On-Road Energy Harvesting in Electric Vehicles

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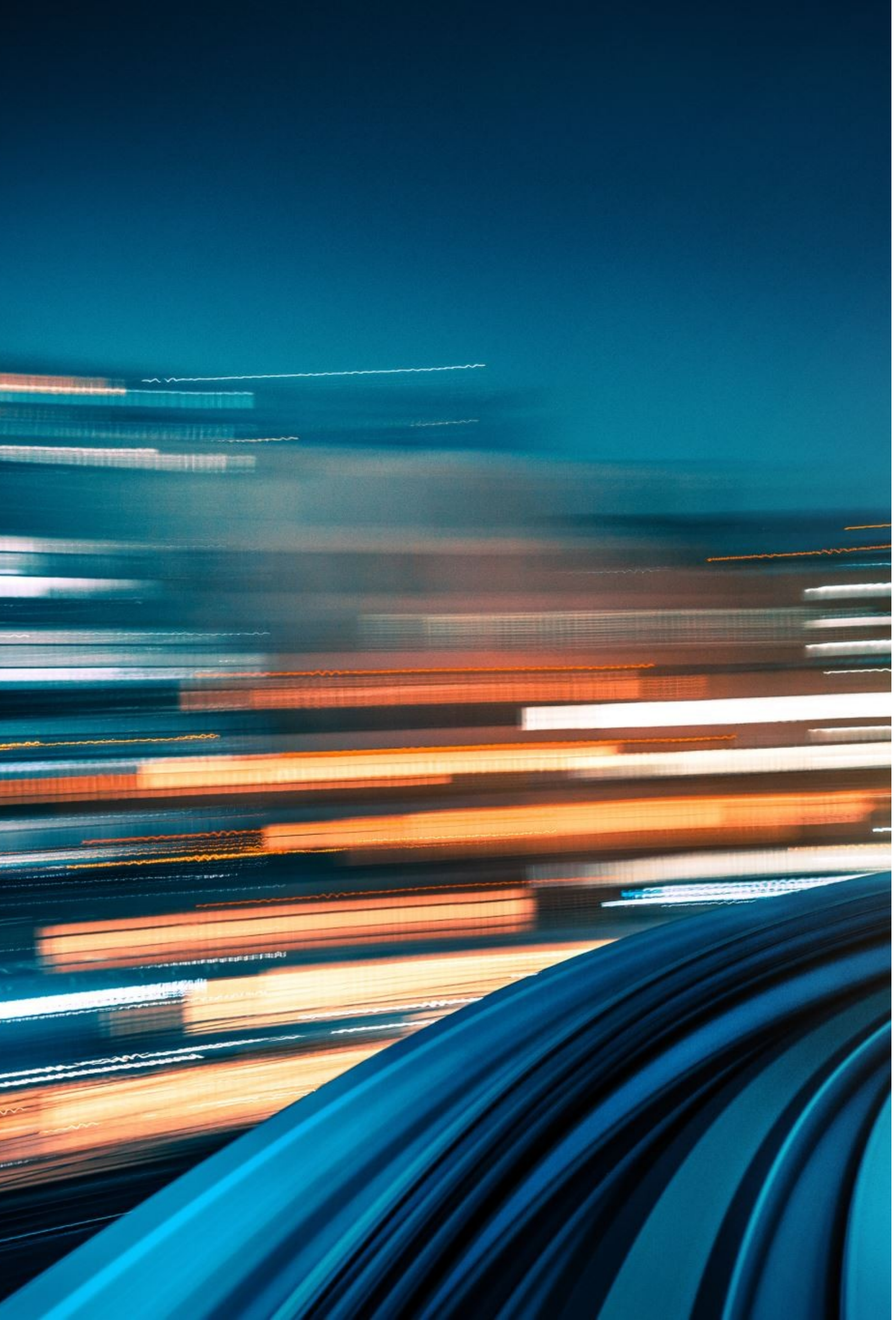


Introduction

- A fundamental change is happening in the automotive industry where we are seeing a rapid shift to the design and production of electric vehicles (EVs)
- Although the vehicles are becoming more efficient with time there is still room for improvement in regard to how far these vehicles can travel with the amount of energy stored in the battery
- Our team's mission was to design a device that can harvest excess energy from various sources within and surrounding the vehicle to power some function of the vehicle (i.e., headlights, stereo, etc.)

Design Requirements

Customer Requirements:

1. Lightweight
2. Inexpensive
3. Must supply enough power to perform at least 1 vehicle function.
4. Must not ruin vehicles aesthetics
5. Must be a device that is added on to an existing vehicle.
6. Must capture and use at least 3 forms of energy

Engineering Requirements:

1. Weight (<150 lbs.)
2. Price ($1500)
3. Power (80 watt*hr.)
4. Aesthetically Please (Y/N)
5. Aftermarket Device (Y/N)
6. 3 types of energy used (Y/N)
7. Withstand average road wear (Y/N)

Design Solution

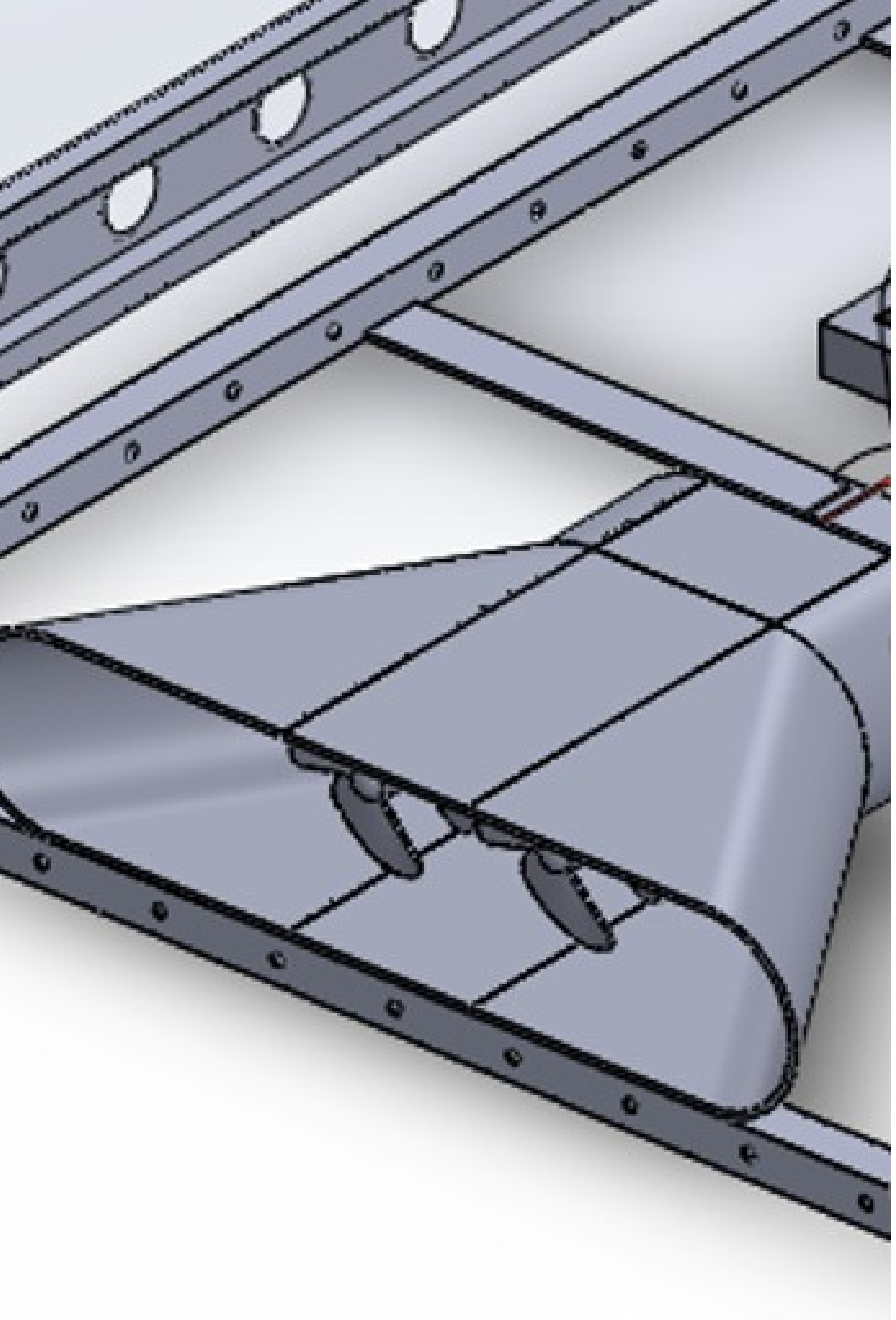
- Team's design comprised of 3 subsystems which harvest energy with varying methods in order to derive power which is stored within a lead acid battery
- Two subsystems are designed for low voltage low current trickle charging while final subsystem is designed for bulk charging of the battery

Solar Subsystem

- Components: Solar panel, solar charge controller, inline fuse
- Method: Solar energy captured by the panel which converts this into electrical energy then passed to a charge controller which leads to the battery
  - This component of the design provides the bulk charging mentioned earlier
- Effectiveness: Testing of design displays an average power output assuming average sun exposure time of 12 hours we see power output estimate of

Thermoelectric Subsystem

- Components: (20) Thermoelectric generators (TEGs), boost converter, inline fuse
- Method: Mounted to a heat source TEGs will generate electricity via Seebeck effect which is sent through boost converter then to the battery
    - One of two subsystems to that will aid in maintaining charge of battery once it has been fully charged
- Effectiveness: During lab testing team was able to show that for average road conditions the generators are able to produce power on order of



Wind Energy Subsystem

- Components: 3D printed nozzle, (2) 12V DC brushed motors, boost converter, inline fuse
- Method: Mounted under vehicle nozzle directs air to the fan blades on motor which spin and generate electricity which then goes to boost converter and finally the battery
  - Other method for trickle charging the battery due to low current output from the motors
- Effectiveness: Team was able to show during tests that the power output was around during average driving conditions

Decision Making

Nozzle

- Choice of a 3D printed nozzle due to inexpensive nature and capability of lasting against average roadwear.
- 3D printed nozzle motor blades in order to obtain better airflow; which resulted in optimal and efficient battery energy output.

Thermoelectric Generator

- Environmentally friendly by use of naturally stemmed energy sources
- Solid state devices that make for more reliability and less likeliness to wearing due to no involvement of moving mechanical parts
- Use of pairs of 10 TEGs in series; then wiring of both pairs of TEGs in parallel in order to double voltage and current to produce a more efficient subsystem.

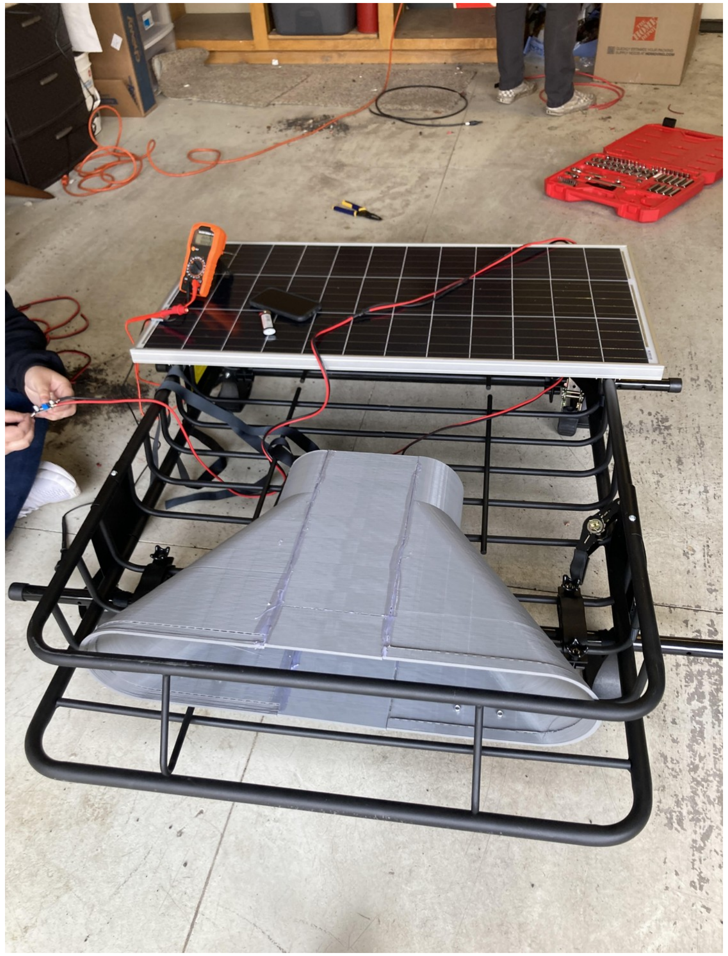
Solar Panel

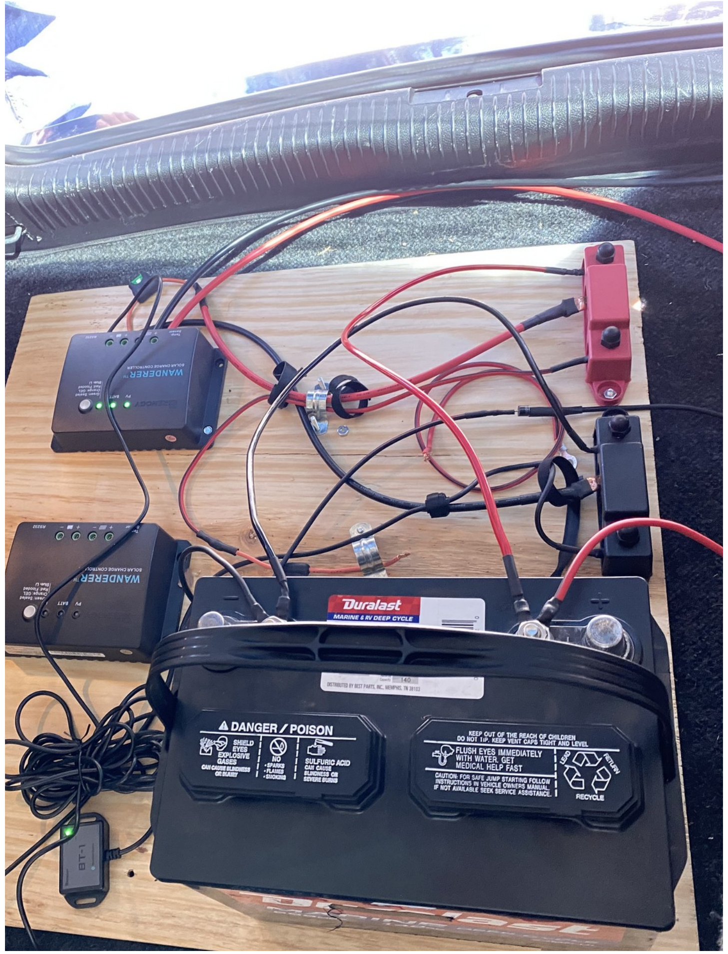
- Conversion of light energy into an alternative energy source.
- Both cost and energy effective.
- Use of particular sized solar panel, more surface to produce higher energy output

Manufacturing

- Manufacturing began with 3D design of nozzle and fan blades
- Next the TEGs were wired 10 in series with 2 sets of these wired in parallel then mounted between aluminum plates
  - Module was connected then to a boost converter
- Next the team received the nozzle from the 3D printer and assembled this and then mounted the DC motors to the inside of device wired in series with one another
- Team received solar panel and roof rack for testing design, so the nozzle and solar panel were mounted onto roof rack

Manufacturing





- Battery was placed on wooden board for testing along with charge controller and wires were fed through tube brackets for organization

Testing

- Testing of nozzle was done by attaching roof rack mounted nozzle to car and driving down road to test average road wear at speed as well as to measure power output
- Simultaneously the solar panel was tested using a multimeter device attached to charge controller which gave team output data for solar charging
- TEGs were tested in lab under expected conditions under average operation using a rheostat and a multimeter
  - Measured temperature gradient gave team a metric for how much power could be output based on temperature reading

1397.04

Budget

Total Expenditure

Parts Tools/Supply Contingency

Total Budget: $1500
Total Spent: $1397.04
Remaining Budget: $102.96

Budget

EV Moghaddam Purchase BOM

Team Members: Terrell Blackgoat, Miles Dziedziewicz, Austin Engelbrecht

Order Status Key
on hand
ordered
need to order

Part Number	Vendor Name	Part Name	Quantity	Description of Item	Make/Buy	Function	Item #	Size	Total Cost	Link	Order Status	Note
1	Amazon	DC Motor	1	775 DC Motor DC 12V - 24V Max 12000 RPM Ball Bearing Large Torque High Power Low Noise Gear Motor Electronic Component Motor 2-Pack (with Bracket)	Buy	Converts Kinetic energy into electricity	[illegible]	5.12 x 3.66 x 3.15 inches	33.50	[illegible]		Picked Up
2	Amazon	TEG	2	Geelfan 10PCS TEC1-12706 Thermoelectric Cooler Heat Sink Heatsink Cooling Peltier 12V 5.8A	Buy	Converts temperature difference to electricity	[illegible]	6.1 x 6.1 x 0.2 inches	42.90	[illegible]		Picked Up
3	Amazon	Solar Charge Controller	1	Tréexel 30A Solar Charge Controller, 12V/24V Solar Panel Charger Controller with Adjustable LCD Display and Dual USB Port for Open, AGM, Gel, Lead Acid Batteries	Buy	Protects battery from overcharging and discharging	[illegible]	5.31 x 3.07 x 1.61 inches	30.34	[illegible]		Picked Up
4	Amazon	Thermal Paste	1	ARCTIC MX-4 (incl. Spatula, 4 g) - Premium Performance Thermal Paste for all processors (CPU, GPU - PC, PS4, XBOX), very high thermal conductivity, long durability, safe application, non	Buy	used to attach TEG to system	[illegible]	1.2 x 2.8 x 5.9 inches	14.37	[illegible]		Picked Up
5	Amazon	Solar Charge Controller	1	Renogy Wanderer Li 30A 12V PWM Negative Ground Solar Charge Controller Solar Panel Regulator w/ Temp Sensor Function Fit for Lithium, Sealed, Gel, and Flooded Batteries, Wanderer Li	Buy	Protects battery from overcharging and discharging	[illegible]	6.46 x 4.31 x 1.76 inches	30.27	[illegible]		Picked Up
6	Amazon	temperature sensor	1	Renogy Battery Temperature Sensor Solar 118 0.03, Compatible Adventurer/Rover Charge Controllers	Buy	Protects battery from overcharging and discharging	[illegible]	118 x 0.03 x 0.03 inches	8.67	[illegible]		Picked Up
7	Amazon	electrical tape	1	Scotch Electrical Tape, 3/4 in by 66 ft, Black, 1-Roll	Buy	protect exposed wires	[illegible]	3.5 x 0.6 x 3.6 inches	2.14	[illegible]		Picked Up
8	Amazon	12 guage wire	1	InstallGear 12 Gauge AWG 50ft Speaker Wire True Spec and Soft Touch Cable - Red/Black	Buy	wires for TEG and nozzle	[illegible]	4.06 x 3.35 x 2.8 inches	14.99	[illegible]		Picked Up
9	Amazon	Anemometer	1	testo 405i Hot-wire Anemometer I Wireless Smart Probe for air velocity, in duct airflow and temperature	Buy	used to measure airflow and temperature	[illegible]	7.87 x 1.65 x 1.18 inches	124.50	[illegible]		Picked Up
10	Amazon	Charge Controller	2	Renogy Wanderer Li 30A 12V PWM Negative Ground Solar Charge Controller Solar Panel Regulator w/ Temp Sensor Function Fit for Lithium, Sealed, Gel, and Flooded Batteries, Wanderer Li	Buy	Protects battery from overcharging and discharging	[illegible]	6.46 x 4.31 x 1.76 inches	60.54	[illegible]		Picked Up
11	Amazon	Temp Sensor for Charge Controller	2	Renogy Battery Temperature Sensor Solar 118 0.03, Compatible Adventurer/Rover Charge Controllers	Buy	Protects battery from overcharging and discharging	[illegible]	118 x 0.03 x 0.03 inches	17.34	[illegible]		Picked Up
12	Amazon	Solar Panel	1	HQST 100 Watt 12V Monocrystalline Solar Panel with Solar Connectors, High Efficiency Module PV Power for Battery Charging Boat, Caravan, RV and Any Other Off Grid Applications	Buy	Converts solar energy to electricity	[illegible]	40.12 x 1.18 x 20.00 inches	97.64	[illegible]		Picked Up
13	Amazon	Solar panel wires	1	[illegible] 50 Feet 10AWG Solar Extension Cable with Female and Male Connector with Extra Free Pair of Connectors Solar Panel Adaptor Kit Tool (50FT Red + 50FT Black)	Buy	10 guage wire used to wire up solar panel	[illegible]	600 x 0.12 x 0.12 inches	74.95	[illegible]		Picked Up
14	Amazon	Bus Bars	1	4 Post Power Distribution Block Bus Bar Pair with Cover - Made in The USA - 250 Amp Rating - Marine, Automotive, and Solar Wiring (3/8)	Buy	used to wire all the components into on bar to hook onto the battery	[illegible]	7.7 x 3.5 x 2.6 inches	43.49	[illegible]		Picked Up
15	Amazon	Wire Terminal Connectors	1	[illegible] AWG 3/8" Stud (10 pcs.) UL Heavy Duty Battery Ring Terminal Connector, Tubular Electrical Wire End Cable Lugs, Bare Copper Eyelets (Bell)	Buy	used to connect to bus bar	[illegible]	4 x 4 x 2 inches;	14.63	[illegible]		Picked Up
16	Amazon	30 Amp Fuse	3	Littelfuse 0FHA0030XP ACS ATO HD Carded Inline Fuse Holder with 30 Amp Fuse	Buy	Protects battery from overcharging and discharging	[illegible]	4 x 3.8 x 1.6 inches	42.24	[illegible]		Picked Up
17	Autozone	Battery	1	Duralast 24MD-DL Group 24 Deep Cycle Marine and RV Battery	Buy	Store harvested energy	24MD-DL	9.875 in x 6.8125in x 10.25 in	122.99	[illegible]		Picked Up
18	Amazon	roof rack	1	Arit Motoring 64" x 39" Roof Rack, Rooftop Basket Cargo Carrier with Rack Extension, Tie Down Strap and Net, Black Steel	Buy	Roof rack basket for harvesting system	[illegible]	34.84 x 23.82 x 8.07 inches	161.89	[illegible]		Picked Up
19	Amazon	roof rack cross bars	1	Bosh Hardware Universal Roof Rack Cross Bars 2 PC	Buy	Roof rack to crossbar for roof basket	[illegible]	47.6 x 4.8 x 3.2 inches	71.60	[illegible]		Picked Up
20	Amazon	PLA filament	1	PLA 3D Printer Filament, SUNLU PLA Filament 1.75mm Dimensional Accuracy +/- 0.02 mm, 1 kg Spool, 1.75mm, PLA Black	Buy	Used for 3D Printer	[illegible]	8.19 x 8.15 x 2.83 inches	23.96	[illegible]		Picked Up
21	Amazon	Boost Converter	1	Songhe XL6009 XL6009E1 Boost Converter Module DC - DC 3.0-30V to 5-35V Output Voltage Adjustable Step-up Converter Board Module Better Than LM2577 (5pcs)	Buy	for TEG to output higher voltage	[illegible]	3 x 2.3 x 0.8 inches	9.75	[illegible]		Picked Up
22	Amazon	Vehicle Headlight	1	Optilux Hella H71070307 XB Series H7 Xenon White Halogen Bulbs, 12V, 100W, 2 Pack	Buy	Harvesting system will power this component	[illegible]	N/A	$26.45	[illegible]		Picked Up
23	EV Moghaddam Team	Generator Fan	2	Fan blades for generator	Make	Uses blades to turn generator	N/A	7 in diameter	N/A			Picked Up
24	EV Moghaddam Team	Nozzle	1	3D Printed Nozzle	Make	Holds DC Generator mounts and controls flow rate	N/A	20in x 20in x 10in	$210			Picked Up
25	Amazon	Lead-Free Solder	1	Worthington 331760 Wire Solder, 95/5 1 lb. Roll	Buy	Solder all components together	[illegible]	2.2 x 2.2 x 2.2 inches	$31.74	[illegible]		Picked Up
26	Amazon	10 AWG Wire	1	GS Power Flexible 10 AWG (American Wire Gauge) 50 Feet Stranded Oxygen Free Copper Red/Black Bonded Zip Cord Cable for Car Audio Stereo Amplifier 12Volt Automotive Harness LED	Buy	Extra wire for components	[illegible]	7.01 x 6.97 x 2.52 inches	$48.61	[illegible]		Picked Up
27	Home Depot	Aluminum cutting blade	1	DIABLO 8-1/2 in. x 80-Tooth Aluminum Cutting Circular Saw Blade with Bushings	Buy	Cutting Aluminum Plate	[illegible]	8-1/2 in	$34.97	[illegible]		Picked Up
28	Home Depot	Deburring Tool	1	Husky Deburring Tool	Buy	Deburring aluminum plate	[illegible]	N/A	$9.98	[illegible]		Picked Up
29	Home Depot	Pipe Hanger	3	Oatey 1in Galvanized 2-hole pipe hanger strap (2pack)	Buy	used to attach solar panel to roof rack	[illegible]	1in x 6in	$5.49	[illegible]		Picked Up
30	Home Depot	Drill Bit for Metal	1	Dewalt 1/8 in. Black and Gold Split Point Drill Bit (2-Pack)	Buy	used to drill holes into the solar panel	[illegible]	N/A	$3.27	[illegible]		Picked Up
31	Home Depot	Nut and Washer Set	1	185 - Piece Zinc Plated Nuts and Washer Kit	Buy	used to bolt solar panel onto roof rack	[illegible]	N/A	$5.30	[illegible]		Picked Up

Future Work

- **Better design**
  - Improve design to fulfill customer requirement of being aesthetically pleasing.
    - Finding a way to hide the nozzle within the structure of the electric vehicle (ex: via air vents of the vehicle).
    - Mounting the solar panel to be flush with the roof of the electric vehicle.
    - Finding a way to make
- **Approval of design for larger scale or compact project usage**
  - Examples : commercial use for electric semi trucks or consumer use such as personal electric vehicles.
- **Plans on improvement of thermoelectric generators**
  - Prototyping flexible thermoelectric generators to mold against complex shapes within the vehicle such as the engine, exhaust, etc.
  - Finding a way to cool down the thermoelectric generators via a coolant system.
- **Improvement on battery selection**
  - Appropriate choice in affordable, efficient and optimal powered battery
    - Choosing between flooded lead-acid, gel cell, absorbent glass mat, or lithium.

Thank you for listening!

Questions? Comments? Concerns?