EV Moghaddam

Terrell Blackgoat
Miwa Dawidowicz
Austin Engelbrecht

Project Description

1

Sponser

Dr. Hesam Moghaddam

2

Task

Design a device that can be added onto an electric vehicle (EV) that gathers excess forms of energy to be then stored and directed toward the use of the vehicle somehow

3

Goal

Allows the vehicle to eventually save electrical energy thereby increasing the performance of the vehicle

4

Importance

Any effort towards having a cleaner earth is beneficial for all of us as well as pushing the field of the automotive industry to become more efficient in the long run will better the field

Background

- **Objective**: Design an aftermarket product that can harvest energy while the EV is on the road.
- The product will include two components:
  - solar panel
  - thermoelectric generator.
- The current design will help conserve battery and provide approximately 50 watts of power.
- The current design must save large amounts of energy while trying to be light and efficient as possible

Benchmarking

- Thermoelectric generators (TEG)
  - TEG1-12611-6.0
    - Volts: 4.2V
    - Amps: 3.4A
    - Watts: 14.6W
    - Size: 56mmx56mm
    - Cost: $48/pc (Thermoelectric-generator.com)
  - TEG1-12611-8.0
    - Volts: 4.8V
    - Amps: 2.7A
    - Watts: 13W
    - Size: 56mmx56mm
    - Cost: $60/pc (Thermoelectric-generator.com)
  - TEG1-4199-5.3
    - Volts: 6.7V
    - Amps: 1.12A
    - Watts: 7.5W
    - Size: 40mmx40mm
    - Cost: $33/pc (Thermoelectric-generator.com)

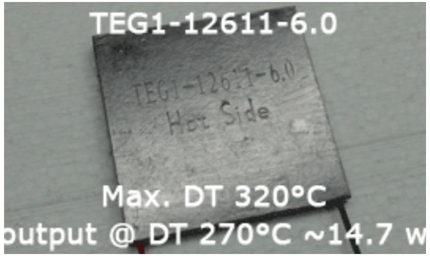


Figure 1: TEG1-12611-6.0 [7]

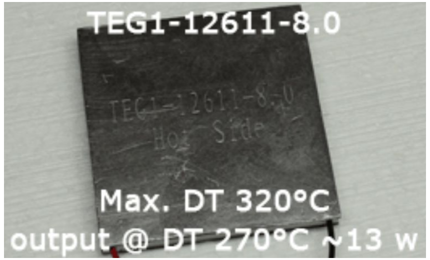


Figure 2: TEG1-12611-8.0 [7]

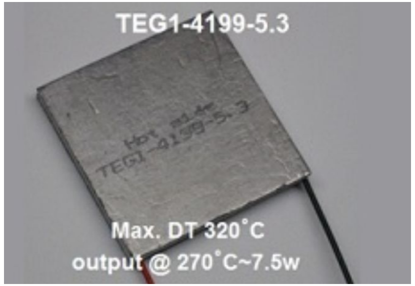


Figure 3: TEG1-4199-5.3 [7]

Benchmarking

- Rooftop solar panels
  - Monocrystalline Silicon Solar Panel
    - Volts: 18V
    - Watts: 300W
    - Size: 670mmx1129mm
    - Cost: $117.09 (walmart.com)
  - Monocrystalline Solar Panel
    - Volts: 12V
    - Watts: 100W
    - Size: 48in x 21.5in x 0.08in
    - Cost: $167.19 (renogy.com)
  - Polycrystalline Flexible Solar Panel
    - Volts: 5V
    - Watts: 100W
    - Size: 435mmx200mmx30mm
    - Cost: $37.63 (alexnld.com)

Figure 4: Monocrystalline Silicon Solar Panel [8]

Figure 5: Monocrystalline Solar Panel [9]

Figure 6: Polycrystalline Flexible Solar Panel [10]

Literature Review - Thermoelectric Generators (TEGs)

- Thermoelectric generators (TEGs) are used to convert thermal energy into electrical energy via the **Seebeck effect.**
- Environmentally friendly since TEGs do not contain chemical products and operate silently since they do not have moving parts [3].
- TEGs have become an area of interest in the field of energy harvesting
  - Energy efficiency (~4 - 5%)
  - Free of maintenance for about 30 years.
  - Long lifetime (over 100,000 hours of continuous use).

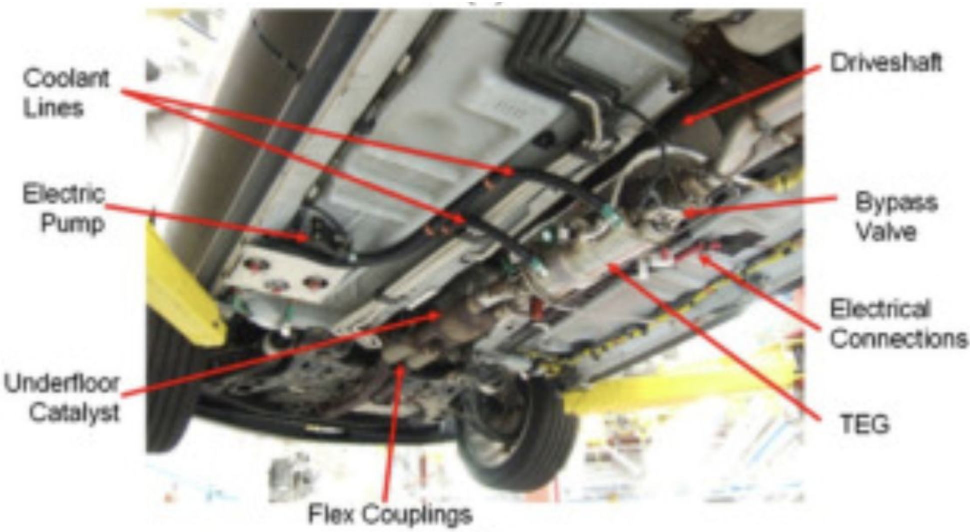


Figure 7: Integration of the TEG into the underfloor of a Ford vehicle. [3]

Literature Review - Solar Powered Cars

- Solar Powered cars are environmentally friendly
  - produces no pollution or greenhouse gases
- Solar energy gets converted from thermal energy to electrical energy and stored in the car's accumulator.
- Lightyear one has a driving range of 425 miles with one single charged battery.
  - Tesla's model S driving range: 379 miles.

Figure 8: Lightyear One covered in a total of 16 sq ft of solar panels on it's roof and hood. [4]

Literature Review - Harvest Energy from Brake Discs

- Use thermoelectric generators (TEG) to restore energy from braking system.
- Simulations showed that at 25°C, the disk brake reached 200°C and the TEG delivered about 4.25W.
- Just know, that brake discs can get hotter than the simulation temperature.
- The test showed that the TEG efficiency is about 0.3% of the total thermal energy from the braking system.

Figure 9: Full disc and pad used in simulation test [6]

Literature Review - Water Immersion & Offshore Wind Farm

- (1) - This journal entry describes the efficiency gain from using a water immersion cooling technique for solar panels
  - This is useful to our project because it gives us some insight into the newest technology in the field of solar energy
- (2) - This article uses an offshore wind farm in Denmark as a benchmark to correlate determine the relationships between many differing variables in wind-energy generation
  - This is relevant to our study because it will help the team understand how these variables can be used to calculate the total energy gained in order to help choose three different forms of energy

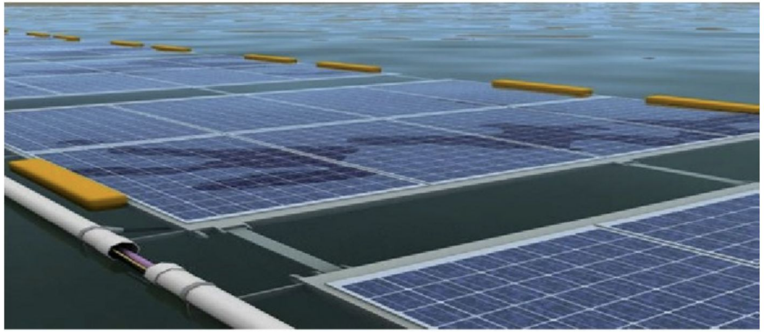


Figure 10: A strip of submerged photovoltaic panels. [1]

Customer Needs

- Must not add a significant amount of weight
- Must not cost a lot of money
- Must supply enough power to perform at least one vehicle function
- Must not ruin the vehicles aesthetics
- Must be a device that is added on to an existing vehicle
- Must capture and use at least three forms of energy

Engineering Requirements

- The team have turned this list into a set of engineering requirements that act as the goals or guidelines for the design task.
- Device must be able to withstand road conditions
  - Weight (< 150 lbs)
  - Price (≤ $1000)
  - Power (≥ 80 Watts)
  - Aesthetically Pleasing (Y/N)
  - Aftermarket Device (Y/N)
  - Three types of energy used (Y/N)
  - Withstand average road wear (Y/N)
- This was accomplished by taking the customers wants and finding measurable ways that we could meet their desires

Quality Function Deployment (QFD)

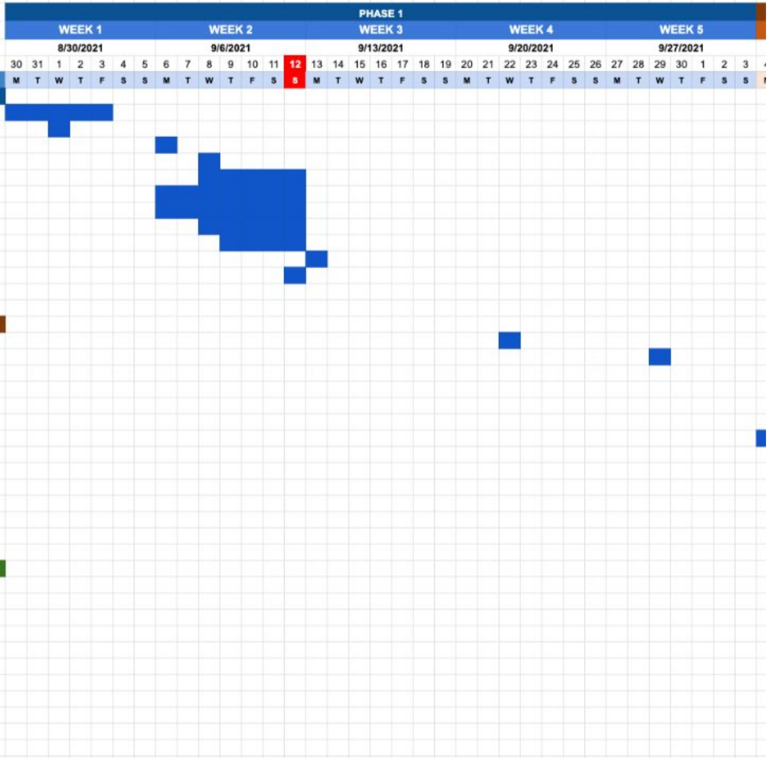
Legend	
A	TEG1-12611-8.0
B	Monocrystalline Silicon Solar Panel

	Weight (lbs)	Price ($)	Power (W)	Aesthetically Pleasing (Y/N)	Aftermarket Device (Y/N)	3 types of energy used (Y/N)
Weight (lbs)						
Price ($)	+					
Power (W)	0	+				
Aesthetically Pleasing (Y/N)	0	0	0			
Aftermarket Device (Y/N)	0	-	0	0		
3 types of energy used (Y/N)	+	+	++	0	0	
Able to withstand avg roadwear (Y/N)	-	+	0	+	+	0

Design Requirements / Customer Requirements	Importance	Weight*	Price*	Power*	Aesthetically Pleasing*	Aftermarket Device*	3 types of energy used*	Able to withstand avg roadwear*	Customer Competitive Assessment: 1 Worst	2	3	4	5 Best
1) Not add significant weight	6	9	2	2	2	2	2	4				AB	
2) Must not be too epensive relative to the vehicle	5	1	9	4			3	3			B		A
3) Must supply enough power to perform at least one vehicle function	9		4	9		4	7			A		B	
4) Does not compromise the vehicles aesthetics	5	3			9	5		4		B			A
5) Is an add on to the vehicle	3				6	9	3	2					AB
6) Device captures at least 3 different forms of energy	4		3	7	2	3	9			A		B	
7) Device must be durable enough to withstand road wear	3	2			5			9					
Technical Requirement Units		lbs	$	Watts	N/A	N/A	N/A	N/A					
Technical Requirement Targets		150	1000	80	N/A	N/A	N/A	N/A					
Technical Importance: Absolute		80	105	141	98	112	135	92					
Technical Importance: Relative		7	4	1	5	3	2	6					

Figure 11: House of Quality

Schedule - General Overview



EV Moghaddam

Company Name

Project Manager : Miwa Dawidowicz

Project State: 8/30/2021

Display Week: 1

TASK	ASSIGNED TO	PROGRESS	START	DAYS	END
PHASE 1			8/30/2021		9/13/2021
Team Charter	Team	100%	8/30/2021	5	9/3/2021
Set up Meeting With Dr. Moghaddam	Austin Engelbrecht	100%	9/1/2021	1	9/1/2021
Time Card 2	Team	100%	9/6/2021	1	9/6/2021
Meeting with Dr. Moghaddam	Austin Engelbrecht	100%	9/8/2021	1	9/8/2021
Project Description	Austin Engelbrecht	100%	9/8/2021	4	9/12/2021
Background & Benchmarking	Terrell Blackgoat	100%	9/6/2021	6	9/12/2021
Literature Review	Team	100%	9/6/2021	6	9/12/2021
Customer & Engineering requirements	Austin Engelbrecht	100%	9/8/2021	5	9/12/2021
Schedule & Budget	Miwa Dawidowicz	100%	9/9/2021	4	9/12/2021
Time Card 3	Team		9/13/2021	1	9/13/2021
Presentation 1	Team		9/12/2021	1	9/12/2021
Meeting with Dr. Moghaddam	Team			1	
PHASE 2			9/22/2021		11/1/2021
Staff / Team meeting	Team		9/22/2021	1	9/22/2021
Staff / Team meeting	Team		9/29/2021	1	9/29/2021
Task					
Task					
Task					
Task					
Presentation 2	Team		10/4/2021		10/4/2021
Staff / Team meeting					
Staff / Team meeting					
Preliminary Report	Team		10/11/2021		10/11/2021
Website Check	Team		10/18/2021		10/18/2021
Analytical Analysis Memo	Team		10/25/2021		10/25/2021
Presentation 3	Team		11/1/2021		11/1/2021
PHASE 3			11/8/2021		12/6/2021
Staff / Team meeting	Team				
Staff / Team meeting	Team				
Staff / Team meeting	Team				
Task					
Task					
Task					
Prototype Demo	Team		11/29/2021		11/29/2021
Final Prototype	Team		11/29/2021		11/29/2021
Website Check			12/6/2021		12/6/2021
Final Report	Team		11/8/2021		11/8/2021
Final CAD/BOM	Team		11/15/2021		11/15/2021

Figure 12: General overview of EV Moghaddam's Gantt Chart

Schedule

EV Moghaddam

Company Name

Project Manager : Miwa Dawidowicz

Project State: 8/30/2021

Display Week 1

TASK	ASSIGNED TO	PROGRESS	START	DAYS	END
PHASE 1			8/30/2021		9/13/2021
Team Charter	Team	100%	8/30/2021	5	9/3/2021
Set up Meeting With Dr. Moghaddam	Austin Engelbrecht	100%	9/1/2021	1	9/1/2021
Time Card 2	Team	100%	9/6/2021	1	9/6/2021
Meeting with Dr. Moghaddam	Austin Engelbrecht	100%	9/8/2021	1	9/8/2021
Project Description	Austin Engelbrecht	100%	9/8/2021	4	9/12/2021
Background & Benchmarking	Terrell Blackgoat	100%	9/6/2021	6	9/12/2021
Literature Review	Team	100%	9/6/2021	6	9/12/2021
Customer & Engineering requirements	Austin Engelbrecht	100%	9/8/2021	5	9/12/2021
Schedule & Budget	Miwa Dawidowicz	100%	9/9/2021	4	9/12/2021
Time Card 3	Team		9/13/2021	1	9/13/2021
Presentation 1	Team		9/12/2021	1	9/12/2021
Meeting with Dr. Moghaddam	Team			1	

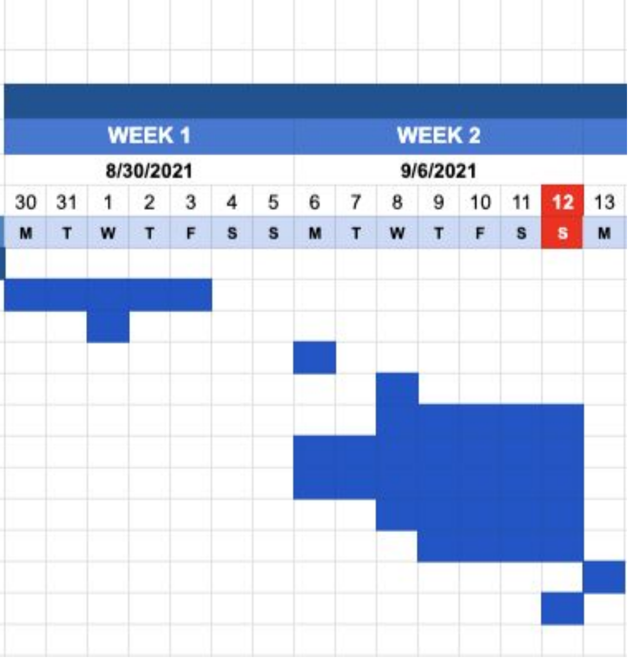


Figure 13: Detailed overview of Phase One of EV Moghaddam's Gantt Chart

Budget

- Current budget is at $1000.
- Rough estimate of how budget will be utilized:
  - $900 for prototyping
    - ~$800 Car Parts (solar panels, TEGs, Capacitors, etc.)
    - ~$100 Tools
  - $100 for contingency budget
  - Subject to change if necessary.

Figure 14: Keeping track of budget. [5]

Literature Review Documents

(1) Mehrhotra, Saurabh, et al. "PERFORMANCE OF A SOLAR PANEL WITH WATER IMMERSION COOLING TECHNIQUE ." *International Journal of Science, Environment and Technology*, vol. 3, 3 Mar. 2014, pp. 1161–1172., doi:ISSN 2278-3687.

(2) Barthelmie, R. J., and L. E. Jensen. "Evaluation of Wind FARM Efficiency and Wind Turbine Wakes at the Nysted Offshore Wind Farm." *Wind Energy*, vol. 13, no. 6, 28 June 2010, pp. 573–586., doi:10.1002/we.408.

(3) Nesrine Jaziri, Ayda Boughamoura, Jens Müller, Brahim Mezghani, Fares Tounsi, Mohammed Ismail, A comprehensive review of Thermoelectric Generators: Technologies and common applications,Energy Reports, Volume 6, Supplement 7,2020, Pages 264-287, ISSN 2352-4847,https://doi.org/10.1016/j.egyr.2019.12.011. (https://www.sciencedirect.com/science/article/pii/S2352484719306997)

(4) T. An, "Study of a new type of electric car: Solar-powered car," *IOP Conference Series: Earth and Environmental Science*, vol. 631, p. 012118, 2021.

(5) <div>Icons made by Freepik from www.flaticon.com</div>

(6) Adama Coulibaly, Nadjet Zioui, Said Bentouba, Sousso Kelouwani, Mahmoud Bourouis, Use of thermoelectric generators to harvest energy from motor vehicle brake discs, Case Studies in Thermal Engineering, Volume 28, 2021, 101379,ISSN 2214-157X, https://doi.org/10.1016/j.csite.2021.101379. (https://www.sciencedirect.com/science/article/pii/S2214157X21005426)

Literature Review Documents

(7) “Thermoelectric power generator MODULE SELECTION,” *Thermoelectric Generator*, 31-Jul-2014. [Online]. Available: https://thermoelectric-generator.com/thermoelectric-power-generator-module-selection/. [Accessed: 13-Sep-2021].

(8) TheShamaness, Matthew, Ddogsdad, and WalmartCustomer, “120W/240W/300W portable+safe+waterproof ip65+flexible solar panel car charger outdoor power monocrystalline silicon for car rv boat,” *Walmart.com*, 23-Feb-2021. [Online]. Available: https://www.walmart.com/ip/120W-240W-300W-Portable-Safe-Waterproof-IP65-Flexible-Solar-Panel-Car-Charger-Outdoor-Power-Monocrystalline-Silicon-For-Car-RV-Boat/353238155?wmlspartner=wlpa&selectedSellerId=101014596. [Accessed: 13-Sep-2021].

(9) “100 watt 12 Volt flexible Monocrystalline solar panel,” *Renogy United States*. [Online]. Available: https://www.renogy.com/100-watt-12-volt-flexible-monocrystalline-solar-panel/?gclid=CjwKCAjwyvaJBhBpEiwA8d38vKzIWc47DFuOFxIrUSqnkth02pDnXhoMkn5bWqQkmjiI3PGcrFkU7hoC5AoQAvD_BwE. [Accessed: 13-Sep-2021].

(10) “100W polycrystalline flexible solar Panel Portable Multi-purpose EMERGENCY CAR Ship camping phone charger,” *Alexnld.com*. [Online]. Available: https://alexnld.com/product/100w-polycrystalline-flexible-solar-panel-portable-multi-purpose-emergency-car-ship-camping-phone-charger/. [Accessed: 13-Sep-2021].