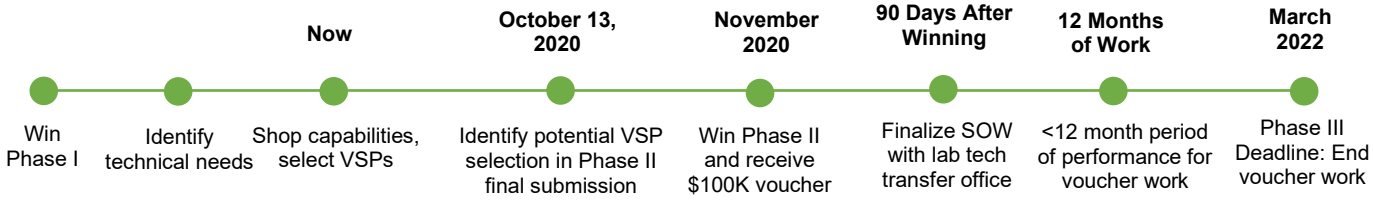
NATIONAL LABORATORY CAPABILITIES

Winners of Phase II will receive up to $100,000 in non-cash vouchers per team to access tools, equipment, and expertise at national labs and other approved Voucher Service Providers (VSPs) within the American-Made Network to support pilot-scale demonstration in Phase III of the Li-Battery Recycling Prize.

Each Phase III team may utilize up to three VSPs —labs and non-labs included. A team must use at least one-half of voucher funding ($50,000) at one or more national labs and may use a maximum of one-half of their voucher (up to $50,000) at a non-national laboratory VSP. The minimum amount of work with any VSP must be $10,000.

Working with a National Laboratory



Step 1. Identify your technical needs for the next phase of the competition and beyond.

Step 2. Familiarize yourself with national lab capabilities.

- Review the presentations from the virtual Demo Day to learn more about leading national lab research in energy storage.
- Reach out directly to the voucher representative for each of the national labs.

Step 3. Select a national lab to work with. Coordinate potential voucher work, anticipated tasks, and deliverables with a designated Voucher Representative.

Step 4. Include your voucher selections in your Phase II submission package due October 13, 2020.

Step 5. Should you win Phase II, immediately coordinate another meeting with your Voucher Representative to develop a Statement-of-Work (SOW) within 90 days of the winner announcement.

For voucher work with NREL: Your SOW will be forwarded to the NREL technology transfer office. From there, you will enter into a contract so that work can commence.

For voucher work with other national labs: Send your SOW to the lab's voucher representative. They will work directly with you to get an agreement in place to conduct voucher work.

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Step 6. After the agreement and/or contract has been signed, begin voucher work. The period of performance for all voucher work is 12 months, with the opportunity for a no-cost extension as long as work is completed by the submission deadline for Phase III.

Argonne National Laboratory (ANL) Capabilities

Voucher Representative: Jeffery Spangenberger (JSpangenberger@anl.gov)
Location: Chicago, IL

Argonne National Laboratory works in every link of the battery's value chain. From modeling and analysis to materials discovery and characterization, from scale-up to tear down and recycling. Argonne is relied upon to build and test all types of cells and has a well-known standardized testing facility. The capabilities, facilities and expertise can be used to help Prize recipients improve and progress their research in many areas such as cell building, cycling, and aging. Argonne also developed the EverBatt model for cost and environmental impacts at the various stages of a battery's life including collection, transportation and recycling. Lastly, Argonne is the home of the Vehicle Technologies Office's battery recycling program, ReCell. The ReCell laboratories house materials processing, recycling equipment and related tools and expertise.

Capabilities:

- Material discovery
- Materials characterization
- Process scale-up
- Process and systems modeling
- Cell fabrication
- Performance testing

Facilities:

- ReCell battery recycling facilities
- Materials Engineering and Research Facility (MERF)
- Cell Analysis, Modeling and Prototyping (CAMP)
- Electrochemical analysis and Diagnostics Laboratory (EADL)
- Post-Test Facility
- Electrochemical Discovery (EDL)

National Renewable Energy Laboratory (NREL) Capabilities

Voucher Representative: Voucher Representative: Matt Keyser (matt.keyser@nrel.gov)
Location: Golden, CO

NREL conducts a wide range of battery research and development spanning the materials, cell, pack, and system levels. A recognized leader in battery thermal analysis and characterization, NREL evaluates electrical and thermal performance of battery cells, modules, and packs, full energy storage systems, and

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the interaction of these systems with other vehicle components. In addition, NREL provides a comprehensive and detailed focus on the science of battery safety that integrates multiscale, multi-domain models with sophisticated experimental characterization capabilities to develop an extensive understanding of battery failure mechanisms, risks posed during failure, and the influence of cell design on failure mechanisms.

As part of DOE's Lithium Battery R&D Recycling Center, ReCell, NREL conducts research to cost-effectively reclaim and recycle critical materials from spent lithium-based batteries and is incorporating analysis and data in a system dynamics framework to identify challenges related to the global and regional impacts of the interlinking supply chains associated with battery manufacturing and recycling.

Capabilities:

- **Battery Thermal Analysis and Characterization**
- **Surface Analysis Cluster Tool:** In-situ study of surface chemical changes that occur during growth and processing of materials under various conditions using an ultrahigh-vacuum trolley system accessing multiple surface characterization tools – XPS, UPS, AES, TDMS, SIMS, and TOF-SIMS.
- **High-Performance Computing**: NREL uses multi-scale electrochemical-mechanical high-performance computing capabilities to facilitate 10-minute charging via energy-dense electrode designs.
- **Battery Lifetime Modeling:** Predict how various Li-ion technologies degrade under different usage scenarios. Reduced-order models of physical degradation mechanisms extrapolate accelerated aging test data to real-world use scenarios.
- **Battery Diagnostic Tools:** to look at variability (cell-to-cell and batch-to-batch) that affect second use of batteries or recycling methods for different cell components.

Facilities:

- **Science of Battery Safety Laboratory:** Furthers abuse characterization of batteries using comprehensive real-time, multiscale, multi-domain models with state-of-the-art experimental characterization capabilities.
- **Battery Thermal and Life Characterization Facilities:** Evaluates and designs efficient energy storage systems, as well as battery cells, modules, and packs using NREL's one-of-a-kind calorimeters provide critical heat generation and efficiency data for energy storage systems.
- **Battery Cell Fabrication, Analysis, and Breakdown (CFAB) Laboratory**: Contains a variety of materials and equipment to build customized, multi-layer batteries, such as coin cells and pouch cells, to evaluate for safety and performance requirements.
- **Electrochemical Energy Storage Laboratory**: Analyzes advanced electrolytes, synthesis of battery materials, and the structure and transport properties between electroactive battery materials and either a liquid or solid-state electrolyte.
- **Behind-the-Meter Electrical and Thermal Energy Storage Laboratories**: Integrates behind-the-meter battery storage, electric vehicle charging, commercial buildings, and other renewable and energy-efficient technologies to facilitate the development of new innovative solutions for a highly electrified future, including extreme fast charging and thermal storage options.

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Oak Ridge National Laboratory (ORNL) Capabilities

Voucher Representative: Ilias Belharouak (belharouaki@ornl.gov)
Location: Oak Ridge, Tennessee

The DOE's Battery Manufacturing R&D Facility (BMF) at ORNL was launched in 2010. The facility's core mission is to expedite innovations in advanced battery materials research, battery manufacturing, and cell prototyping that enable low-cost, high-energy, safe, and long-life cells capable of fast charging. The facility provides the ability to analyze every aspect of battery cell development, from raw materials and electrode dispersion preparation to finished product and performance testing. BMF also provides the ability to integrate any component into a complete battery and analyze how well it works and how it can be improved. The facility houses the equipment and instrumentation necessary to research every step in the battery manufacturing process with an emphasis on advanced materials, electrode formulation chemistry, rheology of slurries, innovative coating technology, and high-performance electrode architectures. In addition, BMF develops efficient recovery processes for the separation of black mass from current collectors. The separation processes use green solvents that are inexpensive, nontoxic and do not cause water and/or air pollution, and do not incur a penalty in terms of damages to active materials and current collectors. The recovery of cathodes and anodes from spent lithium-ion batteries have high peeling-off efficiency and are cost effective, scalable, energy efficient and environmentally friendly.

Capabilities:

- Energy Storage Research
- Roll to Roll Manufacturing

Facilities:

- Battery Manufacturing R&D Facility

Sandia National Laboratories Capabilities

Voucher Representative: Kyle Fenton (krfento@sandia.gov)
Location: Albuquerque, NM

Sandia National Laboratories is an internationally recognized leader in energy storage system safety and reliability research. Sandia's Battery Abuse Testing Laboratory (BATLab) focuses on:

1. Understanding the mechanisms that lead to energy storage system safety and reliability incidents
2. Developing new materials to improve overall energy storage system safety and abuse tolerance,
3. Performing abuse testing
4. Advancing testing techniques
5. Performing detailed failure analyses
6. Developing strategies to mitigate energy storage cell and system failures.

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In addition to core battery abuse testing capabilities, the BATLab is home to the world's largest and most comprehensive battery calorimetry laboratory, the DOE's largest lithium-ion cell prototyping facility, battery component analytical and diagnostic capabilities, and extensive failure-analysis and characterization tools. Sandia also has experience with siting MW size Li-battery demonstration projects, field monitoring, and performance validation.

Capabilities:

- Characterization and Failure Analysis
- Energy storage components for transportation and energy storage for the electric grid

Facilities:

- Battery Abuse Testing Laboratory (BATLab)
- Cell Prototyping Facility
- Battery Calorimetry Laboratory

Idaho National Laboratory (INL) Capabilities

Voucher Representative: Seth Snyder (seth.snyder@inl.gov) and Dustin Crowton (dustin.crowton@inl.gov)
Location: Idaho Falls, ID

Battery research at INL includes the Critical Materials Institute Lithium-ion Batteries Recycling, Battery 500 Consortium, enabling extreme fast charging program, enabling advanced diagnostics, prognostics and life prediction for improving battery performance and safety, and physics-based machine learning.

Facilities:

- Battery Test Center (BTC): BTC is the lead battery life and performance testing facility for the Vehicle Technology Office. The BTC has over 800 battery test channels with the capability from coin cell to vehicle level pack testing. The BTC uses advance diagnostics and prognostics to estimate the calendar and cycle life of different high energy and high-power battery technologies. The BTC works closely with OEMs through the U.S. Advanced Battery Consortium (USABC) to validate the life and performance of advanced battery systems.
- Non-destructive Battery Evaluation Laboratory (NOBEL): NOBEL tests batteries in off-normal conditions and outside the specifications. Testing can include temperature and electrochemical extremes, and mechanical stress such as vibration and shock. NOBEL has been instrumental in evaluating, developing different modules, and pack-level advanced diagnostics and prognostics methods.
- Electric Vehicle Infrastructure Laboratory (EVIL): EVIL develops and evaluates solutions for EV charging infrastructure integration with the electric grid. The research activities include high power EV charging grid interaction, cyber-physical security, EM-field safety, and operational performance characterization. These research areas primarily focused on conductive charging and wireless

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charging technologies designed for electrified transportation. The primary areas of research at INL's EV infrastructure lab include:

- Grid integration interaction of emerging EV charging infrastructure technologies
- Wireless power transfer (WPT) electromagnetic-field (EM-field) safety for stationary & in-motion WPT: design, develop, and verification testing
- Cyber-physical security assessment, analysis, penetration testing, and mitigation solution development for high-power EV charging infrastructure
- Characterization of high power EV charging infrastructure
  - Conductive charging up to 350kW (J1772 CCS, CHAdeMO, J1772 L2/L1)
  - Wireless power transfer: (up to: 200kW for light duty, 500kW for MD/HD)

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