



**HOOSIER HEAVY HYBRID
Center of Excellence (H³CoE) at
Purdue University**

PI: Greg Shaver
Purdue University
May 15th, 2013

Project ID #
TI023

Timeline

- Start – Oct 2011
- Finish – Sept 2016
- 31% Complete

Budget

- >\$2,000,000 total
 - \$1,000,000 from DOE
 - >\$1,000,000 from Purdue & Industry Partners
- DOE funding to date
 - \$463,128 received
 - \$22,048 spent (travel+1 yr. fellow stipend)
- Cummins funding to date
 - \$157,681 received
 - \$26,242 spent

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

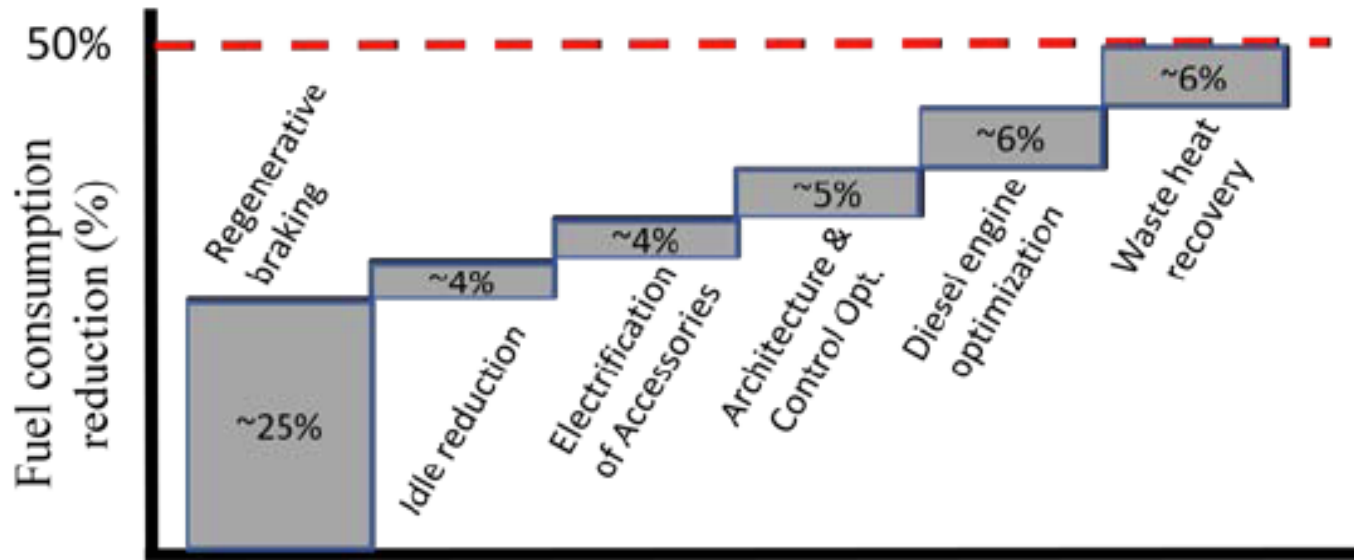
- Purdue – lead
- Industry – to date



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.

- 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

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

- Provide H³CoE Research Fellowships & industry-driven/funded projects to address challenges and unique opportunities for medium/heavy-duty hybrid vehicles
 - 1st Fellow: currently working on a Cummins co-funded activity (since August 2012)
 - 2nd Fellow: to start on same project in August 2013
 - 3rd Fellow: candidate identified, would start Summer 2013
 - 4th Fellow: candidate identified, would start Aug. 2013
 - **Biggest challenge so far: industry co-support of projects**
- Deploy/enhance course content, and provide a Hybrid Vehicle Systems Certificate (HVSC).
 - New HEV course, offered in Fall '12 (again in Fall '13)
 - Certificate program final approval in Fall 2012 (1st interdisciplinary certificate at Purdue!) 12 students so far

- Partner with regional industry partners that manufacture medium/heavy-duty hybrid vehicle components.
 - Strong partnership with Cummins
 - Co-funding a DOE GATE Power Electronics project
 - Discussions ongoing for a 2nd co-funded DOE GATE project
 - \$1M in support of “Cummins Power Lab” in new Purdue facility
 - Others developing more slowly
- Use the web to provide information, including fellowship and certificate program details, and research projects.
 - Website launched this spring

1st H³CoE Co-Funded Project :

Enabling Plug-In Capability 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)

- 1st offering in Fall 2012 (2nd in Fall 2013)
- Faculty: Oleg Wasynczuk and Maryam Saeedifard
- Description: Intro. 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
- Fall '12 enrollment: 28

- Final approval in Fall '12
- 1st Interdisciplinary certificate program at Purdue!
- Students required to:
 - take 1 class in each of 3 areas
 - Attend one poster show/workshop

Architecture (complete one)
ABE 69100/ME 69700 <i>Hydraulic Power Trains & Hybrid Systems</i>
ECE 59500 <i>Hybrid Electric Vehicles</i>
Energy Storage or Controls (complete one)
CHE 50000 <i>Intro to Energy Storage Systems</i>
MSE 59700 <i>Design & Simulation of Rechargeable Batteries</i>
ME 57500 <i>Theory & Design of Control Systems</i>
Prime Mover (i.e. motor/engine) (complete one)
ECE 61000 <i>Energy Conversion</i>
ABE 59100/ME 59700 <i>Design & Modeling of Fluid Power Systems</i>
ME 54000 <i>Internal Combustion Engines</i>

www.purdue.edu/discoverypark/h3coe/



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Hoosier Heavy Hybrid Center of Excellence (H3CoE) at Purdue University

Advanced Ground Vehicle
Power at Purdue

Multidisciplinary research is
leading to clean, efficient,
fuel-flexible vehicles.

**Multidisciplinary research leading to clean, efficient, fuel-flexible vehicles**

March 27, 2013

Tight budgets, environmental pressures and rising energy demand – all challenges facing the world today. The International Energy Agency (IEA) says the highest priority should be on becoming energy-efficient, as this offers the highest potential for



Contact Us

Dr. Gregory Shaver

Associate Professor

School of Mechanical
Engineering

e-mail: gshaver@purdue.edu

News

Purdue Aims to Fill Engineer Shortage with Hybrid Program

February 12, 2013

A certificate program aimed at addressing the shortage of engineering graduates with experience in heavy hybrid programs has been developed at Purdue. The program administered through Purdue's mechanical engineering program, was developed for the Hoosier

HOOSIER HEAVY HYBRIDS CENTER OF EXCELLENCE

The Hoosier Heavy Hybrid Center of Excellence (H3CoE) is a five-year funded project by the Department of Energy (DOE) Graduate Automotive Technology Education (GATE) program. The objective of this center is to comprehensively train, educate, and equip the next generation of research scientists and engineers to address technical challenges (and respond to opportunities) unique to medium/heavy-duty hybrid vehicles - which to date have prevented the deployment of cost effective, highly efficiency commercial vehicles for the U.S. and global markets.

The project, which falls under the umbrella of the Purdue Energy Center Advanced Ground Vehicle Power and Energy Storage initiatives, seeks to help identify technology pathways for a 50 percent reduction in commercial vehicle fuel consumption and greenhouse gas emissions. The five-year project began Oct. 1, 2011.

The H3CoE has developed, and is currently running, two new programs at Purdue, including the Hybrid Vehicle Systems (HVS) Certificate, and GATE Fellowship programs.

Hybrid Vehicle Systems Certificate

The Hybrid Vehicle Systems (HVS) Certificate is available to graduate students in good standing in the Schools of Mechanical, Agricultural and Biological Engineering, Chemical Engineering, Materials Engineering and Electrical and Computer Engineering. The certificate program is focused on providing students a framework for gaining relevant expertise in the area of advanced hybrid vehicle systems. The HVS Certificate requires 9 hours of graduate level coursework along with attendance/passing at one HVS workshop or poster show. A full description of the eligibility requirements and steps to apply for the HVS Certificate Program can be found [here](#).

H3CoE Fellowships

Through a combination of funding from DOE, Purdue, and industry partners, the H3CoE pairs faculty-advised graduate students with industry partners on industry-driven projects focused on solving challenges unique to medium/heavy-duty hybrid vehicles. For more information about current project, [click here](#).

Links

- [DOE](#)

Facilities

- [The Ray W. Herrick Laboratories](#)
- [The Maha Fluid Power Research Center](#)
- [The Energy Conversion Research Laboratory](#)
- [The Purdue Power Magnetics Laboratory](#)
- New Construction – Cummins Power Lab at Purdue (Fall 2012)
- New Construction – Seng-Liang Wang Hall (Jan. 2013)
- The "Cyber Cell" for Hybrid System Testing at the Cummins Technical Center

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Certificate Program - Hoosi... X



Contact Us

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Associate Professor
School of Mechanical
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e-mail:
gshaver@purdue.edu

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Hybrid Vehicle Systems Certificate

Administered by the School of Mechanical Engineering – Purdue University

Introduction

The Hybrid Vehicle Systems (HVS) Certificate is available to graduate students in the Schools of Mechanical, Agricultural and Biological Engineering, Chemical Engineering, Materials Engineering and Electrical and Computer Engineering. The HVS Certificate requires 9 hours of graduate level coursework along with attendance/passing at one HVS workshop or poster show. Below are the eligibility requirements and steps to apply for the HVS Certificate Program.

1. Any degree seeking graduate student in good standing (cumulative GPA of 3.0 or higher) in one of the Purdue Schools of Engineering listed above, on West Lafayette campus only, may be considered for admission to the HVS Certificate program.
2. Purdue students initially apply to the program by submitting the **Preliminary Application Form (Click here to download)** to the HVS Certificate Program (the ME Graduate Office). The student's major professor's signature is required on the application form.
3. The preliminary application form will be reviewed and if approved, the student will be advised to complete the Purdue Graduate School application specifically for the Hybrid Vehicle Systems certificate program. The Graduate School application will require payment of the application fee. This fee is currently \$60 for domestic student and \$75 for international students.
4. The HVS Certificate program requires completion of 9 hours of graduate level coursework selected from the approved course list. The courses must be completed with a grade. The approved course list and requirements are on the **HVS Certificate Program – Worksheet (Click here to download)**.
5. In addition to the coursework, the certificate requires attendance/passing at one HVS workshop or poster show.
6. A minimum GPA of 3.0 must be maintained for all graded courses applied to the certificate. Grades of B- or below are not allowed.

Links

- [DOE](#)

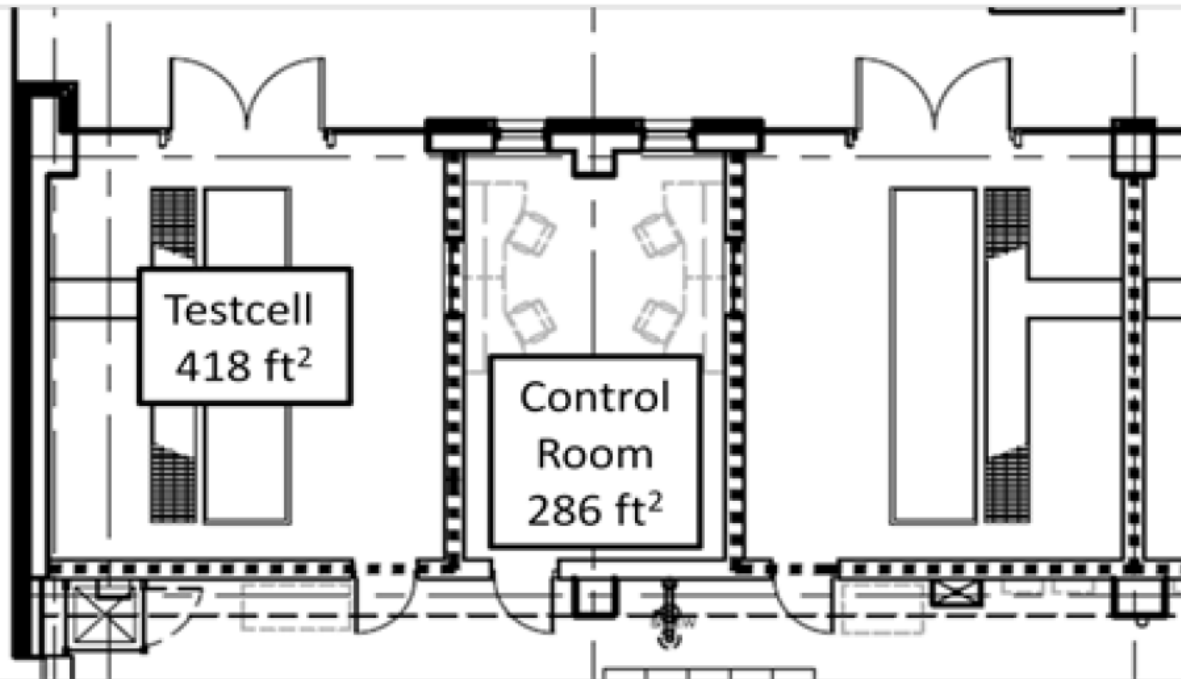
Facilities

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- [The Purdue Power Magnetism Laboratory](#)
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- Cummins
 - Co-sponsoring research project
- Allison, Precision Air, John Deere
 - In discussion regarding research project co-sponsorship.

- FY13 (10/2012 – 9/2013)
 - Hold a poster show/workshop in 2013 Q3
 - Continue focus on starting additional research projects that are co-sponsored by industry.
 - Begin move into new Cummins Power Lab
 - Hold another call out for certificate program in 9/2013
- FY14 (10/2013-9/2014)
 - Continue regular poster shows/workshops, and industry co-funded research projects.
 - Grow # of students in certificate program.

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



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

View from north east



View of cell #1 & control room from north



View of cell #3 from north



View of cell #3



View of cell #3



Control room window
from w/in test cell



Control room #1



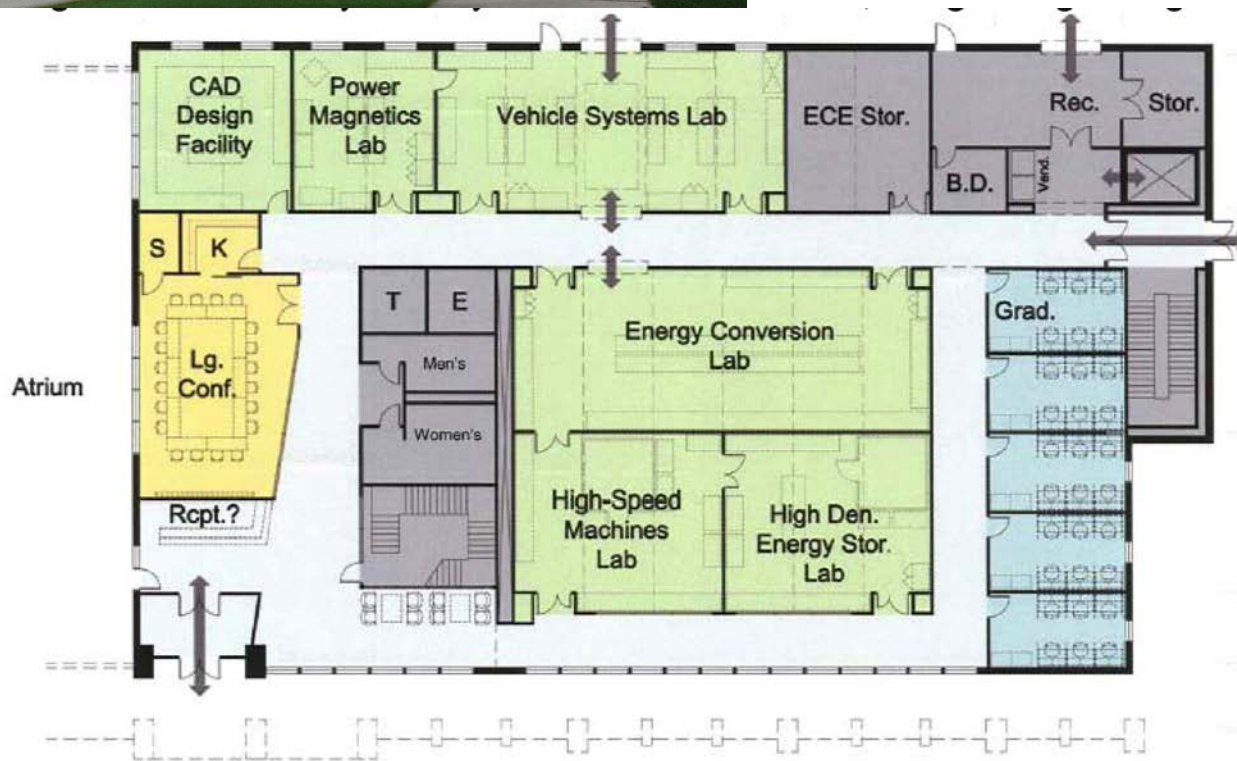
Control room window
from w/in test cell



South view of powertrain
area from w/in building



- Scheduled to open in 2014.



Includes expanded
Labs for:

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

- Purdue GATE Hoosier Heavy Hybrid Center of Excellence (H³CoE) 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.
 - Efforts underway to secure additional
- Final approval for certificate program, 12 students so far
- New facilities will enhance/enable efforts of H3CoE