Design for Manufacturing, Reliability, and Economics

Team 2

Electric Vehicle Range Extension

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ABSTRACT

This report includes the basic design of our project with the aspects of manufacturing, reliability, and economics in mind. For manufacturing, the project assembly is discussed from start to finish, noting major components and how they interface with each other. For reliability, the life cycle of our design was analyzed through major concerns that could arise from extended use. With economics, our budget is broken down into all expenditures over the two semesters and is graphically shown. A discussion of competing products is included.

1. Design for Manufacturing

First the team disconnected the main cart power wire and slid the selected current sensor over it. The power was provided to the sensor through a voltage regulator and attached the voltage output pin through a voltage divider assembly and into one of the analog pins on the microcontroller. the team did the same with the current sensor for the converter system and later, the solar panel current sensor. The microcontroller was placed in a plastic black box underneath the bench to pervert water, dirt, and debris from destroying it.

The team then connected the start and stop preexisting relay wires to different digital pins on the micro controller. The generator power output was rerouted directly to the two Mean Well power converters. A relay was then added in line with the converter system on top of the passenger rear wheel well. The relay was powered by a transistor that was connected to the microcontroller. A digital potentiometer was inserted in the black box with the micro controller, wired appropriately, and attached to the variable resistance pins on one of the converters.

A code was then derived that would transmit the sensor data back to a computer and allow the user to turn the generator on when desired and regulate the power output of the converters.

The solar roof dimensions were measured and sent with the order to the solar roof company. When the solar roof came in we aligned the 4 holes on the roof with the 4 holes on the cart and inserted a washer and rubber spacer between each hole and bolted it down. The power wires to the solar panel were directly connected to the respective terminals on the battery bank.

The assembly process did take longer than expected because of unforeseen problems and longer than expected part delivery time. However, this design could not be done without all components on the system. Every component is necessary for the operation of the vehicle.

An exploded view of this project was not generated due to CAD work not having to be completed for our design. The main components of the assembly, such as the generator, propane tank, and solar panel can be seen mounted to our vehicle in Figures 1 – 3 below.

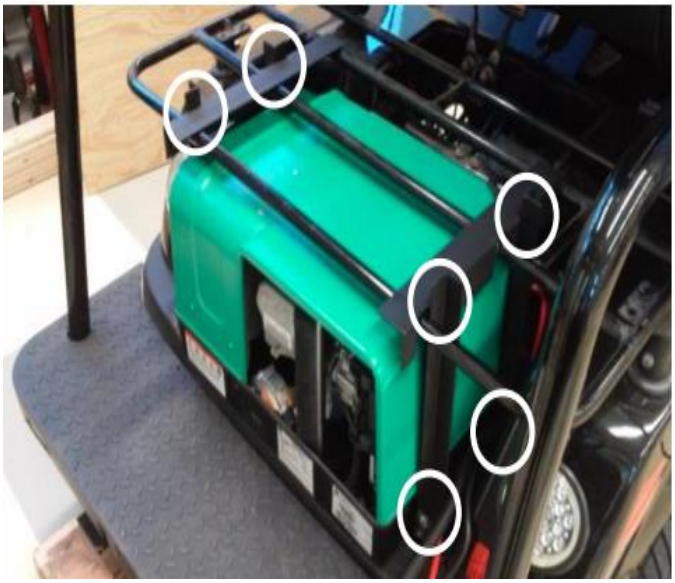

Figure 1. Generator location and mount

Figure 2. Propane tank mount and location

Figure 3. Electric vehicle with solar panel installed

2. Design for Reliability

Reliability is a very important aspect when designing any system. Our prototype is built of several subsystems that have to interface with each other in order for proper function. Therefore, it is necessary for the reliable operation of these subsystems to ensure that the vehicle is always kept running as intended. The mechanical., and electrical systems include the DC electric motor, the generator, batteries, solar panel, and microcontroller.

With our prototype having the base platform of a golf cart-like vehicle, it performs perfectly after one use, and even a hundred uses. When this number continues to grow exponentially, some reliability concerns to begin to show up. These concerns mainly have to do with the lifetime of components and damaging events that are bound to occur at some point. With regular use, the batteries, which take a bulk of the wear, should last around 4 – 5 years. This life cycle depends on the quality of the batteries themselves, the way in which they're charged each time, and on how they're stored. Also over time, some electrical components will most likely experience some level of corrosion. This corrosion depends on the climate the vehicle is exposed to while being tested and stored. This corrosion can also be limited by proper care and cleaning of the electrical components. Another large reliability concern over an extended amount of use is effect of vibrations on electrical components. Over time, sensitive connections and mounting can wiggle themselves loose. The loss of an electrical connection could cause the entire system to become inoperable. If bolts on the solar panel, generator mount, or propane tank mount were to come undone, damage to these components could occur, causing a wide range of potential issues and costs.

3. Design for Economics

Table 1. Budget Breakdown

Description	Store	Amount
Velcro, Plastic container	Home Depot	$9.41
Electrical Tape, Wire, Heat Shrink, electrical Connectors	Home Depot	$32.76
Heat Shrink Lighter	Home Depot	$4.56
Heat Shrink, Black Tape, Nuts and Bolts	Lowe's	$14.78
Heat Shrink	Hobby Town USA	$3.42
High Current connectors	Radio Shack	$5.08
Transistors	Radio Shack	$5.77
Heat Shrink	Home Depot	$6.36
Zip Ties and wire Cripms	Lowe's	$13.93
Hatch Box 1KG 1.75mm 3d printer PLA	eBay	$22.99
150A AC DC Current Sensor Module DIN rail mount	eBay	$26.00
Arduino Pins, Arduino, LCD screen with buttons	DFRobot	$82.75
Honeywell CSLA1CH 150A current sensor	eBay	$31.15
18 Gauge Wire 10 colors 25ft ea	eBay	$19.95
Heat Shrink and fuse holder	AutoZone	$17.72
Electrical Solder	Lowe's	$10.74
Voltage Regulator	Radio Shack	$2.14
Butane	Lowe's	$5.36
flash light batteries	Walmart	$5.35
Tool Box, Electrical Tape, and other components	Lowe's	$68.72
Steel Wool	Home Depot	$4.28
Electrical tape, fuses	Home Depot	$4.21
Arduino Uno	Radio Shack	$24.18
Liquid-Tight Conduit, Power Cord	Home Depot	$28.02
Electrical Connectors	Radio Shack	$18.81
Potentiometer - Digi Pot Click	Micro Controller Pro's	$16.90
LCD Screen- LCD Keypad shield X 2	Micro Controller Pro's	$11.50
Arduino Uno R3 - At mega 328 Assembled	Micro Controller Pro's	$24.95
Premium Female/Male Extension Jumper wires -20X6	Micro Controller Pro's	$1.95
	Total Electronics	**$553.00**
Solar Panel Roof Kit	EV Solar systems	$1,550.00
	Overall Total	**$2,103.00**

The team was initially provided with a budget of $2,000 to achieve the goal of an increase of range by 15% for the electric vehicle. Once the team began improving the electrical components, and once the solar panel price was determined, the team needed a small extension in our budget due to the several electrical components that needed to be exchanged and improved along with the price of the solar panel. The overall budget was increased by $300 dollars for the team to be able to insure all the circuit components were safe, reliable and stationed. The breakdown of the team budget can be seen above in Table 1. This extra allotment extended the budget to be $2,300 in which $553 went towards the necessary components and $1,550 went towards the non-traditional power source chosen. This has allowed the team to be left with a remaining $197. Below is a pie chart illustrating how the budget was allocated.

- **Total: $2,300**
- Original: $2,000

- **Electrical Components**
  - $553 -24%
- **Solar Roof Kit**
  - $1,550 – 67%
- **Remaining Amount**
  - $197 – 9%

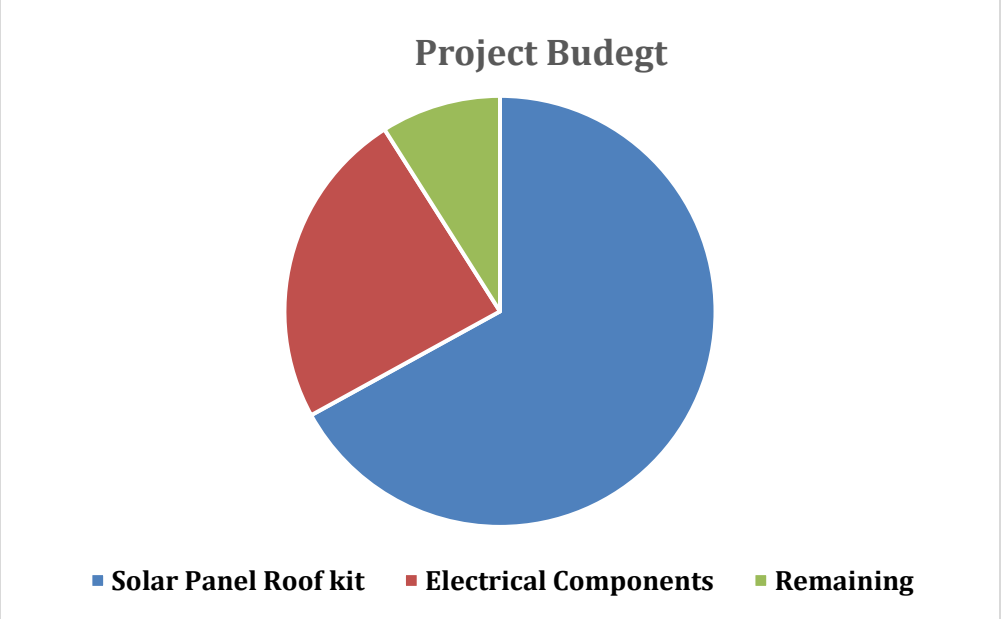

Figure 4. Use of Team Budget

On the market today, all of the necessary components in order to achieve the same vehicle operation as Team 2 are available. There are also some leading manufactures that produce hybrid vehicles that have a natural gas mode or solar panel mode. These vehicle prices start at $12,000 and have customizing options that can increase that price. However, there are not any products on the market that can run on an electric generator, solar panel,

and a battery bank all at once. To obtain this, one would have to purchase these subsystems separately and incorporate them together such as Team 2 did.