Second Generation Bicycle Charging Station

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Midpoint Report

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Abstract

There were several components of the first generation bicycle charging station that needed to be addressed to make it more accommodating for users, more efficient, and more educational for students of all backgrounds.

The second generation bicycle charging station needed to be easily moved around campus for demonstrational purposes. The final design must also include a display that will provide users with information about power generation both graphically and numerically. Additionally, the station must include various small electronics chargers and a three-prong AC outlet. Finally, the build must fit within the design budget, granted through the NAU Green Fund, of $1600.00.

The final design implements an upright, three speed bicycle that will utilize a chain drive to transmit the rotational energy to the generator in order to charge electronic devices. The bicycle utilizes rotating stands to be fully functional in providing human powered mobility, yet allows the bike to transform into a stationary configuration for charging purposes.

1.0 Project Background

1.1 Project Summary

In 2012, a team of engineers designed and built a bicycle generator intended to power small electronics and educate the public about electrical power generation. The purpose of this project is to design a second generation of the Bicycle Generator in the Engineering Building at Northern Arizona University. The current design, located on the second floor of the Engineering building, is limited in both its power output and ability to address user needs. The 2nd Generation Bicycle Charging Station project team aims to redesign the charging station in a way that improves the portability, efficiency, usability, and versatility of the assembly to better aid in the design's overall purpose.

1.2 Project Statement

Our team's goal for this project is to "Provide students with a way to understand and compare the amount of energy required to power and charge electronic devices with the amount of energy produced by pedaling a bicycle."

2.0 Design Updates

2.1 Bike Stand

In the original design for the bike stand, the unit was to be welded together as one piece using one inch diameter AISI 4130 steel rod. After meeting with our client and further analysis on the total weight of the second generation bicycle generator, the frame was redesigned to utilize a lighter-weight hollow galvanized steel pipe. The pipe allowed for the charging station to be conducive to replication without requiring excessive machining or welding. A frame built from more common components, utilizing fasteners instead of welds, will allow for greater ease of duplication by eliminating the custom welding required for the original design.

The bicycle axle-stand connection will be accomplished by the combination of a tee joint, flare nuts, and a PVC bushing. As shown below in **Figure 1**, the rear axle will be screwed into the PVC bushing, protecting the threads from wear and deformation.

(a) **(b)**

Figure 1 – (a) Stand Connection Mechanism. (b) Completed Rear Stand.

The bushing slip-fits into the flare nuts, providing a connection that is both stable and able to rotate. Rotation at this connection is necessary in order for the stand to be moved into the transportation configuration. The component breakdown for the rear stand is shown in **Table 1**.

Table 1: Stand Purchases

Stand Purchases			
Part	Quantity	Cost ($)	Total ($)
pipe pex 3/8 X 5	1	1.89	1.89
tee glv 1/2"	2	2.79	5.58
1/2 inverted flare nut	4	2.79	11.16
nipple black 1/2" X 5.5"	1	2.49	2.49
5/8 flare swivel	4	6.79	27.16
nipple galv 1/2" X 5.5"	3	2.29	6.87
nipple galv 1/2" X 6"	1	2.49	2.49
nipple galv 1/2" X 2.5"	2	1.49	2.98
tee blk 1/2"	1	2.29	2.29
nipple black 1/2" X 2.5"	2	1.49	2.98
pipe galv tbe 1/2" X 18"	2	7.49	14.98
tee glv 1/2"	1	2.79	2.79
nipple black 1/2" X 3"	4	1.79	7.16
nipple black 1/2" X 12"	4	3.99	15.96
nipple galv 1/2" 9"	2	5.99	11.98
nipple galv 1/2" X 6"	4	2.49	9.96
tee glv 1/2"	4	2.79	11.16
elbow glv 1/2" 90 deg	2	2.49	4.98
cap galv 1/2"	2	2.79	5.58
Y joints galv	2	12.35	24.71
			Total
			150.44

Table 2: Stand Returns

Stand Returns			
Part	Quantity	Cost($)	Total ($)
nipple black 1/2" X 12"	2	3.99	7.98
nipple galv 1/2" X 5.5"	2	2.29	4.58
nipple galv 1/2" X 6"	1	2.49	2.49
			Total
			15.05
$150.44 - $15.05 = $135.39			

As seen in **Table 2**, the rear stand costs $135. The stand team's next task involves the construction of the front stand. The front stand will be significantly less complex than the rear stand because the front wheel lacks a gearset and is stationary. The front stand will function as a balancing mechanism, while the rear stand bears the majority of the load. Similar to the rear stand, the front stand will be made from common components such as pipe. This eliminates the need for custom machining or welding.

2.2 Generator

In order to finalize gear ratio selections for the user it is necessary to determine at what set of rpms the generator reaches optimization while still allowing the users to turn the crankset. The benefit of a comfortable rpm range setting is to generate the greatest amount of power. For this task a variable control motor is to be utilized in order to simulate user power input and create the power curve which will show the team at what settings the generator will perform in its sought range. In order to accomplish this task a coupler **(Fig 2(a))** and adaptor plate **(Fig 2(b))** were needed to correctly link the generator with the variable motor. Also shown in **Figure 2(c)**, is the generator mounted to the base plate

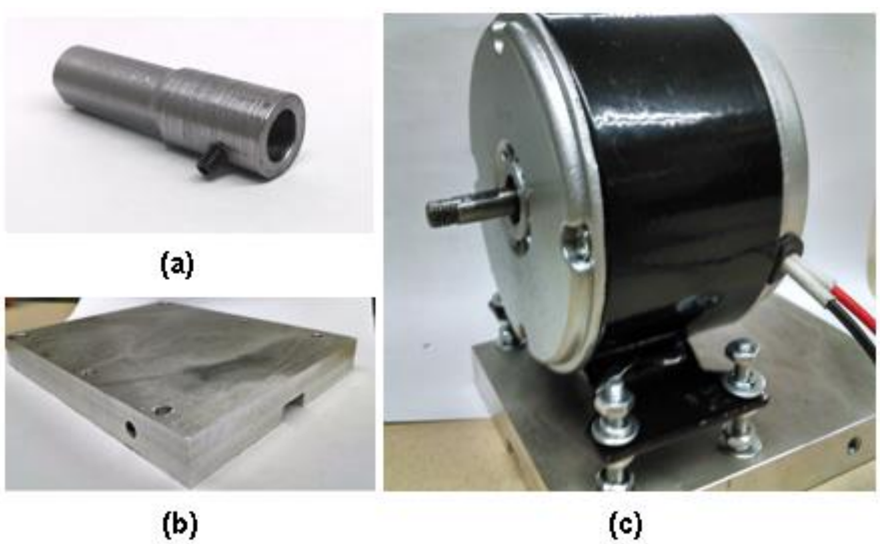


Figure 2 – (a) Machined coupler for generator shaft to variable motor coupler. (b) Machined baseplate for generator. (c) Generator on the base and secured with adjustable hardware.

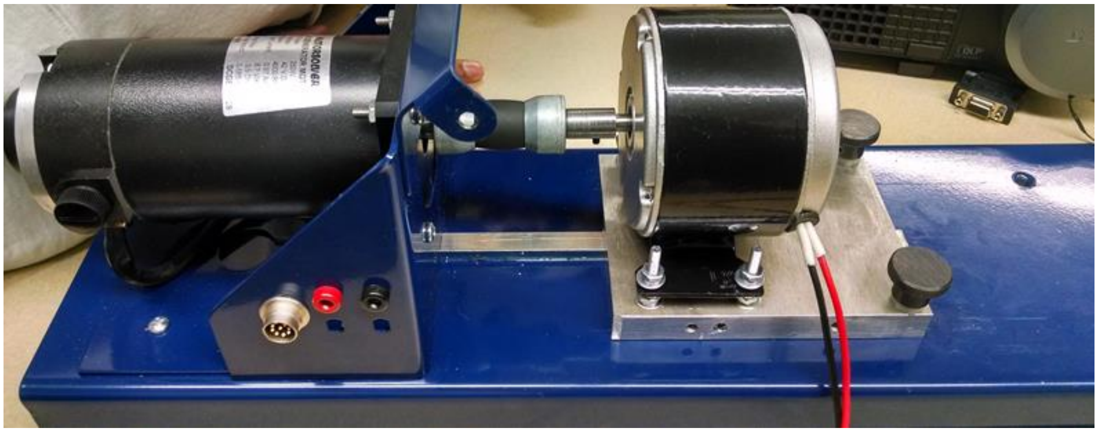


Figure 3 – Generator mounted for testing with variable motor (protective cover removed)

The goal for the team is to have testing of the generator with the variable motor, the setup of which can be seen in **Figure 3,** completed the week of March 3rd. Also scheduled to be completed is the mounting of the generator to the bike accomplished by March 10th. The connection of the generator sprocket will occur at that time and allow for final testing of the generator and display on the final setup. The chain sprocket will be adapted to the generator by an adapter sleeve and secured by a set screw. The sleeve built for the initial generator testing will be reused for this purpose.

2.3 Housing for Electrical Components

As per our clients request, the housing for all electrical components will be made from Plexiglas allowing for users to see the various electronics that make up the display. Since there are very delicate parts associated with the electrical components, the housing (**Figure 4**) will be made of shelves allowing for the fragile ribbon cables to be held in place. The touch screen itself will be inset to the housing, allowing for optimal interaction. In addition, there will be a small lip on the face of the display housing to allow users to place their small electronics.

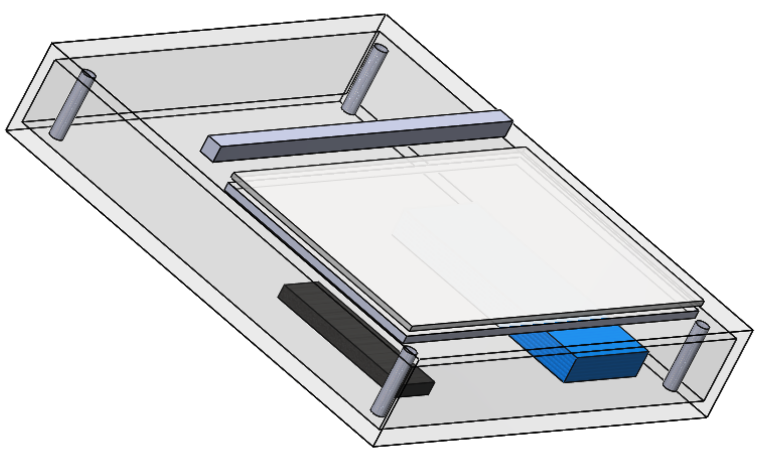


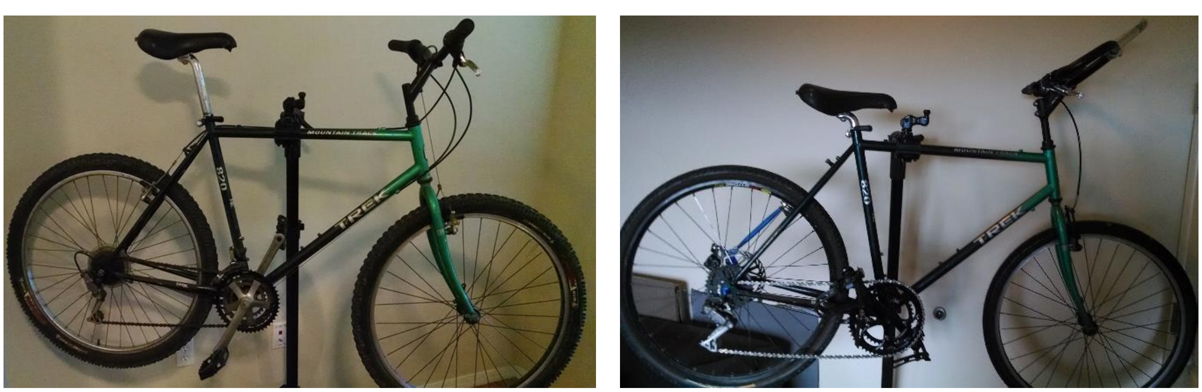
Figure 4 - Display Housing.

The display will be connected to the bicycle through the use of extension arms that connect directly to the bicycle handlebars. These arms will mate with mounts screwed directly into the display housing, providing a secure attachment. Since the attachments use common button head screws to connect, extra security precautions will be taken in the form of a cable lock from the display housing to the bicycle frame. **Figure 5** provides a view of the mounting hardware that will be used.

Figure 5 - Mounting Hardware for Display Housing

2.4 Main Bike Components

Having gotten a fully functional bicycle donated from a local bicycle shop in town (**Figure 6(a)**), for use with this project, the budget that would have gone to purchasing a new bicycle instead has gone to the upgrading lower quality components. **Figure 6(b)** specifically shows the bike with added upgraded components. The difficulty when upgrading components is checking that the new selections will mesh smoothly with the overall system.



(a) **(b)**

Figure 6 - (a) Original donated bike setup **(Before)**. (b) Bike with upgraded components added **(After)**.

For steering the bike, the previous setup had shortcoming to allow for adjustibility and ergonomics. To overcome these a handlebar, that allowed for multiple hand positions and thus a wider dispersion of work over more muscles, was purchased. Building off this base ergonomic handlebar grips, more bar extenders and a trigger shifter with brake lever were added. An adaptor for the steer tube attached to the front tube was also obtained to allow for a more structurally sound handle holder to be used. All the previously described components can be seen laid out in their persective orientation in **Figure 7** below.

Figure 7 – Layout of upgraded componets for steering and ergonomics.

In the original setup of the donated bike, the drive system components were not sufficient to create the gearing ratios and smooth rotating motion desired. To change this a new bottom bracket cartridge bearing (**Fig. 8(a)**), Pedals with toe cages (**Fig. 8(b)**) and larger toothed crankset (**Fig. 8(c)**) were purchased. The original cartridge bearing was in questionable age and condition prompting the decision to replace it with a new unit. The selection of this unit makes replacement faster and easier for the basic user over the alternative requiring disassembly and reassembly of a lower cost unit. The pedals selected allow users to increse the generation of power by engaging more muscle fibers and keeping their feet engaged with the pedal at all times. For the upgraded crankset it has a useful feature of having replaceable chainrings to utilize lower replacement costs and removing the smaller chainring from the component. By removing the smaller chainring the bike system can be further simpified by removing a front shifter unit and the controls to that unit leading to less moving parts and needed maintanance

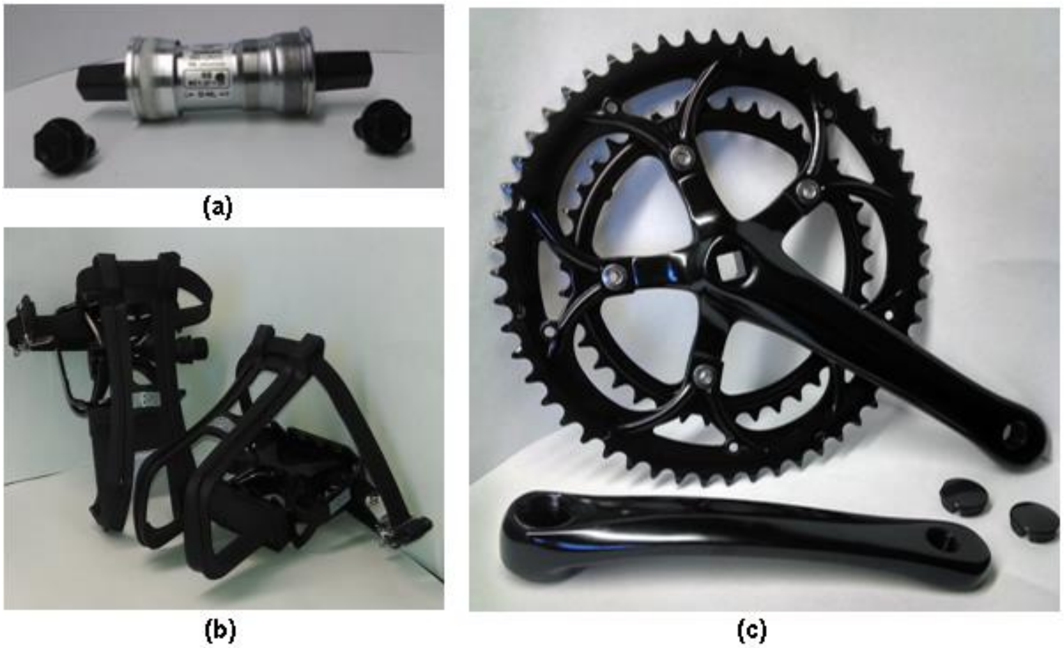


Figure 8 - (a) Cartridge bottom bracket bearings. (b) Pedals with toe cages and straps. (c) Crankset with replaceable chainrings.

Another feature that was changed from the original bike was the use of a donated rear disc brake wheel. This setup allows for the rearrangement of the gearing as well as repositioning of the rear brake. Specifically, the design looks to incorporate direct chain drive from the rear wheel to the mounted generator on the bicycle and the previous rear brakes were in the path of the chain necessary to turn the generator. In order to make the conversion from a standard wheel to a disc brake wheel, adaptors were purchased along with a disc brake caliper to continue having braking to the rear wheel. Those adaptors and brake caliper are shown in **Figure 9.**

Figure 9 - Disc brake setup.

Finally, other components that have been upgraded include 2 new chains, new tires, new inner tubes, wrapping bar tape and v-brakes for the front wheel. One of the new chains will be for used in turning the rear wheel while the second chain will turn the generator from a separate rear chainring on the rear wheel. The tires that were chosen are smooth in the center of the tread with knobs off to the sides allowing for low rolling resistance, as well as traction when making turns, during the transporting of the system from one location to another. From first glance this bike may look odd, but when thought about in terms of combining a stationary exercise bike and a functional bike the design intent becomes clearer.

3.0 Project Timeline

In order to remain on task the team has been using Gantt charts for project timelines. **Figure 4** reports the updated timeline as of the midpoint presentation. Remaining events can be seen in the Gantt chart and reflect a projected timeline to completion. The week of March 10th will be integral to the project as it will reflect completion of the bike stands, generator mounting, and collection of the display materials as well as starting work on the operations manual, final bike tune-up, and the final testing phase with the electrical team. Other key upcoming events are building the final presentation that will be presented to the NAU Green Fund and preparation for the UGRAD symposium.

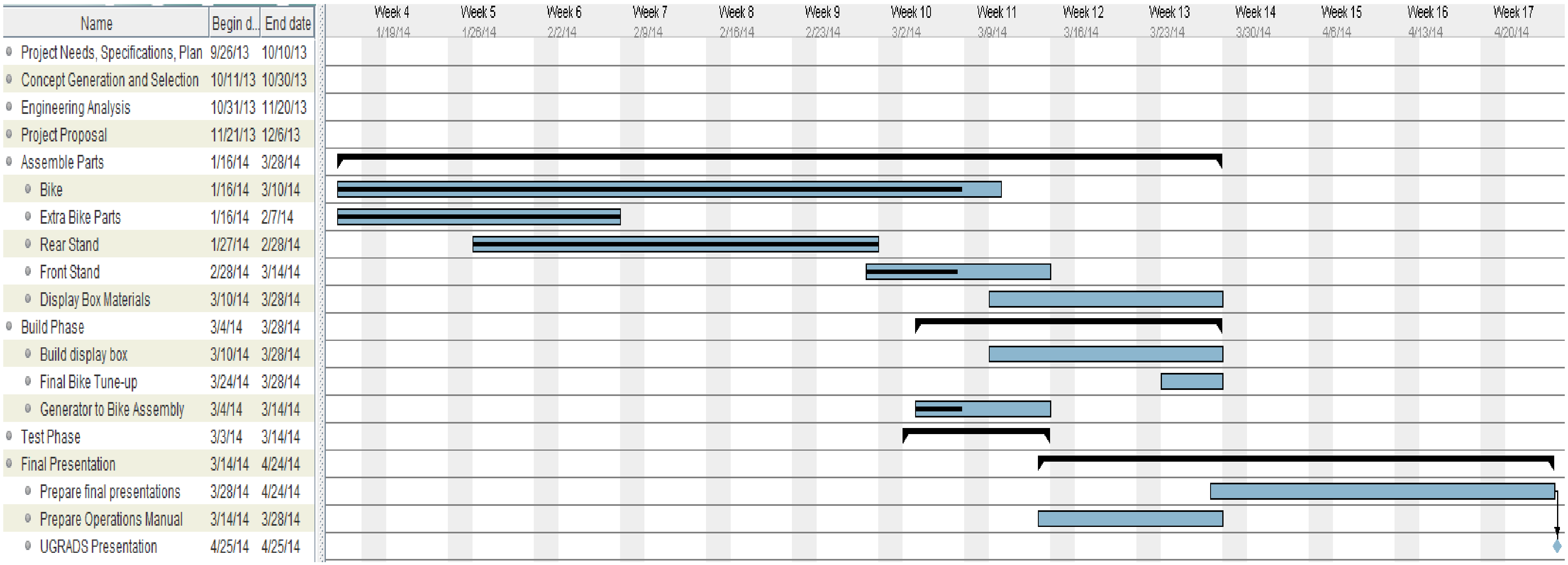


Figure 4: Updated timeline.

4.0 Cost Analysis Update

The second generation bicycle charging station was given a budget of $1600 by a grant from the NAU Green Fund. This budget will cover both electrical and mechanical components for the second generation charging station. For this report, only the mechanical components will be budgeted as can be seen in **Table 2** below. The cost of the bicycle and seatpost clamp have been eliminated because both were donated for the project. The cost of the stands have been reduced from $350 to $250. The total estimated cost of the mechanical components for the project is $425. The remaining funds will be used for electrical components and act as a buffer for material costs.

Table 3: Updated Budget

Material	Cost ($)
Bicycle	$0
Handlebars	$50
Stands- Front and rear	$250
Gear Cassette & Derailleur	$50
Seatpost Clamp	$0
Tools To Be Included	$10
Fasteners	$15
Display Box	$50
Grand Total	$425

5.0 Conclusion

The second generation bicycle charging station project is progressing on schedule. The donation of a geared bicycle and other workable parts has reduced the expected expenditures. New tires, a gear shifter, grips, handlebars, disc brakes, and front gear cassette have been installed. Small changes to the original stand design include using a lighter material as well as a simpler design to allow for easy replication. The stand can be attached to the bike as soon as the solid axle is acquired. The generator is ready to be mounted to the bike pending electrical team testing scheduled to be finished the week of March 3rd. The display housing will most likely be transparent, to increase the potential for educational use. Design for the housing has begun and will continue as the necessary configuration for the electronics is determined. Final testing and compiling of the operations manual are scheduled to begin the week of March 10th in order to meet the UGRAD symposium and capstone deadlines.