Texas Tech University

TECHSAN WIND

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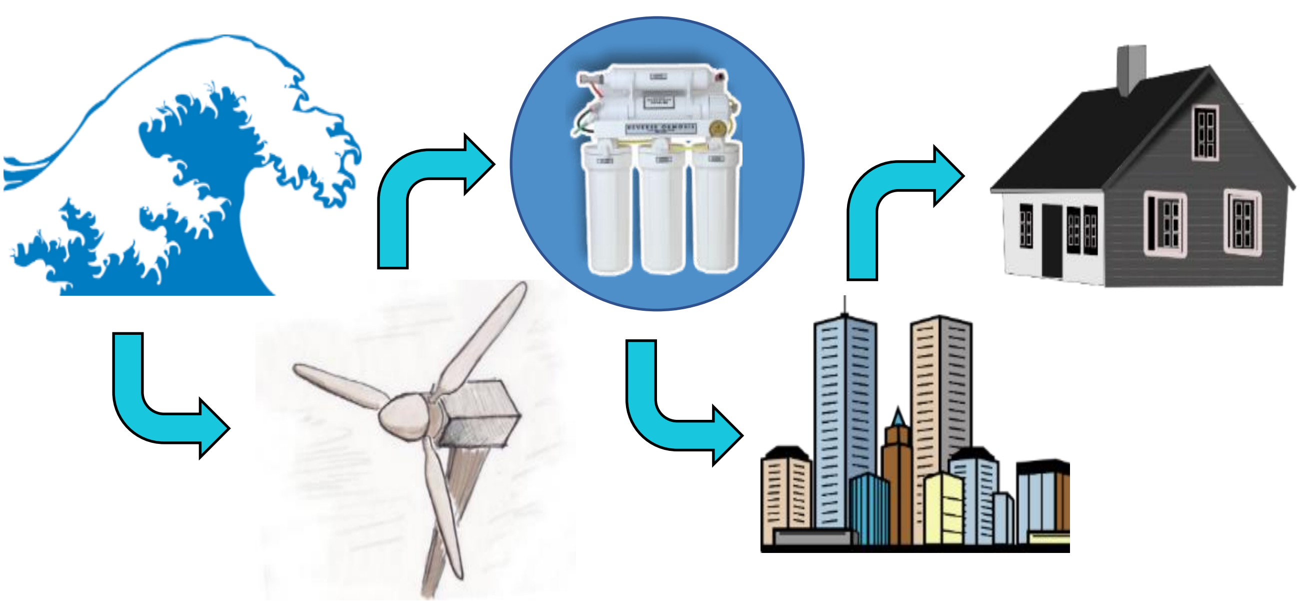


1. Executive Summary

The following document explains and supports a potential investment opportunity in Techsan Wind, LLC. The initial startup costs will be approximately $5,200,000, 25% of which will come from a maximum amount of 3 shareholders, 15% coming from applicable loans/grants, and the remaining 60% stemming from debt. The total amount Techsan Wind requires from shareholders is around $1,300,000, with a rate of return (ROI) of 12% for each investment. The company will utilize Reverse Osmosis Desalination (ROD) systems to purify seawater and transform it into a potable form. This will in turn be sold to municipalities with a high demand for this resource.

Investments are required in order for Techsan Wind to purchase the ROD systems, as well as the materials required for the manufacturing of the company's turbines. The wind powered, desalinated water will be sold for $4.74 per 1,000 gallons in order to compete with cities' water costs, and break-even costs will occur after five years of operation.

The company's Technical Team built a small scale testing turbine for the purposes of the Department of Energy Collegiate Wind Competition in May of 2018 in order to examine the feasibility of the full scale market turbine. The differences between the small and market scale turbines is discussed in the Technical Design section of this report. The market turbine will be a 1 MW upwind machine with a hub height of 80 meters and a rotor diameter of 70 meters. The full-scale turbine is based primarily on the National Renewable Energy Laboratories WindPACT 1.5MW machine.

The marketing team of Techsan Wind issued customer surveys and performed a consumer and drought analysis to determine what specific United States regions needed the company's product the most. In doing so, the surveys identified that the southern portion of California is the most drought stricken region year-round in the United States, and therefore, an optimum market for Techsan Wind's product. Through the market research, there are an estimated 5.2 million households in Southern California that the company can potentially affect; providing approximately 360 gallons of water per household, or 1.9 billion gallons in the entire region per day.

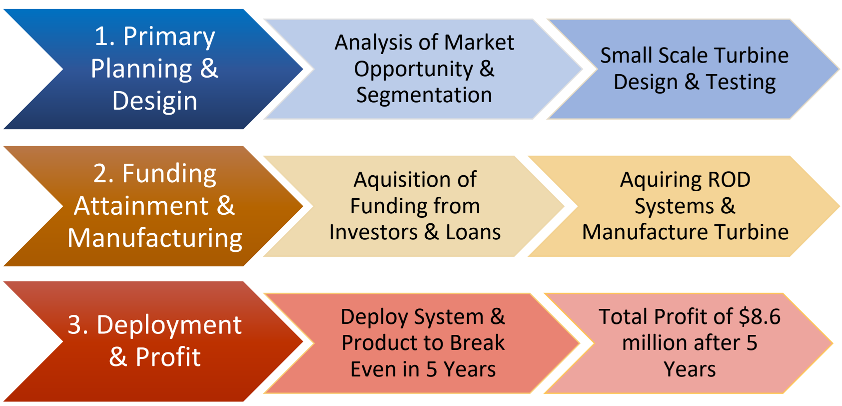
The investment potential and what it will entail will be discusses throughout the Business, Technical and Shareholders section. The Business portion of the following report describes the market opportunity provided to Techsan Wind as well as how the company plans on utilizing that opportunity and ensuring the longevity of Techsan Wind's future. The Technical section details the design of the test turbine, pre-competition testing results, and how the test turbine compares and contrasts to the expected company market turbine.

2. Table of Contents

3. Business Plan

3.1 Business Overview

Techsan Wind strives to supplement an innovative and renewable solution to the country's demand for clean water. The creation of this company derived from members of the Business Team being personally affected by the lack of potable water in various regions of the United States. The Business Team therefore envisioned a way to penetrate the water market utilizing green technologies in place of traditional energy sources, while providing a decreased cost of water to consumers. Upon an analysis of market location wind potential, amount of power required for the ROD systems, and the ability to run in island mode, the Technical Team developed a small-scale test model of the company's market wind turbine design. Testing the small scale machine allowed for adjustments to be made in order to perform ideally at the 2018 Collegiate Wind Competition. Also, the Technical team had the opportunity to examine which components of the test turbine would be ideal for scaling up, and what would need to be added to suit the actual market location.



Following an analysis of consumer need, favorable market location, and potential competition, the Business Team devised a plan for combatting the water crisis in areas of the United States and divided the company's mission into phases. One of the key distinguishing features of Techsan Wind is that the company will introduce a new product to an existing market, without the requirement to connect to the electrical grid. See **Figure 1** for general phase overview and timeline, section 5.3 for a more in depth explanation.

3.2 Market Opportunity

Techsan Wind has identified a market gap in providing potable water to regions going through drought. Specifically, as California continues to recover from the recent extreme drought, as well as facing more potential droughts, the state will need up to 11 trillion gallons of water to replenish their water sources to pre-drought levels. Techsan Wind's system can provide a minimum one million gallons of potable water a day helping to counteract California's lack of water. Based on the market location statistics, this supply of water can impact up to 5.2 million households that are currently experiencing a lack of water. While non-renewable energy sources and solar systems can provide energy to purify water, they both have disadvantages that can be overcome by using wind turbines in the potable water response market. Unlike most ROD systems on the market, Techsan Wind's system doesn't tax the local grid, meaning a lower and stable water price. The ROD system also has net zero emissions into the air and operates off-grid in case of energy shortage. The renewable energy powered system helps support California's goal of reaching the state's Renewable Portfolio Standard of 33% renewables by 2020. Similarly, the system corresponds to California resident's ideals, as recently 76% of adult constituents favored setting a target of 100% renewable energy. Techsan Wind reached out to other communities to run a market analysis to prove the need for the company's ROD system. With positives results, the company decided to act and supply areas in California with potable water.

A drought analysis was conducted through the government website drought.gov to determine a focus area based on uncommon or extendedly stricken drought areas. Through this analysis, Techsan Wind determined that Southern California is stricken most often with drought compared to the rest of the market within California state. The total population of Southern California in 2016 was 23.8 million people and accounting for roughly 60% of the total Californian population. The number of gallons per day has only continued to climb with rising population and agricultural needs. According to the California Department of water resources, each single-family home uses 360 gallons of water a day as of 2011. Based on the United States Census Bureau, the average size of a single-family household is 2.9 people and there are roughly 12.8 million households in Southern California as of 2016. Based on a 2008 study, 68% of the Californian population lives near the coast. Taking this into account, Techsan Wind's possible market to roughly 5.2 million households that are within an impactful distance of the initial facility and all later constructed facilities. The information gathered reveals that with 5.2 million households using roughly 360 gallons per household, southern California would need 1.872 billion gallons a day. Due to the fact that some of this information is over half a decade old, this number is a conservative estimate, and the actual demand is considerably higher.

3.2.1 Market Segmentation

Techsan Wind will encounter four primary competitors in several aspects of the market including technology, power supply, and water desalination. One of the company's leading competitors will be IDE Technologies. This company desalinates seawater globally, with several facilities in the United States. Business is conducted by entering densely populated market regions with drought that express a need for additional water resources. Techsan Wind will focus on the smaller scale, allowing the company to reach the cities and towns that are currently being overlooked for densely populated regions. Another advantage Techsan Wind holds over this company is that the ROD systems are powered solely by renewable energy and do not contribute to harmful carbon emissions.

Desalitech, a Reverse Osmosis technology provider, will prove to be a strong competitor as they offer advanced desalination modules. This allows for Desalitech to have a market presence throughout the United States. These modules, however, utilize generic power supplies such as grid connections. Techsan Wind's advantage with this company will stem from the sale of a compact unit that provides not only desalinated water but also the power generation technology necessary to run the system. The ROD system also has the ability to operate in island mode, meaning the system can switch from grid connected to stand alone operation.

In an effort to promote renewables, pre-existing technology is being retrofitted with solar panels; creating an additional renewable energy competitor within the desalination sector. Techsan Wind will be able to rival this competitor by utilizing substantially less land. The solar farm size necessary to power these facilities would require copious land parcels. Techsan Wind's unit would require 700 square meters of space per megawatt turbine, but a solar farm will take up approximately 4000 square meters per megawatt in comparison.

Standard electric providers will also prove to be a source of competition within the desalination market. Currently, most facilities are powered by the grid. This allows for the desalination companies to purchase power at low rates. On average, Techsan Wind's water price is lower than a municipality's generation price. Techsan Wind's capability to counter this will stem from the ability to not only supply a compact unit that does not require the purchasing of power, but also the ability to operate in island mode. Should there be an instance when a standard electricity generation facility is not able to provide enough power, Techsan Wind's system will still maintain it's production capabilities.

3.3 Company Ownership

Techsan Wind is a private corporation that will sell a new product to an existing market without saturating the market's prospects. In the company's third phase, expansion into other regional markets will be accomplished by developing new products or further improving the wind driven ROD system to exponentially expand Techsan Wind's presence in the market.

Variability in start-up costs are derived from possible grant programs that may be available to different site locations or system setups. By providing drinking water to the coastal regions of the United States, the corporation qualifies for national and state programs that fund the expansion of drinking water. Techsan Wind will apply for a loan under the Water Infrastructure Finance and Innovation Act. In order to bring the system and product to the market, Techsan Wind is seeking shareholders to help offset taking on additional debt. Municipalities are being considered to invest in the model because they can be offered governmental grants that corporations are not eligible to receive. Banks and local businesses that could support Techsan Wind are also being considered as possible shareholders. To help cover the high startup cost, Techsan Wind desires to pull in two or three investors to invest up to 25% of the total startup costs. The shareholders will have to be knowledgeable and experienced with investing on startups and will be given a competitive rate of 12% to be above the current rate of return of the stock market.

3.3.1 Management

Chief Executive Officer: Jazirae Duncan

Jazirae Duncan has a Bachelor's degree in Wind Energy from Texas Tech University, and serves as the CEO of Techsan wind. She chose to participate in the competition because she strives to positively represent the Wind Energy program at Texas Tech University as well as pursue potential investors in her company's prospects. Jazirae holds a strong passion for the future of renewable energy and especially enjoys implementing her knowledge to the business aspect of the industry. She prides herself in being a largely logical thinker, preserving an image of the big-picture rather than allowing herself and the team's ideas to stray from Techsan Wind's overall plan, evidently preserving the future of the company. She also exhibits organizational and management skills, allowing her to thoroughly assist in the day-to-day performance of both teams, while also efficiently delegating responsibilities and ensuring the team members stays on schedule. Excited to watch the Techsan Wind company grow, both through the time applied to working towards the competition, and afterwards, she expects each member of Techsan Wind will apply what they have learned through this competition process to their future endeavors.

Chief Operations Officer: Jared Garrand

Jared Garrand serves as the Chief Operations Officer of Techsan Wind, and joined the company in order to apply his background in Wind Energy and industry software. This competition proved to be an efficient means to gain experience with communicating with industry leaders and receiving feedback that will benefit himself as well as his employees. His key role within Techsan Wind is delegating specific duties to each member of the Business Team and personally overseeing daily tasks. These duties range from assembling information, performing market research, or reaching out to different companies to collect market information. Furthermore, he brings a form of unique and intense leadership to Techsan Wind that assists the company's progress as well as the overall growth of the Business Team members.

Chief Financial Officer: Joshua DeWees

Heading the company finances as CFO is Joshua DeWees, who employs his extensive experience with management, Mechanical Engineering, Wind Science, Business Management, and

Entrepreneurship. His university involvement during his undergraduate career has aided him in becoming extremely well versed in public presentations, professional speaking, mediating member disagreements, and developing strategic financial plans for the company. Moreover, he has represented Texas Tech University multiple times beforehand, including leading Student Information sessions, the Alumni Cocktail Hour and Tailgate, Global Laboratory for Energy Asset Management and Manufacturing(GLEAMM), and currently the Department of Energy Collegiate Wind Competition

Chief Technical Officer: Chance Zajicek

Chance Zajicek serves as the Chief Technical Officer of Techsan Wind and engages his college background of Wind Science, Engineering and Software. Chance's primary role is to oversee the Technical Team within Techsan Wind, and monitor the construction and testing of the model turbine for the competition. He is also responsible for performing consistent communication between the Business and Technical Teams, as well as the CEO. His specific tasks working towards the competition consist of utilizing his knowledge of generators and airfoils to positively contribute to the model turbine. Chance also possesses strong communication and presentation skills, which he uses to help guide the Technical Team in both their presenting as well as their industry relationships. Strategic Advisors: Techsan Wind will utilize the services of four strategic advisors at no cost to the company. These advisors have given their time in order to improve the design of Techsan Wind's wind turbine and advise the management staff on the processes related to improving Techsan Wind's business model. These advisors have specialties in areas relating in business and wind turbine technology.

Strategic Advisors

Dr. Andy Swift has a bachelor's degree in mathematics and mechanical engineering, a master's in mechanical engineering, and a doctorate from Washington University, St. Louis. Dr. Swift's Master's Thesis was over "Computer Aided Design of a Solar/Wind Energy System," this makes him very adept in assisting Techsan Wind's technical staff in the design of the market and scale turbines.

Cesar A. Negri is a Wind Science and Engineering (WiSE) Ph.D. student at Texas Tech University starting fall 2017. He is part of the GLEAMM research team as a Research Assistant (RA) under Dr. Stephen Bayne supervision. Negri received his Control and Automation Engineering bachelor degree at Sao Paulo State University (UNESP) in 2008 and began working as commissioning and protection engineer at Acom Energy in Sorocaba, Brazil. In 2012 he was promoted to project manager and 2015 he received his Project Management specialization certificate at Getulio Vargas Foundation - Brazil. Cesar has been a great resource for the creation of the model scale wind turbine.

Dr. Scott Clark is the Vice President of Engineering at Brandon and Clark Inc. Brandon and Clark is a company that specializes in sales and servicing of electrical components. Brandon and Clark Inc. also focuses in electric motor repair, with a significant portion of their business related to serving the needs of regional wind power companies. This makes Dr. Clark adept at advising the team on the generator type for the company's model scale wind turbine.

3.4 Development and Operations

Techsan Wind's offices will be located in a city between Los Angeles and San Diego, California. The location of Techsan Wind offices and parts warehouse have been selected to be in this area due to the proximity to the company's suppliers, ports and initial site location. Techsan Wind market turbine will have variable hub heights, rotor diameters, and generators for variable wind climates. RO facilities will be designed to meet requirements for permitting organizations to minimize effects on wildlife and other environmental factors. The necessary modifications to different sites will moderately affect different method of production. Wind turbine IEC will affect startup cost depending on the average wind speed and turbulence intensity making different types of wind turbines more viable in different locations. Water discharge back into the ocean is an environmental hazard if not handled correctly. Techsan Wind will work closely with the Food and Drug Administration, Environmental Protection Agency, and United States Coast Guard to ensure proper environmental standards are met.

3.4.1 Suppliers

The turbine will be assembled by outsourcing the various components from specialized companies. For blades, a design created by Techsan Wind and a proprietary coating will be sent to a blade manufacturing company, who will then produce the blades. MFG Wind was selected to supply the blades as well as the nacelle and nosecone. MFG Wind has a facility in Adelanto, California and offers help in prototyping and first article fabrication. The same process will be followed with the tower through Korindo Wind, with a facility in Los Angeles, California. Delivery will be arranged for the construction site, where all components will be combined, and the turbine will be constructed. Items such as electrical wires, power electronics, and transformers will be purchased through opening bids and selecting the lowest price for bulk supply. The company will contract local construction companies in the market location to lay foundations, roads, and other aspects. This in turn will help support the local economy.

Techsan Wind has chosen to outsource the turbine components in order to save on costs. If turbines and other aspects were to be built in-house, an abundance of machinery and equipment would need to be purchased. However, the price of this equipment would not be feasible, as the company would be constructing a minimal number of turbines annually. The machinery in turn would spend the majority of the year not in use, making outsourcing more cost effective compared to purchasing unnecessary equipment.

The suppliers of the ROD systems will be selected based off lowest bulk pricing through opening bids. Additional components of the ROD system, such as pipes and filters, will be purchased similar to turbine components by purchasing in bulk from regional suppliers who offer discounted prices.

Techsan Wind will employ technicians to maintain the turbines; however, they will not provide maintenance for the ROD system. The company will contract out the ROD system care to the company the system will be purchased from.

3.4.2 Manufacturing

Techsan Wind would not need to produce large quantities of turbines as some other turbine designers would. This is due to Techsan Wind only producing wind turbines for desalination of seawater at this point in time. The turbines will be designed in house but produced by a turbine manufacturer and shipped to the desired location once a contract agreement is reached. The clean drinking water could be trucked, packaged, or piped to its desired location. The preferred method of sale and transportation is to create a water purchase agreement with the city, community, or municipality that needs the water and then pipe the water to an agreed location.

5.3 Strategy and Implementation

Phase 1: Pre-Investment Planning

Techsan Wind's marketing division began consumer surveys and market analysis to determine a demand and identify a sustainable market to deploy the company's product. Also during this phase, the Technical Team began the design, construction and testing of the company's model turbine. During testing of the small-scale model, the needs of the target market were taken into account to ensure the full scale machine operates ideally. After preliminary testing, adjustments will be made to improve the efficiency and performance of the turbine once it is scaled up to market size. Phase 1 is expected to be completed within one year, and the company will then transition to attaining funding.

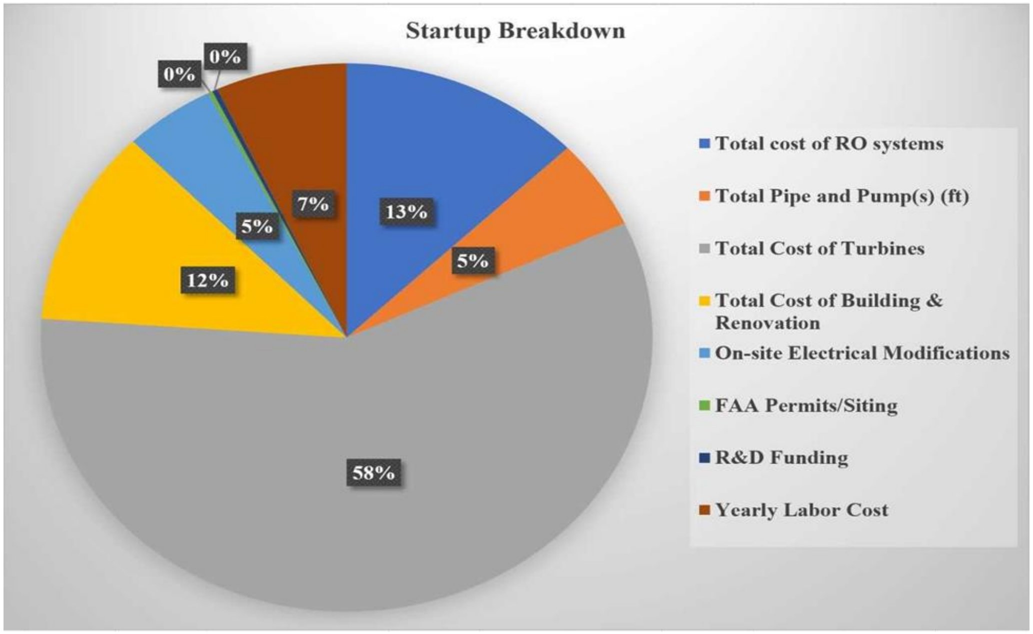
Phase 2: Funding Procurement & Manufacturing

After the first year of planning and technical designing, Techsan Wind will begin advertising to potential shareholders to equate to the 25% necessary for the start-up expenses. Once adequate funding is obtained, ROD systems and turbine components will be purchased and manufacturing will begin. It is expected that manufacturing be completed in a minimum of two years. Also during this phase, the company will set up its base in a city between Los Angeles and San Diego.

Phase 3: Deployment and Profit

Sales are the main focal point entering into Phase 3. After a minimum of three years conducting market research, performing technical designing, and acquiring funding, Techsan Wind will begin making sales to the Southern California region, the pre-determined market area. The objective within this phase is to sustainably introduce the company's product into the market. By addressing the target market first, the feasibility and scalability of the product will be assessed. The market is predicted to shift during phase 3, therefore Techsan Wind will adapt its technology, product and marketing methods to adjust accordingly to consumers. This will ensure success promote company success within the project and ensure the longevity of Techsan Wind.

6.1 Start-Up/Acquisition Summary



The pre-investment planning phase will involve the analysis of risk factors for airspaces, local ecosystems, and markets for both environmental and financial project impediments. This will involve conducting a biological study and a local market analysis to determine the safest way to ensure the company's success and longevity. The next phase will involve the necessary modifications to wind turbines, ROD systems, water intake methods, and byproduct management vital for the safety of the project and its local ecosystem. These necessary modifications include using a more resistant epoxy to handle the caustic air that the turbines will experience near the coast. Through the help of the local municipals, cost will be reduced by utilizing existing water pipelines when possible. This serves a dual purpose allowing for the facility to easily and effectively stay within city ordinance and code, while minimizing land acquisition needed for the potable waters transportation. The largest example of this is in California at the Claude "Bud" Lewis Carlsbad Desalination Plant who pump the fresh water they produce 10-miles to the nearest San Diego County Water Authority distribution system in San Marcos.

6.2 Start-Up Expenses

The initial expense totals to $5,187,841. This number is estimated using a surplus of piping and pumps to account for possible modifications needed for the facilities. The initial expense also depends on the price of land. Thus meaning, the required start-up expense would more commonly have the opportunity to be cheaper based off of materials.

6.3 Determining Start-Up Capital

Start-Up Capital was determined based on a variety of factors. The cost of turbines and the subsequent number of turbines needed based on the power demand account for a substantial portion of the cost. The necessary model and size of the ROD systems, piping needed, and pumps, also account for the start up capital cost. A portion of the initial capital is for upgrading and creating a collection and distribution network from Techsan Wind's turbines to the ROD systems. Though the systems initial capital is large it does cover a variety of technology whose life spans range from 10 years with the desalination systems to 25 years for the wind turbines.

6.4 Pricing

Techsan Wind developed a pricing strategy to be competitive within southern California water prices. The average price per 1000 gallons is seven dollars and the company's cost per 1000 gallons is $4.74 at minimum to meet a five-year debt repayment plan. The cost includes an adjustable markup percentage with planning for during- and after-debt cost. This will enable the facilities to operate at competitive prices during the initial debt repayment phase and in future operations. This policy will allow us to maintain cheaper prices ensuring Techsan Wind's competitive abilities within the market.

IDE Technologies designs large-scale projects. Due to their choice of location near a Metropolitan area and necessary transportation modifications, the competitor's startup cost is significantly higher in comparison to Techsan Wind's. The major advantage over this company is that they do not focus on smaller scale facilities, only those of larger sizes.

Desalitech ROD systems range widely in price depending on the size of the project. For Techsan Wind's project, a system would cost between several hundred thousand dollars to a million dollars depending on the conditions of the water, the location, and exact size. While this is cheaper than Techsan Wind's system, they do not offer a power supply.

A utility-scale solar installation that would supply sufficient power to a system roughly the size of the ROD system would cost approximately $4 million. This price includes the panels themselves, as well as development costs for retrofitting a preexisting system. While this is slightly cheaper than Techsan Wind's product, it does not allow for new sources of water to be accessed. Furthermore, wind gives landowners the option to proceed using land for agriculture, while solar limits this opportunity due to facility size.

Standard water municipalities in these regions typically have water prices higher than what Techsan Wind offers. Depending on the region and their pre-established base prices, the difference in price can save customers a significant amount of money. With Techsan Wind's prices being below what the industry offers, the company will be able to attract customers to purchase from us.

In order to stay ahead of the market, Techsan Wind's company will monitor changes in technology. As innovative technology emerges the company system can be altered to ensure that the company is up to date with the newest technology.

6.5 Income Projection Statement

As previously mentioned Water Purchase Agreements or WPAs allow for unique modifications to separate facilities based on the water need, net profit demands, and regional water prices. Thus, allowing for areas of higher overhead to meet their need through the use of a higher mark-up percentages. Total Net Sales will change from facility to facility allowing for higher Gross Profit Margins when in regions of acceptable WPA prices. This diversity gives Techsan Wind a leg up by allowing the company to exist and thrive in markets that may otherwise be overlooked.

6.6 Profit and Loss Statement

The profit and Loss Statement would be variable depending on the location of different desalination facilities. This variability comes from the average water price in each region as well as the regional cost of land acquisition and ecosystem management techniques needed. Utilizing the implementation of a WPA, the company can guarantee sales pricing to meet the company's profit margin and operating expenses, while still being cost competitive with local facilities.

6.7 Balance Sheet

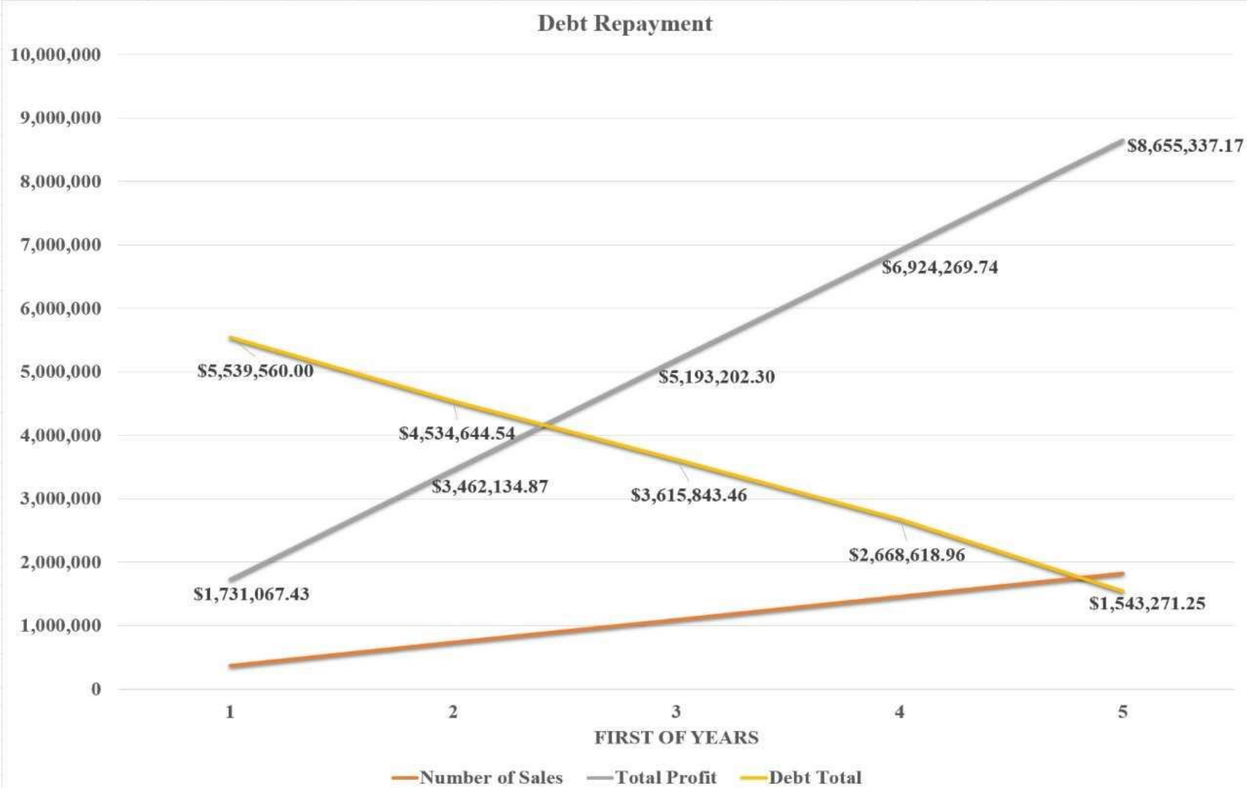
Cash Flow Statement					
Month	1st Quarter	2nd Quarter	3rd Quarter	4th Guarter	Year End
Number of Sales	91,300.00	91,300.00	91,300.00	91,300.00	365,200.00
Cash value of Sales	$482,797.77	$482,797.77	$482,797.77	$482,797.77	$1,931,191.10
PTC Monthly Credit	$84,096.00	$84,096.00	$84,096.00	$84,096.00	$336,384.00
REC Monthly Income	$8,760.00	$8,760.00	$8,760.00	$8,760.00	$35,040.00
Operational Cost	$44,352.00	$44,352.00	$44,352.00	$44,352.00	$177,408.00
Net Cash Flow of Operations	$531,301.77	$531,301.77	$531,301.77	$531,301.77	$2,125,207.10
Labor	$90,000.00	$90,000.00	$90,000.00	$90,000.00	$360,000.00
R&D	$12,500.00	$12,500.00	$12,500.00	$12,500.00	$50,000.00
Current Debt Total	$5,415,561.27	$5,409,400.04	$4,980,825.04	$4,552,250.04	
Interest	$422,413.78	$0.00	$0.00	$0.00	$422,413.78
Debt Repayment	$428,575.00	$428,575.00	$428,575.00	$428,575.00	$1,714,300.00
New Debt Total	$5,409,400.04	$4,980,825.04	$4,552,250.04	$4,123,675.04	
Net Profit	$226.77	$226.77	$226.77	$226.77	$907.10

In the above figure the balance sheet for year 1. In the appendix section is the full balance sheet over two year increments.

6.8 Sales Forecast

The predicted post debt profit would revolve around the WPA sale price and the amount of contracted and additional sales. A WPA of $4.74 and a sale of 1000 units of a 1000 gallons per day would gross $4,740 dollars per day for 365 days. The yearly income before expenses would be 1.73 million dollars. This is a predictable income based on the WPA, but more profit would be available during high water demand periods by selling the water by demand.

6.9 Break-Even Analysis



5. Technical Design

5.1 Design Objectives

The key turbine elements detailed in the Technical sections include:

- **Low cut-in wind speeds** - *5 meters per-second
- **Low maintenance costs** - *Substantially lower maintenance costs by eliminating the gearbox and opting for a direct drive system
- Operation in island mode - *Ability to operate without pulling power from the grid

The following explains why the components of the turbine were chosen in order to achieve the Technical Team’s aforementioned design demands for the market scale turbine.

The Techsan Wind turbine was designed to optimize cut-in speeds under 5 meters per second, and the ability to operate in island mode. The ability of the turbine to operate in island mode offers the turbine freedom from grid constraints and equips utility companies for more diverse business operations. Locations with a lack of grid interconnection nearby are not an issue when afforded the ability to operate in island mode. If the grid experiences issues, the turbine possesses the ability to disconnect and continue to operate effectively. The system is direct drive to reduce maintenance costs and down time. The market and model turbine utilize two generators. The first generator is small and allows the turbine to cut in and produce power in low wind conditions. As wind speeds increase, the second generator is engaged. At rated power, both generators are operating. The projected output of the market turbine is 1 MW. The small generator produces 250 kilowatts, and the large generator produces 750 kilowatts.

Each reverse osmosis desalination unit requires a total of 1.8-2 MW of power to operate. Therefore, each system requires a minimum of two, 1 MW turbines installed to meet the demands of the system. To output the required amount of electrical generation needs, the generators chosen are standard, permanent magnet, high performance generators tailored towards low wind speeds. Implementing permanent magnet generators eliminates the need for a gearbox, thus reducing maintenance costs. The large generator has a higher than desired cogging torque; therefore, a start up analysis was developed and applied to the generator system to meet the required starting torque through higher lift forces. As a result of the direct drive and high torque process, the Techsan Wind model turbine operates at a relatively low Tip Speed Ratio (TSR) of 4-6, resulting in a quieter market turbine. Having a quieter market turbine allows Techsan Wind to place ROD systems closer to the selected water and wind market without violating noise ordinances.

5.2 Market and Model Turbine Differentiation

A small scale model turbine was built and tested in a wind tunnel at Reese Technology Center in order to demonstrate the viability of accomplishing the design plan of the market turbine. The model turbine differs from the full scale model primarily because of constraints in the test facility. The blades are one main area of differentiation. The blades for the model turbine are optimized for Reynolds numbers of around 50,000, but the design for the market turbine blades are much larger than those of the model. The market turbine blades must be optimized for Reynolds number of 5,000,000 or greater. This optimization results in different twist and taper characteristics than the blades on the model turbine. Also, a shark-fin tip will be added to the blades of the market turbine. The shark fin tip helps to reduce eddy currents and turbulence at tip of the blades, as well as lowering noise levels.

The rotor utilized on the model turbine differs from the market turbine due to testing constraints as well. The model turbine rotor utilizes a rotor from a remote control helicopter and allows for 30 degrees of negative pitch angles. The blade roots for the model turbine had to be adjusted to accommodate the modified helicopter rotor used. This root adjustment gave the blades a more desirable range of pitch. The rotor is designed to have large range of pitch in the negative direction, therefore the blades were twisted negatively at the root to allow a greater range of pitch. The root of the blades on the market turbine will not need to be attached at an angle because the expected rotor will be industry standard. If the model turbine rotor, without blades attached, was directly scaled up to match market turbine dimensions, it would be 12 meters in diameter instead of the typical 3 meters seen in industrial sized machines.

Tower

The tower on the market turbine consists of 3 segments, where as the tower for the model turbine is a single segment. The market turbine tower will be split into 3 segments to assist in project transportation. The tower for the model wind turbine was constructed from a single piece of galvanized steel and has a height of 60cm. Internally, the tower of the model wind turbine has a diameter of 3.65 cm, and an outer diameter of 4.29cm. The base was cut out of steel manufactured to meet the specified mounting pattern and dimensions of the Department of Energy Collegiate Wind Competition. The tower for the market turbine will be a steel tubular tower with a height of 80 meters.

Nacelle

The nacelle design for the market and model turbine are relatively the same, aside from materials. For the market turbine nacelle, fiberglass material will be utilized due to its expected high strength to weight ratio. Fiberglass has young’s modulus of 72 gigapascal. The nacelle of the model wind turbine was constructed using 3D printed PLA plastic material, which has a low young’s modulus value of 46 megapascal. The PLA material utilized in the model turbine does not have quite as high of a strength to weight ratio as the fiberglass, however it serves well as a low cost, easily accessible representation of the fiberglass that will be used for the market turbine. The enclosure is made up of three separate sections; the top section, the bottom section, and the back section. The three sections connect together to enclose the internal systems of the wind turbine. The bottom section of the nacelle mounts to a flange, which connects to the tower and the yaw system. Within the bottom section of the nacelle are brackets for the generator mount, rotor mount, and the yaw gear. A hole was placed in the top of section of the nacelle with a bearing fitted inside to assist the wind vane. The back section of the nacelle is connected to both the top section and the bottom section of the nacelle with a series of pegs. The back section holds the nacelle together by acting as a keystone to keep the enclosure in place.

Safety

In the market turbine tower, OSHA required standards for job safety will be implemented. These standards include, but are not limited to, addressing fall risks for any personnel climbing the turbine. The market turbine will conform to industry standard by implementing a landing every 30 feet. To adhere to the OSHA standards for electrical and mechanical safety, a lock-out tag-out system will be developed to ensure that there is reduced risk of an electrical incident while maintenance is being performed on the turbine. All persons working on the turbine will be required to wear the appropriate Personal Protective Equipment (i.e., hard hat, safety glasses, gloves) before entering the turbine. Furthermore, every person coming into contact with the turbine will receive training on the risks and precautions of working on or in the wind turbine, which will be at the discretion of the contractor hired for maintenance.

5.3 Static Performance Analysis

The open source program Qblade conducts a performance stress analysis on the blades while in operation. Techsan Wind ran an analysis of the model turbine blades to ensure that the materials being used would withstand the pressure forces of the wind. As a result, some parts, such as the servo motors, were replaced with other parts or materials that would be able to operate better under the strain caused during power generation. Once the airfoils are optimized for the market turbine, a stress analysis will be run on the industrial scale blades. Based on the stress analysis, the market blades will be adapted to ensure the turbine's ability to operate under high pressure winds.

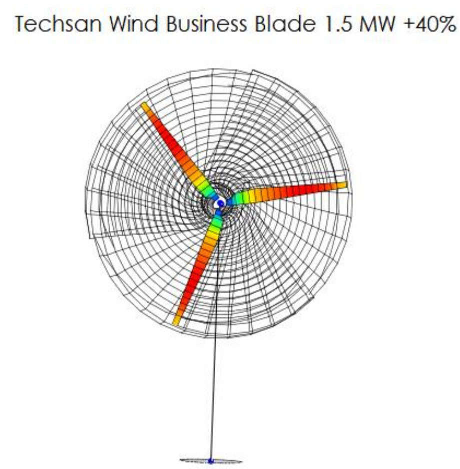
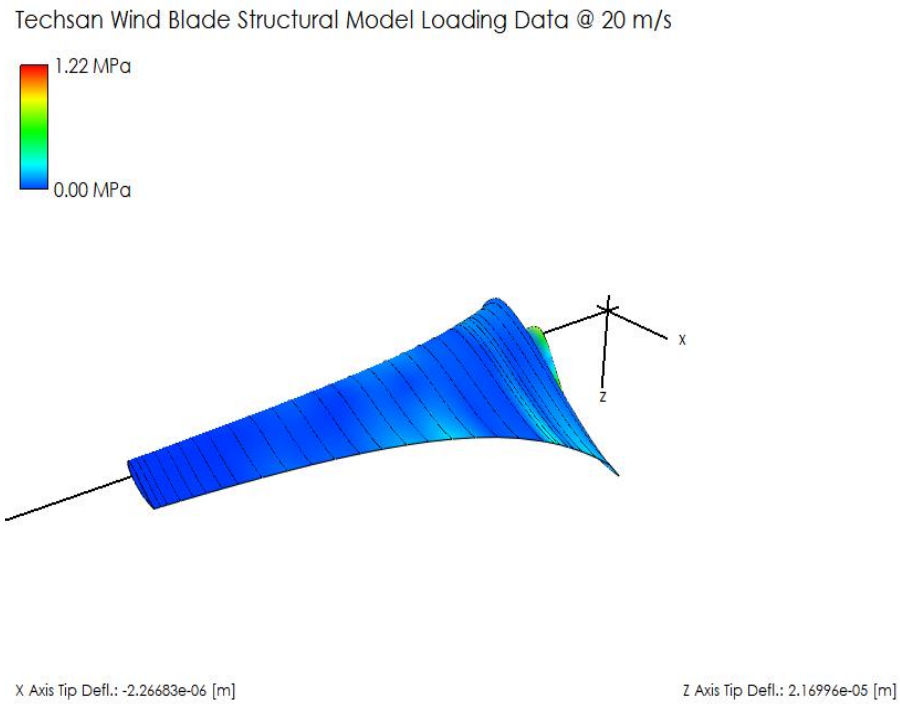
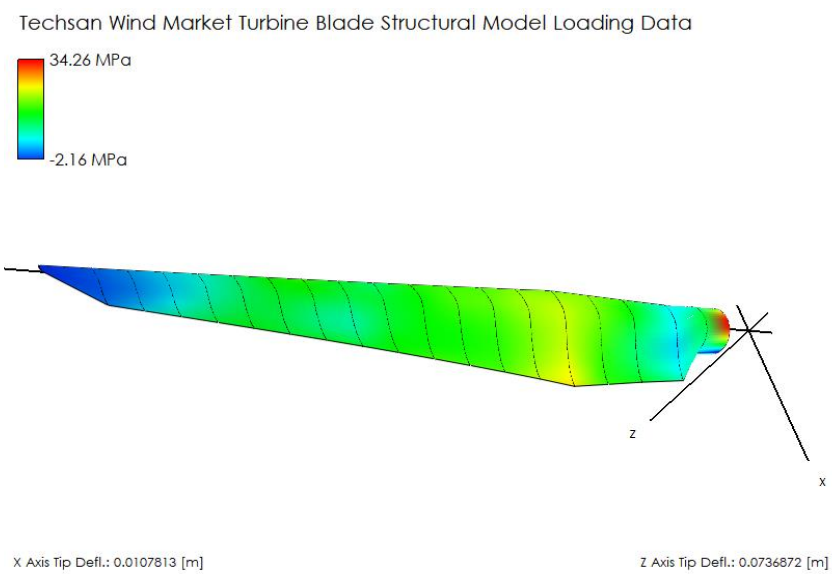


Figure 1: Static Blade Performance

Given the blade material as Carbon Fiber Nylon-X, the properties are a tensile modulus of 6000 megapascal and a density of 1000 kg/m^3. A static blade/loading test was initiated on the model turbine. The normal and tangential loadings were imported from a simulation of our turbine operating at 20 m/s. The test resulted in a tip deflection of -0.0226683 mm in the x-axis and a tip deflection of 0.0216996 mm in the z-axis. The blade experienced a max stress of about 0. 80 megapascal at the root of the blade during the static blade/loading test, while the surface of the blade experiences 0.1 to 0.3 megapascal of stress.





As for the market turbine static blade/loading test, the normal and tangential loadings were imported from a simulation of the market turbine running at rated power (16.3 RPM). The material properties of the market blades have an elastic modulus of 73,000 megapascal and its density is 1000 kg/m^3. While running at rated power the blades experienced a tip deflection of 10.7813 mm in the x-direction and a tip deflection of 73.6872 mm in the z-direction. The blade also experienced a maximum stress of 34.26 MPa at the root while the surface of the blade experienced -2.16 MPa to approximately 25 MPa.

5.4 Wiring Diagram

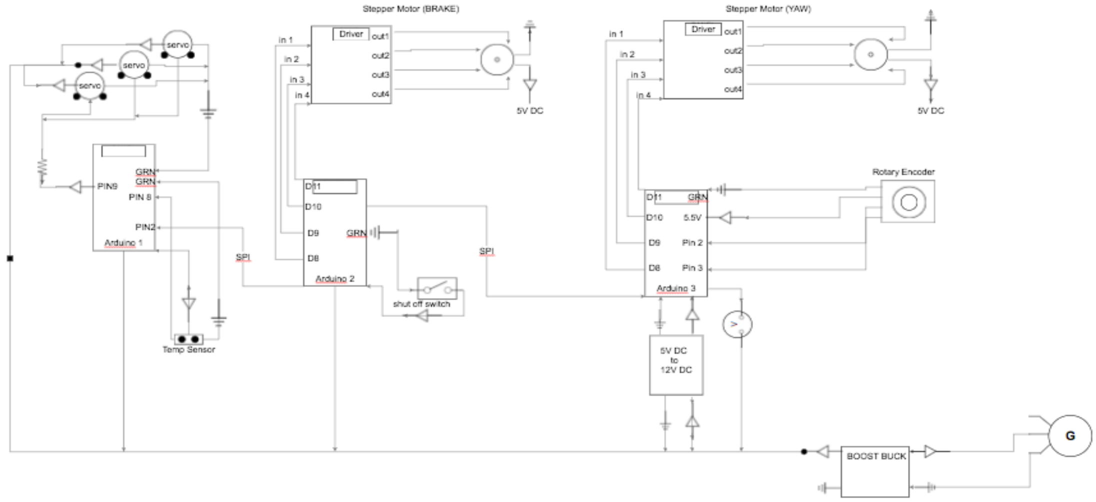


Figure 2: Wiring Diagram

In the diagram above, power is generated at the bottom, marked by the generator, and feeds into a boost buck converter for processing the amount of voltage into a usable amount for all of the electronics. The power then passes from the main line into the Arduino microcontrollers, servos, stepper motors, and a voltage meter. The microcontrollers consume 9 Volts each and will be providing current to a rotary encoder, temperature sensor, and small switch. The microcontrollers will also be sending information back and forth to each other with Serial Peripheral Interface (SPI) communication, and sending commands to the servo and stepper motors to control the break and yaw systems. The two separate stepper motors will consume 12 Volts and 5.5 Volts each. All of this will manage how the wind turbine operates.

5.4.1 Load System & Associated Safety Factors

Model Turbine Load

The load for the model wind turbine aims to closely replicate a variable speed pump. The variable speed pumps will be the primary electric load for the market turbine. At low wind speeds, the generator needs a smaller load. Because the designed turbine's load is resistive and the voltage is constant, the impedance presented to the generator by the load will increase at lower wind speeds. The load resistance acts inversely to the power.

Power = Voltage^2 / Resistance

As wind speeds increase and the power generated by the generator increases, the load resistance will decrease to allow the generator to supply a greater current. Voltage is constant and power has a direct relationship with the current.

Power = Voltage * Current

Market Turbine Load

The load for the market turbine is a ROD system. The main components to the market turbine load are the variable speed pumps in the ROD system. The variable speed pumps move water from the source to the desalination unit, and help push the water through the membranes in the ROD system.

5.4.2 Generator Design

For both the market and model turbines, a dual generator design was selected. Utilizing a small and large generator allows the turbine to cut in much earlier than if only one large generator was used. The small generator on the market turbine outputs 250 kilowatts and the large generator outputs 750 kilowatts. The small generator in the model is a 2500 RPM brushless permanent magnet DC generator (PMDC) which peaks at 120 volts. The small generator features two sealed bearings internally, which helps initiate more steady start-ups. It also has low cogging torque, that allows cut in speeds under 5 meters per second, and powers the control system, which in turn engages the large generator in higher wind conditions. The market turbine's small generator follows the same concept, but has an output of 250 kilowatts. The gears seen in the image to the right illustrates the mechanism, which engages the large generator. The gears do not increase or decrease RPMs, but simply add the rotation of the rotor shaft to the shaft of the large generator located on top of the small generator.

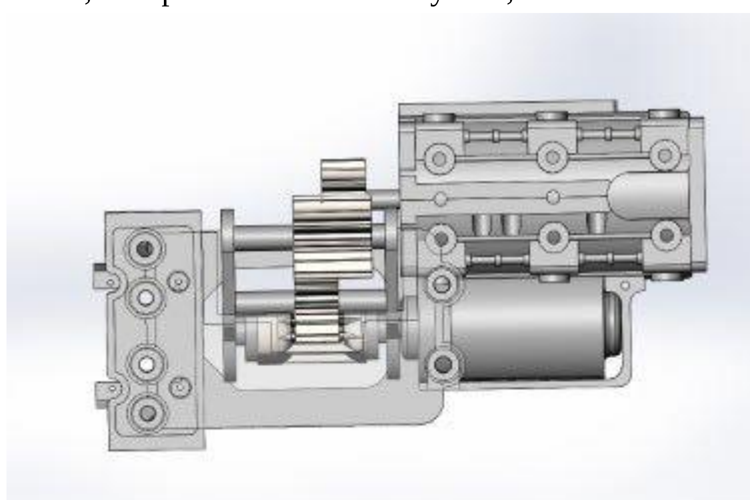


Figure 3: Dual Generator Design

For the large generator, a PMDC was selected because of the low maintenance costs and dependable performance. After testing various PMDC generators, the *Windstream Power* permanent magnet DC generator was selected for the model wind turbine based on the generator's high quality and resistance to overheating. The cogging torque of the generator is 0.0585 Newton-meter (0.043 pound- feet or

0.518 pound-inches), which must be overcome in order to achieve start up. The permanent magnets in the generator are two high-energy C8 ceramic magnets. The steel generator shaft measures at 8mm diameter, 38mm in length, and a 1mm full-length flat. The armature has 12-slots and a 42mm diameter wound with AWG30 wire, which has a fusing current of 10 amps.

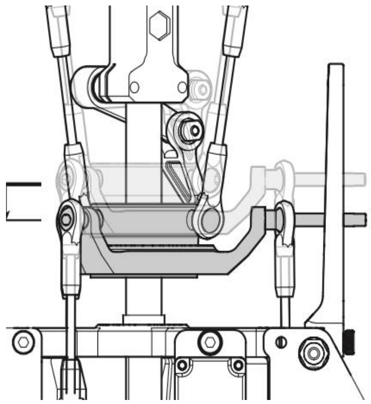
The generator brushes are the main components of the full-scale turbine that will require occasional maintenance. The brushes are low cost and can be easily replaced by removing locking mechanisms. According to market analysis, replacing brushes in a market turbine sized generator costs roughly $1,000 per turbine. By comparison, replacing a gear box for a similar sized machine can cost roughly $250,000.

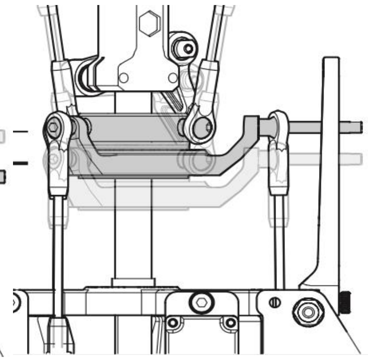
The large generator's bearing systems consist of two double-sealed 26mm OD ball bearings. The rotation speed is zero to 5,000 rpm (84 Hertz) with power being generated at all speeds. The power output is highly dependent on the load applied. For mounting, the generator has four M4 holes on the front and rear end caps. The generator has a weight of 1.5Kg (3.3lb). It has an internal resistance of 21 ohms and an inductance of 40mH. The large generator of the market turbine will consist of a 424 pole PMDC generator, will output 670 volts, and is rated at 750 kilowatts.

Rotor Design

The model turbine's active pitch control uses a direct flybarless control (DFC) rotor head system. This rotor system is a 3-bladed rotor with adjustable pitch, controlled by three separate servo motors and a swashplate that pivots to pitch. The 3-bladed pitching mechanism will closely resemble the full scale turbine with individual pitch. For the market turbine individual pitch motors with battery backup will be used to control blade pitch in island mode. However, on the model turbine, the use of pushrods with the DFC rotor head system was chosen because of wind tunnel space constraints and the small scale of the machine. Illustrated to the right, the collective pitch movement utilized by the rotor system is demonstrated to the full degree angle pitch of zero degrees to 60 degrees. In figure 2, the lower setting for the swashplate indicates the rotor pitch degree is at zero-degree pitch, with the push rods in uniform position for the collective pitch movement. Each pushrod is attached to a ball hitch pivot point on the swash plate for better torqueing from the servos. In figure 3, the higher setting indicates a 60 degree pitched blade setting for maximum lift from the wind to help with cut in speeds. With collective pitch, the swashplate is uniformly moved up and down to pitch the blades to the required degree for rpm correction as needed. Initially, a smaller rotor was considered for preliminary testing. The rotor was made primarily made of plastic instead of aluminum, and operated the same as the current rotor. However, the preliminary rotor was half the size of what was needed for the model. Concerns with forces applied to the rotor led to the aluminum rotor being chosen for stronger pressure points at crucial areas of the rotor. The upgraded aluminum rotor would also better represent that of the market turbine's.

Figure 4: Model Rotor **Figure 4: 0 Degree Pitch** **Figure 5: Full Pitch**





Yaw Design

Both turbine models will utilize an active yaw system. The yaw system on the market turbine will use a much larger and more powerful motor, yet the concept will remain the same as the test turbine. The motor will receive input from a wind vane and align the nacelle with the wind inflow. The motor will drive a gear connected to the bottom of the nacelle and yaw the turbine back into the wind. For the model turbine, active yaw is achieved using a gear mounted at the bottom of the nacelle, a short body Nema 17 bipolar stepper motor, a series of plates with bearings in between, a wind vane, and a rotary encoder. The gear is driven by a stepper motor that receives an input signal from a photovoltaic rotary encoder attached to a wind vane. The direction of the wind will determine how many steps the stepper motor will take to yaw the turbine back into the wind. To assist the motor in turning the nacelle, a bearing system is utilized to ease the stress on the motor and gear system.

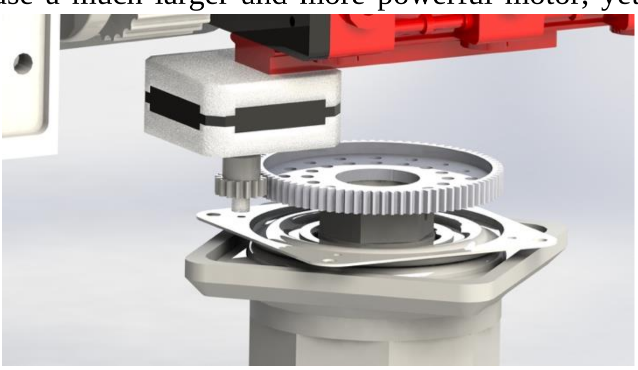


Figure 7: Yaw System Design

5.4.3 Control Systems

The Techsan Wind design is centered on an Arduino microprocessor due to its capabilities and cost effectiveness. The Arduino microprocessor works well with handling multiple inputs while having the ability to change and manipulate outputs quickly and effectively. The model wind turbine will approximately replicate the control system utilized in the market turbine, such as the way the system reacts to the environment or how the pitch is utilized. All of the electrical components of the model turbine will be powered through the turbine generator, while the market turbine has the ability to run off the electrical grid. Obtaining and handling current measurements, RPM feedback, voltage measurements, and temperature monitoring will slightly differ in the size, accuracy, and power needed to run the machine. However, the main ideas of the model and market turbine are the same.

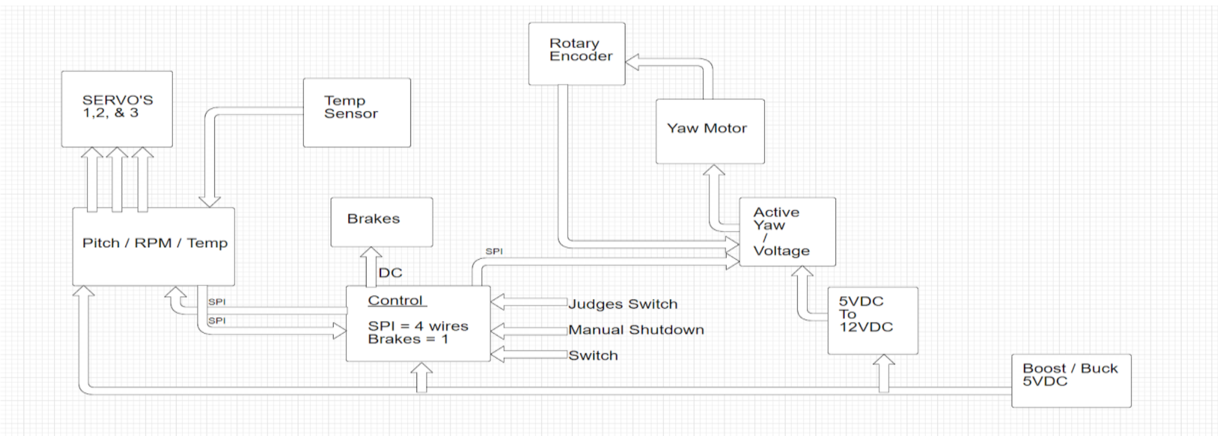


Figure 8: Control System Diagram

5.4.4 Aerodynamics

The Techsan Wind market and model turbine designs utilize an active pitch control system to adjust the electrical output of the turbines. Active pitch is a key operating component to the machines. The active pitch assists with increasing the lift forces from the blades, resulting in lower start up speeds. Active pitch also helps to control the power output of the turbine, specifically by inducing drag forces on the blades at wind speeds higher than that of rated power.

Servo Motors

The full scale turbine will use electric motors to pitch the blades. The model machine utilizes servo motors to represent the electric motors used in the market turbine. The three main servos applied to the pitch control system are SG90 9g micro high speed servos, which model the electric pitch motors used in the market turbine. An electric motor was implemented over a hydraulic pitch motor to help with space constraints in the nacelle of the model and consistent operation to match the market turbine pitching motors. The dimensions of the servo motors are as follows: length 0.91 in (23mm), width 0.48 in (12.2 mm), and height 1.14 in (29.0 mm.) The servo motors provide high torque at a low weight ratio, which is needed with the selected rotor. A high torque to low weight ratio is needed in order to physically move the arms of the servos with the blades. A 3-pole motor is used to power the servos, providing the torque needed. With the independent movement from a servo, it is possible to aerodynamically assist the yaw system by creating thrust in the adjacent direction from one blade.

Blade Analysis

Initially, the NACA 0015, the NACA 0012, and the NREL HAWT airfoils were all explored as potential airfoil candidates. The NREL S823 was chosen over the other airfoil choices based on quality performance statistics at low Reynolds numbers, and the lift characteristics at low wind speeds. The NREL S823 airfoil was optimized using QBlade software and in-house codes to meet the needs of the selected generator, optimize cut in speeds, and achieve desired power output. The model turbine performs at 50,000 Reynolds Number, which is at the lower bound than most of the current software calculate.

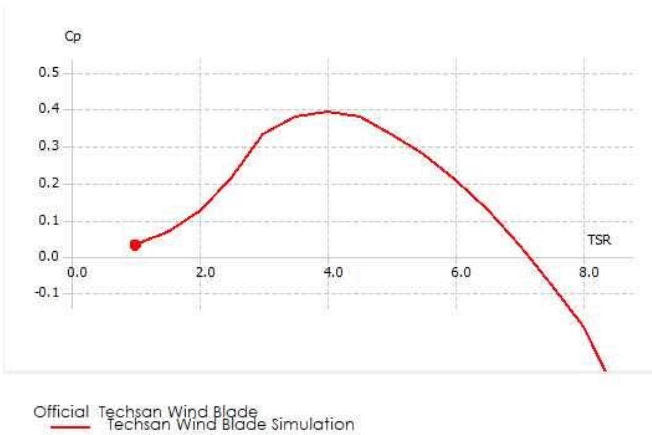


Figure 9: Cp/TSR Curve for Blade

Techsan Wind's Aerodynamic Engineers used Qblade to design blade geometry with the selected airfoil. Qblade runs a stress and performance analysis for expected generation of the rotor under a variety of wind and turbulence conditions. For the market turbine, the blades are relatively large, but Q-blade will be used to optimize the blades at Reynolds number of 5,500,000 for industrial design and production of the full sized machine. The Market turbine will have a Tip Speed Ratio (TSR) of 4-4.5 at rated power, which is much lower than the industry standard of 7 TSR. A lower TSR means the turbine will run

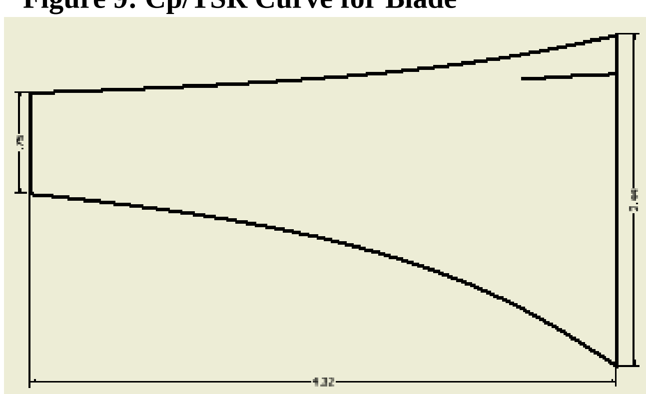


Figure 10: NREL S823 Model Blade Drawing

slower, therefore quieter. A shark-fin tip will also be added on the market turbine blades to reduce eddy currents, turbulence at the outside edge of the rotor and aeronautic noise due to turbulent winds. The small scale blades had to be adjusted to accommodate the modified helicopter rotor so that the blades would have full range of pitch. The rotor was designed to have large range of negative pitch; therefore, the blades were twisted negatively at the root to allow positive use of that range.

In the first phase of testing, the blades designed using Q-Blade did not perform as expected. A Start-Up Torque Analysis was developed to understand how to to overcome the rotational resistance created in the generator. The Start-Up Torque Analysis program made it possible to mathematically analyze the relationship between rotation of the blade in respect to the specified generator. The information was used to amend the blades further to increase lift and torque per rotations of the blade, thus leading to lower cut in speeds. These new blades are 1.5cm longer and wider at the base where the blades attach to the rotor. Testing results of the new blades show a 30% reduction in cut in speed.

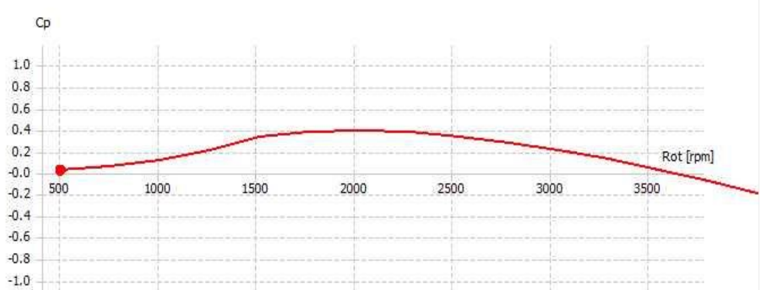


Figure 11: Cp/RPM Curve

The blades will utilize a textured film to help reduce drag and increase lift. The textured film is a new technology developed by Dr. Burak Aksak at Texas Tech University, Dr. Chamorro at the University of Illinois Urbana-Champaign, and Dr. Castillo at Purdue University. Dr. Aksak's study, published in Proceedings of the National Academy of the Sciences (PNAS), showed that the film can significantly reduce drag by delaying boundary layer separation and shrinking the size of the separation bubble. On the market and model wind turbines, the film will be applied to the airfoils and is expected to reduce drag by up to 30% and increase lift by up to 40%. During Techsan Wind's initial manufacturing phase, an original blade will be designed, printed, and have the texture film is applied, to create a master mold. The remainder of the blades can be coated with the textured film using this mold. The mold feature is cost effective and feasible for the full scale wind turbine because most of the cost incurred by coating the blades will be in coating the initial blade to generate the master mold.

5.5 Preliminary Testing Results

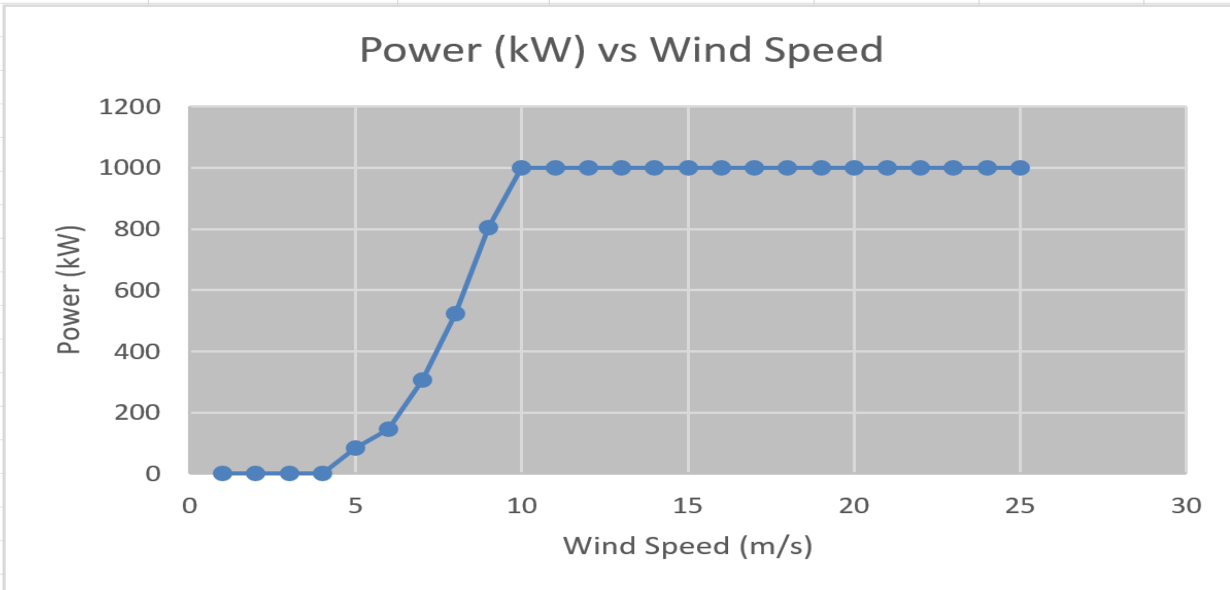
During initial testing stages, a single generator design was utilized for the model turbine. The cut in wind speed of the model turbine was 8 meters per second. A cut in speed of 8 meters per second is higher than acceptable, the airfoil was reworked in an attempt to generate better lift forces, and thus, lower the cut in speed. The airfoil was given a higher degree of twist, and the root was attached at an angle to allow for 30 more degrees of pitch. After airfoil modifications were made, a cut in speed of 7 meters per second was achieved. The airfoil adjustments succeeded in generating more lift, yet the cut in speed was still higher than desired. To lower cut in speeds even farther, a second, smaller generator was applied to the machine. The smaller generator has half the cogging torque of the larger generator. Starting the small generator has a cut in wind speed of approximately 4.5 meters per second. The small generator continues to generate power for the remainder of time the turbine is running. Once the small generator reaches 1160 rpms, the large generator engages and adds power production.

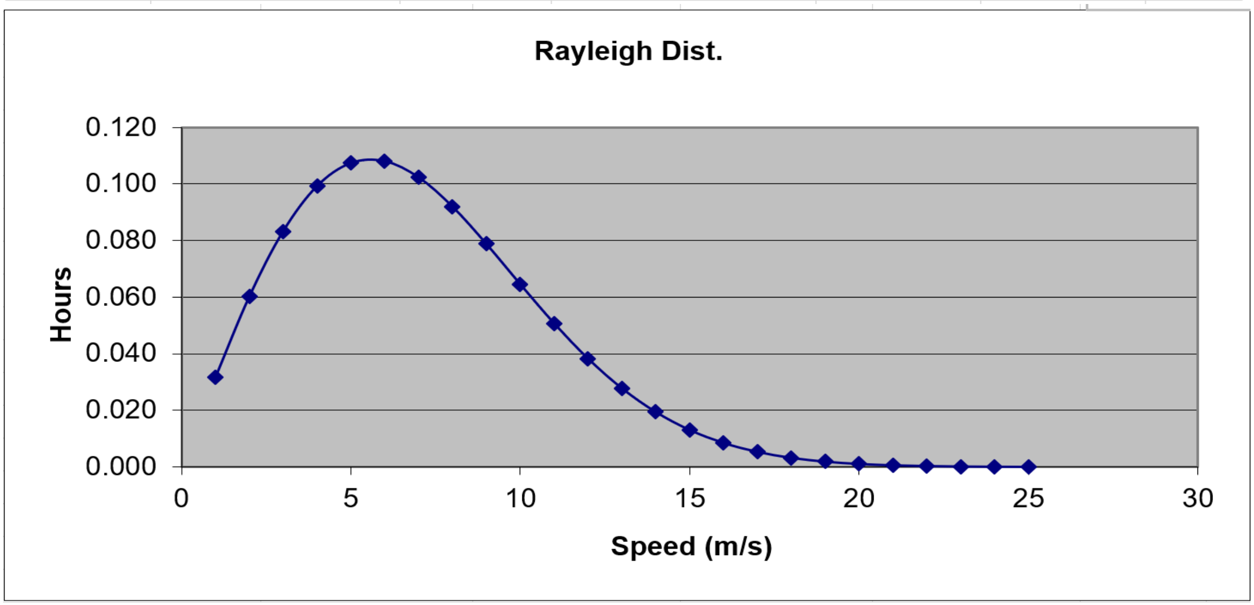
<u>8. Appendix</u>

Cash Flow Statement													Year 1
Month	January	February	March	April	May	June	July	August	September	October	November	December	Year End
Number of Sales	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	365,200.00
Cash value of Sales	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$1,731,067.43
PTC Monthly Credit	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$336,384.00
REC Monthly Income	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$35,040.00
Operational Cost	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$177,408.00
Net Cash Flow of Operations	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$1,925,083.43
Labor	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$360,000.00
R&D	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$15,000.00
Current Debt Total	$5,187,841.27	$5,410,910.00	$5,282,260.00	$5,153,610.00	$5,024,960.00	$4,896,310.00	$4,767,660.00	$4,639,010.00	$4,510,360.00	$4,381,710.00	$4,253,060.00	$4,124,410.00	
Interest	$351,718.73	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$351,718.73
Debt Repayment	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$1,543,800.00
New Debt Total	$5,410,910.00	$5,282,260.00	$5,153,610.00	$5,024,960.00	$4,896,310.00	$4,767,660.00	$4,639,010.00	$4,510,360.00	$4,381,710.00	$4,253,060.00	$4,124,410.00	$3,995,760.00	
Net Profit	$523.62	$523.62	$523.62	$523.62	$523.62	$523.62	$523.62	$523.62	$523.62	$523.62	$523.62	$523.62	$6,283.43

Cash Flow Statement													Year 3
Month	January	February	March	April	May	June	July	August	September	October	November	December	Year End
Number of Sales	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	365,200.00
Cash value of Sales	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$1,731,067.43
PTC Monthly Credit	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$336,384.00
REC Monthly Income	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$35,040.00
Operational Cost	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$177,408.00
Net Cash Flow of Operations	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$1,925,083.43
Labor	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$360,000.00
R&D	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$15,000.00
Current Debt Total	$2,990,844.54	$3,487,193.46	$3,358,543.46	$3,229,893.46	$3,101,243.46	$2,972,593.46	$2,843,943.46	$2,715,293.46	$2,586,643.46	$2,457,993.46	$2,329,343.46	$2,200,693.46	
Interest	$624,998.92	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$624,998.92
Debt Repayment	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$1,543,800.00
New Debt Total	$3,487,193.46	$3,358,543.46	$3,229,893.46	$3,101,243.46	$2,972,593.46	$2,843,943.46	$2,715,293.46	$2,586,643.46	$2,457,993.46	$2,329,343.46	$2,200,693.46	$2,072,043.46	
Net Profit	$523.62	$523.62	$523.62	$523.62	$523.62	$523.62	$523.62	$523.62	$523.62	$523.62	$523.62	$523.62	$6,283.43

Cash Flow Statement													Year 5
Month	January	February	March	April	May	June	July	August	September	October	November	December	Year End
Number of Sales	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	30,433.33	365,200.00
Cash value of Sales	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$144,255.62	$1,731,067.43
PTC Monthly Credit	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$28,032.00	$336,384.00
REC Monthly Income	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$2,920.00	$35,040.00
Operational Cost	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$14,784.00	$177,408.00
Net Cash Flow of Operations	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$160,423.62	$1,925,083.43
Labor	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$360,000.00
R&D	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$1,250.00	$15,000.00
Current Debt Total	$1,124,818.96	$1,414,621.25	$1,285,971.25	$1,157,321.25	$1,028,671.25	$900,021.25	$771,371.25	$642,721.25	$514,071.25	$385,421.25	$256,771.25	$128,121.25	
Interest	$418,452.28	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$418,452.28
Debt Repayment	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$128,650.00	$1,543,800.00
New Debt Total	$1,414,621.25	$1,285,971.25	$1,157,321.25	$1,028,671.25	$900,021.25	$771,371.25	$642,721.25	$514,071.25	$385,421.25	$256,771.25	$128,121.25	-$528.75	
Net Profit	$523.62	$523.62	$523.62	$523.62	$523.62	$523.62	$523.62	$523.62	$523.62	$523.62	$523.62	$1,052.37	$6,812.19





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