1.5 Concept Generation:

Concept 1.

This concept utilizes a standard undershot waterwheel to spin a geared alternator and produce electricity. The device uses side-mounted floats, and is anchored in place using two elastic cords attached to the frame. The device contains 4 systems: (1) wheel/frame, (2) powertrain, (3) alternator/electrical, and (4) anchoring. All systems are required to produce a basic, functional hydroelectric power generator.

The waterwheel is a flat blade design, with 8 total blades. The wheel is suspended in a stationary position so that its blade tips are the only components to make contact with the water. The frame is produced from hollow aluminum tubes, and holds the waterwheel with wooden bearings. It also holds the alternator/electrical system, and is suspended by two anchor ropes. The wheel/frame system will be easy to construct and implement, but is the least efficient of all waterwheel configurations, and may induce considerable drag when suspended in the water.

The powertrain is a simple pulley system or bike chain system. A calculated ratio will determine their size. The powertrain is a simple design from readily-available parts, but is susceptible to weathering, and is limited in the gear ratios it may produce.

The alternator is marine grade (waterproof), and produces 12V of electricity at various currents based on spin-rate. It is readily available, and easy to implement into a design, but does require a power conditioning system to be constructed. Additionally, this concept does not account for on-board energy storage.

The anchoring/flotation system is simple to implement and will maintain the generator's position in a moving body of water. With the floats attached to the frame, the device is anchored by wrapping the bungee anchor ropes around stationary objects (i.e. trees, stakes, pillars…). Advantages include ease of use and readiness of materials, but this system requires the presence of stationary anchor points, and may weather and degrade over time.

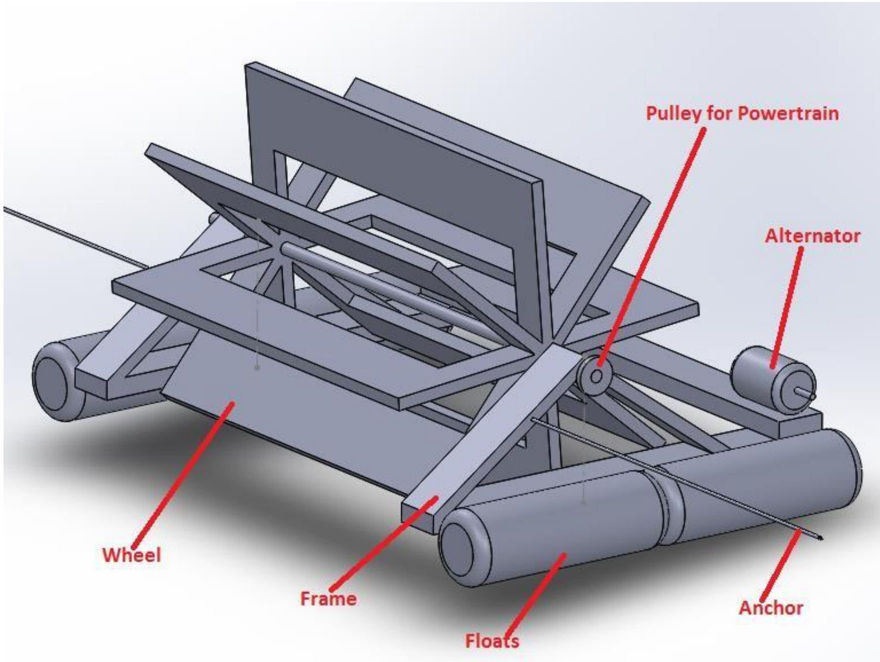


Figure 1. Concept 1 isometric view.

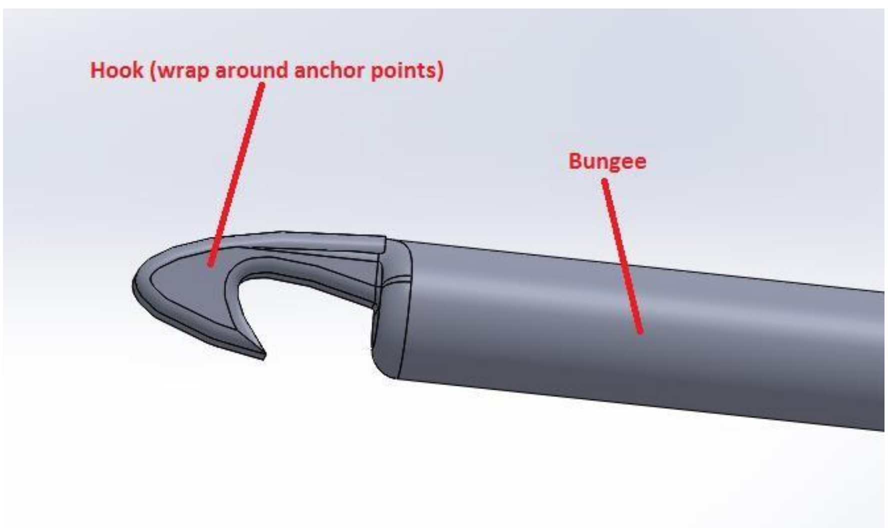


Figure 2. Concept 1 Anchor design.

Concept 2.

Our primary project goal is to develop a project concept that allows us efficiently utilize as much power as possible from a river or ocean source. Our success at realizing that goal will be measured in terms of torque generated from our source of choice. There are many potential ways to efficiently utilize a large portion of power made available by water, but many of these methods are intrusive to the environment or local creatures inhabiting those areas. Additionally, our design needs to be easy for someone to deploy and maintain after receiving only basic tutelage pertaining to the device's operation.

I envision that our design will consist of horizontal slats spanning the length of the waterway. The longer the slats, the more energy it will be possible to capture from the flow of the water. Two designs that have been created by other people to achieve this are presented in *Figure 5* and *Figure 6*. Our generator will be attached to either one or both sides of the water wheel and will be integrated with a gearing system that will allow us to maximize our turbine RPM's from our generated torque. A partially submerged undershot waterwheel (*Figure 5*) seems as though it would be best, since it would only encounter resistance at the submerged slits. Conversely, a fully submerged wheel would encounter resistance at all points of rotation, which would reduce the power available for harnessing.

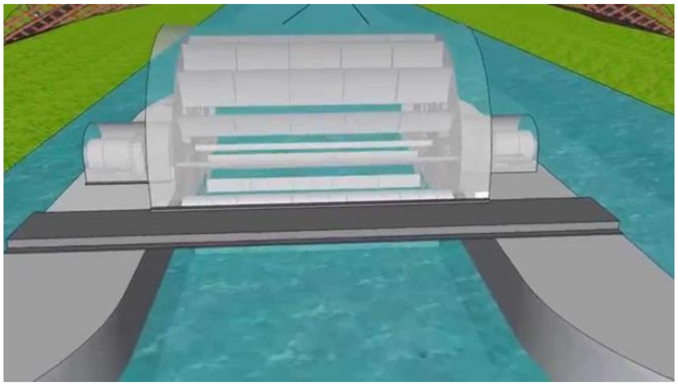


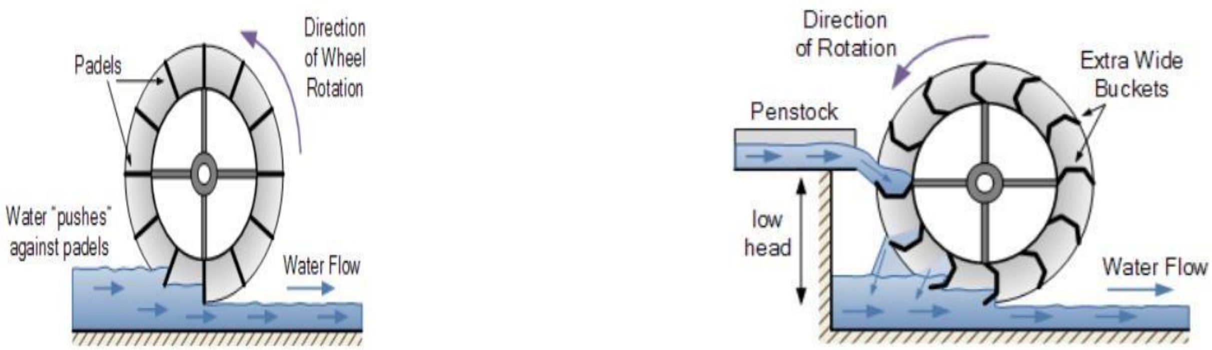
Figure 3 – Horizontal slit-type water wheel.

Figure 4 – Horizontal slit-type water wheel.

Concept 3.

(Breast shot Waterwheel)

The third design is based off a breast shot waterwheel. This type of water wheel is a more efficient variant of the undershot waterwheel, but it is harder to create than the simpler undershot. In both the undershot and breast shot waterwheel flowing water is manipulated to generate power. However, they differ in the method in how they manipulate fluids. Undershot waterwheels (shown in Figure 1(a) are the most basic type of water wheel, and use the flow of water against its fins while the water flows under the water wheel to generate power. Breast shot waterwheels on the other hand redirect flowing water to the center of the waterwheel to displace a larger volume of water. In certain cases, like in the example shown in Figure 1(b) this type of water wheel can generate power from water flowing at the middle of the wheel and under it at the same time. Since the breast shot water wheel design displaces more water and generates power from two different sources of flowing water it is more efficient than the basic undershot waterwheel.



(a) (b)

Figure 5: (a) Diagram of an undershot waterwheel. (b) diagram of a breast shot water wheel.

Concept 3 (displayed below in Figure 2) uses a similar breast shot waterwheel design shown in Figure 1(b). This device will have two floatation devices on each side of the waterwheel that will allow it to float on top of the water.

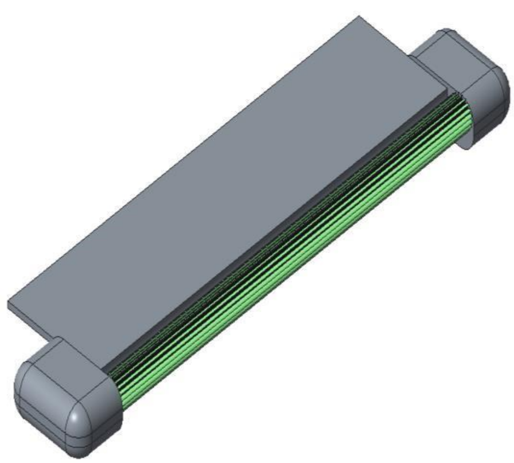


Figure 6: Concept 3 Creo Model

The operation of this device would start with water flowing on the surface of a river being directed by the water channel (shown below in Figure 3(a)) to the middle of the waterwheel. This would be like how water was manipulated in Figure 1(b). When the water reaches the waterwheel, it would fill the fins and cause the wheel to rotate. While this is happening, the water flowing under the device will also generate rotational motion. An example of the type of water wheel that would be used is displayed in Figure 3(b).

(a) (b)

Figure 7: (a) Water channel. (b) Waterwheel.

The alternator and powertrain system will be housed in one of the floatation buoys that attached to this device. A belt and pulley power train will be used to transfer the mechanical energy to the alternator. Ideally a marine grade alternator would be used to generate around 12V of electricity, but this would depend on the flow rate. The other floatation buoy will house the batteries that will store the energy generated from this device.

To anchor this device to shore the operator would use a fishing rod like pole as a stake in the ground to hold the device in place. Attached to the rod would be semi elastic cable that attach themselves to each of the devices buoys. This anchoring system would allow the device to be set up and secured in a variety of different ways. While at the same time allowing the device to adjust for changing current speeds and the water level. The downsides to this anchoring system will depend on the durability of the parts and how effective the anchoring stake is.

Concept 4.

This concept will utilize a spherical turbine as seen in Figure 8, as opposed to a waterwheel for the rotating component of the system. This design shown in Figure 8 is just for illustration as it is used for an in-pipe scenario. The spherical turbine for this design will be submerged under the water while mounted underneath a hollow waterproof cylindrical base that will house the electrical components.

The cylindrical base will have a layer of insulating foam surrounding the circumference of the electrical housing, enabling the device’s flotation. In water operation of the device would then perform very similar to a buoy or a floater used for chlorine tablets in swimming pools. This design would create a gyroscopically stable floating device which is an important aspect to the portability/versatility of the product. The biggest pro in such a framework for this design is the scalability. The exact same fundamentals along the framework of the design can be used on larger and smaller scales with minor modifications to maximize the usability and portability at various scales.

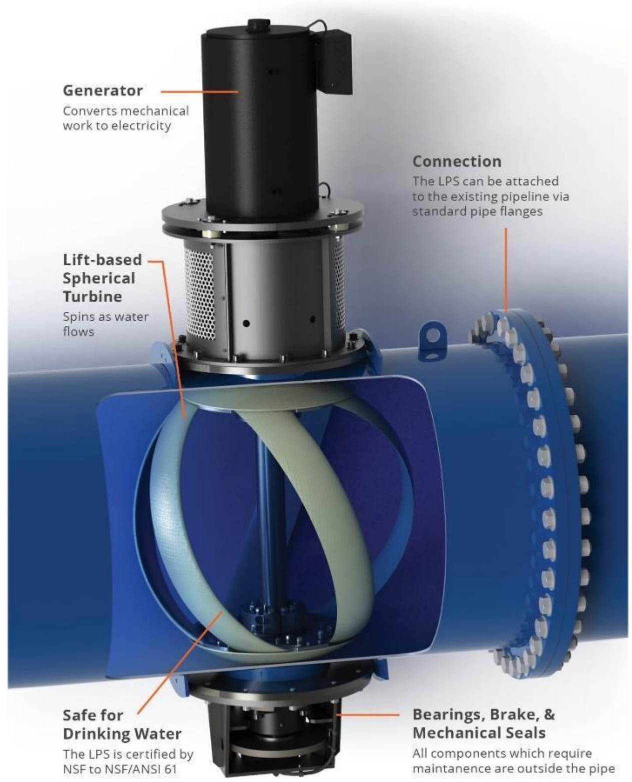


Figure 8: Spherical turbine design (in-pipe) from Lucid Energy.

For instance, the initial prototype we intend to produce a smaller scale version of the product that will be able to achieve a minimum voltage and electric current of 12V and 2.2A, respectively. This would be capable of providing power to most electronic devices today including smart phones, laptops, etc. For such a device the size of the system can be minimized and portability increased by implementing a detachable spherical turbine from the waterproof housing and flotation. The turbine could also be designed in such a way that it could be folded to appear linear, making the turbine along with the electrical housing easily stow able for recreational users like campers or backpackers. On larger scales these features would not be as necessary but the framework of the entire design would remain relatively the same at larger scales.

This device could also implement a complex gear train system that would be controlled using a microprocessor or microcontroller. This would facilitate the multitude of flow rates that the device could experience to ensure the maximization of torque generated by the turbine. For the initial prototype a simpler gear train system may be employed. Simply because at smaller scales the space for such a complex gear system may be unavailable and perhaps unnecessary for the power output trying to be achieved by the design.

The electrical components to be within the floating cylindrical housing include the alternator, power electronics, a microprocessor for design scales that implement a complex gear system, and finally energy storage devices. For the initial prototype the energy storage devices should be able to store enough energy to completely charge a phone 1-2 times. For larger scales of the design energy storage on the device may not be as important. Underwater electrical cables could be employed to directly inject power into the grid from where ever the device may be in use. Perhaps even to power electronic devices directly while the device is in use.

The device would be secured using elastic cables that would be mounted or attached to the side of a floating cylindrical base and staked into the ground or connected to other infrastructure near the water source. This would ensure the device's up right operation while not disturbing the gyroscopic nature of the device's framework within the water. The way the device can be secured in the water will really depend on each individual situation but can be easily accomplished with elastic cables in numerous scenarios. This design could be utilized in a large variety of water sources that could include rivers, streams, and oceanic scenarios.

Selection Criteria:

Table 1

System 1: Wheel/Frame

	Concept 1 *Basic Undershot*	**Concept 2 Partially submerged undershot**	**Concept 3 Breast shot Waterwheel**	**Concept 4 Spherical Turbine/Gyroscopic floating framework**
Pros	Simple to build, basic materials	Simple, good efficiency	simple design	Scalability, portability, simple framework
Cons	Lacks water efficient design, drag	Large and bulky. Spans across large portion of waterway; affecting portability aspect of design.	Is not as easy to mass produce when compared to simpler designs, and the design may not be that efficient in slow moving rivers of streams.	Environmental impact of such a turbine unknown.

Table 2

System 2: Powertrain

	Concept 1 ***Pulley/Bike Chain***	**Concept 2** **Complex Gear Train**	**Concept 3** **Belt & Pulley**	**Concept 4** **Complex Gear Train (or simple)**
Pros	Simple pulley or bike chain, readily available, easy to install	Maximize torque depending on flowrate	Simple concept, easily implemented	Maximization of torque or simplicity of design
Cons	Limited gear ratio, rust/slacking of belt or chain	Complex needs additional electrical components to control	Limited gear ratio	Complexity or limited gear ratio

Table 3

System 3: Alternator/Electrical

	Concept 1 ***Marine Alternator***	**Concept 2** **Marine Alternator**	**Concept 3** **Marine Alternator**	**Concept 4** **Marine Alternator**
Pros	Alternator waterproof, readily available	Waterproof, simple	Waterproof, simple	Waterproof, simple.
Cons	Requires fast spin rate, power conditioning system must be created, no storage	Requires fast spin rate, power conditioning system must be created, no storage	Requires fast spin rate, power conditioning system must be created, no storage	Requires fast spin rate, power conditioning system must be created, no storage

Table 4

System 4: Anchors/Flotation

	Concept 1 ***Bungee/Foam***	**Concept 2** **Unspecified**	**Concept 3** **Fishing pole/elastic cords**	**Concept 4** **Gyroscopic Flotation/Elastic Cable Positioning**
Pros	Readily available bungee (anchor) and foam (float material, can be anchored to anything	N/A	The elastic nature of this anchor system will allow this device to adapt to different current flow rates and the rising and falling of the water level.	Ease of use, maintains portability aspect of device
Cons	Susceptible to weather damage, drag on floats, must have accessible anchor points	N/A	Exposure to the elements and continues wear and tear could make this system have a shorter lifespan compared to the use of stainless steel.	Submerged turbine means a minimum operating water depth is required