Vehicle Technologies Office

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

ES297: Computer Aided Engineering of Batteries (CAEBat) Program Introduction

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Overview

- Vehicle Technologies Office Energy Storage Overview
- CAEBat History
  - Program Objectives
  - Phase I
  - Phase II
  - Phase III
  - Phase IV
- AMR Agenda
- Conclusions

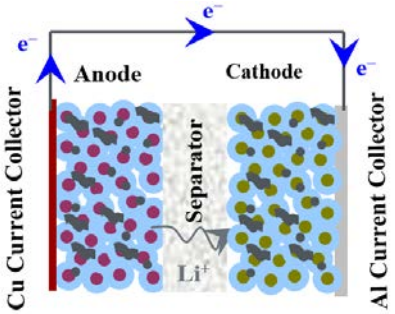
VTO Energy Storage R&D Overview and Strategy

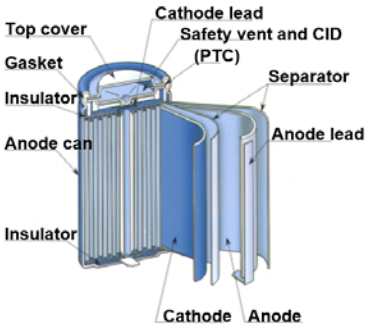
CHARTER: Develop battery technology that will enable large market penetration of electric drive vehicles

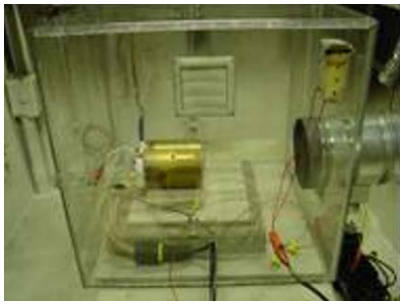
Cost Goal: $100/kWh$_{(useable)}$

Energy Storage R&D

- **Battery Materials Research (BMR)**
- **Applied Battery Research (ABR)**
- **Battery Development**
- **Battery Testing, Design, & Analysis**







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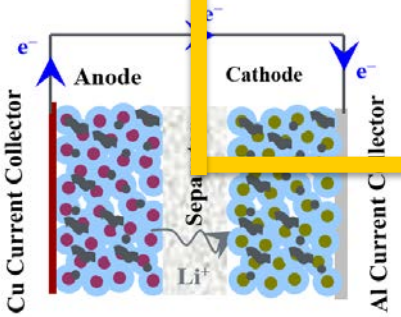
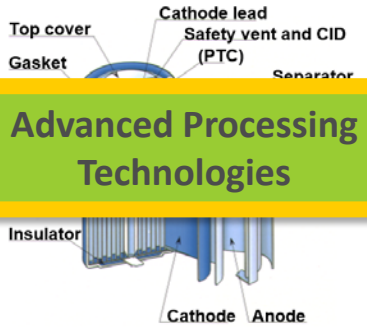
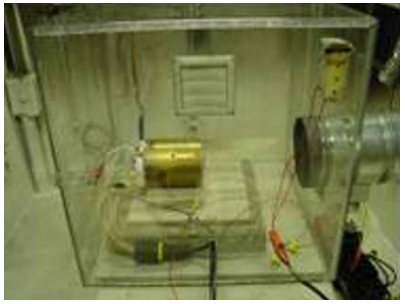


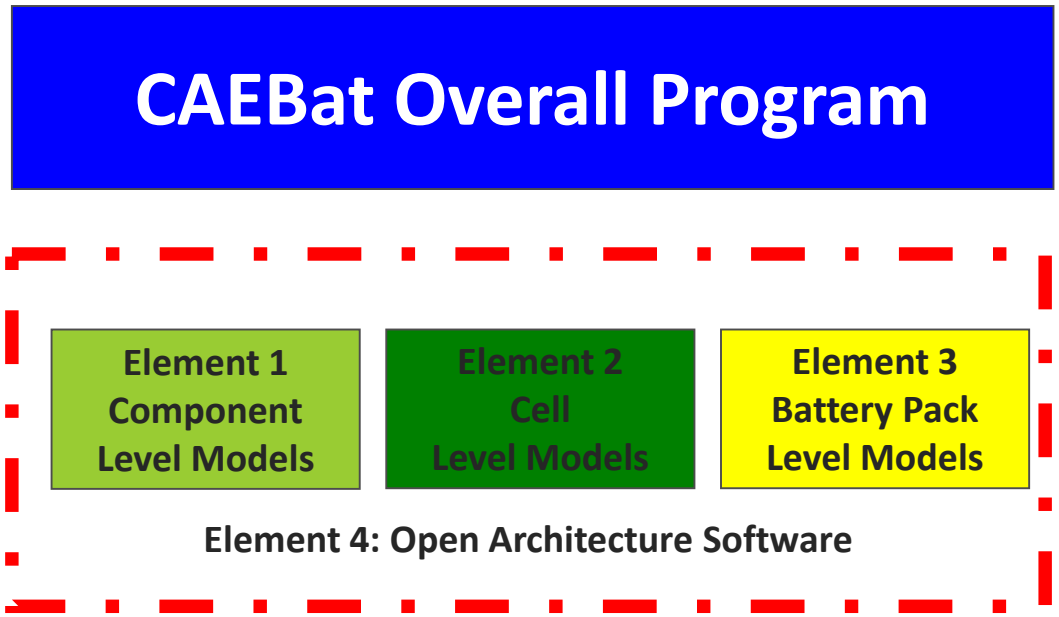


Advanced Processing Technologies



CAEBat Initial Program Objectives

- Program was intended to incorporate existing and new models into a battery design suite with the goal of shortening battery design cycles and optimizing batteries (cells and packs) for improved performance, safety, long life, and low cost
- Battery design suite must address multi-scale physics interactions, be flexible, expandable, validated and verified

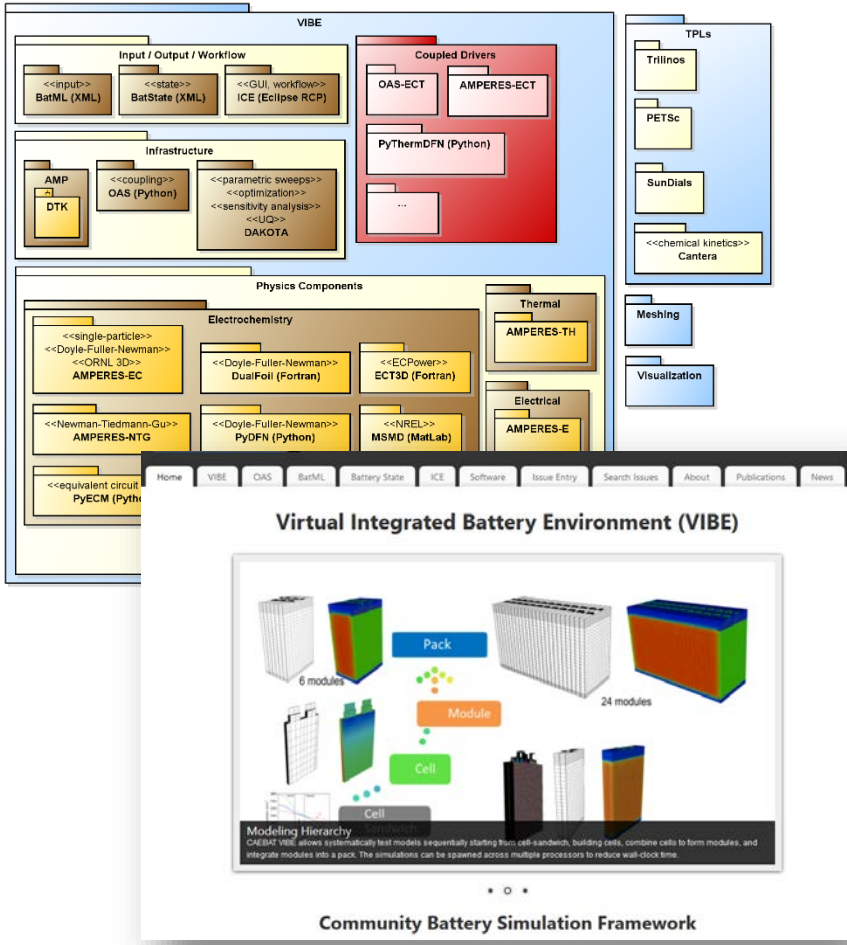


CAEBat History: Phase I

- Initial solicitation issued in 2011 for industry to address Elements 2 & 3
- 3 teams were selected with $7M in DOE funds:
  - EC Power / PSU / Ford / JCI
  - CD-adapco / Battery Design / A123 / JCS
  - GM / ANSYS / E-Sim
- Projects completed FY15
- Resulted in 3 commercially available software packages
  - EC Power's AutoLion
  - CD-adapco's STAR-CCM+/Battery Simulation Module
  - ANSYS's FLUENT/Total Battery Simulator Module
- Conservative estimates predict around 150+ users/paid licensees

CAEBat History: Phase I – Open Architecture

- In parallel to 3 industry awards, ORNL was tasked to develop an open architecture that would enable users to mix and match models from each battery level (i.e. materials component, cell, and pack)
- ORNL developed VIBE – a Virtual Integrated Battery Environment
  - Standardized input and outputs for various elements
  - Battery model library
  - Includes visualization and meshing
  - Allows optimization parameter sweeps using DAKOTA
  - Can be downloaded in a Virtual Machine @ http://batterysim.org/
  - Complete Documentation available with help support
- Over 300 downloads from labs, academia, and industry all over the world
- Website receives almost 500 hits/month

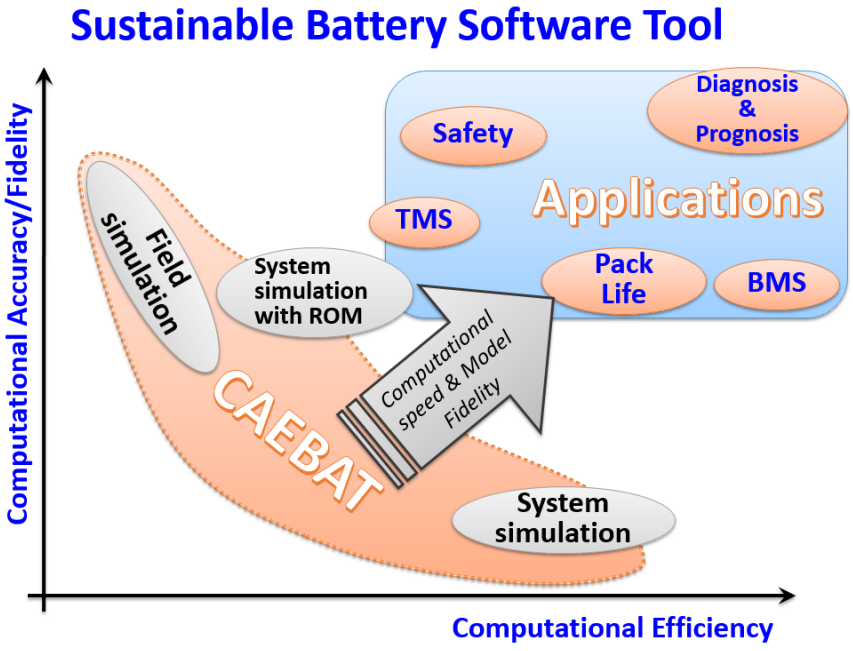


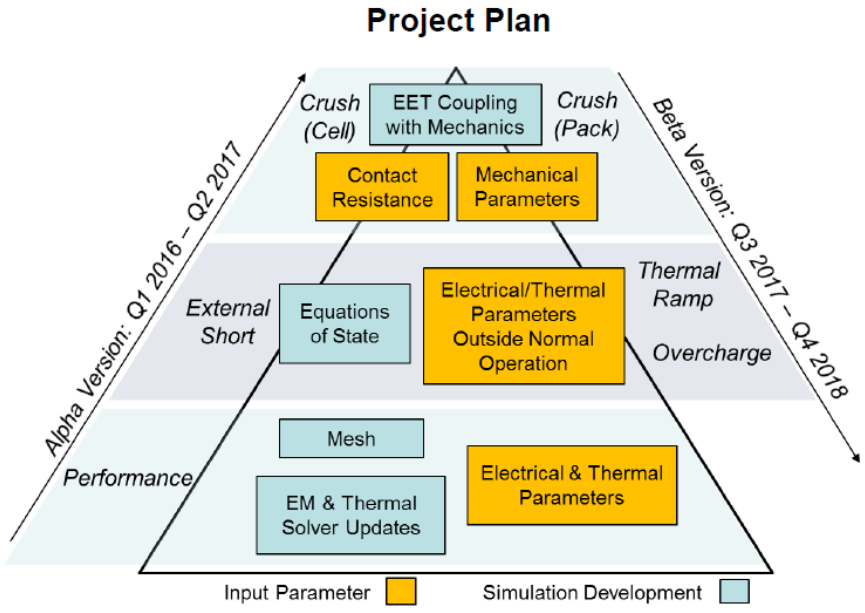
CAEBat History: Phase 2 and 3

- 2nd solicitation issued in FY13 to expand upon the current state of electric drive vehicular battery computer-aided engineering models
- Projects were 2 years in duration (FY14 and FY15)
- 3 teams were selected with $4.5M in DOE funds:
  - NREL / ANSYS / MIT
  - EC Power
  - Sandia / Oak Ridge / Colorado School of Mines
- Phase 3 Lab Call issued in FY15 to improve modeling of safety events, computational speed, and microstructure models
- 2 lab consortiums awarded 3 year projects (FY16-FY18) at ~3.5-4M/yr
  - NREL led team with ANL, SNL, ANSYS, and Texas A&M
  - ORNL led team with LBNL and SNL

CAEBat History: Phase 4

- 2015 FOA selected 3 projects to award with 2 ultimately being funded
  - Ford, ORNL, and Livermore Software Technology Corporation (LS-Dyna)
  - GM, ANSYS, NREL, and Esim
- 3 year projects ~$5M in DOE funds



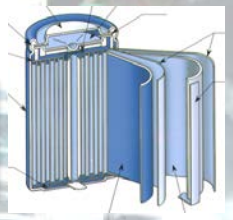


AMR Agenda

Time	ID	Project Title	PI	Organization
11:15	es297	Computer-Aided Engineering of Batteries (CAEBAT) Program Introduction	Brian Cunningham	DOE
11:30	es298	Efficient Simulation and Abuse Modeling of Mechanical-Electrochemical-Thermal Phenomena in Lithium-Ion Batteries	Shiram Santhanagopalan	NREL
12:00	es299	Microstructure Characterization and Modeling for Improved Electrode Design	Kandler Smith	NREL
13:45	es300	Enhancement and Deployment of VIBE, the Open Architecture Software (OAS) Environment	Srikanth Allu	ORNL
14:15	es301	Experiments and Models for the Mechanical Behavior of Battery Materials	Sergiy Kalnaus	ORNL
14:45	es302	Microstructure Imaging and Electrolyte Transport Property Measurements for Mathematical Modeling	Venkat Srinivasan	ANL
15:15	es303	Exploring How Electrode Structure Affects Electrode-Scale Properties Using 3-D Mesoscale Simulations	Scott Roberts	SNL
16:15	es296	Development and Validation of a Simulation Tool to Predict the Combined Structural, Electrical, Electrochemical, and Thermal Responses of Automotive Batteries	Chulheung Bae	Ford Motor Co.

For More Information…

www.vehicles.energy.gov



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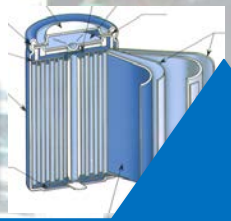

Special thanks to TARDEC support & collaboration!

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