NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Thermal Test Facility

Enhanced fuel efficiency standards along with increased consumer adoption of environmentally friendly automobiles have auto manufacturers racing to put more hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and fully electric vehicles (EVs) on the road. To make these options practical, automotive batteries must operate at maximum efficiency, performing at optimal temperatures in a wide range of driving conditions and climates, and through numerous charging cycles. NREL's Thermal Test Facility (TTF) can provide precise measurement of heat signatures from batteries under various load conditions.

Thermal Characterization of Batteries

High temperatures degrade batteries faster, while low temperatures decrease their power and capacity, affecting vehicle range, performance, and cost. NREL's Isothermal Battery Calorimeters (IBCs) are the only calorimeters in the world capable of providing the precise thermal measurements needed to ensure safer, longer-lasting, and more cost-effective, electric-drive vehicle batteries. To help meet consumer demand for both green and affordable car models, NREL—with support from the U.S. Department of Energy (DOE)—is using IBCs to help the auto industry design better thermal management systems for energy storage cells, modules, and packs for these electric-drive vehicles. Four models: the Large-Volume IBC, module IBC, cell IBC, and micro calorimeter make it possible to test a full range of energy devices.

What Makes Battery Temperature Important?

A well-designed thermal management system is critical to the life and performance of HEVs, PHEVs, and EVs. Regulation of battery pack temperature helps maximize performance (power and capacity) and charge acceptance (during regenerative braking), while minimizing battery degradation, and vehicle operating and maintenance expenses. Because batteries are electrochemical devices, their performance and lifespan are affected by temperature. High temperatures increase side reactions, leading to shorter battery life and greater battery replacement costs. Surges in temperature can also jeopardize safety by triggering battery fires or explosions. Development of precisely calibrated battery systems relies on accurate measurements of heat generated by battery modules during the full range of charge/discharge cycles, as well as determination of whether the heat was generated electrochemically or resistively.

The breakthrough technology of the Isothermal Battery Calorimeters (IBCs) has been recognized with an R&D 100 Award, known in the research and development community as "the Oscar of Innovation."

2013 R&D 100

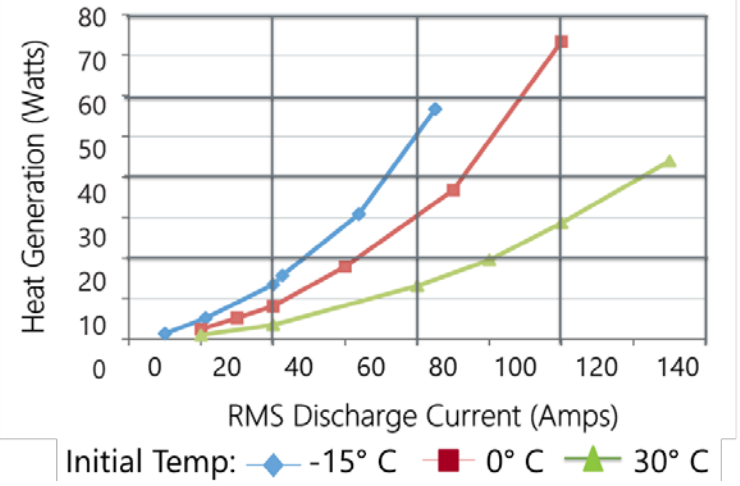
Award Winner

IBCs are the only calorimeters in the world that:

- Determine heat levels and battery energy efficiency with 98% accuracy
- Provide precise measurements through complete thermal isolation.

IBCs make it possible to:

- Accurately measure the heat generated by electric-drive vehicle batteries
- Analyze the effects of temperature on battery systems
- Pinpoint ways to manage temperatures for the best performance and maximum life.



Heat generation curves for a PHEV battery at various discharge currents and temperatures: This critical information helps regulate battery temperature by identifying efficiency losses across different operating conditions.

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NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

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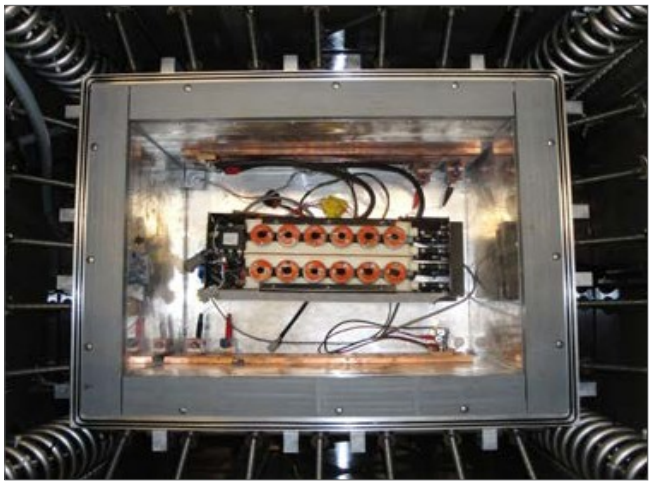
IBC Highlights

- Ability to test cells from 0.001 Ah to 100 Ah
- Ability to measure battery packs with energy content of 4 MWh to 10 kWh
- Assessment of heat systems, including interconnects
- Innovative thermal isolation and isothermal bath providing errors of less than ±2%
- Simulation of full conditions and charging cycles
- Ability to test liquid-cooled batteries

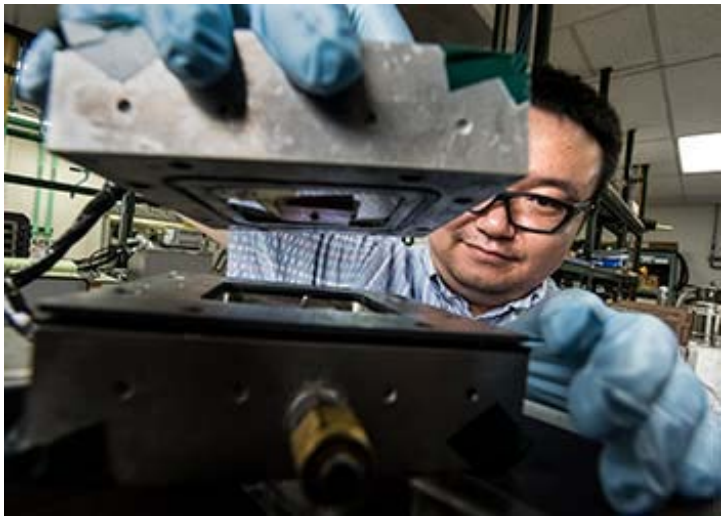


A large battery module in the Large-Volume IBC test chamber, with cooling/heating coils in each corner.

Micro Calorimeter

NREL's micro calorimeter examines the thermal signature of battery chemistries early on in the design cycle using popular coin cell and small pouch cell designs, which are simple to fabricate and study. Fundamental analysis of material limitations at the coin-cell level gives engineers, materials researchers, manufacturers, innovators, labs, research and development (R&D) organization, and universities the ability to experiment with a wide range of chemistries so they can determine which variations and combinations work best in an actual battery setting.

Micro Calorimetry Highlights



NREL's micro calorimeter enables examination of new chemistries in small format cells, small electronics, wearable devices, and sensors.

- Flexible chamber design accommodates testing of different cell sizes at a consistent, known pressure
- Fast response times (seconds to minutes)
- Evaluates kinetic and thermal properties
- Powerful tool for early-stage materials R&D to assess material stability and compatibility across multiple cell components
- *In operando* measurement of reaction heats within individual cells under actual load cycles
- Analyzes cell abuse kinetics mechanisms, as well as thermal limitations under normal operation
- Compares thermal response across various chemistries, cell design parameters, cycling conditions
- Ideal for studying engineering modifications (coating effects, thermal interfaces, effect of impurities, porosity changes, wetting, binder adhesion)

For information on partnership opportunities, please contact:

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