ELECTRIC ENERGY STORAGE

January 12-13, 2011 Phoenix, AZ

Vincent Pusateri

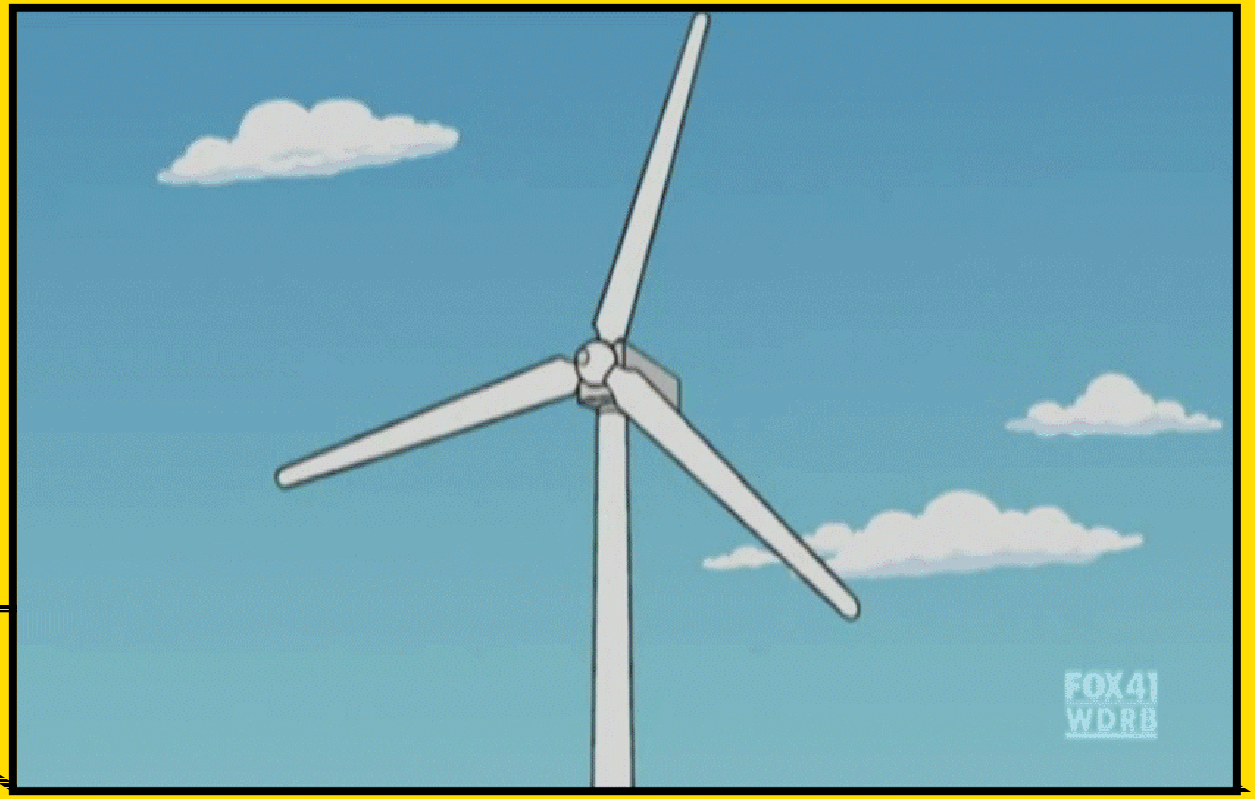
GS Battery (USA) Inc.

Sr. Director, Business Development

GSEA GEORGIA SOLAR ENERGY ASSOCIATION

SEPA solar electric power association

The Simpsons Go “Off Grid”

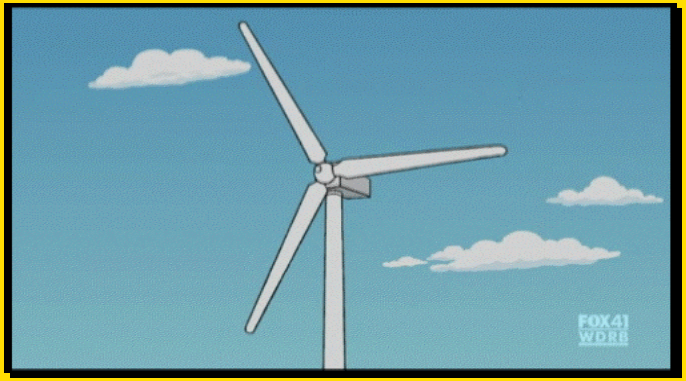


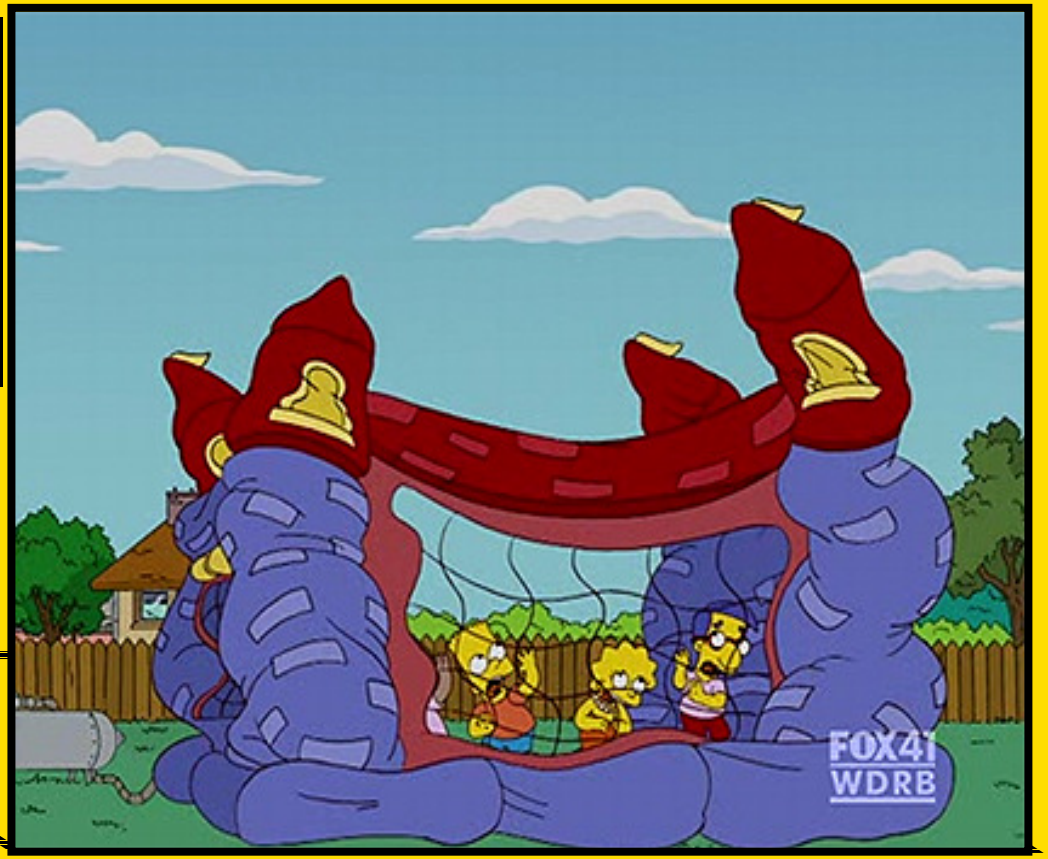
The Simpsons Season 21 Episode 19
The Squirt and the Whale

The Simpsons Go “Off Grid”

The Simpsons Season 21 Episode 19
The Squirt and the Whale

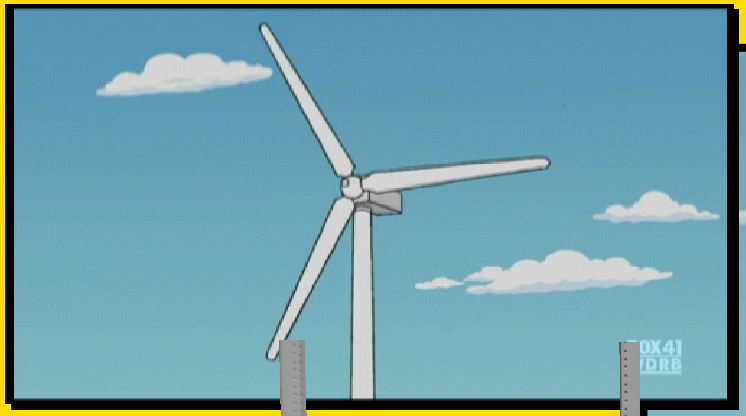
Without Battery Storage.





The Simpsons Season 21 Episode 19
The Squirt and the Whale

With Battery Storage Solution.



The Simpsons Season 21 Episode 19
The Squirt and the Whale

Assessing Battery Storage Solutions for the Utility Distributed Energy Market

I. Distributed Energy Storage System (DESS)

II. Value Chain for DESS

III. Comparing Battery Chemistries for DESS

IV. Current DESS Applications

V. Future Applications for DESS

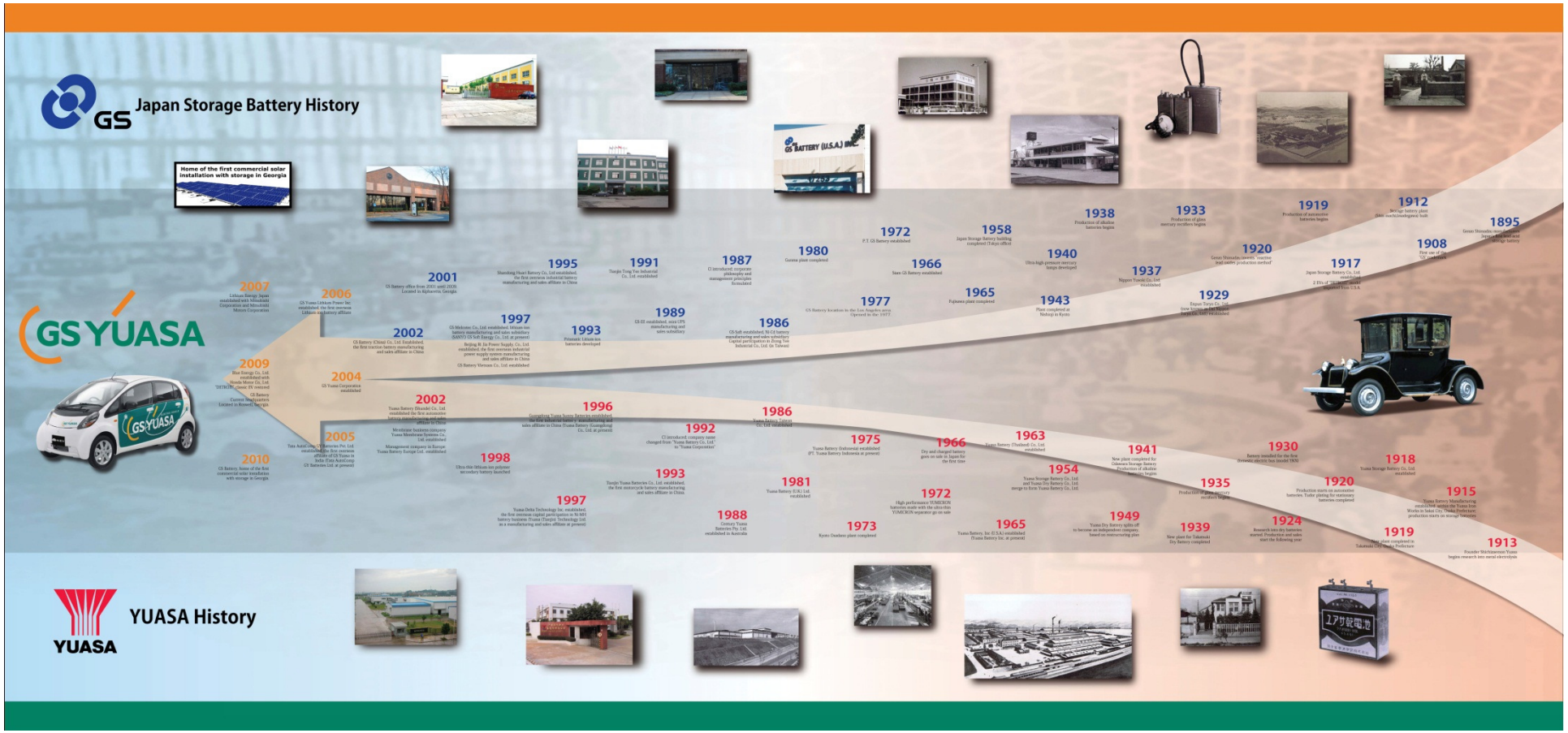
History of GS Yuasa

In 1917
Genzo Shimadzu

Founded Japan Storage Battery Co., Ltd. Shimadzu-san succeeded in developing the first lead acid battery in Japan. He is a holder of 178 patents in over 12 countries.

In 1918
Shichizaemon Yuasa

Founded Yuasa Battery Manufacturing. During World War I, Yuasa-san expanded the company to provide batteries world wide. He developed the first EV batteries in Japan and introduced them to Ford, GM.



Major Products

Automotive Batteries

Automotive

Motorcycle

Advanced Batteries

Satellite

Aircraft

EV/HEV

Industrial Batteries and Power Supply System

Motor Power

Water purification plant

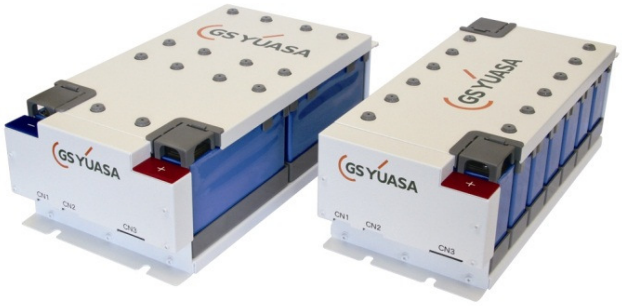
Backup Power

Telecommunications

Photovoltaic power

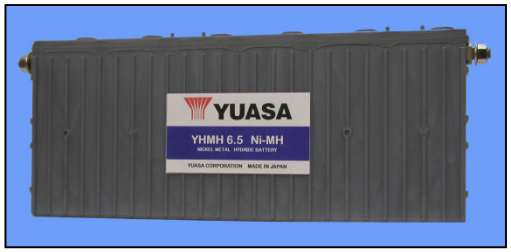
New Products

Large-sized Lithium-ion Battery



Ni-MH batteries

HEV

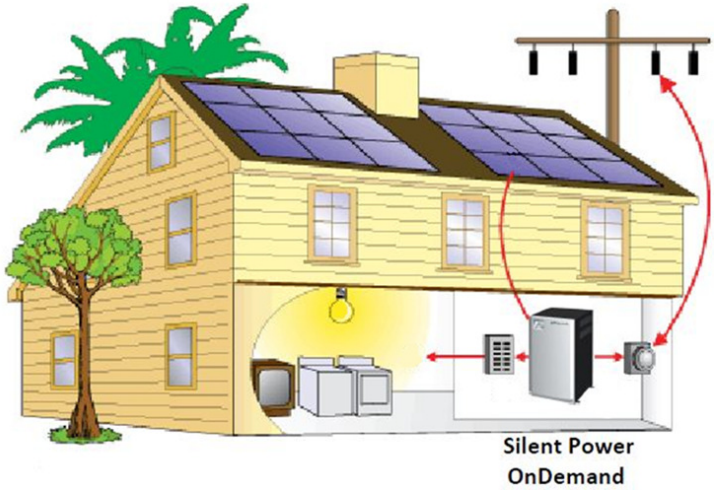


Advanced Lead Acid batteries

Distributed Energy Storage System (DESS)

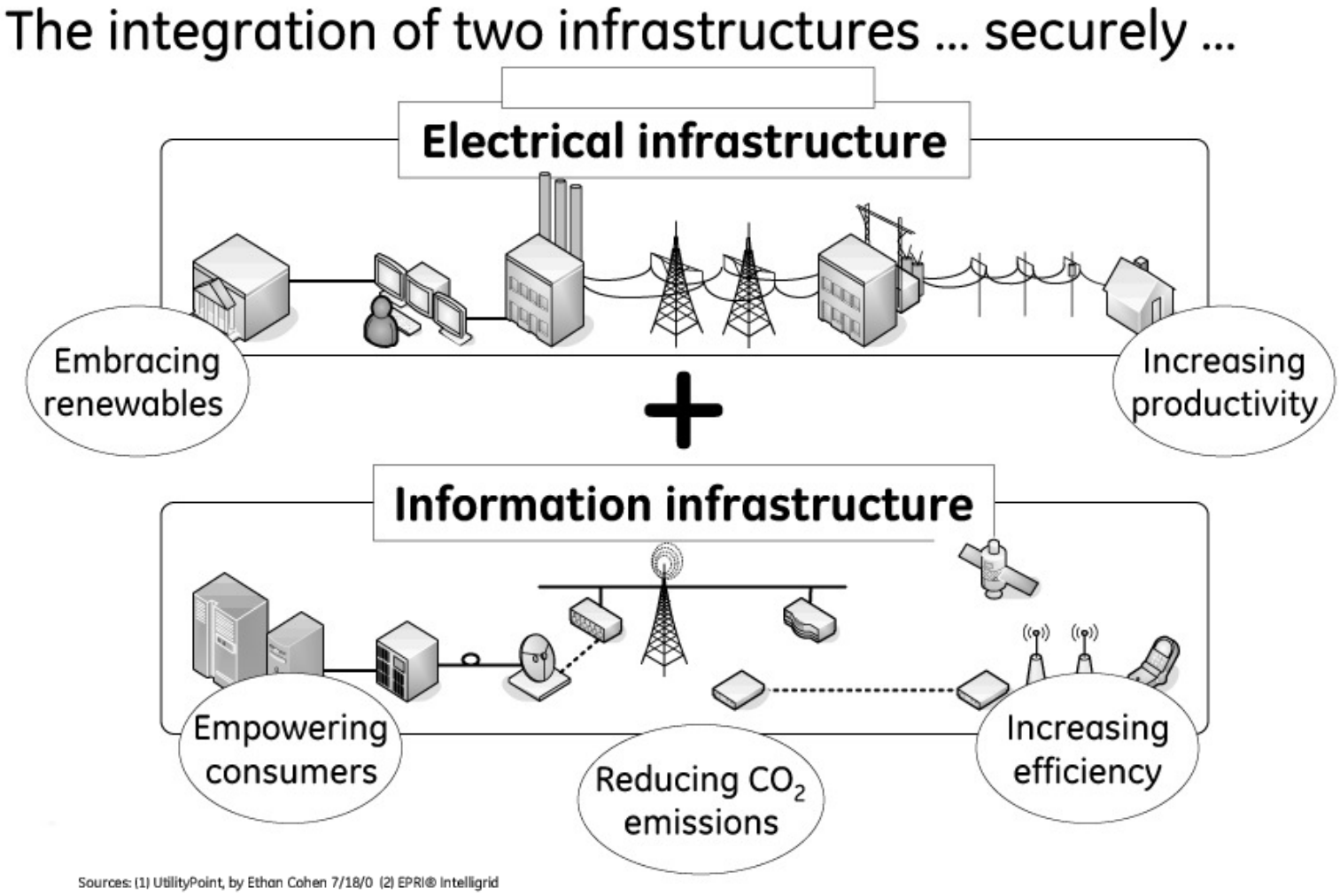
What is DESS?

- **DESS** - **Distributed Energy Storage System** - uses renewables to decentralize power generation and storage . DESS includes:
  - **CES** – **Community Energy Storage** - small distributed energy storage unit connected to the secondary of transformers serving a few homes or commercial sites
  - **RES** – **Residential Energy Storage** – integrates small distributed energy storage unit into one residential site building



Distributed Energy Storage System (DESS)

What is Smart Grid?

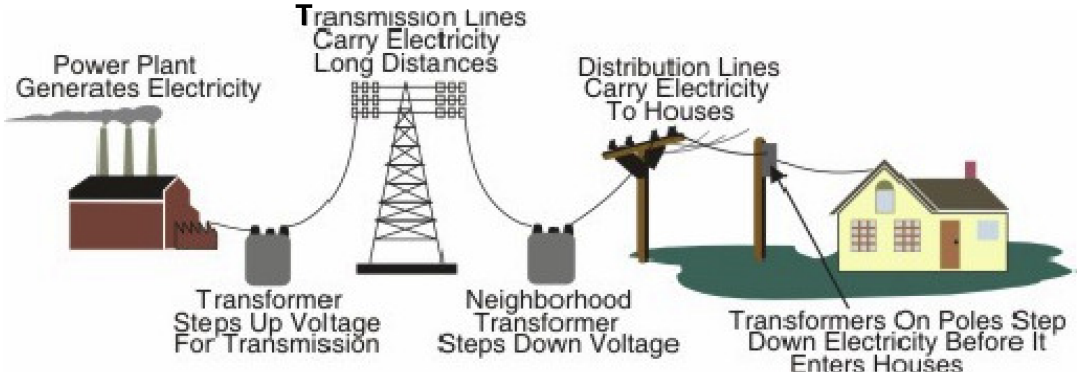


Distributed Energy Storage System (DESS)

The Evolution of the Electric Utility System

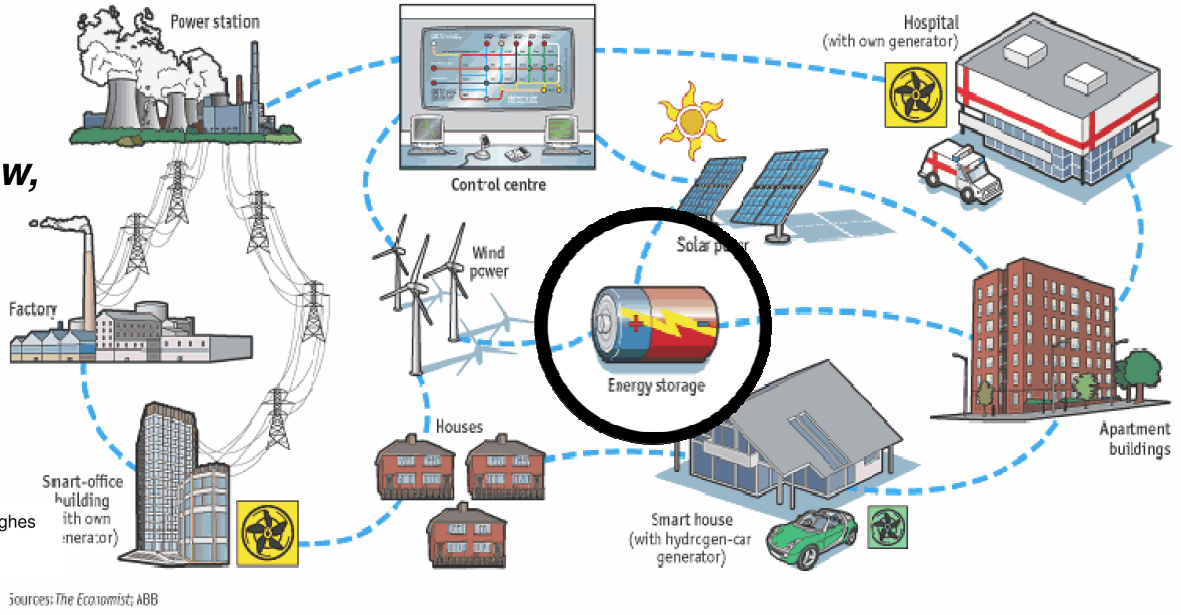
Before **Smart Grid:**

One-way power flow, simple interactions



After **Smart Grid:**

Two-way power flow, multi-stakeholder interactions

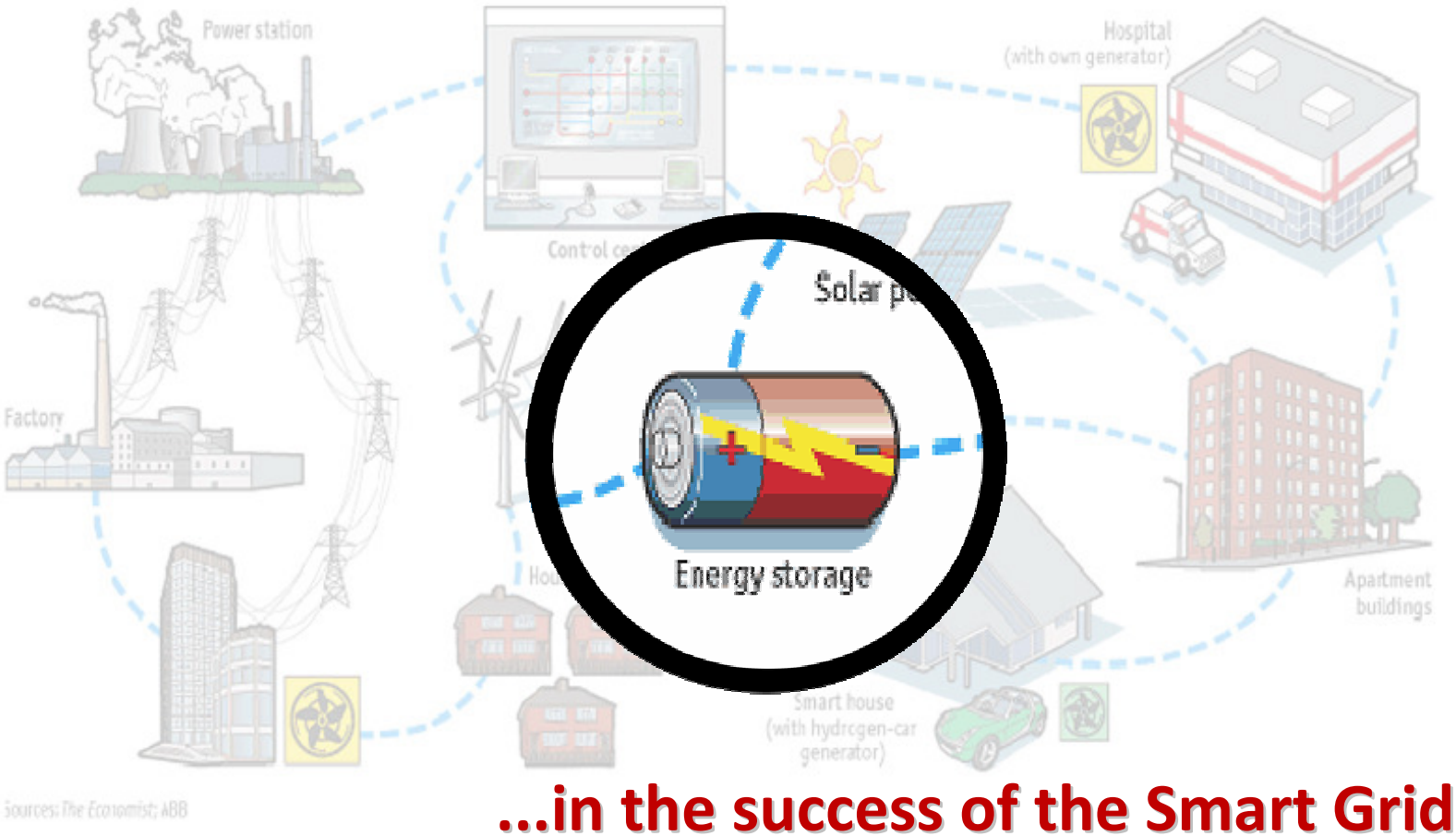


Adapted from EPRI Presentation by Joe Hughes
NIST Standards Workshop
April 28, 2008

Distributed Energy Storage System (DESS)

The Evolution of the Electric Utility System

Energy Storage is a central component...



...in the success of the Smart Grid!

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

Distributed Energy Storage System (DESS)

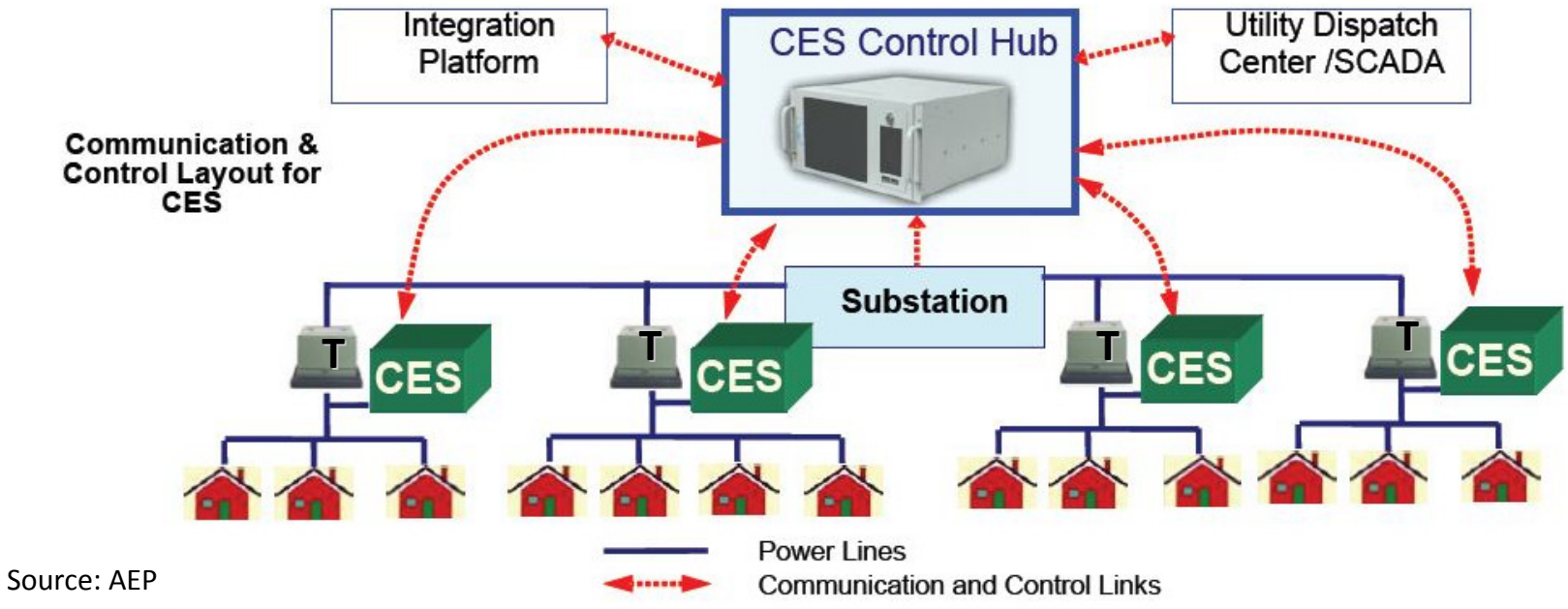
CES Benefits

Local Benefits:

1. Backup power
2. Voltage correction

Grid Benefits:

3. Load Leveling at substation level
4. Power Factor Correction
5. Ancillary services



Source: AEP

Distributed Energy Storage System (DESS)

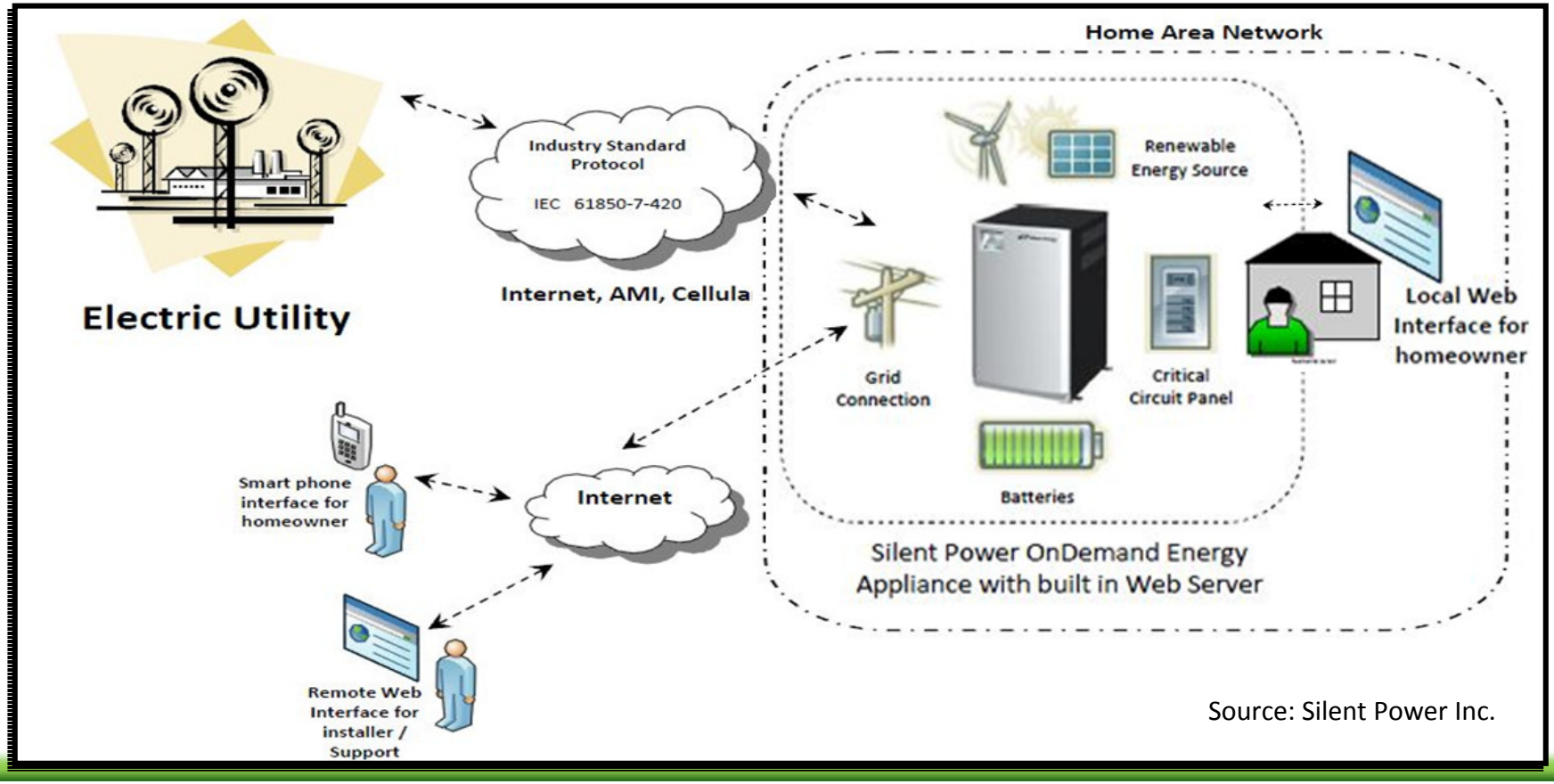
RES Benefits

Local Benefits:

1. Backup power
2. Renewable shifting
3. Demand response
4. Voltage correction

Grid Benefits:

5. Power factor correction
6. Some ancillary services



Source: Silent Power Inc.

Value Chain for DESS

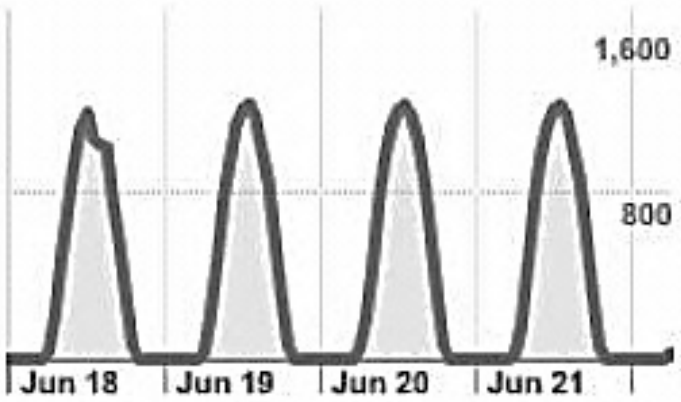
Wind/PV Variability and Intermittency

Variability:

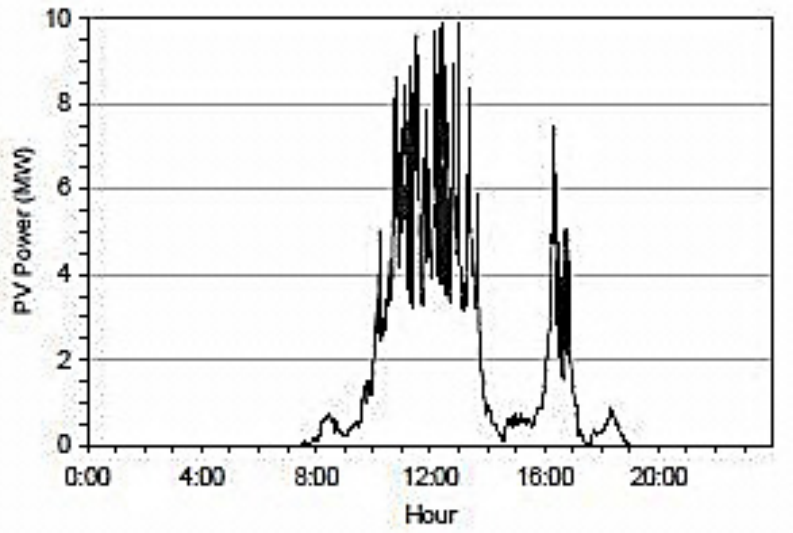
- Caused by day/night cycles
- Predictable
- Slow

Intermittency:

- Caused by cloud cover
- Somewhat unpredictable
- Fast

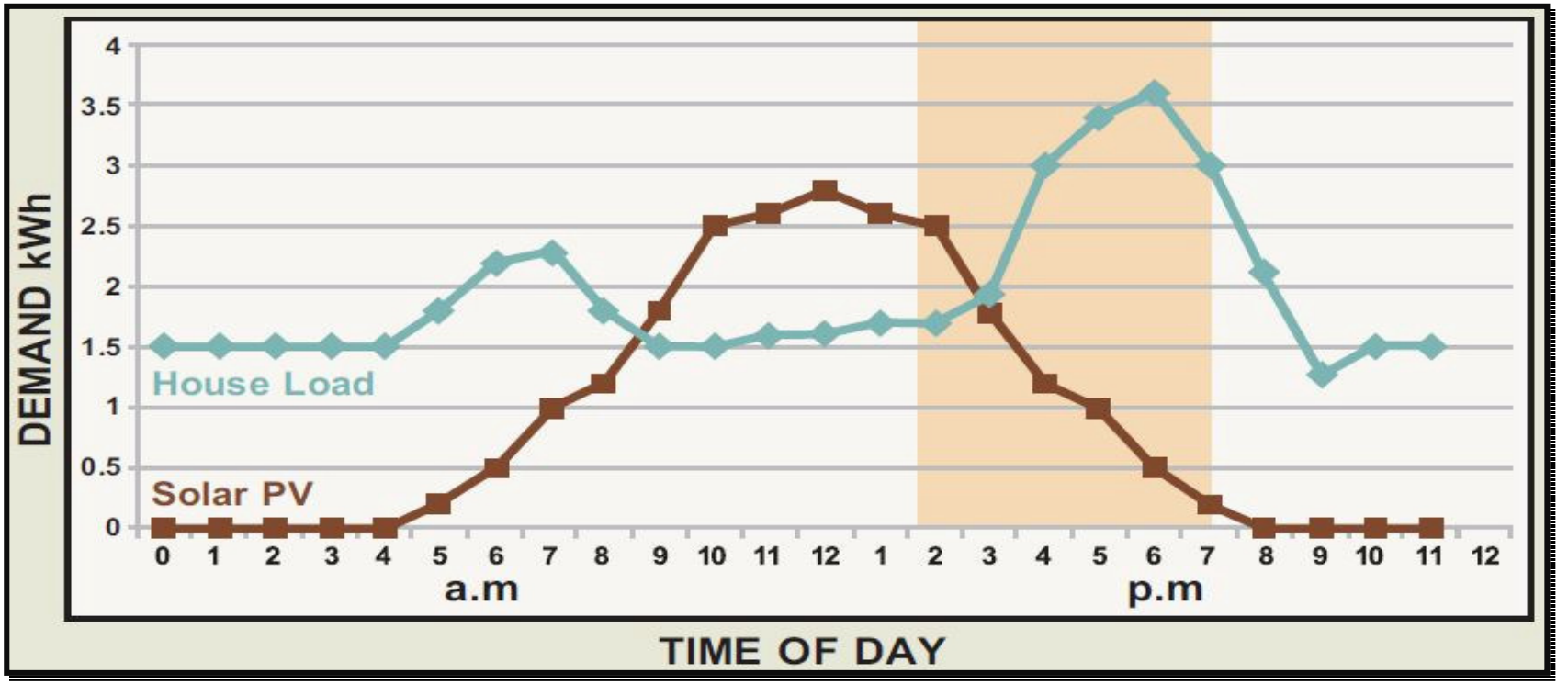


Source: GE



Value Chain for DESS

Residential PV & Energy Storage – Peak Shifting



- Solar power and load peaks are shifted by ~5 hours.
- The greatest value to the utility may be aggregation of many residential systems.

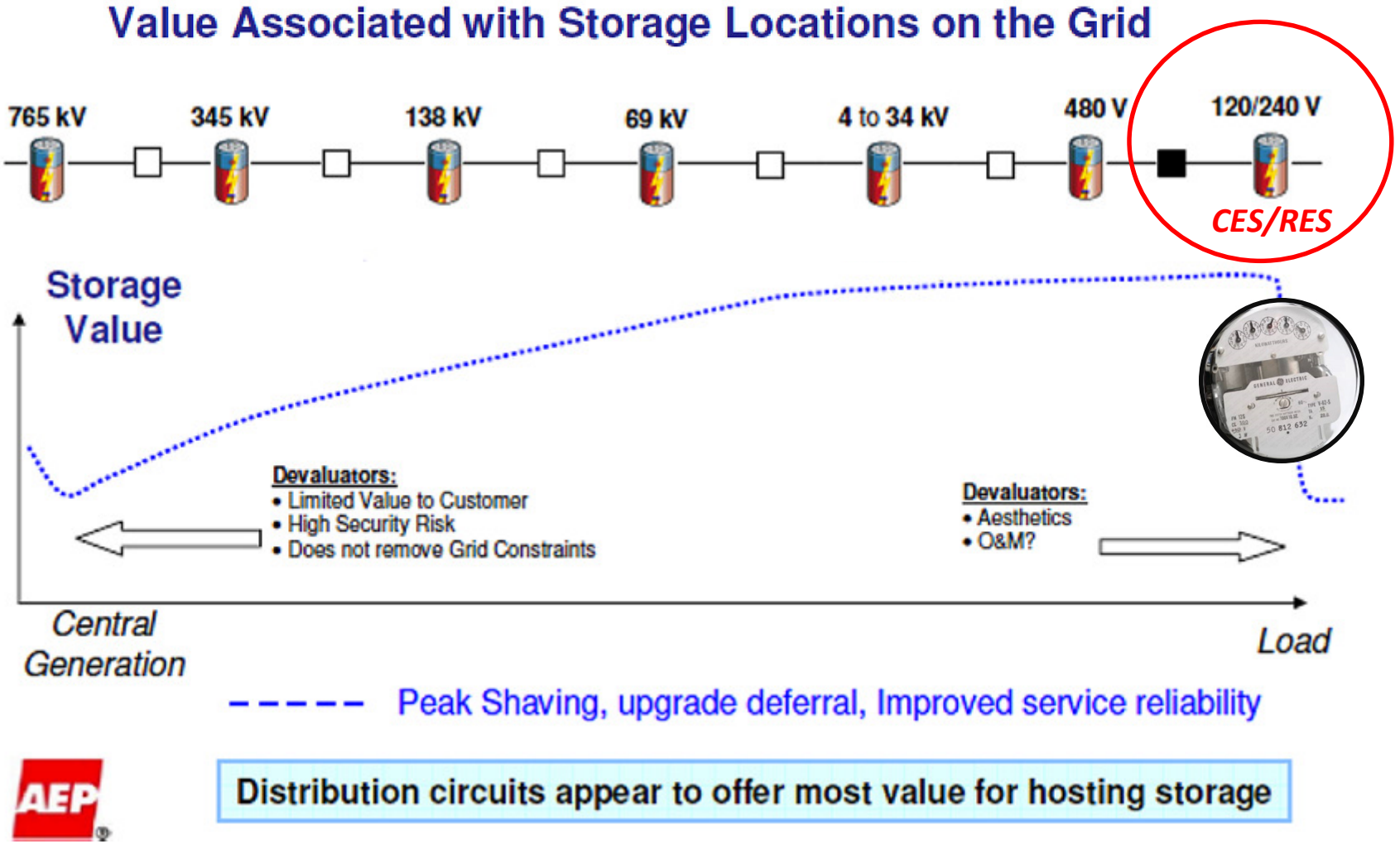
Source: Silent Power Inc.

Value Chain for DESS
Benefits/Applications of Storage

Category	Benefits
Electric Supply	1. Electric Energy Time-Shift 2. Electric Supply Capacity
Grid Operations (Ancillary Services)	3. Load Following 4. Area Regulation 5. Electric Supply Reserve Capacity 6. Voltage Support
Grid Infrastructure	7. Transmission Support 8. Transmission Congestion Relief 9. Transmission and Distribution Upgrade Deferral 10. Substation Onsite Power
End-User	11. Time-of-Use Energy Cost Management 12. Demand Charge Management 13. Electric Service Reliability 14. Electric Service Power Quality
Renewables Integration	15. Renewables Energy Time-Shift 16. Renewables Generation Capacity Firming 17. Wind Generation Grid Integration

Source: SANDIA Report SAND2010-0815, *Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide*, Jim Eyer & Garth Corey (February 2010)

Value Chain for DESS
Distributed Storage Value Curve



Distribution circuits appear to offer most value for hosting storage

Value Chain for DESS

Comparison RES vs CES

REQUIREMENTS	CES	RES
Site Engineering	100% Paid by Utility	Part of Solar PV install
Installation Costs	100% Paid by Utility	Part of Solar PV install
Customer Acceptance	NIMBY, low	Opt in
Communication Costs	100% Paid by Utility	End customer broadband
Balance of system and inverter reuse	None	Reuses solar inverter and components
30% Federal Investment Tax Credit Applicability	None	100%
Volume to drive down cost	1,000(s)	10,000(s)

Source: Silent Power Inc.

Value Chain for DESS

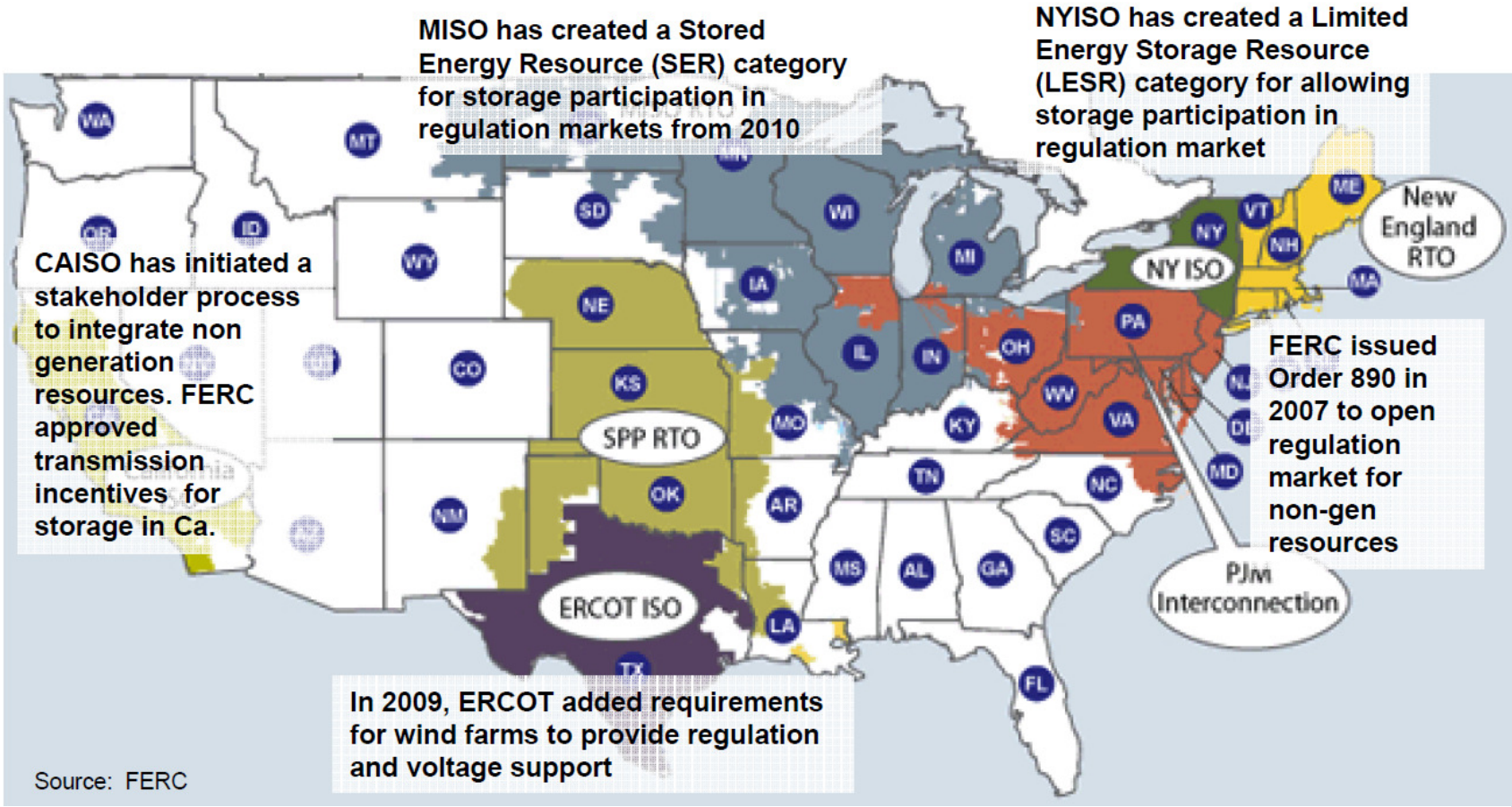
Utility Energy Storage – Legislation

Federal Legislation

- The Storage Technology of Renewable and Green Energy Act of 2009
- Explicit support for RES and storage on commercial buildings
- Removes requirement for renewable resource to receive the investment tax credit
- Great opportunity for commercial and residential customers to reduce/eliminate demand charges

Value Chain for DESS

Policy initiatives to integrate energy storage in grid



US Congress has proposed "Storage Technology of Renewable and Green Energy Act" of 2009 to provide investment tax credits for storage projects.

Comparing Battery Chemistries for DESS

- **Proven Reliable Technology**
  - Evaluate production batteries, not engineering samples only
  - Manufacturer's history and financials
  - Reliable test data to UL/IEEE Standards
- **Optimization of Storage for DESS Applications**
  - Operate in a controlled environment
  - Reliable and consistent charge controls
  - Energy density/Discharge rate
  - Roundtrip efficiency
  - Size and space
- **Economics of battery storage compared to other solutions (flywheel, compressed air, etc.)**
  - Cost per Wh
  - Cost per Cycle
- **Maintenance and Service Life**
  - Life in years and cycles
  - Replacement costs
- **Safety and Environmental Impact**
  - Recyclable
  - Non-hazardous materials
  - No risk of fire or explosion

OSHA®

Comparing Battery Chemistries for DESS

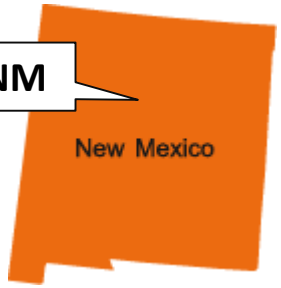
	VRLA Mono-block	Advanced VRLA	Advanced VRLA Hybrid	Lithium-ion Manganese mixed metal
	 SLX246-12	 SLE-1000	 SLC70-4V	 LIM50E
Nominal Capacity	246Ah/20HR	1000Ah/10HR	80Ah/20HR	50Ah/1HR
Nominal Voltage	12V	2V	4V	3.7V / cell
Cycle life **VRLA: DOD 70% / 50%** **Li-ion: DOD 100%**	----/Up to 1000	2000 / 3000	3000 / 4000	Over 3000
Design floating life at 25ºC / 77ºF	10 years	8+ years	10 years	10+ years
Maximum Discharge rate	2C	1C	1C	6C (60 seconds) 4C (Continuous)
Operation Temperature	0 to 40º C 32º to 104º F	-10º to 45º C 14º to 113º F	-10º to 45ºC 14º to 113º F	-10º to 45º C 14º to 113º F
Round trip efficiency	Up to 80%	Up to 80%	Up to 85%	95%+
Cost per Wh	$0.14	$0.29	$0.92	$1.5 to $2.5
kWh Cost per Cycle	$0.14	$0.10	$0.23	Less than $0.50
Specific energy (Wh/kg)	41.8	31.3	29.1	109

Current DESS Applications

Project	Customer	Product	Market	Benefit Used
Mesa Del Sol	Forest City Enterprises	SLC70-4V (20.48kWh)	RES functions for commercial bldg.	PV Energy Time Shift
TVA SMART	EPRI/TVA	SLC70-4V (46.08kWh)	RES functions for EV charge stations	Energy Time Shift Site Voltage Support PV Firming
Suniva	Suniva	SLC70-4V (11.52kWh)	RES functions for commercial bldg.	Electric Service Reliability and Power Quality PV Energy Time Shift
GSB	GSB	SNS-3000 (144kWh)	RES functions for commercial bldg.	TOU Energy Cost Management Electric Service Reliability and Power Quality

Current DESS Applications

Mesa Del Sol



PV/Storage project – Albuquerque, NM

- 15kW PV system with battery storage
- (3) 5kW Power Conditioning Systems with PV and battery inputs
- (2) of the PCS units have (32) SLC70-4 batteries at their input for a total of 20.48kWh of storage

Sandia National Laboratories

GS

GS YUASA

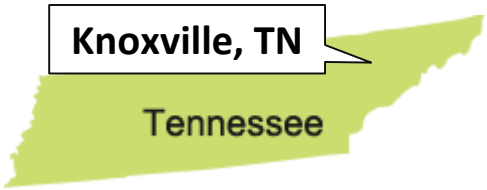
FORESTCITY

PNM

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

Current DESS Applications

TVA SMART



EV Charging Site – Knoxville, TN

•EV Charging site with 6 charge stations that are assisted by PV and battery storage.

•GSB's scope included providing:

- (3) 10kW battery charger/inverters (Silent Power OnDemand)
- 3 sets of (48) SLC70-4 batteries for a total of 960Ah (46.08kWh) of storage

EPRI

GS

GS YUASA

Silent Power INC.

EATON

TVA

Current DESS Applications

Suniva

PV/Battery System – Norcross, GA

- 5kW PV System with battery storage
- GSB's scope includes providing:
  - (1) 5kW battery charger/inverter (Silent Power OnDemand)
  - (36) SLC70-4 batteries for a total of 240Ah (11.52kWh) of storage

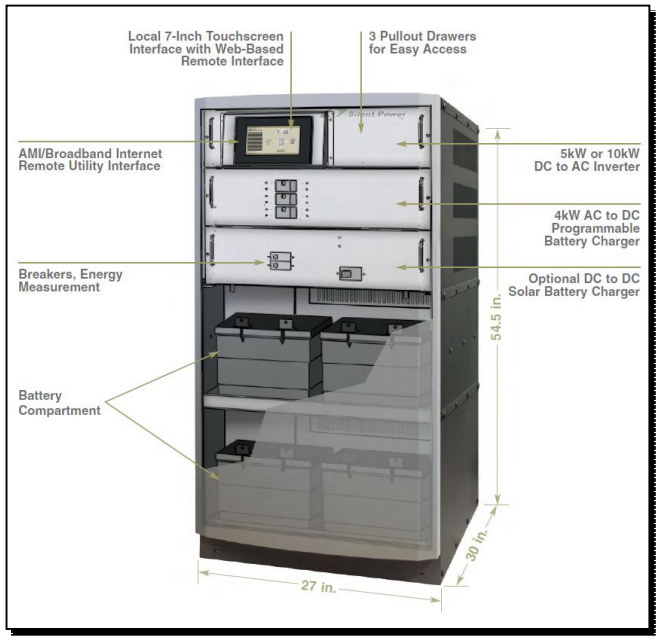
Suniva

GS

GS YUASA

Silent Power INC.

GEORGIA POWER
A SOUTHERN COMPANY

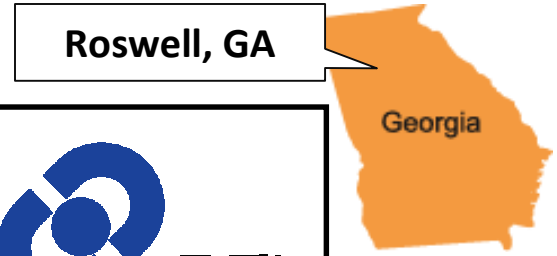


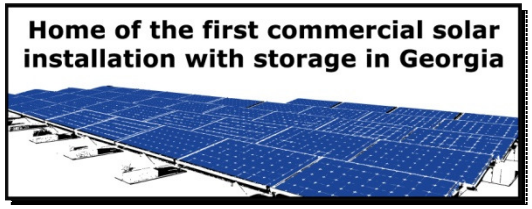
Current DESS Applications

GS BATTERY (USA) Inc.

PV/Battery System – Roswell, GA

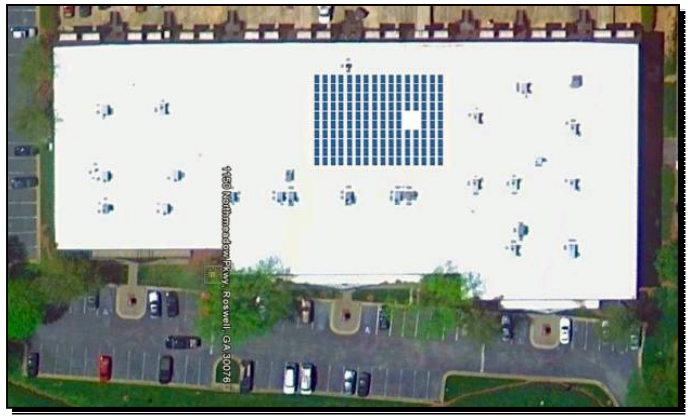
- 30kW PV system with battery storage
- (6) SMA 5kW PV Inverters
- (3) SMA Sunny Island Battery Charger/Inverters
- (24) SNS-3000 for a total of [illegible] of storage





GS YUASA

GEORGIA POWER
A SOUTHERN COMPANY



Future Applications for DESS

CES

Proposed CES Project

•30kW Community Energy Storage (CES) System.

•The proposed system consists of (3) parallel 10kW battery charge controllers/inverters each connected to a 48V battery rack of (24) SLE-1000 batteries for a total of 3000Ah (144kWh) of capacity.

•This system will have AMI (Advanced Metering Infrastructure) communication capability.

•All of this equipment will be enclosed in a weatherproof building with ventilation.

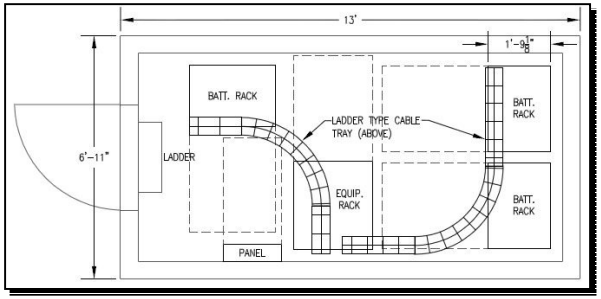
•Future Lithium design options are 30% smaller than VRLA

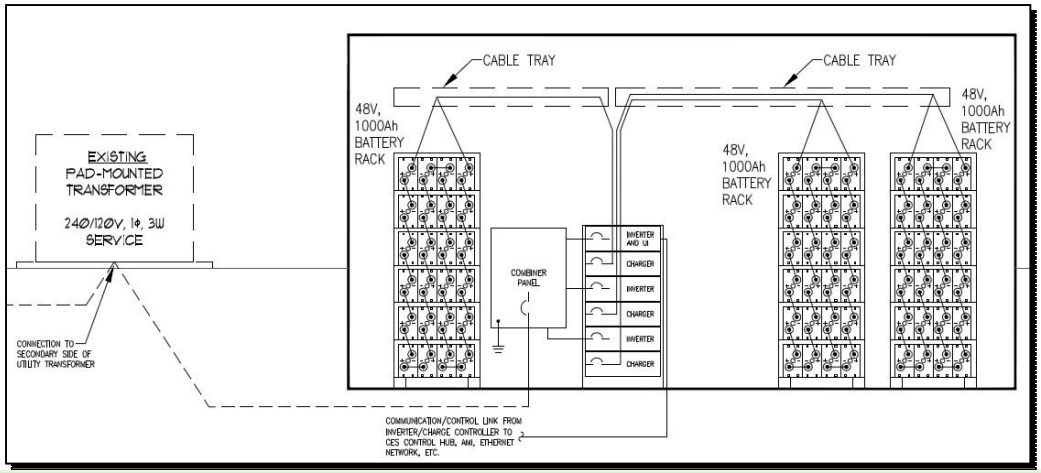
EPRI

GS

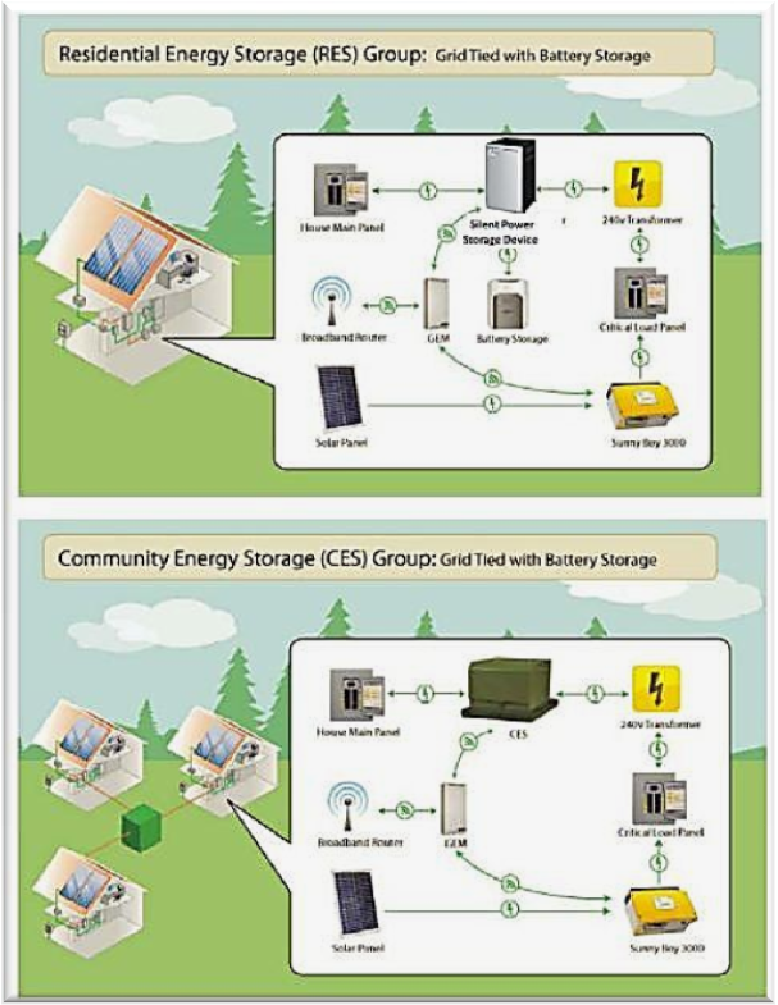
GS YUASA

Silent Power INC.





Future Applications for DESS



Anatolia SolarSmart ^{sm} Homes Community

- High building efficiency measures
- 2kW PV systems

•Installing 15 RES and 3 CES units

•Firm renewables, reduce peak load and improve reliability

•Utility and customer portals will be used

•Price communicated to affect changes in customer usage

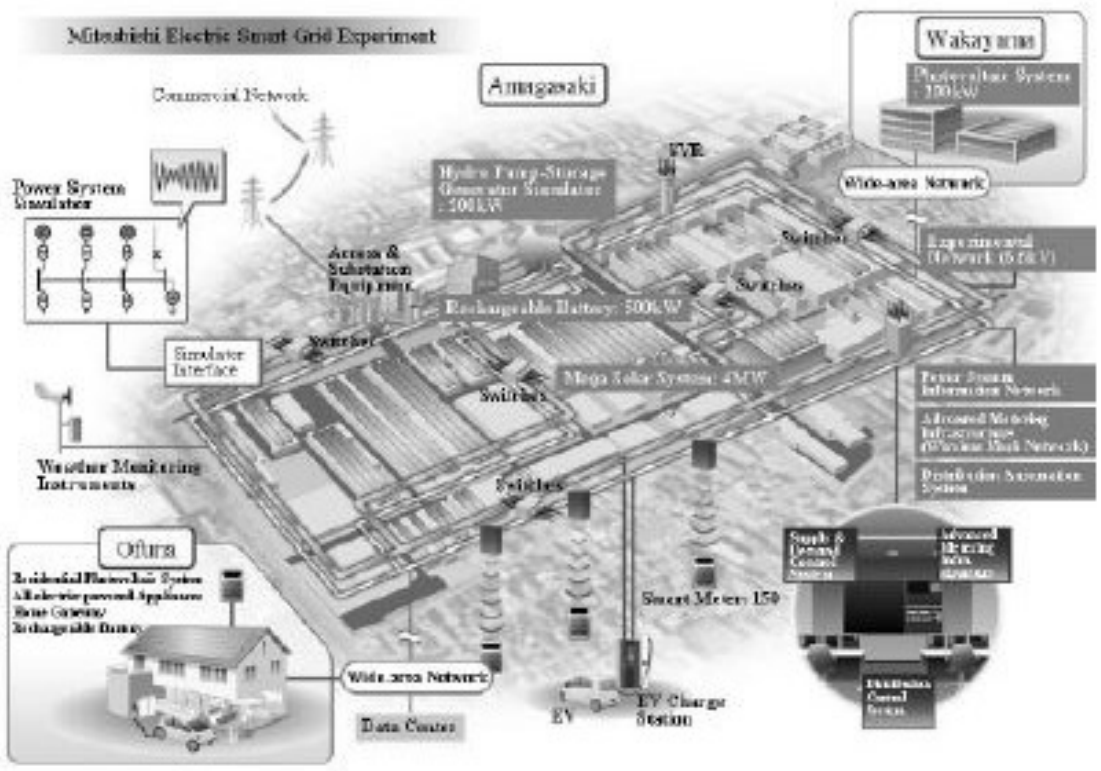
•Quantifying costs and benefits

Sources: SMUD, Silent Power Inc.

Future Applications for DESS

Virtual Power Plant Case Study III: Amagasaki PEV/PV pilot

- 4 MW PV array
- 500 kW Li-Ion battery system
- 150 smart meters
- PEV charge station

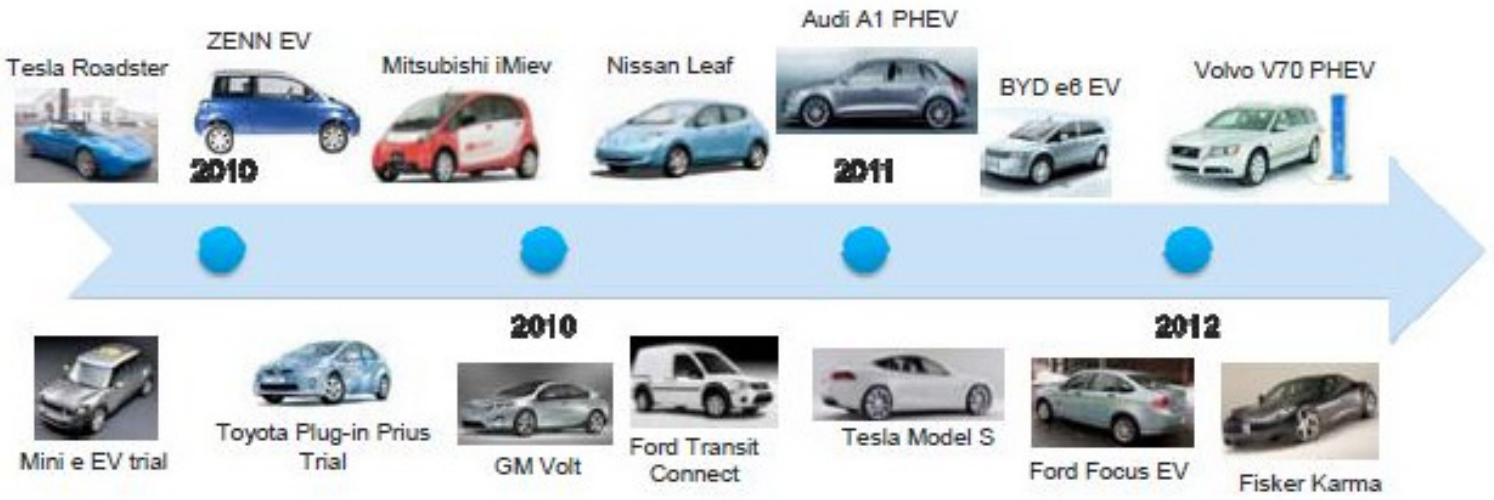


Source: Solar Power International

Future Applications for DESS

Global market will see first wave of EVs by end of 2010

"Overall, we believe by 2020, 17% of the global automobile market could be comprised of HEVs, PHEVs, and full EVs, up from 1% today" – Deutsche Bank, November 3, 2010

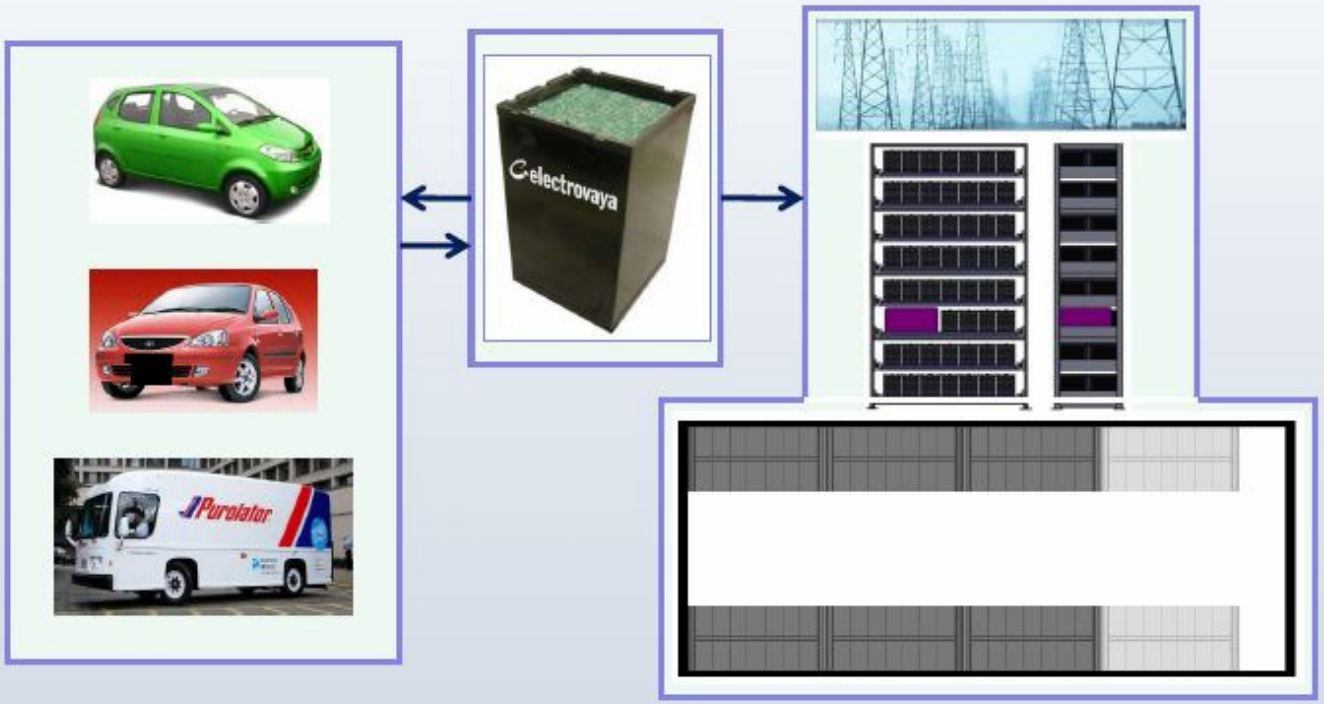


Future Applications for DESS

CEF Funded Energy Storage Demonstration Project

CEATI INTERNATIONAL

Utility-Scale Electricity Storage Demonstration Using New and Repurposed Lithium Ion Automotive Batteries



DESS Summary

- DESS will be necessary to support Renewable Generation due to variability, intermittency and existing generation capacity
- RES and CES storage solutions offer benefits to the utility and customer
- Guidelines need to be established when choosing a storage technology and Battery chemistry
- Storage Cost benefit analysis requires battery storage optimization to achieve lowest cost per Wh and cost per cycle
- Storage Reliability must include several criteria and not just battery design life
- EV respent batteries may not be a viable solution for DESS stationary storage for cost and reliability reasons

ADVANCED STORAGE SOLUTIONS

THANK YOU

Vincent Pusateri

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