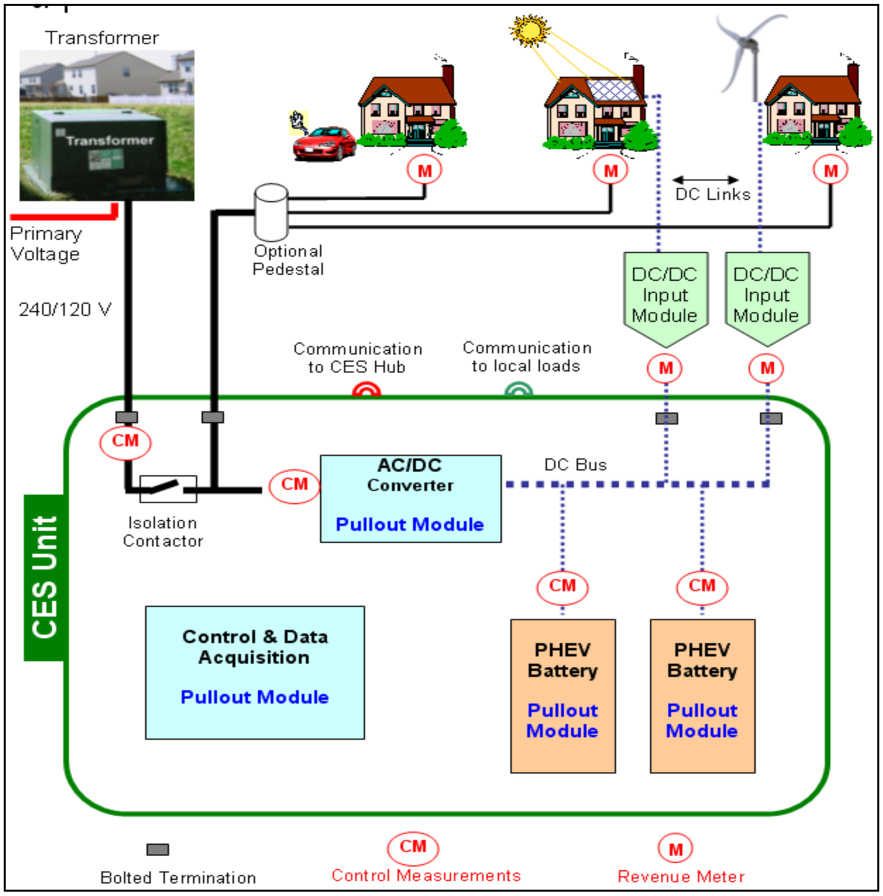

Figure 4- CES components and their location with respect to the transformer and residential units

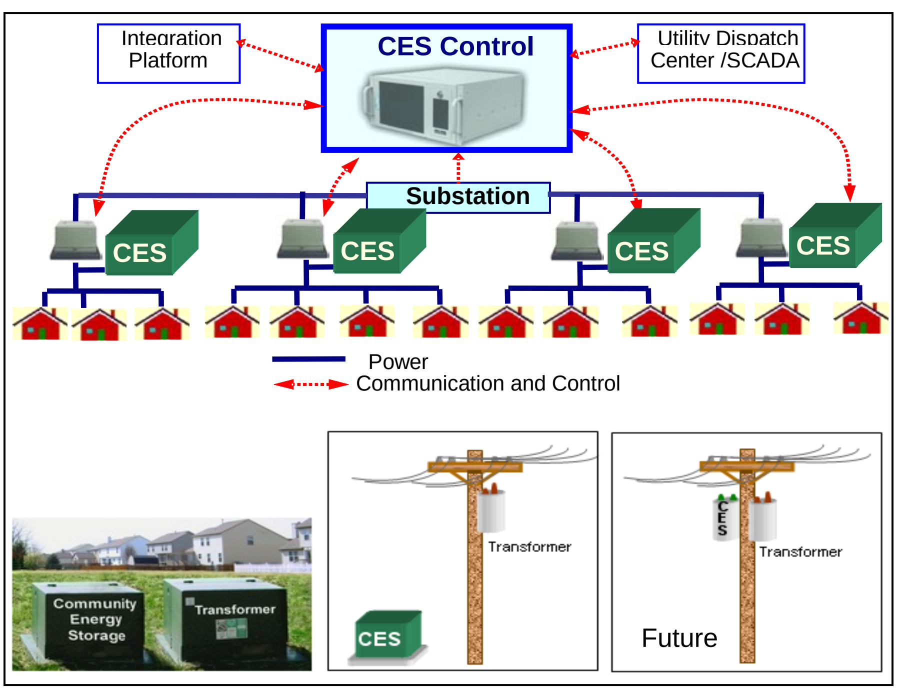

Figure 5 – Possible locations of CES and their fleet-based control functioning as a virtual substation battery

Besides the above advantages to substation batteries, CES has some additional strategic values for utilities that are facing a growing number of customers with solar energy systems. A challenge associated with customer owned and operated generation, particularly the renewable resources, is the intermittent nature of these sources and its availability that does not match the grid need.

Along with the challenge of intermittency, availability of such generation to customers could accelerate the onset of "**net-zero"** energy homes or neighborhoods. The U.S. Department of Energy (DOE) has a goal to develop net zero energy homes by 2020. These homes will consume as much electricity as they produce. As low cost energy storage systems become available to these customers, or they may purchase it as a "storage service" from a local business, they will become grid-independent and utilities may lose 30-40% of its load. This threat to the traditional utility business model can also be turned into an opportunity if utilities install CES near their customers to serve and retain customers while serving the grid needs. Such strategic values of energy storage are shown along with market and service values in figure 6.

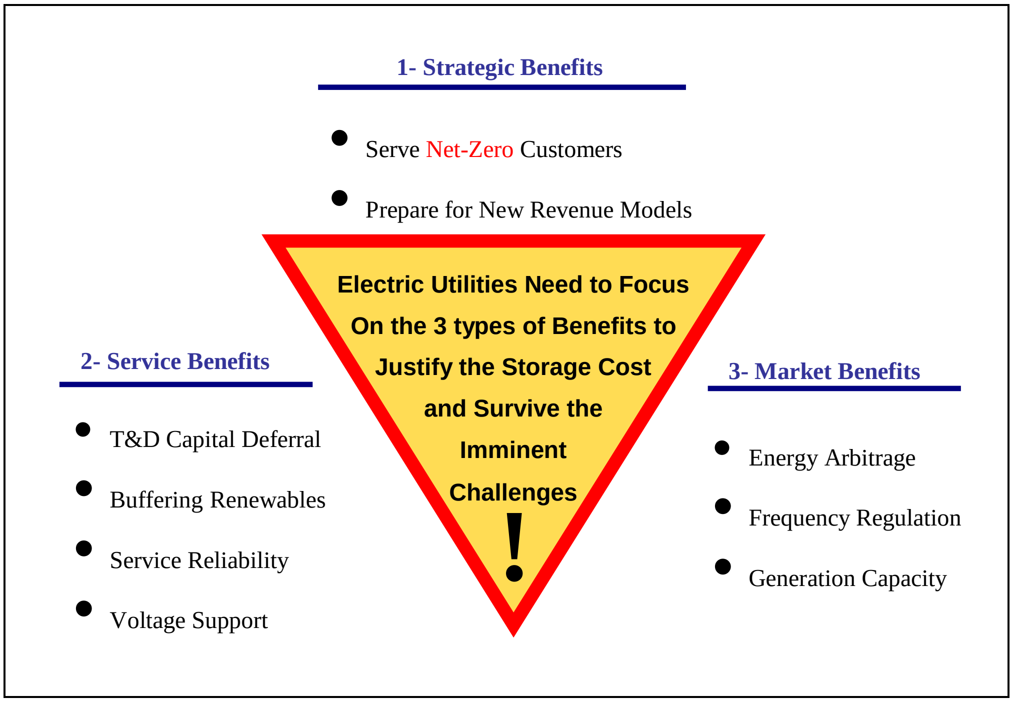

Figure 6: Categories of utility storage benefits

In order to be able to satisfy many, if not all, of the three types of storage benefits, a strategically preferred energy storage solution should have the following four characteristics:

1. **Very Close to Customers**
   - To provide backup power,
   - To buffer customer renewable energy resources,
   - To provide voltage support

2. **Grid-Connected**
   - To perform load leveling for capital deferral and optimize grid operation,
   - To offer frequency regulation & other ancillary services
   - To allow sharing distributed resources among customers

3. **Utility-Operated**
    - To gain improved safety
    - To be able to dispatch the energy more effectively,
    - To optimize grid performance

4. **Utility-Owned**
    - To take advantage of load diversity (multiple customers on one storage)
    - To help standardization
    - To achieve commodity pricing
    - To be able to socialize the cost

Besides trying to benefit from as many storage values as possible, utilities need to search for ways to further reduce the cost. One important criterion in the decision to move towards the CES platform was the expected lower cost of electric transportation batteries that are intended to be used in CES. Leveraging the intense global competition for the development of batteries to be used in electric vehicles is critical to the fast penetration and extensive deployment of CES systems. Several developed countries value electric vehicles as means for reducing their carbon footprint and less reliance on foreign oil and have found the development of electric cars in their national interest. Thus there is a big push from governments encouraging the development of electric vehicle infrastructure and manufacturing of more energy dense batteries that will be used in electric vehicles. CES is designed to leverage this market and its forecast cost, over the next five years is expected to be about $1000/kW or $500/kWh comparing favorably with existing battery technologies today. This lower cost and higher penetration of CES will enable utilites retain customers, optimize grid operation and buffer renewable energy resources thereby increasing value to the electric utility and customer as well.

AEP sees higher value in utility owned and operated, grid-connected energy storage units located closer to utility customers.