CSU Ventures
Speeding Technology to the Global Marketplace

Advanced Electric Drive Vehicle Education Program: Colorado State University Ventures

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CSU Ventures
May 15, 2012

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: 72%
- NCE requested to Sept 2013

Budget

- Total project funding (2/29/12)
- DOE share: $2.5M
- Contractor share: $0.95M
- Approximately 28% cost share

Barriers

- Access to veterans and Native Americans, Career knowledge
- Acceptance of new training methods and approaches
- Parochial processes at educational institutions
- Budget considerations at secondary schools and colleges
- Risks: Time needed to develop relationships

Partners

- Interactions/collaborations:
  - OEMs, CO National Guard, Marines for Life, NFPA, Veterans for Green Jobs, Denver Metro Clean Cities, Spirit of the Sun, Denver Indian Center, Association of Service Providers of America, Emergency Services Association of Colorado
- Project team:
  - Ricardo, CSU, GT, MRI, Gooru, Arapahoe CC, Red Rocks CC, Douglas County Schools

Relevance: The ~~Problem~~ Opportunity

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…shortage of STEM educated resources.

And then there is the unemployment issue!

1. http://www.citytowninfo.com/education-articles/career-exploration/mechanic-shortages-looming
2. http://www.doityourself.com/stry/techniciansshortage
3. http://www.time.com/time/business/article/0,8599,2040964,00.html#ixzz1G22Cj4Oe

Project Relevance (20%)

- **Objective: to accelerate the market introduction and penetration of advanced electric drive vehicles through focused educational opportunities***
  - Educational and outreach materials for secondary schools and community
  - Technician and first responder training
  - Enhancing engineering degree programs

*(From SOPO)

- **CSUV Team Addresses:**
  - President's Jobs Initiative
  - Education
    - Expands undergraduate and graduate engineering curriculums
    - STEM in secondary schools
      - Student education
      - Teacher education and workshops (CEUs given)
    - Careers orientation and familiarization
    - PHEV incorporated into technician training at ACC (seminar course)
  - Safety
    - First Responder courses for Fire, EMT/Paramedic, and Police
    - Fleet and Community Outreach/Training
  - Community Outreach, Team Building and Under-represented Populations

Barriers (Relevance)

- **Barrier – Access to veterans and Native Americans**
  - Conducted focus groups with relevant populations so as to tune message
  - Working with veterans groups focused on post-service veterans
  - Working with National Guard, tribal advocacy groups and tribal elders
  - Difficulties for veterans – Legal / privacy issues, timelines to impact post-military career options
  - Difficulties for Native Americans – "on the reservation" requirements for educational funding
  - Urban Native Americans - Lack of effective communication channels to potential participants. Working through associations, institutes of higher education and NFPs

- **Barrier – Career Knowledge**
  - Career nights at high schools
  - Teacher training and workshops
  - Mentor program with local industry
  - Gooru (web-based knowledge management platform for teachers and students)

Barriers (Relevance)

- **Barrier** - Acceptance of new training methods and approaches
  - Continue to use new methods that facilitate easy access to training and visualization
  - Developing hands-on visualization teaching aids
  - Look for ways to save cost
- **Barrier** - Parochial processes at educational institutions
  - Couse, degree and certification approvals at universities is laborious and challenging
- **Barrier** - Budget considerations at secondary schools and colleges
  - Time demand on teachers and faculty members
  - Student performance standards and top-down requirements take some flexibility out of what is taught and how it is taught

gooru
Learning is Social

Gooru is a free web application platform for teachers and students to use as a tool for discovering over 2,600 standards-aligned and personalized study guides, & complete lesson plans on a variety of math and science topics.

edNovo

Gooru is developed by Ednovo, a nonprofit 501(c)(3) organization | © 2012 Ednovo

Project FEVER-

Fostering Electric Vehicle Expansion in the Rockies

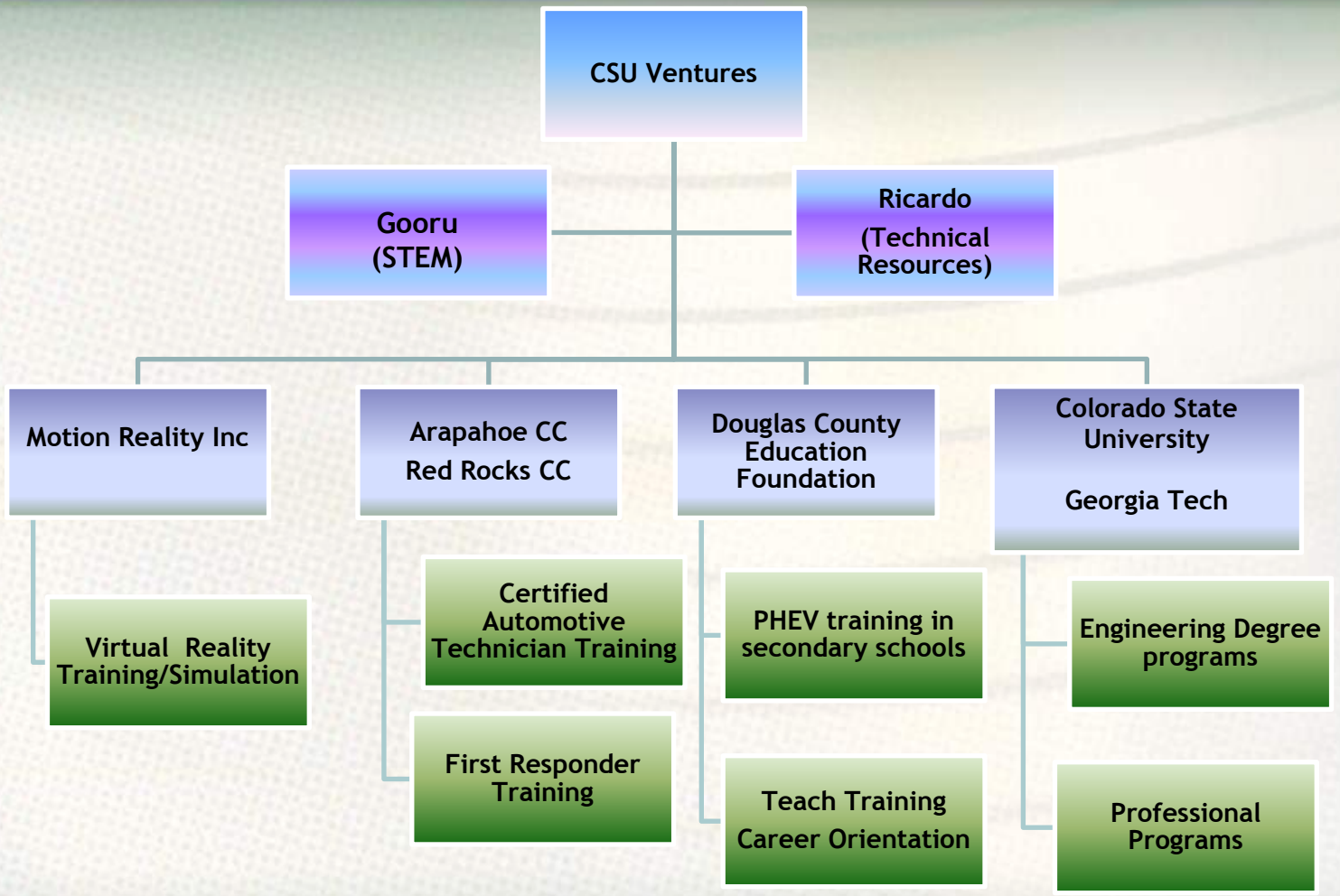
- Denver Metro Clean Cities Coalition program
- Part of the Clean Cities Community Readiness and Planning for Plug-in EVs and Charging Infrastructure Funding Opportunity
- Purpose: Create a community based electric vehicle infrastructure readiness plan, implement activities to support EV deployment in the future.
- Statewide effort across CO (U.S. Dept. of Energy for the state of Colorado).

Colorado State University
EcoCAR2
PLUGGING IN TO THE FUTURE

CSU, one of 16 universities to compete in EcoCAR2

- EcoCAR2: 3 year -collegiate advanced vehicle technology engineering competition established by the U.S. Department of Energy and General Motors and managed by Argonne National Laboratory. (T Bradley, Dept. of Mechanical Engineering)
- Purpose: -hands-on, real world experience for engineering students to design and construct a production-ready Plug-in HEV from the 2013 Chevrolet Malibu without compromising performance, safety and consumer acceptability


CSUV Team (Relevance)



supported through DOE:DE-EE0002627

Advanced Electric Drive Vehicle Education Program*

*A multi-linked approach that combines PHEV education from secondary through postgraduate/professional courses

Secondary Education

Professional Development for Teachers

"Incorporation of P/HEV education into the classroom"

Rationale of approach: maintain sustainable education by assisting teachers to integrate the fundamental principles of P/HEVs in existing curriculum .

a) updates & enhances Science, Technology, Engineering, & Math concepts by using plug-in/hybrid electric vehicles as a "vehicle" to engage students in fundamental science principles
b) provides teachers with opportunity for professional development
c) includes 21st century workforce skills

Industry Needs (21st Century Workforce skills) → PHEV Core Concepts ("fact sheet" of important principles that underlie P/HEV technology) → Education Standards (State/National Standards)

Douglas County School District — Learn today. Lead tomorrow.
Poudre School District

Professional Development for Teachers:
- Continuing Education
- STEM Training

- Mini Lecture Series: • Overview • Technical components
- Activity Workshop: • Demonstrations • Exercises + Experiments for the classroom → PHEV Curriculum Hands-on Activities (Batteries; Regenerative Braking; Combustion & Emissions; Math exploring CO2 Emissions)
- Internet Links & Resources: • Professional contacts • academic • workforce/Community Colleges • Industry

Partnership with district schools:
•Poudre School District (Larimer County)
• Douglas County School District (Douglas County Education Foundation)

Reinforcing automotive technology training in the high schools

Douglas County Educational Foundation — Community Support for Learning Excellence

Ponderosa High School Auto Shop, Douglas County, Parker, CO

-provided assistance in expanding equipment needs & teacher support for hands-on experience for students.

career connect

Career Connect features industry professionals showcasing their specific companies/organizations & their broader career fields to high school students.

Automotive Technology

Career Connect visited the HONDA training center in Denver, Colorado.

Higher Education

New College Courses Developed:

Colorado State University

- *Hybrid Electric Vehicle Powertrains* — Vehicle Dynamics, Engines, Control, Simulation
- *Design of Energy Storage Systems for Vehicles* — Batteries, Fuel Cells, Ultracapacitors
- *Vehicle Computational Systems Design*
- *Control Engineering in Hybrid-Electric Vehicle Propulsion Systems Vehicles*
- *Transportation Electrification (graduate level)* — Electric Motors, Grid Interface, Battery

Georgia Tech

- *Introduction to Hybrid Electric Vehicle Powertrains*
- *Dynamics and Control of Hybrid-Electric Vehicles (graduate level)*
- *Simulation-Based Design of Hybrid-Electric Vehicles (graduate level)*

Engineering Projects for Students

-hands-on, real world experience

Colorado State University — EcoCAR2 — PLUGGING IN TO THE FUTURE

Purpose: to design and construct a production-ready Plug-in HEV from the 2013 Chevrolet Malibu

Supported separately by a grant from: U.S. Department of Energy and General Motors (T Bradley, Dept of Mechanical Engineering)

CSU is one of 16 universities competitively chosen to participate in EcoCAR2

- 3 year -collegiate advanced vehicle technology engineering competition
- established by the United States Department of Energy and General Motors and managed by Argonne National Laboratory.
- the premier senior design competition in N. America whose challenge is to reduce the environmental impact of a Chevrolet Malibu without compromising performance, safety and consumer acceptability

Integration of P/HEV into ACC's Community College Automotive Technology Program

-intensive training in hybrid conversion and hybrid technology repair

Arapahoe Community College

Yukon (four-wheel drive)
Ford Escape,
Honda Insight
Chevy Malibu
Toyota Prius II.
Chevy Tahoe
Nissan Altima

Automotive Technology Wins School of the Year Award! 2011

Professional

Electric Vehicle Safety for Emergency Responders Training

National Fire Protection Association (NFPA)

Arapahoe Community College — Red Rocks Community College

To prepare first responders to be able to operate safely at incidents involving hybrid electric (HEV), plug-in hybrid electric (PHEV) and electric vehicles (EV).

NFPA®

Module I: Introduction
Module II: Basic Electrical Concepts and Hazards
Module III: Vehicle Systems and Safety Features
Module IV: Initial Response: Identify, Immobilize and Disable
Module V: Emergency Operations

Programs held at :
•**Arapahoe Community College** Law Enforcement Academy
•**Arapahoe Community College** Advanced Automotive Technology Center (for Emergency Medical Services Technicians/Paramedics)
•**Red Rocks Community College** Firefighter Academy/Science Program

Short Courses for Professionals

Georgia Tech

- *Plug-in Hybrid Electric Vehicles (distance learning course)*

Colorado State University — College of Business

- *Maintenance Theory and Practices for Vehicles/PHEVs*

Advanced Training on Hybrid Vehicles for Professional Automotive Technicians

Arapahoe Community College

Certificate in hybrid vehicle technology
Convert hybrid vehicles into plug-in hybrid electric vehicles
40 hours of hybrid training for professional technicians
High-Voltage Systems Safety

Veteran Outreach Campaign

Veterans Green Jobs

Other Technical partners:

RICARDO — motion reality

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CSU Ventures
Speeding Technology to the Global Marketplace

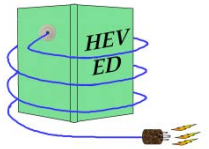
Approach – Secondary School Teacher Education Program

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 → H&EV Core Concepts → State/Nat'l Education Standards

"fact sheet" of important principles that underlie HEV technology

"How to incorporate HEV Ed into the 6th-12th grade classroom"

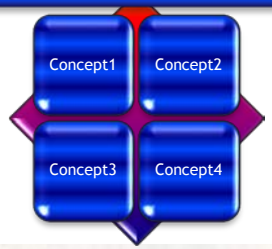


Partnership w/ district schools:
Poudre School District (Larimer County) & Douglas County School District

Teacher Continuing Education Training
ONSITE

- Lecture Series
  - •Overview
  - •Technical components
- Workshop
  - •Demonstrations +
  - •Exercises +
  - •Experiments for the classroom
- Internet
  - Links & Resources
  - Gooru
  - •Professional contacts
  - •academic
  - •Workforce/Community Colleges
  - •Industry

H&EV Curriculum Activities



Archive for future/remote use (webinar)

Take back into the classroom

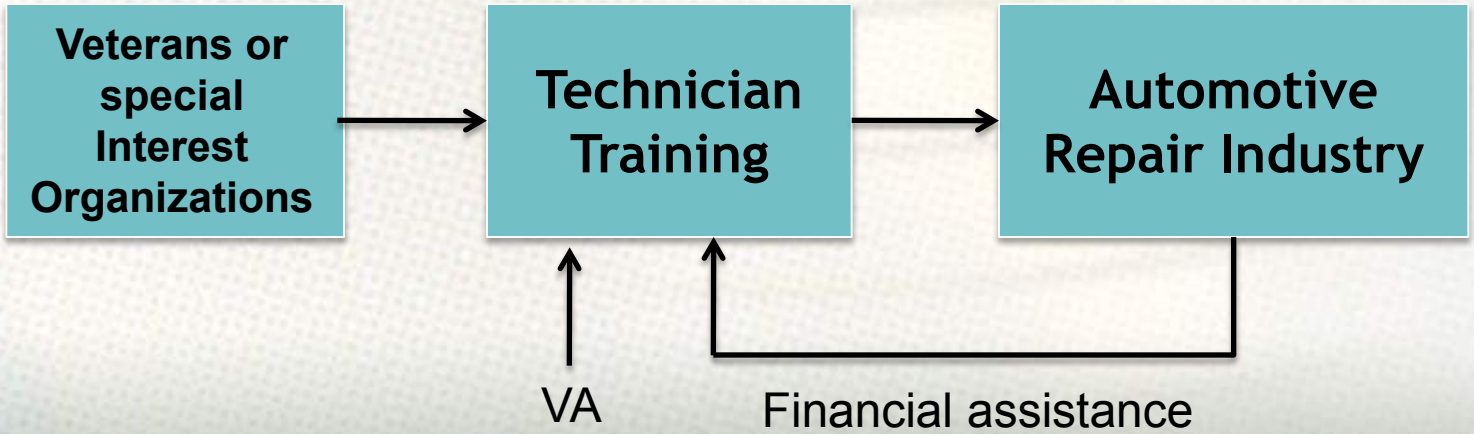
Training offered to all teachers and counselors to better integrate information across disciplines

Highlights of Approach (35%)

- Create a multi-linked approach that combines PHEV education from secondary through postgraduate/professional courses.
- Team with NFPA to license and develop first responder course for fire, paramedics and police. Providing training cooperatively with the DOE FEVER project and Denver Clean Cities project
- Explore new ways to train technicians using virtual reality including simulations
- Working with Eco-CAR 2 at CSU to provide outreach opportunities
- Develop an outreach program that reaches the students, teachers and community. Teamed with Gooru for web based information.
- Conducting outreach to under-represented groups (veterans, women and Native Americans)

Highlights of Approach (35%)

- **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
  - Through student job site visits and outreach with students and parents, opportunities in the automotive and PHEV fields are being communicated
  - Working a mentoring program for middle and high schools
- **Focus on a job funnel path for under represented groups such as veterans, women and Native Americans**



Accomplishments (40%)

Deliverable Status

- **Outreach**
  - Program Central Outreach Website – complete using Google, migrating to Gooru
  - Master Community Site – initial site operational. Being modified to include CSU Eco CAR 2 website and Denver Clean Cities Project FEVER websites.
  - On-line Marketing (career information, jobs and general information) being migrated to Gooru
  - Core Materials Generation: incorporated into Professional Development Workshop for teachers and Gooru
- **Technical Training**
  - Facilities including vehicle procurement – complete except for cut-away mock-up for First Responder training.
  - Academic Hybrid Tech Safety /Repair, and First Responders Education - complete/on-going
  - Hybrid Automotive Safety & Technician Training coursework – complete; training sessions on-going
  - First Responder Hybrid Safety coursework – complete; training sessions starting in April 2012
  - Virtual Reality – simulation of battery disarming/rearming task complete. Working on step-in training for viability assessment. OT effort continuing, next experimental data session this summer.

Accomplishments – Deliverable Status Undergraduate, Graduate and Professional Courses

- **Survey and meet with industry to learn educational requirements/topics to include in courses**
  - Status: Complete
- **Develop undergraduate PHEV course and share between CSU and GT**
  - HEV Powertrains course, first taught Fall 2010 at GT, was ported to CSU as ENGR 580A1 and taught for the second time in Spring 2012 semester to 17 students.
  - CSU's Vehicle Energy Storage System Design course (MECH 523) is complete was taught for the first time in Fall 2011 semester to 15 students.
- **Develop graduate courses as listed below:**
  - Simulation Based Design of Hybrid-Electric Vehicles course is being taught to 10 students in Spring 2012 at GT.
  - Control Engineering in Hybrid-Electric Vehicle Propulsion Systems has been submitted for departmental review and once approved, will be taught in Fall 2012 at GT.
  - CSU's Transportation Electrification course (MECH 680) was offered to 6 students in Fall 2011.
  - EV/HEV Computational System Design course scheduled for Fall 2012 at CSU.
- **Develop professional short courses:**
  - GT's PHEV/HEV short course is compete, ready for migration into a distance learning environment
  - CSU's Maintenance Theory and Practices for Vehicles/PHEVs short course content is complete. Efforts are underway to incorporate assessment methods and migrate into a distance learning environment.

Accomplishments

Secondary School Outreach, STEM and Career Familiarization

Multiple **Career Connect events** featuring industry professionals showcasing their specific companies/organizations & their broader career fields to high school students.

Examples:

Automotive/Technology - Examines county fleet management and operations, auto fabrication technology and automotive careers at a dealership.

- Career Connect visited the HONDA training center in Denver, CO;
- Douglas County Public Works (Operations Department - Fleet Management Division)
- Hanksville Hot Rods, Inc.

Engineering - Lockheed Martin Corporation speakers & hands-on activities:

- "What is Engineering and How Do I Get Involved?"
- Activity: "Newton's Car" - Design Night #1 - Mechanical / Automotive Engineering

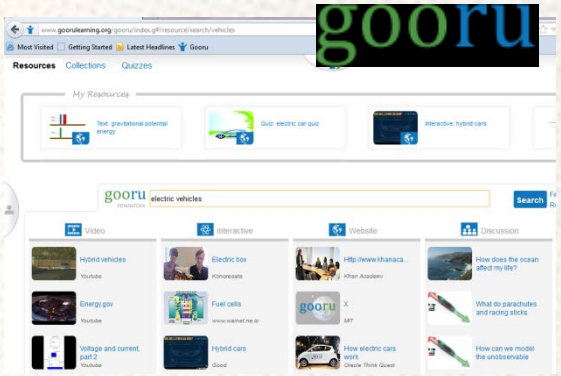
21st Century Fire Service - South Metro Fire Rescue Authority

- Activity : Participants will learn about vehicle crashes and how we extricate patients from crashed vehicles.

Accomplishments

Professional Development Workshop Series Teachers:
"Electric Vehicle Education in Classroom"

- A variety of hands-on activities: For example, one hands- on activity kit ("Regenerate!") developed specifically for VEEP involves a progressive understanding of energy transfer and regenerative braking in advanced electric vehicle. (see Listing under Teacher Workshop Details)



- Gooru website: a repository of our workshop educational materials, videoed presentations and core content about the inner workings of advanced vehicles-- available for all educators across the world; workshop participants will also be introduced to Gooru to create their own lesson plans of science and math concepts that underlie PHEV technology.

- Post-workshop assistance is provided by the CSU EcoCar2 vehicle innovation team to assist with classroom activities & presentations

Collaboration & Coordination (5%)

- **Partners**
  - CSU and Georgia Tech: Research universities developing 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 to participate.
  - Arapahoe Community College (ACC): One of the top Auto Training programs in the nation. Training Center for GM, Chrysler, Honda, Nissan, Ford certified auto technicians. First responder training for paramedics/EMTs and police
  - Red Rocks Community College: Fire Academy in collaboration with Denver West Metro Fire Fighter Academy
  - Douglas County Schools: Feeder school for ACC and developing Auto Tech program in their high schools
  - Motion Reality Inc.: World leader in the development of motion capture technology and virtual reality.
  - Ricardo Inc.: World leader/Subject Matter Expert in vehicle engineering and associated systems.

Collaboration & Coordination (5%)

- **Collaborators**
  - Veterans for Green Jobs: Funnel process to focus returning veterans into this industry
  - Colorado Governor's Energy Office: Extend Governor Ritter's message on energy conservation and renewables to include HEVs and education/community awareness
  - American Lung Association / Denver Metro Clean Cities Coalition
  - Northern Colorado Business Report
  - City of Fort Collins, CO
  - Veterans for Green Jobs/Veterans to Farmers
  - Colorado National Guard
  - Marines for Life Mentor Program
  - Nissan of North America
  - Office of Naval Research
- **Collaborations**
  - Raytheon: Provides Mr. Goodwrench training and other automotive training throughout the industry.
  - US Army, National Guard and USMC: Continuing to explore ways to vector returning veterans into vehicle technology programs and maintaining the technical competencies required by the respective reserve forces.
  - Visiting OEMs and large dealerships to get program content input.
- **Technology or Process Transfer**
  - Seeking to reproduce technician training funnel process with other community colleges and industry participants.

Future Activities

- **Development of courses is almost complete – finalize**
  - Offer short courses/First Responder training sessions
- **Focus will be on**
  1. Outreach to under-represented groups
  2. Community outreach via Blue Earth Conference, Bixpo (Northern Colorado Jobs Fair) and Odyssey
  3. STEM development for teachers
  4. Mentor development; industry to secondary schools
  5. First Responder training sessions throughout Colorado (starts in Spring 2012)
- **Continue to work our Jobs process and obtain funding for students**

Summary

Objective: to accelerate the market introduction and penetration of advanced electric drive vehicles through focused educational opportunities

Deliverables:

- Educational and outreach materials for secondary schools and community: continuing
- Technician and first responder training: courses complete, training underway
- Enhancing engineering degree programs: almost complete, courses being offered

Barriers: Barriers identified and overcoming. Time to develop relationships and access to under represented groups are major constraints.

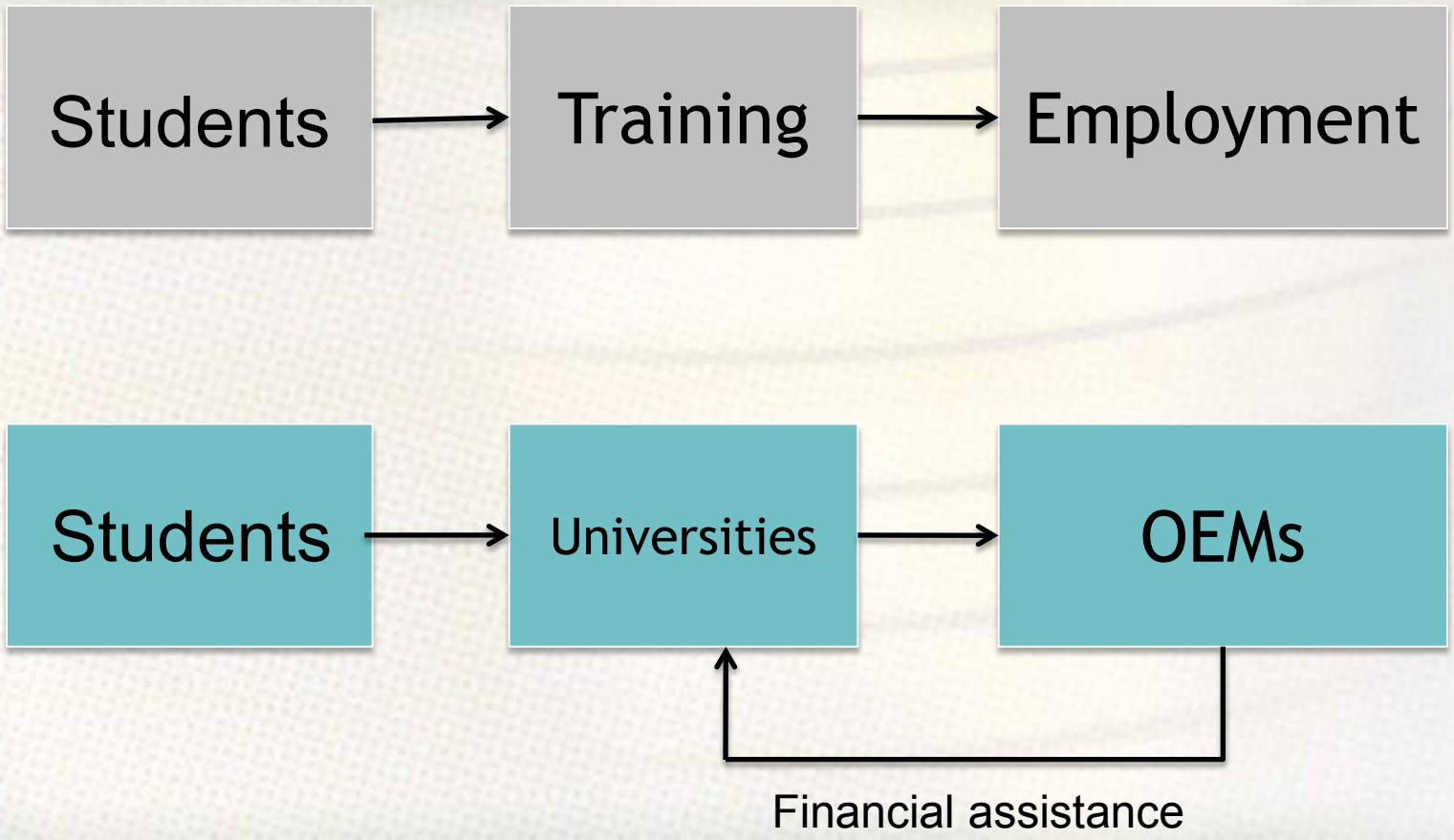
Collaborations: Extensive

Jobs process path: Continuing to develop relationships

Questions?

Technical Back-up Slides

Highlights of Approach (35%) -The Jobs Process



Teacher Workshop Details

Lectures Presentations:

Why PHEVs?: the Basics: perspectives, environmental issues, challenges faced, emissions, history
An Industry-Informed Curriculum Design: input on 21st century workforce skills
Modern PHEVs: explanation of the function of these vehicles; vehicle types and classifications
Vehicle Components; inner workings of electric motors and generators; powertrains
Vehicle Emissions and Environmental Impact: "Well to Wheels" discussion
Electricity/Energy Storage/Batteries Part 1
Regenerative Breaking: review of energy transfer, kinetic energy, electrochemical energy
Energy storage/Batteries Part 2: Prieto battery; challenges faced in energy storage-(Dr. Amy Prieto)
Smart/Electric Grids: Challenges faced for EVs; dispatch, renewable energy
Challenges faced; Safety issues

Examples of Workshop Activities:

Activity 1 -view major components of vehicles that will be parked at the EOC brought up from Arapahoe Community College Auto Tech Program/local dealers
Activity 2- How hybrids Work-review of classroom activities for students
*Activity 3-field trip-*CSU's Engines & Energy Conversion Lab (EECL) *guest speaker Mr. Zimmerle*
Activity 4-Measuring & calculating CO2 emissions in the classroom;
Activity 5- Making a Rechargeable Battery (hands-on activity kit for the classroom)
Activity 6- Capturing Energy: Regenerate!! Regenerative braking (hands-on activity kit for the classroom)
Activity 7-Incorporation of core content into class plans and alignment with education standards-Gooru platform
Activity 8-Electric vehicles as a topic for applied school Mathematics
Activity 9-using web resources and workshop content to establish class plans and approaches in Gooru- a teaching platform

Under Development March 2011-June 2012: Materials that can accompany HEV Exhibit

DELIVERABLES AT EXHIBITS *(as appropriate per venue)*

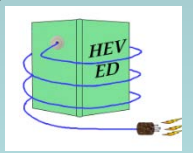
Public Engagement of HEV Technology

The exhibit will be used as a teaching tool public education & 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 H&EV Core concepts on gaming spin wheel
-----aimed to engage general public & increase knowledge about H&EVs, industry challenges, environmental impacts

Handouts:

1) H&EV 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

Arapahoe Community College

Automotive Technology Department

- Named Top Automotive Program of the Year 2011 by Tomorrow's Technician Magazine
- Serves as the Training Center for GM, Chrysler, Honda, Nissan, Ford certified auto technicians
- Among the first automotive technology programs in the US to be training college students on hybrid technology
- Develop technical, on-site curriculum to train automotive technicians on PHEVs and EVs
- Working with Motion Reality on simulations

EMT/Law Enforcement Department

- Develop a curriculum to train first responders in circumstances associated with PHEVs and EVs.
- Assist in development of relevant PHEV and EV safety courses for other educational levels.

Projected Outcomes & Integration of Overall Outreach Program

Douglas County Educational Foundation
Community Support for Learning Excellence
HEV ED
Poudre School District
Teacher training

Incorporates H&EV core content into current courses for enhancing STEM curriculum

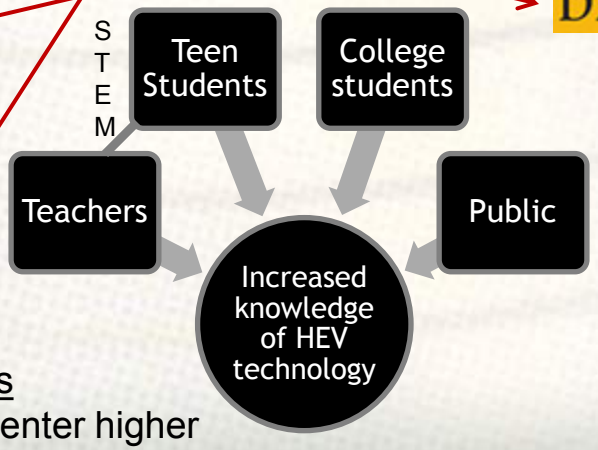
Middle & High school students

HEV Exhibit for programs at schools, museums & community events

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

ARAPAHOE COMMUNITY COLLEGE

High/Middle School students involved with HEV exhibit at museum public programs



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

Several layers of integration across organizations