U.S-China
Clean Energy Research Center on Clean Vehicle Collaboration

Overview of CERC-CVC

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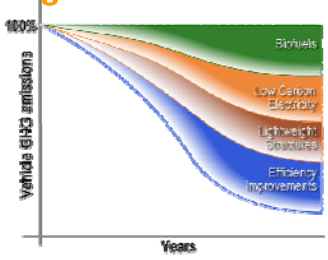
US-China Clean Energy Research Center: Clean Vehicle Collaboration (CERC-CVC)

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

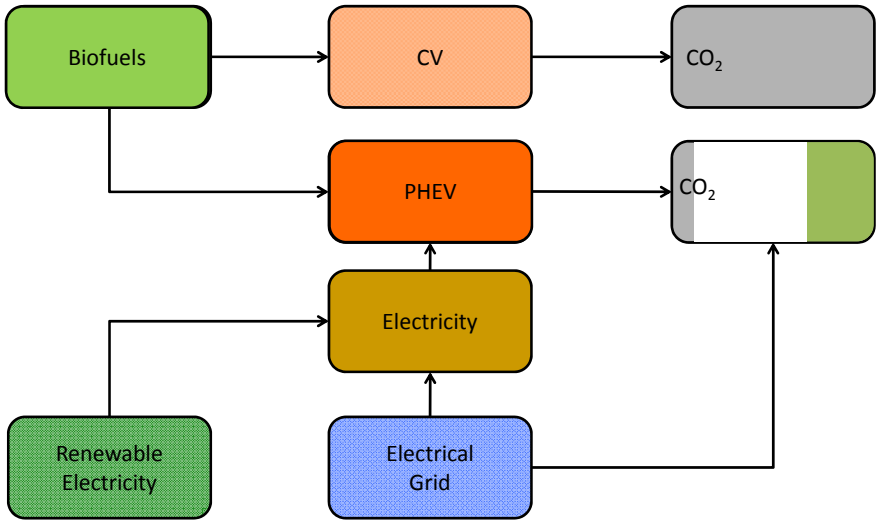
through the synergy of:

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

guided by a holistic life cycle design and optimization framework



Need for Alternative Vehicle Technology and Fueling Strategies



UNIVERSITY OF MICHIGAN

Building The Dream Team

- Academic Partners in US and China
  - UM, OSU, M.I.T.
  - Tsinghua, SJTU, China Academy of Sciences, Beijing Institute of Technology, Wuhan University, Tongji University, Tianjin University
- Government/ State Entities
  - DOE, MOST, ORNL, SNL, JBEI, ANL, EPA, City of Ann Arbor, MEDC
- Committed Industry Partners in US and China
  - U.S. Charter Members: Cummins, Fraunhofer, Ford, GM, Toyota
  - Members: A123, Chrysler, BorgWarner, Delphi, Transportation Research Center, First Energy, MAGNET, American Electric Power, PJM, Dayton P&L, Huntsman
  - Chinese Members: Beijing Hyundai Automotive, DongFeng Motor Corporation, Chongqing Changan Automobile Co. Ltd, Geely Automotive
- $50M of funding over the next five years

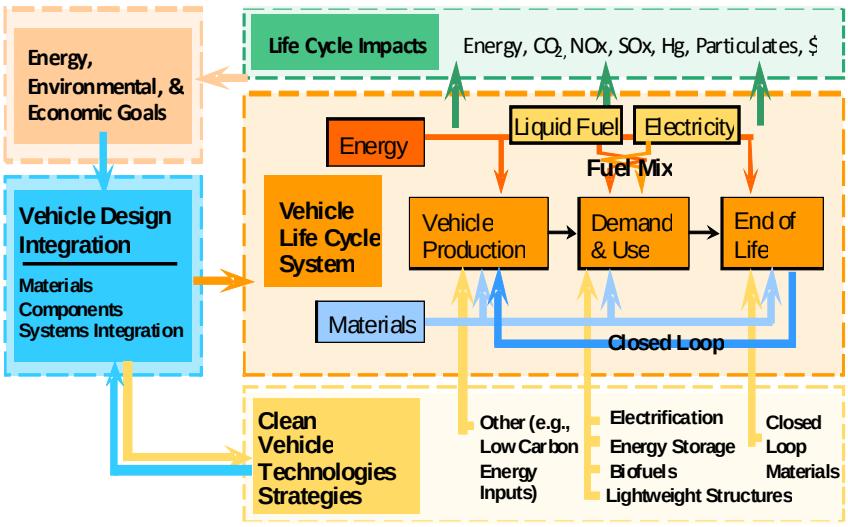
CERC-CVC Thrust Areas

- Energy Systems Analysis, Technology Roadmaps and Policies
- Vehicle-Grid Interface
- Vehicle Electrification
- Batteries and Energy Conversion
- Advanced Biofuels and Clean Combustion
- Lightweight Structures

Energy Systems Analysis, Technology Roadmaps and Policies

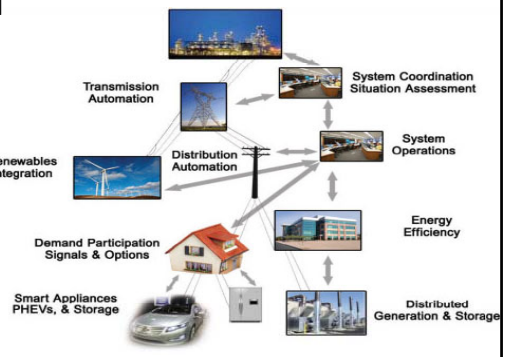
1. Energy Systems Analysis
   a. Set CV Technology Performance Targets
   b. Develop vehicle life cycle model to guide design
2. Optimize Fuels and Electricity Blends for Vehicle Propulsion given driving and charging patterns
   a. Develop regional fueling strategies
   b. Identify optimal vehicle technology combinations
3. Vehicle, Market and Policy Analysis
   a. Develop Technology Roadmaps and inform policy and standards for CV deployment
   b. Integrate CV Technologies and Optimize Vehicle System Design with Applications to Vehicle Test Beds

Energy Systems Analysis, Technology Roadmaps and Policies



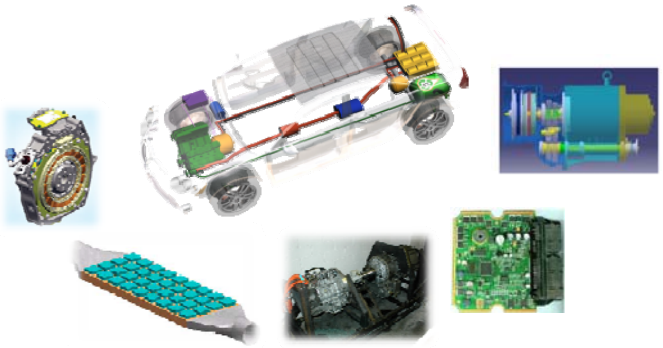
Vehicle-Grid Interface

- Develop control strategies, protocols and communications requirements for vehicle – grid interactions.
  - Address local (distribution) and system-wide impacts.
  - Support renewable generation.
- Develop recommendations on electricity infrastructure protocols and standards for accelerating electric vehicle deployment in U.S. and China
  - in collaboration with energy systems analysis, technology roadmaps and policies thrust.



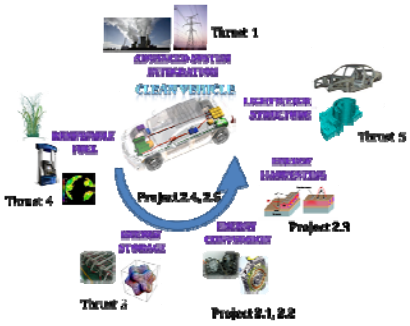
Vehicle Electrification Goal

- To develop new concepts, models, methodologies, and tools to construct, analyze, design and simulate key components of electrified vehicles, and to study their controls and integrations.



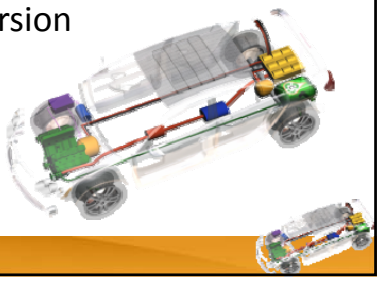
Vehicle Electrification Projects

- Energy Conversion (electric motors and traction transmissions)
- Waste Heat Recovery
- Configuration design, component sizing and control of hybrid vehicles
- Integrated Fault Diagnosis and Prognosis for Hybrid and Electric Vehicles



Batteries and Energy Conversion - Goals

- To develop fundamental understanding of degradation mechanisms in Li-ion batteries at all relevant length scales
- To develop the next generation of high energy density batteries based on Li-air and Li-sulfur chemistries
- To develop novel thermoelectric materials for highly efficient energy conversion

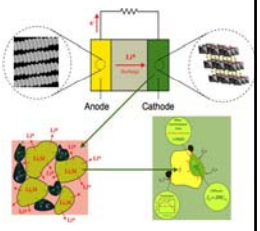


DA1

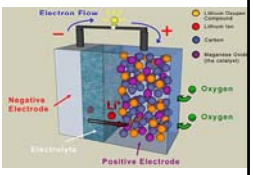
Batteries and Energy Conversion

projects needs updating LI-Su in China and Thermoelectrics

- Li-ion focus:
  - Modeling and control for battery health management
  - Generation of Energy Storage Devices with Controlled Aging
  - Multi-scale Characterization
  - Thermal Modeling
  - Fundamental study of degradation mechanisms
  - Fundamental Studies of Solid Electrolyte Interface



- Li-air focus:
  - Characterization of the catalyst microstructure and morphology during charge/discharge cycles
  - Identification of the rate limiting mechanisms to understand the origin of the high charging potential
  - Identification of mechanisms by which cathode catalysts facilitate discharge and recharge
  - Screen for optimal catalyst compositions and morphologies



Slide 12

DA1 needs updating to include Li-sulfur work and thermoelectrics
Dennis Assanis, 1/10/2011

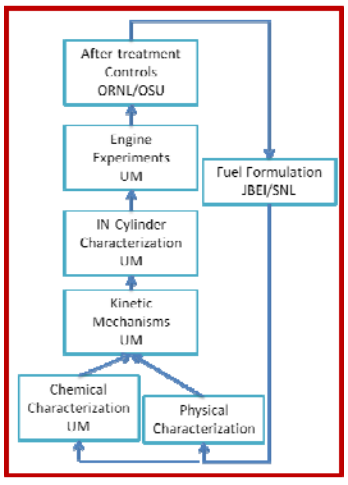
Biofuels and Clean Combustion - Goals

- Create and demonstrate a comprehensive and broadly applicable framework for synthesis of next generation biofuels and blends, and combustion of these biofuels in advanced engines.
- Uniqueness of the effort: the interconnected technical goals between synthetic biology and combustion chemistry and engines.

Advanced Biofuels – Projects

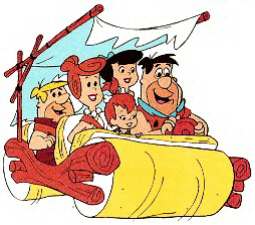
needs a figure that shows China contributions

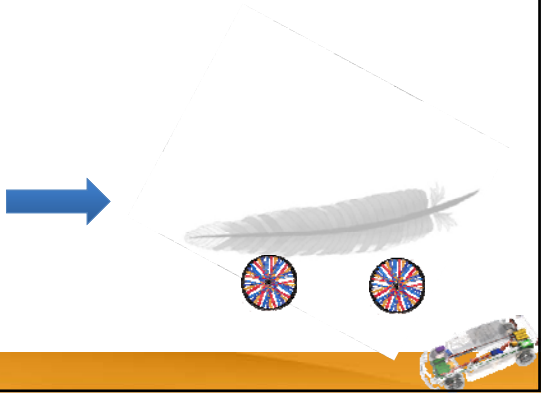
- Chemical and Physical Characterization of Biofuels
- Development of Chemical and Physical Models for Novel Fuels
- In-Cylinder Characterization of Biofuels and LTC Engine Experiments
- Integrated powertrain and aftertreatment system control for clean vehicles
- Tailored Biofuels for Next-Generation Engines



Lightweight Structures - Goals

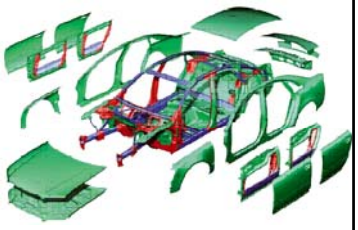
- Develop guidelines, methodologies, and tools to design and manufacture low-cost, energy efficient, high-performance, ultra lightweight vehicle body (and other) structures.

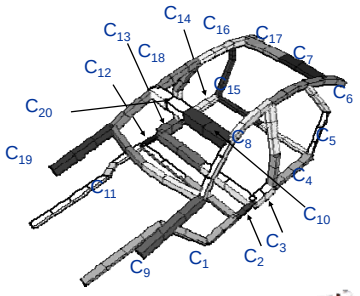




Lightweight Structures - Projects

- Computational Design of Strong Lightweight Alloys
- Low-Cost Production of Carbon-Polymer Composite Components
- Robust Forming Processes of Lightweight Alloys
- Robust Joining Processes of Lightweight and/or Dissimilar Materials
- Lightweight, Multi-Material Vehicle Structure Design and Optimization



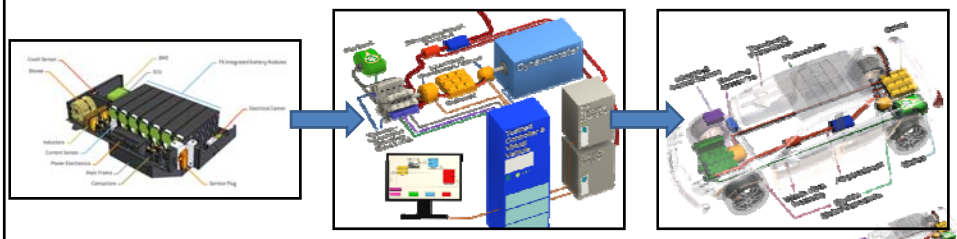


Key Scientific and Technological Innovations

- New electrified vehicle architectures with optimized power management and controls
- Control strategies, protocols and communications requirements for vehicle – grid interactions
- Novel materials for energy harvesting, storage and conversion
- Combustion science for novel biofuels and its application to symbiotic design of innovative engine cycles and processes
- Breakthrough structural designs that provide substantial weight savings
- Life cycle design methodologies to guide system development that meets renewable resource constraints

CERC-CVC Test Beds

- Sub-system:
  - Initial demonstrations in the CERC-CV laboratories
- Powertrain-in-the-loop testbed:
  - Key to early integration and demonstration of sub-systems (new biofuels, energy materials, waste heat recovery, sensors, controllers, and hybrid concepts)
- Fully integrated vehicle testbed:
  - Full scale integration of propulsion, energy harvesting and ancillary systems through University/Industry/International partnerships



High Level CERC-CVC Metrics

- Joint conferences, workshops and symposia organized
- IP disclosures filed; US, China, and international patents issued
- Commercialization of CERC-CVC IP by OEMs, suppliers and start-ups
- Journal and conference papers published
- Students graduated and students hired by CERC-CVC members and affiliates
- Post-doctoral fellows trained
- Number, frequency, duration of personnel exchanged/collocated among organizations
- Awards received (individual, team, technology)
- Prestigious lectureships/keynotes given at national and international conferences