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GRAND CHALLENGE SUMMIT

ESGC Impacts and Insights – National Lab Focus



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U.S. DEPARTMENT OF ENERGY



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Lab Resource Visibility: Lab Partnering Service & Visual Patent Search

Erik D. Spoerke
Sandia National Laboratories
Full Group Size: ~50



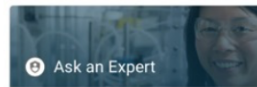
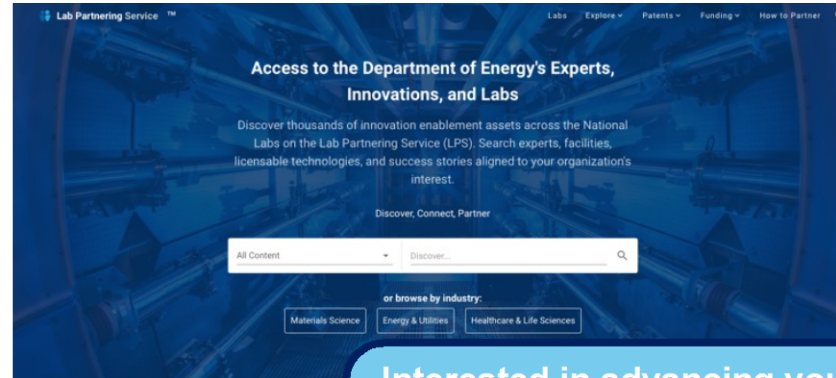
Lab Resource Visibility: BIG PICTURE

MOTIVATION: High visibility of DOE and National Lab capabilities, expertise, and intellectual property for energy storage stakeholders will *increase collaboration and accelerate U.S. Technology Development & Deployment.*

APPROACH: Tailor Office of Technology Transitions (OTT) virtual resources for highlighted *energy storage content.*

KEY RESOURCES:

- Visual Patent Search(VPS)
 - 26,873 DOE-funded Patents
- Lab Partnering Service (LPS)

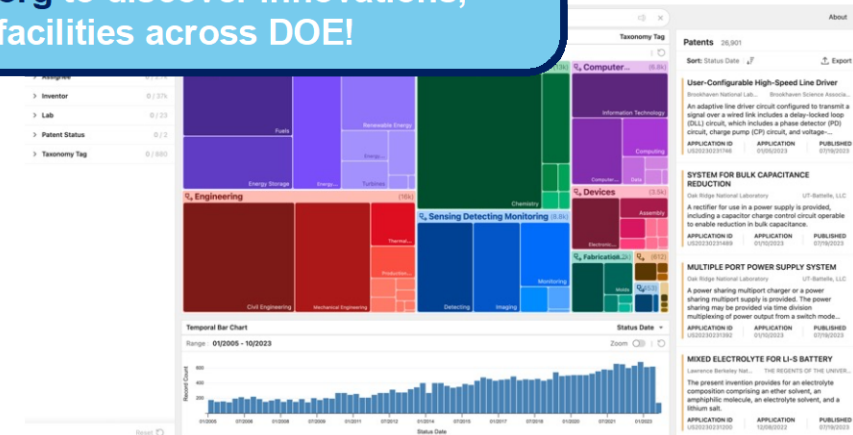


Interested in advancing your work through partnership with National Lab resources and experts?
Visit [Labpartnering.org](https://labpartnering.org) to discover innovations, experts, and facilities across DOE!

Energy Storage Grand Challenge Visual Patent Search

Quickly explore nearly 2,000 Energy Storage patents and patent applications using the Visual Patent Search tool.

vps.labworks.org/v2/explorer



Labpartnering.org

Discover hundreds of technologies, experts, facilities, and success stories across the National Labs. Connect directly with the National Labs on their Energy Storage innovation and expertise.

Lab Resource Visibility: Visual Patent Search

Lab Resource Visibility: WHAT HAPPENED (VPS)

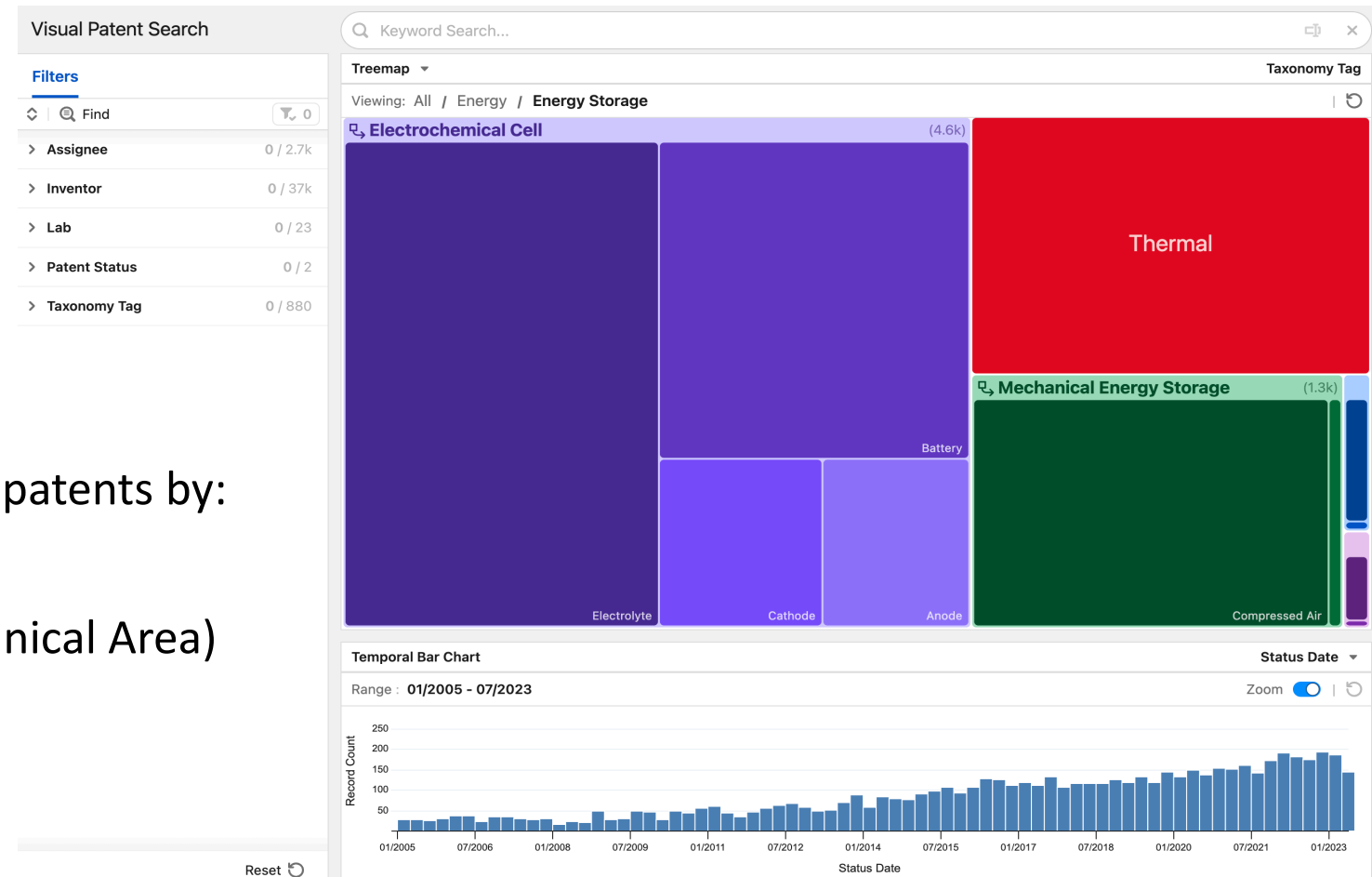
APPROACH: Create a dedicated ESGC patent site and tailor the taxonomy for comprehensive, accurate access to energy storage patents.

TEAMING:

- Scott Dowson (PNNL)
- Laura Burke (OTT)
- ESGC Tech Transitions Working Group
- Jagjit Nanda (ORNL/SLAC) and Erik Spoerke (SNL)

GOAL: Tailor exploration of Energy Storage patents by:

- Topic
- Assignee
- Inventor
- National Lab
- Patent Status
- Taxonomy Tag (Technical Area)
- Keyword Search



Lab Resource Visibility: VPS RESULTS

APPROACH: Create a dedicated ESGC patent site and tailor the taxonomy for comprehensive, accurate access to energy storage patents.

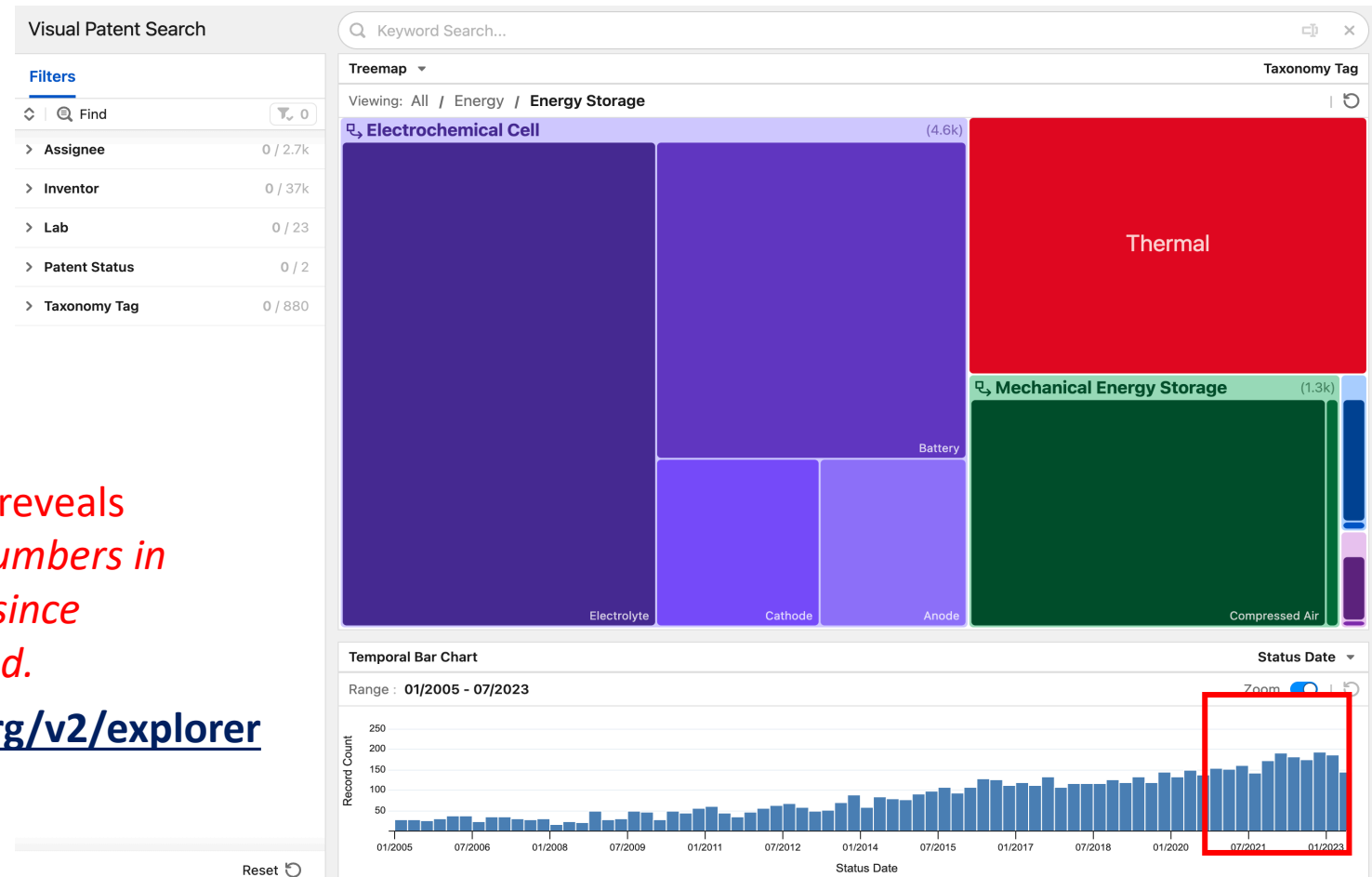
TEAMING:

- Scott Dowson (PNNL)
- Laura Burke (OTT)
- ESGC Tech Transitions Working Group
- Jagjit Nanda (ORNL/SLAC) and Erik Spoerke (SNL)

VPS ESGC site allows users to explore and connect with **6,392** DOE patents specific to energy storage technology and technology components

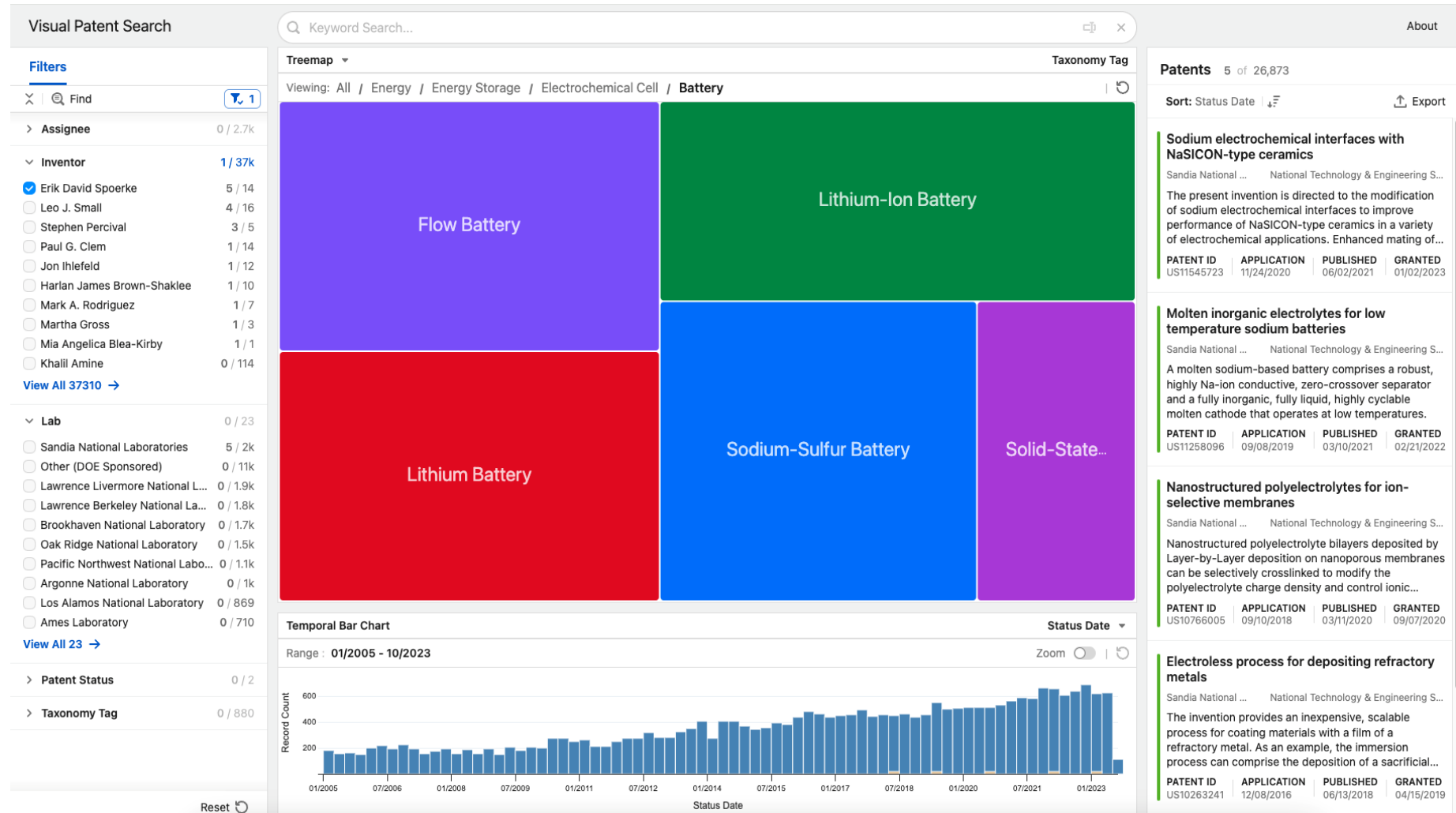
Patent Tracking reveals *record patent numbers in energy storage since ESGC was started.*

vps.labworks.org/v2/explorer



Lab Resource Visibility: VPS RESULTS

- ✓ Site enables exploration/identification of specific energy storage patent lists.
- ✓ Patents can be referenced, reviewed, or exported.
- ✓ Tool serves as an accessible tool to enable collaborative technology transitions!



Lab Resource Visibility: Lab Partnering Service

Lab Resource Visibility: WHAT HAPPENED (LPS)

APPROACH: Create a dedicated ESGC site (Popular Topics Page) within Lab Partnering Service (LPS) and tailor the content for comprehensive, accurate access to DOE energy storage resources at the National Labs.

TEAMING:

- Aaron Vimont (NREL)
- Laura Burke (OTT)
- Lauren Amagai (SNL)
- ESGC Tech Transitions Working Group
- Jagjit Nanda (ORNL/SLAC) and Erik Spoerke (SNL)

The screenshot shows the Lab Partnering Service (LPS) website. The header includes the LPS logo and navigation links for Labs, Explore, Patents, Funding, and How to Partner. Below the header, the page is titled 'Explore the Lab Partnering Service' and features a grid of topic cards. The 'Energy Storage Grand Challenge' card is circled in red. The footer contains the U.S. Department of Energy logo and the Office of Technology Transitions logo, along with links for About, Office of Technology Transitions, How to Partner, and Developers.

ESGC.Labpartnering.org

Lab Resource Visibility: LPS RESULTS

ESGC.labpartnering.org

ESGC Popular Topics Page allows users to:

- Explore & Identify National Lab
 - Experts
 - Facilities
 - Technology Summaries
 - Success Stories
- Explore Topical Areas
 - Bidirectional Storage
 - Chemical and Thermal Storage
 - Flexible Generation and Controllable Loads
 - Policy and Valuation
 - Power Electronics

Lab Partnering Service™
Powered by the Office of Technology Transitions in the U.S. Department of Energy

Energy Storage Grand Challenge

The Department of Energy's (DOE) Energy Storage Grand Challenge (ESGC) is a comprehensive program to accelerate the development, commercialization, and utilization of next-generation energy storage technologies and sustain American global leadership in energy storage. This comprehensive set of solutions requires concerted action, guided by an aggressive goal: to develop and domestically manufacture energy storage technologies that can meet all U.S. market demands by 2030.

Filters: clear filters

View: By Labs | Sort By: Relevance | Items/Page: 25

Search

Energy Storage Grand Challenge

- Bidirectional Electrical Storage (70)
- Chemical and Thermal Storage (14)
- Flexible Generation and Controllable Loads (11)
- Policy and Valuation (0)
- Power Electronics (3)

All Laboratories

- Experts (41)
- Facilities (70)**
- Technology Summaries (74)
- Success Stories (29)

Showing 1 - 25 of 70

Distributed Energy Technologies Laboratory

Facility | Sandia National Laboratories | Bidirectional Electrical Storage | Electric Grid | Electrochemical/Battery Systems | Energy Storage

The Distributed Energy Technology Laboratory (DETL) at Sandia National Laboratories is a multipurpose research facility designed to integrate emerging energy technologies into new and existing electricity infrastructure to accommodate the nation's increasing demands for clean, secure, and reliable energy. Researchers at the DETL perform advanced research on generation, storage, and load management technologies at component through system levels. DETL staff examine...

Capabilities: Communications Interoperability, Cybersecurity, Systems Integration and Control

Advanced Power Electronic Conversion Systems Laboratory

Facility | Sandia National Laboratories | Bidirectional Electrical Storage | Electrochemical/Battery Systems | Energy Storage | Flexible Generation

The Advanced Power Electronic Conversion Systems (APEX) Laboratory supports the development of advanced power conversion topologies and intelligent control strategies. Research in the APEX laboratory focuses on robust and fault-tolerant conversion systems for utility-scale energy storage. Applications of

Mechanisms for Lab partnerships are identified.

Users can submit requests to contact experts or learn more about National Lab resources.

Lab Resource Visibility: REFLECTIONS AND THE FUTURE

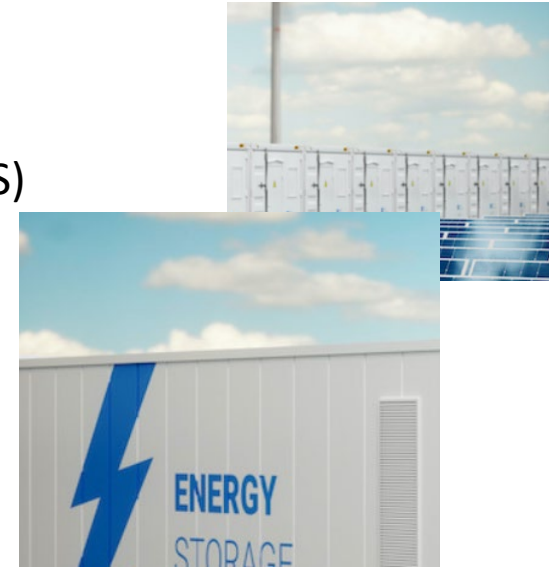
THESE ARE EVOLVING SYSTEMS:

- Continued refinement and updates will help maintain comprehensive resource accuracy
 - ❖ National Lab Capabilities matrix (ESGC Technology Development Track)
- As the field evolves, so will these resources
 - ❖ VPS is scheduled to evolve into a next generation Visual Intellectual Property Search (VIPS)
 - ❖ VIPS will include Patents as well as Opensource and Proprietary Software

THESE ARE CREATIVE OPPORTUNITY SPACES:

Labs: Work with your Tech Transitions Teams to make sure your work is represented.

Stakeholders: Take advantage of these resources to find partners, identify technology, and partner for success in energy storage.



The potential value of these systems can only be realized if the community take advantage of them...these resources are for YOU, so make the most of them!

ESGC.labpartnering.org

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THANK YOU

*Special Thanks to Stephen Hendrickson, Anna Siefken, and James Fritz for support from
the DOE Office of Technology Transitions*



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National Laboratory Capabilities and Collaborations

Michael Starke
Oak Ridge National Laboratory



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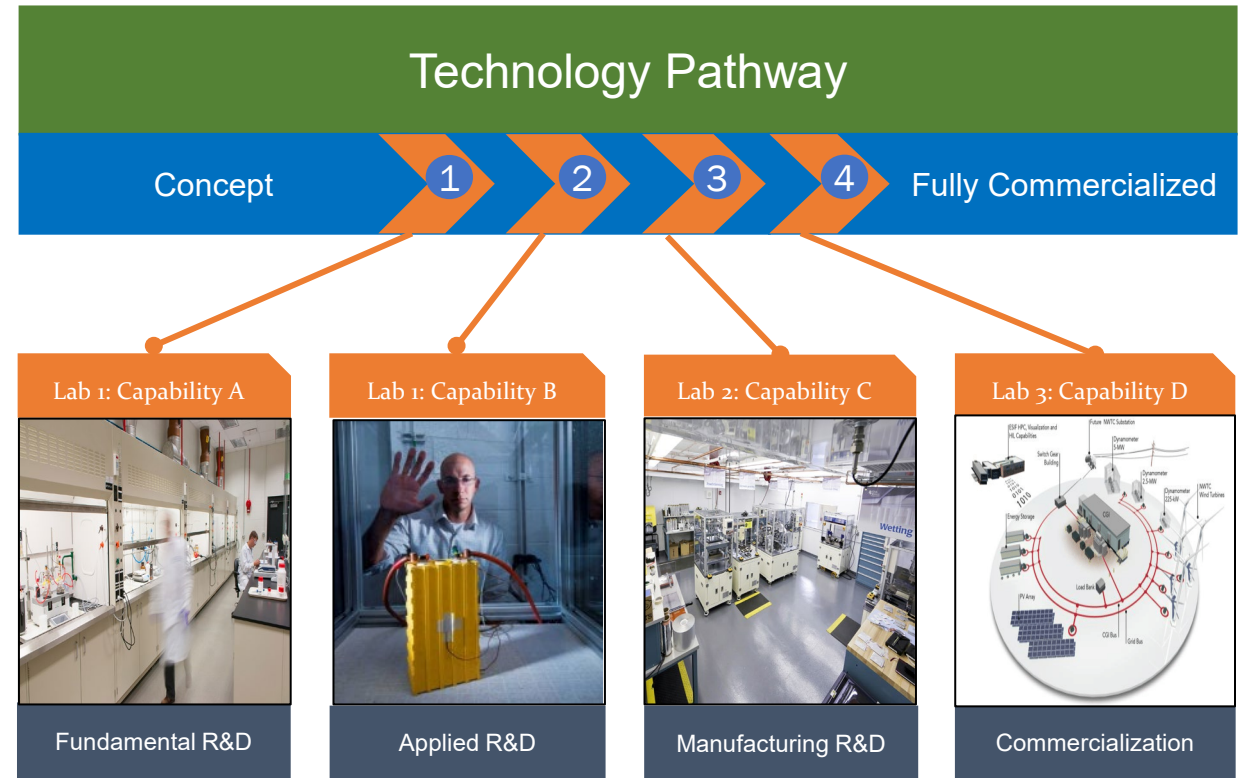
Defining Lab Capabilities and Collaborations: BIG PICTURE

DRIVING INTEREST: Maximize US impact of DOE investment in National Labs

GOAL: improve connectivity to lab resources in timeframe to support decarbonization targets

APPROACH: Identify facilities and capabilities for innovators to connect.

DETAIL: **Lab Partnering Service Discovery** arranges lab capabilities in a system that maximizes innovation speed



Defining Lab Capabilities and Collaborations: WHAT HAPPENED

APPROACH: Construct a mapping of the DOE National Laboratory facilities and capabilities and publicly showcase



- ID,
- Lab Facility,
- Facility URL,
- Facility Description ,
- ESGC Technology Area
- Technology Type
- Capability Category
- Capability/Pathway Stage(s)
- Addressed R&D
- Focus Short Description
- Grouping Location
- Linkages Reference (information)
- Early Stage R&D
- Mid Stage R&D
- Late Stage R&D
- Links to Media (Pictures, Videos, etc.)

Defining Lab Capabilities and Collaborations: RESULTS

- Identified nearly 300 unique capabilities in energy storage development.
- Transitioned to Lab Partnering Service (LPS) (<https://labpartnering.org/labs>)

X-Ray Sources



Advanced Light Source (ALS)
BERKELEY LAB



Advanced Photon Source (APS)
Argonne NATIONAL LABORATORY



Linac Coherent Light Source (LCLS)
SLAC NATIONAL ACCELERATOR LABORATORY



National Synchrotron Light Source II (NSLS-II)
BROOKHAVEN NATIONAL LABORATORY



Stanford Synchrotron Light Source (SSRL)
SLAC NATIONAL ACCELERATOR LABORATORY

Nanoscale Science Research Centers



Center for Functional Nanomaterials (CFN)
BROOKHAVEN NATIONAL LABORATORY



Center for Integrated Nanotechnologies (CINT)
Sandia National Laboratories
Los Alamos NATIONAL LABORATORY EST. 1942



Center for Nanophase Materials Science (CNMS)
OAK RIDGE NATIONAL LABORATORY



Center for Nanoscale Materials (CNM)
Argonne NATIONAL LABORATORY



The Molecular Foundry (TMF)
BERKELEY LAB

Neutron Scattering Facilities



Spallation Neutron Source (SNS)
OAK RIDGE NATIONAL LABORATORY



High Flux Isotope Reactor (HFIR)
OAK RIDGE NATIONAL LABORATORY

Other User Facilities



Environmental Molecular Sciences Laboratory (EMSL)
Pacific Northwest NATIONAL LABORATORY

DOE Lab User facilities provide researchers with access to advanced characterization capabilities using synchrotrons, neutrons, and electrons.

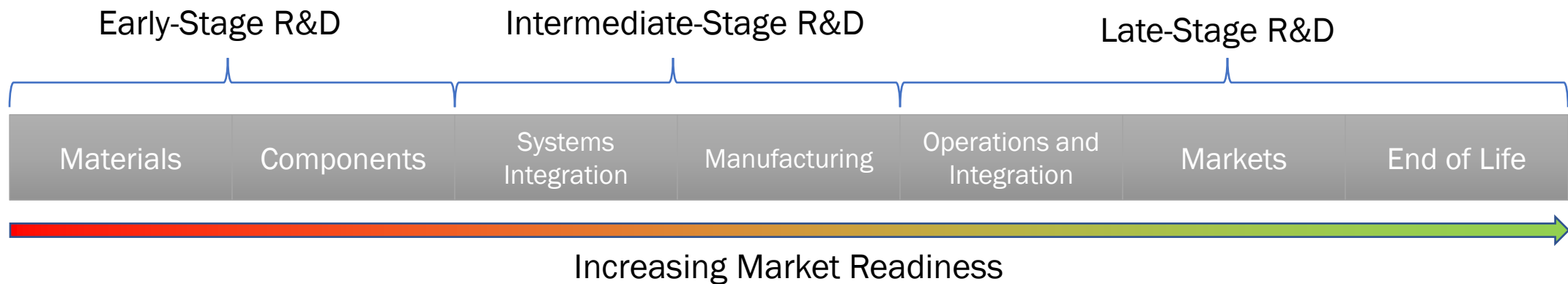
Defining Lab Capabilities and Collaborations: REFLECTIONS & THE FUTURE

- Challenges:

- Establishing capabilities that exist in the National Laboratories while addressing specific readiness and domains specific to energy storage.
- Identifying touchpoints between National Laboratories may include technology gaps (which are now opportunities that should be addressed)

- Reflection:

- Significant undertaking and understanding impact is difficult until more data is collected.



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ROVI – Overview

Rapid Operational Validation Initiative

LEADERSHIP TEAM:

- NREL – Kandler Smith (*speaker*)
- PNNL – Vince Sprenkle, Wei Wang
- ANL – Sue Babinec
- INL – Eric Dufek
- ORNL – Michael Starke
- SNL – Valerio De Angelis

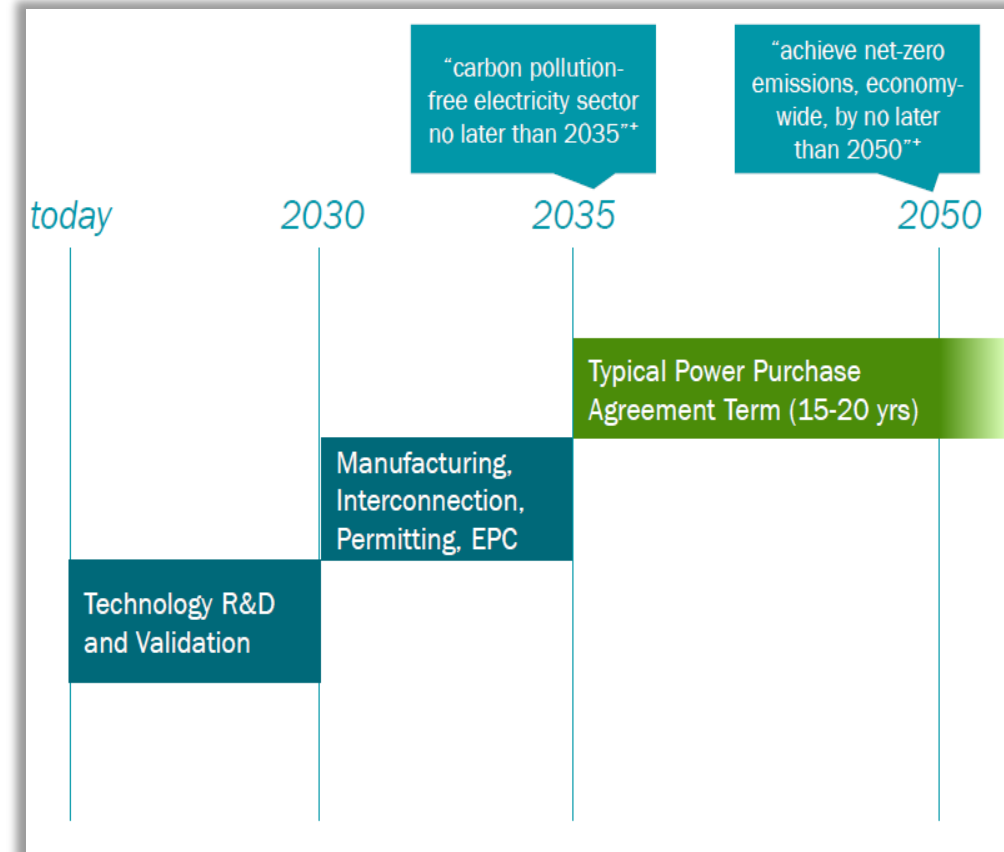
Full Group Size: 20



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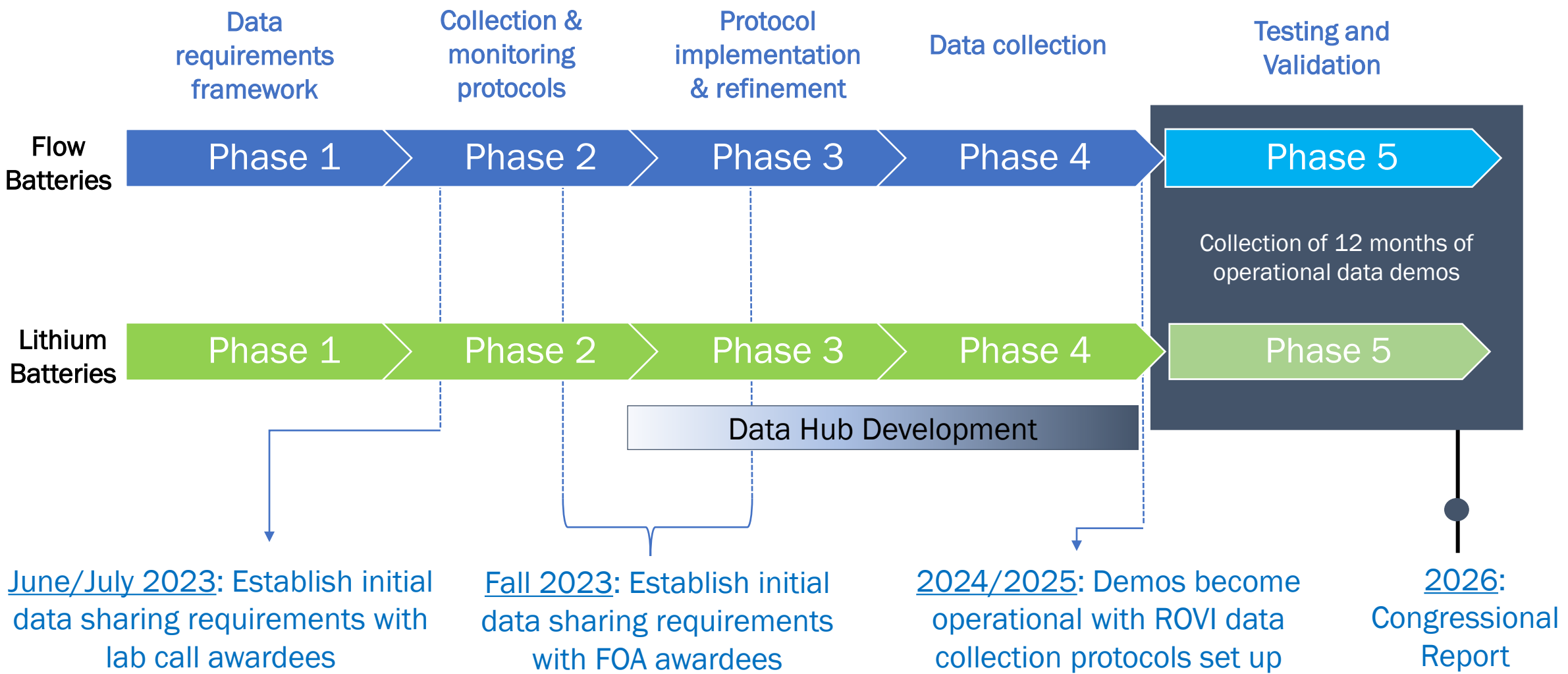
ROVI: Big Picture

- **PURPOSE:** Transformational acceleration of ES development timelines
- **HOW:** New testing, data science & validation methods
 - 15+ yrs investment-grade predictions with <1-yr data
- **DETAIL:**
 - Develop AI/ML predictive tools
 - Create data collection standards & analysis framework
 - Address critical gaps in data needs: lab, synthetic, field
 - Develop standard testing protocols
- **HISTORY:**
 - “Testing and Validation” requirements in the Energy Storage System Research, Development, and Deployment Program of the [Energy Act of 2020](#) (U.S. Code § 17232 (b)(3))
 - [Bipartisan Infrastructure Law](#) appropriated \$505M for FY22-25 grid-scale long-duration ES demos (Nov. 2021)
 - 2022 OE ROVI lab call awarded to PNNL/SNL/ANL/ORNL/INL/NREL team



ROVI Industry Roundtable, Nov. 2021

ROVI: Presently Executing Phase 1, Planning Phase - 4



ROVI: Progress to Date

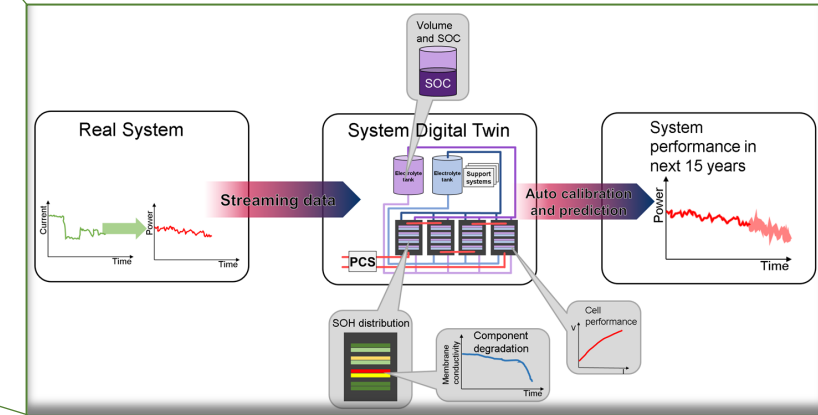
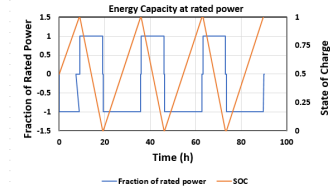
6-Lab Leadership team

Thrust	Status
1) Data Framework	Consulted representative stakeholders. Delivered draft data requirements to DOE for Li-ion, flow, and hybrid flow.
2) Use Cases	Drafting reference performance test
3) Models & Tools	Surveying available tools (physics models, ML/AI, digital twins) Outlining pipeline for data → prediction from lab & real-world data
4) Accelerated Testing	Determining relevant sub-scale hardware & drafting test document
5) Data Hub	Surveying available platforms Developing requirements

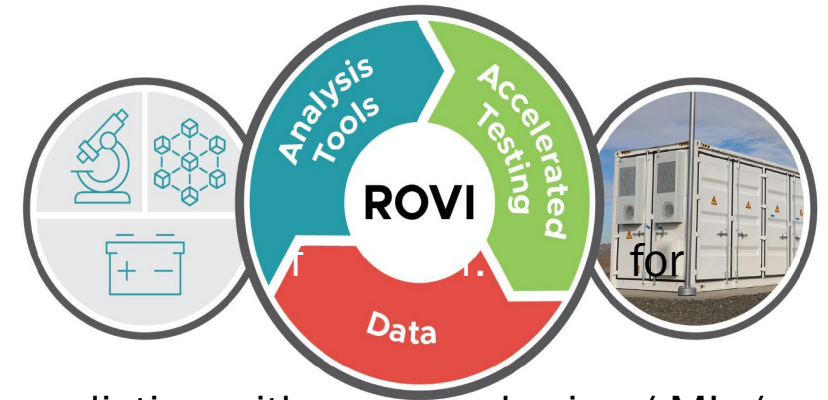
- Metadata/specs.
 - System layout
- Streaming data
- Operation & maintenance log

Metadata	Unit	Value	Description
System Specifications			
1 Rated power	kVA		Provide energy at which Rated Power is measured.
4 Rated energy	kWh		Provide power at which Rated Energy is measured.
5 Min operating temperature	°C		
6 Max operating temperature	°C		
7 Preferred operating temperature window (lower to upper bound)	°C		
8 Min SOC operating limit	percent		
9 Max SOC operating limit	percent		
10 Power Conversion System (PCS) Specifications			
11 Power conversion system rated power	kVA		For each PCS
12 AC/DC bidirectional inverter rated power	kVA		For each bi-directional inverter
13 AC/DC bidirectional inverter rated voltage (in/out)	V _{ac} / V _{dc}		For each bi-directional inverter
14 AC/DC bidirectional inverter rated current	A _{ac} / A _{dc}		For each bi-directional inverter
15 DC/DC bidirectional converter rated power	kW		For each converter
16 DC/DC bidirectional converter rated voltage	V _{high} / V _{low}		For each converter
17 DC/DC bidirectional converter rated current	A _{high} / A _{low}		For each converter
18 # of DC/DC converters	-		For each PCS
19 # of AC/DC inverter	-		For each PCS
20 String Specifications			
21 Total # of strings in system	-		To each other or to converters/inverter?
22 How are strings connected?	-		To each other or to converter?
23 Total # racks per string	-		To each other or to converter?
24 Total # racks in string with dV/dt configuration	-		To each other or to converter?

- Round-trip efficiency
 - Capacity @ rated power
 - Repr. use cases
- Pulse power
- Response time



ROVI: Reflections & The Future



• **VISION:** critical bridge between storage science & deployment
accelerated validation of existing & new technologies

• **RESOURCES:** Broad US National-Lab team with *extensive battery skillsets*: life prediction with physics / ML / twins, data protocols & data hub development, accelerated testing, deployment testing, data science

• **ACCOMPLISHMENTS:** *Delivered prelim ROVI data requirements to DOE for LDES Awardees*

OBSTACLES:

- Data-sparse lifetime prediction with minimum cost, time, and uncertainty
- Extending Li-ion + VRFB experience to disparate LDES technologies
- Hardware availability for accelerated testing

WHAT IS NEXT:

- LDES awards & negotiations
- Establish data-sharing requirements with awardees

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Manufacturing & Supply Chain

Greg Krumdick
Full Group Size: 50



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Manufacturing & Supply Chain Working Group

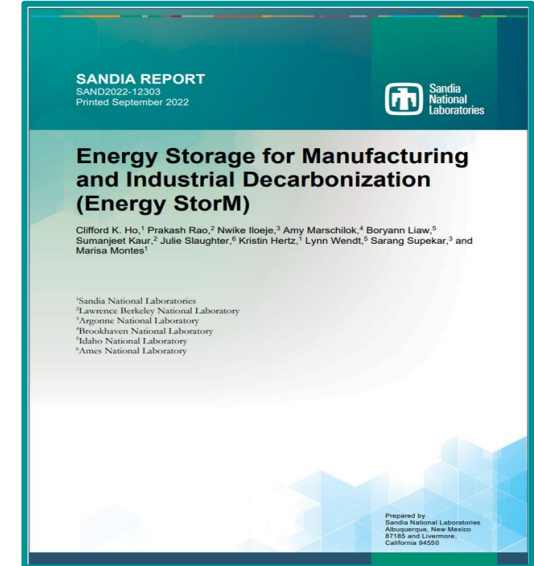
- **OBJECTIVES:** Address major M & SC challenges
 - Lowering manufacturing costs
 - Accelerate scale up of manufacturing innovations
 - Enable reliable sourcing of critical materials and components across supply chains.
- **APPROACH:** Established three subgroups
 - Energy Storage for Manufacturing
 - Manufacturing for Energy Storage Subgroup
 - M&SC Analysis Subgroup

- Workshops
- Analysis Seminars

Manufacturing & Supply Chain Workshops: What Happened

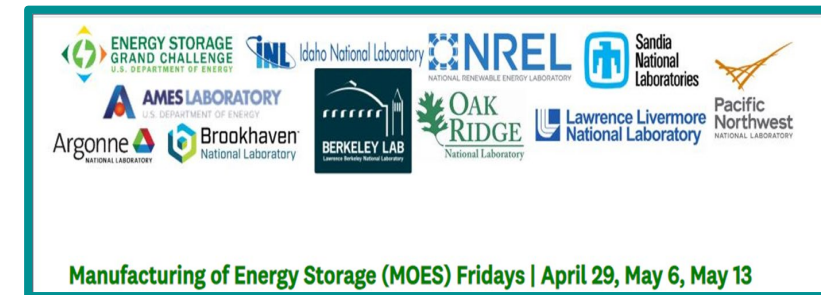
- **Energy Storage for Manufacturing and Industrial Decarbonization (Energy StorM)**

- February 8-9, 2022
 - ~500 attendees each day



- **Manufacturing of Energy Storage (MOES) Fridays:**
Brought together ES device manufacturers with researchers & companies working on emerging manufacturing technologies

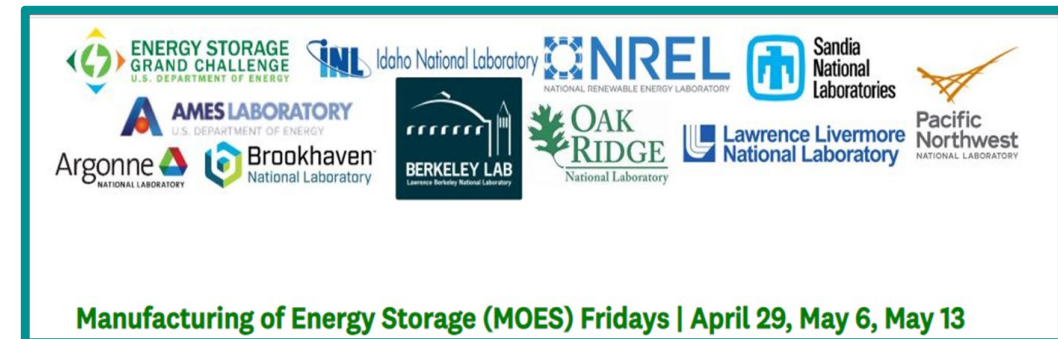
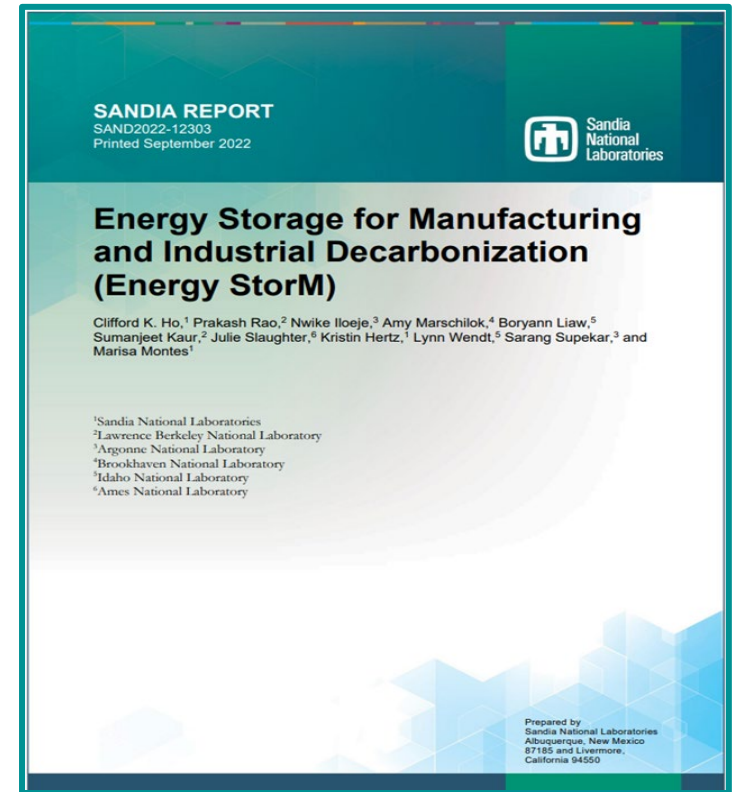
- Thermal Storage April 29, 2022
 - ~100 attendees
- Flow Batteries – May 6, 2022
 - ~100 attendees
- Solid State Batteries – May 13, 2022
 - ~150 attendees



Workshops: Results

- **ENERGY StorM: 55 page report**
 - Identified needs, challenges, & opportunities
 - Identified key gaps, and integration issues.
 - Electrochemical
 - Thermal
 - Chemical

- **MOES's FRIDAYS: 25 page report**
 - Enhance collaboration significantly
 - Identify technology to be transferred
 - Determine if there are gaps
 - Uncover potential pitfalls



Manufacturing and Supply Chain Working Group: Reflections

- Complexity & breadth of Manufacturing and Supply Chain challenges are generally not well understood.
- These challenges are not going to be solved by a single lab or researcher.
- It will take large collaborations of national labs, universities and industry working together with multiple DOE offices to be successful.



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Manufacturing & Supply Chain Analysis

Sarah Smith

Full Group Size: 20



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Manufacturing & Supply Chain Analysis: Big Picture

- **WHAT:** *Subgroup* within the Manufacturing & Supply Chain track looking at analysis capabilities and modeling tools
 - E.g. life cycle analysis, technoeconomic analysis, system dynamics models
- **GOAL:** Assess the current state of capabilities and tools and identify gaps
- **APPROACH:** Connect researchers across DOE labs and DOE-funded projects

Example Tools



Manufacturing & Supply Chain Analysis: What Happened

- Compiled information on lab models and capabilities
 - Spreadsheet exercise
- Held a Seminar Series
 - 12 seminars
 - Presenters from 6 institutions
- Supported Energy StorM Workshop
 - Session on Analysis and Valuation



MANUFACTURING AND SUPPLY CHAIN ANALYSIS

Virtual Seminar Series

This seminar series showcases manufacturing and supply chain modeling and analysis capabilities across DOE-funded national labs and institutes. Topics include models, datasets, and study results that are directly relevant to, or could potentially be applied to energy storage technologies. The series is part of a broader effort to identify capabilities and gaps in this area across the DOE complex and foster collaborations across different groups.

Schedule

Every other
Monday from 1:30
- 3:00 pm ET

Webinar Details

Join Microsoft Teams on your computer or mobile app

[Click here to join the meeting](#)

Or call in (audio only)

+1 630-556-7958, 59500554# (Phone Conference ID: 595 005 54#)

Contact Dr. Sarah Smith (sjsmith@lbl.gov) to receive future information and/or schedule a presentation. **Speakers and participants** from all DOE labs are welcome!

Upcoming Talks



April 18, 2022 - Jeff Spangenberg & Qiang Dai, ANL
EverBatt: Battery Life Cycle Cost and Environmental Impact Tool



May 2, 2022 - Fu Zhao, Purdue University through CMI
Life Cycle Assessment and Techno-Economic Assessment of Lithium
Recovery from Geothermal Brine via Sorption-Forward Osmosis



May 16, 2022 - Liz Wachs & Colin McMillan, NREL
Characterizing the Opportunity Space for Flexible Industry Adaptation of
Variable Renewable Energy and Storage



May 30, 2022 - Memorial Day (No Meeting or Seminar)



June 13, 2022 - Amgad Elgowainy, ANL
Technoeconomic Analysis of Hydrogen Storage and Delivery Infrastructure



June 27, 2022 - Mark Bryden, AMES
Systems Analysis and TEA of Hydrogen Storage and Thermal Energy Storage
Technologies

Manufacturing & Supply Chain Analysis: Results

- **ACCOMPLISHMENTS:**

- Created a community through seminar series
- Compiled detailed capabilities across 5 labs
- Showcased information via the Energy StorM workshop

- **IMPACTS:**

- Connected researchers within and across labs
- Provided a platform for researchers to share their work
- Laid the groundwork for subsequent MESC scoping efforts

- **OBSTACLES:**

- High level of engagement needed to create comprehensive list of capabilities
- Strong interest in topic, but lack of clear pathway to grow efforts

Manufacturing & Supply Chain Analysis: Reflections

- Goal accomplished – building a community of analysts and researchers, educating each other on models and abilities.
- Identified gaps and opportunities for future research.
- Laid the groundwork for ongoing efforts in the supply chain analysis space across DOE

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POLICY & VALUATION : ESGC National Lab Focus

JEREMY TWITCHELL

FULL GROUP SIZE: 80

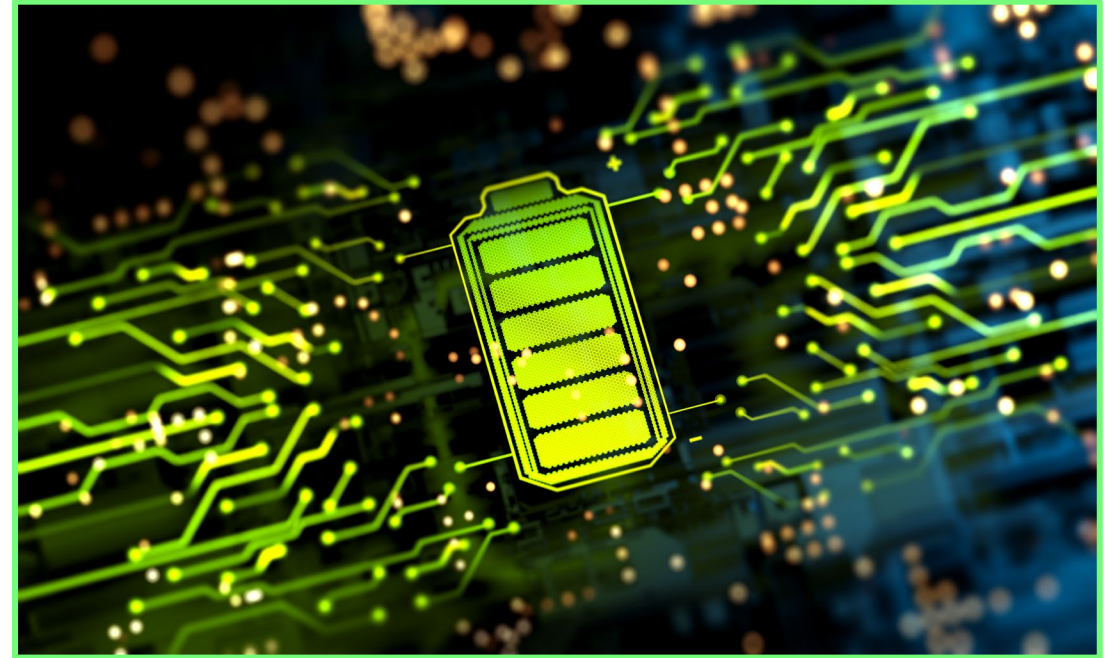


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Policy and Valuation:

“Creating space for the other ESGC tracks to do their thing”

- **PROBLEM:** Energy storage doesn't fit into traditional regulatory paradigms
- **SOLUTION:** New planning practices, market designs, and policies are needed
- **HOW:** Provide objective assistance to DOE, utilities, regulators, and policymakers in creating a supportive environment for ES
- **HISTORY:** P&V is one of the original ESGC tracks and includes participants from industry, academia, DOE, and all 17 national labs



Policy and Valuation: What Happened

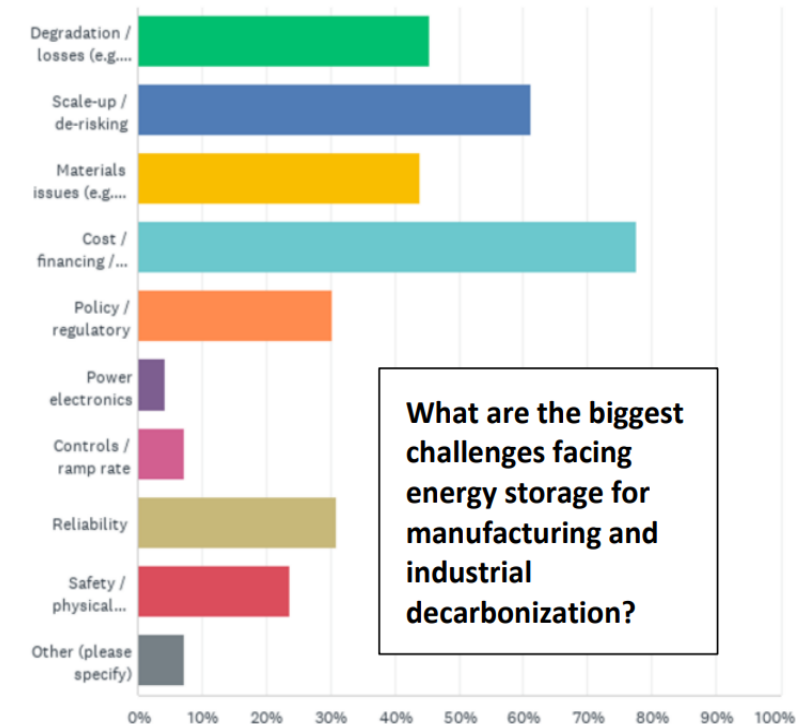
- **GOAL:** Coordinate laboratory energy storage capabilities, facilities, and activities with ESGC objectives
- **WHAT WE DID:** Build a coalition of more than 230 people
- **KEY ELEMENTS/ACTIVITIES:**

ESGC Summit Participation (2021-2023)

Multi-lab meeting on safety, siting, and permitting (Nov. 2021)

Energy Storage Community of Practice Webinars (Ongoing)

Energy Storage for Manufacturing and Industrial Decarbonization Workshop (Feb. 2022)



What are the biggest challenges facing energy storage for manufacturing and industrial decarbonization?

Policy and Valuation: Results

Energy Storage for Manufacturing and Industrial Decarbonization Workshop



Workshop Report
summarized key takeaways and opportunities for additional study

Multi-lab meeting on safety, siting, and permitting



Siting and permitting work incorporated into the Office of Electricity's Energy Storage Program (forthcoming reports)

ESGC Summit listening sessions



Increased programmatic work on long-duration energy storage policy and compensation

Policy and Valuation: Reflections & The Future

OUTSTANDING NEEDS:

- More data in accessible format (like the ESGC's [Energy Storage Cost and Performance Database](#))
- Market design and compensation models for long-duration energy storage (LDES)
- Supportive regulatory environments and demonstrated viability

NEXT STEPS:

- Multiple publications on storage siting
- Additional resources on LDES policy and market design

ASPIRATIONAL GOAL:

- Further explore practical implications of the rapid ES growth
- Further inform regulatory and other approval processes (interconnection, siting, etc.) that projects will have to navigate

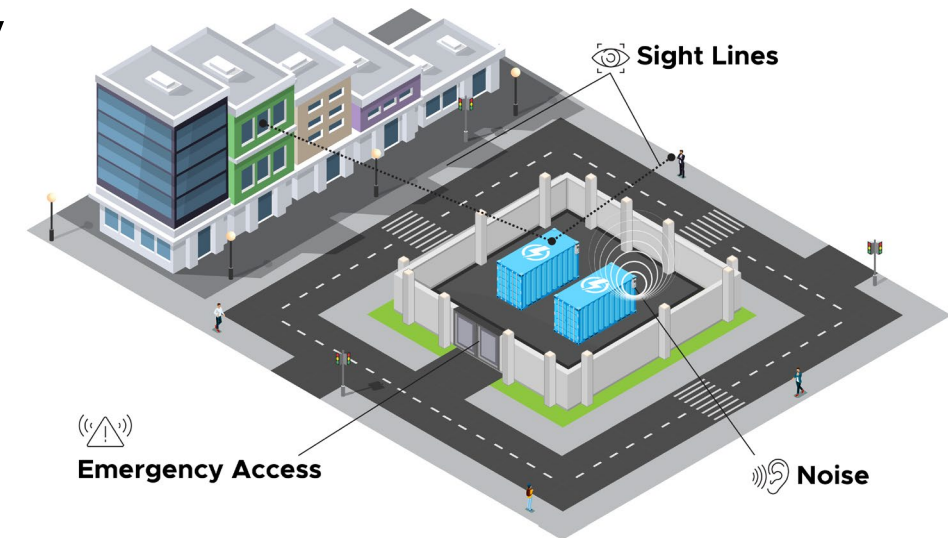


Image from forthcoming report on storage siting targeted at local planners

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Workforce Development



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GRAND CHALLENGE
U.S. DEPARTMENT OF ENERGY

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Full Group Size: 20

Workforce Development Working Group

- Help to develop the broad workforce required for research, development, design, manufacture, and operation of energy storage systems
 - Assess the current state of the national energy storage workforce, and identify gaps including R&D, manufacturing, and the installation sectors of the energy storage workforce.
- ESGC Roadmap
 - ESGC Listening Sessions
 - Connecting with others to learn about best practices

Workforce Development – What Happened

Listening Sessions:



Identifying and Understanding National Energy Storage Workforce Gaps



Building Solutions to Address the National Energy Storage Workforce Needs



Measuring Success and Impact on National Energy Storage Workforce Solutions

Workforce Development – Results: Listening Session Findings

- Lack of Energy Storage Career Awareness
- Connecting Industry and Academia to Build Talent Pipelines
- Building a Diverse Workforce
- Explore Alternative Training Programs
- Create an Energy Storage Workforce Development Network

Workforce Development: Reflections

- **ACCOMPLISHMENTS**

- Brought together disparate voices from academia, industry, non-profit, and workforce development organizations
- Convening across the lab complex around workforce needs

- **IMPACTS**

- Created a national convening space for all to be involved
- Curated the current state of energy storage workforce as of 2022

- **OBSTACLES**

- Difficult connecting with diverse voices across multiple siloed organizations
- Defining a scope of work within the large energy storage workforce opportunity space
- Available resources limited the full convening impact

- **LEARNINGS**

- National workforce conversations are siloed
- Huge desire for a national convener that can provide standards and structures
- DOE Labs are already strong partners in their regional communities