Standardizing

Community Energy Storage (CES)

"A Game Changer"

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Ali Nourai
American Electric Power
Electricity Storage Association

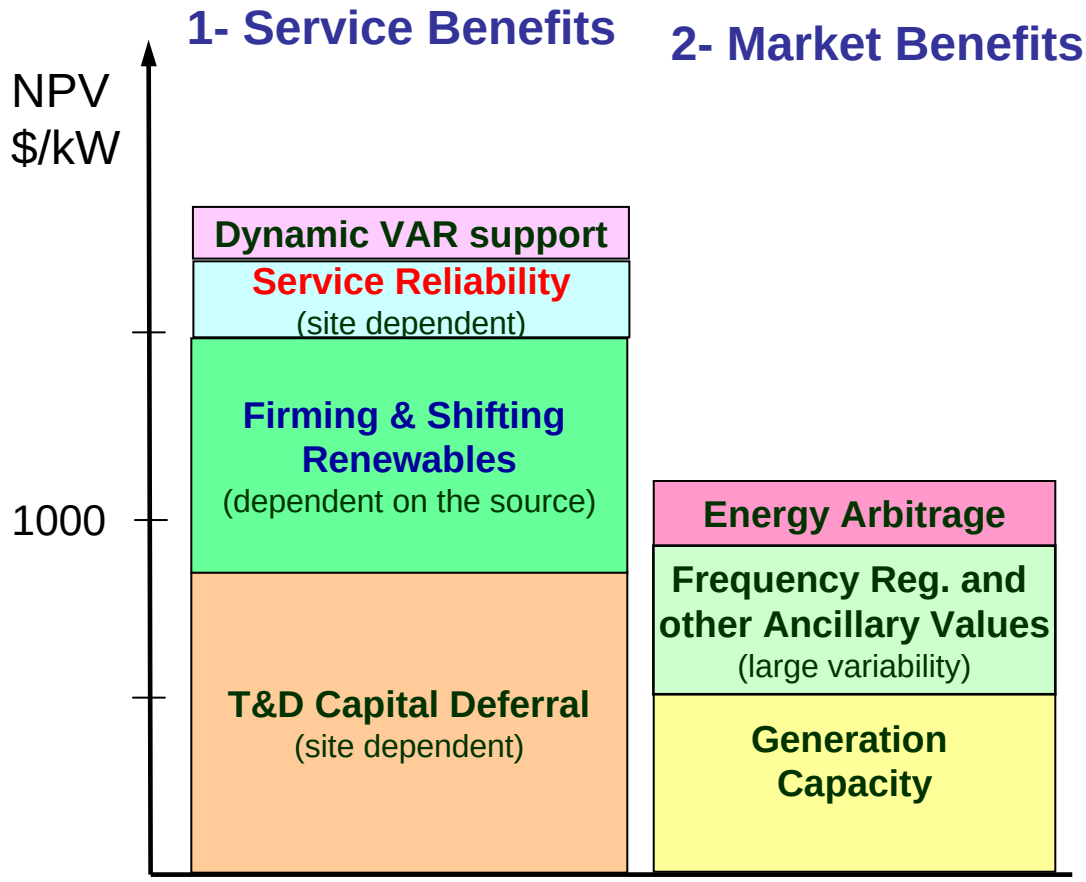
Operational Challenges to the Utility Business

To name a few...:

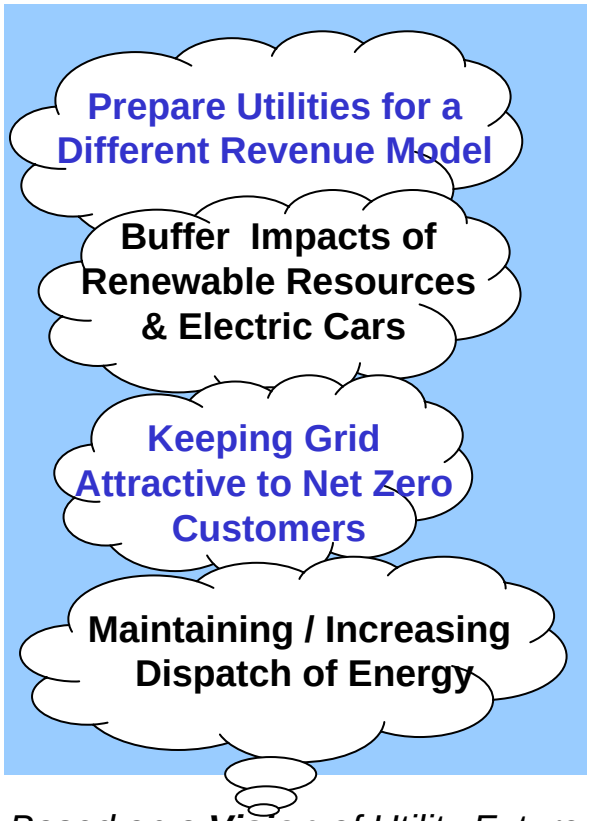
- Renewable generation, owned and operated by utility customers, has grown and continues to grow at a very fast pace
- Customer renewable DG is intermittent, often not available when needed and out of the control of the utility operator
- Plug-in Electric Vehicles are coming

Energy Storage is a key to mitigating these impacts

Utility Benefits of Energy Storage



Based on studies for AEP sites with NaS



*Based on a **Vision** of Utility Future*

Storage can Benefit both Customers and Utilities

Success with Substation-scale Storage

1 MW, 7.2 MWh installed in 2006

- Deferred substation upgrades

Three installations in 2008 (2 MW Each)

- Demonstrate “Islanding”
- Sub-transmission support

Another 4MW, 25MWh substation will be on-line in 2009

Building on Success …

Substation batteries are great, but …

We need to get MORE out of energy storage:

- More value to our customers
- Lower cost per stored kWHr
- Greater Flexibility for Deployment
- Higher Efficiency (including T&D losses)
- Better fit into Smart Grid, the way of the future

Community Energy Storage (CES)

CES is a small distributed energy storage unit connected to the secondary of transformers serving a few houses or small commercial loads

- ***Uses New or Used batteries from Electric Cars***
- Offers All Values of Substation Batteries when ***aggregated,***
- Offers Backup Power to customers
- Buffers Customer Renewable Generation
- Makes Charging Time of electric cars a less critical issue

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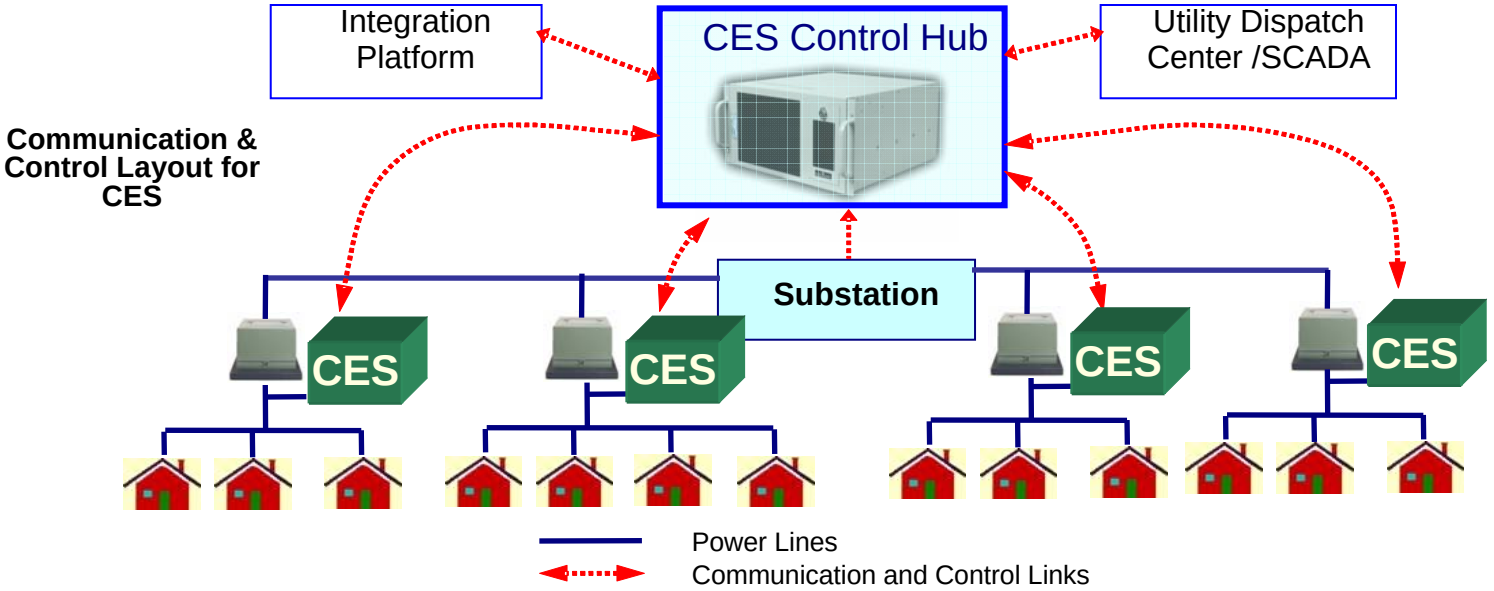
CES Key Functionalities

Local Controls/Benefits:

1) **Backup power** for the local need of the few houses connected to it
2) **Voltage** correction

Grid Controls/Benefits:

3) **Load Leveling** based on substation and grid needs
4) **Power Factor** Correction
5) **Ancillary** services through further aggregation at the grid level



Advantages of CES to Substation Battery

- Higher electric service reliability to customers
- Easier installation (a 240 V appliance)
- Easier maintenance (lower required skills)
- More likely to be a standardized commodity
- Unit outage is less critical to the grid (smaller)
- Lower resistive loss in wires (closer to customer)
- A better fit into the Smart Grid programs

Advantages of Using Electric Car Batteries

- Safe for public deployment (well established safety standards)
- Low cost
  - *Fierce global competition*
  - *US national priority*
  - *Option to use used PHEV batteries*
- Compact
- Reliable
- Efficient
- Wide operating temperature
- Easy recycling & lower environmental issues

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CES Cost Forecast

PHEV, and its battery development, is a **US National Priority** as well as having an extensive global competition

Pending the successful market penetration of PHEV, CES cost forecast (for a 2-hour system) over the next five years is:

- **$1,000 /kW** Commodity Pricing will keep this number low

or

- **$500 /kWh** PHEV Penetration will push this number down

CES Specifications

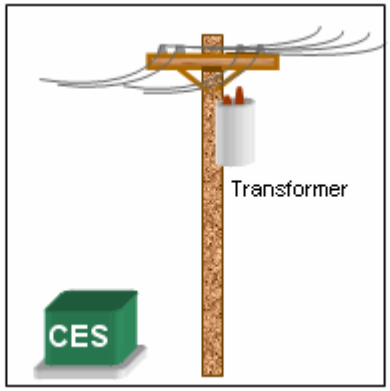
AEP Specifications for CES is “OPEN SOURCE” for Public Use and Feedback.
Latest Version available from

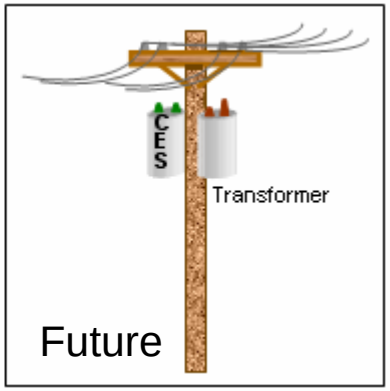
www.aeptechcentral.com/ces

Key Parameters	Value
Power (active and reactive)	25 kVA
Energy	25, 50, 75 kWh
Voltage	120V / 240V
Net AC Energy Efficiency	85+%

CES Location & Size

CES Location





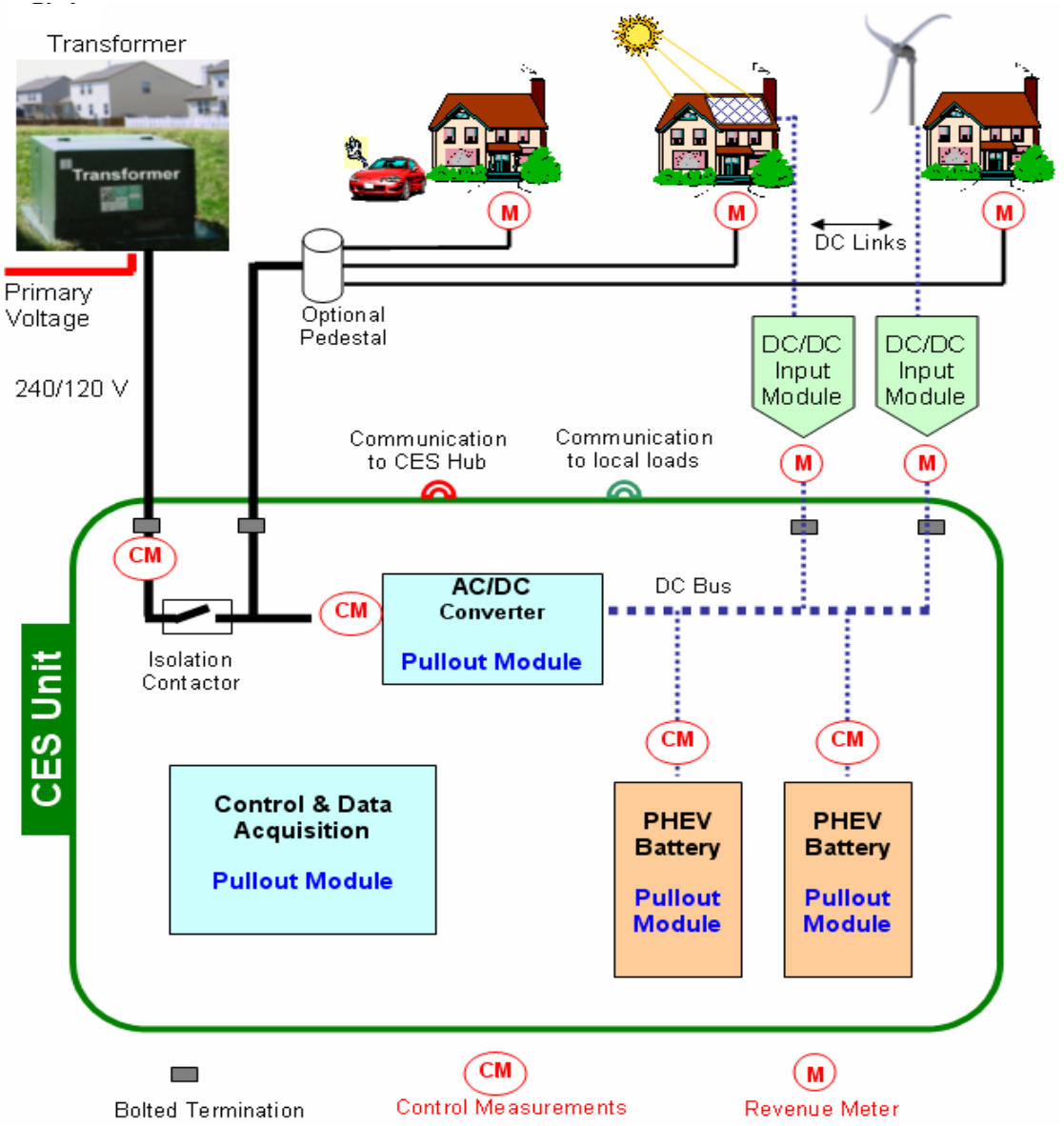
25 kW CES Sizes

4.4. The CES Unit enclosure size may vary according to the power and energy rating, and shall not be more than indicated below:

Power (kW)	Energy (kWh	Width (Inches)	Depth (Inches)	Height (Inches)
25	25	38	40	35
25	50	38	50	35
25	75	38	50	42

These dimensions describe the maximum outside measurement of the enclosure walls. An additional 6 inches is permitted for any external protrusions such as cooling fins or communications antennae.

CES Layout


Transformer
Transformer
Primary Voltage
240/120 V
Optional Pedestal
M
DC Links
DC/DC Input Module
DC/DC Input Module
Communication to CES Hub
Communication to local loads
CM
CES Unit
Isolation Contactor
AC/DC Converter
Pullout Module
DC Bus
Control & Data Acquisition
Pullout Module
PHEV Battery
Pullout Module
PHEV Battery
Pullout Module
Bolted Termination
Control Measurements
Revenue Meter

CES – HUB Main Information Exchange

HUB to CES

Reactive Power Request	In / Out	Percent
Real Power Request	In / Out	Percent

CES to HUB

Operating Mode	Standby/Tripped/Available	state
Real Power Actual	In / Out	kW
Reactive Power Actual	In / Out	kVAR
Real Power Available		kW
Reactive Power Available		kVAR
Energy Available		kWh

Excluding alarms, settings, and logged information

CES – Misc.

3.1.6. **Inrush Capability -** When islanded, the CES Unit shall also have capability for 1.5 x rated kW and 2.5 x rated kVA for 3 seconds to allow it to serve the frequent motor-start demands of residential loads. This inrush duty will be 4 times per hour on top of continuous, full load.

9. Environmental

CES shall be designed to perform all its functions in the following outdoor environment:

Operating Ambient Temperature:	-30°C to +50°C
Survival Ambient Temperature:	-40°C to +60°C
Humidity:	10% to 100% condensing
Transportation / Storage Ambient Temp:	-30°C to +50°C for up to 6 months
Altitude:	Sea level to 2000 m without kVA derating
Seismic risk:	Uniform Building Code Zone 4

Communications between HUB and CES Fleet

13. Communications

The CES Unit shall include multiple communications options such as cellular, mesh node, Wi-Fi, and Wi-Max. Selection between communications options will depend on specific sites. An appropriate communications board and antenna shall be provided when this determination is made.

The preferred control interface protocol is DNP3. IEC-61850 is an acceptable alternative between the Hub and the CES Unit. The control interface protocol will be specified by the purchaser.

CES Islanding

Transition into Islanding

7.1.2. Automated sensing and responding to anomalous system conditions shall be in compliance with IEEE 1547-2003, specifically Section 4.2.3 on Voltage response and Section 4.2.4 on Frequency response. It is intended that the CES Unit respond to momentary or permanent outages such that electronic appliances like computers would continue to work through transition to islanding. On transition to islanding, the CES Unit shall achieve stable AC output voltage and load following within 4 cycles.

Transition out of Islanding

7.3.6. Synchronization shall begin and the Return Delay Interval shall begin when the Stable System interval has expired.

7.3.7. The Return Delay interval shall be calculated at the time the Stable System interval expires. This is intended to spread the fleet return through a period of time (with a known maximum duration), prevent simultaneous returns, and accelerate the return of CES Units with the lower levels of charge. It may be

HUB Communication & Control

CES Resource Availability

Utility Distribution Dispatch Center

Manual Commands
System Requirements

CES Control Hub

or Integration Platform

Station / SCADA

Transformer & Circuit kW, kVAR flow

Available Energy
Charge/Discharge Rate

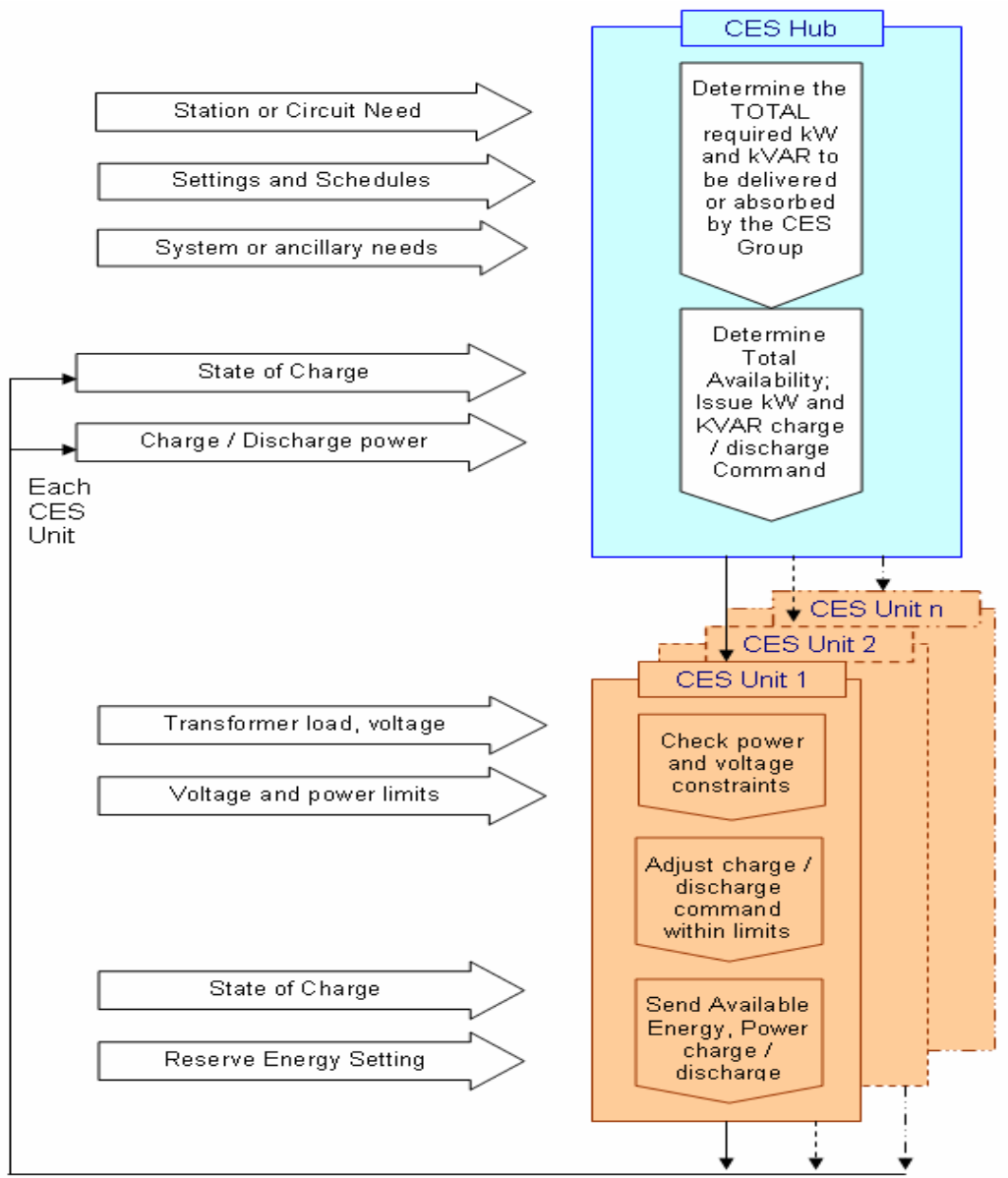
Charge / Discharge Command
Settings Change

CES Unit(s) Battery & PCS
Charge Management
Operating mode
Voltage Constraints
Power Constraints
Islanding

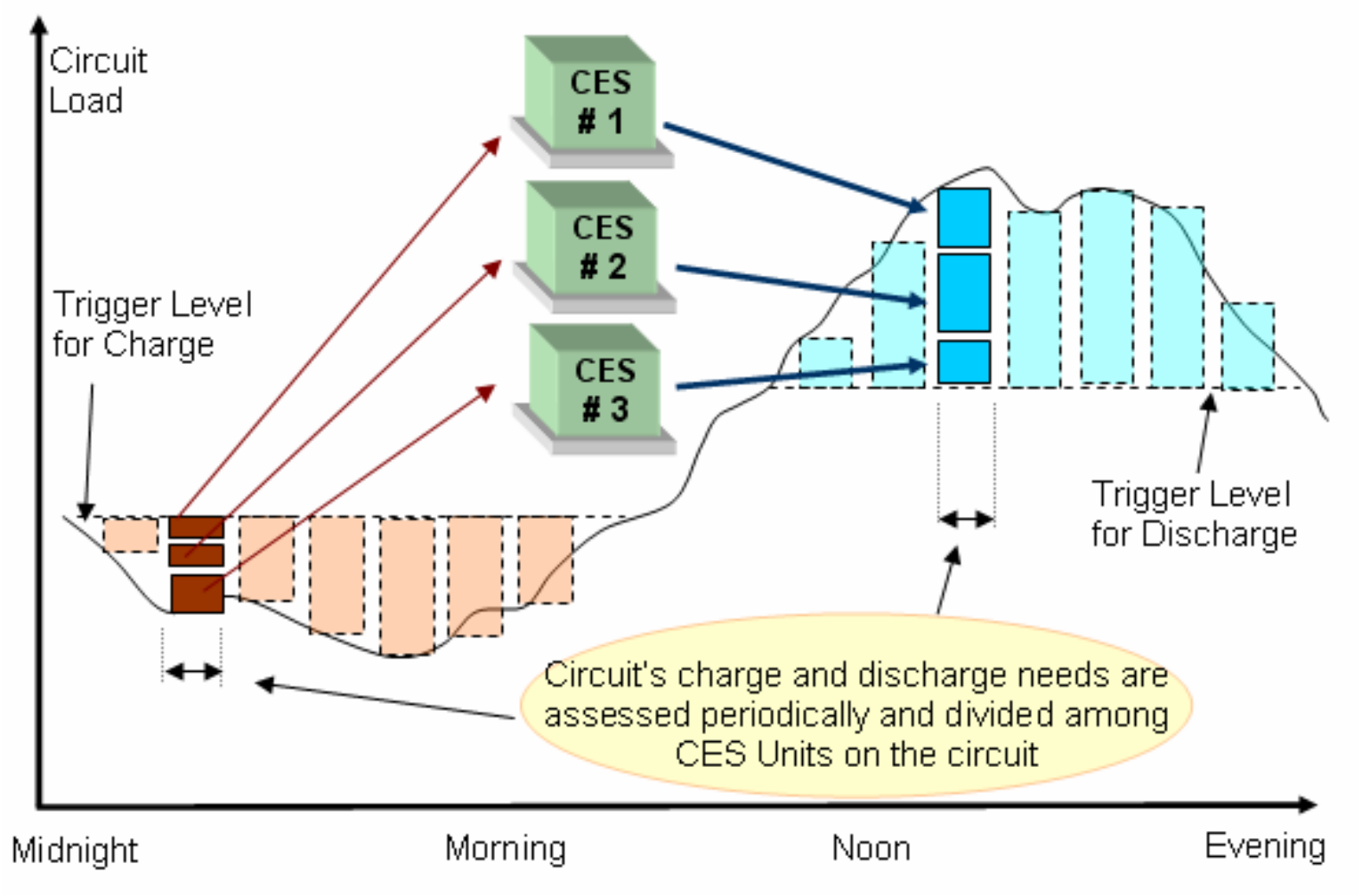
On Battery
(Future)

Residential Monitor

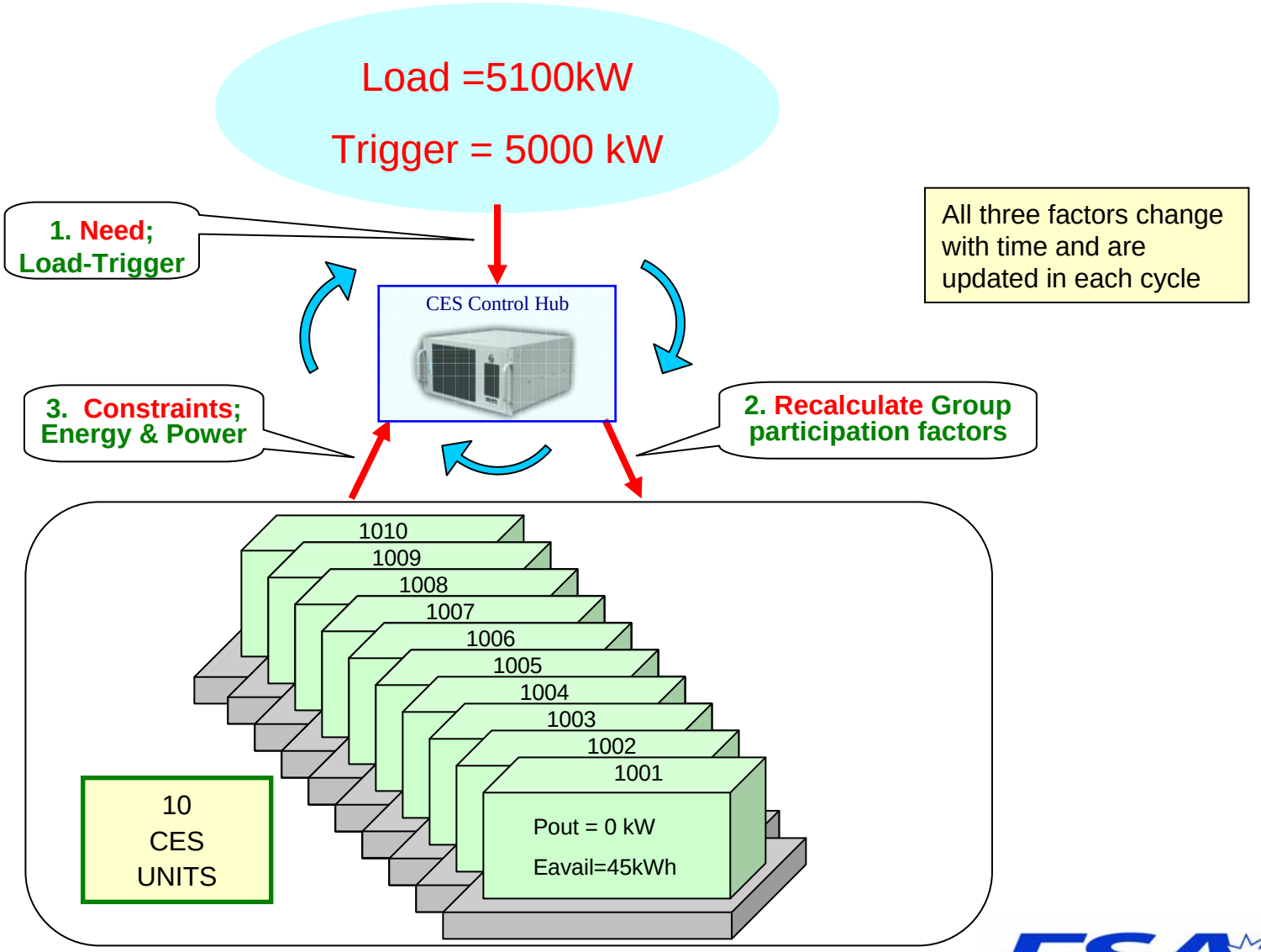
HUB Runs CES units as a FLEET



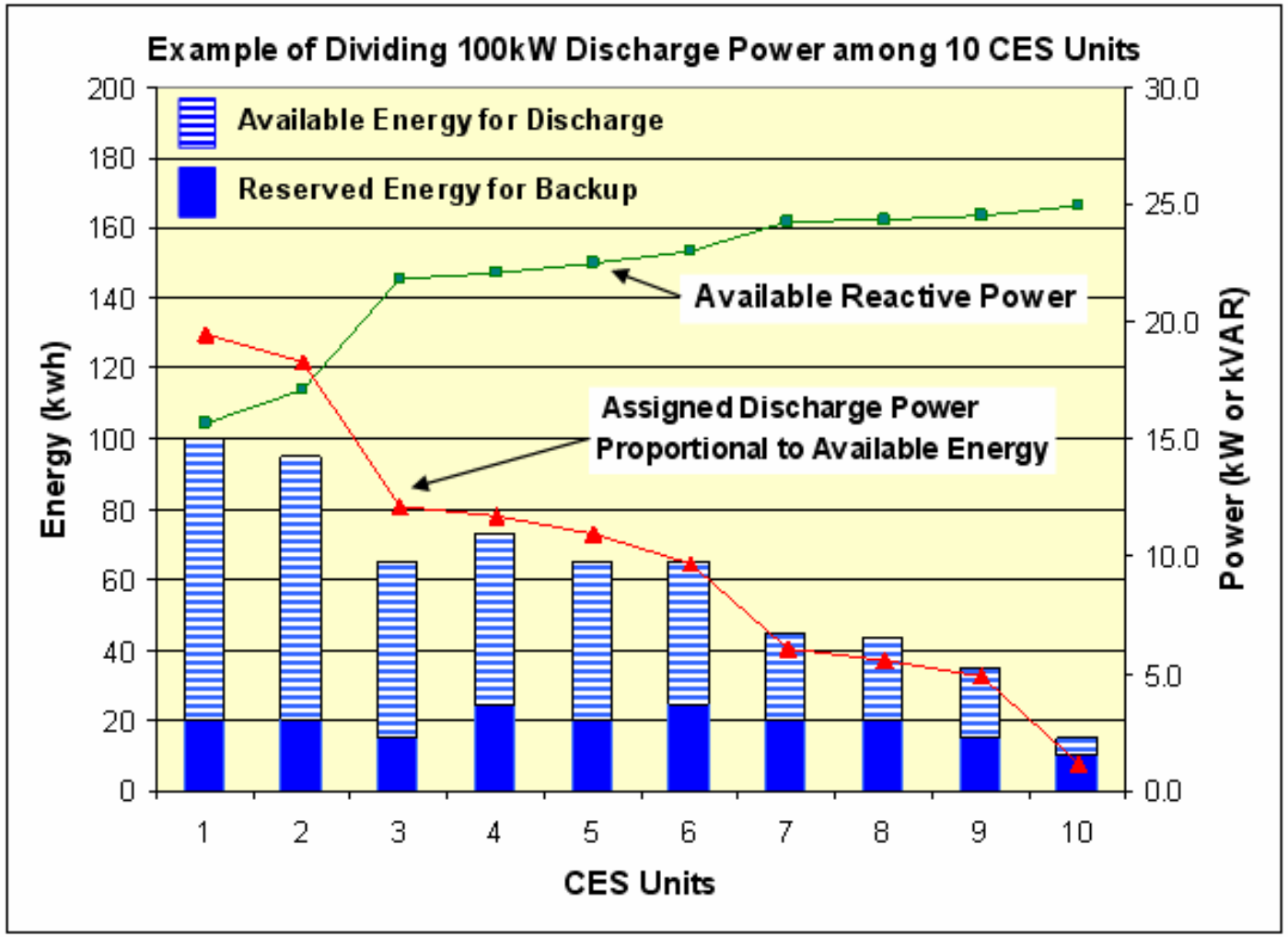
HUB Dispatches Charge & Discharge Allocations



Information Flow Diagram



Levelizing Energy Distribution among CES Units



Applied Priorities for Discharging CES Units

Constraints

1. Individual CES Unit and site (transformer) power limitations
2. Individual site voltage limitations (avoid overvoltage or under voltage)
3. Preservation of individual CES Unit reserve charge

Real Power

4. Real power peak shaving by manual command
5. Real power peak shaving by schedule
6. Real power peak shaving for station requirements
7. Real power peak shaving for circuit requirements

Reactive Power

8. Reactive power correction by manual command
9. Reactive power correction by schedule
10. Reactive power correction for station requirements
11. Reactive power correction for circuit requirements

Discharge Requirements are reassessed periodically to follow load and accommodate priorities

Areas for Further Development

1. Standard Acceptance Test plans (electrical, physical, environmental, interfaces)
2. Emphasis of single phase dispatch; load balance correction; real and reactive
3. DC bus grounding requirement
4. Definition of momentary overload (inrush); starts per hour
5. Alarm, operating status, settings tables
6. Operating mode definitions, list of commands
7. Overhead (pole mounted) version of storage unit
8. Specification of DC Input module
9. DDC Interface standardization
10. Storage unit to Hub / Integration Platform interface
11. HAN requirements
12. Communication and Security requirements
13. Historical basis to automate determination of trigger levels
14. PQ – flicker mitigation, harmonic filtering

License for CES Storage Unit and Control Hub

- Developed by American Electric Power (AEP) with input by others.
  - AEP's intention to make it freely available to and for the use of all utilities, vendors and other interested parties.
  - Suggested further development of specification; welcomed contributions from others
  - Created a license and attached as appendix A of Specifications
- CES Functional Specification license*****
  - Collaborative effort of AEP and others
  - Protects Functional Specifications by copyright and/or other applicable law.
  - Worldwide, royalty-free, non-exclusive, perpetual license subject to the terms and conditions
  - Rights
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