Engineering Student Technology Committee

http://www.engr.colostate.edu/ESTC

College of Engineering

Colorado State University

The Engineering Student Technology Committee (ESTC) invites proposals from students, faculty, and staff for technology related equipment to enhance the student educational environment in the College of Engineering at CSU. Each year, the ESTC allocates funding for strategic projects that will have a near-term benefit to students. This year, the committee is soliciting proposals in the $5K - $40K range. Proposals must be primarily for equipment and have a direct benefit to the educational mission of the college. Please review the Charge for Technology (CFT) manual for permissible use of CFT funds: http://ucft.colostate.edu/aspx/www.ucft/pdf/cftmanual.pdf.

The ESTC is particularly interested in intra-departmental proposals or proposals that benefit a large cross-section of students. Partnerships with the ESTC that fund projects beyond the limitations of the CFT are especially compelling. Note that the committee is not, in general, interested in funding projects that are specific to a particular research group or that affect only a small number of students. To submit a project proposal, please complete this form and send it as an e-mail attachment to estc@engr.colostate.edu by April 30 for full consideration.

1. Title of Proposal: **Electric Drivetrain Teaching Center**

2. Proposal Participants:

Primary Contact for Proposal

Name: **Daniel Zimmerle** _____E-Mail: dan.zimmerle@colostate.edu _____

Department/Major: Mechanical Engineering _____

Circle One: Undergraduate Student Graduate Student Faculty Staff

Additional proposal participants

Name: **Thomas Bradley**_____E-Mail: _____

Department/Major: Mechanical Engineering _____

Circle One: Undergraduate Student Graduate Student Faculty Staff

Name: _____E-Mail: _____

Department/Major: _____

Circle One: Undergraduate Student Graduate Student Faculty Staff

3. Proposal Abstract (limit to 100 words):

Electric vehicles will become a significant portion of the worldwide vehicle fleet over the next decades, with some estimates envisioning as penetrations in excess of 20% by 2020. These vehicles contain technologies far different than technologies in current fossil-fuel vehicles. It is critical that CSU equip ME and ECE graduates with experience in this fast growing field.

We propose to leverage ESTC funding with a recent $20K grant from the Clean Energy Supercluster and complementary funding from other sources, to build an "electric drivetrain teaching center," (ElecDTC) where students can acquire hands-on experience with batteries, power electronics, traction drives, grid interfaces and controls for electric vehicles. The center will be housed in the InteGrid Laboratory at the EECL, and will be available to all departments interested in this burgeoning field.

4. Proposal Budget

List of items to be purchased and cost

Item	**Cost**
Traction Motor (60 KW)	$ 9,500
Couplings & other drive train components	$ 2,200
Mounting skid & structural components	$ 1,200
Control/Data acquisition hardware	$ 3,200
Electrical enclosure, sensors	$ 1,600
Wireless torque sensor	$ 3,500
Assembly labor (undergraduate students)	$ 3,750
Total Request	**$ 24,950**

Dollar or percentage amount requested from ESTC:

This proposal requests the amount listed above: $24,950. Contributions from other projects are listed in the section "CFT Funding Leverage." Leveraged amounts:

$20,000 Clean Energy Supercluster grant for grid-attached storage (Peter Young/Dan Zimmerle)
$24,000 Funding graduate student for two semesters to drive construction and early characterization (Tom Bradley)
$24,450 In-kind match from California Motors (electric drive development company) (Brian Huff, CalMotors & Dan Zimmerle, CSU)

5. Full description of proposal:

The need:

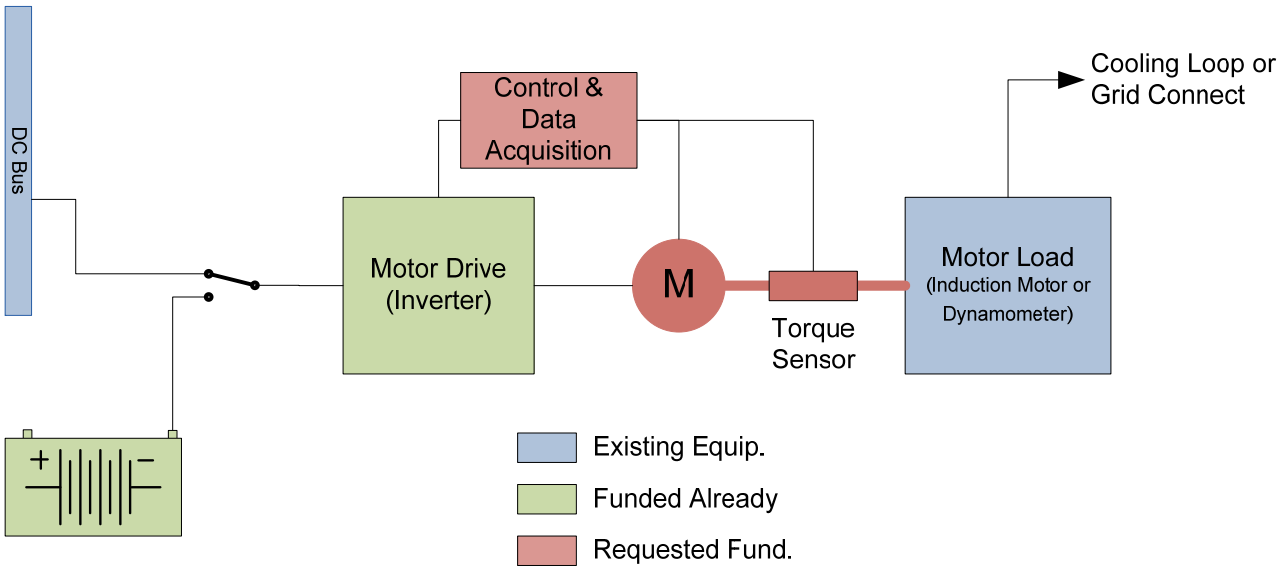
Electric vehicles are hitting world-wide deployment, ranging from today's current hybrids (HEVs) to emerging plug-in hybrid (PHEVs) and extended-range electric vehicles (EVs). These vehicles represent technologies from three fields previously only considered separately:

- Vehicle drivetrains and related systems, such as braking.
- Electrical power systems, including batteries, motors and power electronics
- Grid interactions, including controlled charging (grid-to-vehicle) and controlled discharging (vehicle-to-grid).

Amalgamating these technologies represents a premier technical challenge spanning ME, ECE, and additional departments (e.g. battery chemistry). Providing hands-on interaction with these systems will equip students for challenging careers in this growing, cross-disciplinary, field. In addition, the focus on energy fits well with the School of Engineering's strategic direction.

What is it:

The proposed equipment will simulate the drivetrain of an electric vehicle, as shown in the figure below.



The system consists of:

- A 15KWh battery subsystem. This component will be funded by a recent grant and proposed matching funding from California Motors. DC power may also be acquired from the DC bus of the PV simulator.
- Motor Drive – drives the traction motor and allows regenerative breaking into to the battery.

- (M) Motor – a specialized electric drive motor of the type utilized for electric vehicles.
- Motor load – provides torque loading to the drive motor, dynamically simulating driving conditions.
- Torque Sensor – provides real-time torque measurements at the output of the traction motor. Torque sensors are unusually complex and costly sensors.
- Controls & data acquisition.

The system, as described above, cannot be built for the requested amount. However, components from a recent Clean Energy Supercluster grant (Peter Young/Daniel Zimmerle), coupled with matching funding from California Motors, can be leveraged to reduce the system cost. These components will be structured to operate as both a grid-attached storage system (for Smart Grid studies) and as the battery and power electronics "front end" for the ElecDTC. The requested funding will fill in the "center" of the system: traction motor, torque sensor, controls and associated balance-of-plant equipment (skid, electrical systems, etc).

The system will be located in the InteGrid Laboratory at the EECL, where all support services necessary to build and safely operate the equipment already exist, including: 480V power supply, breakers, DC power supplies, trained staff and safety equipment. Mr. Zimmerle is the operational owner of InteGrid.

The system will also leverage electric vehicle teaching funds acquired by Dr. Bradley in three additional ways: First, a recently acquired battery characterization system where students can learn about battery chemistries, performance and measurement technologies – another key part of the electric vehicle system. Second, the same funding will also provide for a graduate student for two semesters to drive construction of the electric vehicle teaching center and to do some preliminary characterization and research on the system. Finally, the ElecDTC will be used as a laboratory resource for courses developed during this and other funded efforts.

Student Benefit:

The test center will be equally useful to both ECE and ME students interested in vehicle systems and related power electronics topics. It will provide a complementary laboratory facility to EV courses (Bradley), systems engineering courses (Young) and microgrid/smartgrid curriculum work (Zimmerle).

The primary advantage of the lab will be to allow students hands-on contact with the drivetrain equipment utilized in vehicle systems, as well as the grid interfaces to that equipment – batteries, motors, drives and controls.

CFT Funding:

CSU has seen a significant increase in interest in energy-related studies in general, and Smart-Grid related studies in particular. In addition, the college is currently hiring three faculty targeted at Smart Grid research and teaching. Despite this interest, funding is not currently at hand to build or repurpose existing laboratory facilities to provide the necessary hands-on

contact. CFT funding will help bridge this gap, as well as leverage grants and existing infrastructure.

CFT Funding Leverage:

The proposed funding sits at the crossroads between several areas of growing interest, and thus is in an excellent position to both catalyze and leverage other investments. These include:

- A 20K$ clean-energy supercluster grant to build a grid-attached storage system (battery/inverter/controller)
- A 35 K$ investment in a traction-battery testing capability.
- A substantial grant to develop electric vehicle courses

In addition, the total cost of the project has been reduced by leveraging recent improvements to the InteGrid laboratory, including:

- $60K investment in an inverter/photovoltaic simulator – multiple DC busses, multiple inverters – capable of simulating a variety of grid-attached power systems, such as photovoltaic arrays, wind turbine/inverter systems, and grid-attached storage.
- Builds on a two-year effort modeling the interaction between electric vehicles and the grid, including meta-analysis of regulation, V2G, time-of-use pricing, and other factors. The center will allow detailed testing of certain control models identified during this previous work.