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ENERGY STORAGE AS AN EMERGING TOOL FOR UTILITIES TO RESOLVE GRID CONSTRAINTS

June 18, 2015

E2Tech Presentation

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AGENDA

- Energy storage as a grid solution “high level”
- Specific CEP project examples
- The technology landscape
- Energy storage opportunities in Maine
- Current and future pricing

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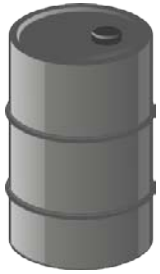
Energy storage increases utilization of existing infrastructure instead of building more

WHY ENERGY STORAGE?

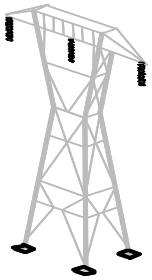
Electricity – the world's largest supply chain – has almost no storage compared with other commodities



World Annual Crude Oil Production
4.75 Bil m³

12.6% Storage Capacity

World Oil Storage Capacity
0.6 Bil m³

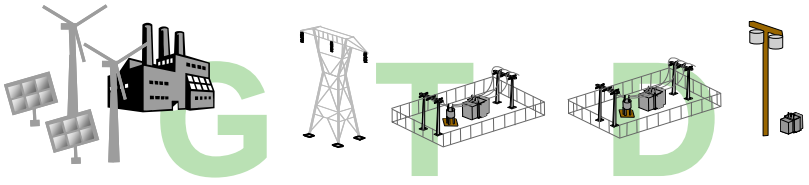


World Electricity Production
20,000 TWh

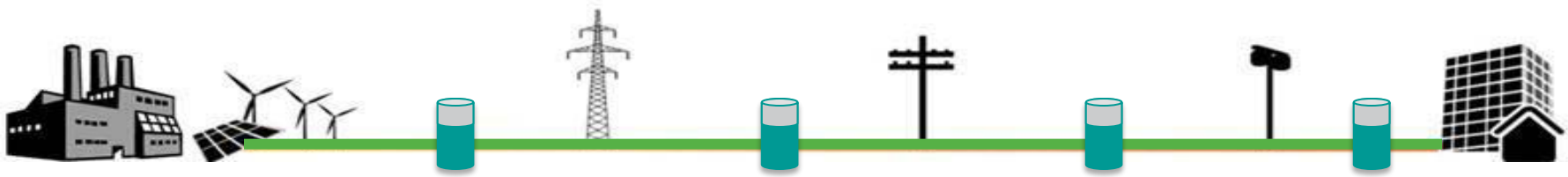
0.0065% Storage Capacity

Electricity Storage Capacity
1.3 TWh

Electric infrastructure is sized to exceed projected peak demand, resulting in massive idle capacity



	G	T	D
# in U.S.	17,350 plants	164,000 miles	3 million miles
Utilization	**47%**	**43%**	**34%**



- **Storage projects can increase the utilization of existing grid infrastructure with targeted siting and operations**
- **Storage can replace or defer new peak-related infrastructure investments in G/T/D, providing new, lower-cost solutions for utilities without on-site emissions or noise impacts**
- **THEREFORE: storage projects can increase reliability *AND* lower costs for electric consumers**

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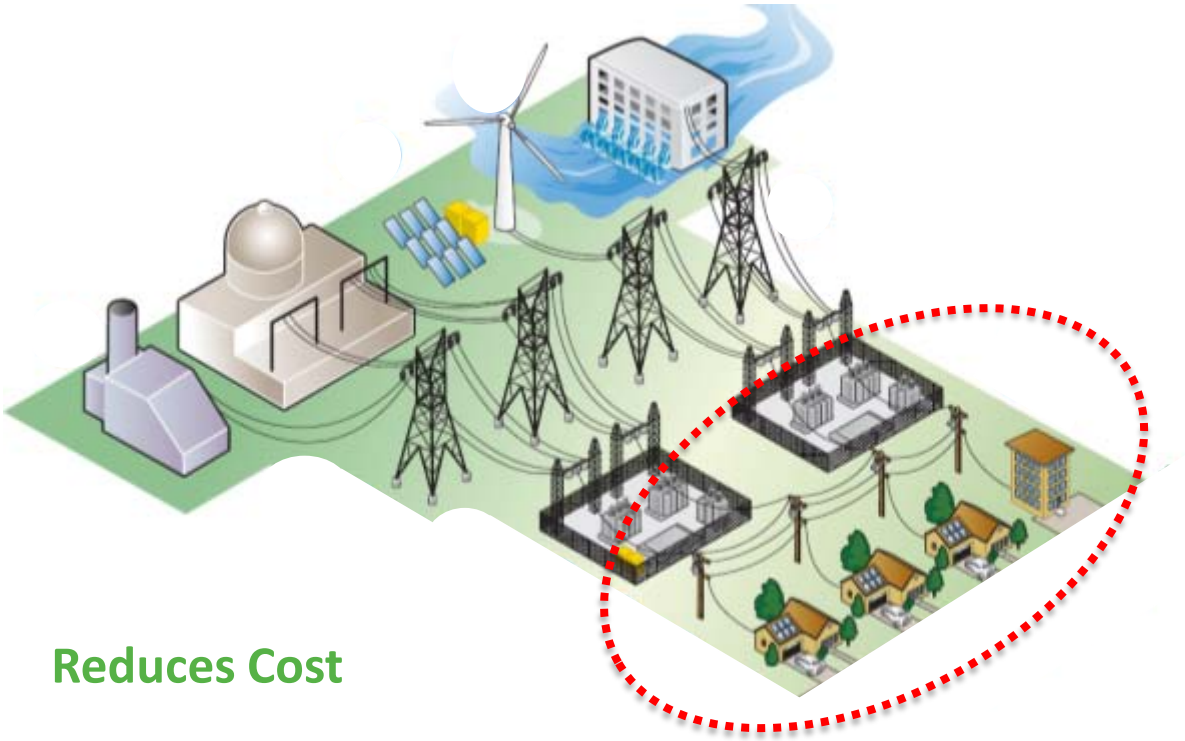
Targeted deployment of energy storage relieves system constraints



LOCATION MATTERS

Reduces Cost

- Avoids costly T&D infrastructure upgrades / reduces ratepayer costs
- Expedites solutions by reducing permitting and construction time
- Extends life / increases utilization of existing infrastructure

Increases Flexibility

- Instantaneous, reliable response / dispatch within load pockets
- Modular design for staged expansion to dynamically respond to load growth

Provides Cascading Relief

- Distribution assets benefit “upstream” feeders, substations and transmission lines
- Buffers grid volatility caused by increasing DG renewables penetration
- Can create additional value in wholesale energy and capacity markets

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Convergent commissioned a 500 kW, 6 hour grid-connected resource to help resolve a sub-transmission constraint in Boothbay, Maine

BOOTHBAY MAINE PROJECT EXAMPLE

"Non-Transmission Alternative" in Boothbay, Maine

- ***$18M in upgrade deferrals*** for Central Maine Power (CMP) as part of a 2 MW pilot program administered by GridSolar LLC
- ***10 months*** from contract signing to COD (Interconnection processes had the longest lead times / limiting factors)

Project Specs	0.5 MW for 6 hours
Contract Terms	Long term agreement to dispatch with 5 minutes notice in summer
Technology	Lockheed Martin integration; advanced Pb-Acid batteries

OTHER PROJECT EXAMPLES

5 MW, 0.5 MWh Flywheel

- **Application:** fast response frequency regulation
- **Technology:** mechanical flywheel with extremely long cycle life
- **Location:** in a fast load growth section of northern Toronto interconnected to the 115 kV transmission system

7 MW, 7 MWh Battery

- **Application:** reactive support and voltage control
- **Technology:** lithium-ion battery integrated by GE
- **Location:** in a 120 MW load pocket on a radial 115 kV transmission line; 60 MWs of PV solar recently added

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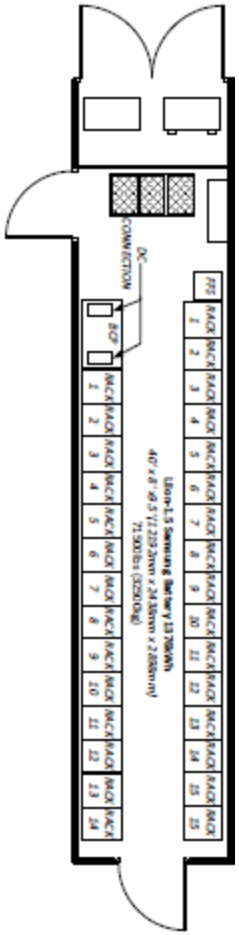
Primary cost is in the AC-DC system (>75% typically)

TYPICAL BATTERY PROJECT LAYOUT

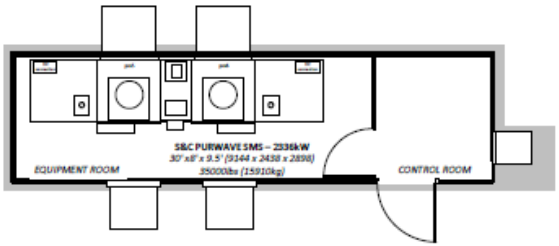
DC Technology

- Storage medium
- Thermal management
- Monitoring & management system
- Containerization & integration
- DC aggregation in series & parallel
- ~600 V DC



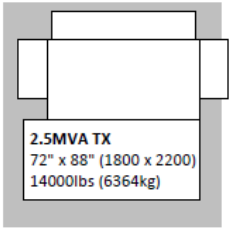
AC-DC Conversion

- Inverter / rectifier
- Reactive & real power control
- Communications & software
- Containerization & integration
- 480 V AC



Site Work & Interconnection

- Switchgear, breakers / relays / other protection
- Transformation
- AC interconnection
- Civil & electrical work
- Concrete / foundations



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Proven storage technologies are available today to address a wide range of applications

STORAGE TECHNOLOGIES OVERVIEW

		Description	Key Points	Summary
Value Regulated Lead Acid (VRLA)		• **Proven tech** • **Used in vast majority of back-up power industry**	• **Inexpensive** ($300 / kWh) • **Constrained life** (~5 years)	• **Low cost / highly financeable** • **Proven tech with long track record of safety / performance**
Lithium Ion	TESLA, LG Chem, NEC, SAMSUNG	• **Variety of vendors, chemistries, & specs** • **High energy density**	• **Less expensive** (~$650 / kWh) • **Longer lifecycle** (10-15 years)	• **Growing track record, commercial availability** • **Pricing dropping ~20% Y-O-Y**
Liquid Metal	FIAMM SONICK, NGK, GE Energy Storage	• **High temp operations** (~300 C) • **Large manufacturers**	• **Expensive** (~$1,000 / kWh) • **Longer lifecycle** (10 years)	• **Higher price points; manufacturers phasing out**
Flywheels	Beacon POWER, temporal	• **High RPMs in a vacuum** • **Delivers power, not energy**	• **More costly** (~$1,000 / kW) • **"Unlimited" life with proper maintenance**	• **For power apps only** • **Purchase from niche suppliers**

Pricing = AC-integrated cost; no install, site prep, interconnection, financing, etc.

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A large group of technology developers are working on next generation energy storage solutions; significant uncertainty but high upside

NEW TECHS & FLOW BATTERIES

Description

- **Early commercialization**
- **Promising specs & prices**
- **Small manufacturers & commercial volumes**

Key Points

- **Inexpensive:** $200-$500 / kWh*
- **High cycle life:** 10-30 years
- **Higher energy density** (in some cases)

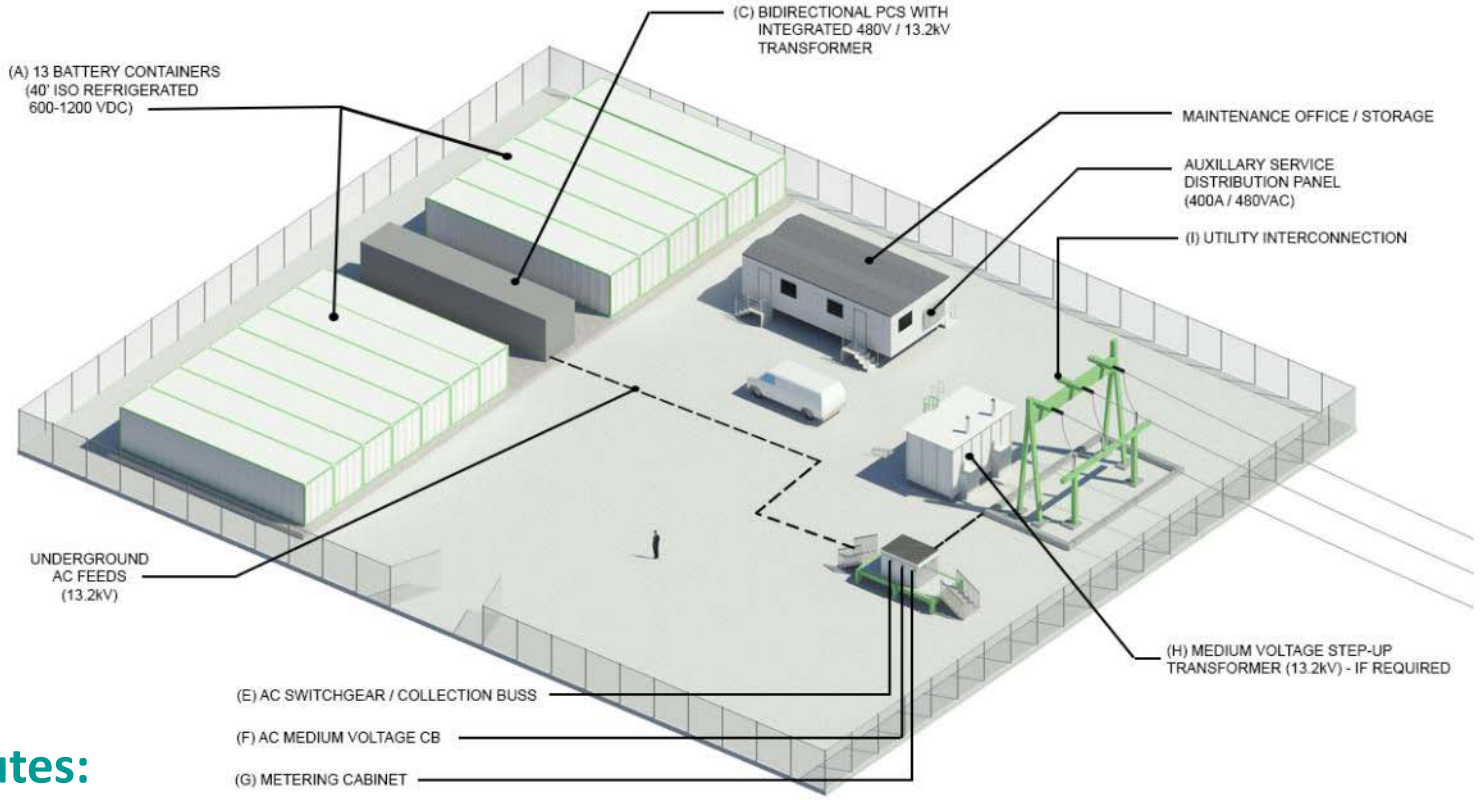
20 MW / 4-hour concept

Summary

- **In pilot / pre-pilot stages**
- **Promising optionality**
- **Enticing price points**
- **Minimal track records**
- **Early stages of financability**

* *AC-integrated cost; no install, site prep, interconnection, etc.*

EXAMPLE 4 MW, 16 MWH LI-ION SITE SCHEMATIC

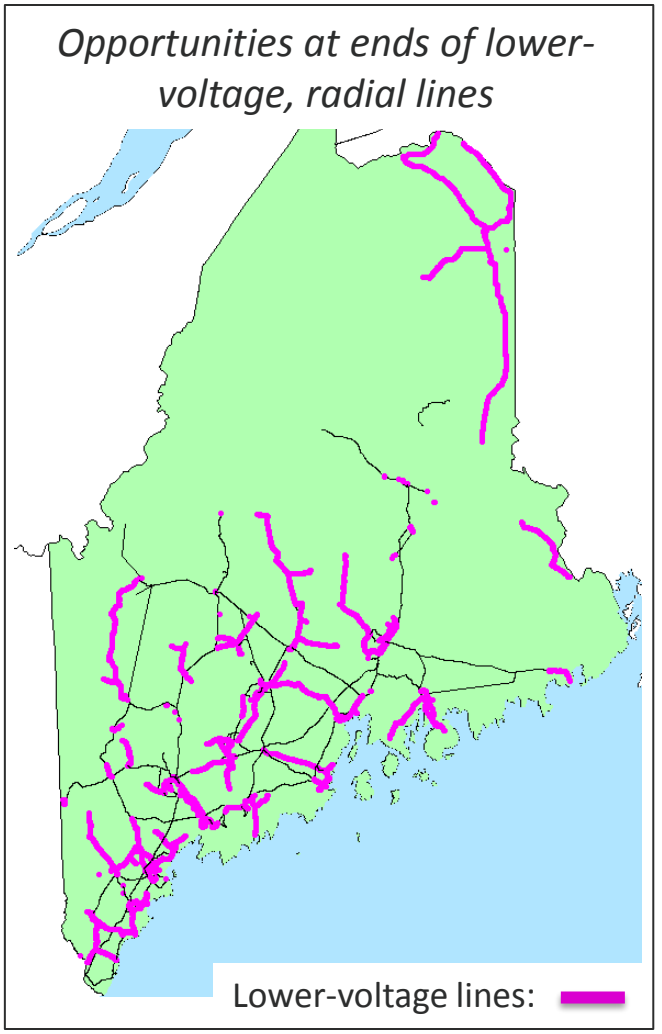


Key Attributes:

- Flexible interconnection
- Full install requires ~11,000 SF (0.25 acres) including clearances
- Includes battery degradation to ensure full 4 MW, 4-hour rating over 10 years

ENERGY STORAGE OPPORTUNITIES IN MAINE

- **Omnibus Energy Bill[1] opened ME markets to non-transmission alternatives ("NTA")**
  - » 3rd party analysis of non-transmission alternatives (NTAs) conducted alongside transmission upgrade [2]
  - » NTA favored by PUC if less than traditional upgrade
  - » Preference given to NTAs with low emissions
- **Several Maine areas served by radial lines with growing summer loads**
  - » CMP has identified ~40 MW of needed NTA resources in mid-coast region
- **Larger transmission issues arising from north-south transport of new wind energy**



1. *State of Maine Legislature **LD 1559** (HP 1128)*
2. *Required for transmission upgrades > 69kV or ≤ 69kV with value over $20M*

UTILITY OPPORTUNITY

- Control energy storage asset design, location, interconnection and operations to resolve otherwise expensive or difficult-to-solve constraints
- Expand and optimize capital spend opportunities
- Help define / shape regulatory environment and “utility of the future”
- Vendors (like CEP!) can provide new contracting mechanisms to diversify risk and make storage work for utilities NOW

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CEP solutions are competitively priced now and will be even more so in a few years

CEP INDICATIVE PRICING

Online Date	Asset Size		10-Year Contract Price NPV * from CEP
	MW	MWh	
May 2016	5	20	$1,880 / kW
May 2017	5	20	$1,680 / kW
May 2018	5	20	$1,375 / kW
May 2019	5	20	$1,200 / kW
May 2020	5	20	$1,120 / kW

- **Price Comparables:**
  - » ConEd (NYC) demand management incentives for ES = $2,100 – $2,340 / kW
  - » New-build CT gas capacity** = $1,200 – $1,500 / kW
  - » Residential solar installed cost = $3,500 – $4,000 / kW
  - » Utility-scale solar = $2,000 – $2,500 / kW

* *8% discount rate; includes NE market revenues to lower 10-year pricing*

** *LMS100 GE CT in NE*

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