PROJECT ONE: MILESTONE 1 – COVER PAGE

Team Number: 26

Please list full names and MacID's of all *present* Team Members

Full Name:	MacID:
khane16	khane16
Sophia Workun	workus1
Sana Khan	khans288
Jackson Lippert	Lippertj
Emilia Pisic	pisice

MILESTONE 1 (STAGE 0) – PRE-PROJECT RESEARCH MEMO

Team Number: 26

You should have already completed this task individually prior to Design Studio 3.

1. Copy-and-paste each team member's pre-project research memo on the following pages (1 team member per page)
   → Be sure to indicate each team member's Name and MacID

We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

- Each team member needs to submit their Pre-Project Research Memo with the **Milestone One Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone One Team Worksheets** document allows you to readily access your team member's work
  - This will be especially helpful when completing ***Stage 1*** of the milestone

Team Number: 26

Please list Team Member that is submitting the memo.

Full Name: Sana Khan	MacID: khans288

Introduction:

Wind turbines are a renewable energy source widely used around the world. They take wind energy and convert it to electrical energy through the use of aerodynamic force. Modern wind turbines have been very reliable and cost effective [1]. They have become larger in size over the last few decades, allowing them to be more efficient and produce a larger quantity of energy. They are designing lighter, sturdier, and performance optimizing parts for wind turbines through advanced technology and research while continuing to improve materials, location, and structure of the turbines [5].

Design factors:

There are many factors that need to be considered when engineering wind turbines. The location of the generator should be closer to the ground allowing there to be easy access to service [2]. Some generators have been built at the top causing many issues with servicing [2]. Many companies producing wind turbines have built them out of steel due to their sturdiness to withstand strong winds as well as their strength to hold the blades in place [4]. However, this may not be the ultimate choice of material for blades. Many companies are looking into using different composites such as carbon-fiber and glass-fiber for the blades [7]. They are temperature-moisture resistant (meaning that they won't corrode and get ruined in moisture or humidity) and provide improved fatigue resistance. Furthermore, this material provides high stiffness and low density and is cost effective which is good for budgeting [7]. Obviously, for the turbine to generate energy it needs large amounts of wind which is why it is built very high up. However, the structure cannot be compromised and needs to be built more thicker and stronger to prevent swaying and movement during strong winds and storms [2]. Wind turbines should contain some braking system where the blades stop spinning just in case winds get too strong to prevent breaking/bending of the blades or over working the generator and causing electrical issues [2]. The location of the wind turbine is very important. Many factors need to be considered such as the weather patterns of the area (snowy, rainy, stormy). This branches off into considering what material should be used to keep the turbines lasting for a long time. For example, using the right metal to construct base and blades so that they don't corrode in rainy/snowy weather or using sturdy metal that won't bend or sway in strong winds. Wind patterns (direction of wind) needs to be considered as well to understand whether or not the wind turbines will thrive in that area. So, if wind only blows north east, positioning the turbine at an angle where the wind optimizes the turning of the blades. In terms of design, there should be three blades because they help keep the angular momentum constant so that the blades can rotate smoothly [3]. They should be constructed thinly to prevent drag and in a curved shape to allow better access for air flow and performance. So, when 1 blade is up 2 are down to promote momentum to keep the blades spinning. Narrow blades give good torque from the wide part of the blade and reduces drag at the fast-moving tip to be able to maximize efficiency and produce the most energy by converting larger than 40% of the wind energy to electricity [6]. Overall there are many designs, structural, and location factors that need to be taken into consideration when trying to make energy efficient, low cost wind turbines that provide a large amount of energy for society.

Copy the references below (use IEEE format)

[1] "How Do Wind Turbines Work?" Energy Efficiency & Renewable Energy [Online]. Available: https://www.energy.gov/eere/wind/how-do-wind-turbines-work. [Accessed: September 26, 2020]

[2] K. Miller-Wilson, “Design of a Wind Turbine.” lovetoknow [Online]. Available: https://greenliving.lovetoknow.com/Design_of_a_Wind_Turbine. [Accessed: September 26, 2020]

[3]. L. Villazon, “Why do wind turbines have three blades?” Science Focus: The Home of BBC Science Focus Magazine [Online]. Available: https://www.sciencefocus.com/science/why-do-wind-turbines-have-three-blades/. [Accessed: September 26, 2020]

[4] M. Froese, “How are blade materials and manufacturing changing to keep up with larger turbines.” Windpower Engineering & Development [Online]. Available: https://www.windpowerengineering.com/blade-materials-manufacturing-changing-
keep-larger-turbines/. [Accessed: September 26, 2020]

[5] “Next-Generation Wind Technology.” Energy Efficiency & Renewable Energy [Online].
Available: https://www.energy.gov/eere/next-generation-wind-

technology#:~:text=Modern%20wind%20turbines%20are%20increasingly,averaging%202.15%20MW%20of%20capacity [Accessed: September 26, 2020]

[6] “Wind Turbine Blade Design, Flat or Curved.” Alternative Energy Tutorials [Online]. Available: https://www.alternative-energy-tutorials.com/energy-articles/wind-turbine-blade-design.html [Accessed: September 26, 2020]

[7] Z. Khaled, Z. Soraya, and Z. Adel. *Fatigue strength prediction in composite materials of wind turbine blades under dry-wet conditions: An artificial neural network approach.*
Sage Publications, Ltd., 2016

Team Number: 26

Please list Team Member that is submitting the memo.

Full Name: Jackson Lippert	MacID: lippertj

Copy-and-paste the pre-project research memo for one team member in the space below

Introduction:

Technologies involving wind energy have advanced significantly over the years, and the push for a greener world and power sources has made this growth possible. The technology has been optimized to cost less, as the price of building a wind turbine has decreased 69 percent since 2009 [1]. The future of wind turbine technology is looking very promising in Canada, with the goal of making 20% of our power generation come from wind by 2025 [2]. This is a huge deal for the green energy sector, as they have proven that wind energy can be an efficient, cheap, and sustainable method of producing power. Most wind turbines are now equipped with a variety of sensors for detecting things such as vibration, humidity and temperature [3], which are extremely useful for collecting data integral to analyzing weather patterns. One of the latest issues that engineers have had to work on is the transmission of the data, collected by the turbines, to a central data hub. This problem is being solved by using private 4G LTE networks, which have the bandwidth and speed necessary to handle the amount of data that must be transmitted [3]. In summary, wind power technology is only getting better, and will most likely be a leading source of energy in the push for a greener world.

Design factors:

There are many design factors to consider when constructing and designing a wind turbine. Possibly the most important is the ability to resist extreme conditions, which may be caused by natural disasters such as hurricanes [4]. Huge forces act on the wind turbine, making it very important to design a structure for the entire turbine that can withstand such strong forces. In addition to the extreme conditions, wind turbines are subject to sustained force caused by the constant force of small gusts of wind. To counteract this, many turbines cannot be made of metal because they will experience metal fatigue, which causes them to crack and catastrophically fail [4]. Due to this fact, the blades of large turbines must be made of different, more flexible alternatives, while still maintaining structural integrity [5]. The shape of the rotor blades must also be optimized to be as efficient as possible, thus, many rotor blades are shaped to produce the greatest lift force while simultaneously producing the least drag force [6]. The design of wind turbines has been optimized over many years, which has resulted in the extremely efficient turbines we have today.

Copy the references below (use IEEE format)

[1] "National Wind Markets," canwea [online]. Available: https://canwea.ca/wind-energy/national/ [Accessed: September 23, 2020]

[2] "Windvision 2025," canwea [online]. Available: https://canwea.ca/pdf/windvision/Windvision_summary_e.pdf [Accessed: September 23, 2020]

[3] "How digitalization and private wireless are increasing wind farm safety and productivity," Windpower Engineering & Development [online]. https://www.windpowerengineering.com/how-digitalization-

and-private-wireless-are-increasing-wind-farm-safety-and-productivity/ [Accessed: September 23, 2020]

[4] "Wind Turbine Design: Basic Load Considerations," Danish Wind Industry Association [online]. http://ele.aut.ac.ir/~wind/en/tour/design/index.htm#:~:text=To%20limit%20the%20influence%20of,the%20turbines%20rotate%20relatively%20quickly. [Accessed: September 23, 2020]

[5] J. Zangenberg, P. Brøndsted, "Wind Turbine Design," ScienceDirect [online]. https://www.sciencedirect.com/topics/engineering/wind-turbine-design [Accessed: September 23, 2020]

[6] M. Jenkins, "Wind Turbine Blade Design Optimization with SimScale," SinScale [online]. https://www.simscale.com/blog/2019/09/wind-turbine-blade-design/#:~:text=Wind%20turbine%20blades%20generate%20lift,of%20the%20blade%2Dshaped%20aerofoil. [Accessed: September 23, 2020]

Team Number: 26

Please list Team Member that is submitting the memo.

Full Name: Ehsaan Khan	MacID: khane16

Copy-and-paste the pre-project research memo for one team member in the space below

There are many sources of energy that we use today. Their makeup, design, structure, effectiveness, cost and impact on the earth varies greatly. There are some that are non-renewable and others renewable. Renewable energy sources are those whose supply is naturally replenishing and much better for the earth than non-renewable ones. These include solar, hydro, biomass, and wind. Wind energy is one of the main sources. It is one of the fastest growing methods of electricity generation in the whole world. Wind energy uses the wind to convert kinetic energy into electrical energy. It is produced using devices called 'wind turbines.[1] They can be individually or more commonly in large groups called 'wind plants' or 'wind farms.'[1] Wind turbines function best in favourable weather conditions, windy conditions. Wind turbines require no fuel and don't produce greenhouse gases or pollution.

However, with all other energy sources, there are drawbacks and problems. Structural problems are the main one. Design and structure of a wind turbine is everything. It defines how well it works, how long it lasts, how much electricity it can produce, if it breaks apart and how, and everything about the turbine. Wind turbines have a propellor-like blade that spins around a rotor which spins a generator, creating electricity. More wind results in more spinning of the blade. There are two main types of wind turbines: Vertical-Axis and Horizontal-Axis.[2] Horizontal ones are the ones we normally picture, and they generally need to face the wind. Vertical turbines are omnidirectional and don't need to point at the wind.

The most important part of the turbine, without doubt is the blade. So, its structure and design are by extension the most important. [2] The blade needs to be both strong and sturdy but also flexible enough to turn well. Whether it should be flat or curved has long been a question for concern. Both have their benefits and drawbacks. Flats are cheaper and easier to build and assemble. They also face the wend completely square and do experience a lot of stress and that can result in accidents. Curved blades are like airplane wings and use the wind to produce lift to help it rotate. [3] This allows this type of blade to move faster thus producing more electricity. However, they do face lots of drag as well.

This is one of the many design factors that must be considered in wind turbine blade design and manufacturing, the better these answers can be, the closer we will be to completely renewable energy dependent.[4]

Copy the references below (use IEEE format)

[1] N. R. Canada, "Government of Canada," *Natural Resources Canada*, 02-Mar-2020. [Online]. Available: https://www.nrcan.gc.ca/energy/energy-sources-distribution/renewables/wind-energy/7299. [Accessed: 27-Sept-2020].

[2] "How Do Wind Turbines Work?," *Energy.gov*. [Online]. Available: https://www.energy.gov/eere/wind/how-do-wind-turbines-work. [Accessed: 28-Sept-2020].

[3] “Wind Turbine Design,” *Wind Turbine Design - an overview | ScienceDirect Topics*. [Online]. Available: https://www.sciencedirect.com/topics/engineering/wind-turbine-design. [Accessed: 28-Sept-2020].

[4] Alternative Energy Tutorials, “Wind Turbine Blade Design, Flat or Curved Blades,” *Alternative Energy Tutorials*, 08-Feb-2020. [Online]. Available: https://www.alternative-energy-tutorials.com/energy-articles/wind-turbine-blade-design.html. [Accessed: 28-Sept-2020].

Team Number: 26

Please list Team Member that is submitting the memo.

Full Name: Sophia Workun	MacID: workus1

Copy-and-paste the pre-project research memo for one team member in the space below

For the past decades, the design of wind turbines has greatly evolved. Since the very first installment of the turbine, scientists and engineers are still improving their designs to create the most efficient and effective wind turbines. The focus towards the design factors has now shifted towards engineering the most reliable turbine with the lowest cost possible. However, due to outstanding factors such as the geographical locations of the turbines, technology to create the optimal wind turbine is difficult. [1] It is impossible to design a wind turbine that will fit in every location and attempting to do so is uneconomic. Each wind turbine requires its own manipulation to the design as well as additional adaptive features to make sure it is successful in its placement. Some adaptive features include larger rotors, additional structural reinforcement, and uprated generators.[1] In order to modify these turbines to achieve optimal results, it is important to understand the design concepts of wind turbines.

Design Factors

There exist two types of wind turbines: horizontal axis wind turbines (HAWT) and vertical axis wind turbines (VAWT). When considering large scale energy generation, HAWT are more likely to be used since VAWT are either immense and expensive or the amount of energy captured is significantly less compared to HAWT [1]. The turbines consist of a rotor, controls, speed increaser, conversion system, and a tower. The rotor outputs rotational kinetic energy that can be converted into mechanical, electrical, or thermal energy. [2] In order to generate electricity, the rotor must be attached to an electric generator.[1] The amount of energy being produced by the turbine depends on the generator size, rotor area/wind map, and the average annual wind speed.[2]

The blades are the part of the turbine that utilizes the energy produced by the wind. The optimal blade is thin, yet capable enough to keep the structural integrity as well as maintain a long life expectancy.[3] The speed at which the blades are set to rotate are calculated so that they do not pass the wind (speed is too slow) or deflect it (speed is too fast). This is called the Tip Speed Ratio.[3] In addition to the speed, the pitch (the angle of the blade) affects the amount of wind energy captured. A blade has three ways in which it can be arranged: nonuniform platform, twist along the blade, and variable or fixed pitch. [2] Often times, using a variable pitch control increases the efficiency of the turbine. With the variable pitch control, the pitch is adjusted so that the power co-efficient is equal to the maximum achievable power co-efficient while preserving a constant tip speed ratio. [3] These main factors as well as other smaller design components must all be considered when constructing a successful wind turbine.

Copy the references below (use IEEE format)

IEEE References

[1] Peter Jamieson, Innovation in Wind Turbine Design. John Wiley & Sons, Incorporated, 2011

[2] Vaughn Nelson, Kenneth Starcher, Wind Energy: Renewable Energy and the Environment. Boca Raton: CRC Press, 2018

[3] “Blades (wind turbine) Selection Guide”, Engineering360. Available:https://www.globalspec.com/learnmore/electrical_electronic_components/power_generation_storage/alternative_power_generators/blades_wind_turbine [Accessed: Sep. 25, 2020]

*If you are in a team of 5, please copy and paste the above on a new page

Team Number: 26

Please list Team Member that is submitting the memo.

Full Name: Emilia Pisic	MacID: pisice

Copy-and-paste the pre-project research memo for one team member in the space below

Wind turbines are a source of renewable energy used widely across the world today. There are many design factors that are implemented in wind turbines to improve their efficiency and maximize energy production. [1]

Design Factors:

Wind turbines are designed to transform the wind's kinetic energy into mechanical energy. As the wind blows past, the blades begin to rotate which turns an internal shaft. The gearbox connects the low-speed shaft to the highspeed shaft to increase the rotations per minute (rpm). The low speed shaft will turn at about 30-60rpm which the gearbox turns to 1000-1800rpm. At this high rotational speed, the generator will be able to produce electricity.[1]

Wind direction and wind speed are two important factors when it comes to the design of a wind turbine. Wind measurements are collected by an anemometer. The data is then transferred to the control which will direct the turbine to face the strongest wind with an optimized angle of the blades. [2] Inside a wind turbine there is a pitch system that ensure the rotor does not turn in winds to high or too low to produce electricity. [3]

The blades have a specific shape to maximize efficiency. The blades have a "Planform Shape" which gets narrower towards the tip to maintain a constant slowing effect. This ensures that the wind will not leave the turbine too slowly, causing turbulence, or too fast, causing wasted energy. [4]

The apparent angle of the wind changes along the blade. The tip of the blade has a greater apparent wind angle, as it moves faster though the air. There is an optimized angle of attack which would generate the maximum lift. To maintain the optimized angle, the blade is twisted further at the tips than the root. The curved side of the blade generates low air pressures, while high pressure air pushes on the other side, resulting in a lift force. Due to the lift, drag and gravitational forces acting on the blade there are many opportunities for the blade to bend. To prevent bending, the blade is thicker towards the root. [5]

Overall, the design of the wind turbine is constantly being improved to maximize the turbines efficiency and ensure most of the kinetic energy of the wind is being converted to mechanical energy.

Copy the references below (use IEEE format)

References

[1] "Basics of Wind Energy," *AWEA*. [Online]. Available: https://www.awea.org/wind101/basics-of wind-energy. [Accessed: 29-Sep-2020].

[2] P. J. Schubel and R. J. Crossley, "Wind Turbine Blade Design," *MDPI*, 06-Sep-2012. [Online]. Available: https://www.mdpi.com/1996-1073/5/9/3425/htm. [Accessed: 29-Sep-2020].

[3] “How Does a Wind Turbine Work?,” *Energy.gov*. [Online]. Available: https://www.energy.gov/maps/how-does-wind-turbine-work. [Accessed: 29-Sep-2020].

[4] Alternative Energy Tutorials, “Wind Turbine Blade Design, Flat or Curved Blades,” *Alternative Energy Tutorials*, 08-Feb-2020. [Online]. Available: https://www.alternative-energy tutorials.com/energy-articles/wind-turbine-blade-design.html. [Accessed: 29-Sep-2020].

[5] “Wind Turbine Blade Aerodynamics - Kimerius Aircraft.” [Online]. Available: https://www.kimerius.com/app/download/5784129509/Windturbinebladeaerodynamics.pdf. [Accessed: 29-Sep-2020].

MILESTONE 1 (STAGE 1) – INITIAL PROBLEM STATEMENT

Team Number: 26

Stage 1: Initial Problem Statement:

What is your first draft of the problem statement? Keep it brief and to the point. One or two sentences should be enough. **For initial problem statement you should be focusing on main function(s) of wind turbine.**

The objective of this project is to create the ideal wind turbine. In order to achieve this, the design must be cost-effective and must maximize the efficiency of a turbine. The design should harvest the most amount of energy from the wind with optimal angles, materials, and motor functions given the environmental factors.

MILESTONE 1 (STAGE 3) – REFINED OBJECTIVE TREES

Team Number: 26

For each engineering scenario, you will be submitting a modified/revised objective tree agreed upon by the group. Each branch of objective trees should have a minimum of 3 layers. This can be hand-drawn or done on a computer.

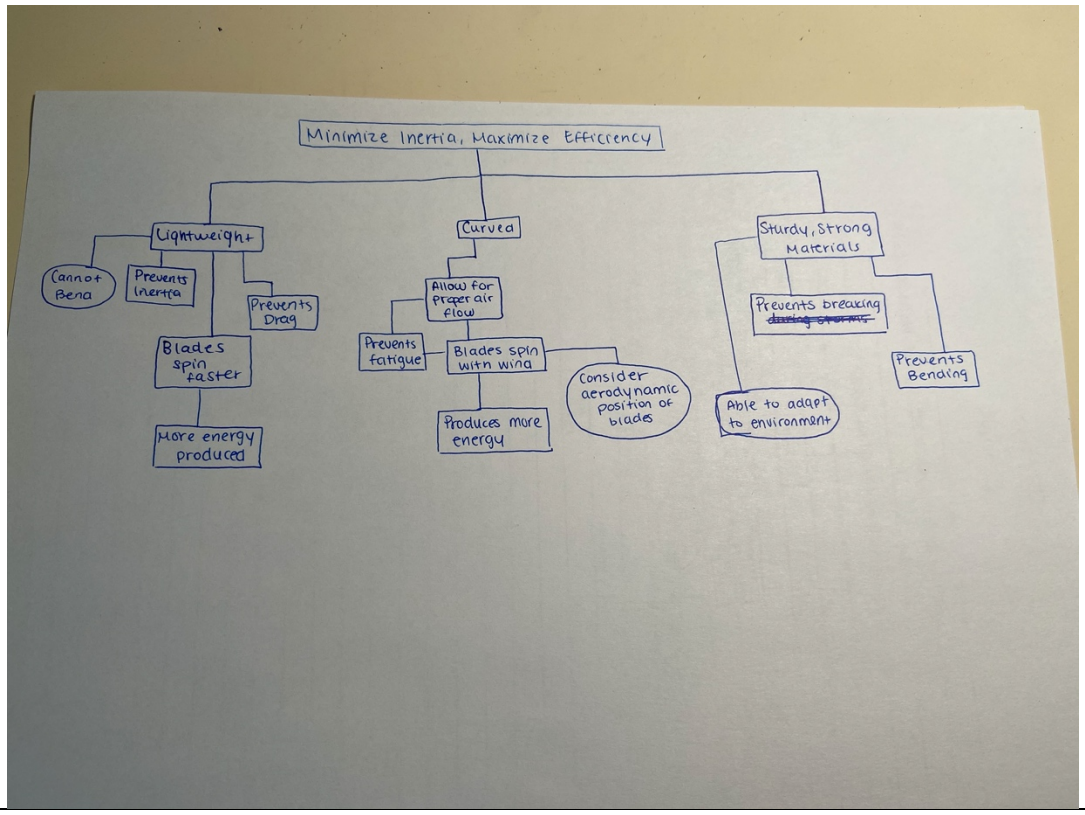
Engineering Scenario #1

The title of the scenario

Renewable Energy for a Large Population

Team objective tree diagram for scenario #1

Please have a copy of refined and finalized team objective tree for scenario #1.



Team Number: 26

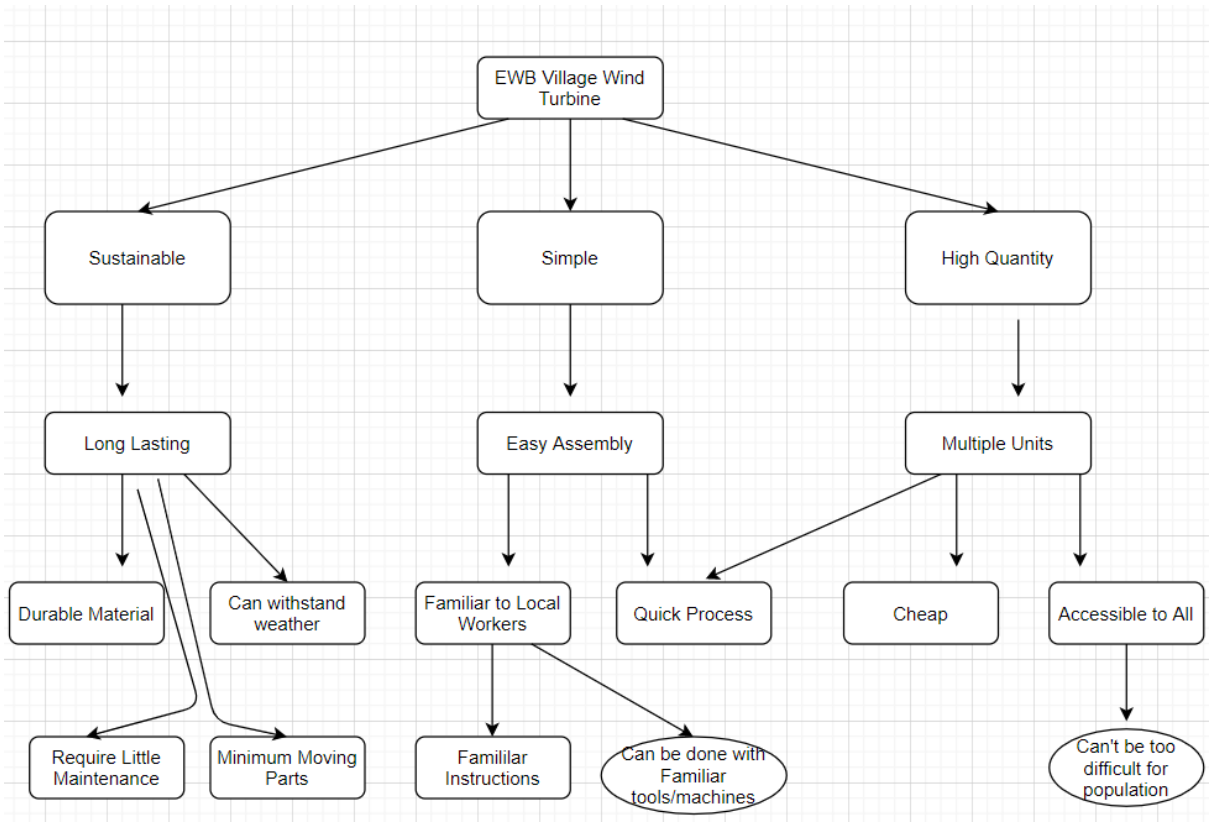
Engineering Scenario #2

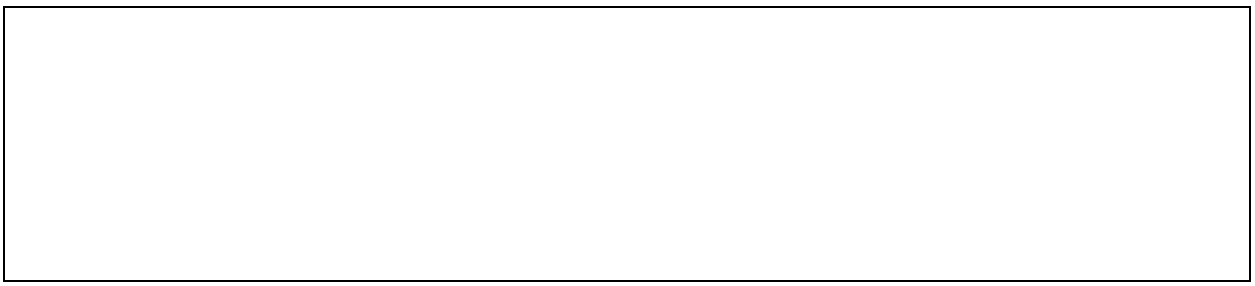
The title of the scenario

EWB Humanitarian Aid Mission
Ehsaan Khan

Team objective tree diagram for scenario #2

Please have a copy of refined and finalized team objective tree for scenario #2.





Team Number: 26

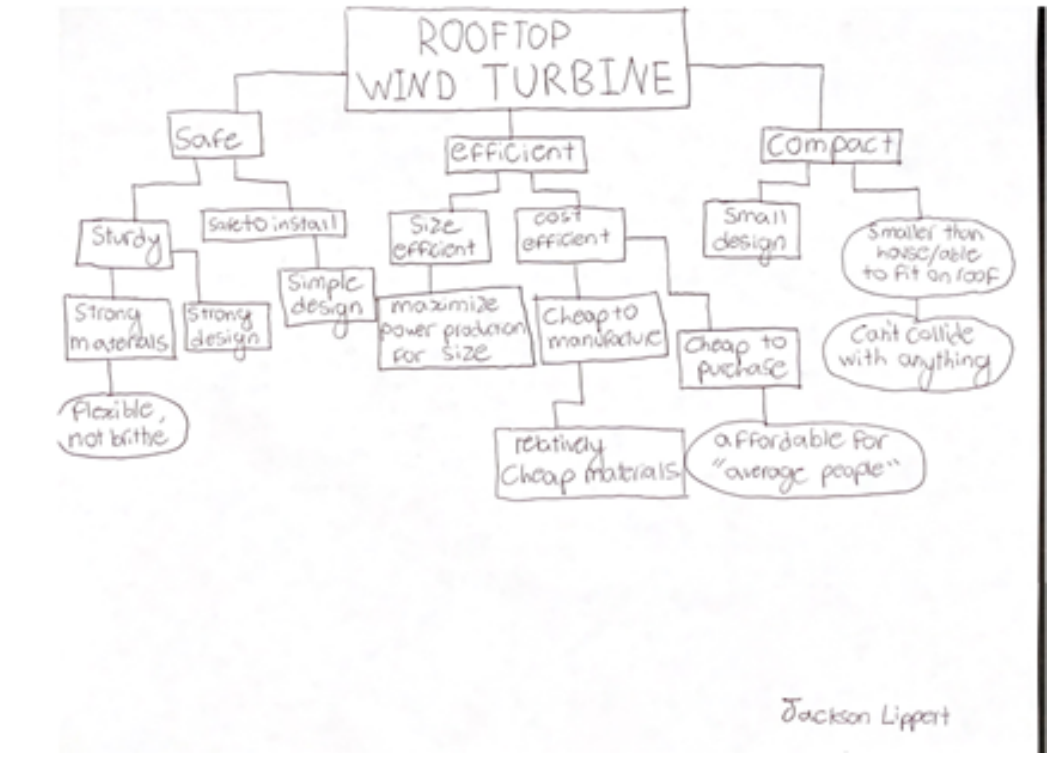
Engineering Scenario #3

The title of the scenario

Residential Rooftop Wind Turbines

Team objective tree diagram for scenario #3

Please have a copy of refined and finalized team objective tree for scenario #3.



Team Number: 26

Engineering Scenario #4

The title of the scenario

A Pioneer in Wind Energy

Team objective tree diagram for scenario #4

Please have a copy of refined and finalized team objective tree for scenario #4.