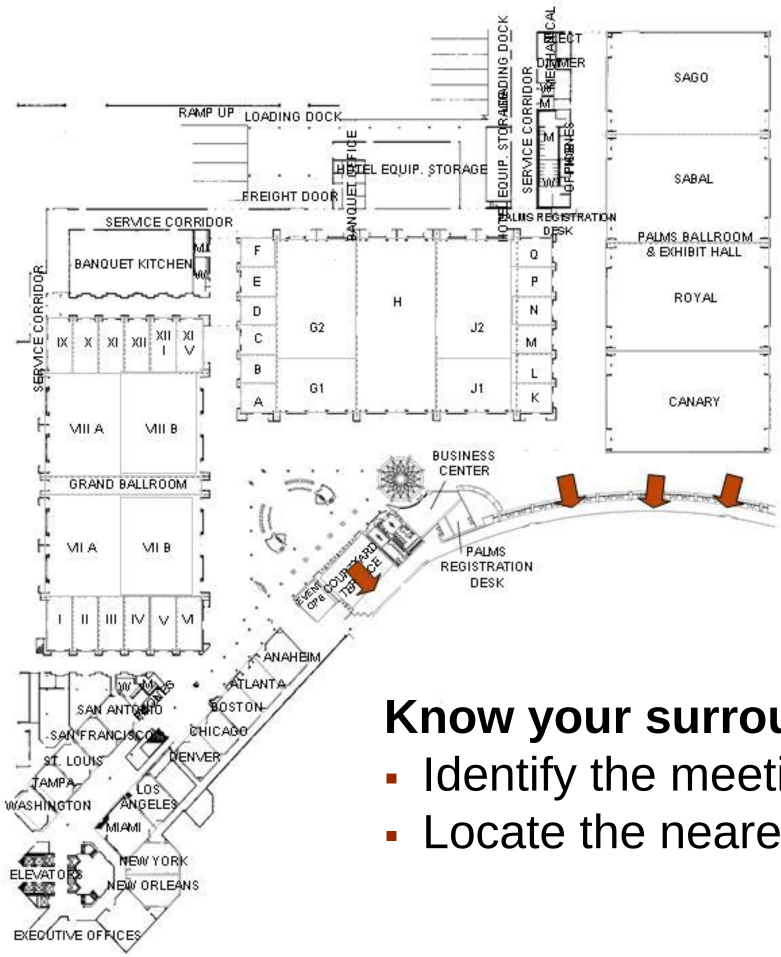
Value Propositions for Dynamic Energy Storage

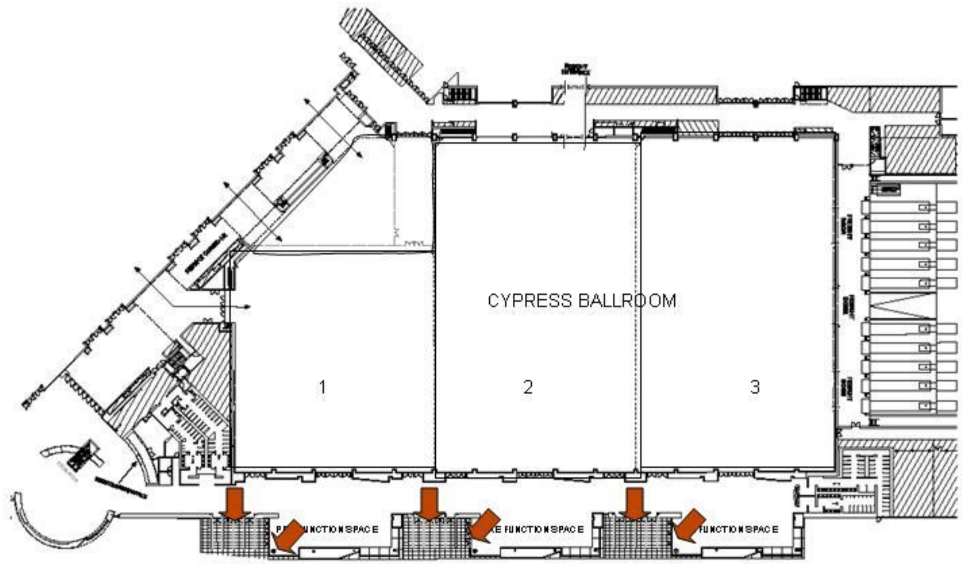
ABB Automation & Power World 2011

Your safety is important to us
Please be aware of these emergency procedures

- In the event of an emergency please dial ext. 55555 from any house phone. Do not dial 9-1-1.
- In the event of an alarm, please proceed carefully to the nearest exit. Emergency exits are clearly marked throughout the hotel and convention center.
- Use the stairwells to evacuate the building and do not attempt to use the elevators.
- Hotel associates will be located throughout the public space to assist in directing guests toward the closest exit.
- Any guest requiring assistance during an evacuation should dial “0” from any house phone and notify the operator of their location.
- Do not re-enter the building until advised by hotel personnel or an “all clear” announcement is made.

Your safety is important to us
Convention Center exits in case of an emergency





Know your surroundings:

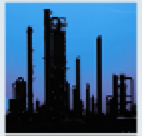
- Identify the meeting room your workshop is being held in
- Locate the nearest exit

The Saft Group in 2010 - Key figures*

*1.33 $/€ exchange rate (Dec. 2010)


Space

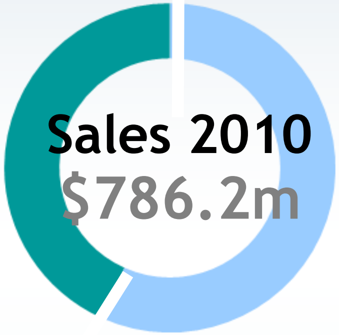

Defence


Industrial standby


Telecommunication

Specialty Battery Group
$345.8m
44.0 %

High performance primary and rechargeable lithium and silver batteries for the electronics, defence and space industries.



Industrial Battery Group
$440.4m
56.0 %

Rechargeable nickel and lithium-based batteries for demanding industrial applications.

Joint-Ventures:
- Johnson Controls-Saft
  HEV and EV batteries
- ASB Group
  Thermal batteries

Equity accounted


Metering and Professional Electronics


Emergency Lighting


Aviation


Clean Energy Storage


Rail and Mass Transit

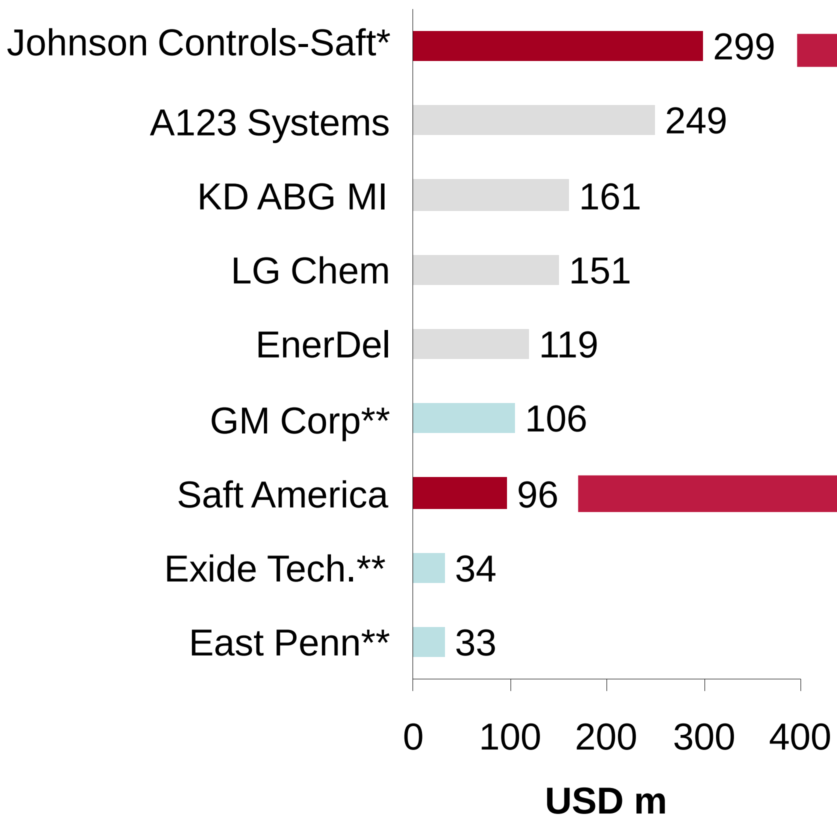
Johnson Controls – Saft Advanced Power Solutions

- JV to leverage Saft's technological leadership in automotive Li-ion
- JCI position as a tier 1 automotive supplier
- First contract to supply Li-ion to a major manufacturer (Daimler)
- Joint purchasing arrangement with Saft
- Synergies with energy storage

saft

Saft: Recognized as a Very Credible Player

Johnson Controls-Saft and Saft are together the leading beneficiaries of the US grants



Michigan project

Jacksonville project

Focused solely on non automotive renewable energy project

** Johnson Controls-Saft industrial project submitted by Johnson Controls Inc. to the Department of Energy*
*** non Li-ion manufacturing projects*

Source: US DoE

Jacksonville project update

- 230,000 square feet (21,400 square meters)
- Over 350 MWh plant capacity by 2015 with room for further expansion
- Start of production H2 2011

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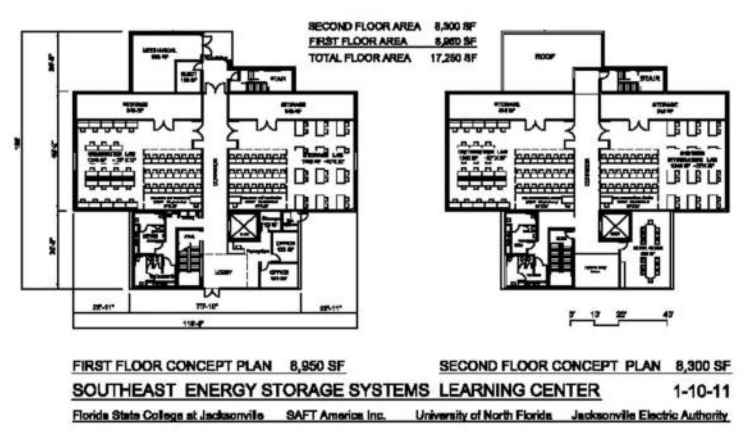
Southeast Energy Storage Learning Center

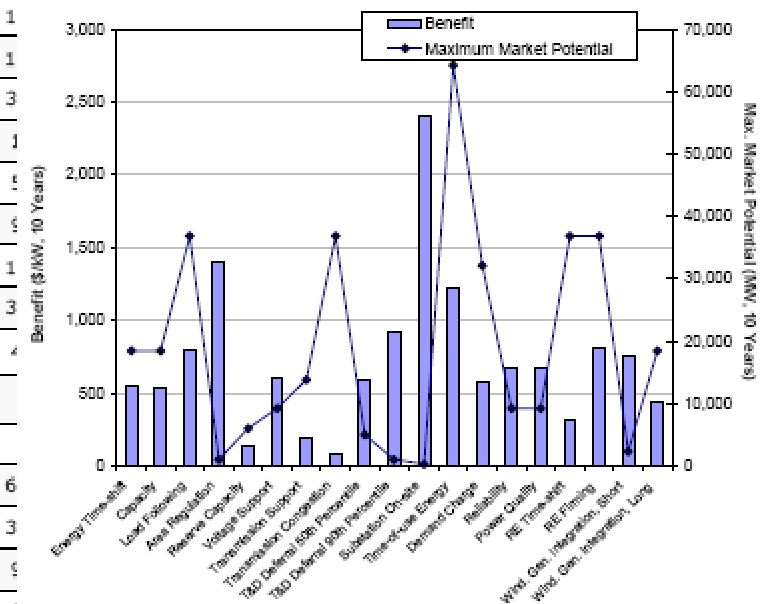


- Saft initiative with Florida-based partners
- Couple 1 MW rooftop PV with 1 MW / 1 MWh energy storage system
- Students will experiment with optimal dispatch
  - > PV output
  - > Grid signals from JEA

Valuing the benefits of energy storage – Sandia

#	Benefit Type	Discharge Duration* Low	Discharge Duration* High	Capacity (Power: kW, MW) Low	Capacity (Power: kW, MW) High	Benefit ($/kW)** Low	Benefit ($/kW)** High	Potential (MW, 10 Years) CA	Potential (MW, 10 Years) U.S.	Economy ($Million)† CA	Economy ($Million)† U.S.
1	Electric Energy Time-shift	2	8	1 MW	500 MW	400	700	1,445	[illegible]		
2	Electric Supply Capacity	4	6	1 MW	500 MW	359	710	1,445	[illegible]		
3	Load Following	2	4	1 MW	500 MW	600	1,000	2,889	[illegible]		
4	Area Regulation	15 min.	30 min.	1 MW	40 MW	785	2,010	80	[illegible]		
5	Electric Supply Reserve Capacity	1	2	1 MW	500 MW	57	225	636	[illegible]		
6	Voltage Support	15 min.	1	1 MW	10 MW	400		722	[illegible]		
7	Transmission Support	2 sec.	5 sec.	10 MW	100 MW	192		1,084	[illegible]		
8	Transmission Congestion Relief	3	6	1 MW	100 MW	31	141	2,889	[illegible]		
9.1	T&D Upgrade Deferral 50th percentile††	3	6	250 kW	5 MW	481	687	386	[illegible]		
9.2	T&D Upgrade Deferral 90th percentile††	3	6	250 kW	2 MW	759	1,079	77			
10	Substation On-site Power	8	16	1.5 kW	5 kW	1,800	3,000	20			
11	Time-of-use Energy Cost Management	4	6	1 kW	1 MW	1,226		5,038	[illegible]		
12	Demand Charge Management	5	11	50 kW	10 MW	582		2,519	[illegible]		
13	Electric Service Reliability	5 min.	1	0.2 kW	10 MW	359	978	722	[illegible]		
14	Electric Service Power Quality	10 sec.	1 min.	0.2 kW	10 MW	359	978	722	[illegible]	[illegible]	[illegible]
15	Renewables Energy Time-shift	3	5	1 kW	500 MW	233	389	2,889	36,834	899	11,455
16	Renewables Capacity Firming	2	4	1 kW	500 MW	709	915	2,889	36,834	2,346	29,909
17.1	Wind Generation Grid Integration, Short Duration	10 sec.	15 min.	0.2 kW	500 MW	500	1,000	181	2,302	135	1,727
17.2	Wind Generation Grid Integration, Long Duration	1	6	0.2 kW	500 MW	100	782	1,445	18,417	637	8,122

*Hours unless indicated otherwise. min. = minutes. sec. = seconds.
**Lifecycle, 10 years, 2.5% escalation, 10.0% discount rate.
†Based on potential (MW, 10 years) times average of low and high benefit ($/kW).
†† Benefit for one year. However, storage could be used at more than one location at different times for similar benefits.



Sandia SAND2010-0815: Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide

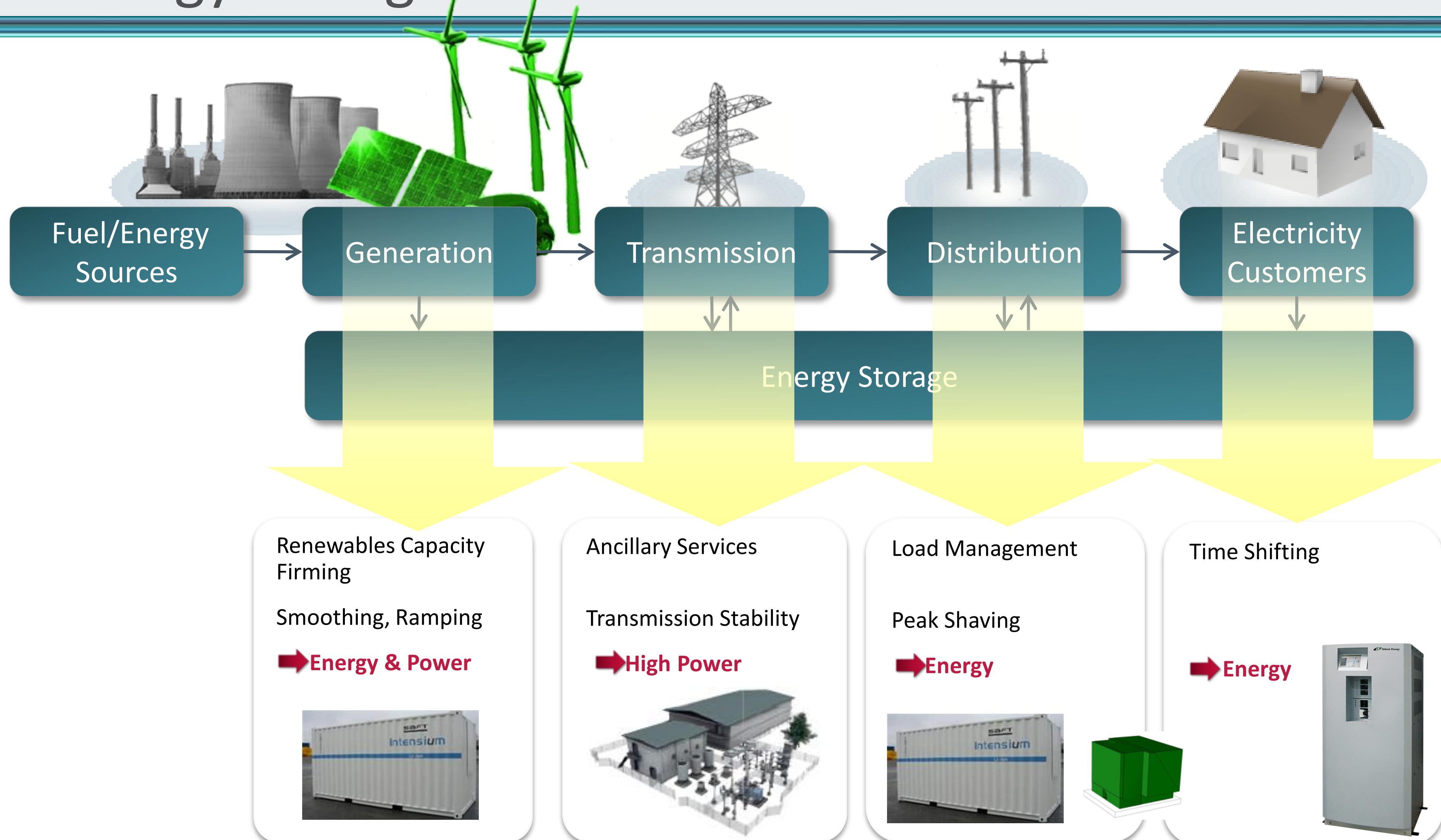
Valuing the benefits of energy storage - EPRI

			PV $/kW-h		PV $/kW	
Value Chain	Benefit		Target	High	Target	High
End User	1	Power Quality	19	96	571	2,854
	2	Power Reliability	47	234	537	2,686
	3	Retail TOU Energy Charges	377	1,887	543	2,714
	4	Retail Demand Charges	142	708	459	2,297
Distribution	5	Voltage Support	9	45	24	119
	6	Defer Distribution Investment	157	783	298	1,491
	7	Distribution Losses	3	15	5	23
Transmission	8	VAR Support	4	22	17	83
	9	Transmission Congestion	38	191	368	1,838
	10	Transmission Access Charges	134	670	229	1,145
	11	Defer Transmission Investment	414	2,068	1,074	5,372
System	12	Local Capacity	350	1,750	670	3,350
	13	System Capacity	44	220	121	605
	14	Renewable Energy Integration	104	520	311	1,555
ISO Markets	15	Fast Regulation (1 hr)	1,152	1,705	1,152	1,705
	16	Regulation (1 hr)	514	761	514	761
	17	Regulation (15 min)	4,084	6,845	1,021	1,711
	18	Spinning Reserves	80	400	110	550
	19	Non-Spinning Reserves	6	30	16	80
	20	Black Start	28	140	54	270
	21	Price Arbitrage	67	335	100	500

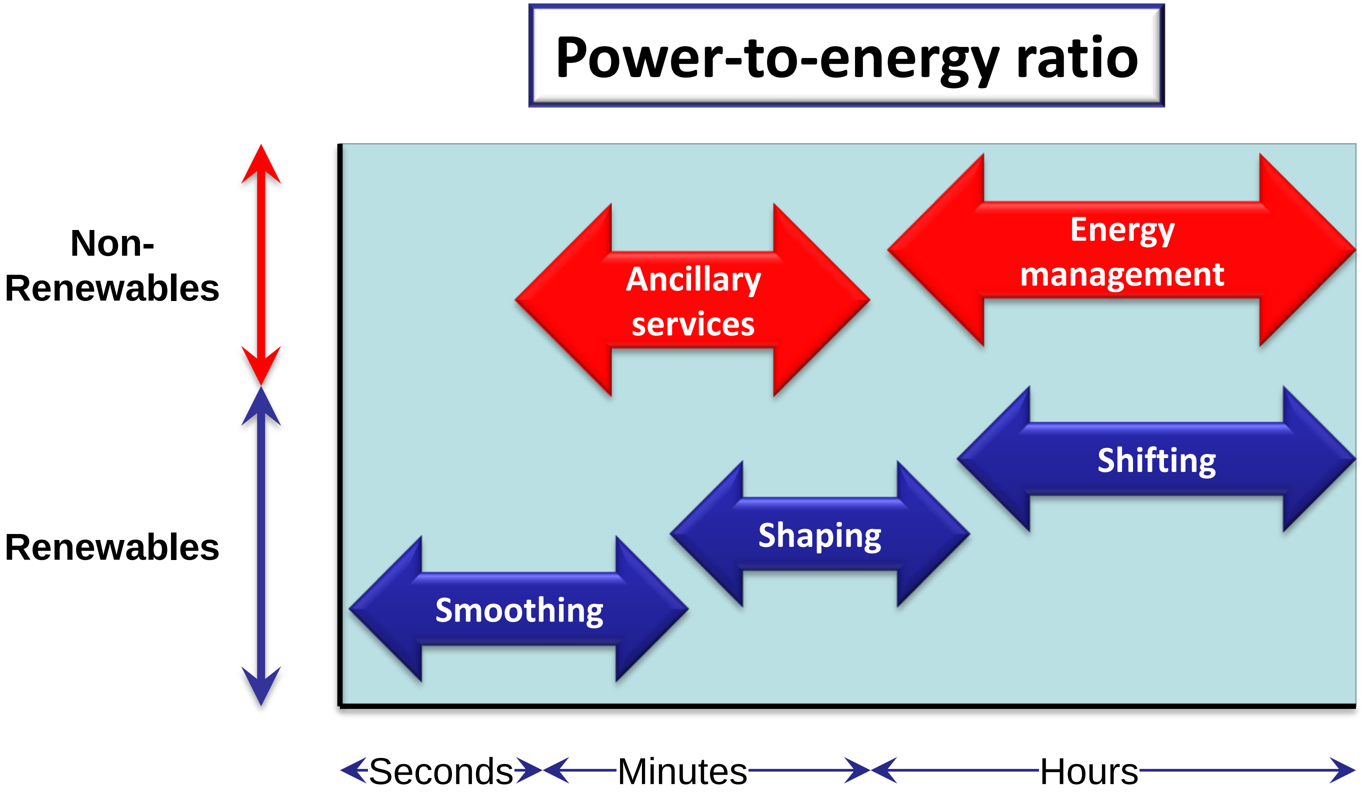
Note: each benefit is modeled in isolation using a consistent battery configuration of 1 MW of discharge capacity and 2 MWh of energy storage capacity, with a 15-year life and a 10% discount rate. Here we introduce the nomenclature "$/kW-h" used throughout this report. In this table it is the present value of the benefits divided by the useable kWh of the energy storage device.

Electric Energy Storage Technology Options: A Primer on Applications, Costs & Benefits – December 2010

Energy storage solutions – location



Energy storage solutions – power & energy



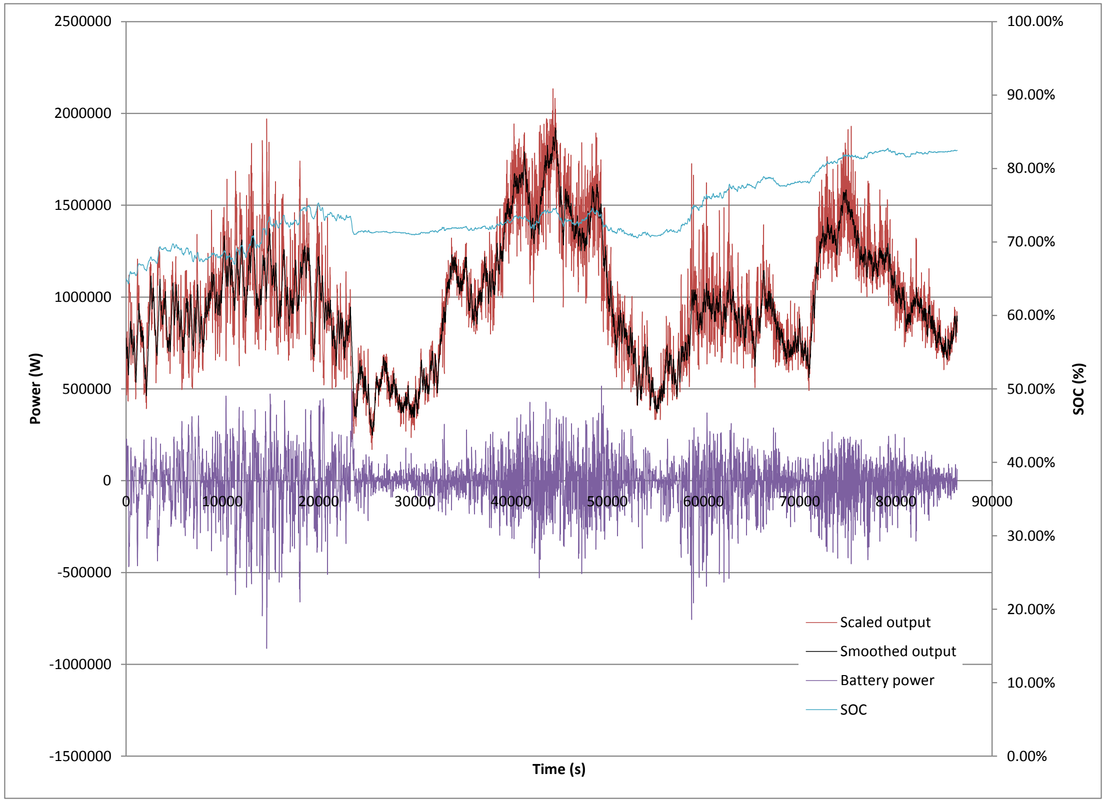
- Li-ion technology has the flexibility to address all these functions

Ancillary services

- Services supporting the basic function of delivering electrical energy to the consumer
- Regulation
  - Frequency regulation
  - Area regulation
  - Pay-for-performance services
- Spinning (synchronized) reserves
  - Instant-on reserves with no fuel consumption
- Black-start capability
  - Instant matching of supply and demand

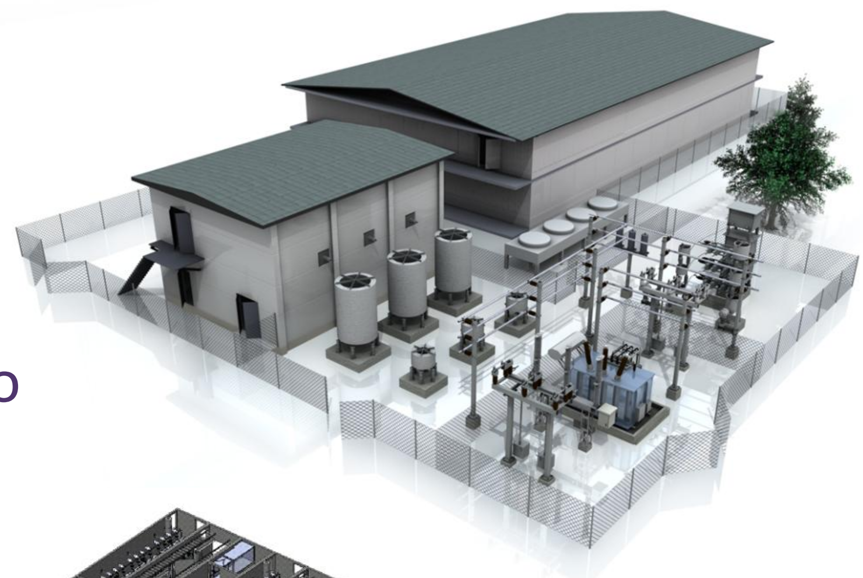
Renewables – smoothing

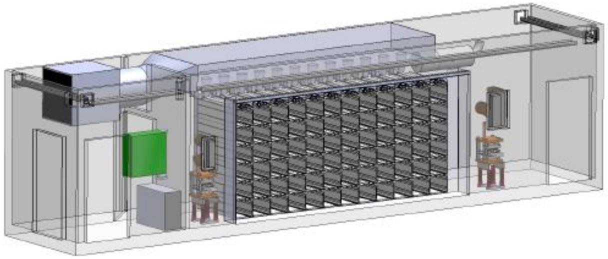
- Example – ramping support for wind farms
- Individual 2.5 MW turbine ramping from full output to zero in approx. 30 minutes
- Storage ratings
  - > Approx. power 1 MW
  - > Approx. energy 0.5 MWh (usable)
- Aggregation of wind output should lead to smaller storage ratings

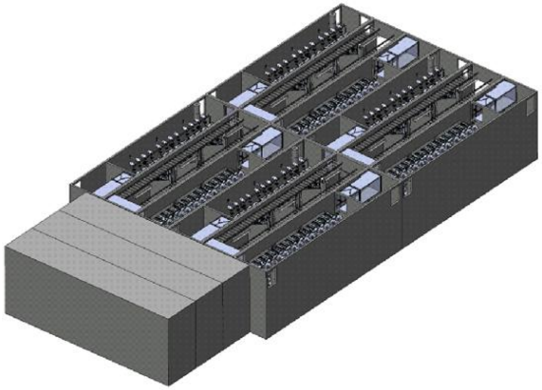


Solutions for smoothing - large-scale

- ABB DynaPeaQ system
  (SVC Light with energy storage)
- Up to 50 MW, up to 1 hour
- Up to 80 kV dc
- Capability to sell VAR support to wind farms



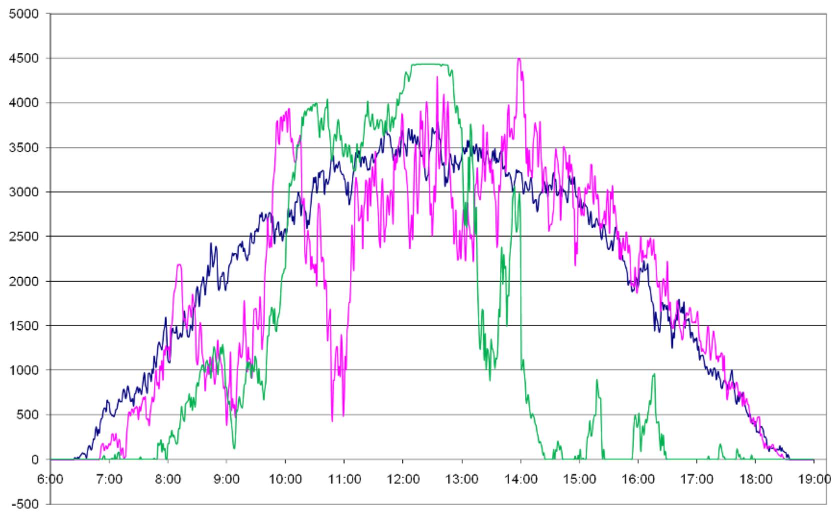




Solutions for smoothing – smaller-scale

- Intensium Max containerized systems
- ISO containers – 20-ft or 40-ft
- Separate PCS
- Allows for maximum flexibility
  - > Transportation
  - > Siting
- Flexible power-to-energy ratio
- Medium power 20-ft
  - > 560 kWh
  - > 1.1 MW, 30 min

Renewables – shaping



Source: Aerowatt

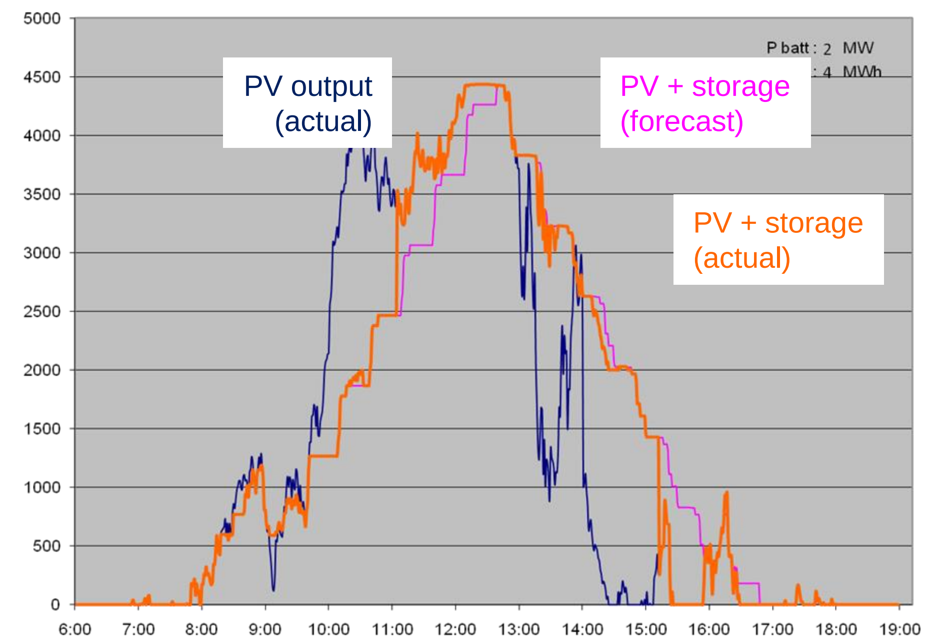
- Allows renewable energy source to be firmed
- Conformance to forecast output
- Especially important in island grids

Smoothing and shaping PV farm output

- Storage of ~20% of daily PV output
- Smoothed injection to grid

- Example:
  > Per MW of PV rating
  > 0.5 to 1 MW battery power
  > 0.5 to 1 MWh battery energy

Worst-case scenario



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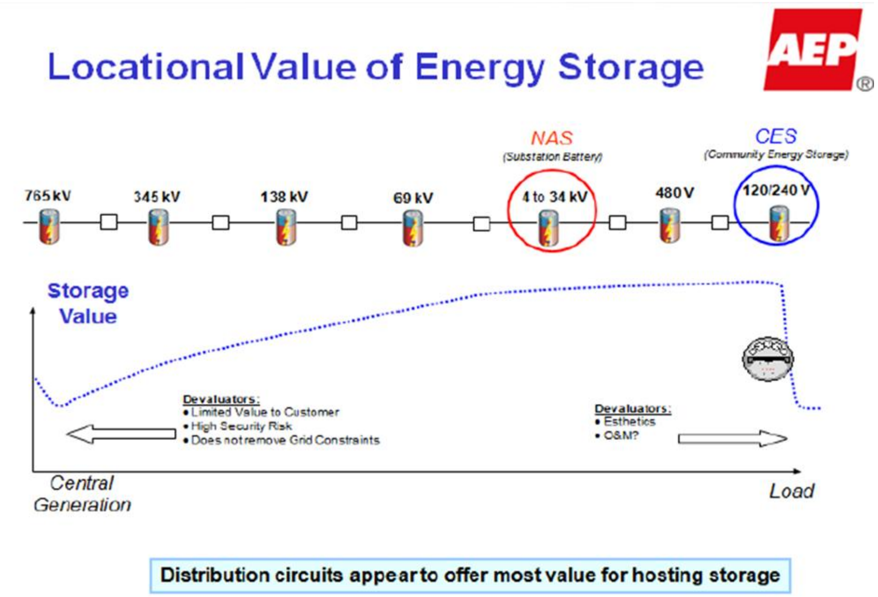
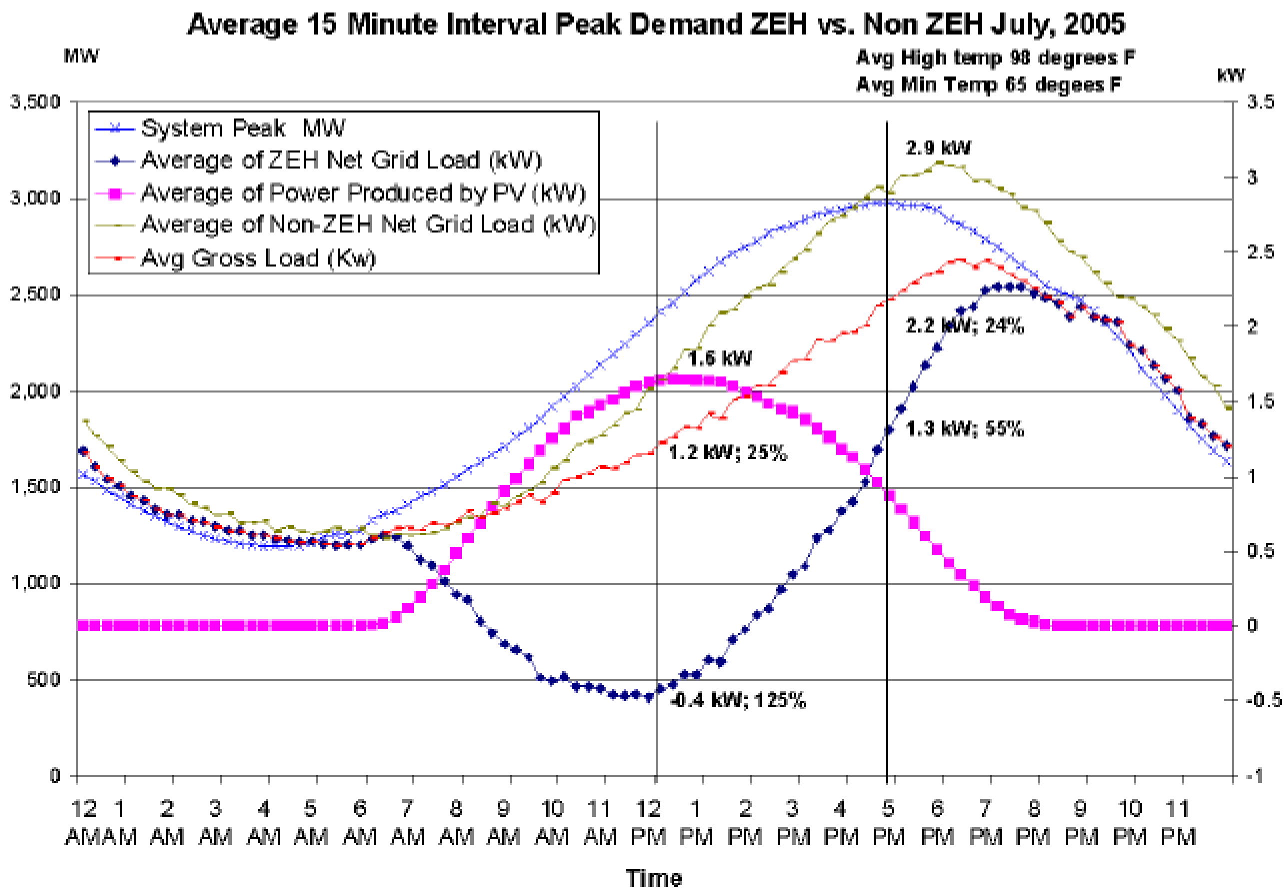
Renewables – shifting

- Hours of storage
- Low value in remote systems
- Locate closer to users to achieve higher value

- Local options
  > Substation storage
  > Community energy storage
  > Residential storage (with rooftop PV)



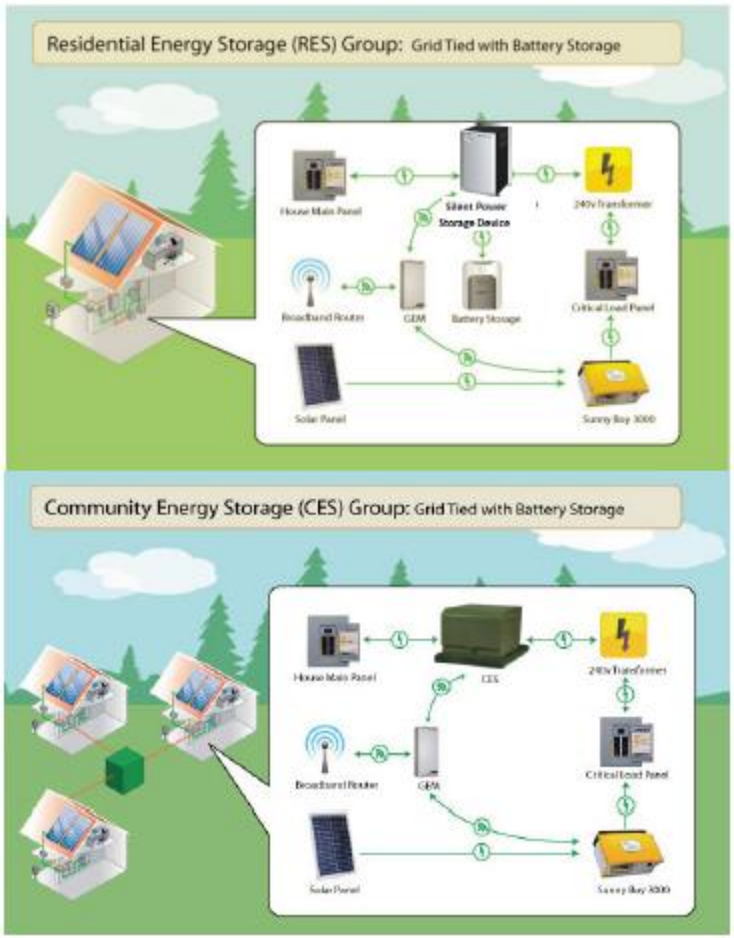
PV peak vs. system peak



SMUD
SACRAMENTO MUNICIPAL UTILITY DISTRICT
The Power To Do More.SM

SMUD Anatolia III project

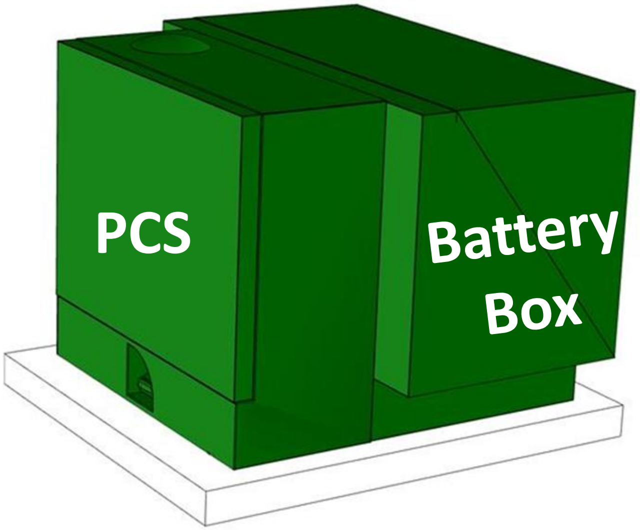
SMUD
SACRAMENTO MUNICIPAL UTILITY DISTRICT
The Power To Do More.[SM]

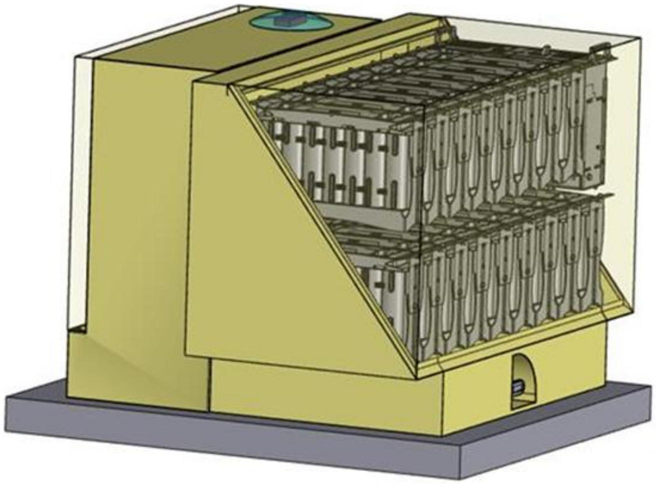


- ARRA FOA 85 Topic 4: High penetration solar development
- Installing 15 RES and 3 CES units in Anatolia 'SolarSmart' Homes that currently have 2kW PV systems
- Installing utility and customer portals to monitor PV, storage, customer load
- Sending price signals to effect changes in customer usage
- Developing specification for smart meter/inverter interface to enable management of distributed PV/storage system with AMI
- Saft is storage partner using advanced Li-ion technology developed for EV

SMUD CES systems

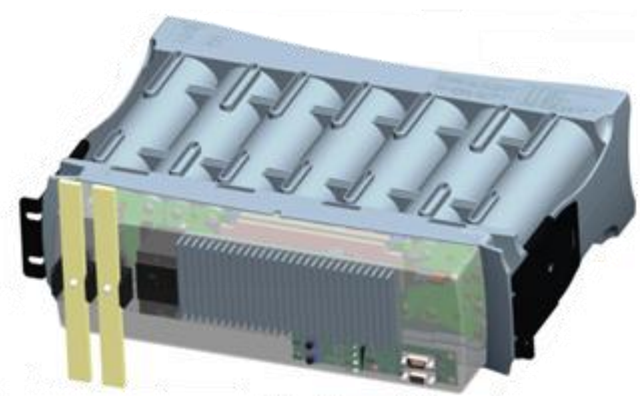
- 30 kW / 34 kWh systems
- Each serving 5 homes
- Partner companies
  - > GridPoint - communications
  - > PowerHub - PCS
  - > Saft - battery





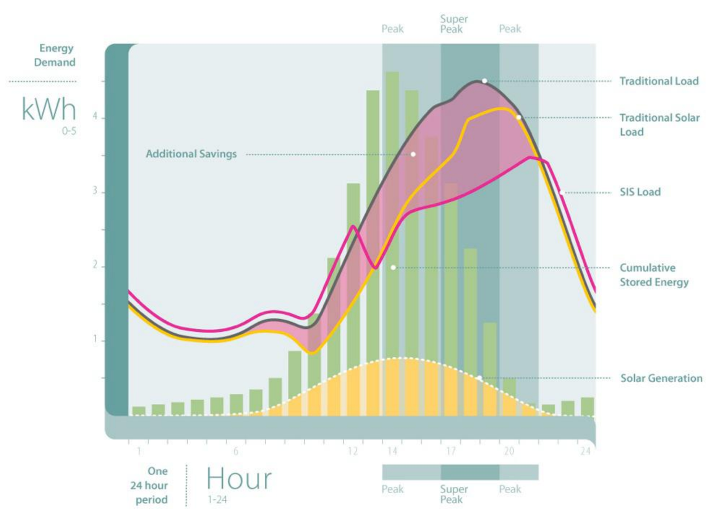
SMUD RES systems

- 4 kW / 8.8 kWh
- Partner companies
    - > GridPoint - communications
    - > Silent Power - PCS
    - > Saft - battery



2500 R Street microgrid project

- Pacific Housing 34-home project in Sacramento
- Enhanced grid benefits with less PV



SUNVERGE

Optimizing value from PV storage

- Minimize cost of storage
  - > Synergies with EV applications for Li-ion
- Storage requirements
  - > Maximum life
  - > Wide operating state of charge range
  - > Very high efficiency (>95% dc)
- Maximize value
  - > Residential PV shifting to avoid peak rates
  - > Explore other value streams

Maximizing value – residential

Value Chain	Benefit		PV $/kW-h Target	PV $/kW-h High	PV $/kW Target	PV $/kW High
End User	1	Power Quality ✓	19	96	571	2,854
	2	Power Reliability ✓	47	234	537	2,686
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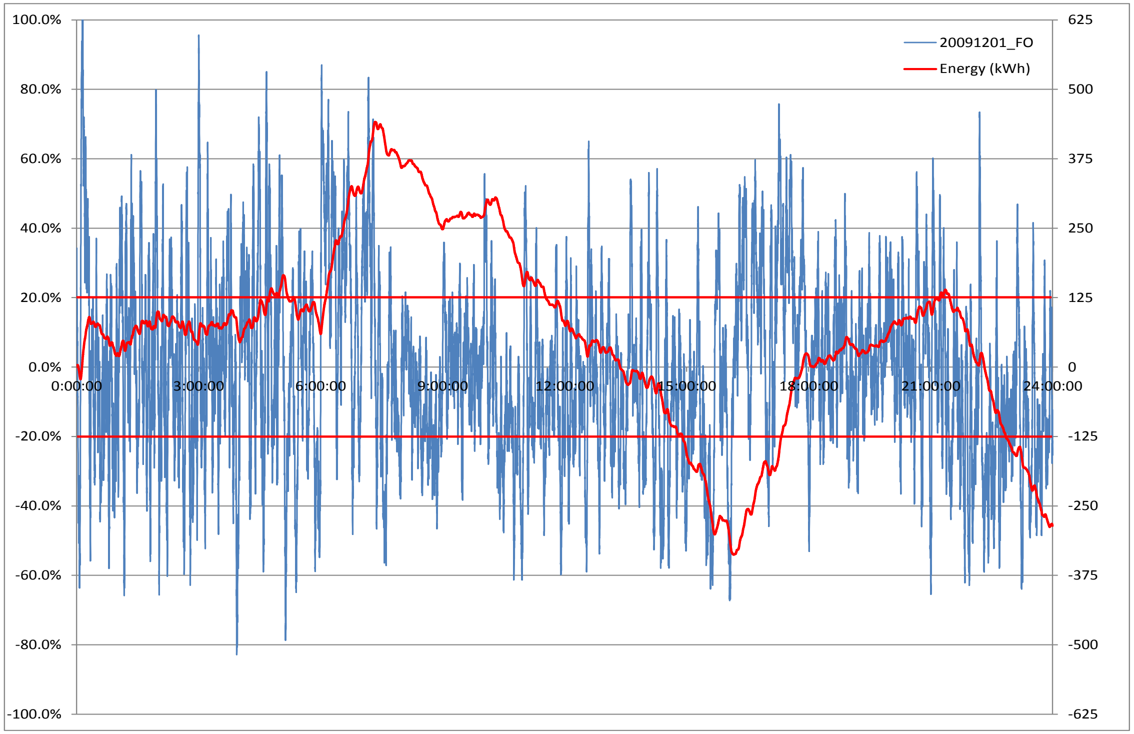
Maximizing value – ancillary services

- Regulation can be challenging for a battery
- Is a short life acceptable?
- Longer life can be achieved by minimizing depth of discharge



- Residual energy can generate value from spinning reserve service while helping to extend life

A final note on CO_2 emissions

- Energy storage could be viewed as resulting in INCREASED emissions
- A lot depends on how the storage is charged
- Significant CO_2 reductions can come from displacing peaking generation and generation for ancillary services

Summary

- The cost of energy storage can be mitigated by addressing multiple value streams
- Energy storage provides solutions to RE integration issues, allowing higher penetration levels
- Energy storage will also make electricity networks function more efficiently through ancillary services

Thanks for listening!

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