Overview of US-China Clean Energy Research Center for Clean Vehicles

Prof. Dennis Assanis, Director
Michigan Memorial Phoenix Energy Institute

UMTRI Inside China Conference:
“Understanding China’s Current and Future Automotive Industry”
November 10, 2010
Michigan Memorial Phoenix Energy Institute: History

- 1948: UM Regents approve resolution to create a World War II memorial to focus on the peaceful uses of nuclear energy: **Memorial Phoenix Project**

- 2006: Michigan Memorial Phoenix Energy Institute established to address the broad energy challenge
  - Science
  - Technology
  - Policy/Human Impacts
MMPEI: Our Future Home

• Phoenix Memorial Laboratory
  – Renovation for 3rd Floor laboratory completed
  – Hydrogen Energy Technology Laboratory moved in

• Additional Renovation and Expansion approved by Regents in December 2009; anticipated completion date Sept 2012.
  – Renovate 2nd Floor laboratory for energy storage research
  – Addition for interdisciplinary collaboration and administration
MMPEI Mission and Goals

• Mission:
  To chart pathways to a secure, affordable and sustainable energy future.

• Goals:
  – Develop, coordinate and promote multidisciplinary energy research and education across the University
  – Grow the intellectual activity and infrastructure in key energy thrusts
  – Establish new faculty and research appointments that combine strengths in science/technology with those in public policy, business, economics and social sciences
  – Serve as a unified voice on energy research and education for the University
Strategic Approach

• Form interdisciplinary, vertically integrated teams in key thrusts
• Integrate public policy, economics and societal efforts in science and technology thrusts to produce realistic and holistic solutions to energy problems

- Clean, Low Carbon Electricity
- Energy Storage
- Sustainable Transportation
- Energy Policy, Economics and Societal Impact
Research Thrust: Clean, Low Carbon Electricity

• UM has significant strengths:
  – Nuclear Engineering (DOE e-hub), solar energy (DOE EFRC), wind (DOE/MPSC/industry)

• Integrate efforts to establish a leading center
  – Cover generation/storage/distribution and integration with carbon neutral buildings and vehicles
Research Thrust: Energy Storage

- Energy storage:
  - Batteries, hydrogen, ...
  - Improve energy & power density at reduced lifecycle cost

- Unique opportunities:
  - Convergence of Bio-Nano-Energy Sciences
  - Strong connection to future vehicle R&D and CN Electricity

Reproduced from Key, Distributed Power Program, Quarterly Review, 2001
Research Thrust: Transportation Systems and Fuels

- UM is at the center of the global automotive industry:
  - History of significant research funding and successful collaborations (GM, Ford, TARDEC,…)
  - Time to revolutionize the DNA of the automobile!

- Other potential sources:
  - Energy providers (petrochemical, utilities, …)
  - Agricultural/biotech industries
  - Emerging initiatives (green tech funds, economic stimuli for infrastructure & intelligent transportation)
Research Thrust: Energy Policy, Economics and Societal Impact

- Pathway to the implementation of technological solutions is via public policy, economics and societal impact
- Pursue a comprehensive approach to overcoming barriers to the implementation of technical solutions
Alternative Energy Technologies for Transportation (AETT)

- An international collaboration between the University of Michigan and Fraunhofer
- Seeded with $2.2M, 5 projects to foster innovative early-stage collaborations
- Addressing the increasing global demand for more efficient and sustainable technologies for transportation.
- The goals:
  - Develop alternative energy technologies for transportation and associated best manufacturing practices that minimize production costs.
  - Target projects with strong potential for external funding, technology transfer and commercialization.
- Discussions for the next phase of the program are on-going
Plug-in Hybrid Electric Vehicles: It’s all connected

- **Exploring PHEVs’ future - DOE - $2 million**
  Strong industry partners explore consumer expectations, impact on grid, greenhouse gas savings.

- **Vehicle to grid - NSF - $2 million**
  Multidisciplinary team looks at ways PHEVs could feed electricity back to the grid, for a fee.

- **Impact on Michigan - MPSC - $2.2 million**
  Assessing the impact of widespread adaptation on the environmental and electrical systems in the state.
Towards the Carbon Neutral Vehicle...
Overview of CERC-CVC

Dennis N. Assanis
Principal Investigator, CERC-CV
Director, Michigan Memorial Phoenix Energy Institute
The University of Michigan
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

- Biofuels
- CV
- CO₂
- PHEV
- CO₂
- Electricity
- Renewable Electricity
- Electrical Grid
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- Grid
- Petroleum
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Building The Dream Team

• Academic Partners in US and China
  - UM, OSU, M.I.T.
  - Tsinghua, SJTU, Wuhan, ...

• Government Entities
  - DOE, MOST, ORNL, SNL, JBEI, EPA, City of Ann Arbor, MEDC

• Committed Industry Partners in US and China
  - U.S. Charter Members: **Fraunhofer**, GM, Cummins, Ford
  - Other Members: Transportation Research Center, Toyota, First Energy, Chrysler, MAGNET, A123, American Electric Power
  - Chinese Members: Beijing Hyundai Automotive, DongFeng Motor Corporation, Chongqing Changan Automobile Co. Ltd, Geely Automotive

• $50M of funding over the next five years
Key Scientific and Technological Innovations

• New electrified vehicle architectures with optimized power management and controls

• 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
Industrial Partnership Structure

Goal: Establish effective collaboration with small and large businesses and augment DOE funding to achieve additional impact

- Two-tiered membership structure:
  - Large corporations provide larger annual membership fee; large corporations with multiple divisions and R&D interests can acquire up to 3 memberships
  - Small corporations provide smaller membership fee
- Each paid membership entitled to a representative on Industrial Advisory Board (IAB) and one vote (up to 3 for multi-division corps)
- Large corporations with 3 memberships will be designated as charter members and be eligible to serve on the executive committee
- Industrial funding will match DOE support and be directed to:
  - support additional students and faculty
  - set-up proof-of-concept test beds and
  - support collaborations with small or high-tech businesses.
Public-Private Partnerships

• Partnership between academia, government and private industry to accelerate the development of high-risk energy technologies
• Projects awarded based on both technical and business merit. Strong emphasis on “path to market.”
• Strong emphasis on collaboration
• Innovative intellectual property right policies
• Project cost-share required for any companies not fitting “small business” definition
UM-Shanghai Jiao Tong University Partnership

- Historical China-US academic partnership for more than 13 years
- Over 200 faculty members have visited, taught courses, given seminars at SJTU/UM
- Over 1,000 US and Chinese students have benefited in the partnership so far
- SJTU/UM Joint Institute with 800 enrolled students founded in 2006
- Active research collaborations in automotive, manufacturing, energy, biomedical engineering, and medical research.
- Joint Research Labs, Faculty Appointments, Research Workshops, Publications, IP

Kathryn Chen
UM-SJTU
Summer 2007
“... when I think of summer 2007, a great sense of satisfaction came into mind, because this is the most productive and meaningful summer in my life so far.”
The University of Michigan–Shanghai Jiao Tong University Collaboration on Renewable Energy Science and Technology & Collaboration on Biomedical Technologies

- U.S. and China are facing human-scale problems that will require global collaborations that bring together the world’s best scientists and engineers.
- The globalization of research is beginning to transform the way big problems are tackled, and UM will be at the forefront of this trend.

**Goals:**
- Develop new technologies that reduce global carbon emissions and their impact on climate change.
- Spur technological advances that improve human health.
The University of Michigan–Shanghai Jiao Tong University Collaboration on Renewable Energy Science and Technology & Collaboration on Biomedical Technologies

• A resolution on collaborative research committing each school to spending $3 million over the next five years.
• First six research teams with researchers from both U-M and SJTU announced in June 2010 at a ceremony in Shanghai.
• Each of the six winning teams receive $200,000.
• Projects were selected from 39 proposals — 20 in the biomedical technologies category and 19 for renewable energy projects.
The University of Michigan–Shanghai Jiao Tong University Collaboration on Renewable Energy Science and Technology

• High capacity Li-air batteries for electric vehicle applications
  Donald J. Siegel, Department of Mechanical Engineering, U-M; Zi-Feng Ma, Department of Chemical Engineering, SJTU; Xianxia Yuan, Department of Chemical Engineering, SJTU.
  Combine experiments and computational modeling to identify optimal cathode catalysts for Li-air batteries that could power low-cost electric vehicles with a driving range comparable to today’s gasoline-powered vehicles.

• High Efficiency Hybrid Solar Cells Based on Carbon Nanotube Enhanced Nanostructures
  Yafei Zhang, Research Institute of Micro/Nanometer Science & Technology, SJTU; Zhaohui Zhong, Department of Electrical Engineering and Computer Science, U-M.
  Integrate single-walled carbon nanotubes into existing silicon and polymer photovoltaic devices to create high-efficiency hybrid solar cells.

• Large panel integrated light transmitting and solar energy harvesting façade systems for net zero energy efficient buildings
  Harry Giles, College of Architecture and Urban Planning, UM; Lian Zhi Wei, Institute of Refrigeration and Air Conditioning, SJTU
  Build and test a prototype of a new, high-efficiency “smart façade” for buildings that captures solar energy, transmits light, provides enhanced insulation and is capable of changing its characteristics through sensor-based interaction with internal building climate controls.
2011 Michigan Meetings: Developing Global Sustainability — China/U.S. Partnerships

• Issues:
  – China and the United States use 30 percent of the world’s total energy expenditure, and are the largest emitters of greenhouse gases.
  – Both countries have major industrial complexes, urban population centers and expansive rural areas that require extensive water management.
  – Both countries’ population centers are dispersed over large geographic areas with economies that rely on extensive transportation networks.

• Focus on policies and technologies needed for energy, transportation, and water that meet the “Triple Bottom Line” of improved performance with reduced cost and reduced environmental impact, while effectively developing and supporting desired economic and social structure.
2011 Michigan Meetings: Developing Global Sustainability — China/U.S. Partnerships

- May 20-21, 2011 on the University of Michigan campus.
- Plenary sessions, panels, and concurrent sessions focusing on important aspects of the meeting’s three themes:
  - Sustainable Energy
  - Sustainable Transportation
  - Sustainable Water Resources.
- Planned participants:
  - U-M, Peking University, Shanghai Jiao Tong University, Tsinghua University faculty and students, as well as other Chinese and U.S. universities
  - Representatives from the energy, transportation and water industries, and government researchers.
Collaboration With State and Federal Agencies

- Increase collaboration with State and Federal agencies to augment resources and impact
  - Collaboration with federal agencies
    - DOE, EPA, DOD, DOT
    - Establish joint laboratories at UM North Campus Research Complex
  - Increase presence in Michigan
    - Focus a major thrust of the University Research Corridor on energy and sustainability
    - Become the home of MEDC Center(s) of Energy Excellence