3RD ANNUAL ENERGY STORAGE GRAND CHALLENGE SUMMIT

ESGC Impacts and Insights – National Lab Focus

ENERGY STORAGE GRAND CHALLENGE
U.S. DEPARTMENT OF ENERGY

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Jeremy Twitchell

Energy Research Analyst, Pacific Northwest National Laboratory

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Lab Resource Visibility: Lab Partnering Service & Visual Patent Search

Erik D. Spoerke

Sandia National Laboratories

Full Group Size: ~50

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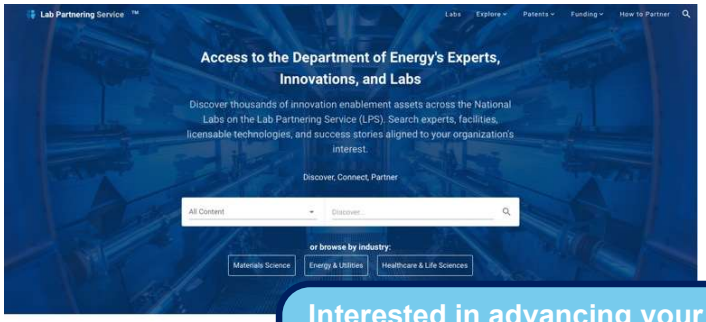
Lab Resource Visibility: BIG PICTURE

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)



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.

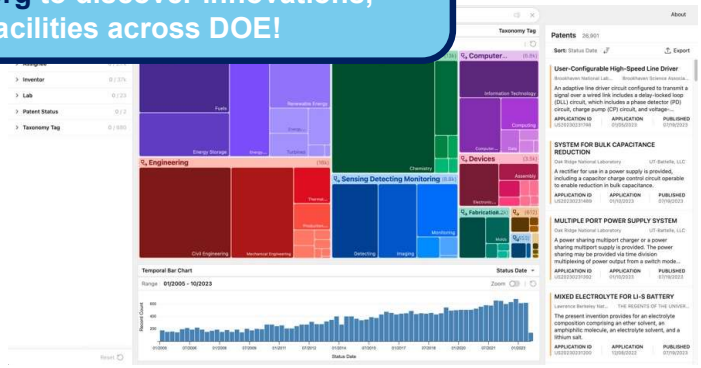
Interested in advancing your work through partnership with National Lab resources and experts?

Visit 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



LAB PARTNERING SERVICE

Lab Resource Visibility: Visual Patent Search

Lab Resource Visibility: WHAT HAPPENED (VPS)

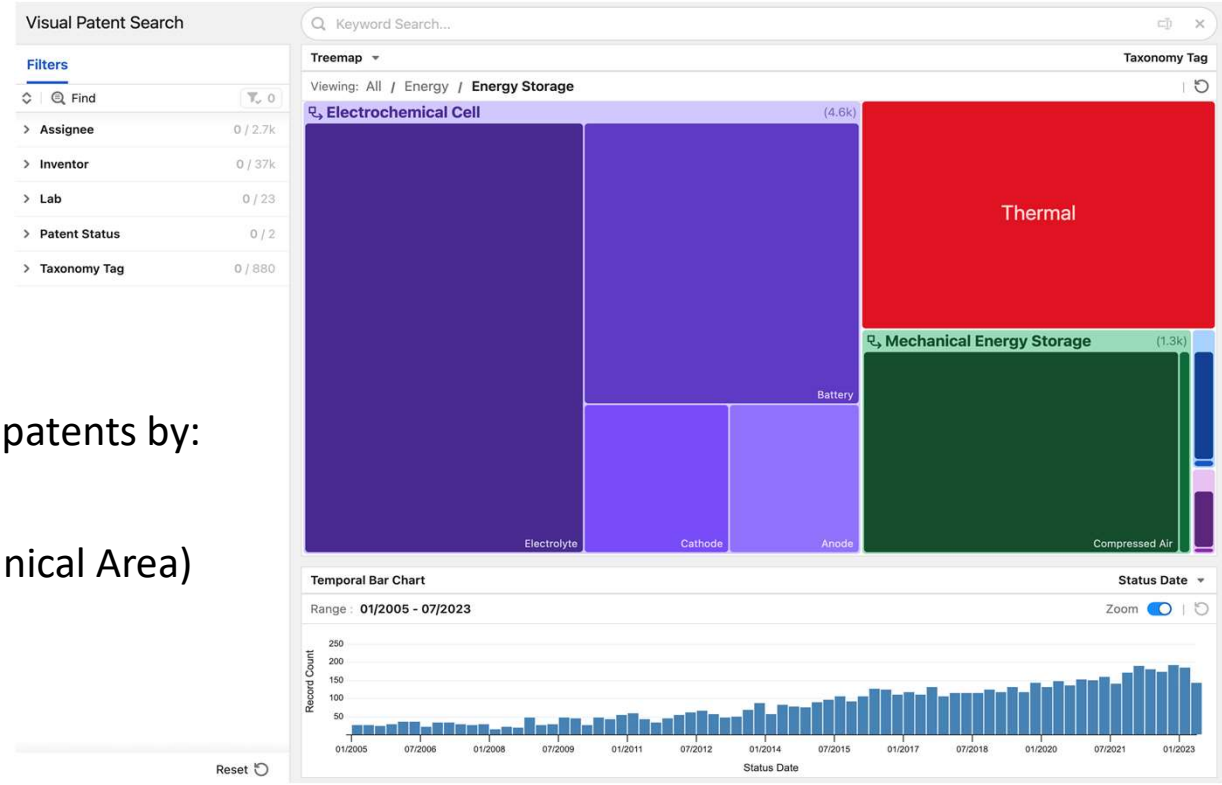
APPROACH: Create a dedicated ESGC patent site and tailor the taxonomy for comprehensive, accurate access to energy storage patents.

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.

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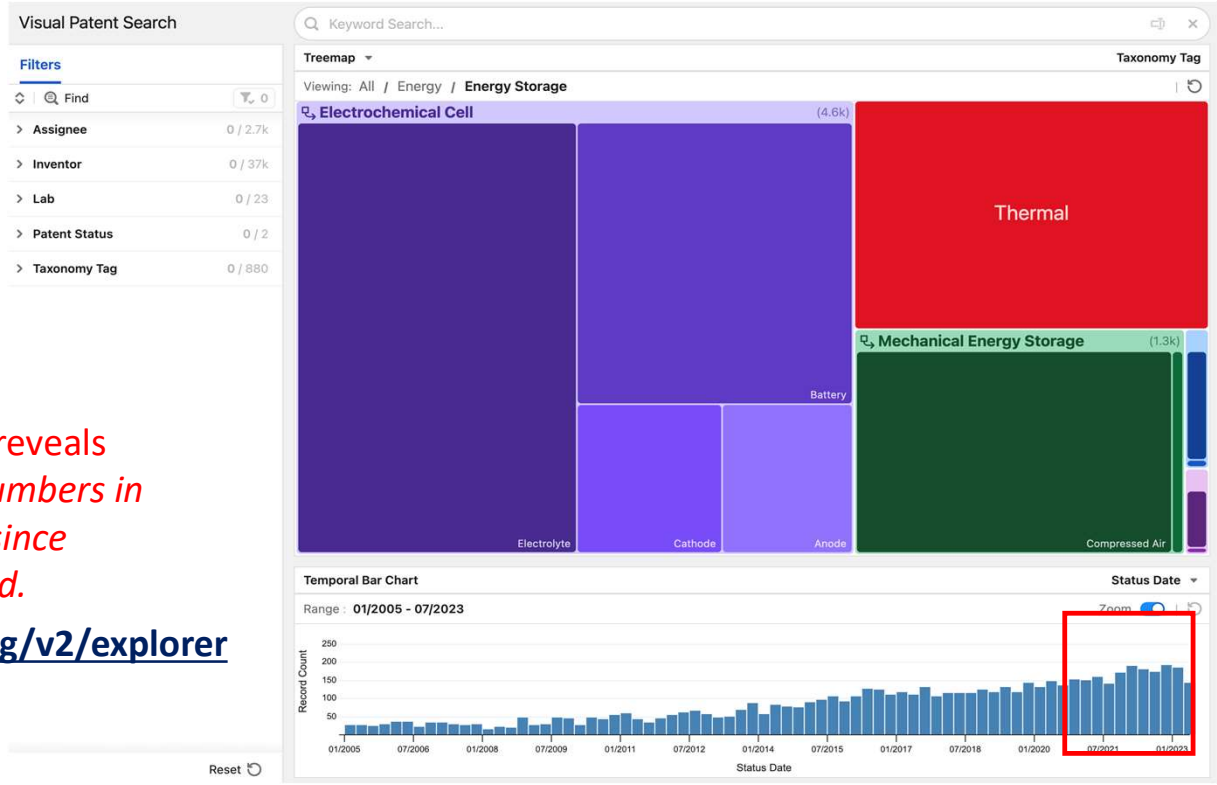


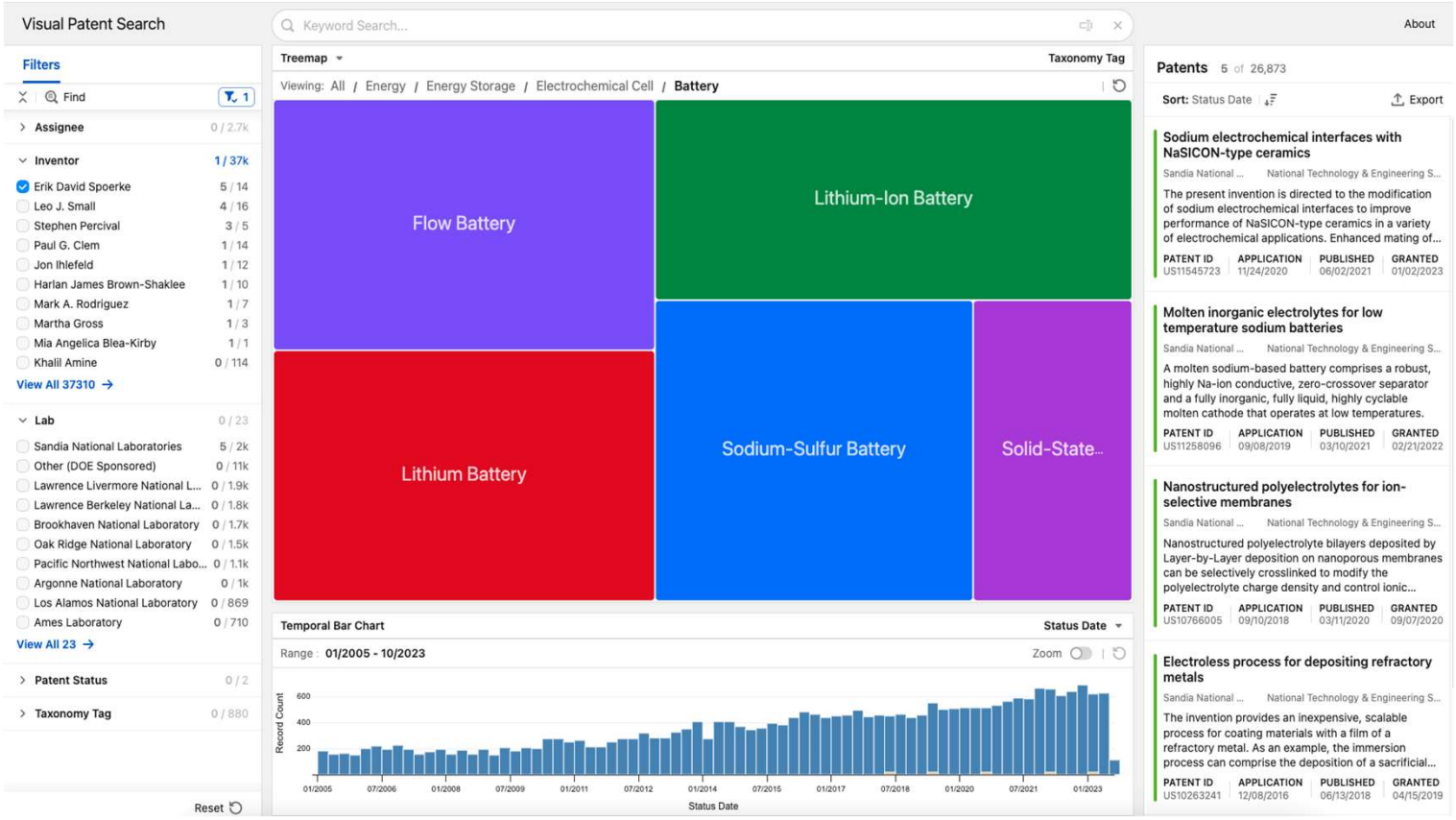
VPS ESGC site allows users to explore and connect with **6,392** DOE patents specific to energy storage technology and technology components

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!



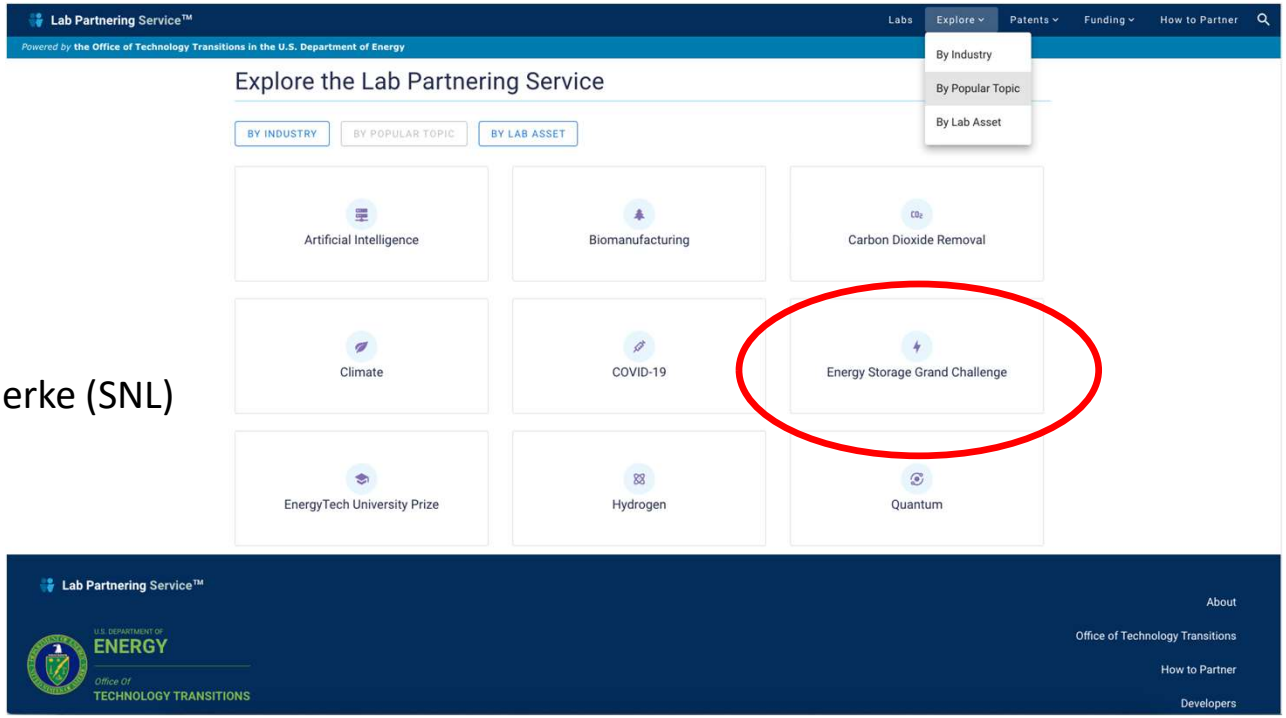
Lab Resource Visibility: Lab Partnering Service

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)



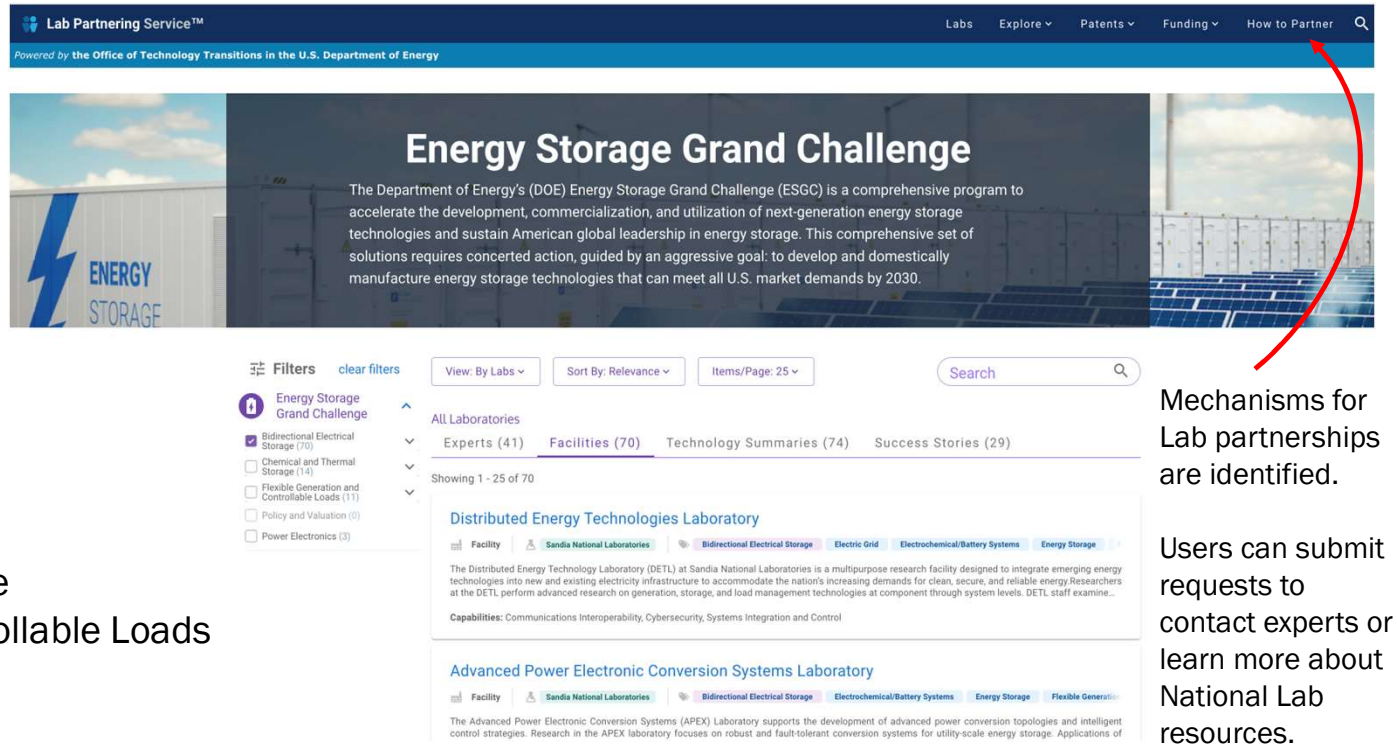
ESGC.Labpartnering.org

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



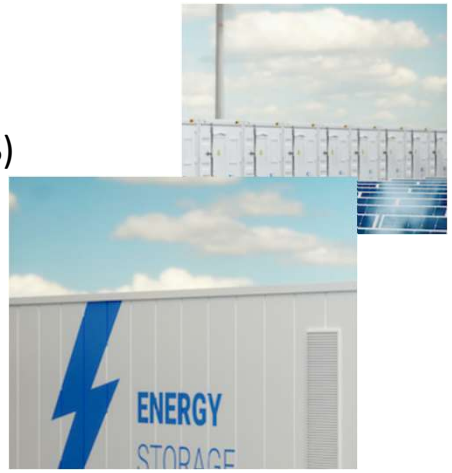
Mechanisms for Lab partnerships are identified.

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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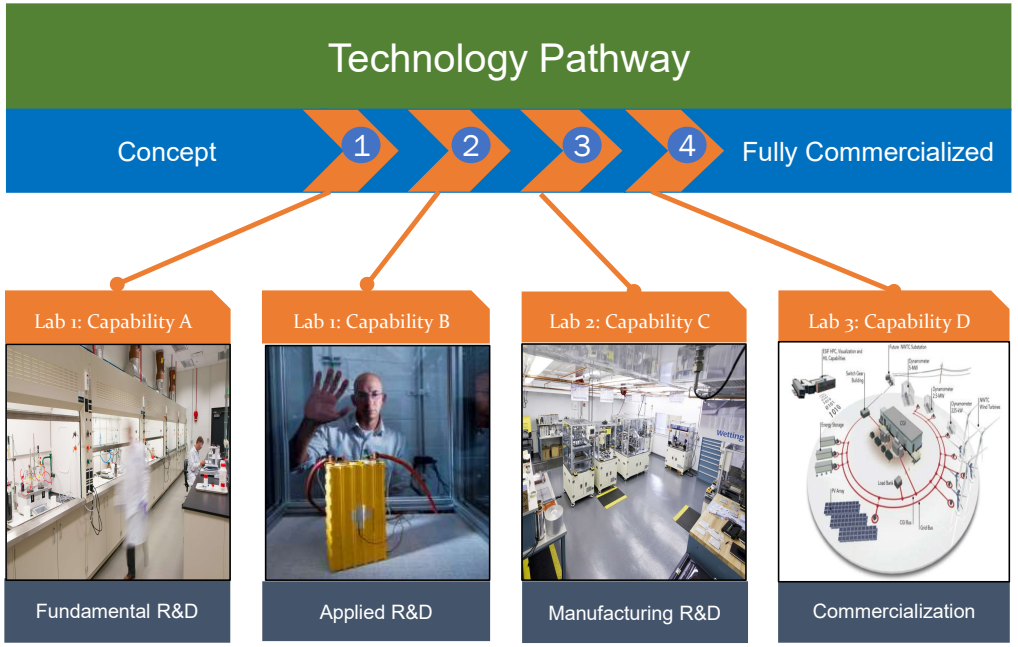
Defining Lab Capabilities and Collaborations: BIG PICTURE

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

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

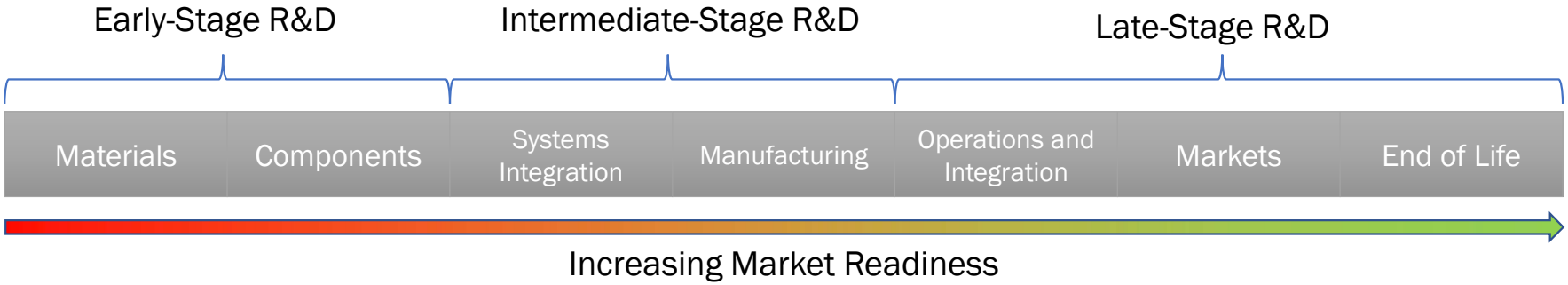
Other User Facilities

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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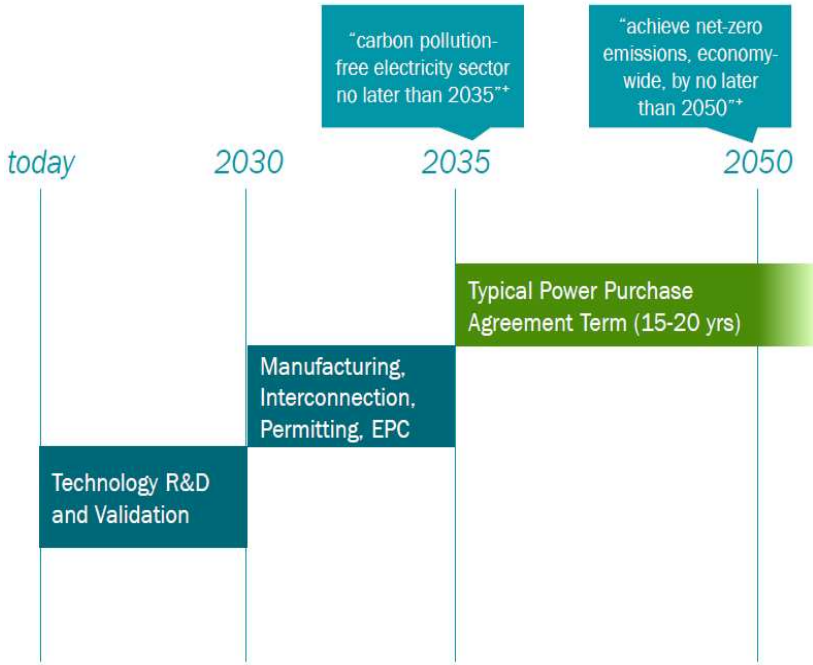
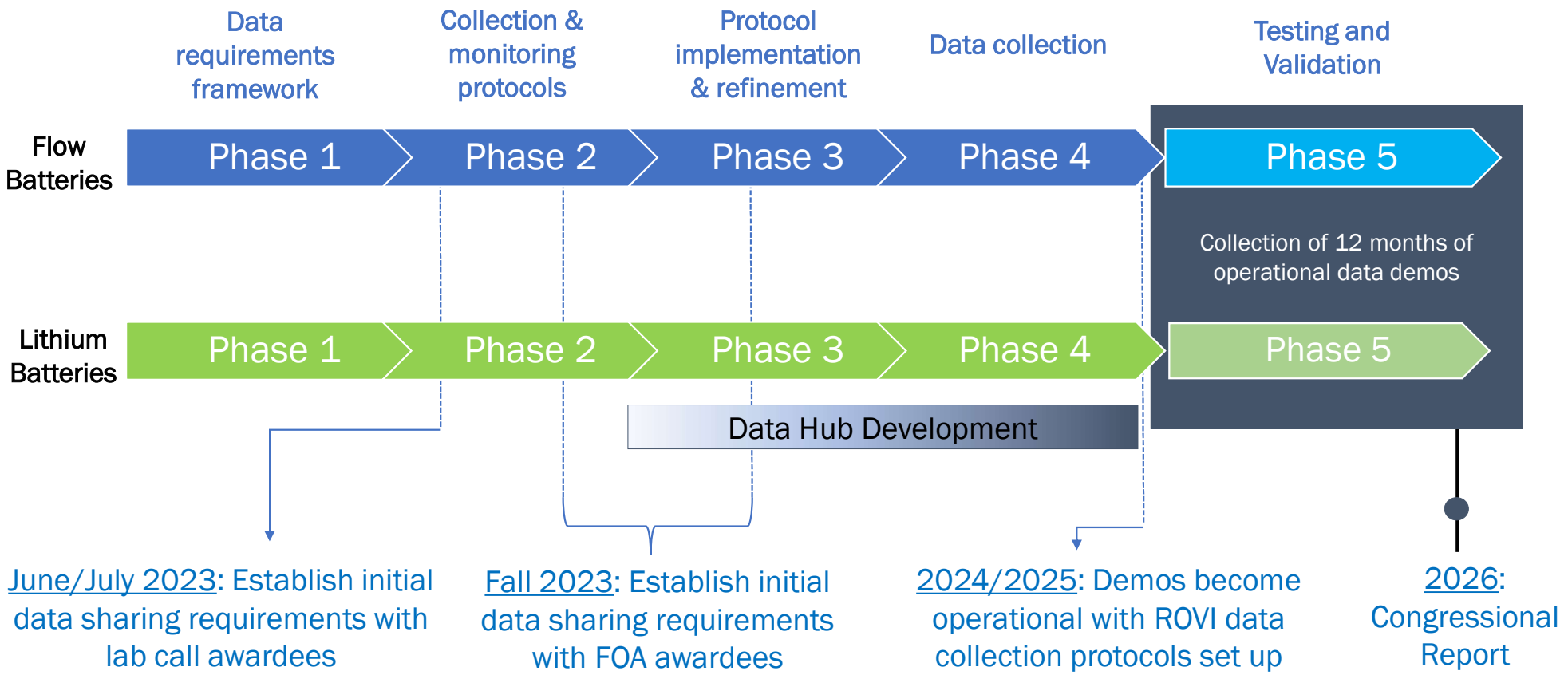
ROVI: Big Picture

- **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



June/July 2023: Establish initial data sharing requirements with lab call awardees

Fall 2023: Establish initial data sharing requirements with FOA awardees

2024/2025: Demos become operational with ROVI data collection protocols set up

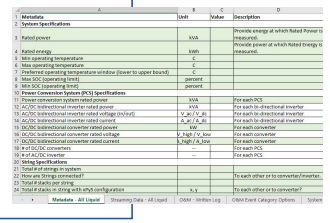
2026: Congressional Report

ROVI: Progress to Date

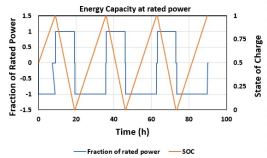
6-Lab Leadership team

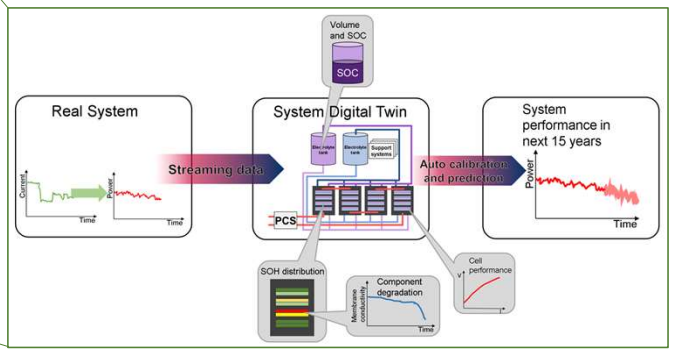
Thrust	Status
1) Data Framework	Consulted representative stakeholders. Delivered draft data requirements to DOE for Li-ion, flow, and hybrid flow.
2) Use Cases	Drafting reference performance test
3) Models & Tools	Surveying available tools (physics models, ML/AI, digital twins) Outlining pipeline for 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



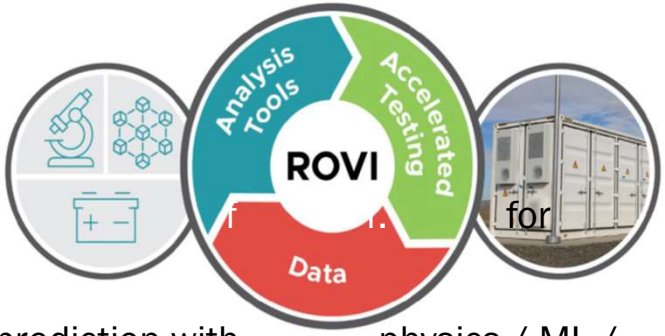
- Round-trip efficiency
  - Capacity @ rated power
  - Repr. use cases
- Pulse power
- Response time





More information: ROVI Overview Panel Session – Thursday July 27, 1:15-2:30

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

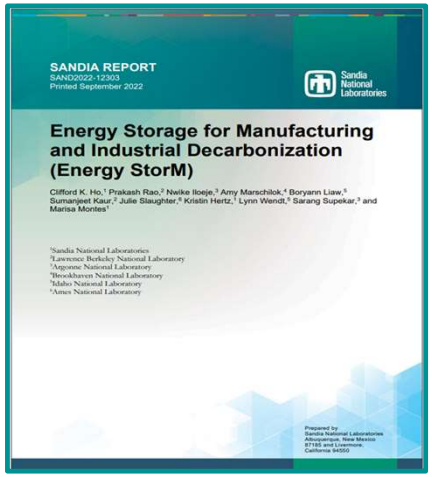
- **OBJECTIVES:** Address major M & SC challenges
  - Lowering manufacturing costs
  - Accelerate scale up of manufacturing innovations
  - Enable reliable sourcing of critical materials and components across supply chains.

- **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

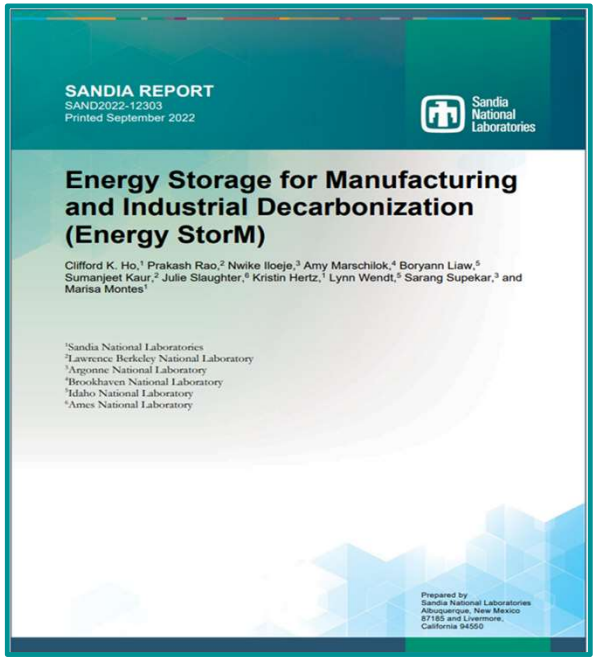


- **Manufacturing of Energy Storage (MOES) Fridays:** Brought together ES device manufacturers with researchers & companies working on emerging manufacturing technologies
  - Thermal Storage April 29, 2022
    - ~100 attendees
  - Flow Batteries – May 6, 2022
    - ~100 attendees
  - Solid State Batteries – 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

GREET LIFE-CYCLE MODEL

LIBRA

INL CoCuNi

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

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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** (sismith@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 Spangenberger & 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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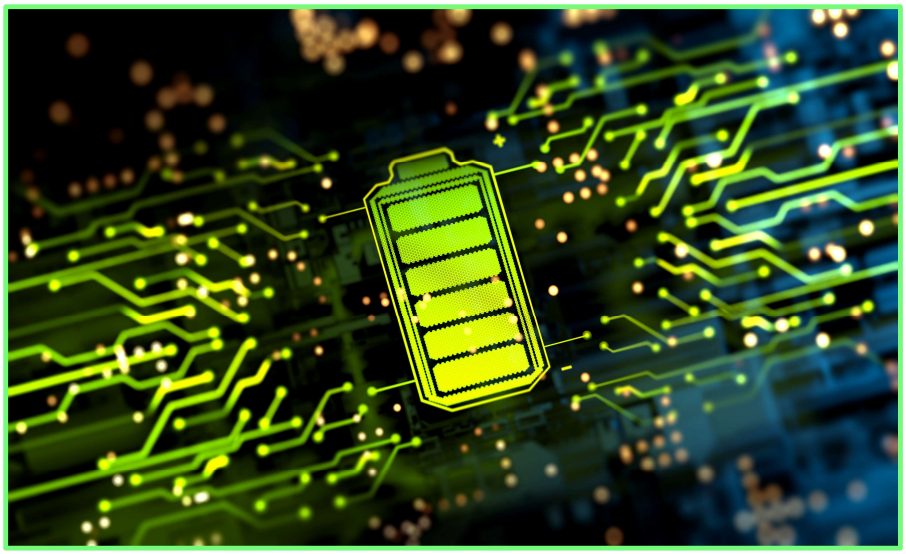
Policy and Valuation:

"Creating space for the other ESGC tracks to do their thing"

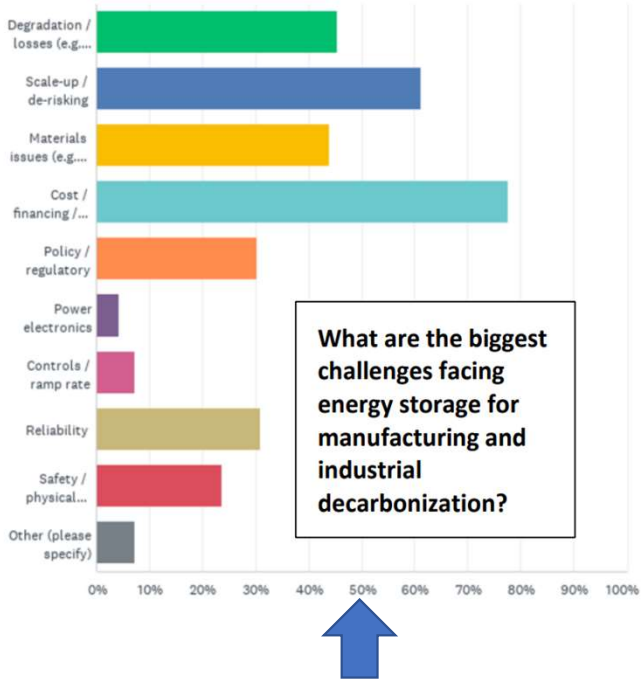
- **PROBLEM:** Energy storage doesn't fit into traditional regulatory paradigms
- **SOLUTION:** New planning practices, market designs, and policies are needed
- **HOW:** Provide objective assistance to DOE, utilities, regulators, and policymakers in creating a supportive environment for ES



- **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**:



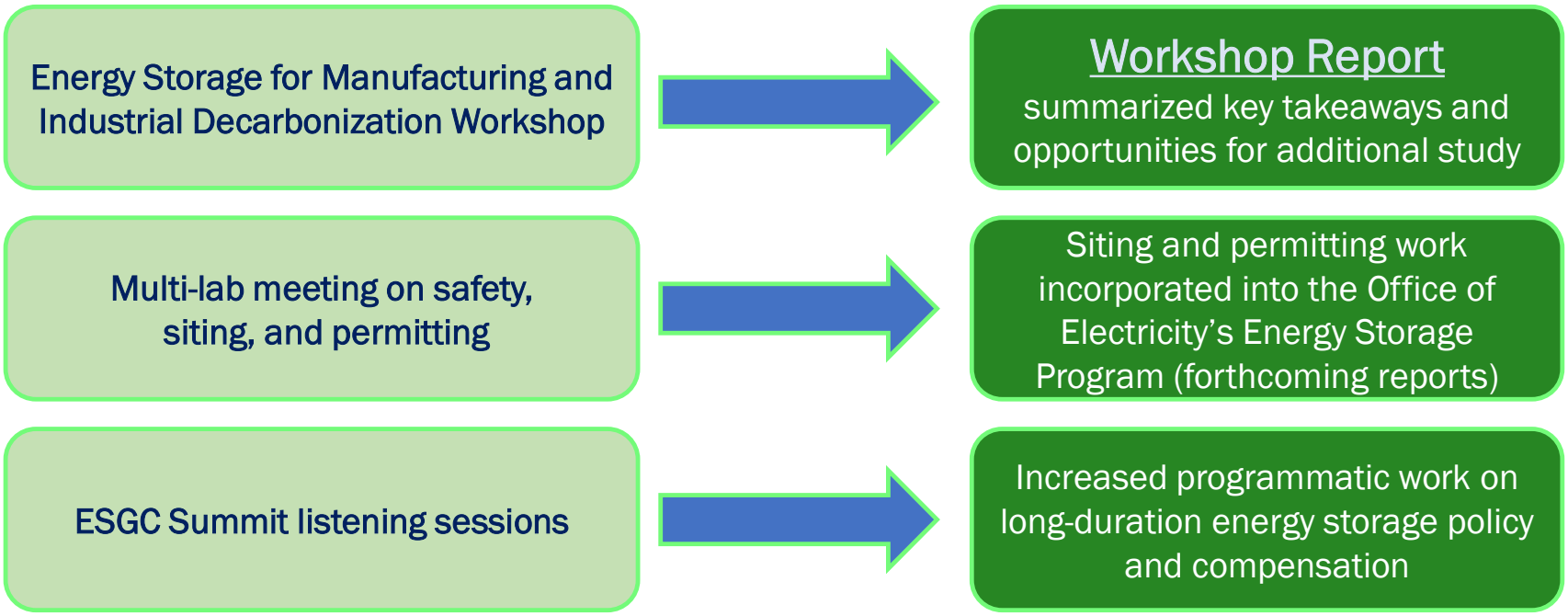
ESGC Summit Participation (2021-2023)

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)

Policy and Valuation: Results



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

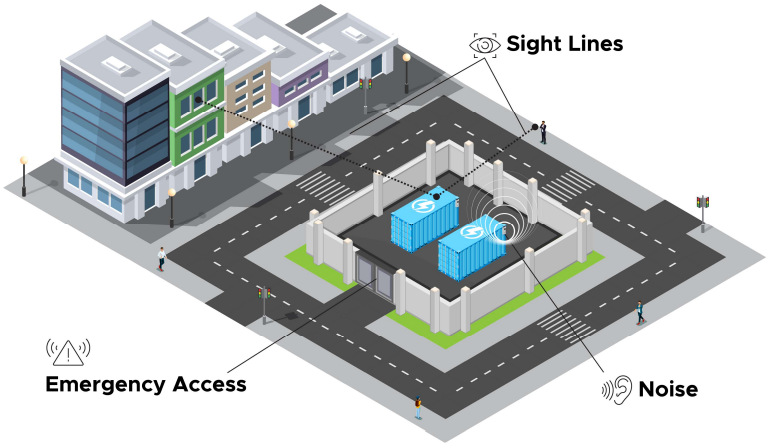


Image from forthcoming report on storage siting targeted at local planners

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

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Workforce Development

Meridith Bruozas

Full Group Size: 20

ENERGY STORAGE GRAND CHALLENGE
U.S. DEPARTMENT OF ENERGY

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