The Pennsylvania State University

Business Plan & Wind Turbine Technical Report
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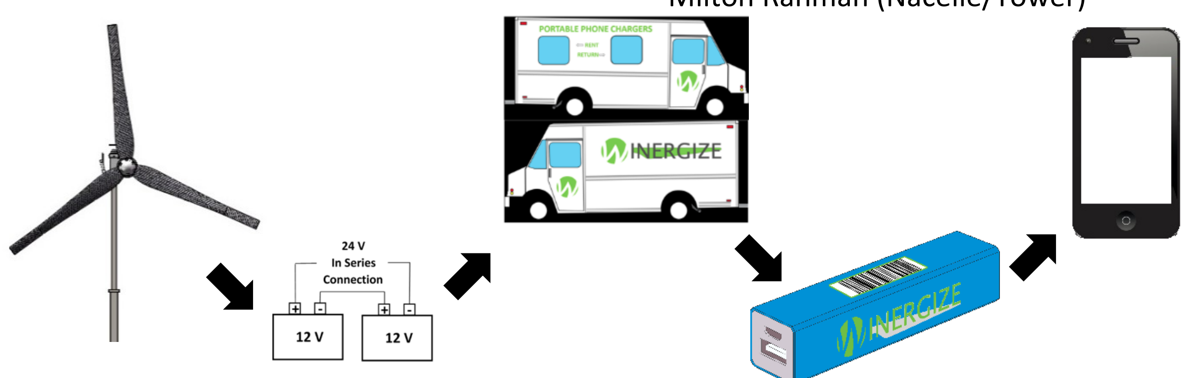

Wind Energy to Power

Strategic Advisors

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Mr. Rick Auhl	Senior Research Associate
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1. Executive Summary

In this document, Winergize, LLC describes and supports an investment opportunity with a ROI of 5:1 in three years. The start-up is seeking a total investment of $200,000 from up to three investors for 33% total ownership in Winergize, a company that rents out wind-re-charged portable batteries, called *PowerPlay,* for drained cell phones at large multiple-day music festivals. Several mobile wind turbines will be deployed around the festival and *ChargeTruck* to make renting conveniently available to the public. A credit card payment of a $10 rental fee with a $10 battery deposit will permit customers to re-charge their cell phones as they continue to enjoy the festival and return the battery up to 12 hours later – when the battery is returned, the deposit is returned.

The investment is needed to manufacture two company proprietary wind turbines, acquire and remodel a standard food truck into the *ChargeTruck*, and purchase 3,300 portable batteries for the first six months of operation at several festivals. The Winergize *ChargeTruck* has a mass charging station inside that allows employees to recharge portable batteries between transactions and acts as the point of sale at festivals for the public. Currently, the team has successfully completed 1:8 scale testing in a wind tunnel at Penn State of the turbine-generator that met design goals over an extensive operating envelope. The turbine-generator design and computer code will also be confirmed by an independent third party in wind tunnel testing over the same envelope at the Department of Energy's Collegiate Wind Competition in May 2016. With on-going turbine development, Winergize will be prepared to receive the necessary investment and launch the company by October 2017.

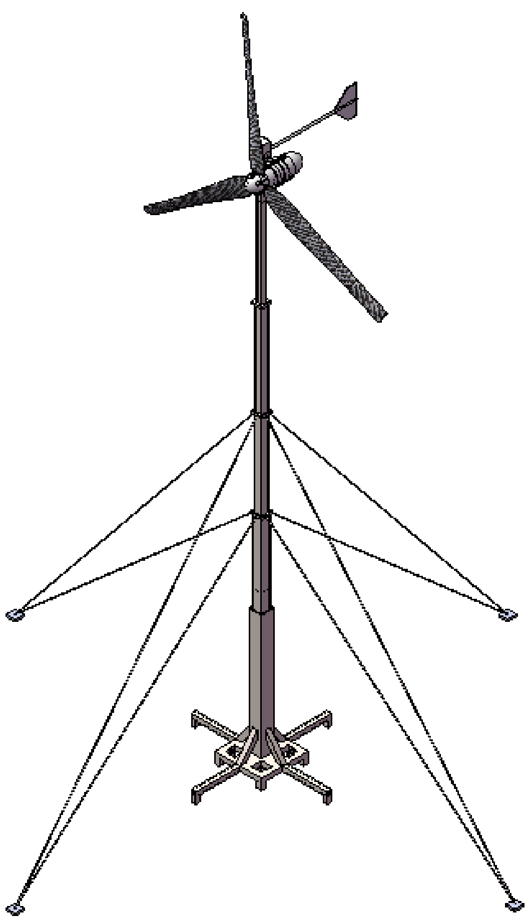

Figure 1: Market Turbine Deployed

Market research and customer validation tests confirm this business model to be successful at 17 targeted multi-day music festivals, with an average daily attendance of 50,000 people. From market research, Winergize has conservatively estimated that 4% of music festivalgoers will rent a battery at least once during each day. Discussion with several festival organizers and operation managers indicate strong interest in having a wind-operated cell phone battery and recharging booth at business compatible vendor fee rates.

The investment opportunity is described in three sections: **Business**, **Technical**, and **Deployment,** with details provided in the appendices. The report is broken down into three sections as to why and how Winergize developed this business investment opportunity after brainstorming and performing financial analysis of a dozen wind turbine applications. The **Business** section describes the three phases of the business: pre-launch, launch, and growth. The **Technical** section describes the design of the business capital equipment (Turbine, *ChargeTruck*, and Batteries) and the test turbine used to confirm the aerodynamic and generator design codes and pre-contest wind tunnel test results. The **Deployment** section establishes the requirements for the design of the Business and Turbines.

2. Table of Contents

3. Business Plan

3.1. Business Overview

The creation of Winergize stems from the founders (CEO, COO, and Operations Manager) having a vision of clean and green energy solutions penetrating current fossil-fuel dependent markets with more efficient methods than competitor standards. After concluding promising market research, Winergize began planning and designing at the market and deployment level before designing at test scale. By analyzing the venue atmosphere, deployment limitations, and design constraints at the market level, Winergize was able to build a small-scale working prototype that reflects similar operating characteristics. The small-scale model allows for lean design iteration efforts before rescaling to market size for manufacturability. During the small scale testing, the Winergize team made minor design adjustments to compete and win the 2016 Collegiate Wind Competition. View **Figure 2** for Winergize's concept planning organization ideology.

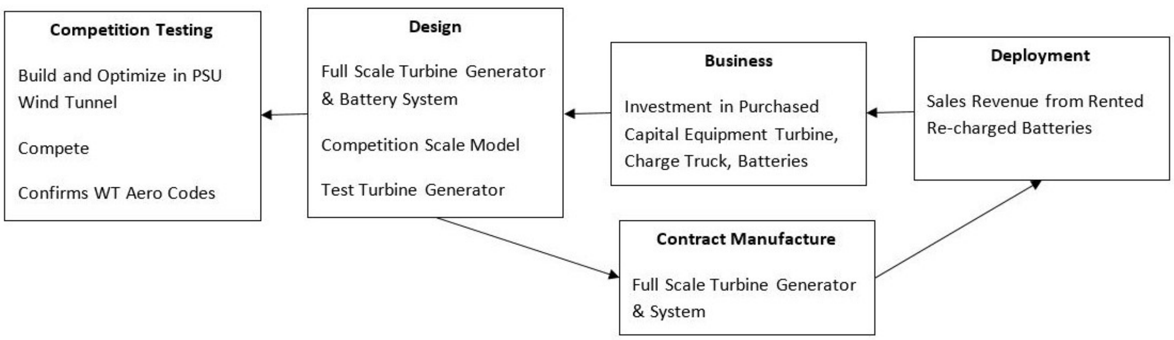

Figure 2: Winergize Concept Planning Organization

To best communicate the founders' vision for emerging clean and green energy solutions, Winergize's company timeline is broken down into three phases:

Phase 1: Prior to Receiving Investment (Pre-Launch)

Winergize will not have obtained any external capital from investors as of May 24, 2016. Until the end of the primary planning and design period is completed, the founders will be working out of a temporary headquarters. The transition to Phase 2 will occur when the investment is received. Additional company development and operations details are specified in 3.4.1 **Phase 1 subsection.**

Phase 2: Investment Acquisition to Break Even (Launch)

Once an investment is obtained, Winergize will purchase the required warehouse space and minimal necessary equipment to stimulate revenue generation in the following months. Phase 2 emphasizes deployment preparation for revenue operations at 17 music festivals while training part-time employees. This Phase is expected to last from October 2017 until Winergize's break-even point in August 2018. Full details are found in 3.4.2 **Phase 2 subsection.**

Phase 3: Stable Operations and Growth (Break Even to Stable Operation)

Winergize will be winding down its first festival season in fall of 2018. Winergize will have broken even and ready to begin expanding company operations. Profits will be reinvested into company equipment (specifically turbines) to increase market capture for following years. By the end of Phase 3, Winergize will have lean deployment operations, steady revenue inflow, and be prepared to penetrate other markets in addition to music festivals. The company's growth strategy can be found in 3.4.3 **Phase 3 subsection.**

During each of these phases, the management team's roles and responsibilities vary and will be described in its respective Phase subsection. Each founder possesses valuable qualities required for the success of Winergize. Along with general responsibilities, the ideal qualities each member possesses are expressed in the **3.3 Management Team Section.**

Winergize's initiative to provide wind-powered cell phone re-charging services occupies a unique market space. Even running at maximum capacity of eight turbines by the end of Phase 3, the market is large enough to avoid becoming saturated. With a business model based on events with large crowd numbers, the maximum number of customers served is limited by possible event space and inventory, not the number of customers the business has access to. Due to this, market capture begins at 4.2% and scales in a linear fashion as more turbines are acquired and deployed. Winergize's recharging system increases throughout Phase 2 and Phase 3.

Reaching maximum market penetration as quickly as possible is crucial to company scaling, as it allows Winergize to develop an industry leading brand that will open new markets and help prevent copycat competitors. Winergize has a unique market strategy and business plan, but little intellectual property rights to use as protection in the business. Despite this, several facets of the business will present ways to gain control of the market and serve as barriers to entry for possible competition.

By the end of Phase 3 (October 2019), Winergize is projected to have attended 48 music festivals, serviced 188,000 customers, generated $2.66 in million revenue, and $1.14 million in net annual profit over the three years (see **Appendix D: Company Financial**). In order to accomplish these projections, initial funding of $200,000 is required from a couple of investors in exchange for 33% equity in Winergize. After three years, the company is expected to be valued at five times the initial investment.

Winergize's pricing strategy in-depth is as follows: a $10 fixed servicing fee in exchange for renting a charged portable battery for twelve hours. During the twelve-hour period, the customer is free to return the battery whenever they desire but will never receive free refills. If the customer fails to return the battery within the first twelve hours, a $10 late fee applies due to the economic opportunity lost to renting the battery to the next customer. In addition to the servicing fee, Winergize will collect a $10 security deposit upon initial transaction to protect company inventory. If the portable battery is not returned within 24 hours of initial purchase, the deposit is forfeited. The estimated battery return rate is 90% of all those who rent a *PowerPlay* within the 24-hour window. Using the suggested pricing strategy, the weighted-average revenue captured is $13.00 per customer, confirmed to be appropriate through customer willingness to pay market research found in **Appendix A: Marketing Research and Survey Results, Figure 33.**

3.2. Market Opportunity

The targeted music festivals take place in remote locations with little to no access to the grid. Festivalgoers experience non-stop music listening 24 hours a day until the end of the festival. When exhausted, festivalgoers return to the camp grounds and sleep in tents or cars. Attendees risk losing the cost of their ticket if they leave the festival for the day, hence making a portable cell phone charging device convenient for the defined consumers. The public has very limited to no access to showers during the event and food is provided in the form of the festival's vendors or what consumers brought with them to the festival. Festivalgoers will often find themselves rotating with friends to nap, get food, and run to the restroom without losing their place in the crowd relative to the stage. Festivalgoers will experience dead cell phone batteries throughout the course of the festival with minimal alternatives, which Winergize solves with *PowerPlay* rechargers.

Winergize addresses the current trend of cell phone dependence of Generation Y while profiting through wind-powered portable battery rentals in its intended music festival market. Users aged 18-24 constantly rely upon these devices for communication, photography, and internet access. The company's portable battery, *PowerPlay*, offers an innovative and portable charging solution to combat the common issue of a depleted cell phone battery at music festivals. Customers are now offered the desired mobility that competitors lack. Because Winergize places customer satisfaction as a top priority, its business plan takes customer interests into account within its pricing strategy, product design, and operations.

In order to better comprehend its users' habits and charging frustrations, Winergize collected demographic, behavior graphic, and psychographic information from potential users through multiple surveys. Sample sizes ranged from 49-96 participants and were conducted through online platforms (such as Facebook) as well as through direct outreach to known festivalgoers. Surveys found that 89.4% of festival attendees were aged 18-24, with an average age of 21-years **(Appendix A: Marketing Research and Survey Results, Figure 34)**. At the multi-day events, as many as 88% of festival goers reported that their cell phones had lost power, and 40% said that this inconvenience negatively impacted their experience due to undesirable recharging conditions **(Appendix A: Marketing Research and Survey Results, Figure 35 and Figure 36)**. 51% of users stated they felt disconnected, annoyed, and angry by their dead batteries and sought opportunities to re-charge their phones **(Appendix A: Marketing Research and Survey Results, Figure 37)**.

With these customer needs in mind, Winergize created an environmentally friendly and risk-free solution to provide a better festival experience to the public. The company intends to capture the music festival market by providing a portable charging service using wind energy. Results showed that 71% of individuals were more likely to purchase a product if it had a 'green' component included (**Appendix A: Marketing Research and Survey Results, Figure 39)**. Field surveys conducted by Winergize indicate that 65% of users whose cell phones lose power would be interested in renting portable batteries to recharge them for a nominal fee **(Appendix A: Marketing Research and Survey Results, Figure 38)**. With a significant majority of the market aware of Winergize in the first year of attendance, business within the industry is expected to grow via social media personal communication by the company's customers.

Presently, festival venues offer one of two charging options. The most frequently seen include charging units, typically generator based, cluttered with wall outlets. The units feature a plethora of entangled wires and festivalgoers waiting for their devices to regain power. The second method uses small lockers to secure the user's cell phone in a compartment that provides power to the device. While both achieve the goal of repowering cell phones, they lack the ability to provide what customers value most—regaining cell phone functionality and mobility without missing the event while doing so. Because Winergize places a top priority on its customers' needs, its portable *PowerPlay* solution lets users have an uninterrupted experience.

Venues can provide free charging services to consumers. Although Winergize competes with a seemingly cost-free platform, indirect costs still exist. While customers do not incur monetary expenses, the opportunity cost of time spent waiting one's turn in line devalues the overall festival experience. Because the majority of festivals occur in off-grid locations, electricity for these services and the majority of amenities is generated through dozens of gas-powered generators. Money saved by customers as an advantage does not outweigh the extreme disadvantage of environmental pollution caused by the aforementioned devices.

To keep the charging service free, the venues offer a barren setup. Stations provide approximately 20- 40 wall outlets to the public to use for cell phone charging. Because of the free service, lines to use the service are common and waiting times can fluctuate between 30 minutes and 2 hours. Once an attendee is able to begin charging, his or her phones is piled on top of other awaiting phones on a ledge. Every phone is unprotected from theft and the environment (e.g. precipitation or overheating). However, the most important issue is that users are forced to stay with their devices to monitor the safety of their cell phones, and as a result miss a portion of the festival. In the event that a cell phone is stolen, the venue is subjected to a potentially costly liability depending on their terms of use. Such liabilities increase the costliness of the "free" service, making its effectiveness questionable.

Direct competitors have been identified within Winergize's marketspace. Winergize is still able to seize available economic opportunity and penetrate market share due to the significant differentiation that

PowerPlay provides. The company's top three competitors are discussed within **Appendix B: Competitor Models and Marketspaces.**

Unlike its competitors, Winergize focuses on its customers' main concern of enjoying the festival while simultaneously striving to enhance their experience by providing necessary charging services. Winergize prides itself on *PowerPlay*'s ability to provide power to users while helping the world stay green. The renewable energy component that wind provides is unique to Winergize and not currently offered by any other competitor. In fact, 86% of users indicated that sustainability and being green were moderately to extremely important to them **(Appendix A: Marketing Research and Survey Results, Figure 40)**. Overall, results showed that 71% of individuals were more likely to purchase a product if it had a "green" component included (**Appendix A: Marketing Research and Survey Results, Figure 39)**. Between its portability, sustainability, and usability, research has indicated that Winergize's product is users' preferred choice in relation to competitors' alternatives.

Further illustrating Winergize's focus on its customers' needs, the company consulted its users to find a pricing strategy that would simultaneously meet their needs and remain profitable. 84.5% of users indicated that they would be interested in renting a portable charger during the event, and 64.9% of users stated that a flat rental fee would be preferable to that of an hourly rate **(Appendix A: Marketing Research and Survey Results, Figure 41 and Figure 38)**. Winergize offers an unparalleled pricing strategy by taking the customers' opinion into account while sustaining profits. Some companies utilize hourly rates that continue to charge individuals indefinitely unless the product is returned. If a product is lost, customers cannot return the unit and are subject to high rates. Other companies charge a flat rate that allows customers to pay a one-time fee and allows customers to exchange units indefinitely. While unlimited exchanges are preferable to customers, the company's profit margins suffer. Winergize's strategy is a unique combination of both customer and company satisfaction, allowing for optimal contentment in equal directions.

3.3. Management Team

Full-time

CEO: Kyle Dolf will be the Chief Executive Officer of Winergize. He has an in-depth understanding of the music festival marketspace, entrepreneurship, and operation management. His peers compliment his strong leadership and communication skills. With prior start-up experience, Kyle understands risk management and taking strategic calculated risks. Holding the traits of responsibility, perseverance, and respect highest, Kyle has the suitable skill-set for the CEO role. He maintains big-picture thinking to ensure the long-term vision is not shrouded by impulsive decision-making.

Within the business, Kyle can successfully communicate the company plan to the other team members to rally them and achieve a common goal. As the main point of contact for the investors, he will report to them the state of the business and effectively explain company decisions and recommendations. With a patience and a level head, Kyle is experienced with handling internal disagreements within a business and strives to maintain a healthy, effective team.

COO: Mitchell Proulx will serve as the Chief Operating Officer, maintaining the responsibility of day-to-day operations of Winergize. Mitchell fits this position well due to his superb organization and time management skills, and technical knowledge of the turbine design. These skills will be extremely helpful when it comes to fulfilling his day-to-day responsibilities and unforeseen problems that may occur. His responsibilities will include purchasing online orders, handling incoming inventory, and preparing *PowerPlay* to be sold to customers. Mitchell's drive and passion for renewable energy makes him a great fit for this position.

As COO, Mitchell will also review attendance projections of the current festival to determine the amount of batteries and turbines required using a predeveloped formula. His effective communication skills will allow him to work smoothly with the CEO and Operations Manager.

Operations Manager: Lucas Maass will serve as the Operations Manager for Winergize. The Operations Manager will develop a training course for the part-time employees, as well as a dissatisfied customer procedure. Lucas is a strong candidate for this position given his logistics internship experience with several distributed energy resource companies. He is an effective communicator, a level-headed individual, and he has a passion for renewable energy. He possesses the ability to make quick decisions, mitigating the risk of customer unruliness.

Part-time

***ChargeTruck* Operators**: Winergize will hire eight to twelve young adults as part-time employees to travel with the full-time employees to the festivals. A college student who has a passion for music festivals and/or renewable energy is an ideal candidate. Each festival will need six employees to work standard eight hour shifts. Potential hires will be recruited through specialized methods within a college environment. The methods include campus flyers, email blasts, social media advertising, and job postings on 'WayUp' and other sites that assist students in finding part-time jobs.

Strategic Advisors: Winergize will have the free services of four strategic advisors to oversee the company and meet with stakeholders when company decisions are being made. Each advisor has been associated with the company since its inception and therefore understands the values and goals while possessing the trust of the founders. The advisors fulfil a part time role of consulting with Winergize's management team upon request for advice and expert opinions about company operations.

Dr. Susan Stewart, a professor and research associate at the Pennsylvania State University with over 12 years of experience in this field has agreed to serve as the Chief Strategy Officer (CSO). As CSO, she is overseeing and guiding the long-term goals of Winergize. Being involved from the beginning, she understands the morals, visions, and integrity that the management team follows. The CSO also guides decision making of all shareholders with the large-picture interest of the company.

Mr. Rick Auhl, a senior research associate at Penn State, as the technical strategic advisor. He has 10 years of experience with the design and construction of wind turbines. His advisory position will focus on guiding decisions related to product design efficiency and manufacturability. He will give recommendations on the best materials to use for turbine construction, developing a turbine maintenance schedule, calculating the optimal generation parameters, and assisting the Winergize team create an electrical system capable powering as many batteries at a time as possible.

Dr. Frank Archibald will be Winergize's corporate strategic advisor. He has over 25 years of experience in product design and business development. As a strong mentor, he has guided Kyle, Mitchell, and Lucas in the right direction in terms of business development and financing. His responsibilities are somewhat similar to those of Dr. Stewart, but his role is actually creating the vision and plan of the business while she is the enforcer of his elements.

Mrs. Maria Spencer, employee of the Pennsylvania Small Business Development Center, has been assisting Winergize in its company development and legal risk mitigation and prevention strategy. Her job is to assist start-up companies to best prepare to avoid failure. Her specific contribution to date with Winergize is providing knowledge and awareness of state and federal payroll laws, insurance opportunities, company valuation, pricing strategy analysis, and networking. In the future, she will continue working with Winergize throughout the company growth providing knowledge about investor relations, company growth, and exit strategies.

Investor(s)
To cover the high startup costs, Winergize desires to have one or at most a few investors to avoid miscommunication and decision making confusion. The investors are expected to be knowledgeable and experienced with investing in startups. The founders will inquire about references from past entrepreneurs the investor has worked with to protect Winergize from potential business hazards. These references will confirm that the investor is reasonable and honest to do business with, as well as, to verify the investor is knowledgeable enough to provide valuable advice. An investor may not be selected unless the he or she is willing to offer advice relating to expanding the business and the markets entered. Seeking counseling from an experienced investor on these matters is a risk reduction technique to avoid making poor decisions that could be detrimental to company growth.

3.4. Development and Operations/Financial Analysis

Within the following section, content regarding **Development and Operations** and **Financial Analysis** were combined into a single section and broken down into Winergize's three phases in chronological order. The structure aims to clarify the activities, roles, and financial status with respect to each stage of company growth.

As mentioned in 3.1 **Business Overview**, Phase 1 is the primary planning stage of Winergize occurring from May 2016 to October 2017. As of October 2017, Winergize is expected to transition into Phase 2 by obtaining the investment and launching the company. Phase 2 represents the time period of Winergize's operation preparation and initial operation until the break-even point. Break-even is projected to occur in August 2018. After breaking even, Winergize will be in the company growth and scaling stage. Phase 3 occurs from August 2018 to October 2020. By the end of the 2020 calendar year, Winergize will be prepared to expand into secondary markets or seek buy-out opportunities.

3.4.1. Phase 1: Prior to Receiving Investment (Pre-launch Phase)

In Phase 1, Winergize will describe its branding strategy, company structuring, and turbine development. During Phase 1, Winergize has and will continue to operate out of State College, Pennsylvania on student budgets developing and testing the necessary engineering equipment to allow the company to operate at music festivals. Along with the engineered equipment, Winergize will develop its brand and marketing strategy around both the music festival consumers and vendor coordinators.

Branding/Advertising Strategy
Winergize's brand combines the idea of sustainability while appealing to the likes of Generation Y and the venues themselves. Its logo represents the idea of green energy through its color scheme, and its message depicts the idea of a cleaner tomorrow with energy created by a renewable source today. At venues, Winergize intends to be seen as an innovative opportunity to attract sustainability-oriented consumers to festivals because of its renewable element. Today's music festival attendees are proven to be very heavily focused on environmentally friendly products. Of the festivalgoers surveyed, 86% placed high importance on sustainability and being green (**Appendix A: Marketing Research and Survey Results, Figure 40)**. Customers will associate Winergize with the festival, thus leading to increased business for both companies—if attendees are interested in green energy and Winergize is present at a festival, the festival and Winergize, by default, are likely to have repeat business. In a mutually beneficial relationship, the venues, customers, and Winergize will all reap the rewards of the positive brand image.

As a company operating at music festivals with a target audience between the ages 18-24, having a strong advertising presence online is crucial to generating revenue. The most effective way for Winergize to advertise will be by operating a social media campaign. According to data collected during large festivals like Coachella, the use of social media apps like Instagram, Facebook, and Twitter significantly increase during festival hours. Winergize plans to capitalize on this free form of advertising. Advertising will also be done conventionally at certain festivals. A confidential venue has already offered Winergize a partnership agreement that includes radio, television, and online space advertisement along with a traditional banner style advertising and the necessary deployment space for eight turbines at the actual festival.

In addition to advertising online, Winergize plans to recruit part-time employees using social media networks at universities and cities with close proximity to given festivals. In addition to social media, there are multiple sites and applications such as WayUp, AngelList, and Facebook, that Winergize will take advantage of, posting open part time positions. Given the incentive of free entry to the festival as well as compensation, Winergize expects to pull from a large pool of qualified and passionate applicants.

Company Structure
Winergize will be formed under the classification of a Limited Liability Corporation (LLC). The flexibility available to an LLC allows Winergize to pursue an appointed officer structure. For Winergize, a board of directors will not be necessary and will not exist. Using the LLC flexibility, the company to create a completely customized operating agreement.

Operating Agreement
An operating agreement is necessary between all employees and shareholders in Winergize to protect the company from destructive irresponsible individual behavior. Full-time employee disagreements and conflict within the company can be an issue for any startup. Winergize plans to explicitly assign the agreed upon roles and responsibilities for each member of the company to ensure that they are unable to be misinterpreted or unrightfully changed. To minimize risk, any disagreement that is serious enough to potentially interrupt the efficiency of the company will be dealt with through a board meeting between all stakeholders. If the issue cannot be resolved through discussion and the operating agreement does not offer decisiveness, a board vote will be conducted and majority vote will be used to settle conflict.

The importance of the operating agreement cannot be overlooked, its terms relate to profit allocation, voting rights, and chain of power. A proper operating agreement can be the difference between substantial profit and dissolution. To ensure the operating agreement is written properly and clearly, a lawyer who specializes in contract law within LLC's will be paid to create Winergize's operating agreement. The lawyer will be given the desired terms and be instructed to keep the agreement straightforward, yet still protective.

Share equity division will be done as follows. A 33-37-20-10 division will be assigned to the investors, CEO, COO, and Operations Manager, respectively. The difference between CEO and COO equity is intentional and designed to ensure that a single person is in charge. An even split between the top two officers of a company has historically led to internal disputes and often dissolution. The top two officers can be viewed as partners with a relatively close level of responsibility/required input. However, due to the increased share percentage, the CEO will assume a greater responsibility.

Obtaining a patent for either the turbine or portable batteries is not desirable or possibly obtainable. Filing and receiving a patent can cost upwards of $10,000 and many hours required to pull off. This time and money could be more effectively spent elsewhere. A patent would not protect Winergize from direct competition as it usually does for most businesses. Another vendor could compete with Winergize regardless of patent status by making a minor adjustment to the business model. For example, they could power the chargers by solar only, or even arrive at the festival with a large amount of chargers fully charged. In addition to intellectual property, the vesting strategy was finalized in Phase 1.

Vesting Strategy
Winergize will adopt a four-year vesting strategy for its shareholders with a "one-year cliff." The "one-year cliff" is a procedure that does not bestow any shareholder with any actual owned stock until the first company year has been completed. At this time, a 25% issuance of overall share ownership for each holder will be disbursed. This strategy eliminates risk and the possibility of a shareholder receiving shares

immediately upon company formation and then walking away. Over the next three years, shares will be disbursed at a consistent rate quarterly. Effectively, each shareholder will officially own 100% of their allocated shares on the fourth anniversary of the company. The strategy described incentivizes each member to contribute consistently while motivating them to seek an ever-increasing worth of their company share, so that as shares are issued these shares are increasingly valuable and the risk of financial disruption is reduced.

Exit Strategy

Winergize's exit strategy is the sale of the company. There will be provisions within the vesting documents that detail the procedure in the event of this happening. Specifically, a "double-trigger acceleration" clause will be formulated. What this clause formalizes is a cause-and-effect scenario, where if two specified events occur, the issuance of a shareholder's is not-yet-disbursed shares will be accelerated to an immediate distribution. These two events are the sale of the company or involuntary termination of the employee.

There will be a specified time period of 12 months where this clause can be "activated." After the time essentially expires, the employee can be fired with a discontinuation of the employee's share vesting schedule. To qualify for involuntary termination, the employee must be fired without a substantial cause (e.g. did not get along with new owner). However, a voluntary resignation by the employee has the potential to qualify if it was a resignation with a reasonable motive. Some possible motives would be an extreme pay cut, severe reduction in responsibilities, or a compulsory relocation request.

Table 1: Major Claims of Operating Agreement

Share Equity Division	Vesting Timeline	Immediate Disbursement of Stock Criteria
Investor(s): 33% CEO: 37% COO: 20% Operation Manager: 10%	25% disbursed after 1 year. Remaining 75% disbursed monthly at constant rate, where 100% disbursed on 4 year anniversary.	i. Sale of the Company ii. Involuntary Termination or Reasonable Resignation iii. Criteria Two Satisfied within 1 Year of Sale of Company

Table 1: Major Claims of Operating Agreement outlines a methodical equity distribution that not only grants the CEO ultimate control but appropriates stock equity to each company executive in fair and appropriate proportions. The vesting timeline has been formulated so that an early exit by a company executive is not financially advantageous to the departing executive. The disbursement period is short enough to maintain fairness and provide incentive for shareholder honest commitment. The immediate disbursement clause has been developed to instill confidence in scheduled shareholders by ensuring a terminated employee receives the shares he/she rightfully deserves. The steps taken within Winergize's operating agreement prevent common startup failures.

Turbine Development

Winergize's main research and development stage occurs during Phase 1. The initial R&D will have accomplished a working model of the market turbine with field testing. Winergize decided upon a first generation upwind turbine featuring a tail fin, an axial flux generator, and a furling braking system (see 4.5.3 Control Systems**: Market Turbine**). The turbines will be ready for production, and the remodeling of a standard food truck into a *ChargeTruck* can proceed once the investment is acquired.

In order to bring Winergize's turbines into existence, the company has developed a stringent manufacturing process that involves outsourcing the components and assembly to third party manufacturers in order to maximize cost-effectiveness and minimize time. The turbine design requires different manufacturing processes to successfully create the finished product. Components may be purchased, stock machined, molded out of fiberglass, or formed from sheet metal. Because no in-house manufacturing will be done by Winergize, the assembly of each turbine will be outsourced as well.

Winergize verified the turbine design before manufacturing through extensive modeling in SolidWorks and calculations following industry design standards for small will turbines. Winergize recognizes and follows performance and safety standards set by The International Electrotechnical Commission (IEC). Standards provided by IEC such as performance testing, strength and safety, reporting and certification, and labeling have all been recognized and met by Winergize's turbine, the only remaining test Winergize will perform before implementation of the turbine at music festivals is acoustic sound testing. The IEC 61400-2 is an international standard established to assess the safety of small wind turbines [IEC 1996]. The standard contains different loading cases to ensure the safety of the blades and the shaft corresponding to the specifications of the overall turbine and the internal components of the turbine. Load cases were tested using the Simple Load Model (SLM) 500 spreadsheet [Wood, 2011]. Calculations provided in the spreadsheet correspond to the turbine specifications and internal components used. All specifications and data of internal components of the turbine were extracted from the model designed in Solidworks. **Appendix H: International Electrotechnical Commission (IEC) - Simple Load Model 500** shows results from the SLM 500 Data Sheet confirming that the turbine will not fail due to multiple crucial loading events. To conclude, Winergize has developed a turbine that meets the standards established by IEC.

The turbine is capable of producing 4 kWh per day at an average wind speed of 4 m/s. Daily power output from the turbine will produce 1.5 charging cycles of the 12 V batteries per day. Since 1.5 charging cycles are required, provision to safely and conveniently transport the 12 V batteries from the turbines to the *ChargeTruck* site has been made. Consequently, 307 portable batteries can be charged per day per turbine based on the capacity of the 12 V batteries allocated to each turbine. **Appendix F: Energy Analysis** includes the calculation to determine how many batteries can be charged per turbine per day. The financial result is that each turbine will generate $3,837 daily at a festival. To reiterate, Winergize operates on a linear business model. Therefore, it is crucial to increase the company's equipment quickly to bring more turbines to each festival to maximize profits.

3.4.2. Phase 2: Investment Acquisition to Break Even (Launch Phase)

In Phase 2, Winergize will have received an investment by October 2017 and begin operating at festivals until the break-even point in August 2018. This section describes the company's location, warehouse start-up equipment, *ChargeTruck* development, turbine manufacturing, festival operations, and first-year financials. During Phase 2, Winergize will move to Salt Lake City, Utah to prepare for the upcoming festival season. The full-time employees will need to secure warehouse space, manufacture all necessary equipment for operations, recruit part-time employees, and finalize vendor paperwork.

Company Location

A high concentration of festivals with moderate wind speeds are in the western region of the United States. Based on the results of a cost-benefit analysis regarding transportation and warehousing in large western cities, Winergize will be headquartered in the cost-effective suburb of Salt Lake City, Utah. The chosen city acts as a central hub system, making the median distance traveled to each festival 10 hours. Outliers include 5.5 hours to Las Vegas, Nevada and 12.75 hours to Seattle, Washington. Salt Lake City proves to have one of the lowest costs of living in the country with an index rating of 92.5. For reference, Nevada and California have ratings of 107.4 and 135.3, respectively. While distance to festivals would show a decrease if located in one of the aforementioned states, the accompanying costs would prove to be significantly more than that of Utah's. Sales tax would see an increase from 4.7% to 9%, and monthly rent for employees living in the area would increase from $868 to $2011. The cost of warehousing by square foot would also show a significant increase if the company were to be located in an adjacent state. In comparison to other location options, Salt Lake City is the clear choice in cost-effectiveness and flexibility for Winergize's purposes.

Warehouse Start-up Equipment

Winergize strives for proper maintenance to ensure longevity and proper function of company equipment. Before deploying batteries to festivals, a desired amount of batteries will be pre-charged at the warehouse mass charging station. The week before Winergize leaves for a festival, the batteries will be rotated through two-hour charging increments. Each portable battery shelving system will be plugged into the wall outlet until the batteries have all charged. Once charging is complete, the shelving system will be moved out of the way and returned to the shelving storage space so the next set of batteries can be charged. Cost for the shelves and electrical system will be $1,200.

When turbines require maintenance, the maintenance station within the Winergize warehouse will be used for repairs. At the turbine maintenance station, annual oil and filter changes will take place. The operating components to be checked include, but are not limited to, the hub, generator, blades, wiring, structure, hardware, load, and guy wires. All bolts will be torqued and the full-time employees will check that the turbine is fully functioning before it is approved and ready for festival use. If a turbine shows signs of wear that would require greater repairs than its worth, the turbine will be decommissioned and working parts will be reused. Annual maintenance costs will be roughly $3,600 for the first year of operation, increasing annually during the next two years of operation to accommodate the costs of maintaining the newly manufactured turbines.

Winergize will require a battery testing station to analyze battery performance and safety. Winergize's *PowerPlay* testing station will run batteries through testing before approving them for customer use. *PowerPlays* will be tested for exterior damage and a performance test that check for short circuits and overcharge. During performance testing, the load will be kept consistent and each battery's designated charger will be used. Batteries will go through a load test with a simple pulsed load to determine if the battery can deliver the specified power.

For quick turnaround between festivals, batteries will be examined for external damage and will be attached to a load test. If the battery passes both the damage and load test, it will be approved for operation. If the battery does not pass initial inspection and is deemed damaged or exceeds its lifecycle, Winergize will recycle them. Winergize will make use of Call2Recycle battery recycling units located within the area of the warehouse. After establishing itself in the market, Winergize is interested in partnering with Call2Recycle, a battery and cell phone recycling company, to ensure batteries are properly recycled and Winergize remains environmentally friendly throughout the entire operation. The total cost for the battery testing station will be $200 at startup of the company to help supply necessary testing equipment.

***ChargeTruck* Development**

In order for efficient transportation and operation, Winergize will purchase a used food truck to serve as Winergize's *ChargeTruck*. The *ChargeTruck* will set up in the vendor area designated by the festival to serve as a base of business operations for employees. Here, customers will approach the windows to rent and return the rental portable chargers, *PowerPlay*. The truck will be equipped with iPads and Square credit card readers in order to assist the Winergize employees in the transaction process. Along with the necessary transaction equipment, the *ChargeTruck* will act as a centralized charging station to transfer the energy captured by the 12V batteries and turbines to the *PowerPlay* batteries. Using conventional electrical practice, current and voltage regulators, and relay systems, Winergize can safely and effectively create a mass charging station to transfer the energy captured in the wind to the good use of the public.

The specific truck Winergize will purchase is a 2004 GMC Food Truck from a vendor in Rochester, NY. The truck will cost about $40,000 and another $10,000 will be allocated for the modifications needed for Winergize's deployment. Another $5,000 will be used for detailing the truck with the Winergize logo to make the truck unique to Winergize, as shown in **Figure 3.** The *ChargeTruck* will be outfitted with a charge station capable of using sixteen 12V batteries to charge over 360 *PowerPlay* batteries. A model of the charge station and a light indicating fully charged for rental is shown below in **Figure 4.** On top of implementing the charging station, Winergize will alter the truck by creating two windows on the truck. One window serves customers returning chargers and the other serves those looking to rent a *PowerPlay*. Also, the inside of the truck will be outfitted with straps in order to properly secure turbines and other deployment materials during all transportations. Once complete, Winergize's vehicle will be prepared to serve as the hub of Winergize's operations at each festival.

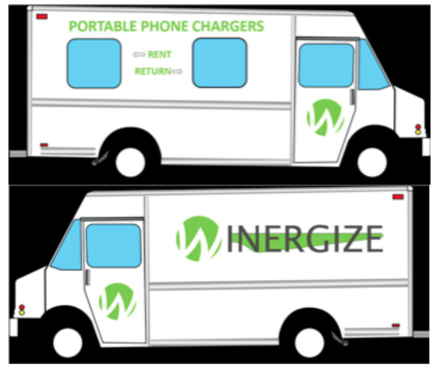

Figure 3: Winergize ChargeTruck

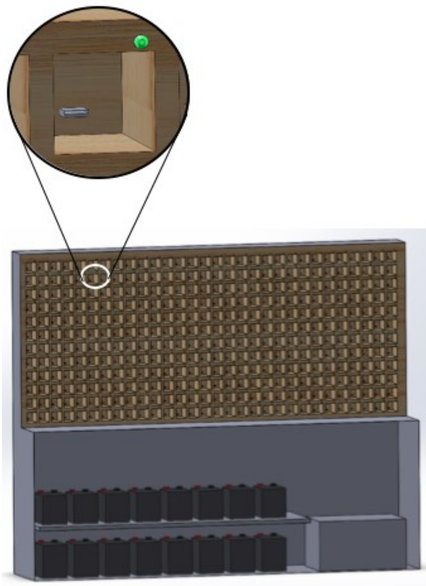

Figure 4: Mass Charging Station Inside ChargeTruck

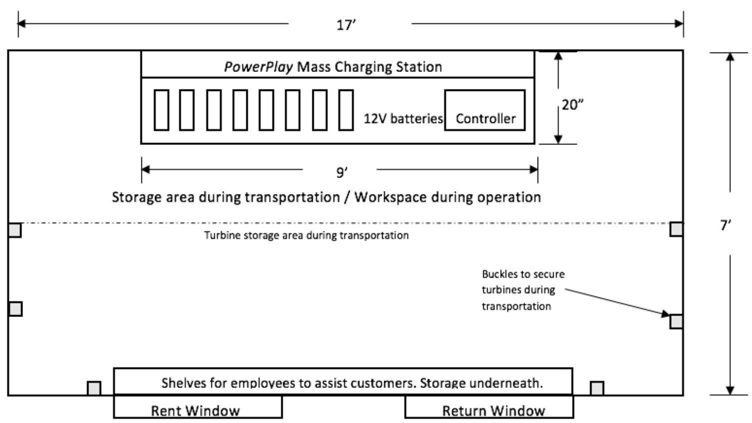

Figure 5: Interior Layout of Winergize ChargeTruck

Turbine Manufacturing

Winergize's turbine design reflects the customer demand specifications, company deployment, and market risk requirements to operate safely and reliably in common music festival environments. To generate the most sustainable business model, the portable turbine was specified to the highest rated power safely deployable in order to maximize profits (see **Turbine Ratings and Specifications**). After this factor had been met, the turbine was designed for efficient deployment- optimized packing geometry and reduced weight for transportability, and protective packing of turbine components.

As stated previously, Winergize will contract out all aspects of manufacturing and assembly to third-party companies. **Table 2** describes the manufacturing methods that correspond with each of the different turbine components along with the vendor and associated costs.

Table 2: Manufacturing Methods on a Component Basis

Wind Turbine Component	Description	Manufacturing Method	Vendor	Cost
Tower	The tower is the base of the entire turbine design and supports the generator and nacelle	Purchase Stock	WORK Lifters	≈ $1250.00
Flight Cases	Flight cases are used for transportation of the generator, blades, and batteries	Purchase Stock	Road Cases USA	≈ $1750.00
Generator	The axial flux generator consists of iron plates, magnets, and coils of wire	Machining	RAPID	≈ $3000.00
Nacelle Assembly	The nacelle assembly includes the frame that supports the generator, the shell around it, and the hub	Machining	RAPID	≈ $6250.00
Tail	The tail is used to stabilize the turbine and assist in braking through a furling mechanism	Machining	RAPID	≈ $750.00
Blades	A mold will be made for fiberglass blade production	Fiberglass Mold	Gurit	≈ $3750.00
Miscellaneous	This includes nuts, bolts, washers, pins, and bearings to be used for turbine construction	Purchase Stock	McMaster-Carr	≈ $750.00

To simplify the manufacturing process, many stock components have been utilized in the design of the Winergize turbine. The base of the turbine is a WORK Lifter model 265R telescopic lifter that will be purchased and then modified. The assembly company will remove the stock wheels and replace them with larger wheels to make it easier to transport at music festivals. In order to make the deployment of Winergize turbines fast and efficient, Winergize chose to purchase stock flight cases to transport the generator/nacelle and electrical system. The generator case will be custom-fit at the assembly company with foam to support the geometry of the generator and nacelle assembly and protect it during transportation. Batteries and an electrical charge controller will be stored inside of a smaller flight case that will also be custom-fit with foam and wood sections. Winergize's axial flux generator will consist of multiple plates of magnets and coils to generate sustainable electricity, which will all be shipped to the assembly company. The braking mechanism (standard furling design) will be made of steel tubes, steel plates and a spring. The items will be welded together by the assembly company.

The custom parts required to construct the Winergize turbine have been designed for manufacturing to minimize cost and adhere to standard manufacturing processes. The 1.7 meter-long blades will be constructed of fiberglass and reinforced with carbon-fiber laminates to improve fatigue resistance. Gurit will custom-make a fiberglass blade mold to manufacture the blades and ship them to the assembly company. The number of blades manufactured will be based on the demand for generating capacity. The nacelle of each turbine will consist of an aluminum frame and a sheet metal shell to ensure maximum strength of the generator. The exterior frame that transfers the weight of the generator and wind loads to the tower will be machined out of aluminum and the shell will be made of sheet metal.

The total cost per turbine is $18,629.09 and is broken down in the bill of materials **(see Appendix E: Winergize Turbine Bill of Materials).** This price reflects the fixed costs of the components and desired quantities.

Festival Operations

In order for Winergize's festival operations to be successful, part-time employment is required. Employees will be tasked with setting up and tearing down turbines while operating the *ChargeTruck* for monetary transactions. The employment positions are best filled with strong, responsible, young adults capable of handling on-site operations. Payment to employees will be set at $10 hourly wage or state minimum wage.

Additional benefits like payment of festival ticket are festival dependent and negotiable as festivals have different vendor packages. After the part-time employees are recruited and trained, they will travel to the festivals with the full-time employees.

There will be two part-time employees on shift at any time. The first employee's primary responsibility is to accept cash/credit card payments and furnish the *PowerPlay* to paying customers. He or she will also scan the barcode of any battery that is rented and log this transaction to ensure the battery is returned within 24 hours. The other employee will exchange batteries to charge up when fully charged batteries are sold. If the part-time employees are not handling product/customer transactions, it is expected both employees will be actively attracting attention to the stand. This includes but is not limited to dancing, holding up company-designed signs, bantering with festival attendees, and exuding a positive attitude. Throughout the duration of the festival, there will ideally always be two full-time employees working with the part-time employees.

The CEO, COO, and Operations Manager are expected to be at every festival. In the event one cannot attend a festival, the other two employees can continue full operation without drawbacks. To minimize risk, the full-time employees will be equally trained to handle festival operations in full. All three will have full understanding of the turbine operation and be able to pack, transport, set-up, take down, and check on the turbines. The CEO and COO will perform daily maintenance checks on every turbine to inspect any potential safety damage, loose guy wires, and an overall operational check. At the end of the festival the turbines will be taken down, the CEO and COO will perform a hub check, inspect the generator, check for rust, and inspect for any fraying along the guy wires. When the chiefs are not performing maintenance checks, they will be assisting the part-time employees and Operation Manager in taking orders, replacing sold portable batteries with new batteries to be charged, and promoting *PowerPlay* to potential customers.

Finances

Upon obtaining investment to initiate Phase 2, it is critical that the money is used wisely and carefully until the company starts generating revenue. To achieve this, all financial activities will be performed in a very conservative manner. Inventory will be ordered at conservative estimates, employees will be paid no more than $10/hour (with the exception of states with the minimum wage greater than $10/hour by state law), and the management staff will take home a combined salary of $24,000 during the first year with potential salary hikes dependent on company performance in the following years. This conservative approach will be continued until the company becomes cash-flow positive, which is projected to occur in August 2018. **Table 3** lists the capital, festival, and operating expenses Winergize is expected to pay during the 2018 festival season.

Table 3: 1st Year Cost Breakdown

Cost Breakdown	Type	Cost
Turbine	Capital	$55,887
ChargeTruck	Capital	$55,000
Start-Up Expense	Capital	$22,850
Advertising Expense	Operating	$3,200
Contracted Services	Operating	$5,400
Maintenance Expense	Operating	$3,600
Office Supplies Expense	Operating	$975
Payroll (Part-time & Full-time)	Operating/ Festival	$42,720
Inventory (*PowerPlay* units)	Operating	$17,880
Insurance Expense	Operating	$2,640
Rent Expense	Operating	$13,500
Supplies Expense	Operating	$2,375
Travel and Meals	Festival	$11,700
Total *ChargeTruck* and Turbine Space Expense	Festival	$46,100
Utilities Expense	Operating	$6,660

Insurance is a crucial component to risk mitigation, and Winergize plans to purchase three contracts to cover the business. Its employees and those who may be affected by any accidents must be protected and insured to minimize potential lawsuits. Winergize will purchase the following contracts:

- **Business Owner's Policy**: Costs $554/year and covers two sub policies: general liability and commercial property.

    - General liability covers Winergize against any bodily injury sustained by a customer or an employee, any property damaged committed by an employee, medical expenses, and any defense attorney costs up to $2 million.
    - Commercial Property covers loss or damage to any and all company equipment as well as any accidental damage, personal items damaged, and lost business income due to equipment damage up to $100,000.
- **Auto Liability Policy:** Costs $1,336/year and covers Winergize if any employee is at fault in case of an accident while driving a company vehicle. This includes damages to the company vehicle as well as damages sustained to a 3rd party's vehicle.
- **Worker's Compensation Policy:** Costs $750/year and covers part-time employees in case of any injuries sustained while on the job. Lost wages and medical expenses will be reimbursed. The injured employee loses their ability to sue Winergize in exchange for these benefits.

As the company grows among the many festivals that will be serviced, inventory checks are needed on a monthly basis. Because Winergize's pricing strategy allows customers to return their *PowerPlays* up to 24 hours after initial rental, there are potential inventory risks that need to be addressed. To combat the inventory volatility, Winergize will always have 6 months' worth of battery inventory in stock. The small cash tied up in battery inventory is a necessary calculated risk.

To better understand available market to capture, Winergize needed to make assumptions regarding product awareness and average daily attendance rates. The company's revenue models are built on the conservative assumptions that 70% of the overall festival attendance will be present on any given day of the festival duration. This assumption is based on the average daily attendance recorded at multiple festivals in relation to their announced overall attendance. Among the 70%, 15% will be aware of Winergize's presence at the festival and the nature of the service provided. Furthermore, 40% of the attendees that are aware of the company will be customers and will receive the service by renting out a battery. This leaves the company with a significant 4.2% market capture rate at each festival considering the attendance at the festivals. This data was gathered through marketing research and surveys sent out to festival attendees as well as data available to the public.

The revenue model relies on wind turbines to charge batteries that are rented to generate revenue. Each turbine can charge and recharge 307 batteries daily, and the company's revenue is limited by the amount of turbines it owns and as a result, the amount of batteries it can charge daily. The standard festival season for Winergize is in the months of February to October. With the exception of 2018, the first year of operation, the standard festival season for Winergize is from February to October. In 2018, Winergize will begin operating in April because two additional months are allocated to turbine manufacturing and part-time employee recruitment and training.

3.4.3. Phase 3: Stable Operations and Growth (Break Even to Stable Operation)

In Phase 3, Winergize will now have broken even during August 2018. Company operations are now lean, stable, and efficient. Winergize has an established customer base and credibility from past music festivals and the company is ready for scaling. This section describes different growth strategies pertaining to partnership leverages, future markets, and financial conclusion.

Partnership Leverages

Winergize's competitive advantages of renewable energy, security, and portability allow the company to penetrate music festivals that have current relations with competitors. As mentioned in 3.2 **Market Opportunity**, venues have expressed to Winergize desire, with urgency, to come to their events because current charging companies cannot perform in an environmentally-friendly manner like Winergize. Although being pursued, even without an exclusive contract, Winergize will maintain its dominant market position. Once a presence has been established at all Winergize's festivals, the festival owners will be reluctant to contract with other companies because of risk that other competitors might disappoint festival attendees. Festival goers will not forget how at a Winergize festival, for the first time ever, they did not have to detract themselves to stand at a station and charge their phone.

Along a different avenue, Winergize is seeking other vendor partnerships to benefit company scaling and growth. The team has identified inherent benefits to working with the proper partner. The goal is to increase demand and sales by promoting electronic merchandise to enhance the atmosphere and performer-audience relationship. Available merchandise of interest may consist of LED light sticks, flashlights, light-up sunglasses, and more. Winergize does not have the aspirations of creating the aforementioned merchandise, but instead promoting new innovative products that may be compatible with recharging services. Lifting the restriction of limited battery supply can entice a company's next innovative product line. The partner can be expected to be a vendor that operates at overlapping festivals annually. Prior to moving forward with a potential partner, all shareholders and strategic advisors will meet to consult the management team to analyze the financial and risks to make the proper decision.

Future Markets

After being operational for three years, Winergize will look to expand into other markets. The key requirements for a market include open space to deploy the turbines, and demand for small personal electronics to be powered during the event. The company cannot consider entering future markets until the company is able to self-sustain the necessary costs required to research and plan for entering the market. The costs will be allocated to performing the required market research, feasibility tests, finding out what is necessary to gain a competitive edge, and figuring out how to bypass any existing barriers to entry and how to establish one. Given preliminary market research, a prospect market for Winergize is NASCAR races that are held with sufficient deployment space available. To diversify customer base, Winergize is interested in addressing a different market segment than Generation Y, but the same principle still applies. Customers inside the track at NASCAR races are required to stay within a certain location for an extended time period without access to electricity. Consumers must once again separate themselves from the event in order to find a charging service. Winergize has the ability to innovate the marketspace with similar operations at music festivals.

Financial Conclusion

Based upon assumptions of market size, conversion rate, pricing, and expenses, Winergize will be able to utilize a $200,000 initial investment to create a business worth more than $3.6 million in its first three years. Profit will be continually reinvested into the company to obtain portable battery inventory and equipment necessary to capture a larger market share year after year. After breaking even in August 2018, the company will expand its capital base during the 2018-2019 offseason and purchase five additional turbines using retained earnings to access untapped revenue. The company will support its existing capital by purchasing one more turbine the following year during the 2019-2020 offseason. Although Winergize has made the assumption that eight turbines is the maximum allowed at any festival due to space, customer need is not restricted. To reiterate, Winergize will only have saturated the demand of 11 of the 17 targeted festivals by the end of 2020. The unsaturated market will allow the company to continue and grow to the point where Winergize will be able to expand further into the music festival market and branch out into future markets.

4. Technical Design

4.1. Design Objective

The primary requirements defined for the turbine design include the following:

- **Sufficient Daily Power Output:** The power output required to meet the business demands.
- **Low Cut-In Speed Operation:** The turbine's ability to start operating at low wind speed.

- **Constant Voltage Output:** The requirement for the turbine's voltage output to be regulated for transport battery charging.
- **Compact Packaging:** The compactness and maneuverability of the entire wind turbine system when packaged for transportation.
- **Minimal Deployment Effort:** The amount of human strength required to set up the turbine.

The following paragraphs discuss the design approach taken to address the demands stated above.

As pointed out in the business segment, the average wind speed at the targeted sites is 4 m/s. **Appendix E**: Winergize Turbine Bill of Materials breaks down the energy analysis for charging 307 portable batteries by each turbine per day. To meet the energy demand to charge the batteries, the turbine has to generate at least 4 kWh daily. Using the Weibull distribution for the daily energy output, a blade radius of 1.7 m is determined to be ideal for the turbine. **Figure 6** shows the daily energy output of the turbine with different blade radii at different speeds.

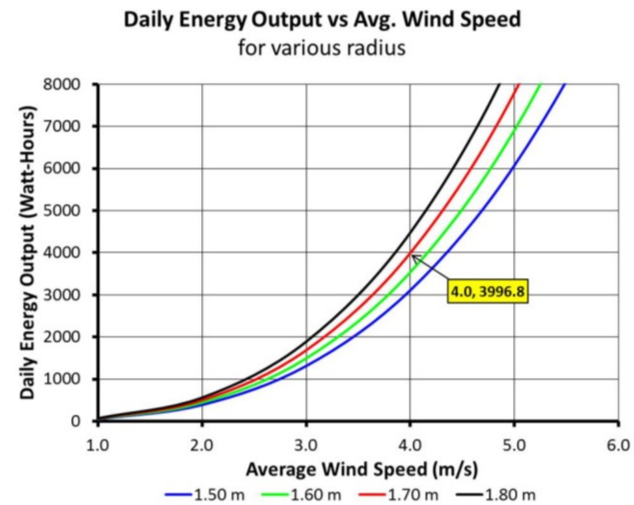

Figure 6: Daily Energy Output of a Turbine with Different Blade Radii at Different Wind Speeds

The wind turbine has to operate at a low cut-in wind speed of 3.5 m/s to ensure that it performs at the ideal average wind speed of 4 m/s which is common at the targeted music events. The wind turbine is designed to use an axial flux generator to operate at the defined low cut-in wind speed. The axial flux generator induces a theoretical zero cogging torque, or mechanical resistance, which is often caused by radially arranged permanent magnets. Axially arranged permanent magnets enable the generator to spin relatively freely at low input torques from the wind due to the absence of cogging torque.

Furthermore, the voltage output has to be maintained at 24 V regardless of the wind speeds to sustain the charging rate. The turbine will simultaneously charge two 12V batteries connected in series, with each battery rated at 12 V. A controller with pulse width modulation technology will be used to control the voltage output through the feedback of the turbine's rotational speeds at different ambient wind speeds.

The three major items to be transported: 1) the tower, 2) the box containing the blades, the nacelle, the generator and the tailfin, and 3) the box containing the batteries and the controllers. It is important to note that the tower can be collapsed into a single unit compactly, whereas the blades are detached from the nacelle for packaging. Since the wind turbine's components are being categorized and packaged compactly, the number of units that can be transported to the music event is maximized, which explicitly reduces the cost of transportation.

To set up the turbine with minimal effort, a telescoping tower, which consists of five sections of squared steel tubes of decreasing size will be used. The concept of a telescoping tower is described in **Telescoping Tower System: Market Turbine**. The tower comes with a winch mechanism that allows the turbine to be erected with minimal effort. To set up, the blades will first be bolted to the hub, then to the nacelle, after which the whole unit will be inserted and fastened to the top section of the tower and then the turbine will be lifted using the winch mechanism.

Two wind turbines, the presentation turbine and the test turbine, were built as proofs of concepts and feasibility. The presentation turbine is a model of the market turbine scaled to 50% with the intention to highlight and exhibit the overall design, and the structural and packaging features. On the contrary, the test turbine is a small-scale prototype of the market turbine to demonstrate the feasibility of the overall design specifications to meet the objectives stated in this section.

4.2. Differences in Market Turbine and Test Turbine

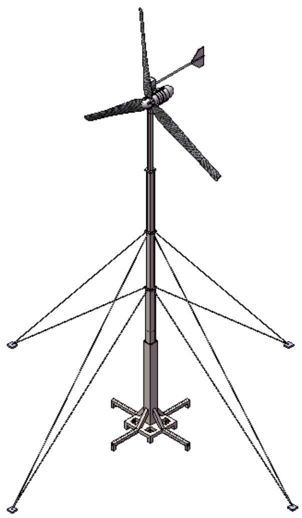

Figure 7: Fully Erected Market Turbine

A small-scale test turbine shown in **Figure 8** was designed, built, and tested in order to prove the feasibility of achieving the design objective of the market turbine. The test turbine differed from the full-scale turbine due to the test facility limitations and the limited purpose of testing. The test turbine allowed the team to test the feasibility of the axial flux generator, the design process for the blades, and the possibility of using an Arduino as a controller. Since the test turbine also needed to meet the requirements of the competition, there are other slight variations between the test turbine and the market turbine.

The design of the market turbine as shown in **Figure 7** includes a furling mechanism to brake. This method was chosen because the furling mechanism is a reliable way of braking the turbine compared to an electrical brake which requires a constant power source. If there is no power source, then the turbine cannot brake. The furling mechanism is also more cost effective compared to an aerodynamic brake which requires a pitching and a constant power source.

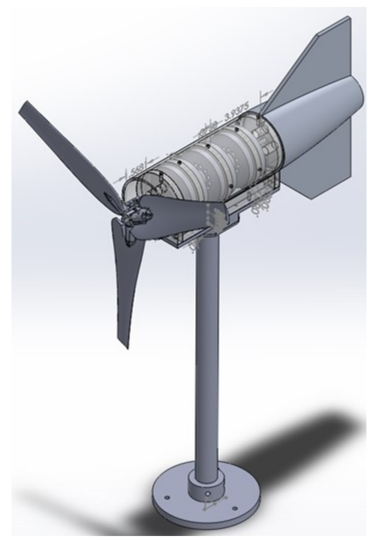

Figure 8: Test Turbine

The furling mechanism design is not reflected in the test turbine because of the test facility limitations. The team's most readily accessible wind tunnel is not large enough for a furling mechanism. To achieve braking and achieve performance within the rules and regulations of the competition, the team decided to vary the pitch of the blades for the test turbine. By pitching the blades, the team is able to brake the turbine and control the turbine by keeping constant power from 11 m/s to cut out. By pitching the blades, the team can search for the maximum power at any particular wind speed.

4.3. Static Performance

In order to design the blades for the test and market turbines, the team used two separate blade design/analysis codes to maximize power output. Excel code was the first used to design Winergize's test and market blades. The blade's chord and twist distributions can be seen in **Figure 10 & Figure 9**, respectively. The operation of the code is explained in more detail in the **Excel Code: Test Turbine**. The second code to be used was "XTURB-PSU: A wind turbine design and analysis tool" [Schmitz, 2012]. This code was used to find the optimal pitch angle at given wind speeds to maximize the power. After all the tests were run and data was analyzed for the test turbine, the team had a good idea of how to design the market turbine blades. The blades could not just be scaled up to the market turbine size, but from wind speed, power, pitch angle, and RPM data the team was able to make general predictions of how the blade should look.

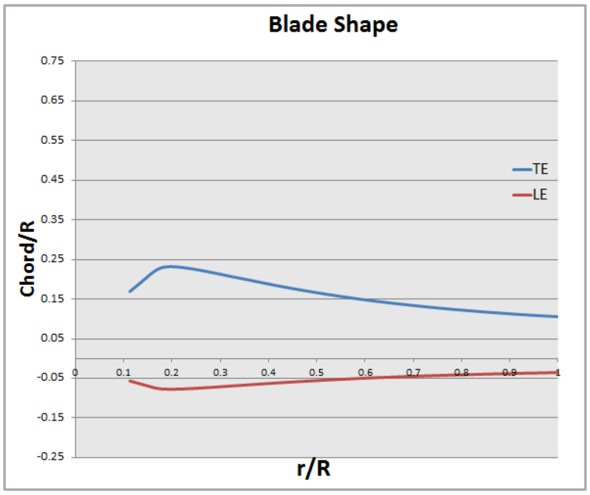

Figure 10: Blade Shape Shown by Normalized Chord Length

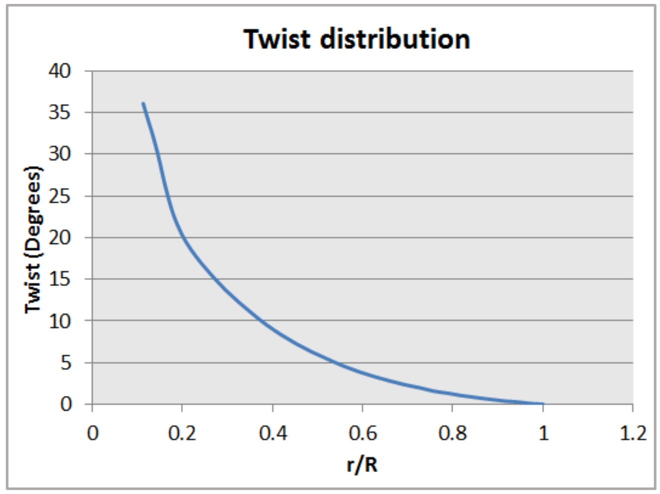

Figure 9: Blade Twist vs. Radial Position

Excel Code: Test Turbine

An Excel workbook was generated using Blade Element Momentum (BEM) Theory to design an ideal set of turbine blades for the competition conditions. For a given blade design, the theory can predict the amount of power generated at a specific condition. This analysis was utilized to find an ideal chord and twist distribution that maximizes the turbine's power generation across the competition's conditions (5 m/s to 11 m/s). This theory couples the momentum balance across a stream tube passing through a wind turbine with lift and drag forces generated at discrete airfoil segments along the span of the blades.

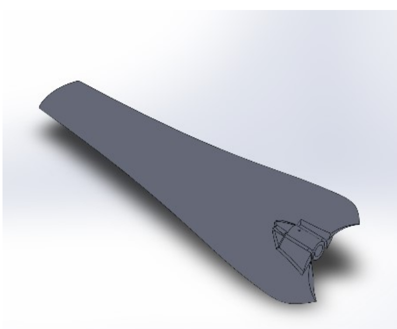

Figure 11: SolidWorks Rendering of the Test Turbine Blade

Using the code, the team made adjustments to blade parameters: chord, twist, angle of attack, and pitch until the predicted power outputs reached a maximum. After finding the best design, the blade shape was output in the form of 3-D coordinates. Those 3D coordinates were input into SolidWorks, and a 3D rendering was created **(Figure 11)**. The reason for using this simpler code was to quickly output a new set of blades that were compatible, in terms of length, width, and attachment shape, with the new variable pitch rotor. Early production of the blades also allowed testing in the tunnel as soon as possible using the variable pitch control mechanism.

XTURB-PSU: Test Turbine

With the completion of the first generation blades, design of the second generation blades was initiated. By analyzing the output capabilities of the Excel code, WT_Perf, and XTURB-PSU, the company was able to conclude that the best code available to design blades optimized for variable pitch would be Dr. Sven Schmitz's XTURB-PSU program. The reasons for using XTurb was its flexibility and accuracy. XTurb has four run modes: check, design, analysis, and prediction. All four modes serve a different purpose; the check mode runs convergence testing for the input file to assure parameter correctness; the design mode uses tip speed ratio and pitch distributions to output thrust and power coefficients; the analysis mode also uses tip speed ratio and pitch distribution but outputs lift and drag coefficients; and the prediction mode uses inputs of wind speeds, rotor RPM, and blade pitch angle and outputs power, lift, and drag coefficients as well as overall power, thrust, tip speed ratio values. XTurb has the flexibility to design for pitch variations through the test situation that will be presented at the competition.

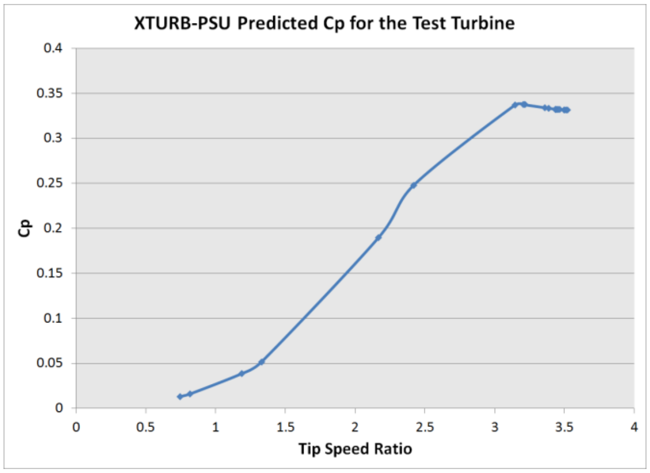

Figure 12: XTURB-PSU's Predicted Cp vs. TSR

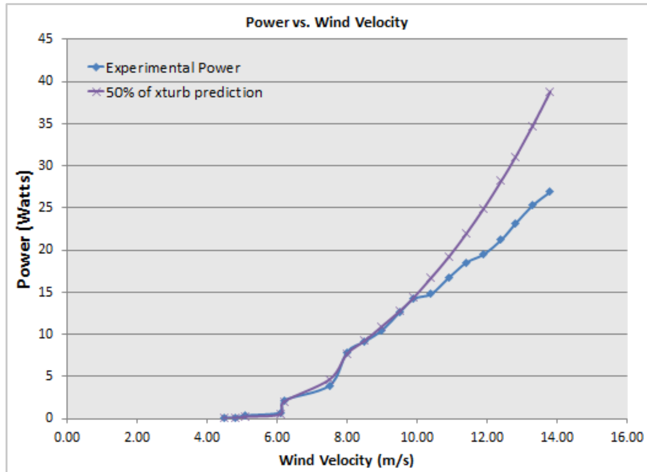

Figure 13: Wind Tunnel Power Results and XTURB-PSU Predicted Power

Equation 1: Power Generation

$$\text{Power} = \frac{1}{2}\rho A v^3$$

Tests were run with the turbine in the wind tunnel, and the blades pitched at zero degrees. XTURB-PSU was run using the same tunnel velocity and rotor RPM recorded during the test. Looking at **Figure 12** that compares experiment with 66% of the predicted power (33% loss from generator efficiencies), it can be seen that XTURB-PSU was accurately predicting the power output up to 10 m/s wind velocity. The reason for the increasing error as wind velocity passed 10 m/s was because the wind speed being recorded was not accurately representing the wind speed the turbine was experiencing. These inaccuracies in velocity are due to the fact that high rotor RPM's a lot of blockage is created and the velocity is altered. Analyzing **Equation 1**, it can be seen that velocity is cubed, justifying the increased power prediction error.

Knowing that XTURB-PSU was accurately predicting power outputs the team ran the program to predict the power output at every pitch angle for each wind speed. With those results the team now knew what pitch was necessary at each wind speed to optimize the power produced.

Excel Code: Market Turbine

The same Excel code used to create the test turbine blades was used to design the market turbine blades. Blade element momentum theory is a useful tool in the design process because changes to the design can be made easily and a rough estimate for the power output can be produced quickly. Because the theory makes many assumptions and simplifications, the team used XTURB-PSU in unison with the Excel code to find a more accurate result for the power output after a design was found using the Excel code. Suggestions would then be made for potential design changes. This iterative process continued until the team settled upon a final design for the market turbine blades.

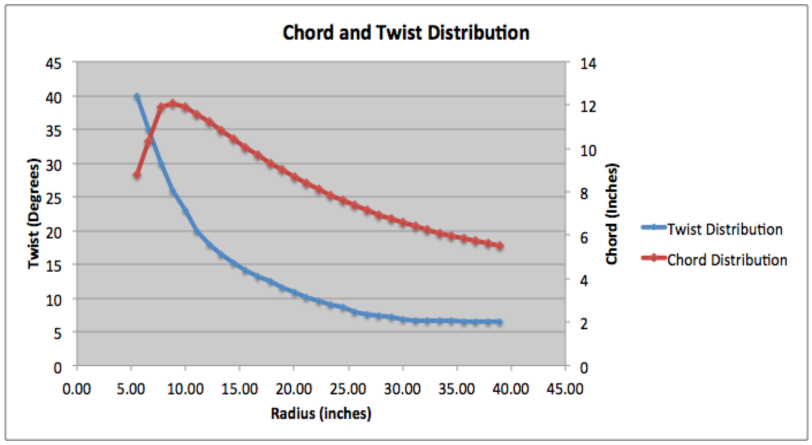

Figure 14: Chord and Twist Distribution vs. Radius for Market

XTURB-PSU: Market Turbine

Similar to the test turbine section, XTURB-PSU was used to make predictions and analyze the blade that was created using the Excel code. After running XTURB-PSU using market turbine blade geometry and operating conditions it was confirmed that the turbine should run at 300 RPM to create a tip speed ratio of 2.9 and maximum power coefficient of 0.41 **(Figure 15).** With that confirmed it was concluded that the blade design created was an effective one.

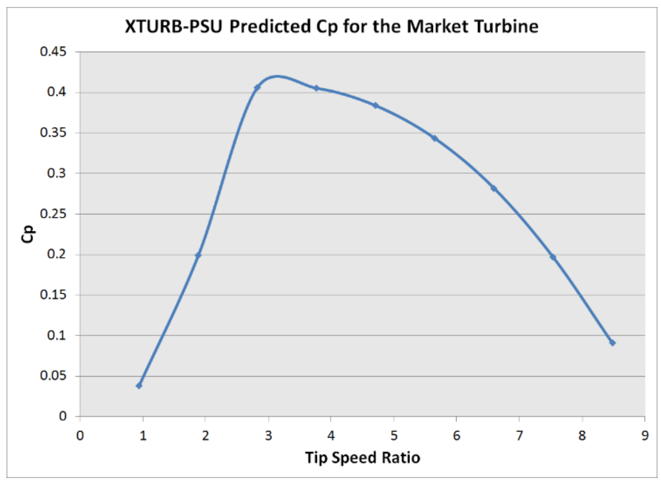

Figure 15: Cp vs. TSR for the Market Turbine Blades at 11 m/s Wind Velocity

Turbine Ratings and Specifications

Table 4: Market and Test Turbine Ratings

	Market Turbine	Test Turbine
Rated power	1.8 kW	20 W
Rated wind speed	11 m/s	8 m/s
Rated speed	300 RPM	1600 RPM
Rotor diameter	3.4 meters	.45 meter
Turbine type	Upwind	Upwind
Blades material	Fiberglass-reinforced	Fullcure rgd720
Battery charging	24 V	N/A
Braking system	Horizontal Furling	Pitching of blades
Cut-in wind speed	3.5 m/s	2.5 m/s
Survival wind speed	20 m/s	18 m/s
Tower typed	Guyed tubular (square tubes)	N/A
Tower height	6.5 m	.62 m

4.4. Telescoping Tower System: Market Turbine

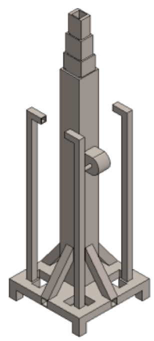

Figure 17: Collapsed Tower

The telescoping tower allows for the market turbine to be collapsed into a manageable size for transportation as shown in **Figure 17**. The fully erected turbine as shown in **Figure 16** is 21 feet tall and can be collapsed to 6 feet tall. The tower features a telescoping mechanism which consists of five sections of square steel tubes with different cross sections.

The winch mechanism makes use of pulleys and steel cables which connect all five sections in such a way that multiple sections can be erected simultaneously. Each section will be automatically locked by pin once the erected length is reached. By adding up the length of each section, it gives the tower a height of 6.5 m which allows the wind turbine to capture more wind and prevent people from reaching the blades.

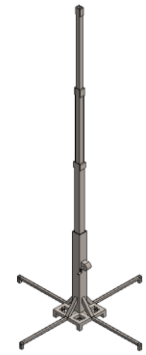

Figure 16: Erected Tower

The tower is capable of withstanding the maximum thrust at a wind gust of 20 m/s, with a factor of safety of 1.98. The von Mises stress, the resultant deflection and the factor of safety are the criteria used to determine the strength of the tower structure under a wind gust. The von Mises stress criteria measures the maximum design stress a structure can withstand. The resultant deflection is a measure of the cumulative deflection of the tower. The cumulative deflection is where the deflection of the top most section of the tower is a cumulative deflection of all of the deflections of each section. Based on the results obtained from the FEA performed, its resultant deflection and von Mises stress are 13.78 cm (**Figure 18**) and 314 MPa respectively at the wind speed of 20 m/s. Consequently, the factor of safety of the tower at a wind gust of 20 m/s is 1.98, ensuring safety at unexpected loading events. It is important to note that a 20 m/s wind gust is used as a safety check for the tower design. The turbine is designed to brake at wind speeds of 15 m/s and higher, which means that the turbine will not be operating at 20 m/s. The braking mechanism of the market turbine is further explained in a subsequent section **4.5.3 Control Systems: Market Turbine**.

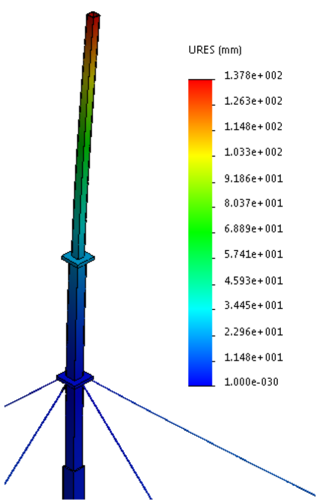

Figure 18: Resultant Deflection in Millimeters

4.5. Electrical System

4.5.1. Load System and Associated Safety Factors

Market Turbine Load

The market turbine is designed to charge two 12V batteries connected in series, so its output is 28V (14V per battery). The need to avoid damaging these batteries results in additional engineering challenges. The generator must output a constant voltage output to charge the batteries; if it outputs too high a voltage the batteries will overheat, and if it outputs too low a voltage they will be damaged by the unstable current. For more efficient conversion from AC to DC, the passive Schottky diode bridge rectifier is replaced by an active pulse-width-modulation based rectifier, as is common in large

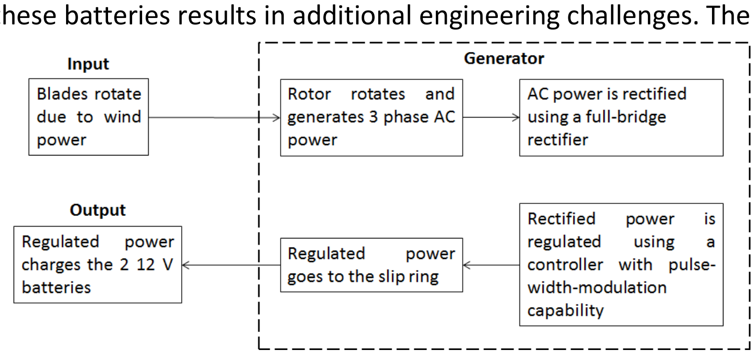

Figure 19: Simplified Black Box Summary of Electrical System

industrial systems. The larger scale of the market turbine electrical system compared to the test turbine results in the need for components which can handle higher currents and dissipate much more heat energy. **Figure 19** is a simplified black box summary of the overall electrical system showing the wind power as input and the battery charging as the output.

Test Turbine Load

The test turbine's load system is centered on a passive 22-ohm wire-wound carbon resistor. The system also contains a watt meter that measures the power currently being generated. A computer reads the wattmeter and displays a clear, engaging visualization of the power data on a screen. The team chose to use a resistor and not a battery for the load (as in the market turbine design), because the resistance of the battery changes as it is charged. The changing resistance will have an effect on the test turbine system which the Arduino is not able to account for.

4.5.2. Generator Design

Market and Test Turbine

An axial flux generator was selected for both turbine designs because the low cogging torque of the generator meets the design objective of a low cut-in wind speed. Between the cogging torque and the desire to produce power at low cut-in wind speeds, the team has researched generators to meet the torque and power demands. Research shows that most off the shelf products have high cogging torque and do not meet the teams design objective. Therefore, the team decided to design and build its own generator. Due to the simplicity and relatively zero cogging torque, the team chose an Axial Flux Permanent Magnet Generator (AFPMG). The market turbine generator was based on a design developed and tested for the test turbine as explained next.

- Magnets
- Gap Between Magnets
- Magnet Core Material
- Wire Selection
- Wire Configuration
- Number of Turns per Coil
- Ideal Shape of Coils and Magnets

Figure 20: Parameters that Effect Power Output

The next step was to study the parameters that affect the performance of the AFPMG [Latoufis, Messinis, Kotsampopoulos, Hatziargyiou, 2012]. The parameters listed in **Figure 20** each have an effect on the power output of the generator.

Magnets: The magnets chosen for the test turbine are D82-N52 magnets by K&J Magnetics, Inc. because of the magnets size, strength, and cost. When comparing magnets, D82-N52 had the best strength to cost ratio. In theory, the thicker the magnets the greater magnetic density. Early in the design process, the team used magnets with thickness of ⅛ inches but later moved to magnets with a thickness of 3/16 inches to improve performance. The power output of the generator is directly proportional to the thickness and the strength of the magnets.

Gap Between Magnets: The design of the generator allows for the distance between the magnets to be adjusted, as seen in **Figure 21**. As the gap between the magnets is adjusted, the magnetic density passing through the coils is directly affected. By decreasing the gap between the magnets, the magnetic flux density is increased therefore creating a greater power output. The gap between magnets is directly proportional to the power output of the generator.

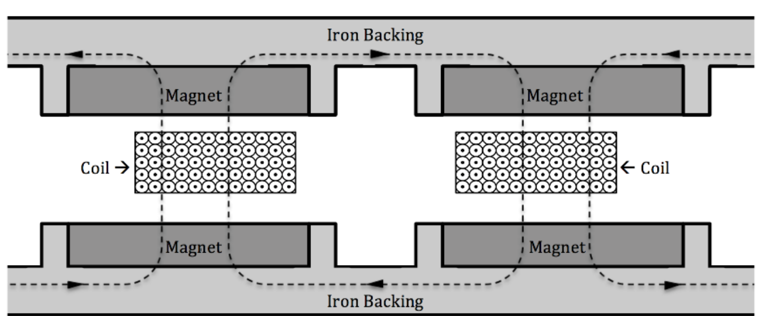

Figure 21: Displays Gap between Magnets and Backing of Magnets with Iron

Magnet Core Material: The material used for the rotor, which holds the magnets, is iron. The iron which backs the magnets increases the magnetic flux density passing through the coils. In an early design, the team used plastic for the rotor and saw a significant increase in power output when a future design used iron. The material used for the rotor is directly proportional to the power output.

Wire Selection: Diameter of the wire for the test turbine was chosen carefully to provide enough number of turns to produce desired power output because "EMF" induced in the coil is proportional to the number of turns. On the other hand, if the diameter of the wire is too small, the resistance of the wire gets too high, which decreases output. Another downside of small wire is that it can be burnt out at high currents that occur at high RPM. Also, the wire must be insulated because the skin effect induced by stranded wires makes the core of the wires carry less current, which also diminishes generator's output. Considering all these correlated variables, the wire size for the test turbine design is 26 gauge, which is slightly bigger than the 30 gauge of the wire used in the first and second generation designs.

Wire Configuration: The arrangement of the coils has an effect on the internal resistance of the generator and also the power output of the generator. The two arrangements of the generator that were tested were the star and delta wirings. The team is currently using the star wiring because of the slight increase in power output.

Number of Turns per Coil: The more turns in each coil will increase the power output of the generator. The issue the team faced was that by increasing the number of turns, it also increased the thickness of the coil and distance between the magnets. The team chose a thickness of the coils of .375 inches.

Ideal Shape of Coils and Magnets: The ideal shape of the coils and magnets is a trapezoid. Due to the ease of manufacturing, circular coils and magnets were used.

Magnet to Coil Ratio: Three-phase coils provide the most efficient power output while keeping AC output constant. The optimum ratio of magnet-to-coil per phase is 4:3. Any other magnet-to-coil ratio will not produce power because the current produced by the magnet's magnetic flux through the coils will cancel each other out. The current will cancel because the magnetic poles of two magnets are facing in opposite directions as they pass a coil. Therefore, the current travels in opposite direction and cancels out. To keep the 4:3 ratio, twelve magnets on each magnet plate and 9 coils on each coil plate were built in the generator.

From the information collected above, a spreadsheet was created which contains a theoretical analysis and a prediction of performance. The spreadsheet allows for theoretical changes in the design before physical changes. The theoretical analysis was completed to show the effect each of the parameters, stated above, has on one another. The Excel code calculates the voltage output, current output and the power output of a particular set of parameters. This allowed the team to perform a sensitivity study by changing a parameter to help understand the effects each parameter has on the output of the generator. For example, to determine the number of turns in the coil, see Equation 2.

Table 5: Definition of Symbols

Symbol	Definition
Φ_{max}	Maximum Flux per Pole (Wb)
B_{mg}	Magnetic Flux Density
n	(RPM) from Blade Design,
E_f	Voltage from a Single Generator
k	Winding Coefficient
q	Number of Coils per Phase
p	Number of Pole Pairs

Equation 2: Number of Turns per Coil

$$N_c = \frac{\sqrt{2}E_f}{q \cdot 2\pi \cdot k_w \cdot \Phi_{\max} \cdot n \cdot p / 120}$$

Different Generator Design: The performance data shown in the **Table 6** illustrated nine different test results from three different generations of the generator. All the electric outputs in the table were recorded at 1600 RPM. First generation design built in summer 2015 was tested first with two different changes to improve its performance. In the first generation tests, the wiring configuration was changed from Star to Delta, and various small electric loads were tested. However, it did not improve performance. After that, second generation was designed with one more stage. As a result of second generation test, the performance was improved from 2.67W to 7.12W. However, that power was only 35% of what the team was shooting for the competition. There were several big changes made in the third generation design. The wire diameter was decreased to 26 gauge, numbers of the magnets and coils per stage were increased to 12 and 9, respectively, and disks of the magnets were changed to Iron. The rectifier was replaced with a more efficient Schottky diode. At the end of the 3rd generation design tests, the power output was increased from 7.12W to 16.16W.

Table 6: Output of Each Generation of the Generator

	Tests	Electric load	Stage Number	Wire thickness	# of turns	# of magnets	Voltage(V)	Current(A)	Watts(W)
1	1st generation	20	1	30	300	8	7.3	0.364	2.67
2	1st (High RPM)	various	1	30	300	8	N/A	N/A	N/A
3	1st (Delta Wiring)	10	1	30	300	8	3.76	0.375	1.41
4	2nd (Phase 45)	40	1	30	300	10	N/A	N/A	N/A
5	2nd (1 Rectifier)	40	2	30	300	8	15.72	0.393	6.18
6	2nd (2rec in series)	40	2	30	300	8	16.9	0.422	7.12
7	3rd generation	9	1	26	250	12	10.4	1.16	12.13
8	3rd (Iron Disk)	9	1	26	250	12	11.6	1.29	14.95
9	3rd (Iron, Schottky)	9	1	26	250	12	12.06	1.34	16.16

Generator Design: Market Turbine

The market turbine generator as displayed in **Figure 22 and Figure 23** utilizes the generator design model developed from the research performed and the theoretical analysis established in previous section **4.5.2 Generator Design**. With an assumed turbine Cp of 0.35 and an assumed generator efficiency of 0.7, the generator will produce at least 124.6 W at a wind speed of 4 m/s to produce 4 kWh a day from the wind power analysis for a turbine with blade radius of 1.7 m. Moreover, the generator will produce at least 24 V at a wind speed of 4 m/s to maintain the batteries' charging state.

The optimized market turbine generator design provides a power output of 184.5 W and voltage output of 27.9 V at wind speed of 4 m/s, ensuring a daily power output of 4 kWh while maintaining a constant charging state. **Table 7** is a summary of the optimized generator design's specifications.

Table 7: Generator Comparison

	Market Turbine	Test Turbine
Magnet Grade	NdFeB 38	D82-N52
Gap between Magnets	0.65 in.	.47 in.
Number of Turns per Coil	145	285
Magnet to Coil Ratio	4:03	4:03
Shape of Coils and Magnets	Circular	Circular
Arrangement of Wires	Y-shaped	Y-shaped
Number of Phases of Coils	3 phases	3 phases
Magnet Core Material	Iron back	Iron back
Power output @ 4 m/s	129 W	N/A
Voltage Output @ 4 m/s before Regulation	27.86 V	N/A
Stages	3	1
Magnet Diameter	1 in.	.5 in
Magnet Thickness	0.5 in.	.1875 in.
Wire Gage	17	26
Coil Inner Diameter	0.36 in.	.25 in.
Coil Outer Diameter	1.73 in.	.75 in.
Coil Thickness	0.4 in.	.375 in.

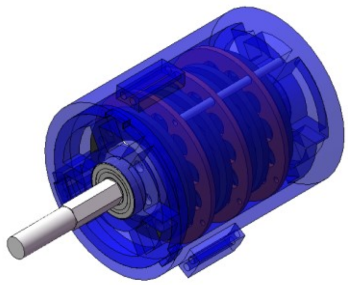

Figure 22: Isometric View of Market Turbine Generator

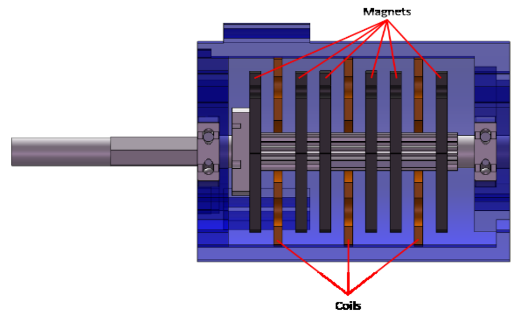

Figure 23: Cross-Section View of Market Turbine

4.5.3. Control Systems

Market Turbine

The market turbine uses a horizontal furling mechanism for control at high wind speeds. The mechanism involves the use of an angled tail fin and a spring with a carefully selected spring constant. The spring acts as an intermediary compressible member between the tailfin and the turbine. When the wind speed is within the range of the design wind speeds of the turbine, the force exerted on the tailfin will not generate a sufficient moment to turn the wind turbine away from the wind. As seen in **Figure 25 & Figure 24**, when the wind speed exceeds the maximum design wind speed of the turbine, the tail fin will have enough moment such that the tailfin is then deflected and the turbine will turn away from the strong wind. Once the tailfin and the turbine are folded into each other, the blades' orientation to the wind is no longer aerodynamic, which brakes the turbine due to the high air drag.

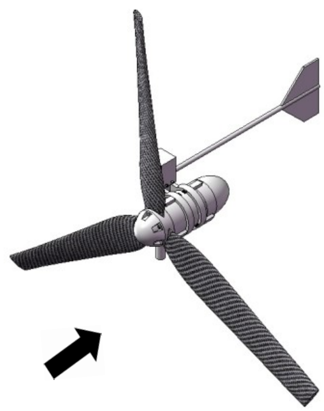

Figure 25: Wind Turbine Operating Under Normal Conditions

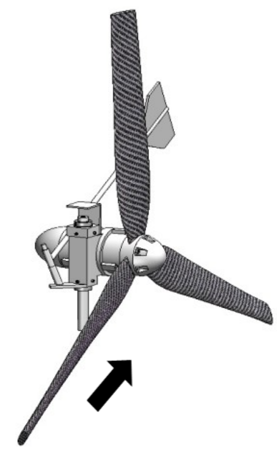

Figure 24: Wind Turbine Turns Away from Strong Winds

The tail fin is oriented at 50° from the center in the yaw axis and 20° from the upwards vertical in the pitch axis.

Since the horizontal furling mechanism is spring loaded, it is capable of making the braking process automatic without the requirement of electrical controls. The absence of electrical controls decreases the total power budget of the turbine at the same time making the brake design less complex and more reliable.

Test Turbine

The test turbine is controlled by an Arduino "Micro" processor. The Arduino is responsible for pitching the blades to find the maximum power output, controlling the rated power, controlling the rated speed, and controlling both of the braking requirements. The Arduino is able to control a servo which changes the pitch of the blades to optimize the power output of the generator. The ability of the Arduino to control the servo allows the turbine to break, control the rated power and speed. **Figure 26** shows the electrical diagram of the test turbine.

The power for the Arduino is supplied by the line connecting the generator's output to the load. The power from the turbine is processed by a Schottky diode bridge rectifier, which converts the three AC phases of the turbine to a DC signal, with a capacitor to filter high frequency components of the signal. The power passes from there to the point of common coupling. A regulator taps into the high DC voltage across the load to a 5 V signal to run the Arduino board. The Arduino controls a servo with pitches the rotor holding the blades. When the turbine brakes, power is supplied to the Arduino via the load, which holds the power line at a minimum of 5 V so that the Arduino can run.

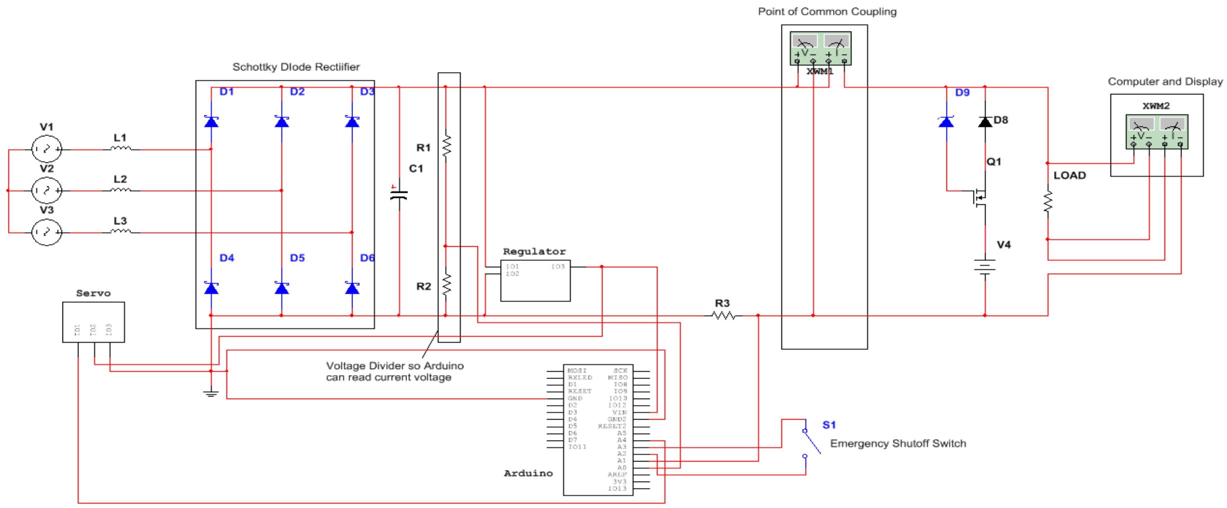

Figure 26: Electrical Diagram on Test Turbine

The Arduino measures the instantaneous voltage at the point of common coupling. The Arduino's pins are wired into a voltage divider circuit in such a way that the processor can sample the instantaneous voltage across the load at any given time. The Arduino also controls the pitch of the turbine's blades via a servo mounted on the rotor shaft; the voltage which the processor applies to the servo determines the pitch of the blades. The Arduino controller is also loaded with a table of voltages that the turbine output at various wind speeds and blade pitches during wind tunnel testing. In this way, the Arduino can read the voltage output by the turbine and the instantaneous servo position and, using this information, consult the table to estimate the current wind speed.

To maximize the power output, the Arduino uses a feedback-loop based algorithm to seek the ideal blade pitch for the current wind speed. In a repeating loop, the Arduino samples the load voltage and blade pitch, uses them to estimate the current wind speed, and sets the blade pitch servo to a new position which is optimal for that wind speed. (The optimal blade pitch position at each wind speed has been determined through experimental testing.) After the servo is moved to a new position, the Arduino waits briefly for the system to stabilize from the sudden change in parameters before beginning this performance optimization process again.

The microprocessor also plays a key role in the power control test. The maximum voltage that the turbine can generate at a wind speed of 11 m/s has been determined through experimental testing. Whenever the voltage generated by the turbine exceeds this key maximum voltage, the Arduino decreases the pitch of the blades slightly to reduce the amount of wind energy captured and reduce the velocity of the rotor. This algorithm loops, as seem in **Figure 27**, until the voltage is reduced to below the 11m/s peak.

The control system also brakes the turbine when the turbine is deliberately shut down, when the load is disconnected, or when the wind speed exceeds a threshold of 18m/s (to prevent damage to the turbine). There is a small 1 ohm resistor in the path of the turbine's main power output; the Arduino constantly

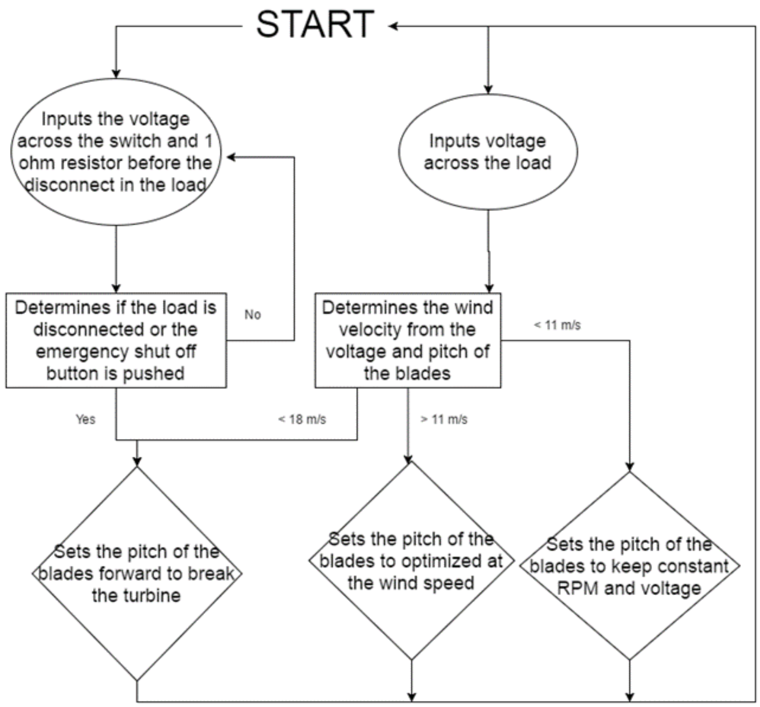

Figure 27: Control State Diagram

measures the voltage across this resistor. When the load circuit is broken, the voltage across the resistor will sharply drop to zero because no current is flowing through it. When the Arduino notices this sharp drop, or when a user pushes a button to signal the turbine to shut down, or when the load voltage exceeds a threshold associated with a wind speed of 18 m/s, the servo moves to a negative pitch angle so that the wind pushes the blades in the opposite direction than the blades normally turn. The rotor immediately slows down and halts as it dissipates its energy against the wind.

The Arduino is thus necessary both for the core functioning of the turbine and for the various challenges the turbine must pass. For this reason it must have a power supply at all possible times, even in the event of the turbine braking or disconnection at the point of common coupling. By switching between different states in response to input cues, the processor can guide the turbine through each of the required control tasks at the necessary time.

Rotor Design

A rotor assembly similar to that of a helicopter was used for the turbine. The rotor angles are controlled by a single collective input from a microcontroller, which will set all three blades to an equal pitch. The microcontroller will supply voltage to a servo, whose position will determine the pitch of the blades. The Arduino will determined the pitch of the blades, described in section **4.5.3 Controls Systems**. The microcontroller will then output the required voltage to the servo which will change the blade pitch. The desired blade pitch will vary depending on the task at hand, and will be chosen to achieve with the rated power, rated rpm, and safety tasks. To perform the safety task the team has chosen to use an "aerodynamic brake." For the safety task, the blades are oriented such that the forces acting on them create a torque in the opposite direction of the current angular velocity. This slows the rotor to a stop, at which point, a one-way locking needle roller bearing will keep the rotor from spinning backwards.

Operational Limits

The turbine will undergo significant and chaotic vibrations when the safety mechanisms are triggered. The blade pitch turning into the wind will create a turbulent flow causing forces much different than what the turbine experiences under normal operation. The forces are from braking at wind speeds up to 18 m/s. The forces raise the question of whether the blades, rotor and servo can withstand the forces and hold the blades at this pitch while the turbine slows down. The team has chosen blades, rotor system and servo that can withstand the forces caused by pitching the blades. Through ample testing, the team has proven that the design can withstand the forces from braking and all safety requirements.

4.6. Testing Results

Dynamometer Testing

The dynamometer stand in **Figure 28** was used to determine the voltage in/out, current in/out, output power, RPM, and torque of the test generation. The torque and RPM were measured with a torque and RPM sensor. The voltage, current, and power were measured with the load. The load's resistance was able to be changed to maximize the power output. The dynamometer test stand allowed the team to test each generation of the generator and compare the power output. Each test allowed the team to see how the theoretical calculations compared to actual data. The testing benefited the team in two ways. First, the testing helped the team better understand the workings of axial flux generators. Secondly, the testing helped the team make adjustments to the code. The adjustment would be for a small errors or to account for the differences between the theoretical and actual.

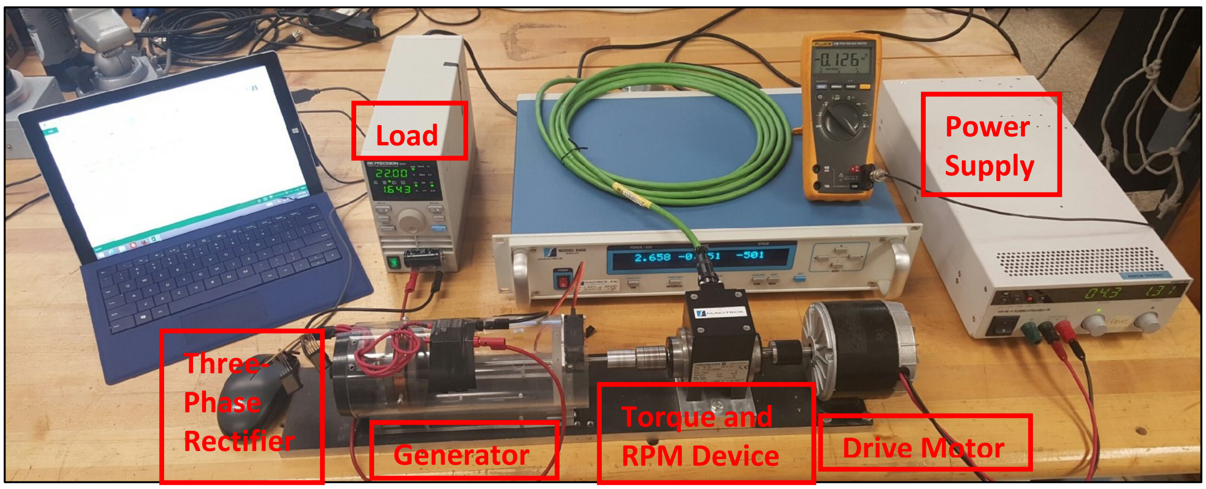

Figure 28: Dynamometer Testing Stand

Wind Tunnel Testing

From the data collected during wind tunnel testing **Figure 29 and Figure 30** could be created. **Figure 29** is the coefficient of power with respect to tip speed ratio; comparing this best TSR to the best TSR found previously in **Figure 12**, it can be seen that both conclude a TSR of around 3 is ideal. Looking at **Figure 30** it can be seen that a blade pitch of zero degrees the power increased linearly and at 14 m/s wind velocity reached a power of 27 Watts.

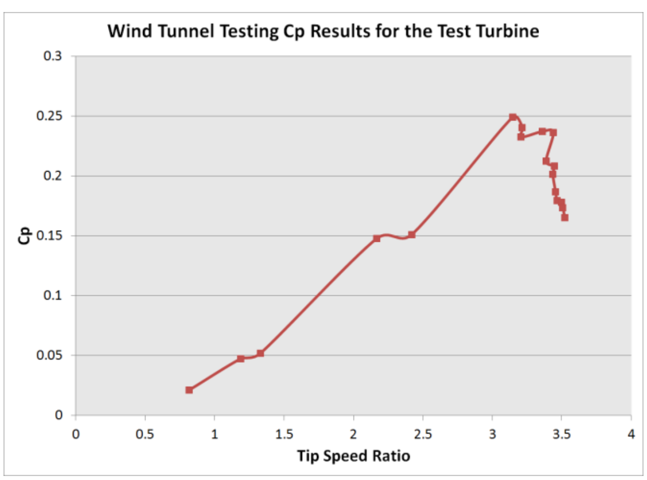

Figure 29: Cp vs. TSR Data from Wind Tunnel Testing

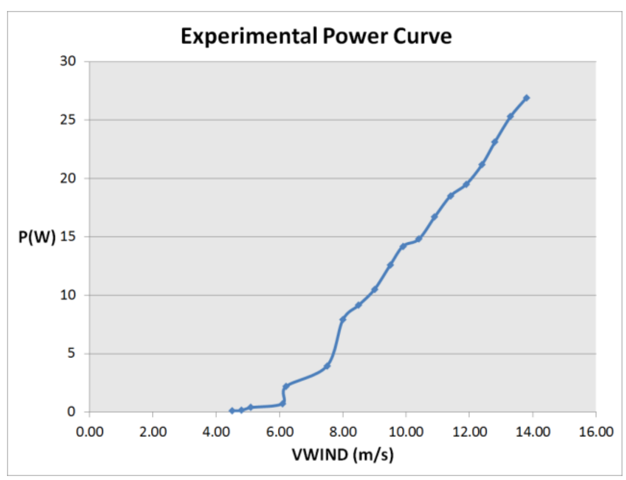

Figure 30: Power vs. Wind Speed Data from Wind Tunnel Testing

5. Deployment Strategy

Winergize's deployment strategy begins at the start of Phase 2 when the initial investment is received and lasts until the end of Phase 3. The deployment strategy covers the following criteria: **Project Site Evaluation and Selection**, **Stakeholder Identification and Communication**, **Deployment Timeline and Project Lifecycle**, and **Installation and Maintenance**. The deployment plan will clearly establish the requirements for both the technical and business aspects of the company, resulting in the development and expansion of Winergize.

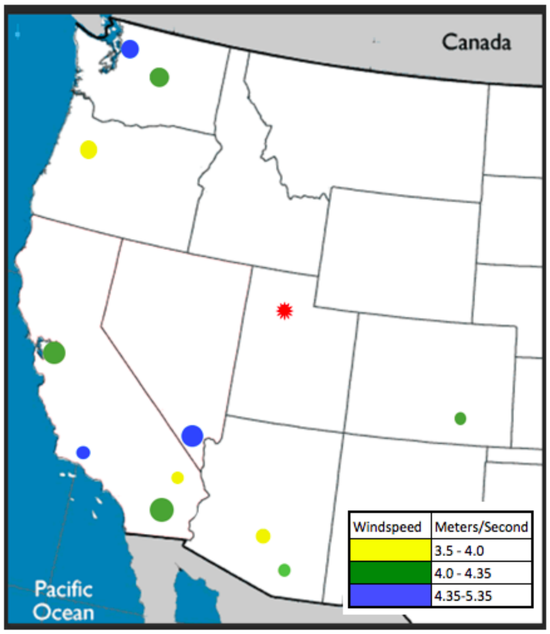

Figure 31: Winergize's Targeted Festival Location and Wind Speeds

5.1. Project Site Evaluation and Selection

Winergize will need to operate at music festivals with the average wind speeds greater than 3.5 m/s in order to make sufficient profit. The festival list and its environment conditions can be found in **Appendix I: Festival Environmental Site Conditions**. The list consists solely of events with wind speeds greater than 3.5 m/s and held in the West Coast of the United States from the months of February to October.

Once Winergize is accepted as a vendor, the management team will gather site-specific information to best understand the environment the company will operate in. Some data of interest may consist of the following: soil composition, tree-line layout, and historical precipitation, temperature, and wind speeds. Because environmental site-specific data can only take the team so far, cooperation with the venue is necessary. Venue layout changes year-to-year. Therefore, every operational year the team will need to contact the venue to negotiate and claim the available space for the turbines. The management team understands that competing vendors desire to be close to the public to sell their products as well. Winergize plans to use this knowledge to its advantage by requesting non-competing turbine space along the perimeter of the festival. Winergize minimizes risk to company equipment, employee operation, and potential hazardous events to the public by capturing space away from high festival activity. Venues have reason to act on this opportunity because Winergize will pay for the space that may be left empty or non-revenue generating. If available turbine space is located within on-site camping area, Winergize will negotiate with the venue the price of space. The company believes the price should be comparable to one or two parking spaces because that is the economic trade-off cost lost to the venue.

5.2. Stakeholder Identification and Communication

Desirable stakeholders will have the same values and vision that align with the company's founders. Stakeholders must possess a true passion for sustainability and appreciate Winergize's lack of reliance on the electrical grid and must value safety as the primary concern during operations. Whether a safety hazard would arise at company headquarters or at a festival, there must be an understanding that the concern over profits and reputation does not exceed safety concerns. Turbines are large pieces of equipment that pose a serious safety risk if not handled, installed, and maintained properly. All stakeholders must be mindful of these issues.

The primary stakeholders are the actual company founders and advisors. The seven aforementioned individuals, the CEO, COO, Operations Manager, along with the four strategic advisors all have a direct tie to the company and must aspire to meet financial projections. The CEO-COO relationship has significant impact on the rest of the inter-company relationships. The Operating Agreement will clearly define the roles of each position, therefore, the relations between the CEO and COO should always stay positive. The founders will always be open to unreserved and honest communication. Issues within the company will not be fully resolved unless this approach is taken. The CEO's charismatic attitude should exude a perception the CEO has embraced the leadership role and is confident and passionate about his duties. The leadership mentality will genuinely inspire the rest of the stakeholders to believe in their responsibilities and work.

One of the most important stakeholders will be Winergize's investor(s). Consistent with the founders' write-up, an investor will have an explicit interest in the success of the company. The rate of their personal gain is directly related to company profits. The investor deserves consistent updates on any significant company decision or company performance after a music festival. The CEO will be responsible for communicating the updates to the investor(s).

5.3. Deployment Timeline and Project Life Cycle

To reiterate aspects of this report, Winergize has broken down its business plan into, Phase 1, 2, and 3. Phase 1 spans the business pre-investment, lasting from the present through October 2017. In this period, Winergize will finalize planning and design aspects of the business. Officially, the deployment plant begins with Phase 2 when the company receives a $200,000 investment in October 2017 and lasts until August of 2018. During that period, Winergize will purchase inventory as well as headquarter space, attend the majority of its first festival season, and see enough revenue to reach a break-even point. In Phase 3**,** Winergize achieves stable operation and begins a period of growth. Phase 3 is characterized by the purchase of additional inventory, increased market capture, partnership agreements, and other indications that the company is scaling up. **Figure 32** illustrates phases and tasks of Winergize's deployment timeline.

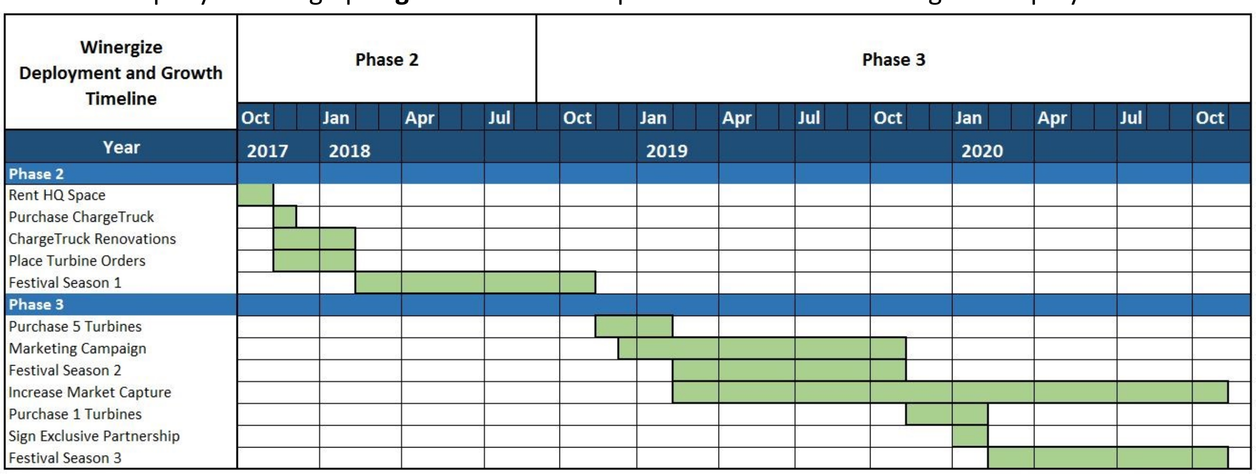

Figure 32: Winergize's Deployment and Growth Timeline

5.4. Installation and Maintenance

The deployment of Winergize's charging system focuses on the following: the transportation of turbines to and from festival sites, operation and maintenance of turbines, and *ChargeTruck* operations. Establishing the processes mentioned above will help to effectively run company operations.

Winergize plans to utilize the company's *ChargeTruck* to transport the turbines from headquarters in Salt Lake City, UT to each festival. All Winergize employees will remove the turbines from the *ChargeTruck* and disperse the turbines around the festival grounds. Each turbine will be transported in three packages; the 2'x2'x6' tower, a 2'x2'x6' box with the nacelle and blades, and a 1'x1'x2' box containing the 12V batteries used to charge the small portable batteries. Winergize will then be responsible for moving each turbine to its designated location of operation. Transporting the turbines within the festival grounds will require a handcart with wheels designed for rough terrain in order to move the turbines around the festival property.

Once the turbines are in position, trained Winergize employees will begin to assemble the turbines. The specific turbine installation procedure is outlined in **Appendix G: Turbine Installation Procedure**. In order to prevent people from getting close to the turbine during operation, a 10’x10’ area will be fenced off around each turbine using 5’ high orange safety net and metal stakes. “Authorized Employees Only” signs will be posted for public awareness and legal protection to state that the public is not allowed to walk within the 10’x10’ space.

Winergize is prepared to go to festivals with different soil and environmental conditions. To ensure the highest turbine safety obtainable, different turbine guy wire support strategies can be implemented. The most common example will be for the turbine guy wires to use screw-in ground stakes in permeable soil conditions. Screw-in ground stakes are best suited for reasonably dry grassy areas with variant ground slope. Stakes are an effective inexpensive conventional solution to reduced loading. In muddy wet conditions, stake pull-out is a major concern. An alternative solution uses rough-edge weighted containers in addition to stakes. Some of the targeted festivals are located in metropolitan areas; to counteract the pavement, rubber weights will replace the use of stakes entirely. Strong adhesion properties between asphalt and rubber allow simple weights with guy wire attachments to be an effective tool. Therefore, by using the combination of landscape stakes, rubber weights, and containers with moderate surface area and rough edges, Winergize can ensure turbine safety regardless of the environmental conditions.

To reiterate from 3.4.2 **Phase 2,** the founders will have the understanding and knowledge to perform turbine maintenance. Daily maintenance checks are required for safe operations, occurring at multiple times during festival operations. Turbines are inspected for external damage, loose guy wires, and performance. When the turbines are taken down, the CEO and COO must perform a hub check, inspect the generator, check for rust, and inspect for any fraying along the guy wires. If a problem or concern is found, the issue is documented and sent to management. Minor adjustments can be performed on site, however any major maintenance procedures will take place in between festivals at headquarters. Similar to the assembly process, tear-down will require first removing the batteries and guy wires, cranking down the tower, dismantling the blades and nacelle, then finally returning the parts to their respect boxes.

6. Conclusion

Winergize has described the promising investment opportunities in the **Business Plan**, **Technical Design**, and **Deployment Strategy.** The company’s sustainable, environmentally-friendly solution provides the cell phone recharging service that meets customers’ demand. Winergize’s turbine-powered, secure mobile methodology provides extreme differentiation to its competitors and a soft barrier to entry. With the help of a 200k investment in exchange for a 33% stake, Winergize is ready to replace the predominantly generator-power charging services with green effective technology. The investment capital will allow state-of-the-art turbines to redefine the operations of an unpenetrated marketspace filled with sustainability-oriented consumers. The fundamental essence of the company’s public appeal and brand loyalty is its turbines. Supported by positive market research results from both industry and customers, Winergize’s 5:1 ROI in 3 years is a conservative financial projection because both parties show significantly stronger interest than the calculated initial 4.2% market capture.

As further company development is required prior to accepting an investment opportunity in October 2017, achieving first place in the Department of Energy’s 2016 Collegiate Wind Competition will be an unmatched milestone completed. The deployment and design requirements were conducted at the market scale, prior to 1:8 scale testing at the Competition. Winergize’s objective is to confirm the generator-turbine design succeeds over the extensive design envelope needed for operation at market scale. Upon design validation, Winergize will return to market scale ready to cooperate with manufacturers and comply with the International Electrotechnical Commission (IEC) safety codes. All opportunities are only available with the help of the investment. Thank you.

7. References

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8. Appendices

Appendix A: Marketing Research and Survey Results

Multiple surveys were conducted to gauge customer interest and are referenced in Market Opportunity. Sample sizes ranged between 49 and 96 respondents. Applicable results are as follows:

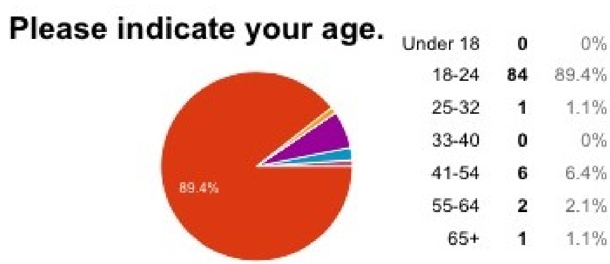

Figure 34: Survey Age Results

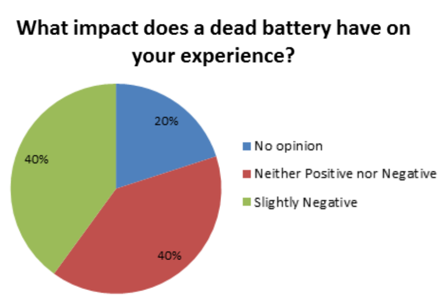

Figure 36: General Emotional Response to Dead Cell Phones

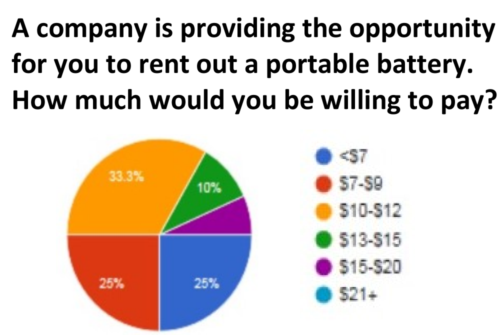

Figure 33: Customer Willingness to Pay

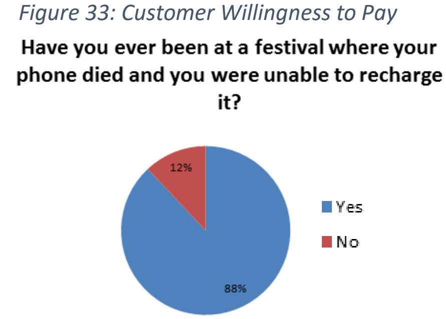

Figure 35: Cell Phone Battery Drainage

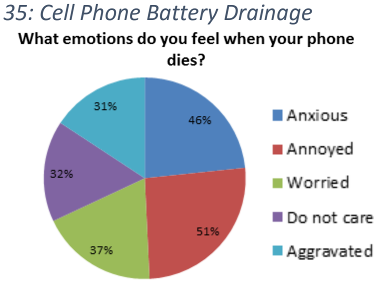

Figure 37: Emotional Response

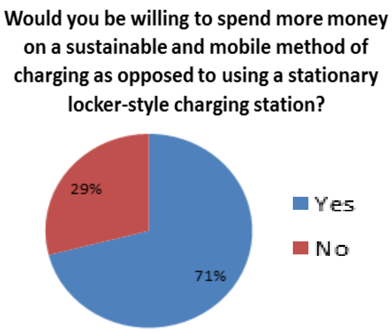

Figure 39: Winergize Value Differentiation

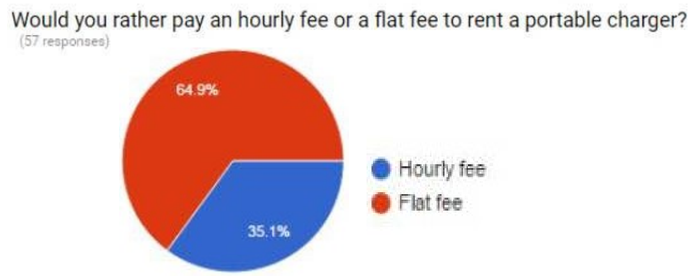

Figure 38: Pricing Strategy Feedback

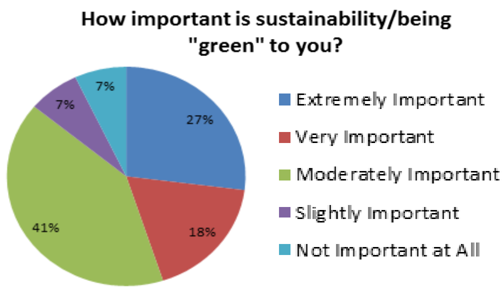

Figure 40: Sustainability Results

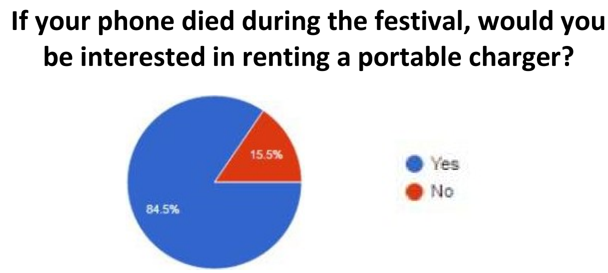

Figure 41: Portable Battery Interest

The referenced graphs supplied crucial information in regard to establishing the target market and recognizing consumer preferences during Winergize's researching stages. Collected data allowed the company to move forward with its business model in a relevant and profitable manner.

Appendix B: Competitor Models and Marketspaces

Direct competitor analysis is described to show the importance and differentiation Winergize possesses. The direct competitors all share a similar end goal to Winergize, but do not use a relatable operation and deployment strategy.

GoCharge

GoCharge primarily focuses on its metropolitan product line. Varying models can be seen in hi tops, coffee tables, and standard tables as well. While waiting to charge their cell phones, GoCharge requires users to watch advertisements. The secondary model that the company offers, GoCharge Eagle, is Winergize's closest competitor. The version uses solar panels to generate electricity that powers stationary locker charging stations. Though it poses an environmentally friendly method, reviews claimed that charging capabilities are very unreliable.

FuelRod

FuelRod rents portable batteries to users but is only available in airports. The company provides their charging service through stations that are set up around terminals, which let passengers deposit and exchange batteries between flights. Stations are situated in a limited number of locations and charge customers a $20 fee for unlimited battery swaps. Typical charge time for an iPhone 5 has been reported to take 6 hours, which is 3x longer than the average charge time.

ChargeTech

ChargeTech is a stationary charging company within the music festival space. ChargeTech partnered with Coachella in 2014 as its cell phone charging vendor. Revenue channels for the company include charging stations at music festivals as well as the sale of portable batteries online for $85. An average cell phone recharges in 2 hours, which is more closely correlated to the charge time at a standard outlet connected to the grid. Though portable batteries can be purchased from the company online, none are sold at the festival. Users that have used ChargeTech negatively reported that it was necessary to stay with their cell phone because the setup does not include a locker station and provided cords are too short.

Appendix C: Investor Financials

This appendix displays investor relevant financial information and shows the current investment value, company evaluation and growth over the next three years. The requested financial investment will stimulate Winergize's revenues to break even by August 2018.

Table 8: Equity Demands, Requested Investment, and Company Valuations

Company Evaluation and Investor Financials	
Investor Equity %	33%
$ Invested	$200,000
Net Income at the End of Year 3	$514,799
Company Value at the End of Year 3	$3,603,590
Investor Equityat the End of Year 3	$1,189,185
ROI	4.95

Table 9: Use of Investment Money

Amount	Use
$55,887	Purchase Three Turbines
$55,000	Purchase and Re-purpose ChargeTruck
$22,850	Start-up Costs and Expenses
$66,263	Cash Reserve to Cover Overhead and Future Capital Expansion

Appendix D: Company Financial

This appendix displays the company's financial information. The following income statements, balance sheets, and cash flows portray Winergize's growth strategy.

Table 10: Annual Income Statements

Winergize, LLC Annual Income Statements			
Year	2017-2018	2018-2019	2019-2020
Revenue			
Investment	$200,000	$0	$0
Revenue Captured	$403,091	$1,025,687	$1,041,651
Total Revenue	**$603,091**	**$1,025,687**	**$1,041,651**
Expenses		**$0**	**$0**
Advertising Expense	$3,200	$6,600	$9,000
Contracted Services	$5,400	$5,400	$5,400
ChargeTruck Expense	$55,000	$0	$0
Maintenance Expense	$3,600	$8,100	$9,750
Office Supplies Expense	$975	$975	$975
Payroll	$42,720	$49,920	$49,920
Inventory	$17,880	$25,149	$21,908
Insurance Expense	$2,640	$2,640	$2,640
Rent Expense	$13,500	$18,000	$18,000
Startup capital Expense	$22,850	$0	$0
Supllies expense	$2,375	$3,075	$3,075
Travel and Meals	$11,700	$16,200	$16,200
Turbine Expense (See Bill of Materials)	$55,887	$93,145	$18,629
Turbine and *ChargeTruck* Space Expense	$49,100	$75,200	$68,600
Utilities Expense	$6,660	$10,230	$12,030
Total Operating Expense	**$293,487**	**$314,635**	**$236,127**
EBT	$309,604	$711,052	$805,524
Income Tax	$98,828	$288,611	$290,726
Net Income	**$210,776**	**$422,441**	**$514,799**

Table 11: Annual Balance Sheet

Winergize, LLC Annual Balance Sheets			
Year	2017-2018	2018-2019	2019-2020
Assets			
Current Assets			
Cash	$210,776	$610,425	$1,105,674
Inventory	$17,880	$43,029	$64,937
Total Current Assets	**$228,656**	**$653,454**	**$1,170,611**
Fixed Assets			
Turbines (See Bill of Materials)	$55,887	$149,033	$167,662
ChargeTruck	$55,000	$55,000	$55,000
Total Fixed Assets	**$110,887**	**$204,033**	**$222,662**
Total Assets	**$339,543**	**$857,487**	**$1,393,273**
Liabilities And Equity			
Current And Long Term Liabilities			
Total Liabilities	**$0**	**$0**	**$0**
Owner's Equity			
Common Stock	$200,000	$200,000	$200,000
Retained Earnings	$139,543	$657,487	$1,193,273
Total Owners's Equity	**$339,543**	**$857,487**	**$1,393,273**
Total Liabilities And Owner's Equity	**$339,543**	**$857,487**	**$1,393,273**

The tables displayed are the income statements, balance sheets, and statement of cash flows. These tables display all necessary information relevant to company financials. The statements detail and breakdown how and when the company makes their money, what the money is spent on, account balances, and use of cash in activities. The income statement shows the growth in revenue and net income over three years as a result of company and its increase in expenses to support the growth. The balance sheet details all the company's accounts and holdings, including the major capital assets such as the wind turbines, *ChargeTruck,* and *PowerPlays*. The statement of cash flows shows the use of cash in all three categories of spending: operating activities, investing activities, and financing activities.

Table 12: Statement of Cash Flows

Winergize, LLC			
Annual Statements Of Cash Flows			
Year	**2017-2018**	**2018-2019**	**2019-2020**
Cash Flows From Operating Activities			
Revenue Captured	$403,091	$1,025,687	$1,041,651
Advertising Expense	$3,200	$6,600	$9,000
Contracted Services	$5,400	$5,400	$5,400
Maintenance Expense	$3,600	$8,100	$9,750
Office Supplies Expense	$975	$975	$975
Payroll	$42,720	$49,920	$49,920
Inventory	$18,469	$25,149	$21,908
Insurance Expense	$2,420	$2,640	$2,640
Rent Expense	$12,220	$18,000	$18,000
Startup capital Expense	$22,850	$0	$0
Supllies expense	$2,375	$3,075	$3,075
Travel and Meals	$11,700	$16,200	$16,200
Turbine and ChargeTruck Space Expense	$49,100	$75,200	$68,600
Utilities Expense	$6,660	$10,230	$12,030
Taxes Paid	$98,828	$288,611	$290,726
Net Cash Flows From Opearting Activities	**$122,574**	**$515,586**	**$533,428**
Cash Flow From Investing Activities			
Turbines Purchased	-$55,887	-$93,145	-$18,629
Food Truck Purchased	-$55,000	$0	$0
Net Cash Flow From Investing Activities	**-$110,887**	**-$93,145**	**-$18,629**
Cash Flow From Financing Activities			
Investment	$200,000	$0	$0
Net Cash Flow From Financing Activities	**$200,000**	**$0**	**$0**
Net Cash Flow	**$211,687**	**$422,441**	**$514,799**

Appendix E: Winergize Turbine Bill of Materials

Table 13: Bill of Materials Used in Turbine Design

Part Number	Part Name	Description	Vendor	Unit of Measure	Quantity	Unit Cost	Total Cost
1	265R Tower	21.3' max height	WORK Lifters	each	1	$1,250.00	$1,250.00
2	Generator Flight Case	48" x 84" x 30"	Road Case USA	each	1	$1,300.00	$1,300.00
3	Battery Flight Case	29.5" x 22.38" x 30"	Road Case USA	each	1	$400.00	$400.00
4	60355K604 Double Shielded Ball Bearing	1 7/8" OD, for 7/8" shaft diameter	McMaster-Carr	each	2	$12.03	$24.06
5	93680A325 Aluminum T-Handle Push-Button Quick-Release Pin	M8 diameter, 65mm usable length	McMaster-Carr	each	1	$26.96	$26.96
6	91274A135 Coated Alloy Steel Socket Head Cap Screw	M6 thread, 8mm long	Mcmaster-Carr	pack of 25	4	$7.80	$31.20
7	91290A138 Black-Oxide Class 12.9 Socket Head Cap Screw	Alloy steel, M4 thread, 5mm length, 0.70mm pitch	McMaster-Carr	pack of 100	5	$13.16	$65.80
8	91290A212 Black-Oxide Class 12.9 Socket Head Cap Screw	Fully threaded, alloy steel, M8 thread, 50mm long	McMaster-Carr	pack of 5	3	$7.59	$22.77
9	91294A336 Black Alloy Steel Flat-Head Socket Cap Screw	Class 10.9, M10 size, 45mm length, 1.50mm pitch	McMaster-Carr	pack of 10	6	$8.09	$48.54
10	90977A037 Medium-Strength Steel Hex Coupling Nut	Grade 5, 7/8"-9 thread size	McMaster-Carr	each	1	$12.43	$12.43
11	57485K84 Set Screw Shaft Collar	For 35mm diameter, black-oxide steel	McMaster-Carr	each	2	$5.37	$10.74
12	126N18 High-Load Dry-Running Thrust Bearing	for 38mm shaft diameter	McMaster-Carr	each	2	$15.72	$31.44
13	92185A509 Type 316 Stainless Steel Socket Head Cap Screw	1/4"-20 thread, 3-1/2" long	McMaster-Carr	pack of 5	12	$5.83	$69.96
14	91290A318 Black-Oxide Class 12.9 Socket Head Cap Screw	Alloy steel, M6 thread, 12mm length, 1mm pitch	McMaster-Carr	pack of 100	3	$10.26	$30.78
15	91290A141 Black-Oxide Class 12.9 Socket Head Cap Screw	Alloy steel, M5 thread, 130mm long, 0.8mm pitch	McMaster-Carr	pack of 5	4	$7.96	$31.84
16	92196A958 18-8 Stainless Steel Socket Head Cap Screw	8-32 thread, 5" length	McMaster-Carr	each	1	$14.49	$14.49
17	DX08B-N52 Neodymium Magnet	1" dia. X 1/2" thick	K&J Magnetics, Inc.	each	96	$12.48	$1,198.08
18	Wire-MW-20-5 Magnet Wire	20AWG, 5lbs, 1575ft	Powerwerx	each	1	$110.00	$110.00
19	Generator Plates	Machined	RAPID	each	1	$1,700.00	$1,700.00
20	Nacelle Assembly	Machined	RAPID	each	1	$6,250.00	$6,250.00
21	Tailfin Assembly	Machined	RAPID	each	1	$750.00	$750.00
22	Blade	Fiber glass molded	Gurit	3	1	$3,750.00	$3,750.00
23	Battery	12V 100Ah deep cycle	VMAX	each	2	$250.00	$500.00
					Shipping Estimate		**$1,000.00**
						TOTAL	**$18,629.09**

Table 13 shows a detailed breakdown of all of the components used in the construction of Winergize's turbine. The bill of materials includes a technical description of each component, the quantity used, the cost, and vendor utilized.

Appendix F: Energy Analysis

The following outlines the calculation performed to determine the number of portable batteries that can be charged by one turbine per day.

Table 14: Symbol Definitions

Definition	Symbol used here
Turbine energy output	E_T
Energy required to charge a large battery	E_{LB}
Energy required to charge a portable battery	E_{PB}
Number of large batteries charged by turbine per day	N_{LB}
Total number of portable batteries charged by turbine per day	$N_{PB\_100\%}$
Number of portable batteries charged by a large battery per day	N_{PB_1LB}
Efficient total number of portable batteries charged by turbine per day	$N_{PB\_85\%}$
Large batteries charge (12 V)	Q_{LB}
Portable batteries charge (5V)	Q_{PB}

Given the specifications of the turbine, the large battery and the portable batteries:

$E_T = 4$ kWh/day @ 24 V

$Q_{LB} = 100$ Ah @ 12 V

$Q_{PB} = 2.2$ Ah @ 5 V

The following calculation can be performed:

$$\boldsymbol{E_{LB}} = \boldsymbol{Q_{LB}} \times \boldsymbol{V}$$
$$= 100\text{ Ah} \times 12\text{ V}$$
$$= 1.2\text{ kWh}$$

$$\boldsymbol{E_{PB}} = \boldsymbol{Q_{PB}} \times \boldsymbol{V}$$
$$= 2.2\text{ Ah} \times 5\text{ V}$$
$$= 11\text{ Wh}$$

Assuming the overall charging efficiency is 100%,

$$\boldsymbol{N_{PBTOT100\%}} = \boldsymbol{N_{PB\_1LB}} \times \boldsymbol{N_{LB}}$$
$$= 109 \times 3.33$$
$$\approx 362$$

$$\boldsymbol{N_{LB}} = {}^{\boldsymbol{E_T}}/_{\boldsymbol{E_{LB}}}$$
$$= 4\text{ kWh} / 1.2\text{ kWh}$$
$$= 3.33$$

$$N_{PB\_1LB} = {}^{E_{LB}}/_{E_{PB}}$$
$$= 1.2\text{ kWh} / 11\text{ Wh}$$
$$\approx 109$$

Assuming the overall charging efficiency is 85%,

$$N_{PB\_85\%} = N_{PB\_100\%} \times 0.85$$
$$= 363 \times 0.85$$
$$\approx 307$$

∴ **307** portable batteries can be charged with the efficiency of 85% over the power output.

Appendix G: Turbine Installation Procedure

Table 15 outlines the specific turbine installation procedure to be followed by Winergize employees during turbine setup.

Table 15: Turbine Set-Up Procedure

Turbine Installation Procedure	
Step 1	Lay out tower in area that satisfies all restrictions to implementation.
Step 2	Place generator on top of tower and lock it in place.
Step 3	Attach blades to nacelle.
Step 4	Carefully crank up tower into operational position.
Step 5	Attach guy wires to tower and stakes/containers/weights.
Step 6	Connect electrical box to bottom of the tower.
Step 7	Erect mesh safety fence around turbine area.

Appendix H: International Electrotechnical Commission (IEC) - Simple Load Model 500

Table 16 includes the results obtained from the International Electrotechnical Commission (IEC)'s Simple Load Model (SLM 500) on the blades and the shaft of the wind turbine. The IEC load model is an international standard established to assess the structural integrity of wind turbines. The model contains different loading cases to ensure the structural integrity of the blades and the shaft corresponding to the specifications of the overall turbine and the internal components of the turbine. The loading cases are represented in Table 16, and a "SAFE" rating constitutes to the criterion being met.

Table 16: Simple Load Model 500 Results

Simple Load Model Results			
Load Case A - Fatigue Loads on Blades and Rotor Shaft			
	Fatigue Damage Limit	Fatigue Damage	Conclusion
Blades	1.00	4.54E-07	SAFE
Shaft	1.00	Infinite Life	SAFE
Load Case B - Blade and Rotor Shaft Loads during Yaw			
	Material Stress Limit (MPa)	Calculated Stress (MPa)	Conclusion
Blades	33.33	0.00	SAFE
Shaft	80.00	78.64	SAFE
Load Case C - Yaw Error Load on Blades			
	Material Stress Limit (MPa)	Calculated Stress (MPa)	Conclusion
Blades	33.33	0.00	SAFE
Load Case D - Maximum Thrust on Shaft			
	Material Stress Limit (MPa)	Calculated Stress (MPa)	Conclusion
Shaft	33.33	0.17	SAFE
Load Case E - Maximum Rotational Speed			
	Material Stress Limit (MPa)	Calculated Stress (MPa)	Conclusion
Blades	33.33	12.72	SAFE
Shaft	80.00	36.55	SAFE
Load Case F - Short at Load Connection			
	Material Stress Limit (MPa)	Calculated Stress (MPa)	Conclusion
Blades	33.33	0.00	SAFE
Shaft	80.00	3.84	SAFE
Load Case G - Shutdown Braking			
	Material Stress Limit (MPa)	Calculated Stress (MPa)	Conclusion
Blades	33.33	n/a	n/a
Shaft	80.00	n/a	n/a
Load Case H - Parked Wind Loads during Idling			
	Material Stress Limit (MPa)	Calculated Stress (MPa)	Conclusion
Blades	33.33	0.76	SAFE
Shaft	80.00	0.00	SAFE

Appendix I: Festival Environmental Site Conditions

Table 17: Festival Environmental Site Conditions

Festival Name	Location	Dates of Festival	Soil/Environment Conditions	Environmental Restrictions (Likert) 1 (No Concern)-5(Extreme)
Lightning in a Bottle	Bradley, CA	5/21-5/25	Grass/Sand Mix	1
EDC Las Vegas	Las Vegas, NV	6/19-6/21	Sand/Dirt Mix	1
Outside Lands	San Francisco, CA	8/7-8/9	Holocene Dunes	2
Sonic Bloom	Rye, CO	6/16-6/19	Drained on Conditioned Grounds	2
Sasquatch	The Gorge, WA	5/22-5/25	Sand	1
Stagecoach	Indio, CA	4/29-5/1	Drained on Conditioned Grounds	1
Punk Rock Bowling	Las Vegas, NV	5/28-5/30	Pavement	2
Further Future	Las Vegas, NV	4/29-5/1	Drained on Conditioned Grounds	1
Bands in the Backyard	Vineland, CO	6/17-6/18	Grass/Sand Mix	1
Life is Beautiful	Las Vegas, NV	9/25-9/27	Sand/Open Desert Terrain	1
iHeart Radio	Las Vegas, NV	9/18-9/19	Pavement	1
Pot of Gold	Tempe, AZ	3/17-3/19	Sand/Open Desert Terrain	1
Capitol Hill Block Party	Seattle, WA	7/22-7/24	Artificial Grass	4
Noise Pop	San Francisco, CA	2/19-2/27	water saturated mud and artificial fill	2
Orgeon Jamboree	Sweet Home, OR	7/29-7/31	Drained on Conditioned Grounds	2
California Roots	Monterey, CA	5/22-5/24	Sand	1
Gem and Jam	Tucson, AZ	2/12-2/14	Pavement	1
The Untz	Mariposa, CA	6/3-6/4	Shrubbery/Trees	2
Bumbershoot	Seattle, WA	9/5-9/7	Clay Soil, High pH, High Compaction	1
BottleRock Napa	Napa Valley, CA	5/29-5/31	Sandy Open	1
Joshua Tree Spring	Joshua Tree, CA	5/12-5/15	Thin Soil, Bed of Limestone	3
Treasure Island	San Francisco, CA	10/17-10/18	Grass/Sand Mix	1

In **Table 17,** site specific soil and environmental conditions were analyzed using the *United States Geological Science Survey* Database. This condensed table exhibits the necessary parameters to determine which deployment strategy is required for the turbines (stakes, weights, and/or containers).