HOOSIER HEAVY HYBRID Center of Excellence (H^3CoE) at Purdue University

PI: Greg Shaver
Purdue University
April 10th, 2012

Project ID #
TI023

Overview

Timeline

- Start – Oct 2011
- Finish – Sept 2016
- 13% Complete

Budget

- >$2,000,000 total
  - $1,000,000 from DOE
  - >$1,000,000 from Purdue & Industry Partners
- Funding for FY12
  - ~$200,000 from DOE
  - >~$200,000 from Purdue & Industry Partners

Barriers

- Barriers addressed
  - Lack of trained engineers and scientists: not enough trained in key areas of advanced energy efficiency vehicle technologies
  - Lack of advanced technology curricula: curricula specific to advanced vehicle technologies not available at a sufficient number of universities.

Partners

- Purdue – lead
- Industry – to date

ESN® ENERGY SYSTEMS NETWORK

Cummins®

Relevance - Objective

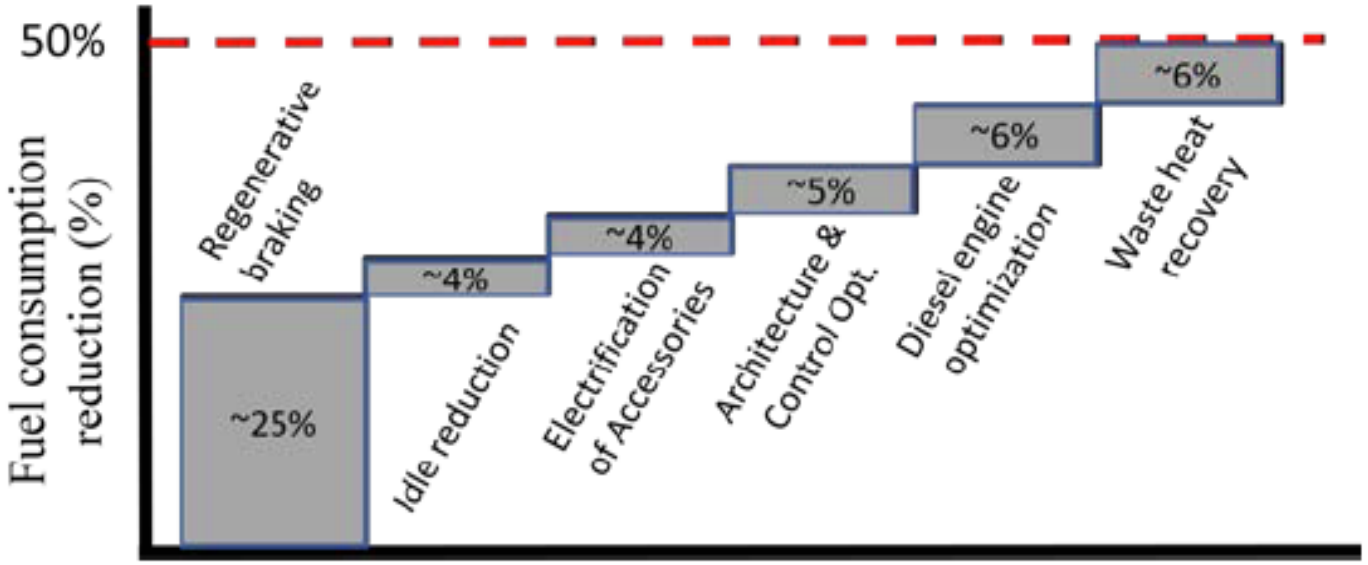
Establish a GATE Center of Excellence that provides multidisciplinary engineering training for graduate students in advanced automotive technology to overcome technology barriers preventing the development and production of cost-effective vehicles for the US market.

Relevance - Motivation

- 21M barrels/day oil usage in U.S.
- 7.6M barrels/day in China, but 9% annual growth
  - Bus market: 11% annual growth rate
  - Heavy truck: 32% annual growth rate
- Heavy vehicle (average)
  - 6.2mpg (vs. 21 for auto/light truck)
  - 74,000 miles/year (vs. 11,000 for auto/light truck)
  - 12,000 gallons/year (vs. 570 for auto/light truck)
- Growth in fuel use tied to heavy vehicles…also target for reduction

Relevance - Motivation

Fuel consumption reduction possibilities for medium/heavy vehicle



Challenges:

- Large braking energy rates
- Engine stop/start (large start torque; aftertreatment management)
- Packaging constraints
- Sub-systems not optimized for hybrids use
- Large diversity of vehicle sizes & duty cycles

Milestone Status

(FY12 – 10/2011-9/2012)

Milestone	Due Date	Status
Finalize strategy/get approvals for Hybrid Vehicle Systems Certificate Program	end of Q2 of 2012	On track.
Select 1st H3CoE fellowship student	end of Q1 of 2012	Complete. First student selected.
Commence research project(s)	end of Q1 of 2012	Complete. First research project (co-funded by Cummins) is under way.
Approval of new course on "Electrification of medium/heavy duty vehicle"	end of Q1 of 2012	Complete.
Deploy website	end of Q1 of 2012	Delayed. Anticipated launch by end of April 2012.

Recurring Milestones	Due Date	Status
Meeting of the project management team.	2011 Q4	Complete.
Meeting of the Industrial Advisory Committee (IAC)	2011 Q4	Phone calls with Delphi, Cummins, and Allison. Meetings with Cummins. Email exchange with Remy, AM General, and Navistar.
External Seminar Speaker	2012 Q1	Delayed until certificate program and IAC established
Poster Show	2012 Q1	Delayed until certificate program and IAC established
Meeting of the project management team.	2012 Q2	Complete.
Poster Show	2012 Q3	Future.
External Seminar Speaker	2012 Q3	Future.
Workshop	2012 Q3	Future.
Meeting of the project management team.	2012 Q3	Future.

Deployment Strategy

1) Provide 7 H^3CoE Research Fellowships & industry-driven/funded projects to address challenges and unique opportunities for medium/heavy-duty hybrid vehicles.

2) Deploy/enhance course content, and provide a Hybrid Vehicle Systems Certificate (HVSC).

3) Partner with regional industry partners that manufacture medium/heavy-duty hybrid vehicle components.

4) Use the web to provide access to papers, presentations, certificate/fellowship programs, and advertise workshops (yearly), seminars (monthly), and poster shows (2/yr).

1st H3CoE Co-Funded Project :

Enabling Plug-In Capability and Engine Optimization for a Heavy-Duty Hybrid Vehicle System via Advanced Power Electronics

- **Industrial partner:** Cummins
- **Hardware Contributions for Phase 1 and 2:** Hybrid system including motor, power electronics, controllers, and battery
- **Budget Outline**
  - Duration: 3/15/2012 – 3/14/2014 (2 years)
  - 2 graduate students fellows
    - stipends via DOE, tuition via Purdue
  - $15K for equipment/supplies
  - $6K travel
  - Faculty AY/summer support
  - Total cost = $346,257
    - Purdue: $104,576 (30.2% of total)
    - DOE: $84,000 (24.3% of total)
    - Cummins: $157,681 (45.5% of total)

New Course – ECE595 (HEVs)

- Recently approved – 1st offering in Fall 2012
- Faculty: Oleg Wasynczuk and Maryam Saeedifard
- Description: Into. to architectures and technologies associated with electric and HEVs including their constituent components.
- Pre-reqs: ECE 321 and ECE433, or Graduate Standing
- Assessment method: 4 projects using Matlab/Simulink
- Expect enrollment: 10-20

Progress

- Certificate Program
  - Seeking plan approval

Exhibit I **Hybrids Vehicle Systems Certificate (HVSC) Approved Course List and Requirements**		
Section 1		
Take ME 597 Hybrid Vehicle Systems Workshop and Seminar, four times during consecutive academic year terms. This class meets monthly, is graded Pass/Fail and includes a poster presentation. A workshop is included in alternating semesters at the instructor's discretion. (one credit course)		
Section 2		
Complete at least one three credit class from **each** of the following areas:		
Architecture (take one)	**Energy Storage or Controls (take one)**	**Prime Mover (i.e., motor/engine) (take one)**
ABE691M/ME697M Hyd. powertrains & hybrid transmission	ChE 500 Introduction to Energy Storage Systems	ME540 – Internal Combustion Engines
ECE595 Hybrid Electric Vehicles	MSE597 Design and simulation of rechargeable batteries	ECE610 Energy Conversion
	ME575 Theory and design of control systems	ABE591M/ME597M Design and modeling of fluid power systems

- Website launch
  - April 2012

Collaborators

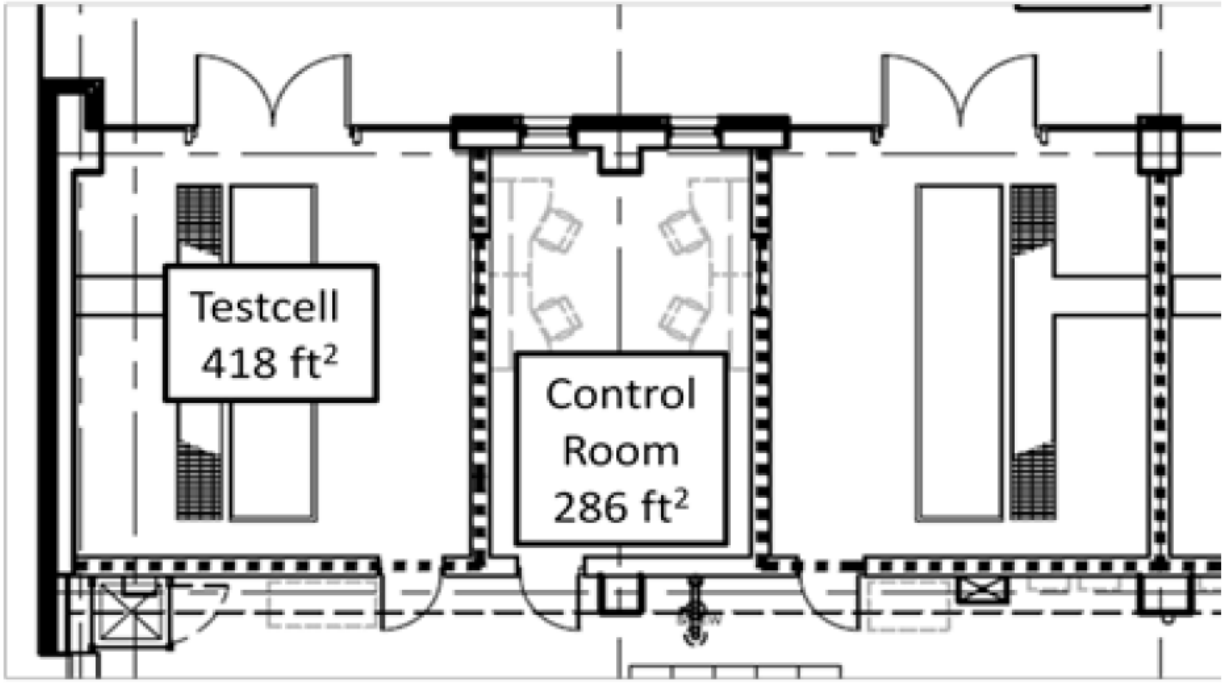
- Cummins
  - Co-sponsoring research project
- Allison, Delphi, Remy, AM General, and Navistar
  - In discussion regarding membership in Industrial Advisory Committee (IAC) and research project co-sponsorship.

Proposed Future Work

- FY12 (10/2011 – 9/2012)
  - Hold a poster show, workshop, and external seminar speaker in 2011 Q3
  - Establish additional research projects that are co-sponsored by industry (with student specific support coming by way of Purdue and DOE).
- FY13 (10/2012-9/2013)
  - Continue regular poster shows, seminar series, workshops, and industry co-funded research projects.

Future Work: Open New Herrick Labs

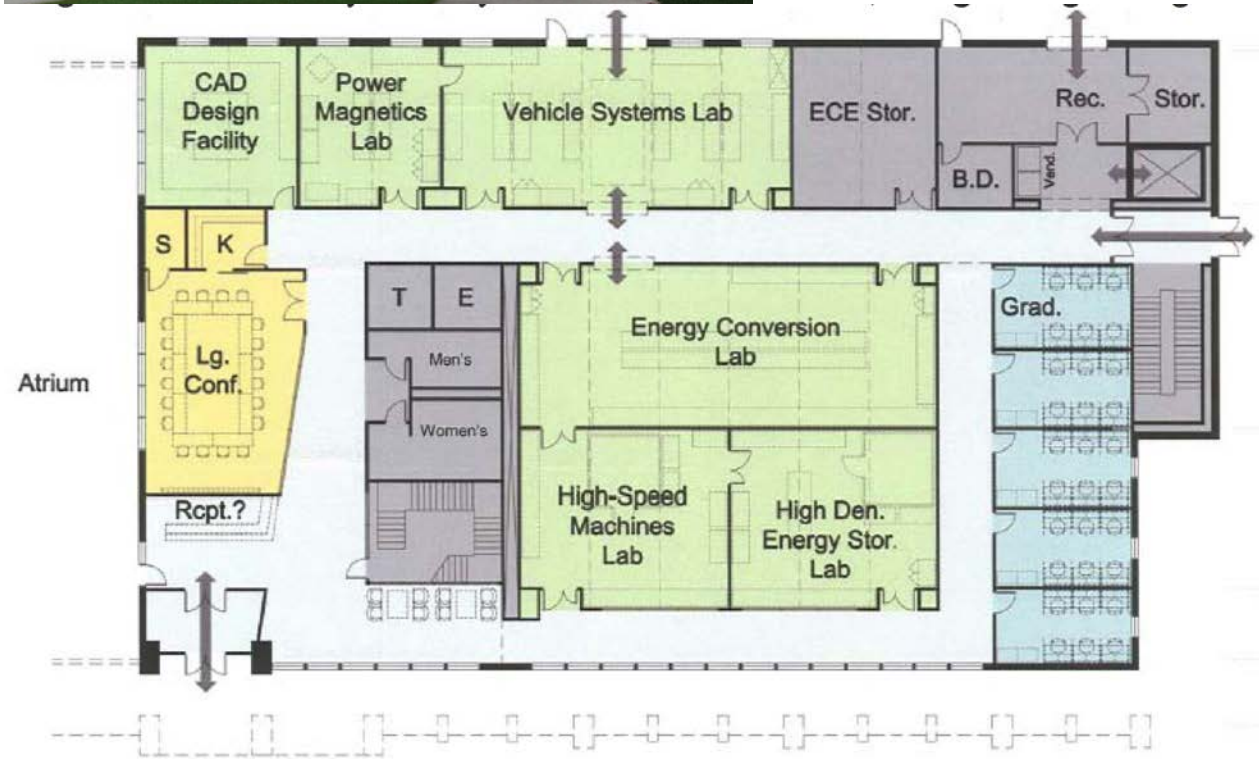
- Phase 1 (of 3)
- 52,000 sq. ft.
- Includes 4 powertrain test cells for advanced medium & heavy duty hybrid powertrains
- Scheduled to open in spring 2013



Layout for cells 1 and 2 (same for 3 & 4)

Future Work: Open New Wang Hall

- Scheduled to open in Spring 2013.



Includes expanded Labs for:

- Power Magnetics
- Vehicle Systems Energy Conversion, and
- High Density Storage

Summary

- Purdue GATE Hoosier Heavy Hybrid Center of Excellence (H^3CoE) project initiated in Oct. 2011.
- Focus on medium and heavy-duty hybrid vehicles.
  - Certificate program
  - Industry co-funded research projects
  - H3CoE Fellowship program
- 1st co-funded project initiated with Cummins on advanced power electronics.
  - In discussions with Allison, AM General, Navistar, and Delphi.
- Seeking final approval for certificate program