State-of-the-Art Electric Vehicle Conversion Program

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Summary

The Santa Rosa Junior College Electric Vehicle Conversion program, in conjunction with members of the North San Francisco Bay Chapter of the Electric Auto Association, will develop a state-of-the-art Electric Vehicle (EV) conversion curriculum by designing, fabricating, assembling, testing and documenting an EV conversion utilizing components such as Lithium Iron Phosphate (LiFePO4) batteries and Alternating Current (AC) induction drive systems. The prototype will be used for classroom material and for staff to travel between campuses and to promotional events. Online documentation and on-demand book and video hard copies will be made available to the public and all 107 other California Junior Colleges that are interested. The project will be completed by the end of 2009. Then the vehicle, book and video will be used in future SRJC EV conversion classes, as well as to promote the program to education, industry, government and the public.

Project Objectives

EVs with battery charging offset by renewable energy generation can be a significant part of the solution to energy independence and emission reductions. Historically, conversions of thousands of petroleum powered vehicles to electric have been done over the past several decades, but many have either been very heavy or have a very short range due to the lower cost, readily available lead acid batteries and Direct Current (DC) drive systems. Furthermore, lead is toxic, so we are trying to reduce its use. Currently, large companies are developing long-range, high-speed, lower-cost electric vehicles, but it is expected to take many years until these vehicles are readily available, and many decades until they and other alternative fueled vehicles displace the entire petroleum powered fleet. Our objective is to combine the reduced cost versions of the past with the high end technologies of today to develop a blueprint for creating light weight, mid-range EV conversions. This project will use state-of-the-art batteries such as Lithium Iron Phosphate ($LiFePO_4$) and Alternating Current (AC) induction drive systems that have been utilized to date only on a small number of vehicles with costly unique designs, and no single conversion has had a complete feature set for safe, reliable and maintenance-free driving to date.

We plan to collaborate with the manufacturers who provide state-of-the-art EV components and the EV converters who have used these components in an open source fashion to develop a common design that can fit in most common compact vehicle models with only minor mounting adapter differences between models. The final product will be more robust, easier to replicate and easier to maintain than current EV conversions. A prototype will be built, fully tested and documented, with a class textbook and video being produced to be used as curriculum for EV conversion classes, starting with the Santa Rosa Junior College (SRJC) DET 193 class. The prototype will be used as classroom material, and for staff travel between campuses and to promotional events. The prototype and the curriculum will be shared with all 107 other California Junior Colleges who show interest, and marketing campaigns will be encouraged to target local auto shops to send their employees to take the class so they can add converting and maintaining state-of-the-art EVs to their line of services. It is expected that this increase in EV awareness and conversion capacity will lead to competition and the formation of a higher volume supply chain for these EVs and their components, which will lead to lower prices and drive even more demand, hastening our much needed transition to sustainable renewable transportation fuel sources.

Background

There is currently no common state-of-the-art EV conversion curriculum. Those who have converted state-of-the-art EVs have done so inefficiently via web research, participating in online discussion groups, and searching for hard-to-find hands-on help. The open source model success in education, software development and now Plug-in Hybrid Electric Vehicles (PHEVs) has motivated us to organize the experience and creativity of the masses interested in EVs and focus it on tangible results towards the goal of reducing the use of fossil fuels.

Need

State-of-the-art EV drive systems are well understood, but new batteries delivering much sought-after longer range, and the effective management of these systems, is in its infancy. Durability testing as well as monitoring and storing data of the voltages of the many cells that make up EV battery packs is straightforward, but the work just hasn't been done yet in the public domain. Coordinating the efforts across people to perform this testing and developing vehicle management systems and then documenting our results will provide a proven list of components and robust system designs such that EV converters and maintainers can rapidly begin creating and supporting these systems in an efficient manner.

Process and Methods

We will obtain a popular late model compact manual transmission donor car, such as a Ford Focus Wagon, Toyota Corolla or Honda Civic. We will either convert an existing SRJC fleet vehicle, or obtain a donation. We will remove all Internal Combustion Engine (ICE) systems including the engine, radiator, fuel tank and exhaust system. We will refurbish the remaining systems including brakes, steering and suspension. We will affix SRJC, AAA and NBEAA logos on the vehicle.

We will purchase the following EV components:

- Deep cycle high power long life large format high specific energy traction batteries such as LiFePO4
- CANBus battery management system
- CANBus AC induction drive system
- CANBus on-board traction battery charger
- DCDC converter as the accessory battery charger
- Cables, fuses, circuit breaker, main contactor and accessory battery

We will fabricate the motor adapter, mounting racks and boxes for the above equipment such that the original body is not permanently modified, the original safety and crashworthiness is preserved and each major component can be easily removed and installed. We will utilize SRJC students and faculty in machining, welding and metal shop classes when possible, otherwise subcontract work to qualified students or vendors.

We will develop a CANBus Vehicle Management Unit (VMU) to drive dashboard gages and lights utilizing the Microchip PIC microcontroller, CANBus interface and CANBus I/O expansion chips. We will utilize SRJC students and faculty in hardware and software related classes when appropriate.

We will assemble the vehicle by utilizing advanced SRJC students taking DET 193, managed by course instructor. We will test the vehicle to determine speed, range and weight performance.

SRJC staff will utilize the vehicle when traveling between the Petaluma, Santa Rosa and Windsor campuses and to promotional events. Existing charging outlets in Lounibos Hall and the Public Safety Training Center in Windsor will be utilized.

We will maintain and repair the vehicle as needed in a timely fashion. We will retest vehicle performance each semester over the life of the vehicle. We will utilize advanced students in DET 193 to do the labor, managed by course instructor.

We will disassemble and reassemble the EV portion of the vehicle to fully document the process and design in both book and video form. We will post both book and video online, and set up both book and video on-demand printing. The title will be "State-of-the-Art Electric Vehicle Conversions", and to keep the title current, it will be revised on a regular basis as new components come out and are proven in EVs. The table of contents will include:

Foreword

Background of project, acknowledgements

Introduction

Target audience, safety precaution, EV history, future EV vision

Requirements

Key features, safety, reliability, ease of maintenance, value

Design

Component and configuration comparisons, final configuration, Specifications, part list, schematics, fabrication drawings and theory of operation

Vehicle Preparation

Obtain donor car; weigh vehicle, measure ride height; remove Internal Combustion Engine (ICE) components;refurbish brakes, steering and suspension

Fabrication

Machine motor adaptor, weld battery and motor mounts, metalwork radiator box and splash shields

Assembly

Radiator box, underbody cable conduit, mount items in vehicle, high power cables, low power wiring loom

Test

Weigh vehicle; measure ride height; program motor controller, charger and BMS; charge and balance batteries; discharge capacity, range, acceleration and hill climbing tests

Specifications

Payload, acceleration, top speed vs. grade, range, charge time, efficiency

Users' Guide

Features, charging, trip planning, loading, starting, shifting, collision avoidance in a quiet car, avoiding overheating, braking, maintaining charge, parking, breaking in new components, towing, storage

Maintenance

Safety precaution, tire inflation, brake inspection, wheel alignment, battery balancing

Troubleshooting Guide and Repair Procedures

Drive system, battery system, charging system, vehicle management system

Frequently Asked Questions

Why EVs, how they work, safety, what can be converted, performance, charging, energy use, costs, reliability, maintenance, where to get one, myths, history, trends

References

Component vendors, conversion shops, knowledge sources

Expected Results

This project will deliver a working prototype with full documentation that can then be used to promote the usefulness of state-of-the-art electric vehicle conversions, and the feasibility of their replication with detailed curriculum and classes available for automotive technicians.

Success Metrics

The prototype vehicle will meet the following performance specifications, such that it is desirable for the largest number of customers given the state-of-the-art:

- >700 lb payload
- <20 second 0-60 MPH acceleration on flat ground
- >70 MPH top speed
- >50 miles average range
- >2.5 miles per kWh from AC outlet
- charge time <3 hours via 240V/30A AC outlet, <12 hours via 120V/15A AC outlet

Awareness

We will promote the program by sharing prototype and curriculum with other interested California junior colleges, proudly displaying the AAA Greenlight Initiative logo on the prototype and mentioning their sponsorship. In addition, include industry and non-profit partners on an advisory committee, as well as showing the vehicle at public events. Moreover, we will present the vehicle and our program to fleet operators, government officials, EV conversion shops, EV component vendors, relevant industry and educational conferences, and the press to encourage enrollment in DET 193 and related classes.

Qualifications of the Project Team

- Steven Cohen: Dean of departments including Industrial Trade Technology which offers several Alternative Fuel Vehicle classes including EV conversions.

- Chris Jones: BSEE and BSME from UC Davis. 17 years experience in telecom industry R&D and manufacturing engineering and project management. Comanaged a multi-million dollar telecommunication test equipment new product introduction and was on time and under budget. Converted 1966 Mustang to $LiFePO_4$ batteries in 2006. NBEAA chapter president since 2006.

Budget

$40Kestimated total, based on posted prices and price quotes obtained in August 2008, subject to change:

- $17K for traction batteries and management system
  One example being considered: 12 Epoch EEV-19-65s directly from Valence Technologies
- $ 8K for AC drive system and adapter
  One example being considered: Azure Dynamics AC24LS motor and DMOC445 controller and custom motor adapter from Electro Automotive
- $ 7K for traction battery charging system
  One example being considered: 2 Brusa NLG513-SCs in parallel
- $ 8K for miscellaneous other EV conversion parts, shop tools, electronic test equipment, documentation materials, and to refurbish and affix logos on donor car

Note: if prices rise or the entire amount is not obtained, other alternative fuel grants will be pursued, discounts from vendors in exchange for test data and publicity will be attempted, and scaled back solutions such as slower chargers or less expensive batteries without a comprehensive warranty will be considered.

Timeline

Investigation: Fall 2008
    Obtain donor car
    Select all major EV components

Design: Winter 2009
    Detailed design of schematics and fabrication drawings

Development: Spring 2009
    Obtain off-the-shelf components
    Fabricate custom components
    Assemble all components

Test: Summer 2009
    Verify performance of vehicle

Documentation: Fall 2009

Disassemble and reassemble car while taking notes, pictures, movies and measurements
Write the book
Edit the video
Post book and video on line
Set up on demand printers for book and video

Product Launch: Winter 2010
Contact press
Show vehicle in fairs, parades, etc
Meet with fleet operators and government officials

Grant Agreement

If we are awarded the AAA Greenlight Initiative Grant, we would be willing to sign the agreement.