NARUC

Winter Committee Meetings

Task Force on Innovation

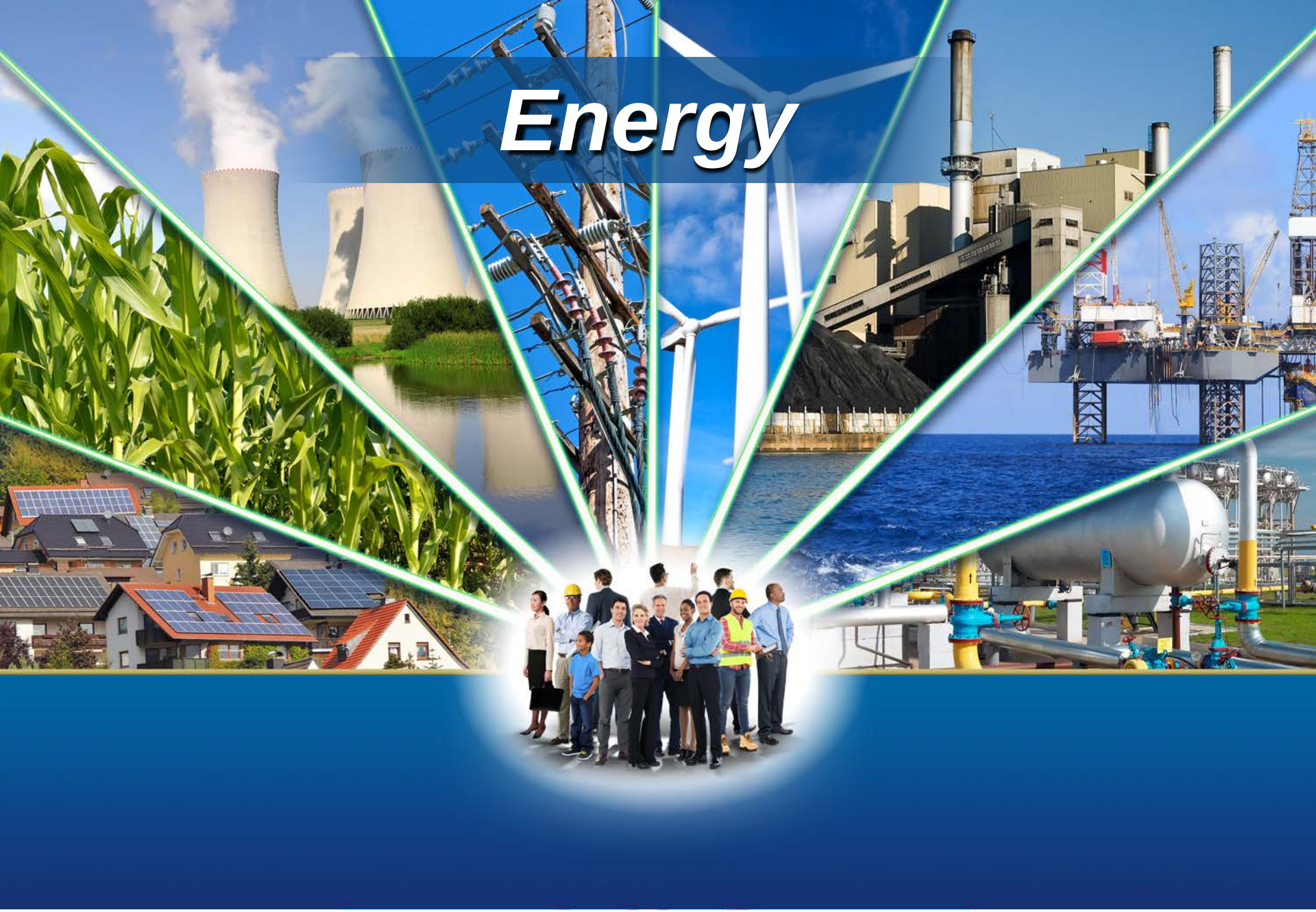
Our Energy Future

Integrated Energy Network

Michael W. Howard, Ph.D., P.E.
President and CEO

NARUC Task Force on Innovation
February 12, 2017

Energy

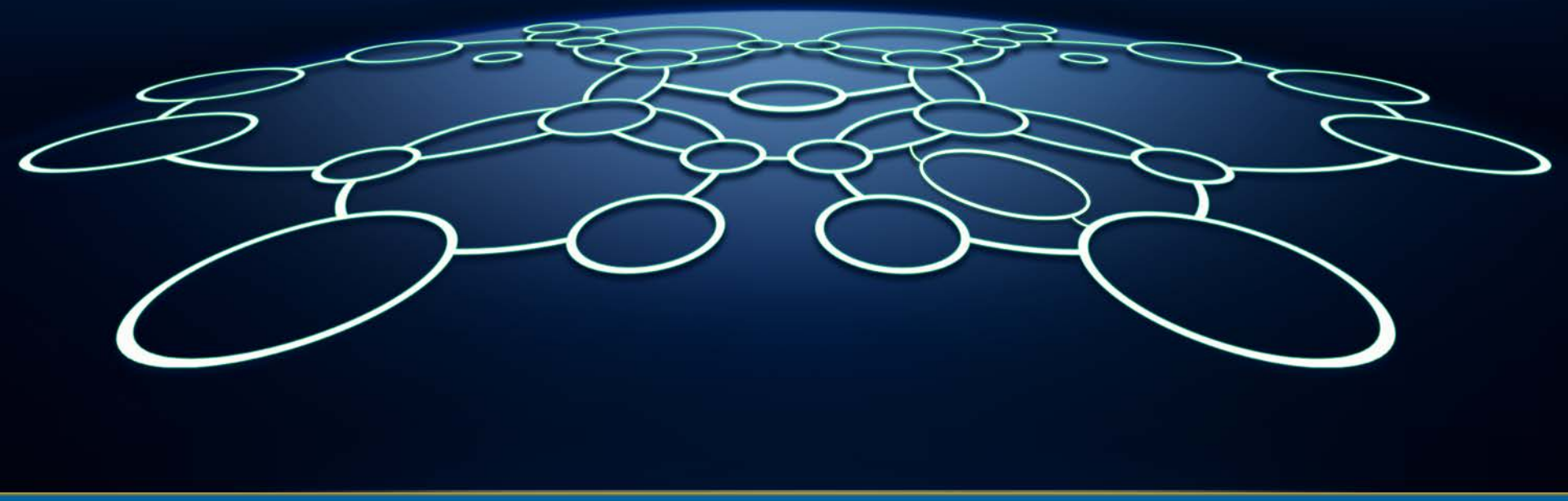


EPRI ELECTRIC POWER RESEARCH INSTITUTE

Integrated

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Network



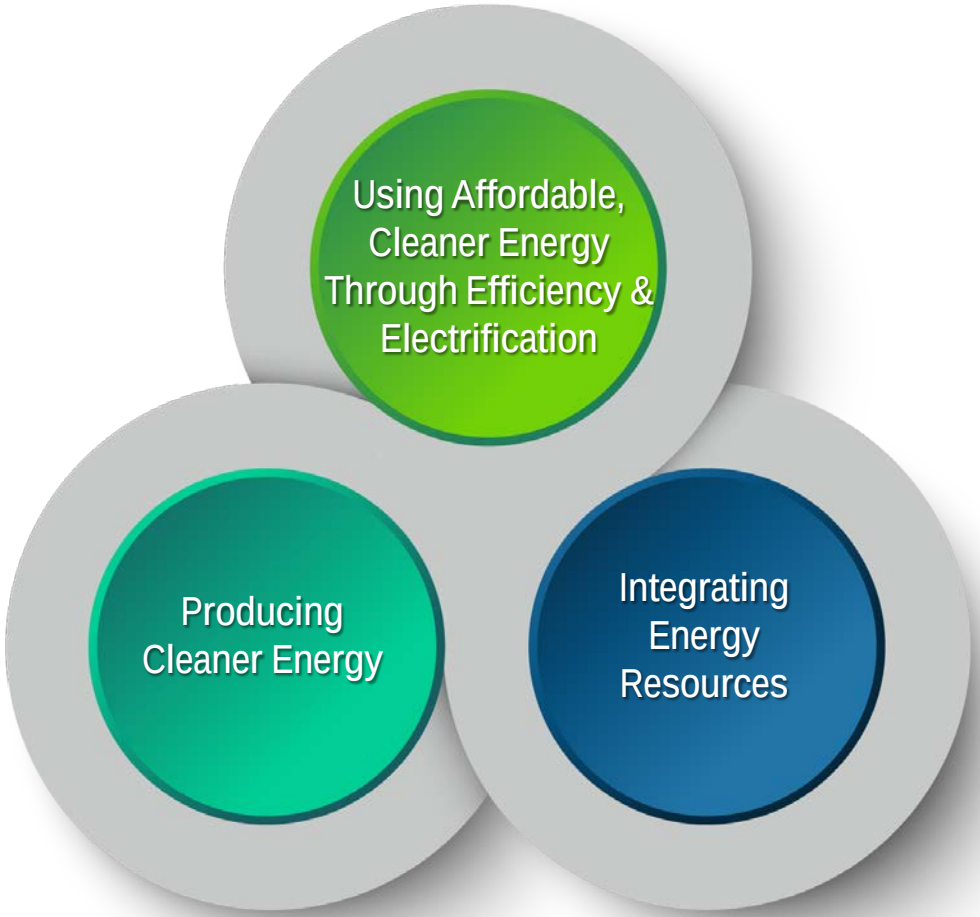
Network

The Value of the *Integrated Grid*

Integrated Energy Network

Imagine an energy future where all forms of energy can be optimally integrated to connect customers with safe, reliable, affordable and clean energy resources

Integrated Energy Network



Connecting Customers with Reliable, Safe, Affordable and Cleaner Energy

Integrated Energy Network

Website: http://ien.epri.com

We welcome your engagement as we continue to advance

The Integrated Energy Network

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Energy Storage for Peaking Capacity Needs

Kiran Kumaraswamy
AES Energy Storage

NARUC Task Force on Innovation
12 February 2017

IPL facility built in under 12 months from ground breaking to commissioning

How fast is fast?

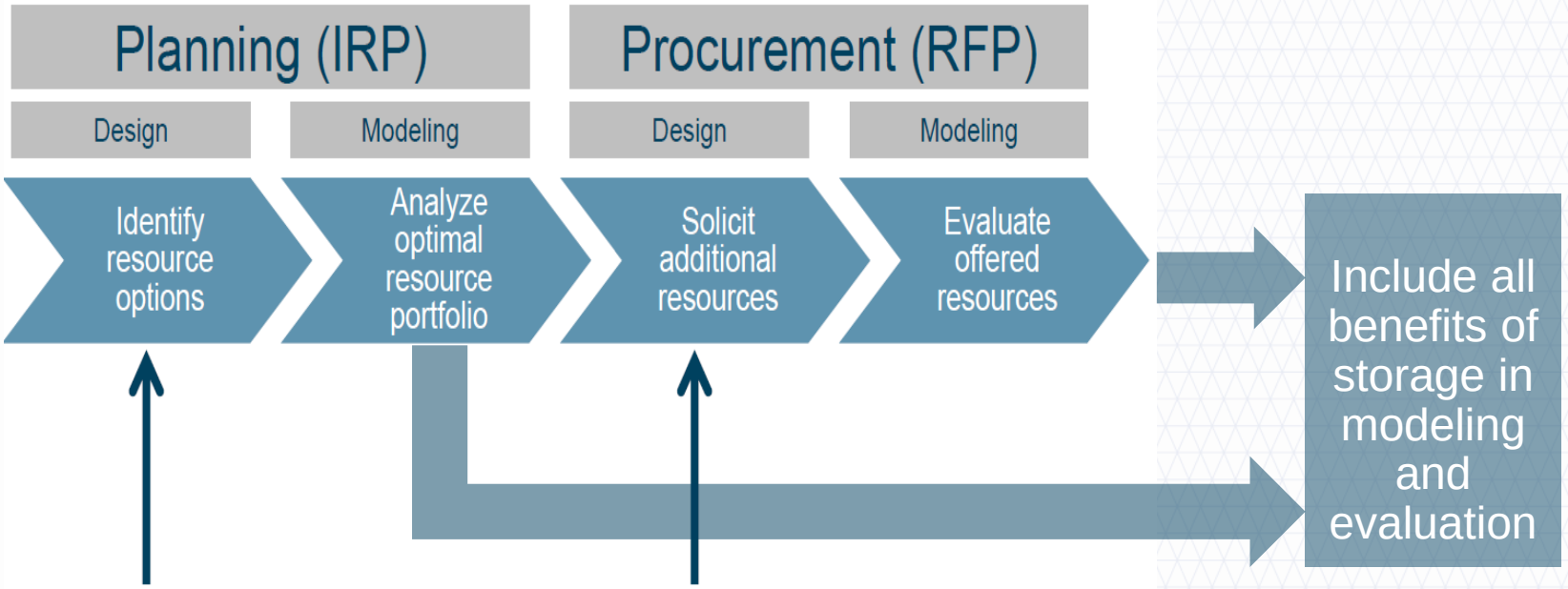
APS builds energy storage for grid reliability in just over 6 months

Right-sizing distribution investments

San Diego Gas and Electric procures 37.5MW in record time

Meeting peak energy needs in southern California

How can states and utilities incorporate energy storage in resource planning and procurement?



- ☑ Include storage as a resource option in Integrated Resource Planning.
  - ☑ Utility
  - ☑ Commission
- ☑ Hold procurement solicitations open to energy storage.
  - ☑ Utility
  - ☑ Stakeholders
  - ☑ Commission or legislature

Thanks!

Kiran Kumaraswamy
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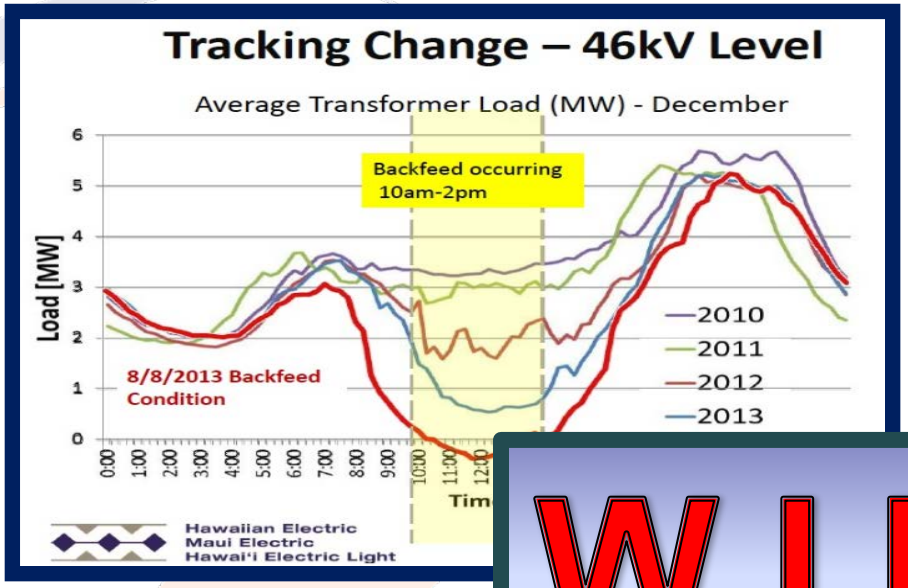
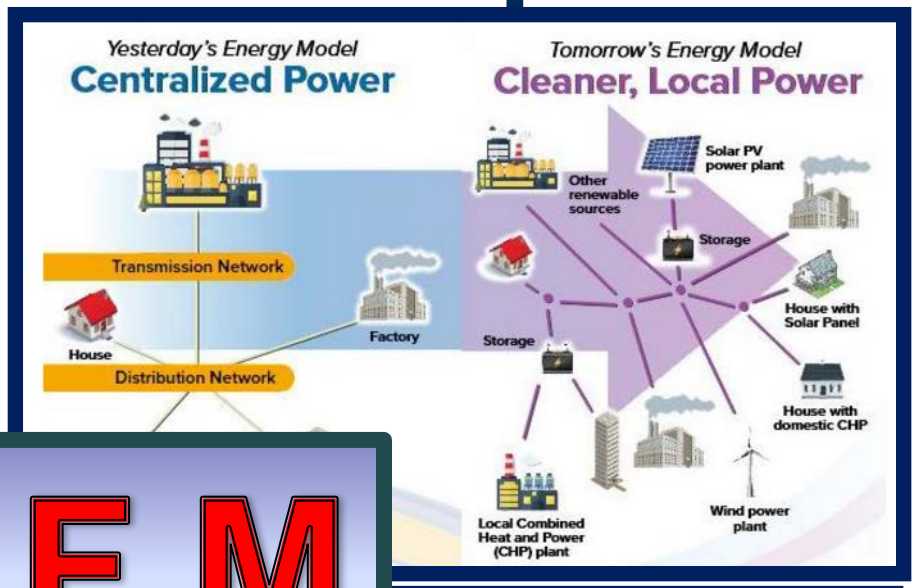
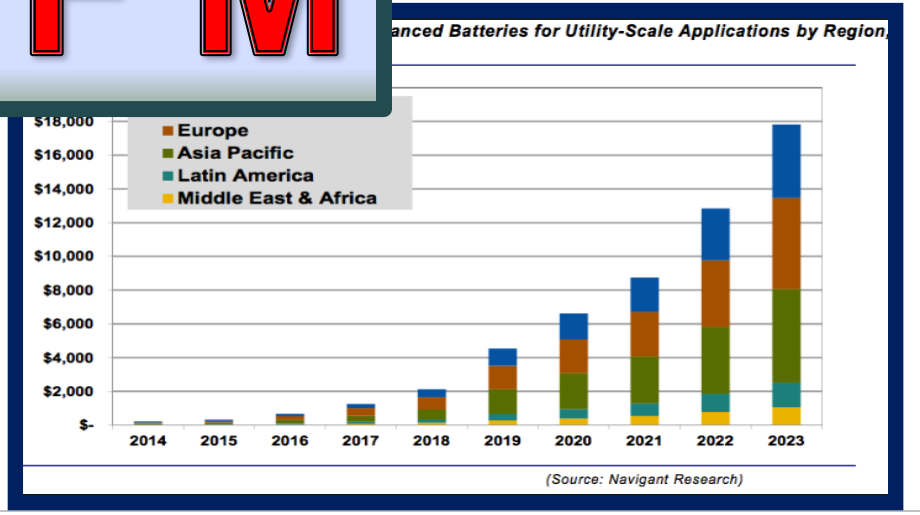
"Integrated Energy Networks & Battery Storage"

Commercial Customer Perspective





WIIFM



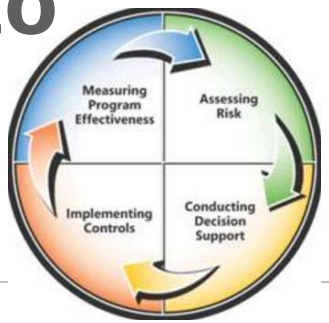
SourceOne
A Veolia Energy Company

High Level Questions:

- **What problem does this solve?**
  - Energy Cost Reduction
  - Improved Self-Supply
  - Power Quality / Emergency Power?

- **Will this investment outperform competing investments?**

- **Will my business be exposed to additional risk?**



Areas of Concern:

- Constructability
- Safety
- Scale
- Permitting
- Business Interruption
- Incentives / Pricing Signals
- Efficiency
- Environmental Impact

Path To Success:

- Big Picture Considerations
  - City Vs. Suburbs
  - Point vs. Aggregated loads
  - Utility Vs. End-User Control, Ownership
  - Leveraging storage to enhance solar / wind throughput
- Market Structuring
  - Differential Pricing
  - Transparent Price Signals

"YOU CAN HAVE BRILLIANT IDEAS, BUT IF YOU CAN'T GET THEM ACROSS, YOUR IDEAS WON'T GET YOU ANYWHERE."

~ LEE IACOCCA

Image Credit: By freshology.com

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LOCKHEED MARTIN

GridStar™ Energy Storage

February 12, 2017

NARUC Winter Meeting

Lockheed Martin Energy

WE'RE ENGINEERING A BETTER TOMORROW™

Energy Management

Solutions to improve the transmission, distribution and us of energy for utilities, commercial enterprises, and federal and state agencies

Energy Storage

Turn-key energy storage systems for commercial, industrial and utility applications

Ocean Technologies

Renewable energy generation by harnessing the tides and ocean temperature gradients

Bioenergy

Innovative systems to convert biomass and waste into energy

Nuclear Systems

Instrumentation and control systems to ensure safety of commercial and government nuclear power programs

Lockheed Martin GridStar™ Energy Storage Solutions

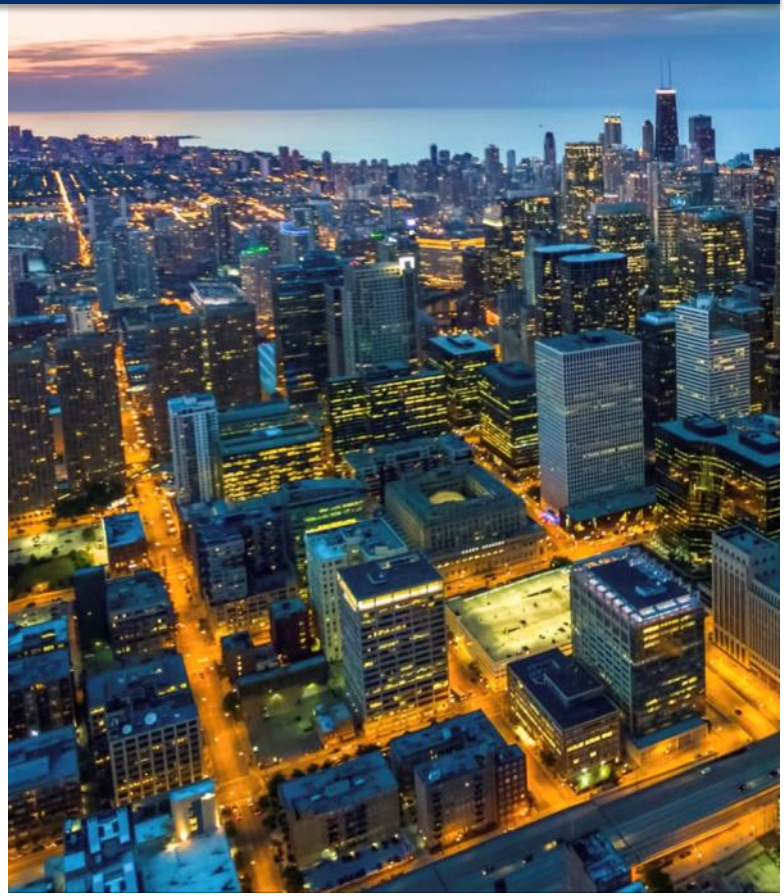
We provide turn-key energy storage systems for commercial, industrial, and utility applications

Our energy storage systems:

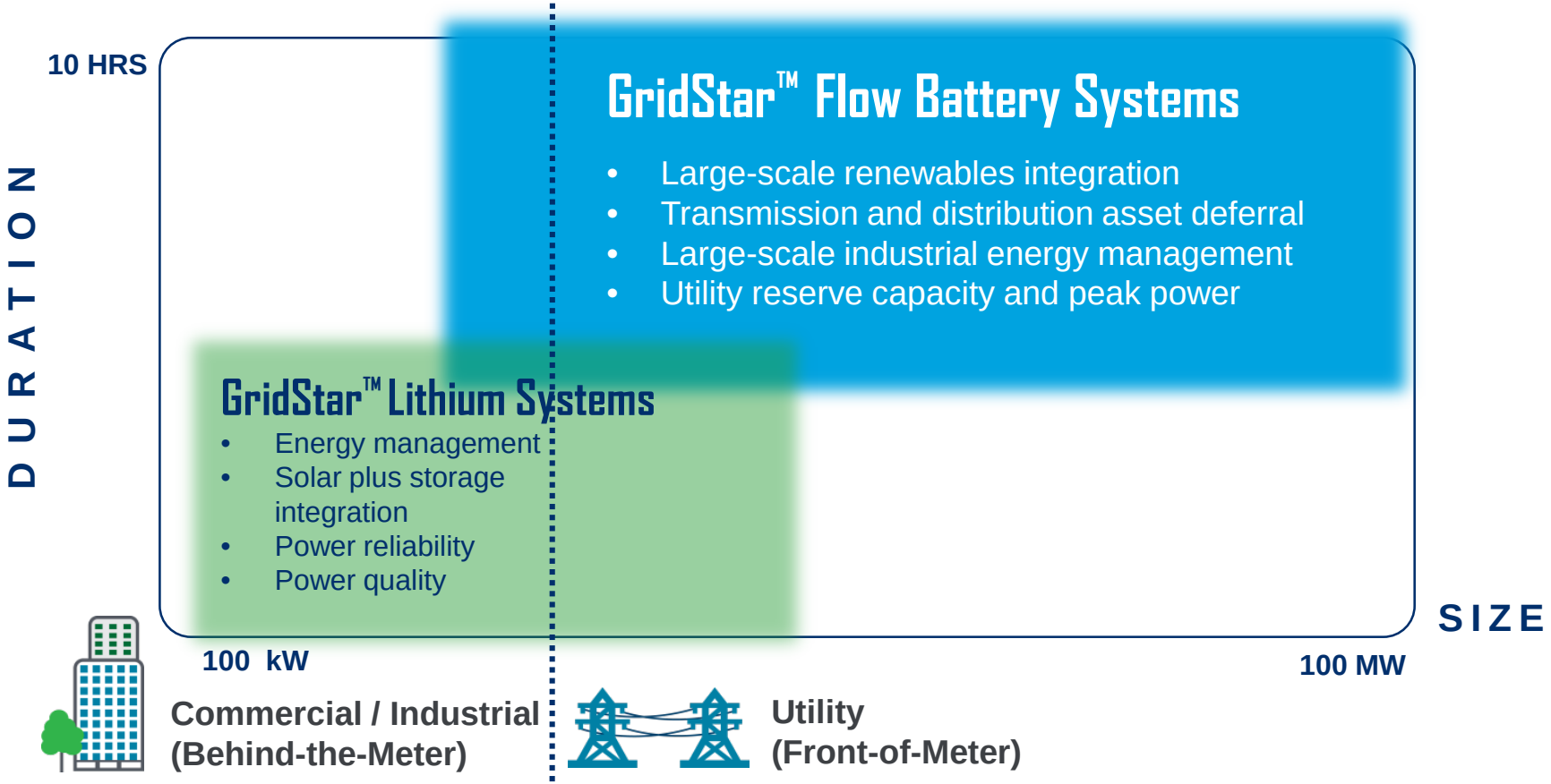
- ✓ **Save our customers money**
- ✓ **Make the grid more efficient, more stable**
- ✓ **Enable the increased use of renewable wind and solar**

Offerings

- GridStar™ Lithium
- GridStar™ Flow



We address a wide range of energy storage market requirements



Our energy storage systems are scalable and address medium and long duration applications.

GridStar™ Lithium

Complete solution. Compact package.

Turn-key outdoor-rated energy storage system including AC/DC protection, power conversion, energy storage, thermal management, and controls

Offering

- ✓ Ease of installation
- ✓ Compact footprint
- ✓ Flexibility – modular 100-375kW$_{AC}$ and 200-610 kWh$_{AC}$ configurations
- ✓ Scalability – simple to scale up to MW-class applications
- ✓ AC-coupling of multiple energy storage units
- ✓ Full Lockheed Martin warranty

GridStar™ Flow Systems

Lockheed Martin Energy is pioneering a new affordable, durable, safe flow battery for long-duration (>4 hours) energy storage

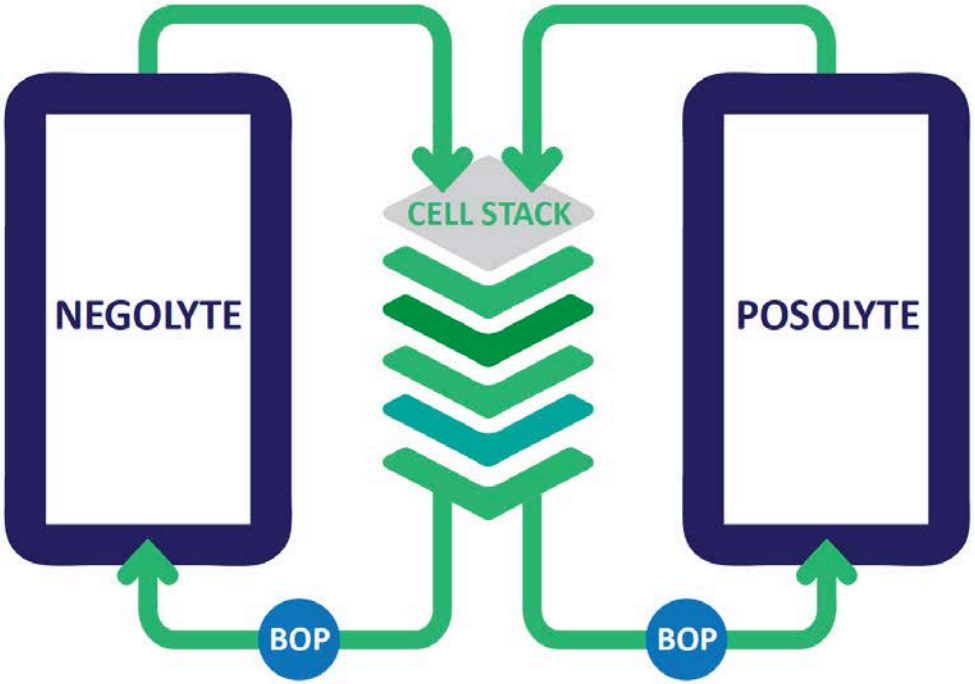
Offering

- ✓ Long discharge duration and deep charge-discharge cycles
- ✓ Low total cost of ownership
- ✓ Long useful life
- ✓ Full Lockheed Martin warranty

Applications

- Large-scale renewables integration
- Transmission and distribution asset deferral
- Large-scale industrial energy management
- Utility reserve capacity and peak power
- Microgrid support

Anatomy of a Flow Battery



CELL STACK:
- Membranes
- Electrodes
- Bipolar plates

ACTIVE MATERIALS:
- Redox-active compounds (Posolyte, Negolyte)

BALANCE OF PLANT (BOP):
- Pumps, tanks, piping
- Control & power conversion hardware

Flow batteries decouple power and energy, lowering marginal cost of multi-hour storage

Challenges of Existing Flow Batteries

Electrolyte issues

– High-cost

– Poor safety profile

High-cost balance of system

Low efficiency

Inadequate durability

Excessive footprint

Existing Flow Battery Chemistries

Vanadium Redox
Zinc Iron
Zinc Bromine
Hydrogen Bromine
Iron Chrome

GridStar™ Flow Benefits

Fundamentally new electrochemistry:

Patented engineered electrolytes with proprietary combinations of transition metals and ligands

Enables improved cell stack and balance of plant components vs. currently available flow battery systems

- ✓ **Higher efficiency**
- ✓ **Longer useful life**
- ✓ **Lower cost**


LOCKHEED MARTIN
LOCKHEED MARTIN
LOCKHEED MARTIN
DANGER
HIGH VOLTAGE
KEEP OUT
LOCKHEED MARTIN

LOCKHEED MARTIN

Lockheed Martin Energy

Energy Storage

storage@lmcoenergy.com

www.lockheedmartin/energystorage

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Storage – Fitting into the New Energy Landscape

Presented by: Schneider Electric - Don Wingate – VP Utility Solutions –
NARUC – Feb 12, 2017

Megatrends are provoking a rise in Energy Demand

URBANIZATION

+2.5B people in cities by 2050

Source: United Nations, DESA

DIGITIZATION

50B connected things by 2050

Source: Cisco

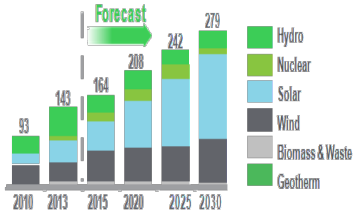
INDUSTRIALIZATION

+50% Energy consumption by 2050

Source: IEA

3D+E equation redefining the energy world…

1 Decarbonization



Huge growth forecast for variable renewables

Solar PV and Storage are expected to count for **32%** of new capacity additions by 2030

2 Digitization

Proliferating automated devices connecting the "grid of things"

Big data integration

Internet of Things will connect **50 bn devices** by 2020

3 Decentralization

Expanding energy consumerism
(smart homes, self-generation, EVs, financing services)

Prosumer challenge

57% of consumers consider becoming power self-sufficient

+

MORE ELECTRIC

Global energy consumption will increase by 40% in next 25 years ... and electricity consumption will increase by 80%

… creating unprecedented change in the power industry

By 2025 traditional centralized model will be complemented by a world of distributed energy,

Pressure on the grid

- **Tomorrow's grid integrating a multitude of DER (DG, storage and flexible loads)**

Distributed Generation

Demand-side Flexibility

•Intelligent markets

•*Solar and storage are reaching Grid parity at zero marginal cost*

Energy Efficiency

Disrupting existing business models

- **Utility-scale generation model disruption (volatile wholesale market, and emerging capacity market)**

New power grid design:

- National / Interco-regional
- Intermediate Microgrids (municipal, regional)
- Prosumers

New regulatory frameworks required

New Energy Landscape

Discussion and Questions

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SOUTHERN CALIFORNIA EDISON®
An EDISON INTERNATIONAL® Company

NARUC Innovation Task Force

Caroline Choi, SVP – Regulatory Affairs
Southern California Edison
12 February 2017

Electric power: largest users of energy storage

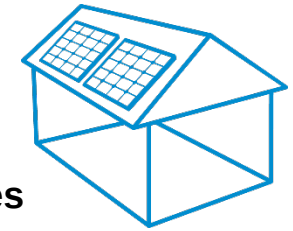
Accounts for 85% of systems installed in 2015

What is stationary energy storage?

Stationary storage is capable of taking electric output and converting it into another form of energy for use on demand.

What are the benefits?

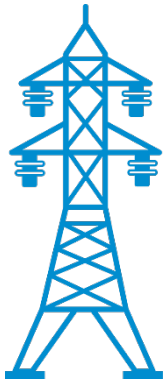
For Homes



Storing solar and wind power could increase time off grid by 2-4 hours.

For Businesses

Control of power costs reduces downtime and production losses.



Improved efficiencies in demand-side management, generation, and transmission.

Source: Barclays Research, September 2015

SCE's energy storage

Procurement Activity	Contracted Transmission Capacity (MW)	Contracted Distribution Capacity (MW)	Contracted Customer Capacity (MW)
LCR RFO	100.5	0	160.5
2014 Energy Storage RFO	0	16.3	0
PRP 2 RFO	0	60	20
2016 ACES RFO	0	22*	0
2016 ACES DBT RFP (UOS)	0	20*	0
Peaker EGT Projects (UOS)	20*	0	0

SCE is positioned to respond to grid needs and strategically pursue innovative use cases for energy storage.

* Over 60 MW of contracted energy storage is already online

List of Acronyms
LCR RFO: Local Capacity Requirement Request for Offers
PRP 2 RFO: Preferred Resources Pilot 2nd Request for Offers
2016 ACES RFO: Aliso Canyon Energy Storage Request for Offers
2016 ACES DBT RFP: 2016 Aliso Canyon Energy Storage Design, Build & Transfer Request for Proposals
Peaker EGT Projects: Peaker Enhanced Gas Turbine Projects

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ComEd
An Exelon Company

Energy Storage
A Utility Perspective

Michelle Blaise, SVP Technical Services

February, 2017

ComEd, An Exelon Company

Our customers:

- 3.9 million customers in northern Illinois

Our company:

- One of four utilities owned by Exelon
- ~6,000 Employees
- Service territory: 11,428 square miles

Our grid:

- Peak load: 23,753 MW (7/20/2011)
- 526,000 distribution transformers
- 65,000 circuit miles of primary distribution
- 53% overhead, 47% underground
- 5,800 circuit miles of transmission

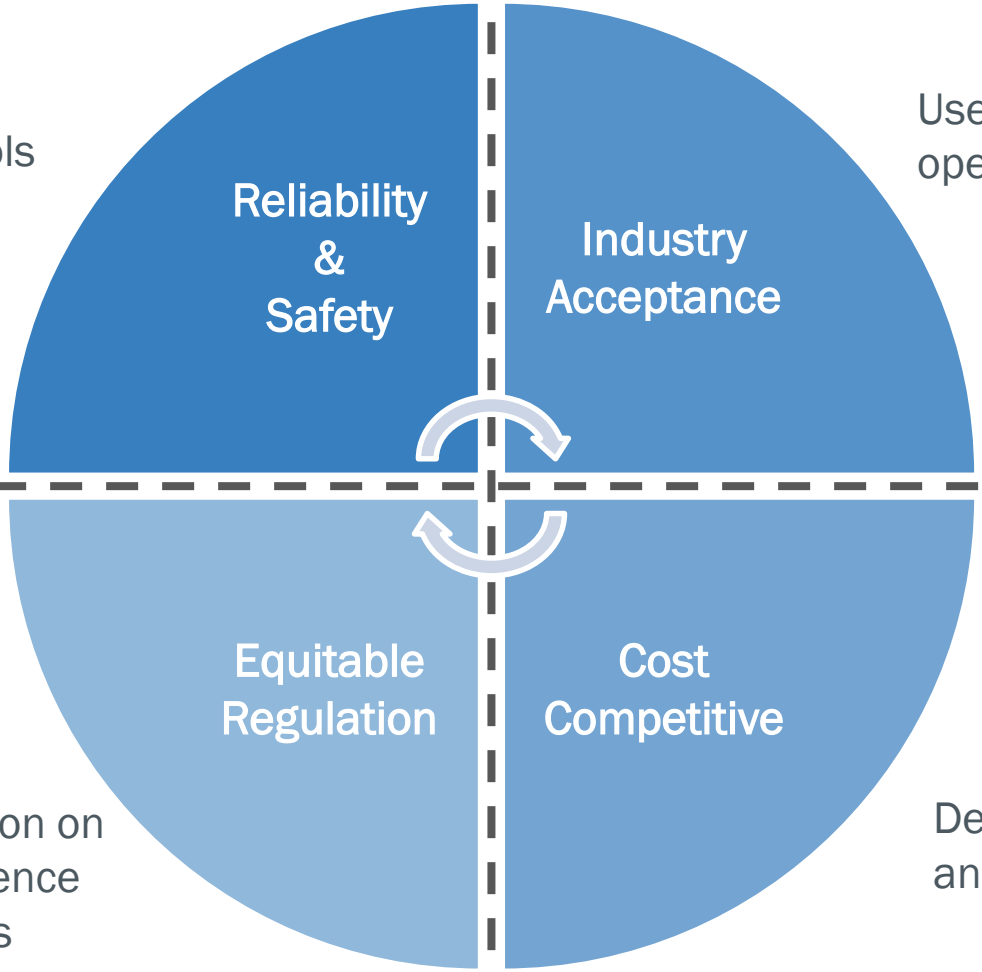
ComEd
An Exelon Company

ComEd's Vision for Energy Storage

There will be viable energy storage solutions for different applications, which will yield positive outcomes with confidence under the prevalent economic, regulatory climate, and energy conditions in our service territory.

viable = cost competitive + reliable & safe + embraced by regulators + industry accepted

Energy Storage Strategy



Document and share performance of installed systems

Perform field-trials and pilots

Validate testing protocols for utility use cases

Use existing planning and operational tools

Track degradation and failure mechanisms

Design tools for multiple grid services

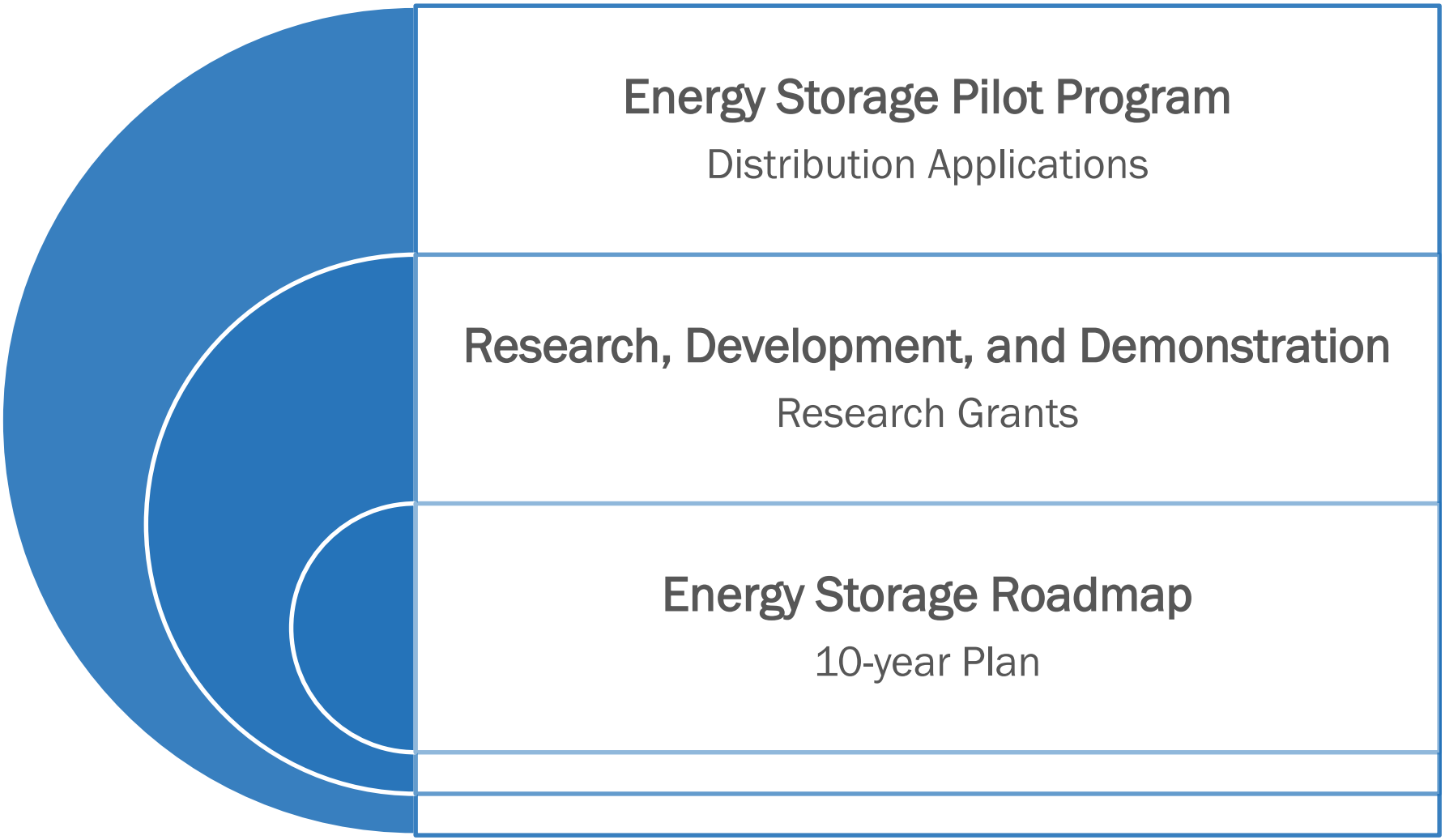
Support development of consensus based codes and standards

Characterization and evaluation of grid benefits of storage

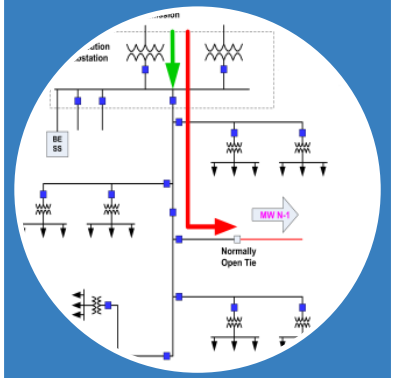
Disseminate information on storage status, experience and realizable benefits

Develop cost-benefit analytical models

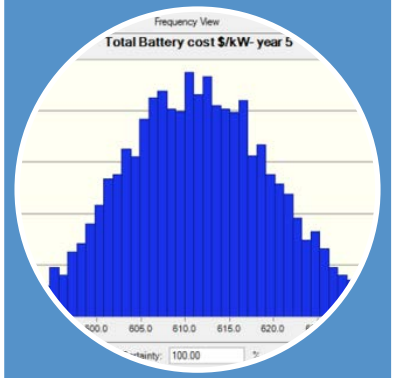
Energy Storage Projects



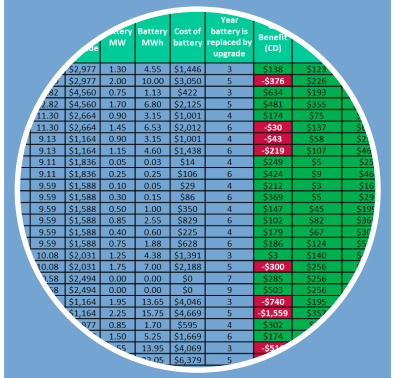
Energy Storage Roadmap



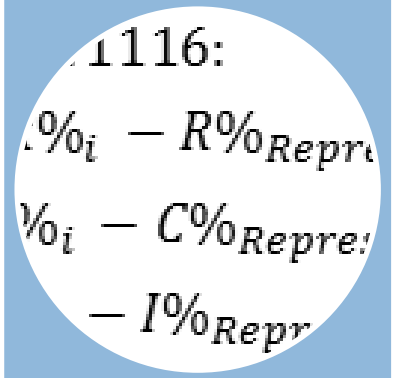
Time-series Power Flow Simulations



Storage Cost Forecast Model



Cost-Benefit Analysis



Extrapolation to ComEd System

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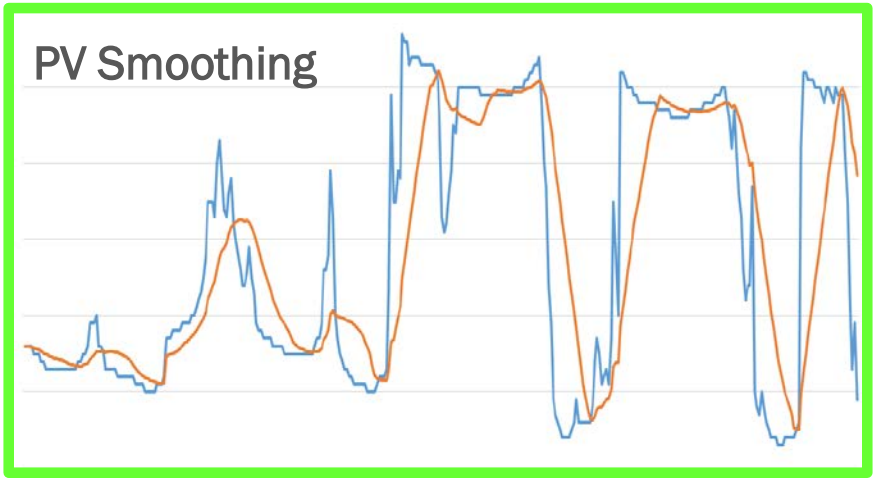
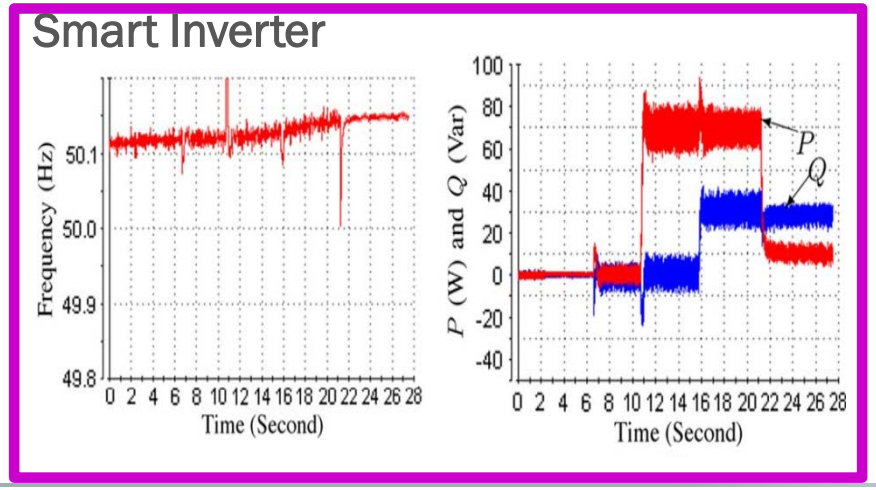
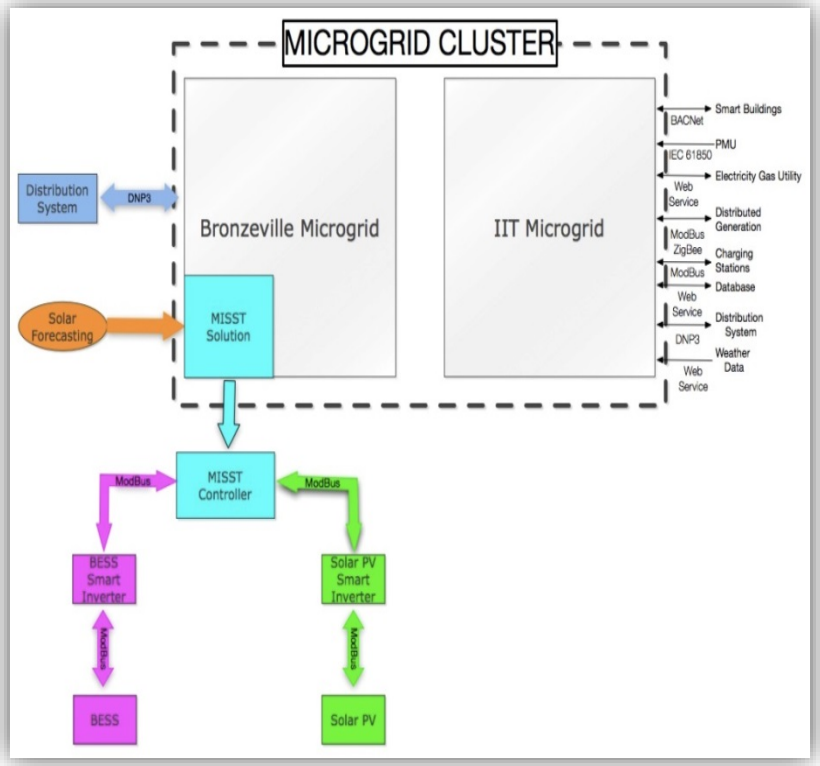
An Exelon Company

Research, Development, and Demonstration

US DOE – Sustainable and Holistic Integration of Energy Storage and Solar (SHINES)



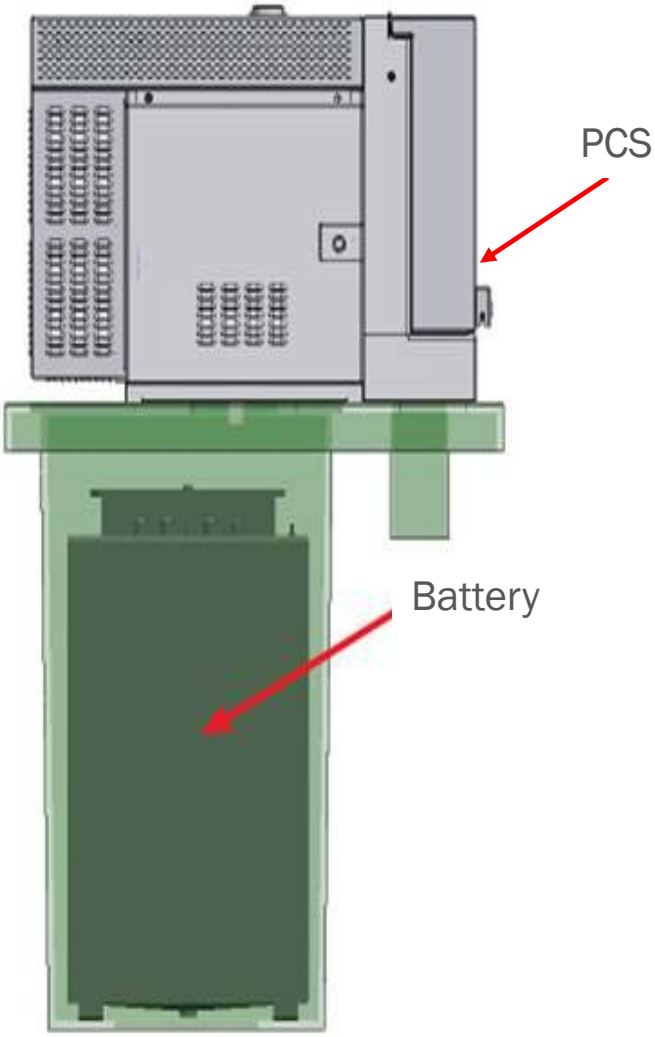




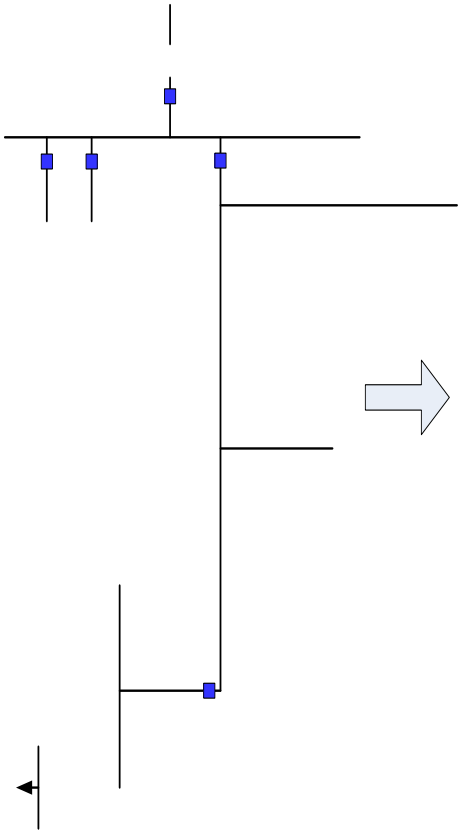
Source: Synchronverters: Inverters That Mimic Synchronous Generators

Energy Storage Pilot Program

Community Energy Storage for Pocket Reliability



Megawatt-scale Energy Storage for Capacity Deferral



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