U.S.–China Clean Energy Research Center
中美清洁能源研究中心
Clean Vehicle Consortium

Update on US Activities

US-China Clean Energy Research Center Clean Vehicles Consortium (CERC-CVC)

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9th China-U.S. Electric Vehicle and Battery Technology Workshop

August 18-19, 2014, Seattle, WA

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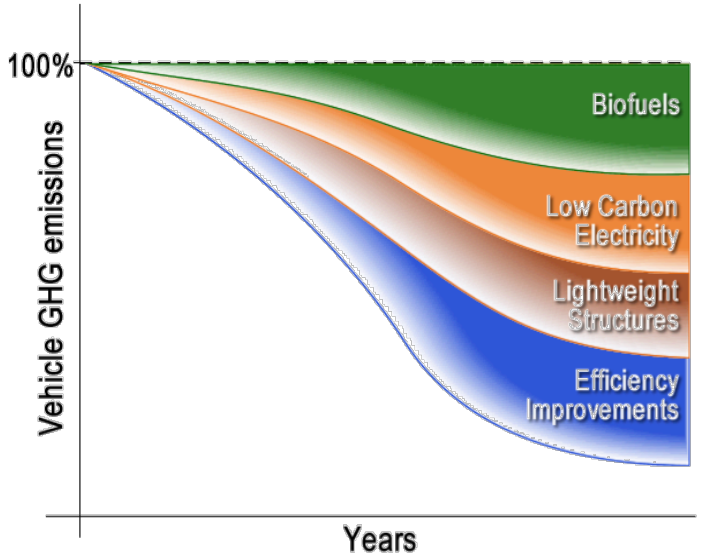
CERC Objectives

"The objective of CERC-CVC is to contribute to *dramatic improvements in technologies* with the potential to *reduce the dependence of vehicles on oil* and *improve vehicle fuel efficiency*"

through the synergy of:

- **Vehicle electrification**
- **Novel energy storage materials**
- **Next-generation biofuels**
- **Lightweight structures**
- **Efficient energy conversion**

guided by a holistic life cycle design and optimization framework



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Academic and National Lab Partners

U.S.

University of Michigan

The Ohio State University

Massachusetts Institute of Technology

Sandia National Laboratories

Oak Ridge National Laboratory

Argonne National Laboratory

jbei Joint BioEnergy Institute

China

Tsinghua University

Tianjin University (Peiyang University)

Beijing Institute of Technology

Tongji University

Wuhan University of Technology

Chinese Academy of Sciences

Beihang University

Hunan University

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Industrial Partners

U.S.

Ford DELPHI DENSO EATON

TOYOTA HONDA pjm TE connectivity Aramco Services Company

China

SAIC GEELY JAC CAERI CNTARC GM

LISHEN Potevio JJE ECTEK KeyPower 科易动力

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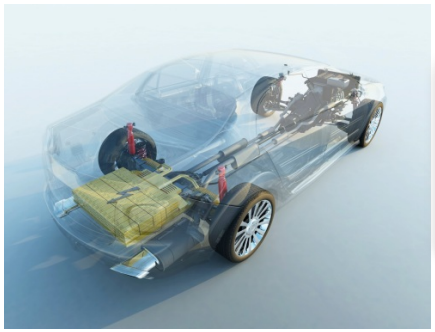
Thrust Areas

1. Advanced Batteries and Energy Conversion

4. Lightweight Structures

2. Advanced Biofuels, Clean Combustion and APU

5. Vehicle-Grid Integration



3. Vehicle Electrification

6. Energy Systems Analysis, Technology Roadmaps and Policies

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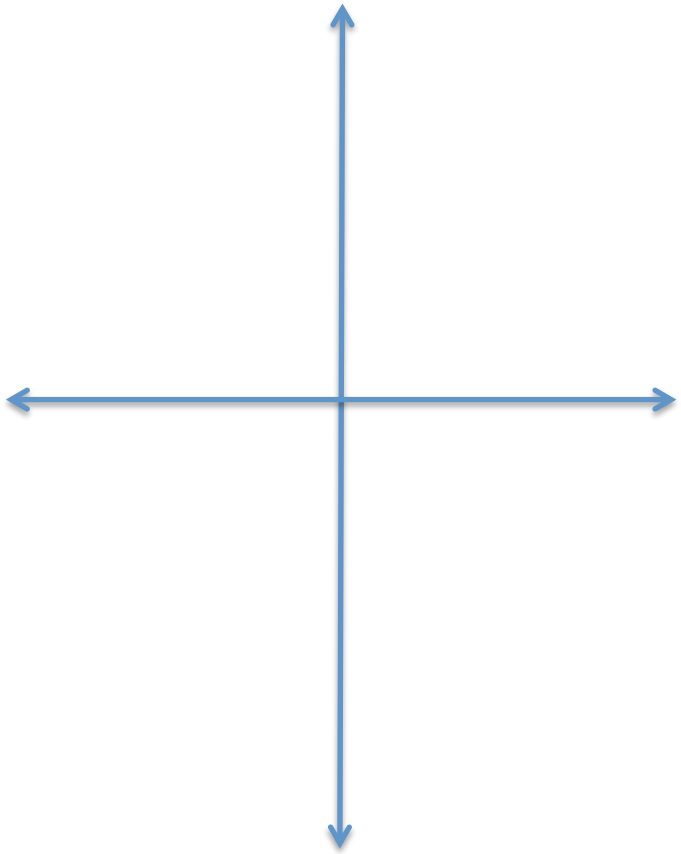
Thrust Area Scope

Atomic Scale

Longer Term/
Fundamental



Applied

Battery Systems

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Battery Research Themes

1. Characterization of Degradation Mechanisms in Li-Ion Batteries

- Multi-scale Characterization of bulk degradation mechanisms
- Characterization of Solid Electrolyte Interfaces
- Computational study of degradation mechanisms resulting from phase transformations

2. High Energy Density Battery Chemistries

- Advanced Li-ion chemistries
- Li-sulfur batteries
- Metal-air batteries

3. Battery Implementation

- Safety
- Reuse & recycling
- Testing protocols & standardization

4. Modeling and control of Battery Systems

- Multi-scale modeling
- Control strategies and health management

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Progress Towards Goals

Plan (2013)	Status (2014)
• Leverage ORNL prototyping facility: – Manufacture LMR-NMC prototype cells – Distribute cells for analysis to partners	• **First round of cells manufactured for in-situ neutron diffraction characterization**
• Develop *in situ* capability to bridge length scales and better understand real-time degradation	• **OSU NDP analysis of real-time lithiation/delithiation kinetics in Sn anodes** (*Angewandte Chemie, 2014*)
• Safety assessment of Li-rich and high voltage systems	• THU analysis of thermal run-away & overcharging scenarios (L. Lu)
• Analysis of recycling efficiency and chemical processes for commercial Li-ion cathode materials	• BIT/ANL team analyzing chemical pathways and life-cycle efficiency (L. Li)
• Develop understanding of promotion mechanisms arising from metal-oxides in metal-air batteries	• **Examined Na-air systems, which show promise for efficient charging. Explored mechanisms for nucleation and transport within discharge phase**
• Age and analyze commercial LFP cells donated to CERC	• OSU using AFM and EELS to characterize LFP cells donated to CERC

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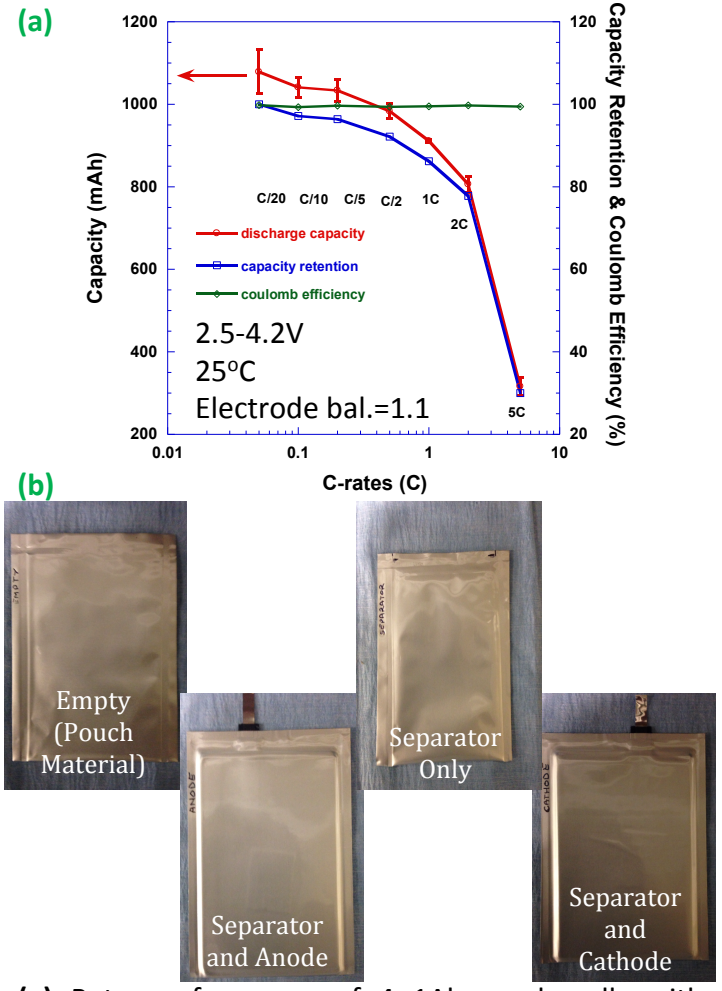
Manufacturing of Pouch Cells for Battery Degradation Studies



(a) Rate performance of 4 1Ah-pouch cells with NMC532 and A12 graphite as cathodes and anodes; **(b)** Special cells for in-situ neutron diffraction background signal analysis

Scientific Achievement

Manufacturing custom large format pouch cells with consistent performance for *in-situ* neutron diffraction studies

Significance and Impact

- Knowledge about components, their composition and cell processing methods will enable CERC partners to more quantitatively analyze battery performance
- Considerably improve our understanding of degradation mechanisms in electrodes aged in large format cells under realistic conditions
- Flexibility in cell design will aid researchers in developing new experimental techniques

Future Plans

- Manufacture and age cells for material characterization and degradation studies to see effect of different parameters such as inhomogeneities, formation cycle current, areal solid loading gradient and aqueous processing

Ford

HONDA
Honda R&D Americas, Inc.

Work performed at Oak Ridge National Lab

Oak Ridge National Laboratory