Battery Balance of System Charrette

Post-Charrette Report

Contacts:
Garrett Fitzgerald, gfitzgerald@rmi.org
Jesse Morris, jmorris@rmi.org

ROCKY MOUNTAIN INSTITUTE

About This Document

The overall objective of RMI's Battery Balance of System work is to foster the development of collaborative efforts between energy storage stakeholders that:

1) Drive down non-cell costs of behind-the-meter energy storage systems
2) Expand the value proposition of behind-the-meter energy storage systems

On November 12, 2014, RMI convened a charrette focused on 1) identifying key barriers and crafting tactical solutions to catalyze market growth, and 2) clarifying cost structures of behind-the-meter energy storage systems. Participants included energy storage companies, utilities, solar developers, regulatory authorities, and members of the research community.

The structure of the charrette allowed for brainstorming of divergent ideas, organic convergence of ideas around a manageable number of themes, collaboration and critical feedback exchanges among participants, and consensus building around key strategies.

Breakout groups were organized on the basis of four major themes that evolved throughout the pre-charrette interview and planning process.

- Hardware and Installation
- Interconnection and Permitting
- Standards and Interoperability
- Value Proposition and Market Creation

Charrette participants initially focused on unpacking recognized challenges that are driving high costs in the industry, and identifying the distinct and limited markets that distributed energy storage is currently participating in across the U.S. The focus of the charrette then turned to brainstorming and designing solutions to identified barriers that both RMI and participants can bring to the market moving forward.

This document summarizes discussions from the charrette, including thoughts and ideas for energy storage cost reduction, business models, and new markets. It also outlines several actionable strategies for industry to consider pursuing in the near term that have the potential to drive down behind-the-meter energy storage system costs and create new market opportunities.

Table of Contents

Challenges, Strategies, and Solutions Identified at Charrette

Top Three Challenges:

- Lack of clarity on revenue opportunities/value proposition of behind-the-meter energy storage systems at the distribution level
- Uncertain "should cost" targets for stationary distributed energy storage systems
- Very limited market scale

Strategies and Solutions for Progress

	Research Needs	Collaborative Partnerships	Demonstration Projects
Cost Reduction	• Clean sheet "should cost" exercise • DOE-funded research projects/prizes	• Nationwide interconnection effort (using CAISO Roadmap) • Coordination among communications standards initiatives	• Public-facing pilots using NREL ESIF testing center • SGIP cost database
New Market Creation	• Energy storage (ES) value at distribution level • Bottom up cost-to-serve analysis • Peer-to-peer electricity system capability	• Pre-approved interconnection queue working group • Additional "Plug and Play" – focused hardware and software initiatives	• Additional distribution-level aggregation pilots • Hot spot DER RFPs/ utility pilots

Project Overview and Charrette Objectives

There are compelling reasons to use collaborative engagement to advance the energy storage industry, but several challenges must also be overcome

Ingoing Charrette Assumptions

- Energy storage has the potential to benefit multiple stakeholder groups across the electricity ecosystem but currently lacks a clear value proposition, largely due to high balance of system costs and a nascent market
- Balance of system costs can be driven down dramatically to expand the value proposition of all energy storage use cases
- New revenue and market opportunities are critical to help industry scale, and to illustrate the real world value of energy storage to customers, utilities, and regulators
- Energy storage is capable of enhancing grid stability while accelerating adoption of renewable energy resources

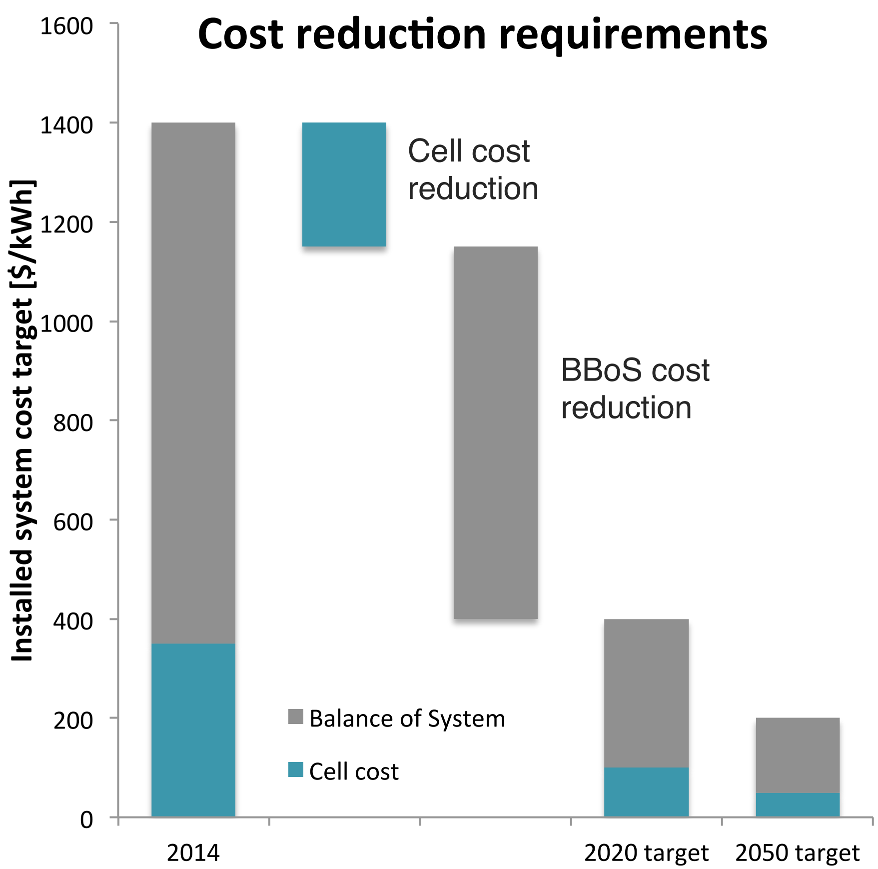
ROCKY MOUNTAIN INSTITUTE

Our purpose:
Rocky Mountain Institute transforms global energy use to create a clean, prosperous, and secure future

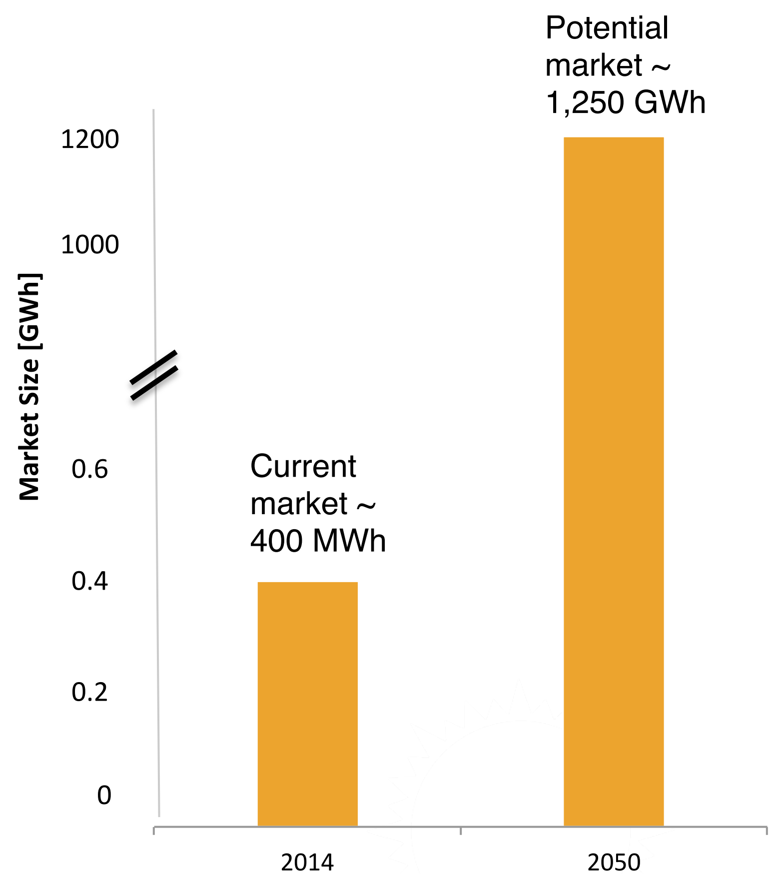
What we do:
Advance market-based solutions that transform global energy use

Our change model:
We engage market leaders to improve performance, and redirect strategic behaviors. For the Battery Balance of System Charrette, we partnered with the energy storage stakeholder ecosystem to develop shared recognition of cost reduction opportunities and develop “win-win” paths to realize them.

Lower BBoS costs are a key enabler of cost-competitive energy storage…

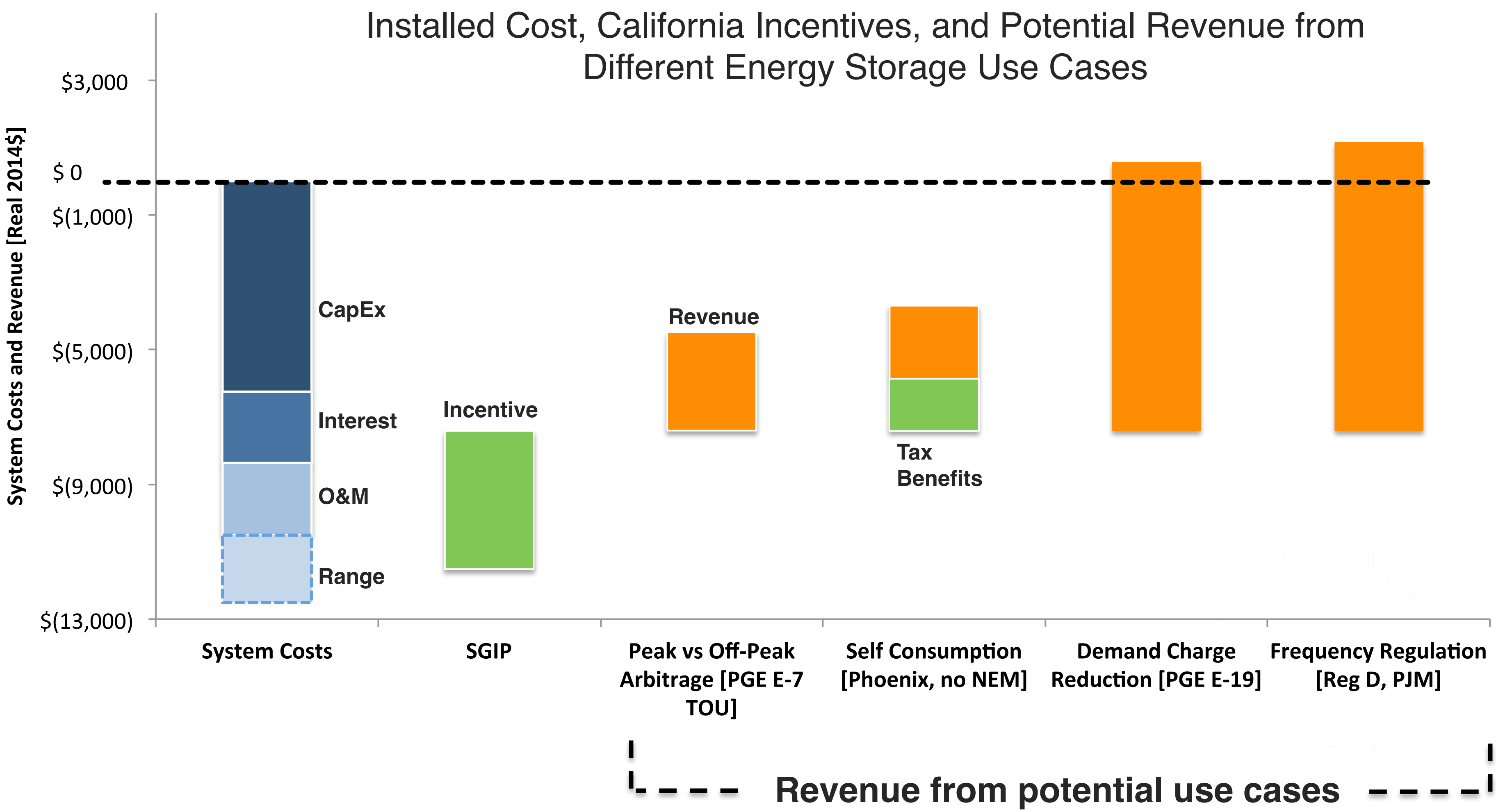


…which could ultimately open the door to an incredibly large energy storage market



2020 target of $100 per kWh based on U.S. Advanced Battery Consortium cell cost target.

Current system costs require large subsidies to make a business case. Even then, value can only be captured under a limited number of use cases in a small number of markets.



• Includes battery cell replacement costs. 5 kWh, 5 kW system financed over a 20 year term.

Many barriers in four high-level categories must be overcome in order to reduce cost and create new market opportunities

Hardware Costs

- Redundant metering
- Lack of standard interfaces
- High power-electronic costs
- Inefficient installation practices
- Lack of industry training
- No modularity

Standardization and Interoperability

- Lack of standard communication language
- Lack of safety/performance certification processes
- Inefficient use of data
- Unnecessary non-recurring engineering costs

Interconnection and Permitting

- Unnecessary interconnection processes and fees
- Screening and fast-track processes not tailored to energy storage
- No accepted risk assessment tools
- No testing protocol to meet utility requirements

Value Proposition

- Lack of clarity in product offerings
- Lack of customer awareness
- High customer acquisition costs
- Societal and regional benefits do not fall under the purview of RTO/ISOs

Charrette Objectives

BBoS Charrette Goals

BBoS charrette participants focused on identifying challenges currently facing the energy storage industry in order to:

- Reduce the cost of behind-the-meter energy storage systems
- Create new or expand existing energy storage markets across the U.S.
- Position utilities, regulators, and end-users to take advantage of the benefits provided by energy storage
- Generate collaborative solutions that stretch across the energy storage ecosystem

Charrette Outcomes

During the charrette, participants collaboratively:

- Identified inadequately addressed challenges facing the industry
- Generated a wide variety of strategies to reduce cost, improve value, and open new markets for behind-the-meter energy storage systems
- Created detailed implementation plans for several strategies
- Committed to follow through with ongoing engagements on specific strategies
- Set the agenda for RMI and the broader research community's focus on distributed energy storage

Charrette Participation List

Interoperability and Standards

Mark Higgins	Strategen
Haresh Kamath	EPRI
Venkat Banunarayanan	DOE
Ryan Wartena	Geli
Ravi Manghani	GTM
Dave Fribush	PGE
Tristan Kreager	SMA
Tim Keating	Sunspec
Ali Nourai	DNV GL
Derek Pearson	Eaton
Shaun Halverson	PGE

Permitting and Interconnect

Pete Klauer	CAISO
Aloke Gupta	CPUC
Ben Kaun	EPRI
Rob van Haaren	First Solar
David Cheng	Sempra
Willem Fadrhonc	Stem
Darren Hammel	Princeton Power
Chris Purvis	Value Energy

Hardware and Installation:

Hunter Dudley	Enphase
Dirk Weiss	First Solar
Matt Keyser	NREL ESLO
Philip Herman	Panasonic
Tripp Hyde	Stem
Margot Malarky	MESA

Value Proposition

Brian Forzani	PGE
Jill Powers	CAISO
John Bryan	Coda
Hunter Dudley	Enphase
Matt Roberts	ESA
Phil Larochelle	Google
John Merritt	Ideal Power
Jenna Goodward	Microsoft
Bevin Hong	ZBB
Colin Law	SunRun
Elise Hunter	PGE
Andrew Tanner	Geli
John Fortune	Sunverge
Ryan Hanely	SolarCity

Rocky Mountain Institute

Herve Touati	|Managing Director	Garrett Fitzgerald	|Associate
Stephen Doig	|Managing Director	Bodhi Rader	|Associate
Jamie Mandel	|Principal	Dan Wetzel	|Associate
Jesse Morris	|Manager	Titiaan Palazzi	|Special Aide
Leia Guccione	|Manager	Will Troppe	|MAP Fellow

Charrette Outcomes

Charrette Outcomes

Each breakout group focused on one of four cost reduction/market opportunity areas to unpack industry challenges and identify solutions and strategies for industry to pursue moving forward

Breakout Groups

Standardization and Interoperability
Explored opportunities to create hardware and software based standards to enhance energy storage interoperability, drive down costs, and enable highly interactive distributed electricity systems.

Hardware and Installation
Detailed the existing distributed energy storage cost stack to better identify clear opportunities for balance of system cost reduction at the component level.

Interconnection and Permitting
Identified strategies to streamline existing interconnection application procedures in order to transform the interconnection process from an onerous, time-consuming, cost-laden one into a tool for both utilities and developers to identify and capture value on the electricity grid.

Market Creation and Value Proposition
Broke apart the various services that energy storage systems can provide in order to identify new market-making opportunities for such systems in various locations across the U.S.

Process

- Step 1: Unpack challenges
- Step 2: Brainstorm solutions
- Step 3: Cross-pollinate ideas with other breakout groups
- Step 4: Design detailed action plans to bring ideas to marketplace

Charrette Outcomes:

Standardization and Interoperability

Issues

Behind-the-meter (BTM) energy storage systems have been developing in niche markets with ill-defined standards and a lack of clarity around system requirements across different levels of operation. There is currently no mechanism that allows grid operators to inform project developers and energy storage customers where and what is required of behind-the-meter systems, from the grid's perspective. The disconnect between grid operators and end users creates a misalignment of resources and can result in counterproductive deployment of equipment in terms of use case, system size, and system location.

In addition to the misalignment between grid operators and system owners, there are clear barriers to market growth resulting from a lack of industry standards and certifications processes for system performance and safety. This issue is further complicated by the fact that there is no industry-accepted protocol for interfacing components with each other and the distribution system, both in terms of hardware and communication.

Key questions

- How can distribution resource planners more effectively communicate in a standardized process how behind-the-meter energy storage can add value both to the grid operator and to the end user?
- What is the most effective method to create industry-accepted standards and certifications that address hardware, software, reliability, and operational performance in order to enhance system interoperability?
- How can energy storage stakeholders quickly and effectively leverage lessons and practices from the PV industry to move towards a more "plug and play" energy storage environment?

Standardization and Interoperability

Brainstorm and synthesize barriers and challenges that constrain market growth of behind-the-meter energy storage systems.

Key Insights

- Don't focus too much on making standards "perfect" because high-level needs will change as the market develops.
- Focus on *de facto* standards over new standards (except for safety); look to the PV industry.
- Make the standards process flexible and easy to expand, easy to update, and open to different business models.
- Develop a rapid qualification process of predetermined standards for utility acceptance of energy storage devices.

Identified Barriers to Enhanced Interoperability:

1. **The industry lacks a process to define system capability requirements**
   - Creating a mechanism that allows transparent communication across the different levels of the electricity grid (BTM, distribution, transmission) will result in greater alignment around the value energy storage can bring to all stakeholder groups.
   - Developing a formally agreed upon dispatch prioritization framework will ensure optimized operation/aggregation of distributed storage systems.

2. **Energy storage devices are not optimized to make use of distribution and feeder-level data**
   - Leveraging the large amount of data available at the point of interconnection will promote optimal operations of storage assets on the distribution grid. The lack of a standard language/protocol is limiting the feasibility of wide-scale data utilization.

3. **The industry needs to align on a single protocol/standard that will enhance interoperability**
   - Creating an industry-accepted standard that addresses communication language, hardware interconnection, system architecture, and distribution grid layout can accelerate system adoption and drive cost reduction.

4. **There is no widely accepted certification group**
   - Developing a group or process within the storage ecosystem that can provide a certification of hardware, software, and reliability performance will alleviate safety and reliability concerns among utilities, project developers, and financiers.

5. **Utilities have no means to absolve responsibility if a customer-owned storage system operating behind the meter causes adverse effects**
   - Creating a mechanism to remove utility liability of a system failure in the customer's home if the utility operates a behind-the-meter system.

Standardization and Interoperability

Identify and segment levers to overcome barriers and roadblocks

Product Performance

- Standardize ports that define data type, speed, etc…
- Standardize product capabilities for safety, use case, performance, reliability, etc…
- Collect all specifications on all ESS component products to decrease engineering time.

Interconnection Standards

- Communication, Hardware, Performance, Security
- Standardize a legal release, i.e., utility not liable for any issues resulting from use of system by utility.
- Create an energy storage interconnection group at utilities.
- Publish standard interconnection guidelines of energy storage for various scales:
  - Residential
  - Commercial and industrial
  - Utility
- Create an integration framework that addresses the following categories:
  - Safety
  - Use case
  - Market functions

Data and Telemetry

- Utilize Self-Generation Incentive Program (SGIP) inspection data to make interconnection faster and cheaper. This can be used for understanding system specifications and performance, system costs, and use case.
- Monitor distribution transformers to provide data for faster fault current analysis (speed up interconnection studies).
- Integrate multi-functionality software-based metering with adequate security.

Software and Communication

- Utilize a common utility command communication protocol based on application use case.
- Coordinate communication/data tool/app with a standard language and format (inverter, feeder, voltage, frequency, management system).
- Develop protocols for aggregating energy storage and communication dispatch for both end customer and utilities.
- Move toward ES as an IP device. Any app can use it and it facilitates multi-stakeholder engagement. Must be addressable and easily networked.

Key Insights

- Many of the strategies that were brainstormed converged around the goal of alleviating issues with the interconnection and permitting process.
- Software and network-based solutions will be key to overcoming interoperability challenges in a way that optimizes for flexibility and future development.

Incorporate feedback from cross collaboration clinic to re-bucket barriers and strategies.

Use the levers and design elements to create detailed short- and long-term strategic action plans that address barriers to market growth.

Key Insights

Plug-and-Play standards were defined across 4 dimensions

1. Hardware
2. Software
3. Communication
4. Application and Aggregation

High-Level Strategy Themes

1. **Current work that can be adapted to storage models**
   Take lessons from PV, power electronics, other similar markets.
   - Communication
   - Interconnection standards
   - Safety standards
   - Performance standards

2. **Inward-facing components at the system level**
   Required elements of the interconnection process
   - Component specification
   - System certification
   - Ports, plugs, and interfaces
   - Safety

3. **Outward-facing interfaces and functionality**
   Components of system operation after interconnection
   - Data to utility
     - What data? And how is it transferred?
   - Communications
   - Operational safety
   - O&M standards
   - Use case certification

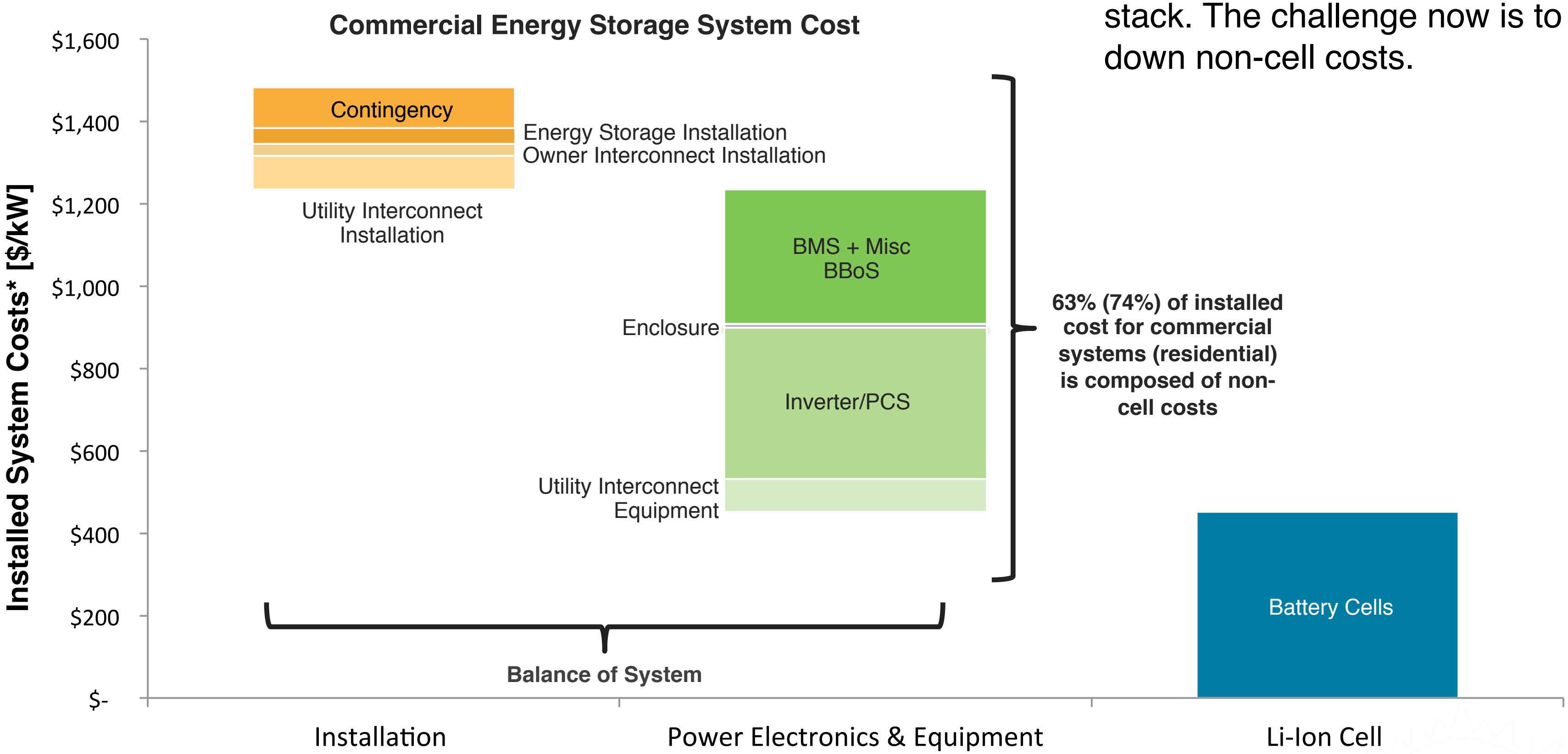
Standardization and Interoperability

Strategy Name	High-Level Description
SGIP Data Utilization	Utilize SGIP inspection data to make “permission to operate” [PTO] faster, collect and aggregate data on system specs, applications/use case, system cost breakdown and any other useful data. Create a storage version of the PV CSI working database.
Software Plug-and-Play for Multiple Applications	Stacking multiple applications and dynamic groupings of BTM assets to address local/central priorities. Should have multiple levels of autonomous operation based on a hierarchical/layered intelligence. Will need to have local safety/ security protocols so that any failures do not propagate upstream. • User-friendly interface • Data transparency • Data relevance
Software Plug-and-Play Communication	Create or use an existing language that will become the industry accepted standard for data and signal communication between ES systems and the utility. Could be Open ADR, Sep2, ICCP, DNP3, etc... But we need to find an agreed-upon and widely accepted/utilized language and communication protocol.
Plug-and-Play interconnection Process	Firm process for interconnecting storage systems to the grid. Define inputs and outputs from ESS and what utility accepts: power, voltage, frequency, physical connection. After all other plug-and-play strategies (hardware, application, communication) have been developed, create a plug-and-play interconnection option where the utility, informed by its distribution system configuration, tells the interconnection applicant the system parameters that must be met to plug-and-play interconnect without any need for grid upgrades.
Online Pre-approved Interconnection Process	Create an industry and utility collaboration to identify the 100+ system characteristics that are critical to interconnection. Then define a standard process for project developers to provide system specifications and certifications online that meet a certain minimum requirement allowing their interconnection application to be automatically approved without the need for so much human interaction.
Local Grid Support from BTM ESS Automation	Create a pilot program for BTM ESS based on a shared service agreement between the host and the utilities where the utility can have direct control over the system for local and system support.
Hardware and Product Performance and Validation/ Valuation	• Standardized product capabilities • Standardized port, which defines data type, speed • Collect all specs on all ESS component product to decrease engineering time

Charrette Outcomes:

Hardware and Installation

Hardware and Installation



Issue:
Cell costs are no longer the largest part of the energy storage cost stack. The challenge now is to drive down non-cell costs.

Key Questions:

- What is the true cost of installation labor?
- Why are coupled AC system configurations still the most prevalent system designs when smart inverters can provide the same functionality at reduced costs?
- How much would standardized physical interconnection points reduce costs?

*Based on: 0.25–2 MWh system size with 1 hour discharge capacity; Sandia, BNEF, RMI

Identified Barriers to Reduced Hardware Costs:

- *Limited Scale:* Limited market scale was repeatedly identified as a major challenge. Given the small market size in the U.S. for behind-the-meter energy storage, it is difficult for companies to mass produce standard product offerings.
- *Metering Requirements that Increase Costs*
- *Labor Market Challenges:* Many electricians working on distributed energy storage systems have never worked with them before or received training, increasing costs and sometimes requiring re-work
- *Lack of Standard Grid Interface*
- *Poor Diagnostics/High Maintenance Costs*: Many energy storage systems have poor diagnostic capability, resulting in iterative on-site maintenance trips to de-bug systems
- *Housing/Foundational Challenges:* When additional foundational work is required, system costs can be increased dramatically

Initial Opportunity Areas to Overcome Barriers and Reduce Costs

Increased Standardization	Redesigned Enclosure	Improved Diagnostics	Metering Changes	Inverter Configuration	Permitting Changes
• Build storage systems entirely in factory (a la Dynapower IPS 500) • Standard grid interconnect for all system sizes • Eliminate advanced terminal switch requirement	• Indoor, not outdoor, rated housings • Move away from metal to plastic housing • Smart siting for large systems to avoid extra foundation	• Digital diagnostics tool to monitor system health and remotely de-bug • Educate system owners to avoid maintenance trips	• Eliminate need for second electricity meter by getting access to data from utility meter	• Create new market opportunities for larger industry and room for more experimentation • Use a single "blade" for enhanced BMS	• State- or federal-level permitting process • Develop "battery-ready" building codes, analogous to PV-ready rooftops

Incorporate feedback from other breakout groups to split industry into three segments.

Flesh out detail around specific cost-reduction opportunities.

Prioritize the most promising near-term strategies for cost reduction (summarized on the next page).

High-Level Strategy Themes

Commercial (50–200 kWh)

Permitting and interconnection fees
- State-wide approval process for permitting and interconnection
- Self-permitting by electricians, as in Germany
- No CPUC fees, notification, or interconnect

Metering requirements
- Use of utility meter, no secondary meter requirements

Siting and location
- Containerized or modular batteries
- New building code that requires space for storage
- Updated building code to include storage requirements

Backup versus parallel costs
- Update UL certification for storage
- New buildings should require by code an Advanced Terminal Switch (ATS) and critical load circuits to be preinstalled, to facilitate storage installation

Labor/materials
- Industry training materials for electricians on energy storage installation
- Integrated disconnect for electrical equipment for storage modularity

Residential (5 kWh)

Module communication
- Communication for the battery management system without dedicated wiring (i.e., via wireless communication or information sent via electric cabling)

Inverter costs
- Reduce material costs of inverters
- Eliminate duplicate circuit breakers
- Heat management through natural convection

Installation costs
- Reduce the amount of time needed to install systems

Hardware and Installation

Strategy Name	High-Level Description
Communication Protocol Standard	Develop a standard to affect interoperability, monitoring, and control of battery systems, inverters, and grid integration.
Inverter Standardization	Standardize the inverter sizes for micro-grid applications: 500 kW, 1 MW, 2 MW
Time-motion Study of Battery Installation	Analyze hundreds of battery storage installations with 5-minute granularity to identify where to reduce installation time and costs.
NREL or DOE-funded Inverter Cost Reduction	Fund research or offer prizes for residential battery storage inverter cost reduction.
Action Plans on Residential Scale	• Develop a training program for technicians, for instance in partnership with Energy Storage Association (ESA), to train technicians in safe and fast energy storage installations. • Work with a utility, like PG&E, and a local jurisdiction to develop new ways of notifying utilities of storage connection. • Work with a utility, like PG&E, to modify or eliminate the requirement of an advanced transfer switch in certain jurisdictions in case of grid failure. • Start a conversation with states around permitting: is it possible to do self-permitting by technicians, like what happens in Germany, and can the approval process be synchronized across the state, rather than by local jurisdiction? • Start a conversation with building code authors about including specific regulations for storage with regard to fire code and structural code specifying energy storage location.

Charrette Outcomes:

Interconnection and Permitting

Issues

Interconnection and permitting have been widely cited as major barriers to the deployment of behind-the-meter energy storage systems. Storage devices operate both as generators and as loads. These unique characteristics result in misalignment and issues when energy storage is subjected to traditional interconnection processes that were designed to deal with generation-only connection requests.

Delayed and onerous interconnection processes impact the energy storage market across many channels in many ways. Interconnection costs can exceed $3,000 and can delay “permission to operate” by over a year.

Non-cost causes for interconnection delays:

- Complicates planning
- Jeopardizes sales
- Creates stranded working capital
- Increases bullwhip effect

Key questions

- How can we capture lessons from other DG interconnection struggles and rapidly adapt them for energy storage applications?
- How can the industry ensure that value and risks are equally shared between installers, utilities/regulators, and end users?
- What is necessary to streamline interconnection and ensure the process is accurately segmented based on impact to grid operations?
- How should the utilities and ISOs inform standards and best practices so that interconnection impact studies can be completed quickly and with minimal costs?

Brainstorm and synthesize the barriers and challenges directly affecting the permitting and interconnection process for behind-the-meter energy storage systems

Key Insights

- Challenges were segmented and broken apart based on those that need to be addressed in the short term (triage) and those that need to be more completely addressed over the long term.

Barrier Identification

1. **Standards and Certification**
    - Lack of testing protocol against utility requirement
    - Lack of statement of utility requirement
    - Lack of safety standards
    - No industry-accepted model or standards
        - per value
        - per chemistry
    - Lack of certifications for necessary dimensions
    - Slow standards process

2. **Interconnection Process**
    - Unnecessary interconnection fees
    - Lengthy interconnection application/approval process
    - Screening and fast-track processes are not tailored for energy storage
    - Lack of clarity in system cost contribution
    - Custom process/design occurs too frequently
    - Lack of tools to assess risks
    - Bias toward hardware solution
    - No way to demonstrate novel technology
    - Minimal acceptance of 3rd party participation in grid

Interconnection and Permitting

Identify strategies and opportunity areas to address barriers to interconnection and permitting and reduce costs

Non-exporting exemptions
Creation of IEEE Standard for non-export system that doesn't disturb the grid
For non-export, move from approval to notification
Lower fees for non-exporting resources within existing testing protocols

Improved application process
Online portal for interconnection applications
Enforce acceptance of electronic signatures

Scaling Solutions
RMI education campaign on regulatory jurisdiction between interconnection, NEM, and permitting
More staff for utility interconnection teams
Capture and disseminate best practices/biggest pitfalls from leading jurisdictions

Interoperability
Battery pack and inverter interoperability standards
"Pre-standards" that pilot storage deployments can model after that enable innovative value streams for evidence of cost-effectiveness/reliability/safety

Performance verification
Common/standardized telemetry requirements between distribution and transmission
Establish "template" for new construction (anticipate solar/storage)
Standard revenue metering specifications between utility meter and resource embedded metering.
Utilize DR metering and telemetry requirements for wholesale market

Standards and permitting
National database on city fire safety standards—best practices
National building code standards for ESS (e.g., fire suppression)
Create DOE performance guidelines for energy storage systems
Eliminate separate fire safety permitting
Model codes and model designs: aggregate a case study brochure of what are deemed accepted installations

Interconnection study
Progressive fee structure for interconnection based on inverter nameplate
Standard, validated methods and tools for utility to perform interconnection studies
Harmonize grid interconnection design and use constraints with most likely and most valuable use cases
Pre-studied pre-allocated blocks of peak injection/peak load along distribution circuits
Transmission/distribution pre-determine areas of the grid where storage could provide value or advantage over other resources

Interconnection fast track
Utility approval of standard third-party AC-side equipment and approval of installation entities
Expedite interconnection given exception for utility controlled resources
Itemize typical circuit cases and standardize solutions for them
Testing protocols from utilities that are established that can be performed for battery types in accordance with national lab standards
Transmission/distribution pre-determine areas of the grid where storage could provide value or advantage over other resources

Interconnection and Permitting

Divide challenges into two categories: **permitting** and **interconnection** (although challenges are similar across the two categories, the solutions have very different impact approaches)

Interconnection Themes

Problem identification
- Identify major concerns from the utility perspective
- Identify common definitions across the ecosystem so all players can communicate effectively and document risks and successes

Build special designations
- Fast-track projects (pre-studies)
- Carve-outs (utility controlled, non-exporting)

Improve technical study process (utility side)
- Develop a checklist of best practices
- Create better modeling and analytical tools for utility use
- Develop protocol for utilities to test impacts of each battery value/chemistry and use that data across different circuit types

Installers/manufacturers build in mechanisms to address interconnection fears
- Move toward certification of devices

Improve business processes of interconnection
- Create dispute process protocol for IC study outcomes
- Allow online submissions and paperwork mitigation
- Create estimable timelines and insurance mechanisms to allow project work to move ahead without waiting for approval

High-level policy/strategy to motivate interconnection

Permitting Themes

Drive toward standards
- Homogenize standards for replicability
- Reform fire and building codes for energy storage specifically (sprinkler example…)

Mechanisms for widespread adoption
- Organizations to disseminate best practices
- Encourage centralized lab testing and certification

Action items with the largest probability of being championed and adopted by the industry.

- Fire safety permitting
- Segmentation of interconnection studies to eliminate/reduce requirements
- Geographic pre-clearance of specific sites for interconnection
- Tools for utilities to perform interconnection studies

(Detailed action plans are summarized on the next page)

Interconnection and Permitting

Strategy Name	High-Level Description
Reinventing Fire Permitting	Create a new set of standards for energy storage systems that properly reflects the risks and safety requirement in regards to fire suppression. Current building codes and fire safety requirements are not designed around Li-ion energy storage system operation and needs.
Segmentation and Streamlining of Interconnection	Elimination of interconnect application for non-exporting flow. There is a need to create segmented (better than current screens) interconnection process so non-exporting systems, which essentially behave as a load decrease/shift, do not need interconnection.
Pre-clearance of Interconnection	In its planning processes and under the direction of regulative and legislative direction, CAISO provides IOUs guidance on how new resources can improve grid capacity, congestion, policy adherence (RPS, DG, carbon, storage, other mandates) and of course electric reliability. Utilities, whether public or investor-owned, do likewise at the level of their distribution networks.
Interconnection Tools for Utility	Create tools to help address the risks to interconnection from a utility perspective that help then to quickly and cheaply identify risks and benefits and drive down costs and times for approval.

Battery Balance of System Charrette

Value Proposition and Market Creation

Issues:

The distributed energy storage market has enormous growth potential. The technology is able to provide a number of different services to customers, utilities, and developers with greater reliability and response time than incumbent providers (thermal power plants).

But, for distributed energy storage to scale and meaningfully contribute to the electricity system of the future, new market opportunities must be developed.

Key Challenge:

Despite the fact that distributed energy storage can provide all of these services, most applications and use cases simply cannot be monetized in the U.S. outside of select shallow markets and small-scale pilot projects in PJM territory, New York, and California.

EPRI identified 14 use cases under five overarching areas

Bulk Energy Services	Ancillary Services	Transmission Infrastructure Services	Distribution Infrastructure Services	Customer Energy Management Services
Arbitrage	Regulation	Upgrade Deferral	Upgrade Deferral	Power Quality
Supply Capacity	Reserves	Congestion Relief	Voltage Support	Power Reliability
	Voltage Support			Retail Energy Time-Shift
	Black Start			Demand Charge Management

Identify where industry should look and how to go about creating new market opportunities

Additional benefits offered by distributed energy storage (regardless of where these benefits can actually be monetized under existing regulatory regimes and policies)

Energy and Load Profile Management:

End-use customers can use distributed battery systems to control their load and energy consumption profile. There are several existing and emerging ways that customers capture value using batteries for this purpose:

- Demand charge reduction (existing)
- Load shifting or arbitrage (existing)
- Self-consumption of distributed generation (existing, mostly non-U.S.)
- Rate responsive load shifting for TOU and dynamic pricing (emerging)

Key Insights:

- Differences in load management applications are driven by the different opportunities to monetize the benefits, but the actual use of the battery is very similar across use cases.
- Many existing values that can be captured by distributed energy storage are well established and have been provided by other generation systems while others provide a relatively new opportunity for energy storage systems.

Market Price Suppression:

At greater scale, distributed battery systems could impact wholesale and retail prices for energy, capacity, or ancillary services, making other energy resources more or less competitive in the market.

Reduced Risk:

Battery storage systems can offer a fuel price or energy price hedge.

Reliability:

Distributed batteries can offer higher reliability to end-use consumers through:

- Backup/standby power in the event of macro-grid outages
- Power quality management for sensitive and high-reliability systems at the customer site

Credits and Incentives:

- Distributed battery systems are eligible for credits like the Self Generation Incentive Program (SGIP) in California.
- In certain configurations, batteries can benefit from ITC and MACRS tax credits

System Efficiencies and Savings:

Distributed storage systems can offer benefits to utilities and grid operators through various system-level efficiencies such as:

- Demand response
- Transmission and distribution infrastructure deferral or avoided cost
- Power capacity
- Reduced line losses

System Performance:

Distributed battery systems can improve local and macro-grid operation and performance through:

- Provision of ancillary services
- Integration of variable renewable generation sources

Identify to whom and where within the electricity system each source of value can be captured. Stakeholders of interest include customers, utilities, and markets or RTO/ISO regions with multiple utilities.

Value for the Customer	Value for the Utility	Value to the System/Market/ RTO/ISO region
1. **Reduced Energy Bills** • Demand charge reduction • Price arbitrage and/or load shifting • Self-consumption of on-site DG 2. **Risk and Price Hedge** 3. **Reliability (backup/standby)** 4. **Enhanced Power Quality** 5. **Environmental Benefits** 6. **Cost Reduction or Private Distribution Deferral** 7. **Enhanced Power Quality** 8. **Future-Proofing and System Flexibility** 9. **Renewable Enabler** • Allows for PV investment where not otherwise allowed 10. **Smart Building/Home Control**	1. **Operations and Maintenance Savings** • Reduced wear on distribution infrastructure • Reduced service calls and maintenance overhead 2. **Improved System Efficiency and Responsiveness (system control)** 3. **Transmission and Distribution Deferral** 4. **Opportunity to Reduce Rates through Reduced Costs** 5. **Resource Adequacy (capacity)** 6. **Enables NEM Alternatives** 7. **Opportunity Cost Management** 8. **Ancillary Services** 9. **New Revenue Opportunities** • Rate-based investments in distributed storage 10. **Customer Engagement** 11. **Smart Grid Enabler**	1. **Ancillary Services** 2. **Environmental and Emissions Benefits** • Increased use of renewable generation • Decreased use of fossil-fueled generation 3. **Energy and Capacity** 4. **Jobs and Economic Development** 5. **Reserves (spin and non-spin)** 6. **Integration of Renewable Generation** 7. **Transmission and Distributed Deferral** 8. **Reduced Line Losses** 9. **Market Price Suppression** 10. **Resilience and Black Start Capability** 11. **Security and Redundancy**

Key Constraints Set by the Breakout Group

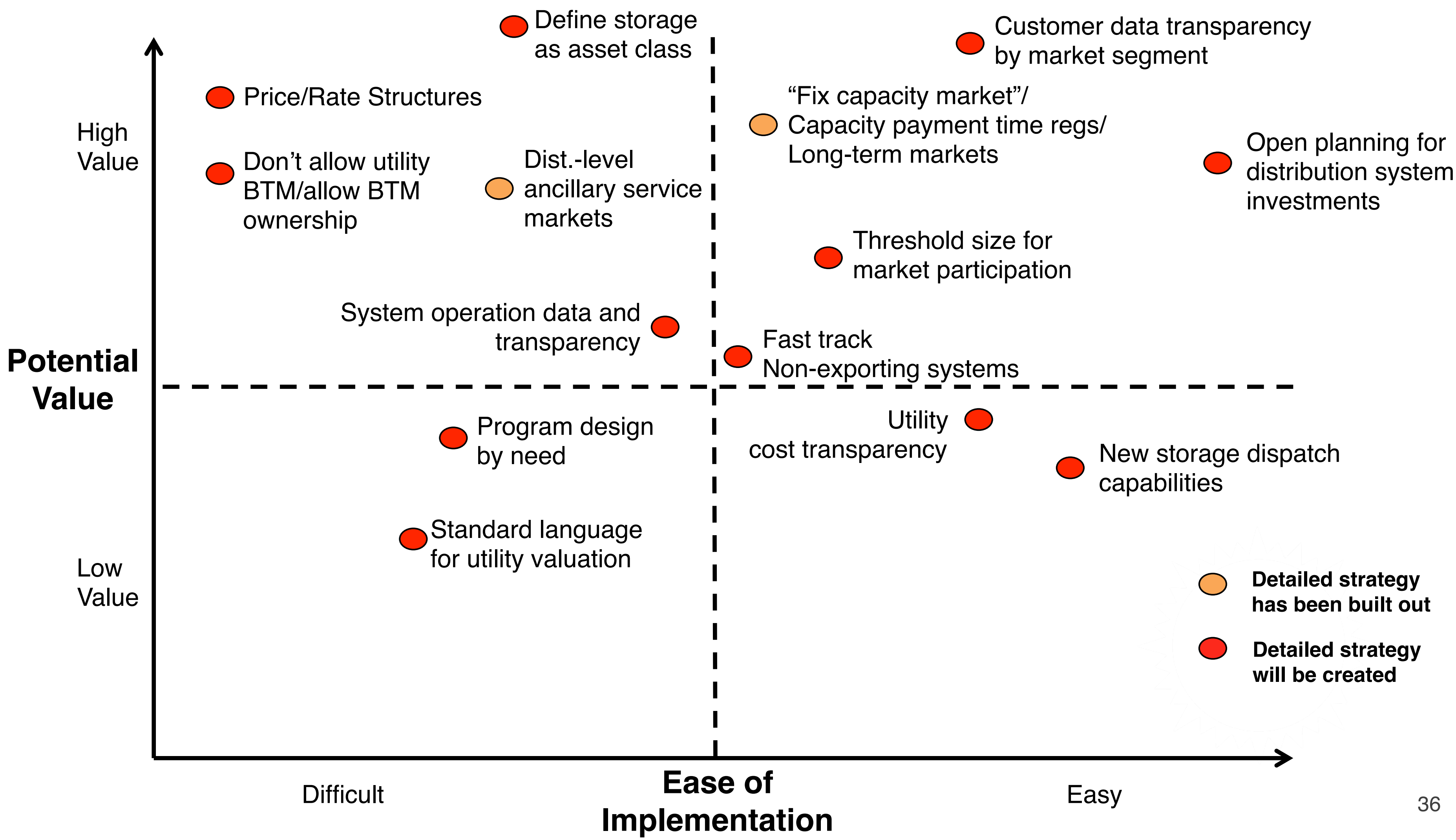
- Customers were only considered who could actually host a system
- Participants recognized the many different types of utilities and generally considered vertically integrated, investor-owned utilities during the charrette
- When considering system-level benefits, the group considered societal and regional benefits that may or may not impact an RTO/ISO

Value Proposition and Market Creation

Explore what factors are inhibiting industry from capturing, or maximizing the value they capture from, specific sources of value through the use of stakeholder mapping

Misalignment Between System Costs and Customer Costs	**Lack of Markets or Market Mechanism to Monetize Value**
• In many places, system costs or needs do not map well to customer costs and needs. This misalignment can prevent a distributed battery system that is providing a benefit to a customer from creating a similar or related benefit to the system operator (often the utility), and vice versa. Examples include: • System peak versus customer peak and the use of battery systems for demand charge reduction or peak shaving • Current rate structures encourage developers to build systems for the customer's benefit, and may not align with system needs • Utilities are incented (through current regulation) to build assets rather than provide a service	• In many parts of the U.S. there are no markets for: • Ancillary services • Aggregated energy (market does not allow aggregation of distributed systems) • Environmental benefits • Small, distributed systems (market requires minimum size to participate, leaving the capabilities of small systems unutilized and undervalued) • There are also many markets where current policies undervalue or penalize battery systems from fairly competing with other resources
Geographic Barriers and Influencers	**Unclear and Diverse Rule Sets Create Risk and Uncertainty for Investors**
• Regional differences can impact the value proposition for distributed battery systems, including: • ISO vs. non-ISO regions • Differences between ISOs • Retail vs. wholesale markets • Areas of dense population • Areas with congestion challenges • Areas prone to extreme weather • Type of utility (IOU, Muni, Co-Op) • Hub-and-spoke system vs. networked	• Regarding distributed battery storage systems, the lack of a consistent value proposition is thought to "scare off" investors. A few examples given by the group were: • Accounting standards for distributed battery systems are not clear • Metering and Sub-metering policies are vague and diverse, lacking standards and guidelines • Residual value of systems is unclear • The group also pointed to the lack of case studies and examples of battery systems "in action" as a problem for investors

Identify and Prioritize Strategies that Have the Potential to Expand the Value Proposition for a Distributed Energy Storage System



Value Proposition and Market Creation

Strategy Name	High-Level Description
Distribution Level Market for Aggregated Behind-the-Meter Systems	A market exists for customers or third parties to provide ancillary services and power management on distribution system networks. Markets at the distribution system level (akin to distribution system operators (DSOs) or DSPs per NY REV), would create a demand for as well as a compensation mechanism for the full range (i.e., power management) that distributed battery systems can offer.
Fix the Capacity Market	The opportunity for distributed battery systems to provide capacity needs to be more thoroughly defined. This can be done through stakeholder dialogue and actual analysis and testing (e.g., PG&E's IRM 2 Pilot Project). Once these capabilities are better defined, state and market regulators need to be engaged to consider and implement appropriate policy revisions.