AMS Pedal Powered Charging Station

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AMS Pedal Powered Charging Station

TEAM ECO DEPOT | UBC Mechanical Engineering

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Table of Contents

Executive Summary 3
Engineering Design Process 4
Value Proposition 4
Identify Needs/Setting Requirements 5
Generating Concepts and Evaluate/Select 7
The AMS Pedal Power Station 9
Using the device 11
Leaving the device 11
Testing 12
Recommendations 13

List of Figures

Figure 1: Engineering Design Process 4
Figure 2: Example of a design requirement 6
Figure 3: Example of an evaluation criteria 7
Figure 4: Isometric View of the final concept 8
Figure 5: Pedal System 9
Figure 6: Table Top 10

Dossier Table of Contents

Dossier 1 – Needs Assessment 1

Dossier 2 – Specifications

Dossier 3 – Project Management

Dossier 4 – Proposal

Dossier 5 – Needs Assessment 2

Dossier 6 – Concept Generation

Dossier 7 – Critical Function Prototype

Dossier 8 – Technical Analysis

Dossier 9 – Design Review

Dossier 10 – Construction Process

Dossier 11 – Detailed Design

Dossier 12 – Validation and Verification

Executive Summary

AMS Sustainability will have a new office space in the newly built student union building (Student NEST). A discussion spawned between members of AMS Sustainability to power electronic devices by a pedaling motion, similar to a bicycle. This idea was refined, and proposed to the UBC Mechanical Engineering Department through the UBC SEEDS Program. The objectives of this project is not only to create a functional charging station, but also to further the goals of AMS Sustainability. AMS Sustainability aims to reduce the ecological footprint of UBC, increase student engagement, as well as increase education and outreach. Thus, Team Eco Depot's focused their solution accordingly.

Team Eco Depot focused on two major areas: to increase student engagement and increase education. In order to increase student engagement, the charging station is designed to become easier to pedal when two students are pedaling, as opposed to one. Secondly, our station will expose students to the process of energy generation and transportation.

The purpose of this report is to guide our immediate clients through our design process. Throughout the entire project, there was a constant and frequent communication between the clients and the engineering team. The design process reflected a balance between the client's needs and the team's resources. The following report describes the engineering design process which include: steps to our solution, the considerations we held, and recommendations moving forward. Many details of the process are referenced in the Dossier.

Engineering Design Process

This section of the reports outlines the process and considerations of our design. The design process is an iterative process. The basic cycle of the engineering process is shown in Figure 1. This cycle creates a structure for designers to follow. However, the process of design is iterative. Throughout the lifespan of the project, each step is revisited time and time again. Only then can the final product truly be realized. The final iteration of each process will be detailed in this report.

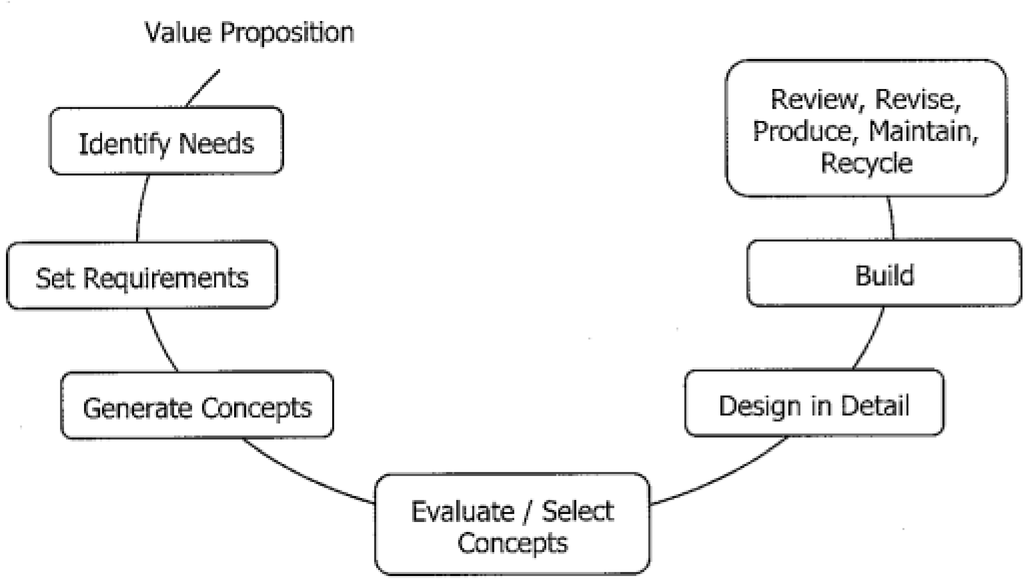

Figure 1: Engineering Design Process

Value Proposition

The value proposition answers the question, "Why are we doing this?"

In 2011, funding for the AMS Sustainability Fund was approved by the student referendum. The fund is used to support student projects approved by AMS Sustainability, the student division at UBC tasked with the job of promoting sustainability goals across campus. Their sustainability goals include, in no particular order of important:

- Reduction of Ecological Footprint
- Increased Student Engagement
- Education and Outreach
- Longevity and Feasibility
- Impact at UBC

Our clients long for an interactive student station inside the AMS Sustainability Center of the Student Nest. Students, faculty, and visitors will all have access to this device. The idea of generating your own pedal power will reduce ecological footprint. However, a major value resides in increasing student engagement and education. By having a project that creates social cohesion through an interdisciplinary environment, sustainability can be further exposed in the community. The educational aspect of our project, which will be described in further detail in the report, truly aligns itself with the goals of AMS Sustainability. True value of this project resides in the social impact the project imposes. Neither monetary nor commercial gain is identified to be the primary value, but the project is not limited to such. The scope of our project is to:

1. Propose a funding application that will cover all costs relative to our project
2. Create a functional prototype to prove our concept
3. Deliver a ready to implement device that will have three separate entities:
    a. A bicycle capable of turning mechanical energy into electrical energy source
    b. A physical base that will regulate the electrical energy source
    c. An attachment to the physical base that will allow users to charge their phone
4. A Final Report

Identify Needs/Setting Requirements

Identifying the needs of a project reduces the risk of failure by determining the issues that the design will fulfill. Needs are broken down into a set of requirements.

Based off meeting with the clients, this device needs to:

1. Promote Sustainability
2. Encourage Student Collaboration
3. Function as a public attraction
4. Portable for movement around a building
5. Not draw energy from external sources

In order to create a device that satisfies these objectives, we broke down the objectives into a set design requirements **(Dossier 2A)**.

Design Requirement	Value [Units] & Type	Justification
Charge an Electrical Device	Dependent on users, typically 15 minutes @ 5watts (phone) - 100watts (laptop)	Our client's primary functional requirement is to have our device be able to charge portable electrical devices. The most common portable devices carried by students are phones and laptops.
Portable	Moveable by 2 people	The device will be moved around and repositioned as stated by our clients
Receive Human Input Energy	50W-150W	The typical power generation capability of a human being is within 50-150W. A safety factor of 3 will be added.

Figure 2: Example of a design requirement

Design requirements are necessary prior to generating concepts to make sure nothing is forgotten throughout the design process. Next, an evaluation criterion is created. . The evaluation criteria is a list that ranks the factors which are important to all the stakeholders (UBC MECH, UBC AMS, UBC SEEDS, Team EcoDepot). A detailed list of our evaluation criteria can be found in **Dossier 2B**. Below are the top 5 evaluation criteria's:

Evaluation Criteria	Justification	Addressing the need of:
Safety	User Safety is a primary concern our device as it will be exposed to the general public. Safety is always a concern for every party involved.	UBC MECH, AMS, SEEDS, Team EcoDepot
Aesthetics (Appeal factor)	The scope of the project is to promote user collaboration and sustainability. Aesthetics is the main factor that draws someone to use the device for the first time.	UBC AMS, SEEDS
Ease Manufacturability	The project must be complete before graduation, as this is the Capstone Project for Team EcoDepot. This time restriction forces designs to consider the time it takes to manufacture the actual device (lead/lag time, manufacture time, assembly time)	Team EcoDepot, UBC MECH
Life Span	The device will represent all the stakeholders, and should last a reasonable duration	UBC MECH, AMS, SEEDS, Team EcoDepot
Ergonomics	Ergonomics is the main factor that will determine whether or not a user will use the device again.	UBC AMS, SEEDS

Figure 3: Example of an evaluation criteria

The design process lays out a framework prior to generating concepts, so that concepts can be efficiently judged. Diligence paid during this step of the design process will result in a product that truly balances all the stakeholders. Next, concepts are generated and using this framework of needs, requirements, and evaluation criteria's, the final design is made.

Generating Concepts and Evaluate/Select

Generating concepts is the intersection of creativity and satisfying the requirements

There are many methods of generating concepts, as well as evaluating them. Tools such as team brainstorming, functional decomposition, and function structure diagrams are all extremely useful for generating concepts. The process of using these tools can be found in **Dossier 6**. Team EcoDepot had the additional resources of concepts and influence from our clients with regards to the geometry and layout of the final device. Through many meetings with our clients, our final concept was approved.

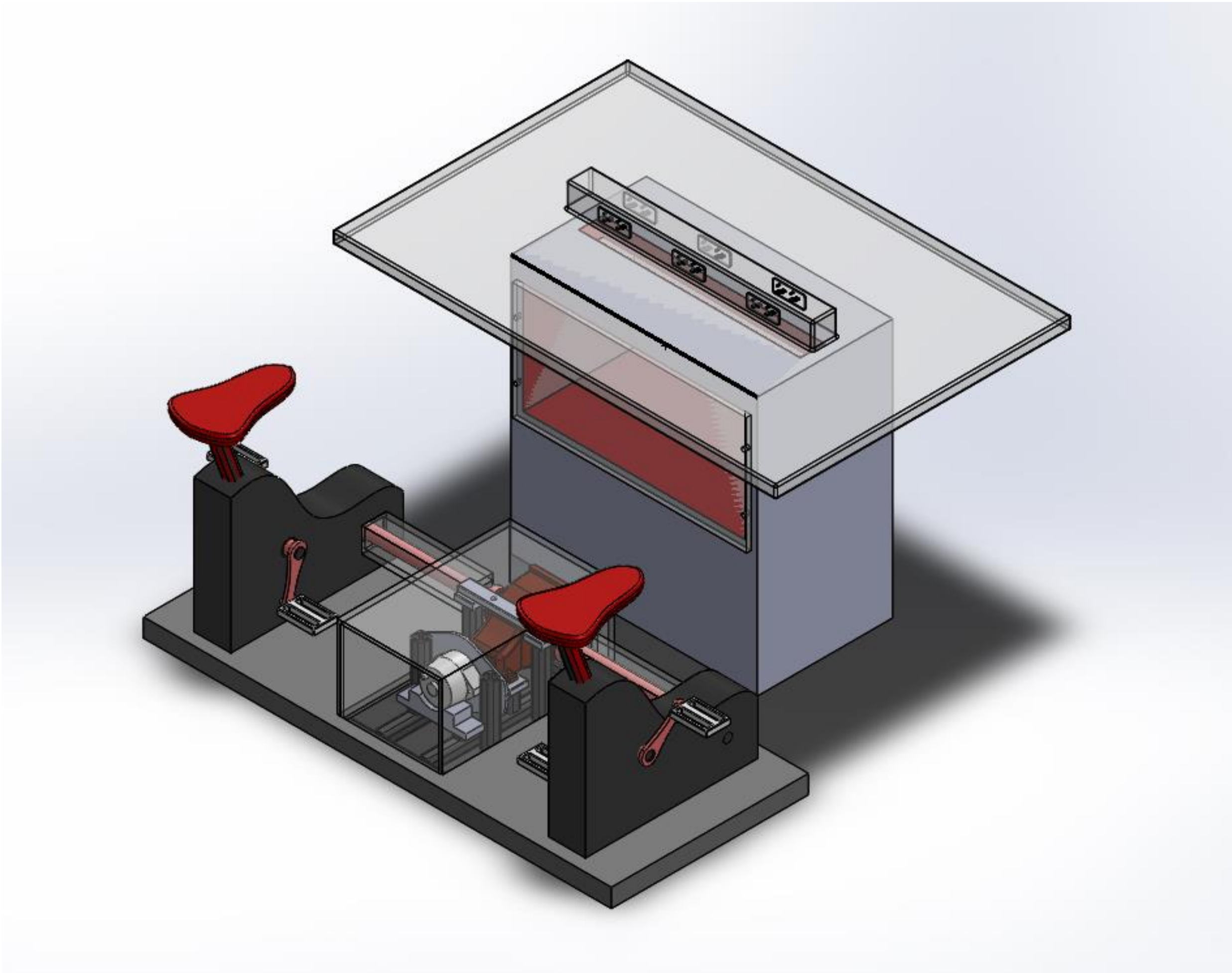

Figure 4: Artwork Isometric View of the final concept

The AMS Pedal Power Station

Figure 5: The final product

As the user approaches the device, they will see two parts to our station. The Base station consists of two pedal stations, connected by a differential. A differential is a set of gears that allow the two users to pedal at different speeds, but still power the same alternator. The alternator generates electricity that will be transported to the charging system via a cable. These components are covered in a Plexiglas casing, which allows users to see exactly how the device is taking there pedal motion and creating electrical energy. The Base station also has detachable caster wheels for transportation. Each major sub system of the Base station is detachable. The Plexiglas casing, wooden base board, the differential, and pedal system can all be taken off for maintenance or replacement. A functional description of the major sub system and there drawings can be found in **Dossier 11**.

The Charging System

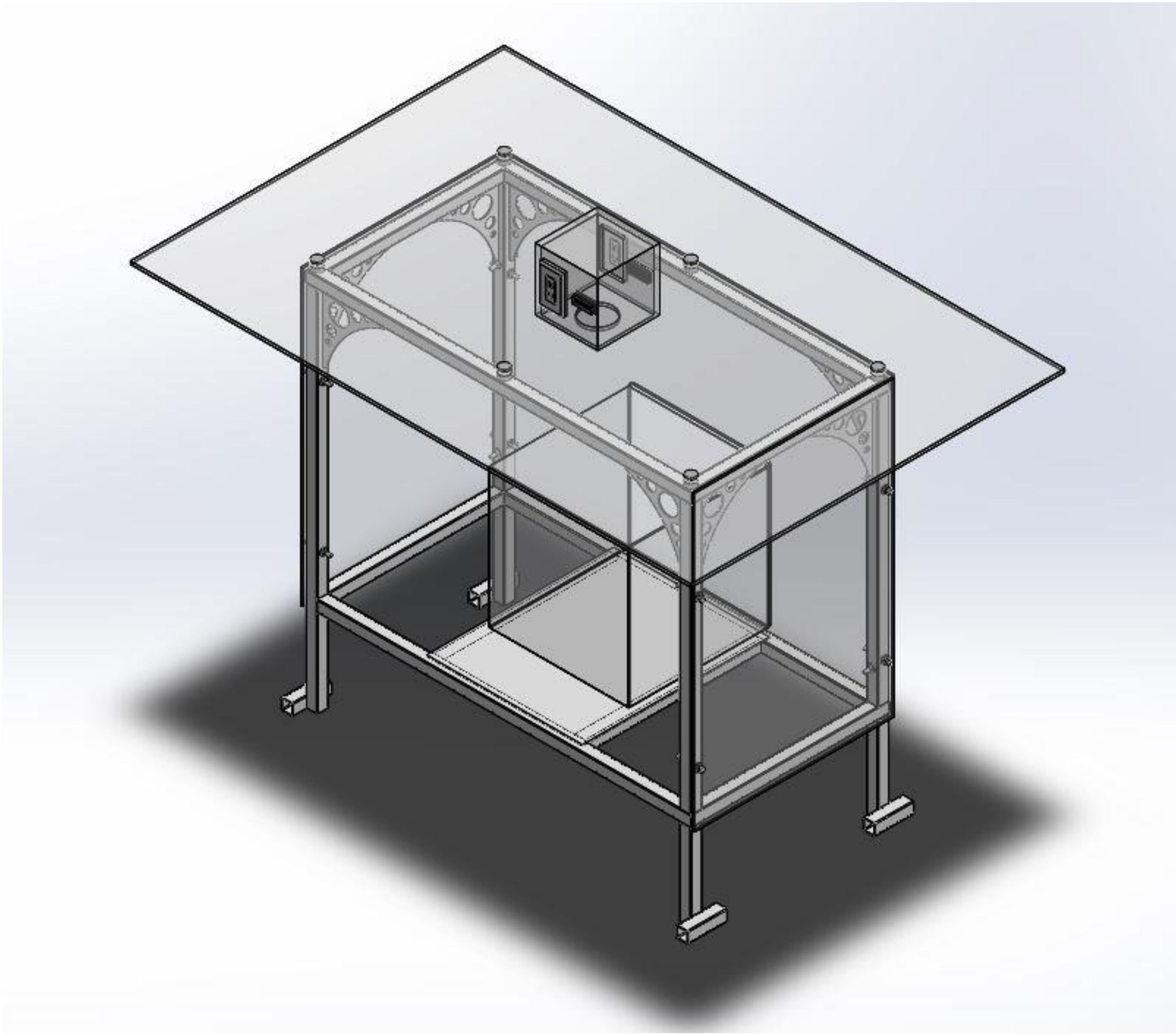

Figure 6: Table Top

The Charging System consists of a table top with a set of outlets for users to connect their device into, and a clear casing of all the electrical regulating components, which we will name the electronic black box.

The electronic black box is designed to allow charging only when the user is pedaling (generating their own energy). This also protects the battery from overcharging or undercharging.

Educational Signage

The process of generating mechanical energy and converting it into electrical energy is very common in power engineering. Instead of humans pedaling, we use moving water that flow through paddles, which turns the generator. This is how hydroelectricity works, and is the primary source of energy in BC.

Using the device

Physical feedback

Once they begin pedaling, there is one main feature they will observe. It is easier to generate the same amount of power when the second user begins pedaling. The differential combines the transmission shafts of both peddlers. This is the key difference between our design, and pre-existing device (a list of pre-existing devices can be found in **Dossier 5**). While there are devices in the market that charge electrical devices, none offer this collaborative aspect of the differential. However, when two people pedal, they are capable of generating more power.

Leaving the device

The experienced we designed for is that a user will leave the device with more knowledge of power creation and transportation. The pedal station give physical feedback to users on how much physical energy is required to produce an equivalent amount of electrical energy. The postage around the device will expose users to how their experience on the bicycle is relevant to power generation in our world today. By using our device, users will have a better sense of how energy in our world is created.

Testing

The purpose of our testing procedure is to verify that the pedal charging station functions as designed. Though each subsystem was tested before assembly, a full assembly test is necessary. We tested our station by getting students to use it. We verified that the mechanical energy was converted into useable electrical energy, and that the expected charge characteristics were achieved.

The following table is a summary of our results:

		Left Side			Right Side				Current Drain(A)	Power Drain (Watts)
Current OutPut (A)		Casual	Medium	Hardcore	Casual	Medium	Hardcore	LED Strip 2m	2.2	26.4
	Jay	0.3	2.2	7.4	0.6	2.7	8.7	Computer Minimum Load	4.5	54
	Male 178cm							word and IE	5.2	62.4
	Shaun	0.3	0.9	8.4	0	1.3	8.8	Starting Video game/CAD	8.9	106.8
	Male 185 cm							Playing games(WOW)	12.5	150
	Victor	0.6	3	6.8	1	3	8.6			
	Male 182 cm									
	Brian	0.2	0.8	3	0.2	0.9	2.2			
	Male 180cm									
	Jance	0.1	0.5	3.2	0.1	0.3	1.8			
	Female 157cm									
	Rick Male	0.2	1.2	3.8	0.8	1.5	6.7			
	Male 170 cm									
	Jason	0.2	0.6	8.6	0.1	0.6	9.2			
	Male 183cm									
	Arjun	0.6	12.3	6.5	0.5	1.4	4.9			
	Male 188cm									
Average Power	(Watts)	3.75	15.77143	71.55	4.95	17.55	76.35			

The full testing procedure can be found in **Dossier 12.**

Testing verified that our prototype functions as expected, and the power output is between 0-110 watts.

Recommendations

Upon completion of this project prototype, a few recommendations can be made for future development. These are recommendations that we feel would increase our client and user satisfaction as well as increase the usability of the device.

1.) Seat Post Adjustability

The seat posts that we used are 27.2mm, and were designed to fit inside a tightly tolerance tube welded to the frame. Due to unforeseen results, upon welding and fabricating, the tolerance turned out to be a little too tight. A solution would be to file down the inside of the tubing so that the clearance better accommodates the 27.2mm seat post. Another solution would be to buy a slightly smaller seat post by 0.1mm. Due to time constraints we were not able to properly solve this issue. Addition of 1.25" quick release seat post collars will allow the user to adjust their seat height to better facilitate their ride style. Slits will have to be cut in the metal tube to allow the metal to flex as the collar clamps down on the post. This can be achieved by using a simple hack saw or any other thin saw blade. Multiple slits at approximate lengths of 1" will allow for more metal flexibility if one slit does not work.

2.) Chain Ring Guards

For additional safety, it is recommended that a simple chain ring guard be installed on the crankset to prevent any clothing or snags that might occur from use of the device. Although this is not a very big safety concern it could be addressed in the near future for further improvement to the device.

3.) Chargers

It would be ideal to have built in phone chargers to accommodate several types of popular modern smart phones. Our design provides USB ports as well as 3 phase standard American wall outlets, but we were unable to accommodate fixed phone chargers without risking the chance of someone stealing them. A solution to this would be to dedicate one of the inverters to solely charge phones. By this I mean you could attach a power bar to the inverter and have several phone chargers placed inside the enclosure and have the cords exit through the box at the top of the table by some means. This would prevent a user from being able to directly unplug it. Do not attach multiple laptop chargers or any combination of devices that consumes more than 200w of total power or the fuse in the inverter will burn leading to a required replacement.

4.) General Maintenance

It is recommended that some minor general maintenance is provided for the device to stay in good condition. Cleaning of the glass tabletop and Plexiglas is required to keep the prototype looking nice and preventing scratches. The wooden base of the pedal station should be kept free of dirt and debris to increase its aesthetic lifespan. The bicycle chains should be lubricated using any common bike lube and tensioned if the chains appear to be loose, see the user manual for more details on mechanical maintenance.

5.) Educational Signage

Educational signage could be beneficial for the people using this device to understand how it works. Signage can be placed inside the Plexiglas by means of tape or any appropriate mounting method. This will allow users to educate themselves on the mechanical and electrical engineering solutions that were developed throughout this capstone project.