Project 1.3.2

Solar Hydrogen Vehicle Project

Megan Fannin, Ayra Jafri, Anish Kachinthaya, Liam O'Flynn
Chou POE 6
11/2/17 - 11/16/17

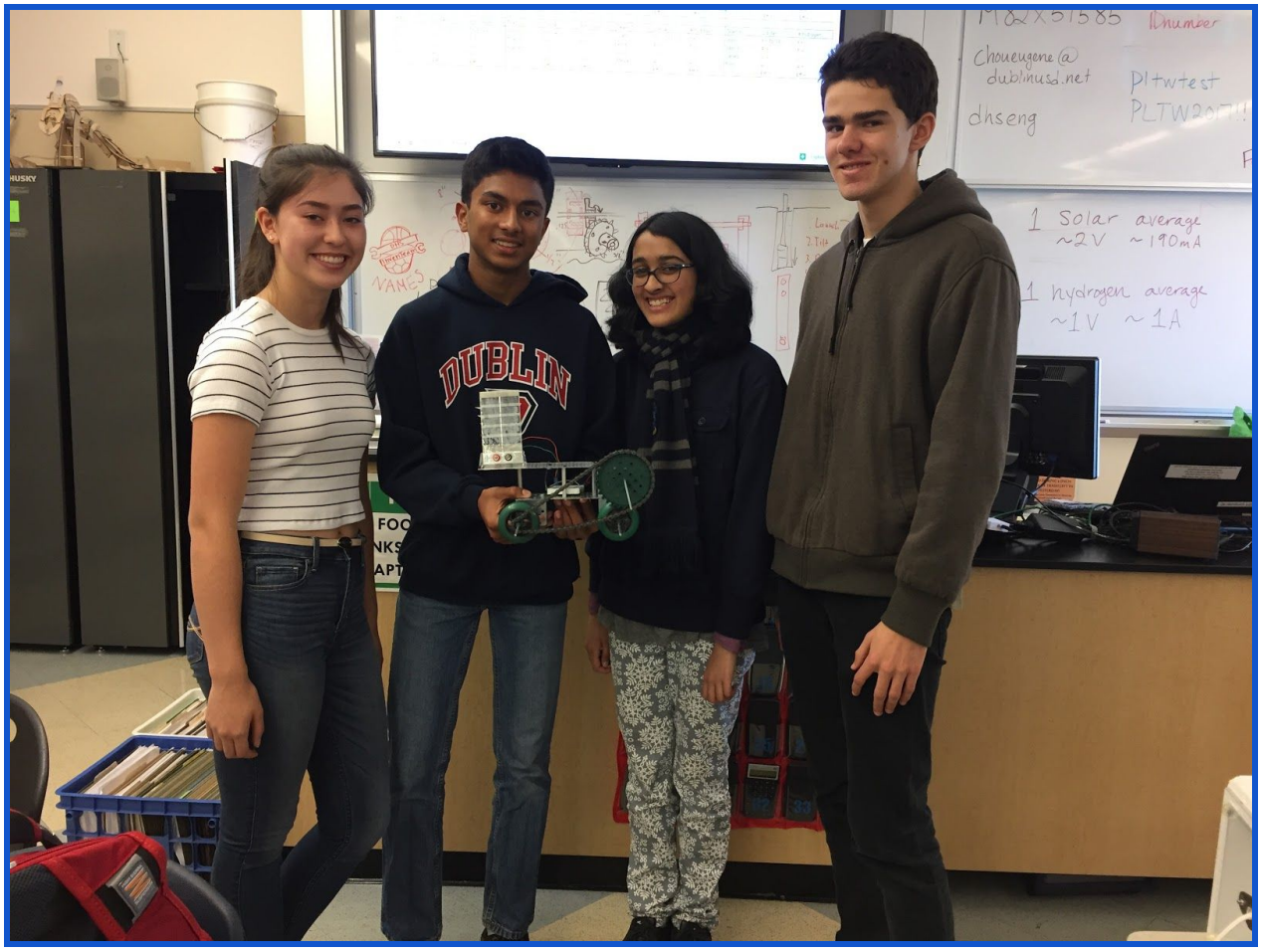


Table of Contents

Design Brief

Client:	Tesla Motors
Designer:	Team Joules
Problem Statement:	The company Tesla Motors wishes to gain some insight about the amount of power and speed capabilities of these sources to support their designs in order to increase the efficiencies of their technology.
Design Statement:	Design, create, and test a prototype that uses a solar module and/or fuel cell as its power source.
Constraints:	- The vehicle must be made using only the materials specified in the equipment list - The vehicle must be able to hold the solar module or hydrogen fuel cell securely and run without tipping the fuel cell - Top view of vehicle must be no larger than 5”x12” - The vehicle must use a breadboard to be be able to easily change between power source configurations for testing purposes - Team Documentation due by November 17, 11:59 pm - Individual Deliverables due by November 29

Deliverables:

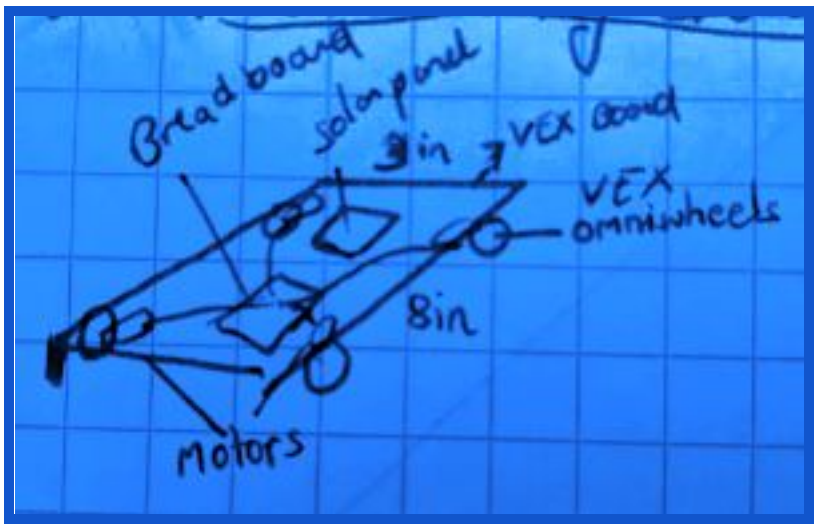
Team:

- Title page
- Table of contents
- Design brief
- Initial vehicle design solution
- Testing summary table(s)
- Power source evaluation & testing
- Summary paragraph
- Reference list of any sources used
- One fuel-cell powered vehicle
- One solar-powered vehicle

Individual:

- Design brief notes & team norms
- Project Log
- Brainstorming sketches
- Table of measurements
- Calculations
- Conclusion questions

Initial Design:



The initial design included a basic chassis consisting of a metal plate. The wheels were attached to the chassis by gear boxes, which held the bearings and the motor that would allow the vehicle to move from one point to another. The power sources were located on the metal plate, which output electricity to the motors. Although it was not specified in the sketch, there were zip ties that would keep the power sources on the metal plate and prevent them from falling over. The overall concept was for a simple, lightweight, and robust vehicle that could cover a distance in a relatively short amount of time in order to maximize productivity.

Our initial design for the single solar cell configuration required modification due to the fact that it was far too heavy for the amount of power supplied by the solar cell. Additionally, our low efficiency and gear ratio contributed to the lack of speed that was exhibited in our tests. To improve these design flaws, we opted for use of a larger gear connected via a chain to a gear that was much smaller in diameter, which led to a higher gear ratio and thus a faster speed. We also omitted many heavy aspects of our design to further increase our speed.

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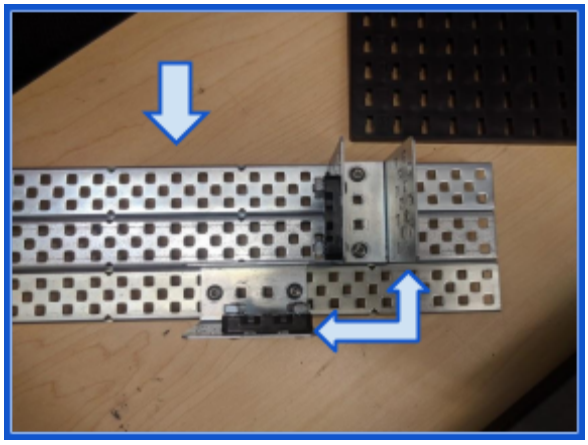
Design Process Images



Description:
This was the original chassis design for our prototype. We attached 3 12 inch c-channels together and 2 rack gear box brackets that would hold the wheel and axles, and the vex motor.

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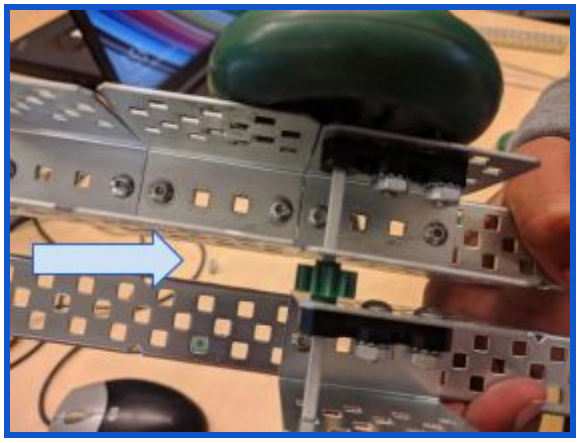

Description:
In our first design, we made a simple modification to the chassis and removed the middle c channel. We added multiple rack gear box brackets to hold the gear chain powering the wheels.

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Description:
We attached bearings to the rest of the gear boxes which held the gears. This shows the gear train that powers the wheels which is geared to speed. Note however, that this is from a previous design, and that a chain and sprocket system was used in the final design of the car.

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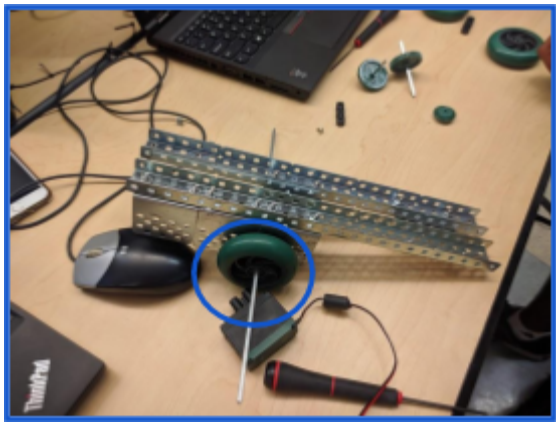

Description:
We added wheels on each side to complete the back part of the prototype, which is powered by the motor, which made the car rear-wheel driven.

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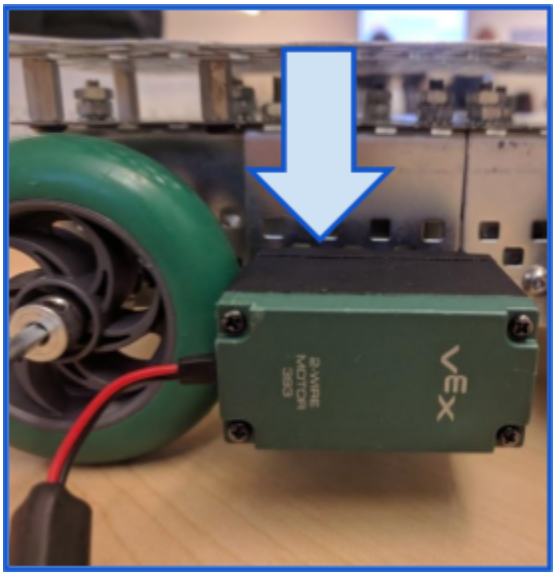

Description:
This image shows the positioning of the motor from a previous design, in which the motor was place on the underside of the vehicle instead of on the top, as seen in the final design.

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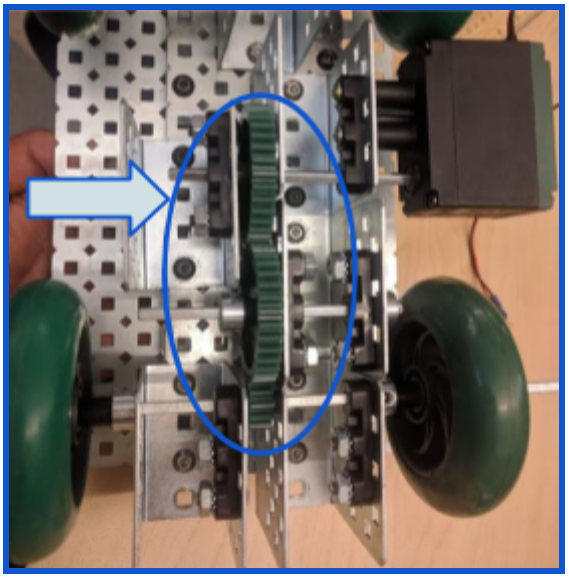

Description:
This image shows a completed view of the bottom of the base, with the complete gear train featured, which has been geared focusing on speed. However, this is from a previous design (specifically the design featured on the left image); the newer design features a chain and sprocket system due to gear train's weight and inefficiency when compared together.

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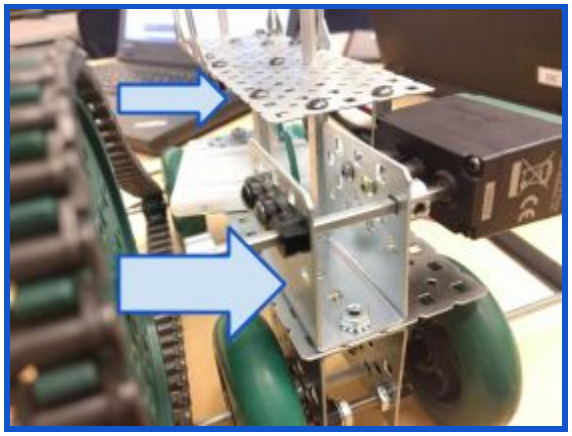

Description:
During a major rebuild, we replaced the c channels with a metal plate and added a gear box on the top of the plate to hold the motor in place.

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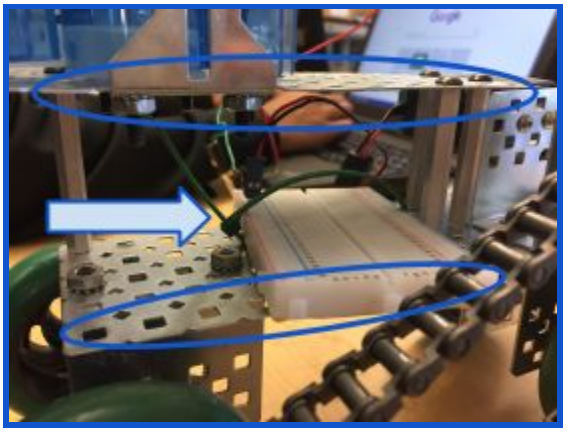

Description:
We utilized zip ties within the breadboard onto the lower chassis, allowing for a slightly more securely attached breadboard. Note that the car has two levels, and that the breadboard is secured on the lower level, while the fuel cells are placed on the upper level.

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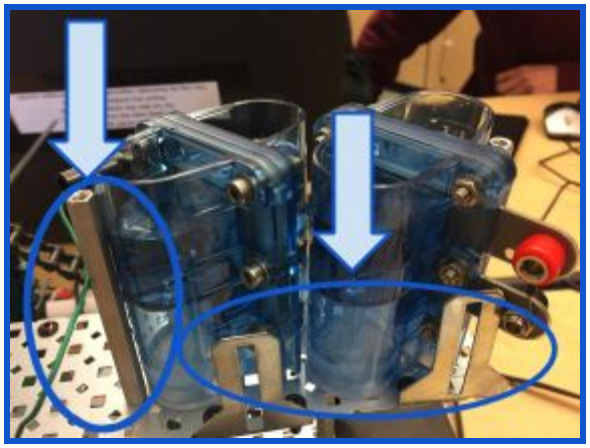

Description:
In order to secure the hydrogen cells on top of the prototype, we added standoffs and braces to the opposite sides of the top metal plate.

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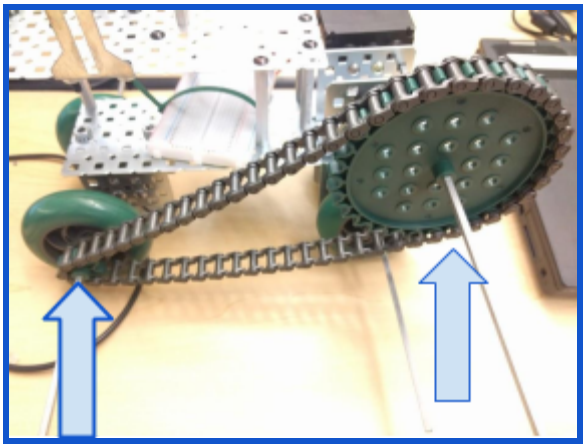

Description:
We the simple gear chain with a chain and sprocket system that connected the axle controlled by the vex motor to the axle that spun the wheels. Going from a large gear to a small gear increased the speed and gear ratio that made the system more efficient. However, the torque was sacrificed as a result.

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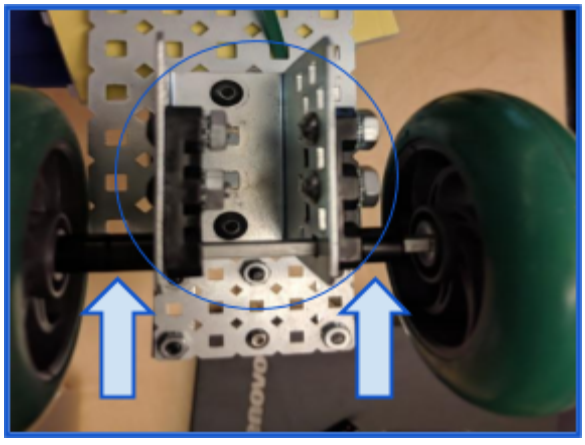

Description:
This image features the front set of the wheels of the car of our revised prototype. As seen above, two gearboxes were utilized to support a metal rod which the wheels are attached to. Spacers, nuts, and bearings were used to widen the spacing between the two wheels, and secure the axles in place. The wheels are driven by the two rear-wheels.

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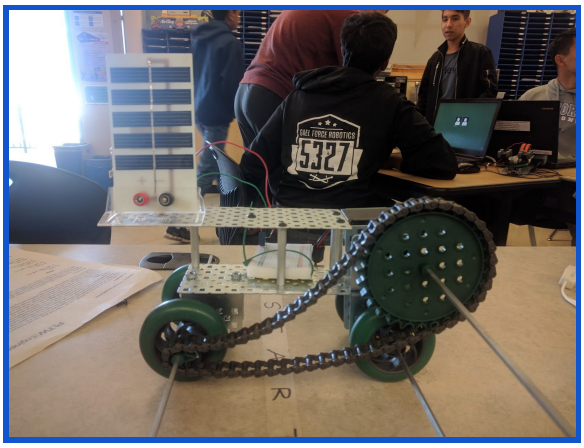
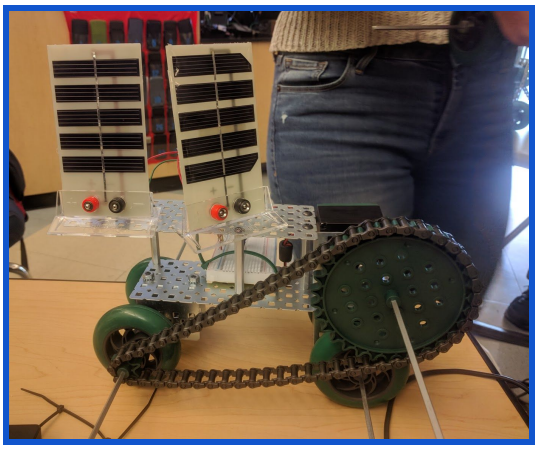
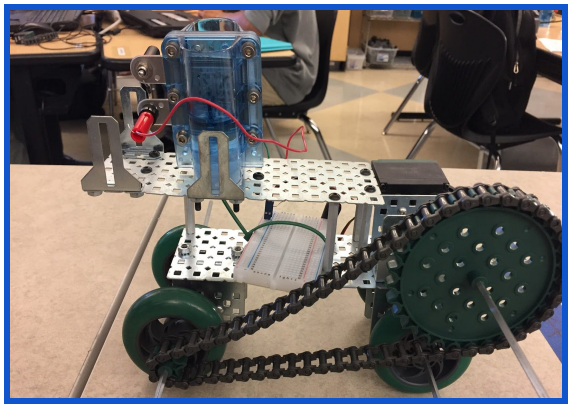
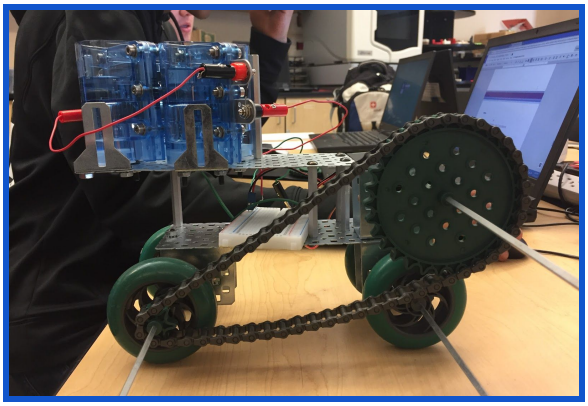
Testing Summary Tables and Calculations

Solar Cells:

1 Solar Cell	2 Solar Cells in Parallel
	
Voltage: 2.77 V **Current:** 48.4 mA **Electrical Power Input:** 0.134 watts **Force:** 0.25 N **Distance:** 1 m **Mechanical Output Power:** 0.026 watts **Time:** 9.57 sec **Speed:** 0.1045 m/s **Efficiency:** 19.49 % **Signatures:** Megan Fannin, Ayra Jafri, Anish Kachinthaya, Liam O'Flynn **Date:** 11/16/2017	**Voltage:** 2.77 V **Current:** 120.5 mA **Electrical Power Input:** 0.334 watts **Force:** 0.73 N **Distance:** 1 m **Mechanical Output Power:** 0.193 watts **Time:** 3.79 sec **Speed:** 0.2639 m/s **Efficiency:** 57.71 % **Signatures:** Megan Fannin, Ayra Jafri, Anish Kachinthaya, Liam O'Flynn **Date:** 11/16/2017

1 Hydrogen Cell	2 Hydrogen Fuel Cells in Series
	
Voltage: 0.89 V **Current:** 1.81 A **Electrical Power Input:** 1.611 watts **Force:** 0.15 N **Distance:** 1 m **Mechanical Output Power:** 0.018 watts **Time:** 8.19 sec **Speed:** 0.1221 m/s **Efficiency:** 1.14 % **Signatures:** **Megan Fannin, Ayra Jafri,** *Anish Kachinthaya, Liam O'Flynn* **Date:** 11/16/2017	**Voltage:** 1.87 V **Current:** 820 mA **Electrical Power Input:** 1.533 watts **Force:** 1.2 N **Distance:** 1 m **Mechanical Output Power:** 0.246 watts **Time:** 4.87 sec **Speed:** 0.2053 m/s **Efficiency:** 16.07% **Signatures:** **Megan Fannin, Ayra Jafri,** *Anish Kachinthaya, Liam O'Flynn* **Date:** 11/16/2017

Power Source Evaluation & Testing Summary Paragraphs

Through the test runs conducted with the various breadboarding configurations of the solar and hydrogen fuel cells, various conclusions were reached. Based on the data collected of the various cell configurations, the most efficient cells were the solar cells, with efficiencies of 19.49% and 57.71% respectively. Thus, the least efficient cells were the hydrogen fuel cells, with efficiencies of 1.14% and 16.07% respectively; very low values when compared to the solar cells' efficiency. Though these results contradicted the original prediction made, the efficiencies of each cell can be affected by multiple variables, including the condition of the fuel cells themselves, energy being lost between the breadboard and the cells, and the weight and overall design of the car. Regardless, in the end, solar cells were much more efficient than hydrogen cells for the car. However, it is important to note that the car developed was designed with increasing the speed in mind, and less on increasing the torque, which may, once again, impact the efficiencies calculated from the data collected. Therefore, the recommended power source, based on the data collected, are solar cells.

Other conclusions reached include determining which type of circuit to configure each pair of cells as. Based on the testing of the different circuit configurations (series and parallel circuits), it was determined that wiring the solar cells in a parallel configuration increased the overall power recorded, while wiring the hydrogen fuel cells in series proved to generate more power. This makes sense as wiring the solar cells in a parallel configuration greatly lowers the resistance, thereby increasing the amount of power received by the motor. Wiring the hydrogen fuel cells in series also increased the power received by the motor most likely due to the current in a series circuit being additive, thus increases the flow of the electrons between the components wired.

A few modifications would be required if the design was to be implemented for use by the masses, paramount of which would be the utilization of a capability to hold and charge power for later use. This could be accomplished via a battery that would be charged by one of our power sources, either the solar cell or the hydrogen cell. Based on the data collected, this would be accomplished via solar cells. Additionally, more effective versions of our power sources must be added, such as larger and more optimally designed solar cells, as to enable the cells to power a much more resource-consuming battery. Unfortunately, hydrogen fuel cells likely would not hold the same prospects as a viable fuel source due to how quickly they lose their respective charge, which is why solar cells would be the optimal choice for a power source.