FLORIDA SOLAR ENERGY CENTER®

Creating Energy Independence

The State of FSEC

FSEC Advisory Board Meeting

March 3, 2017

FSEC Advisory Board Meeting
AGENDA

10:00 a.m.	Welcome and Introductions	Dave Winslow, Chair
10:10 a.m.	Approval of October 21, 2016 Meeting Minutes	Dave Winslow, Chair
10:15 a.m.	Status of FSEC Programs	Jim Fenton
10:30 a.m.	Discussion of Federal and State Energy Policy Report of Florida Energy Office	Louis Rotundo Tommy Boroughs John Leeds
11:00 a.m.	Smart Electric Power Alliance Working Groups (Utilities/Industry/FSEC collaborative funded research to develop solutions in partnership around todays challenges in distributed energy resources)	Jennifer Szaro, SEPA
11:30 a.m.	City of Orlando working with UCF's FSEC on energy efficiency, smart cities, EVs, solar and energy storage FSECs New Energy Systems Integration Division (funded City/University partnerships)	Chris Castro Sustainability Director, City of Orlando
12:05 p.m.	Lunch (Buffet)	
1:05 p.m.	Developing FSEC Working Groups	Jennifer Szaro Jim Fenton
1:50 p.m.	Board Business ▪ Date and Agenda for Next PAB Meeting ▪ Other Board issues	Dave Winslow, Jim Fenton
2:00 p.m.	Adjournment	

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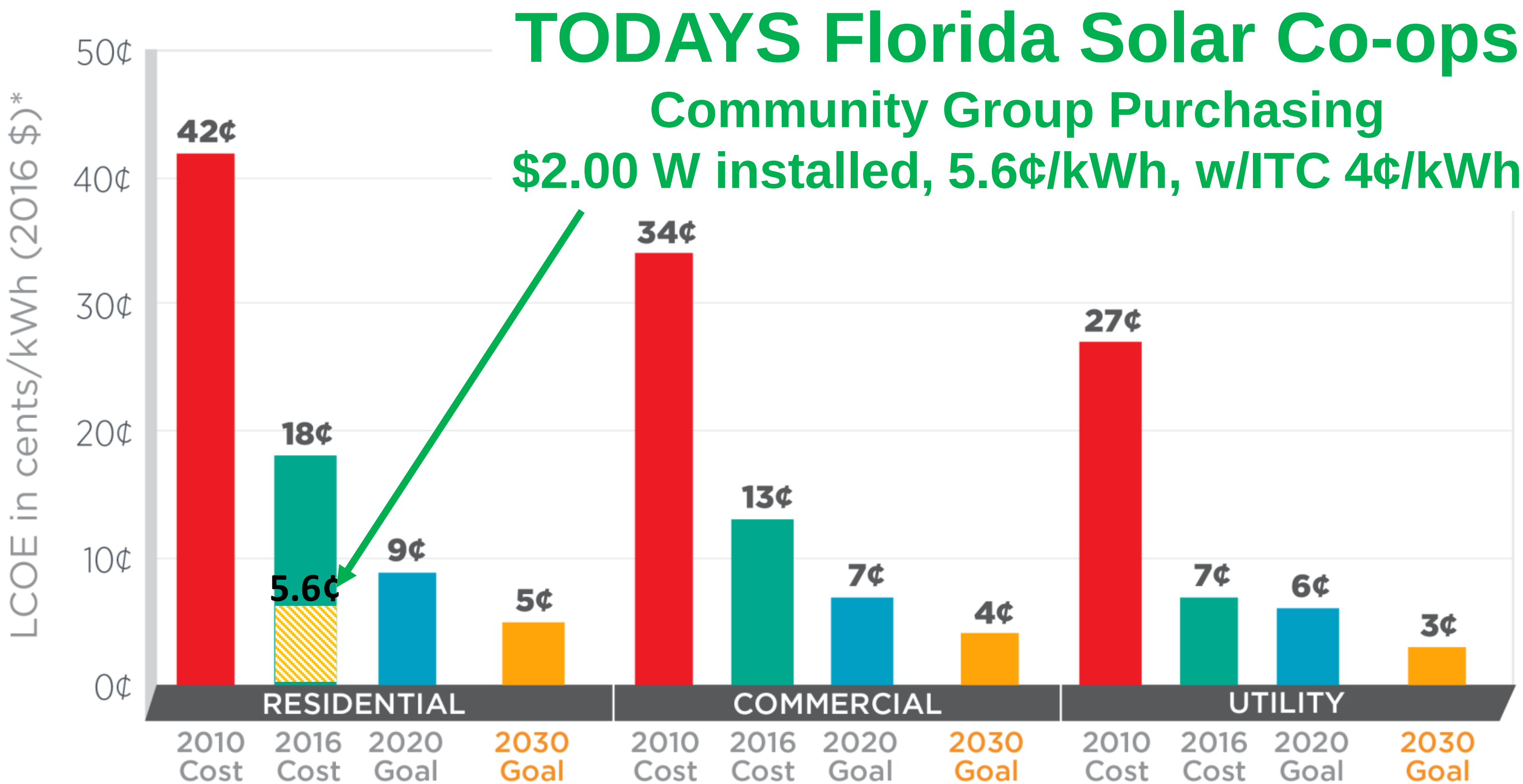
SunShot Progress and Goals



*Levelized cost of electricity (LCOE) progress and targets are calculated based on average U.S. climate and without the ITC or state/local incentives. Utility-scale PV uses one-axis tracking.

Passed Amendment 4, tax exemption for renewable energy devices for businesses as already exists for residences

Recent Utility Solar in Florida

Florida Power & Light flips the switch on three **solar** energy plants
Sun Sentinel - Jan 13, 2017
Florida Power & Light has connected three new 74.5-megawatt **solar** power plants to the energy grid, the **utility** announced Friday. FPL said in a ...

FPL to build **eight** more **solar** farms
Sun Sentinel - Feb 21, 2017
The company anticipates the plants --- combining to create nearly 600 megawatts of power, enough for about 120,000 homes at peak ...

Duke Energy **Florida** plans third **solar** farm
Charlotte Business Journal - Jan 11, 2017
That power is sold to Orlando **Utilities**, and is not used by Duke **Florida**. It also does not include the 5-megawatt Disney **Solar** project, which ...

Duke plans North **Florida solar** project
WJXT Jacksonville - Jan 11, 2017

Gulf Power solar energy farms on target for summer launch

Fla. Public-Private **Solar** Partnership Is Building 120 MW On Military ...
Solar Industry - Jan 20, 2017
Work is well under way on a 120 MW **solar** project portfolio sited on ... from **Florida**-based **utility** Gulf Power and Coronal Energy, powered by ...

OUC's newest **solar** plant will stand on coal ash
Orlando Sentinel - Dec 23, 2016
Justin Kramer, Orlando Utilities Commission Renewable Energy Project Manager, stands among thousands of **solar** panels Thursday, ...

NextEra CEO: Energy storage will replace **gas peakers** post-2020
Utility Dive - Oct 1, 2015
NextEra Energy CEO Jim Robo said he expects energy storage will begin to replace **gas peaking** plants after 2020, PV Tech Storage reports.

Florida Power & Light

2016: three 74.5 MW total of 335 MW
2017: four more 74.5 MW
2018: four more 74.5 MW

Duke Energy Florida

2016: 17.8 MW + 6 MW for OUC
+ 5 MW Disney
2017: 8.8 MW Suwannee County

Gulf Power

2017: 120 MWs on Military Bases

Orlando Utility Commission

13 MW, ~~< 7¢ kWh~~, 5.75 ¢ kWh,
Amendment 4 saves >$200K/yr
8 ¢ kWh from coal, natural gas

NextEra

2020: **Batteries replace** Gas Peakers

vimeo.com/fsec/sponsor

Rooftop Solar

FLSUN
Florida Solar United Neighborhoods
http://www.flsun.org/

In partnership with:

LWV LEAGUE OF WOMEN VOTERS® OF FLORIDA

East Broward Solar Co-op
West Broward Solar Co-op
Sarasota Solar Co-op
Space Coast Solar Co-op
Orange County Solar Co-op
St. Pete Solar Co-op

SAMPLE SOLAR CO-OP COST BREAKDOWN

	5 kW System Average Size	9 kW System Large Size
System cost before incentives (about $2.00/Watt)	$ 10,000	$ 18,000
30% Federal tax credit	$ 3,000	$ 5,400
TOTAL UPFRONT COST	**$ 7,000**	**$ 12,600**
Energy Produced first year (kWh) (1400 kWh per yr/kW)	6750	12150
Estimated Annual Electricity Savings, If Utility cost is **$0.125 kWh**	**$ 844**	**$ 1,519**
Simple Payback (in years)	8.5	8.5
Net Present Value	$ 15,554	$ 27,997
Internal Rate of Return	14.2%	14.2%

$2.00 W installed, 5.6¢/kWh, w/ITC 4¢/kWh

UCF's FSEC Leads in Energy

Federally Funded Industrial Collaborative Partnerships

Building America
U.S. Department of Energy

EVTC
Electric Vehicle Transportation Center

Central Florida Clean Cities Coalition

U.S. PHOTOVOLTAIC MANUFACTURING CONSORTIUM
PVMC

U.S. DEPARTMENT OF ENERGY
Solar Instructor Training Network
Southeast Region

Regional Test Centers
Differentiating PV Quality

Drive ELECTRIC Florida

FEEDER
Foundations for Engineering Education for Distributed Energy Resources

GO SOLAR | FLORIDA

SOLAR READY VETS
U.S. DEPARTMENT OF ENERGY

ENERGYWHIZ
Connecting Schools, Teachers, and Students with Solar Energy

PV, EVs, Energy Efficient Buildings, Load Management, Batteries, Alternative Fuels, Hydrogen, Fuel Cells, Smart Grid Electronics, V2X, Training & Education

FSEC

For UCF's FSEC to-continue to Lead in Energy Transition to Industrial Funded Collaborative Partnerships

- FSEC Driven by DOE solicitations, Change to Driven by value added research for Florida Utilities, Florida DOT, and Florida Industries that consume energy
- Working groups that cooperatively steer FSEC into carrying out collaborative research that provides funding for FSEC researchers and is beneficial to the Working group [Win-Win]
- Opportunities with EV/PV/Energy Storage Demonstration projects (microgrids) at main campus, FSEC (Cocoa) and new Downtown Campus
- UCF Energy incorporates, FSEC, 2 UCF Energy Faculty Clusters, Engineering and Sciences, and Facilities
- Education and Training Opportunities

Vision for FSEC and for NSF ERC

Integrated Smart Building Energy Storage

Create the tools and processes for Net-Zero Energy Communities through the integration of next-generation smart energy storage, solar energy production, electric vehicles and advanced high frequency power-electronics systems, for increased energy efficiency of community buildings and transportation, and improved grid resiliency.

IS-BEST NSF ERC Team

- **Universities:** University of Central Florida [Lead], Case Western Reserve University, Georgia Tech University, New Mexico State University, Illinois Institute of Technology
- **National Laboratories:** National Renewable Energy Laboratory and Argonne National Laboratory
- **Community Partners**: Orlando, Cleveland, Atlanta, Chicago, Denver, Indian Reservations
- **Industrial Consortium:** Modeled after: cSi-PVMC, FEEDER, Drive Electric Florida, ICAMR, SEMATECH, SEPA
- **Industry Partners**: Building Controls, ESCOs, PV w/ Power Electronics, Batteries, H_2 Electrolyzers, fuel cells, EVs, EV infrastructure, Large Building owners, Utilities

Integrated Smart Building Energy Storage (IS-BEST) NSF ERC

Creating the tools and processes for Net-Zero Energy Communities

1. Building Energy Demands
Energy efficiency retrofits, load management, thermal energy storage, vehicle loads

5. Smart Power Electronics and Communication
Smart thermostats and sensors, high efficiency inverters

2. Electrochemical Energy Storage
Batteries, Fuel Cells

4. Vehicle-to-X
Bidirectional, wireless charging

3. Solar Energy Production
Photovoltaics, Hydrogen Production

Cross Cutting Research Areas

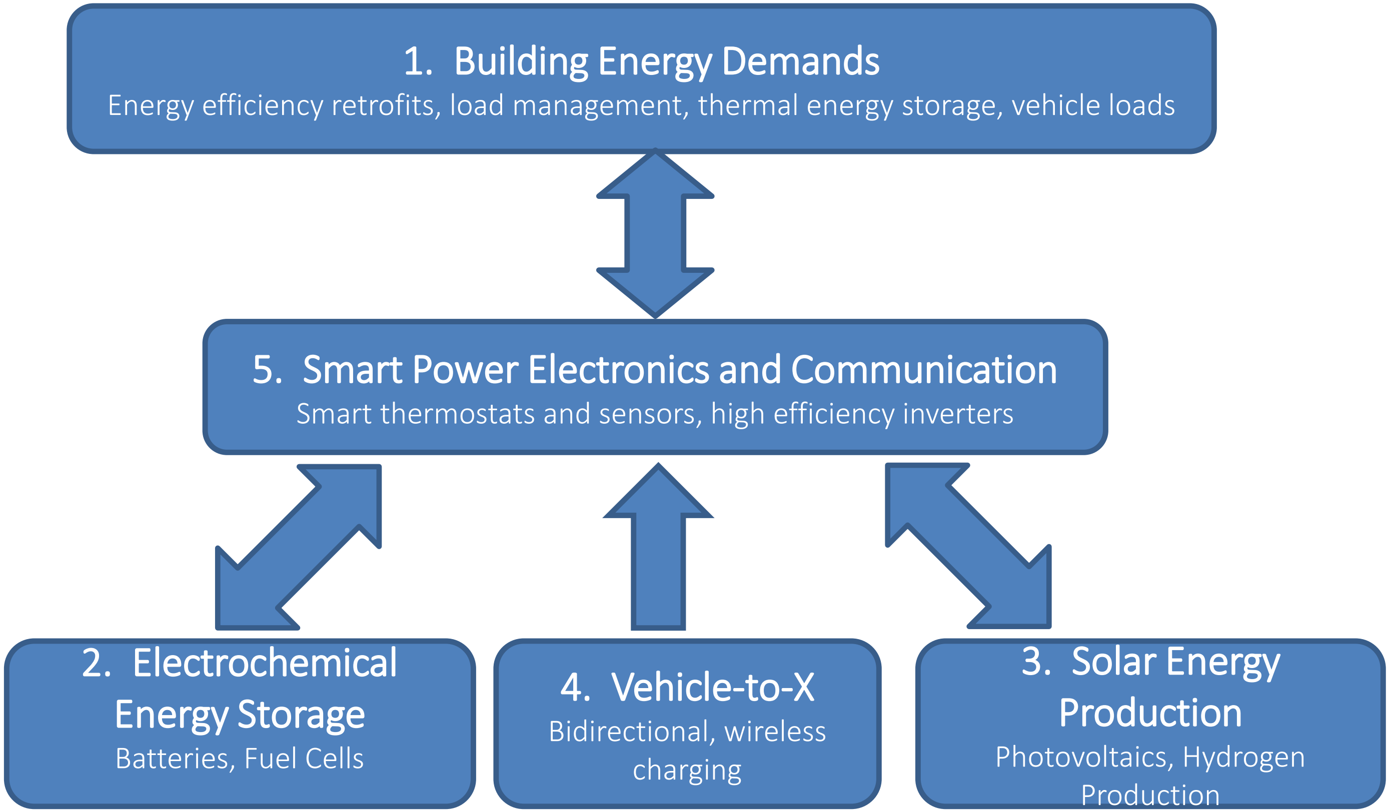
- Wide-Band Gap Semiconductors
- Materials, Packaging and Durability
- Hardware in the Loop
- Grid Integration
- Engineering Education
- Education for non-STEM community

- **What Is a SEPA Member Working Group?**
  - Working groups meet virtually monthly or quarterly and offer SEPA members the opportunity to develop clear solutions to today's challenges around distributed energy resources, including:
  - **Special guest speaker at conference sessions, workshops, and webinars.**
  - **Co-authorship of research publications and blog posts.**
  - **Co-produce presentations**
- **What Do Working Groups Do?**
  - SEPA working groups are designed to give members an active role in results-focused work. The goal is to forward specific technologies and how they relate to the evolving electric sector.
  - Working groups provide value to members through facilitated investigation and discussion of a specific technology or industry trend as identified by SEPA members.

- **SEPA Working Groups**
  - **Community Solar (coming soon)**
  - **Demand Response and Smart Grid**
  - **Electric Vehicles (coming soon)**
  - **Microgrids**
  - **Storage (coming soon)**
  - **Solar Asset Management**
- **Ready to Get Involved?**

  Each working group is a volunteer effort, and participants are requested to set aside a certain amount of hours per month. The members of each working group collaborate with staff to determine the actions that will be taken by the working group subject to certain guidelines.

FSEC Working Groups ???



Cross Cutting Research Areas

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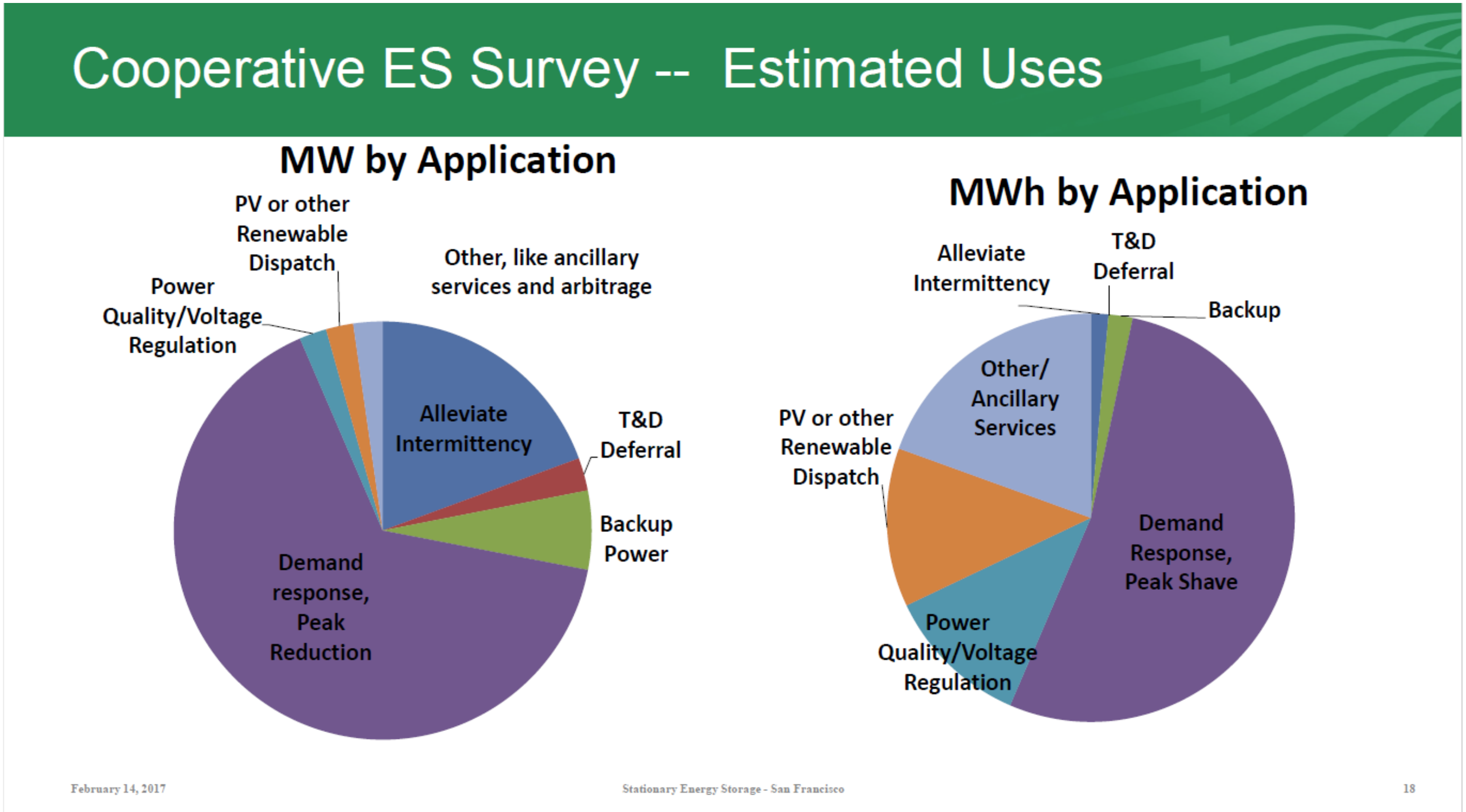
Awards

- Danny Parker, Nazim Muradov, Ali Raissi, and Issa Batarseh inducted into the National Academy of Inventors, UCF Chapter
- Eric Martin received UCF Research Incentive Award
- Nazim Muradov received UCF Research Award
- Continuation Funding of DOE projects
- Siemens provides $750,000 for highly wired teaching lab for running a digital grid (UCF Electr. Engr.)
- "Commercial Buildings Field Studies" from the Institute for Market Transformation

EXTRA SLIDES

Opportunities for Grid-Scale Energy Storage

- Voltage/frequency regulation
- Spinning reserves
- Peak shifting
- Peak shaving (grid and building scales)
- Solar firming
- Arbitrage



Tom Lovas. Utility Storage Needs – An Evolving Market. Next Generation Energy Storage 2017

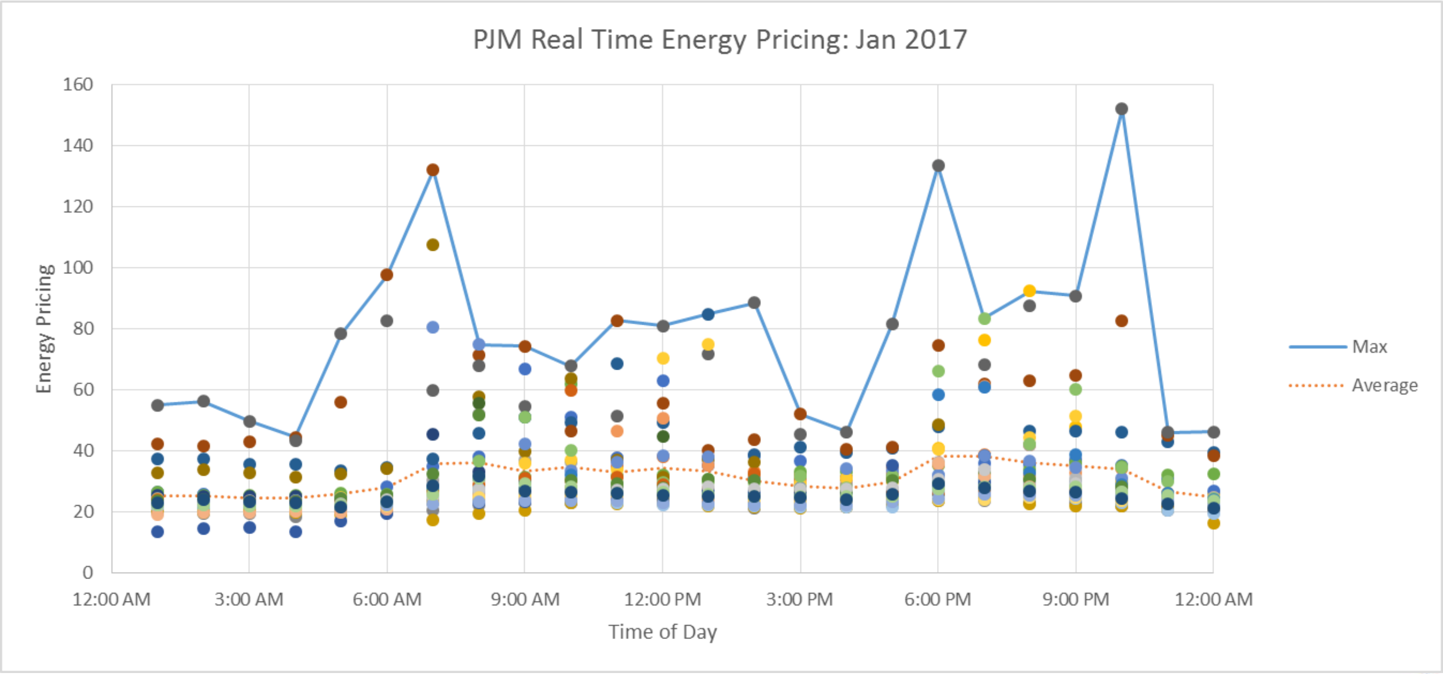
Grid Scale Energy Storage: Case Studies

- Green Mountain Power: 4MW/3.4MWh w/PV [1]
  - Calculated value of storage > $300k/MW/year (demand shaving + freq. reg.)
  - 5-10 year payback
  - Peak shaving during 1 hour of operation saved $200,000
- Sterling, MA: 2MW/2MWh [1]
  - Arbitrage, freq. reg., others leads to >$650k/year
  - < 5 year payback
- Electric Cooperative: 13MW/52MWh w/PV [2]
  - Solar recharges batteries during daylight hours
  - 20-year fixed price of $0.14/kWh

1. Dan Borneo. Developing an Energy Storage Project – A Technical Perspective. Next Generation Energy Storage 2017.
2. Tom Lovas. Utility Storage Needs – An Evolving Market. Next Generation Energy Storage 2017

Grid-Scale Energy Storage: Reducing Costs

- Avoid paying high costs associated with peak power



Response times vs. Applications

Application	Response time	Duration	Current energy costs $/MW-h	System size for participation
Frequency response	2 seconds	> 1 hour	5-40*	
Voltage response				
Primary reserves	10-30 minutes	> 1-2 hours	1-30*	300-400 MW
Solar firming	< 5 seconds	Up to several hours		
Peaker power plants				
Load following		15min to 24 hours		
Arbitrage				

* Z. Zhou, T. Levin and G. Conzelmann. Survey of U.S. Ancillary Services Markets. ANL/ESD-16/1

Selected Energy Storage Use Cases—In Front of the Meter

Unlike technologies related to conventional generation, which have a single use case (i.e., the creation of electricity), energy storage technologies have a variety of use cases in a modern electric system, comprising both "in front of the meter" (or power grid-oriented) and "behind the meter" (or distributed) applications; each use case identified below solves for a particular grid or user "need," which is often most easily achieved with a subset of available energy storage technologies

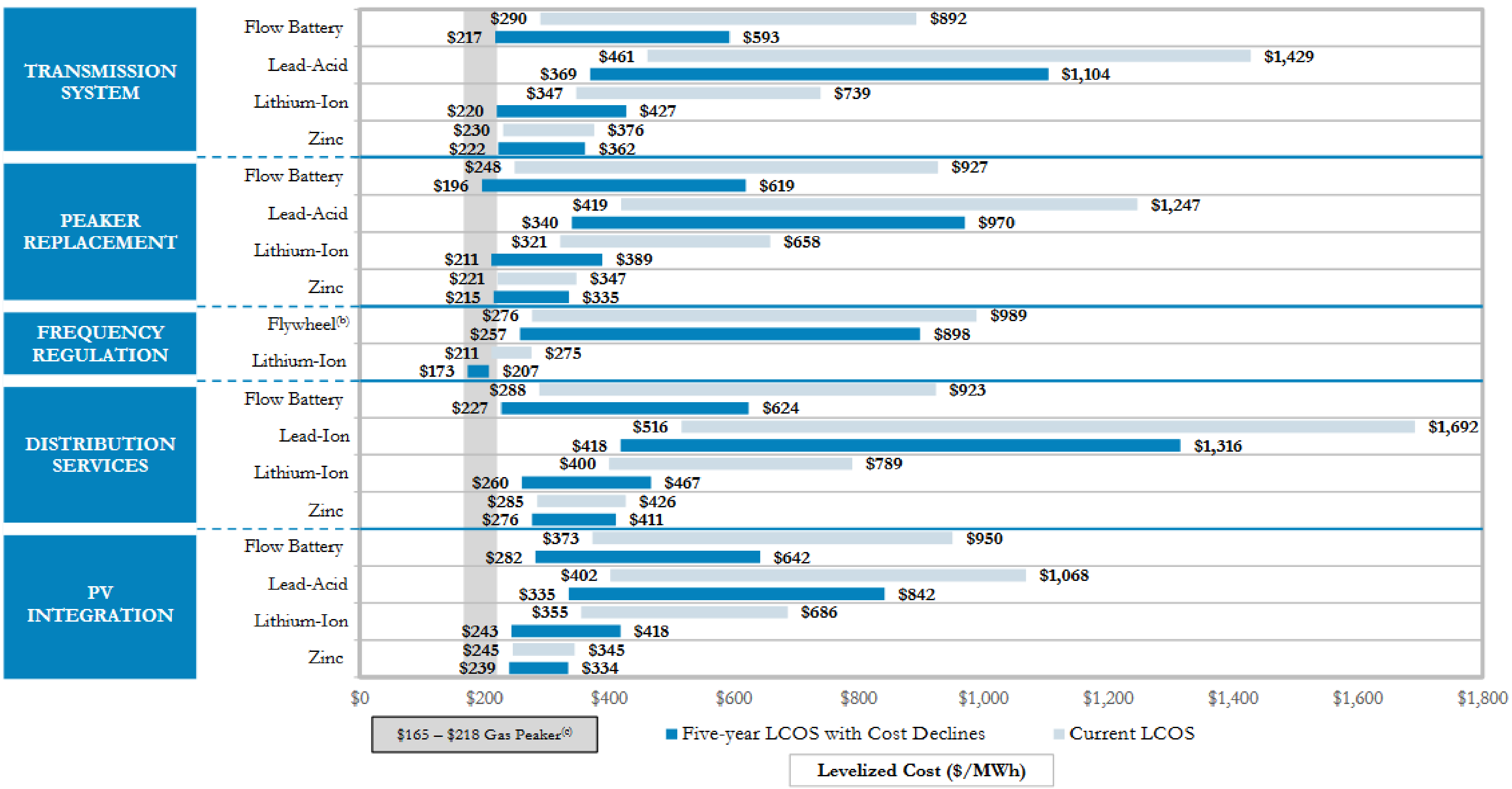
- **Importantly, in practice, a single energy storage system may provide services across multiple use cases, although the feasibility of multiple application energy storage units may be limited by operational and design factors (e.g., sizing for a particular use case could preclude participation in another)**

	DESCRIPTION	SELECTED RELEVANT TECHNOLOGIES	SELECTED CONVENTIONAL ALTERNATIVES[(a)]
TRANSMISSION SYSTEM	Large-scale energy storage system to improve transmission grid performance and assist in the integration of large-scale renewable generation	Lead-Acid, Sodium, Flow Battery, Lithium-Ion, Zinc, Pumped Hydro, CAES	Transmission line upgrade Gas turbine
PEAKER REPLACEMENT	Large-scale energy storage system designed to replace peaking gas turbine facilities	Lead-Acid, Sodium, Zinc, Lithium-Ion, Flow Battery	Gas turbine Diesel reciprocating engine
FREQUENCY REGULATION	Energy storage system designed to balance power to maintain frequency within a specified tolerance bound (i.e., ancillary service)	Flywheel, Lithium	Gas turbine
DISTRIBUTION SERVICES	Energy storage system placed at substations to provide flexible peaking capacity and mitigate stability problems	Lead-Acid, Sodium, Zinc, Lithium-Ion, Flow Battery	Distribution system upgrade Gas turbine
PV INTEGRATION	Energy storage system designed to reduce potential integration challenges or improve the value of solar generation	Lead-Acid, Sodium, Zinc, Lithium-Ion, Flow Battery	Gas turbine Diesel reciprocating engine Alteration of solar production profile

(a) Denotes an illustrative set of "base case" conventional alternatives for a given use case. Actual projects may displace a number of conventional alternatives, in certain scenarios.

Impact Analysis—Capital Cost Decline on Levelized Cost of Storage

Assuming that the Energy Storage Industry's capital cost decline expectations materialize, levelized costs of storage could decrease materially for some use case and technology combinations[(a)]; importantly, expected decreases in the levelized cost of storage are functions of the magnitude of capital cost decreases expected, as well as the relative weight of DC capital costs vs. balance of system and other costs



Source: Lazard estimates.

(a) Assumes median five-year expected DC capital cost declines only, unless otherwise indicated.

(b) Assumes median five-year expected total capital cost declines.

(c) Indicates illustrative conventional alternative to energy storage. Not intended to reflect the sole conventional alternative (or source of value from replacing such alternatives).