Advanced Electric Drive Vehicle Education Program: CSU Ventures

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CSU Ventures
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Project ID:ARRAVT033

This presentation does not contain any proprietary, confidential, or otherwise restricted information
Overview

Timeline
- Project start date: Dec 2009
- Project end date: Dec 2012
- Percent complete:
  - 24% in February 2011
  - 34% in May 2011

Barriers
- Parochial processes at educational institutions
- Acceptance of new training methods and approaches
- Budget and resource considerations at secondary schools and colleges

Budget
- Total project funding
  - DOE share: $4,999,834
  - Contractor share: $1,497,599
  - Fully funded in Dec 2009

Partners
- Interactions/collaborations:
  - OEMs, US Army, USMC, Colorado Governor’s Energy Office (CO), CO and WY TAG, Veterans for Green Jobs, Poudre School District (Larimer County, CO)
- Project team:
  - Colorado State University (CSU), Georgia Tech (GT), Ricardo, MRI, Arapahoe Community College, Douglas County Education Foundation
Objective: A virtual continuous cycle to engage and train students, create jobs, help the HEV segment speed time to market and increase consumer confidence.

Impacts
1. Increased student enrollment
2. Increased training effectiveness in HEV segment
3. Fill projected job shortages
4. Catalyst to quality job creation
5. Speed HEV segment time to market
6. Help industry gain needed infrastructure
7. Wider adoption as industry best practice
Automotive Industry Status:

- Projected 40% to 50% shortage of qualified vehicle technicians over the next 5 to 10 years\(^1\).
- Estimated shortage of 60,000 qualified technicians\(^2\) currently.
- This situation is further complicated by:
  - the introduction of new propulsion technologies such as hybrid-electric vehicles (HEV), all electric vehicles (EV), and their associated support systems.
- Shortage of qualified mechanical or vehicle engineers to support industry

“Kent Niederhofer can’t find enough mechanical engineers to work for him — in southeastern Michigan. You know, where Detroit is, with its 13.3% unemployment rate. Niederhofer is president of the American branch of Ricardo, an engineering consultancy that designs the power trains of some of the coolest stuff around: Bugatti sports cars, huge wind turbines and unmanned aerial vehicles.”\(^3\)

**Bottom Line:** Industry is suffering from an aging workforce and a decade of poor and unrewarding employment opportunities

2. [http://www.doityourself.com/stry/technicianshortage](http://www.doityourself.com/stry/technicianshortage)
3. [http://www.time.com/time/business/article/0,8599,2040964,00.html#ixzz1G22Cj40e](http://www.time.com/time/business/article/0,8599,2040964,00.html#ixzz1G22Cj40e)
The United States continues to lag behind in Science, Technology, Engineering and Mathematics (STEM) on the world stage*

- Through the introduction of relevant examples and technologies in middle school and high school, interest in STEM may be encouraged (model following International Society for Neuroscience - Brain Awareness Week)
- Through student job site visits and outreach with students and parents, opportunities in the automotive and PHEV fields are being communicated (Career Connect)

*On the 2006 Program for International Student Assessment (PISA) mathematics assessment, the United States ranked 24th out of 30 countries belonging to the Organization for Economic Cooperation and Development (OECD), which represents the world’s most advanced countries; and 17th out of 30 on science.

Focus on a job funnel path for under represented groups such as veterans, women and Native Americans

Veterans and Special Interest Organizations → Technician Training → Automotive Repair Industry

VA Financial assistance
Support of the President’s Jobs Initiative:

- **Automotive technician jobs:**
  - Automotive technician jobs already exist...do not need to be created, only filled.
  - Automotive technicians cannot be out-sourced.
  - Number of vehicles on road continues to increase (approximately 150M vehicles -7% -10% new technology vehicles entering market per year, goal of 1 million by 2015).
  - Jobs not minimum wage and easily expand to $70,000 to $80,000 per year with experience.

- **Increased opportunities for women in traditionally all-male work force/environment (1.6% women by occupation).**

- **Approximately 25% of our returning veterans are unemployed (the National Guard is higher).**

- **With changes in technology, opportunities exist for disabled workers and Wounded Warriors.**

Summary - Create a multi-linked approach that combines PHEV education from secondary through postgraduate/professional courses.

• **Secondary Schools**
  - Educate secondary school teachers on PHEVs
  - Provide examples for inclusion in science and math classroom lectures
  - Provide hands-on exploratory lab boxes

• **Technician Training**
  - Incorporate PHEV concepts in technician training
  - Explore new ways to train technicians using virtual reality.
  - Add PHEV safety for technicians and first responders

• **Develop courses for undergraduate, graduate and professional education**
• **Develop an outreach program that reaches the students and community.**
• **Create job-filling paths directly targeting under-represented groups**
Approach – Secondary School Teacher Education Program

Rationale of approach: maintain sustainable education by training teachers to integrate the fundamental principles of PHEVs in existing curriculum a) updates & enhances STEM; b) provides teachers with opportunity for professional development c) includes 21st century workforce skills

Industry Needs • PHEV Core Concepts “fact sheet” of important principles that underlie HEV technology • State/Nat’l Education Standards “How to incorporate HEV Ed into the 6th-12th grade classroom”

PHEV Curriculum Activities

Teacher Continuing Education Training ONSITE

• Lecture Series • Overview • Technical components

• Workshop • Demonstrations + • Exercises + • Experiments for the classroom

• Internet Links & Resources • Professional contacts • academic • workforce/Community Colleges • Industry

Archive for future/remote use (webinar)

Training offered to all teachers and counselors to better integrate information across disciplines

Partnership w/ district schools:
Poudre School District (Larimer County) & Douglas County Education Foundation

Take back into the classroom
### Milestones & Projected Timeline

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<thead>
<tr>
<th>Sept 2010</th>
<th>Nov 2010</th>
<th>Dec 2010</th>
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<tbody>
<tr>
<td>Attended STEMapalooza (local Science &amp; Engineering Outreach Event) to gather proof of concept on potential outreach approaches</td>
<td>Finalized outline of Educational Outreach approach for middle &amp; high schools</td>
<td>Identified availability of potential STEM partners:</td>
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<td>E.g., CSU-CNS-Educational Outreach Center, CSU Clean Energy Cluster, Colorado Clean Energy Cluster</td>
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<td>Established formal partnerships with School districts</td>
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### Career Connect – Approximately Every Month at DC High Schools

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<tr>
<th>Jan 2011</th>
<th>Mar 2011</th>
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<tr>
<td>Established relationship with Fort Collins Museum &amp; Discovery Science Center</td>
<td>Observe input from teachers regarding Teacher Training Workshop for incorporating PHEV Ed into existing curriculum</td>
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<td>Began to Identify PHEV Core Concepts (CC)</td>
<td>Begin organizing existing lessons &amp; creating prototype curriculum activities (labs, classroom exercises) for Teacher Training Workshop</td>
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<td>Align CC to Educational Standards</td>
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Career Connect has had 4 sessions at 3 different businesses for 23 students
Approach / Accomplishments – Secondary School Teacher Education Program

Milestones & Projected Timeline

**Apr 2011**
- Finalize PHEV Ed Core Concepts & their alignment with Educational Standards
- Formal announcement of Teacher Training & Workshop Summer Program to PSD & DCSD through district sites & STEM sites
- Recruitment of teachers/counselors via school visits by STEM coordinator

**May 2011**
- Develop PHEV Ed presentations for Teacher Training Workshop:
  - “Overview of PHEV CC”
  - “How to incorporate PHEV ED into the current classroom”

**June 2011**
- Finalize speakers for Teacher Training Workshop
- Review presentation materials
- Identify workshop partners for teachers

**July 2011**
- Finalize Teacher Workshop curriculum classroom demos/activities

**Aug 2011**
- Teacher Training Workshop Summer Program

**Aug-2011-May 2012**
- Implementation of PHEV Ed in the classroom by the participating teachers
- Assist them in their efforts (CSU engineers, industry professionals, grad students)

**Oct 2011**
- 1st Follow-up Report due from participating Teachers of how/when they will incorporate summer Workshop resources into their classes
- Adjust /assist in any barriers or pitfalls

**June 2012**
- 2nd Follow-up Report due from participating Teachers of how/when they incorporated summer Workshop resources into their classes

**Potential for “PHEV Awareness Week” at schools; hands-on activity exhibits created by students for students & community; outside speakers/guests/exhibits from civic groups & industry**

**CSU Ventures**
Speeding Technology to the Global Marketplace
• Technician Training - PHEV safety has been integrated into the automotive degree and paramedic certificate programs - more than 100 college students have been exposed to his new material
  • All vehicles and equipment ordered and received at both ACC and Ponderosa High School (via Douglas County Education Foundation)
  • Short course for practicing technicians completed and offered 3 times
    • Failed to enroll critical number in course twice (OEMs offering their own courses to their dealers)

• First Responder Training put on hold pending resolution of teaming with NFPA (recommendation from 2010 Merit Review)
  • Participated in technical review of WVU - NAFTC First Responder Training program in July 2010
  • Attended NFPA workshop in November 2010

• Virtual Reality Training Component - has been delayed
  • 3D drawings required and in process of being obtained
  • Will hold course in March 2011 regardless of enrollment
• Survey and meet with industry to determine educational requirements/topics for inclusion in courses
  • Status: Survey in progress with draft available at review

• Develop undergraduate PHEV course and share between CSU and GT
  • HEV Powertrains course taught Fall 2010 through distance learning, with location at GT and delivered through technology to CSU. This course will also be taught Spring 2011 semester at CSU campus
  • Vehicle Energy Storage System Design course in development and scheduled to be taught Fall 2011 semester, both at CSU as well as through Distance Learning, for credit at GT

• Develop graduate courses as listed below:
  • Simulation-Based Design of Hybrid-Electric Vehicles course is being developed and will be taught in Spring 2012 at GT distance learning offered to CSU
  • Control Engineering in Hybrid-Electric Vehicle Propulsion Systems is being developed and will be taught in Fall 2012 at GT with distance learning offered to CSU
  • Transportation Electrification course scheduled Fall semester 2011 at CSU with distance learning offered to GT
  • EV/HEV Computational System Design course scheduled for Spring semester 2012 at CSU with distance learning offered to GT

• Develop professional short courses
  • PHEV/HEV short course 80% complete – ready summer 2011
  • Additional PHEV short courses will be defined based on survey results
  • Course for engineers on Maintenance Theory and Practices for Vehicles/PHEVs offered summer 2011
Projected Outcomes & Integration of Overall Outreach Program

Incorporates PHEV core content into current courses for enhancing STEM curriculum

HEV Exhibit for programs at schools, museums & community events

Teacher training

College Engineering Students taking newly formed HEV courses, involved with Summer Teacher Training Workshop & demos in the classroom, opportunity to participate in public education events

Middle & High school students

• Social Media
• Web – getev.org
• Community Events
• Colorado Clean Energy Cluster and more!

Higher Ed Engineering & Auto Tech programs - high school students are better prepared to enter higher educational programs

Several layers of integration across organizations
Approach / Community Outreach: Public Exhibits

**HEV Core Concepts**

Creation of PHEV Exhibits for Public Programs at local Museums & Community events

- Ft Collins New West Fest, Nelsen’s Old Town Car Show, Rocky Mountain Sustainable Living Fair, STEMapalooza, Odyssey 2012

“Innovation Center” (under construction - opening 2012) of Fort Collins Museum & Science Discovery Center

- highlights local projects (e.g., Clean Energy research at CSU-Clean Energy Cluster)
- 5000 sq feet, of traveling exhibit space
- potential for temporary exhibit in new space following new building opening;

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**Jan 2011**

Established relationship with Fort Collins Museum & Discovery Science Center

**Feb 2011**

Began to Identify PHEV Core Concepts (CC)- what should the general public need to know about PHEV technology?

Outlined plans for Exhibit #1

-Mockup of HEV without the body of the car to illustrate the inner workings of HEVs by using a static display of system components
- Power/energy flows through the system at different phases in the vehicle’s performance will be demonstrated by a series of LEDs

**Mar-May 2011**

Create HEV Exhibit

- obtain components (assistance from Ricardo, OEM, auto parts reps)
- assemble supports/frame with components & external LEDs
- compartmentalized for travel
- Review with Ricardo & Museum reps for accuracy & optimum public reception

**Beginning Summer 2011**

Display Exhibit:

- community locations & events
- Museum
- Teacher Training Workshop
- schools
Identified existing Veteran Resources & Services organizational Events

Form partnership with Veteran Services Groups:
- Participate in agenda of Veteran Events already established:
  - Local (FOCO/Littleton area) Vet. of foreign wars, American Legion, Rotary, Senators events, Governors events for vets
  - Larimer & Arapahoe/Douglas County Workforce Centers
  - CO Vet Services
  - Fed Vet Services, TAPS

Created an informational presentation about PHEV Core Concepts, auto industry/workforce needs

Highlights challenges in the industry and technology; industry & DOL projections

Describes various levels of workforce: from auto tech, master tech to engineering research

Relates the requirements/abilities needed for each job

Explains "How to get there" for each job; requirements & further training; ACCs HEV short course for experienced auto techs, to AA degree, to CSU Undergraduate Graduate/Masters degree program

Includes videos/animation/exhibit or guest speaker where appropriate

Coordinated efforts with representatives from ACC & CSU Veterans resources/financial aid/pre-enrollment/recruitment programs

ACC & CSU provide overview of GIBill/financial aid program

Provide information on how to apply; review website, demonstration

Provide handouts about information presented

Present PHEV Pipeline Program --Partner with ACC & CSU to present information at events sponsored by other veteran service organizations

Larimer County Workforce Workshop/other events

Rotary, Vet of For Wars, Am Legion events

Congressional/Gov ernor's sponsored Vet events

CO Vet events

Federal Vet events/training websites

Follow-up & evaluate with CSU & ACC veteran services/financial aid program reps and participating veterans to evaluate our informational pipeline program

Formal Independent Evaluation

Institutional exchange of data enrollment

surveymonkey.com
Approach / Accomplishments for Underrepresented Groups

• Approach - follow similar model for women and Native Americans as with veterans

• Accomplishments
  • Meeting with local advocacy organizations
    • Colorado and Wyoming National Guard (TAG) ref vets
    • CSU student veterans groups and CSU Veteran Program Office
    • Society of Women Engineers (SWE) at CSU
    • Colorado State University Society for Advancement of Chicanos and Native Americans in Science (CSU-SACNAS)
  • Met with the Colorado Department of Labor and Governor’s Energy Office to discuss job creation
  • Meetings in progress with major corporations and local automotive repair organizations to develop scholarship programs/work-study internship, and employment opportunities
  • Exploring relationships with tribal colleges and American Indian Higher Education Consortium
  • Integrating into Georgia via GT and exploring national presence/effort
  • There are no “Go/No-Go” events for this effort

“Never, Never, Never Give Up” Winston Churchill
Collaboration & Coordination

- **Internal Partners**
  - CSU and Georgia Tech: Research universities developing and teaching courses (undergraduate and graduate) that will be co-taught at both institutions.
  - CSU School of Occupational Therapy: Investigation methods of changing automotive technician maintenance approach to allow for more disabled workers to participate. CSU OT School is a major participant with the VA working with Wounded Warriors.

- **Collaborators: working with the following organizations**
  - Veterans for Green Jobs: Funnel process to focus returning veterans into this industry. Approaching public and private organizations for support.
  - WVU-NAFTC and NFPA on First Responders training
  - Purdue on use of EV Hub (part of HUBzero)
  - Colorado Clean Energy Cluster to co-host regional Odyssey with WVU in 2012
  - Working with numerous agencies/organizations, both Government, Not For Profits and industry for job development

- **Future Collaborations**
  - Will explore with other grant awardees about sharing course materials and possible co-teaching courses
### Major Milestones for Year 2

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Milestone or Go/No-Go Decision</th>
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<tbody>
<tr>
<td>March 2011</td>
<td>Demonstration of first level virtual reality training. (delayed, moved next milestone to October 2011 based on receiving 3D drawings and ACC courses for filming). Go/No-Go will depend on value added and be decided in June 2011.</td>
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<tr>
<td>May 2011</td>
<td>First Responder training and NFPA interaction/collaboration</td>
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<td>July 2011</td>
<td>Beta testing of outreach collaborative space. Implement by December 2011 (on schedule). Inclusion and porting to EV Hub will be decided in July 2011</td>
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<tr>
<td>September 2011</td>
<td>First short course offering. Go/No-Go decision...is enrollment sufficient to pay for course offering? (on schedule)</td>
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<td>Other schedules are contained in individual topical areas.</td>
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Future Activities

• **Year 2:**

  • Complete approval for graduate certificate in Electric Transportation (CSU).
  
  • Complete development of laboratory facilities at CSU to support university-level education program and courses developed under this grant (equipment privately funded).
  
  • Develop training animations of technicians properly repairing virtual vehicles for playback on a dedicated computer with a Head Mounted Display.
  
  • Continue college level course development.
  
  • Continue outreach and development of collaborative space for education and community.
  
  • Continue interaction and cooperation with other grant awardees so as to leverage effort and breath of courses.
  
  • First responder training will be offered throughout Colorado and portions of Nebraska and Wyoming.
  
  • Developing a complementary automotive technician program for Ponderosa High School through efforts with Douglas County Education Foundation
  
  • Integrate under represented groups into the educational objectives and job creation
Summary

The CSUV Team is:

• On target on all programmatic and technical fronts.
• Overcoming the parochial processes at educational institutions through the sharing in course development and multiple delivery sites
• Fostering the acceptance of new training methods and approaches through the integrated outreach plan, development of PHEV core concepts, and incorporation of industry requirements into the educational process
• Bringing community - education - industry together to solve multiple problems.
  • Jobs for veterans, women and Native Americans
  • Qualified personnel to fill the shortage of automotive technicians
  • Rethinking maintenance methodology for the partially disable and Wounded Warriors
• Addressing our national need for improved STEM motivation through relevant, contemporary examples in our secondary schools

“The CSUV Team is on target for developing PHEV related jobs today and in the future.”
Progress Made on Simulation-Based Design of HEVs Graduate Course

- Graduate student hired in January, 2010
- Rapid progress on simulation of 1-Mode (e.g., Prius) and 2-Mode (e.g., GM) HEV power-split architectures
- SAE Paper accepted (right)
- Over 80 slides produced for direct course use, based on simulations presented in the SAE paper
- Fully dynamic simulator completed for the Toyota Prius using Mathworks® Simscape simulation software
- Investigation underway for simulating multi-scale events: resonance excitation of powertrain components, dynamic balancing of ICE torque fluctuations using electric machines controller, etc.
• **Progress Made on Dynamics and Control of Hybrid Electric Vehicles Course**
  
  • Graduate student hired May, 2010
  
  • Specific case study nearing completion based on a two-mode power-split hybrid electric vehicle powertrain
    
    • Derivation of the dynamic model
    
    • Derivation of equilibrium states and analysis of controllability properties
    
    • Design of regulating feedback controllers to stabilize commanded operating conditions
    
    • Computer simulation of transient and steady-state behavior

• **Progress on PHEV Short Course**
  
  • 8 lessons completed, each of 20-40 slides and accompanying narrative (in Word)
  
  • Topics: On-board energy storage, PHEV Architectures, ECVT Architectures, 1-Mode versus 2-Mode ECVTs, ECVT Analysis, PHEV Components, Induction Machines, Power Electronics
Under Development March 2011–June 2011: Materials that can accompany HEV Exhibit

**DELIVERABLES AT EXHIBITS** (as appropriate per venue)

**Public Engagement of HEV Technology**

**The exhibit** will be used as a teaching tool for public education and for 6-12th grade programs in hybrid & electric vehicle (HEV) technology. Our plan is to illustrate the inner workings of HEVs by using a static display of real or mock system components. Components will be arranged as in current vehicles, but without the body of the car. **Our goal is to exhibit the components that make up the power and propulsion systems**, including regenerative braking motors, generators, engines, wheels. A series of LEDs (to highlight specific components) will be used to illustrate the power and/or energy flows through the system at different phases in the vehicle’s performance (start up, at stop lights, uphill, acceleration, low & high speeds, charging). The highlighted items and energy flows will be controlled separately, and the mock-up vehicle may be simulated to run by (hidden) power supplies that make a particular component active (i.e., the wheels). Audience will have access to buttons to highlight the actions of the components as part of this interactive display.

**Game:** True/False of PHEV Core concepts on gaming spin wheel

-----aimed to engage general public & increase knowledge about PHEVs, industry challenges, environmental impacts

**Handouts:**

1) PHEV Core Concepts ➔ pocket pamphlet of THE HEV FACTS: “What everyone should know about HEVs w/ diagrams
2) HEV MYTHS ➔ pamphlet
3) Teacher Kits (CD): Core Concepts/Industry Needs aligned with Education Standards ➔ pamphlet/foldout

**HEV Myths**

Outline of “How to Incorporate HEV Ed into high/middle school courses: includes Lesson plans, demos/experiments/exercises, (as they are developed for the Summer Teacher Training Workshop) PowerPoint(s), links to websites, information of feeder system to higher ed opportunities/careers ➔ ACC/CSU Program information about HEV Ed

4) PROGRAM INFORMATION re HEV Ed in higher Education: **A)** CSU HEV Engineering Courses offered ➔ pamphlet

**B)** ACC/FRCC Automotive Technology Associate Degree in Applied Sciences programs handouts ➔ pamphlet
Outreach: Web and Social Media

- **team.getev.org**
  - Intranet

- **getev.org**
  - Independent source of news and information w/ community

- **Partner Sites**
  - Two-way RSS

- **Industry Sites**
  - RSS Aggregation

- **HUBzero**
  - Two-way RSS
  - Higher ed focus

- **Facebook**
  - Outreach page
  - RSS integration

- **Twitter**
  - Two-way integration

- **YouTube**
  - Outreach Channel
  - Video embed

- **News Outlets**
  - RSS Aggregation

- **Independent source of news and information w/ community**
Outreach: Web and Social Media

- **getev.org Features**
  - Social media integration
  - RSS aggregation and syndication
  - Media rich posts via WYSIWYG
  - Faceted search
  - Editorial workflow and content approval process
  - Branded as an independent resource to allow for flexible use across multiple orgs
- **Timeline**
  - February: Plan
  - March: Design/Brand
  - April: Wireframe/Coding
  - May: Alpha Site/Test
  - June: Beta Site/Train
  - July: Release/Support