Design Project 1 – Renewable Technology Challenge

ENGINEER 1P13 – Integrated Cornerstone Design Projects in Engineering

Tutorial 10

Team Fri-06

SOFIA BEDOYA (bedoyas)

HARSSHAN SAKILAN (sakilanh)

SHATHA JADDAA (jaddaas)

XUANJIN CHEN (chenx412)

FAHD ZADA (zadaf)

Submitted: November 2nd, 2023

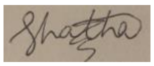
Course Instructors: Dr. McDonald, Dr. Doyle, Dr. Ebrahimi, Dr. Fleisig, Dr. Hassan, Dr. Zurob

Table of Contents

Academic Integrity Statement

The student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University.

Shatha Jaddaa 400533512



(Student Signature)

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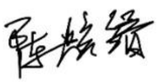

Xuanjin Chen 400475794

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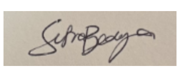
Sofia Bedoya 400508621



(Student Signature)

The student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University.

Fahd Zada 400516007

(Student Signature)

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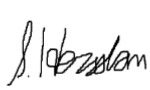
Harsshan Sakilan 400517727



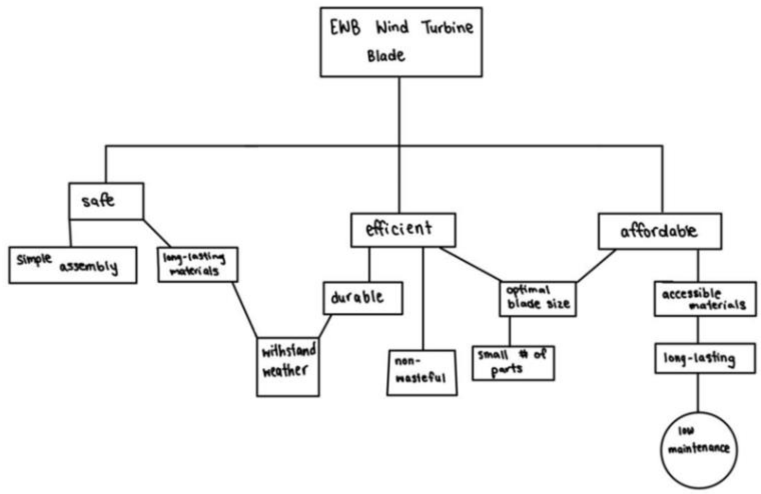
(Student Signature)

1: Finalized Problem Statement

In scenario 2, a couple of key points are mentioned by our discussion. One is the location for setting the wind turbine. Our group should design a simple wind turbine for the Guatemalan village of Santa Cruz La Laguna. To make sure this village has a stable power generation system; the wind turbine must satisfy the electricity needs of the villagers. However, because this village is in a relatively remote area, which means that we should have better control over the budget. In this way, the materials used for the construction of the wind turbine as well as the hardware needed to be cost effective. In addition to that, our group needs a wind turbine that is easy to assemble and maintain. Due to the resource constraints of this village, the wind turbine probably doesn't have access to sophisticated instruments to fix, thus the wind turbine must be sufficiently and easily repairable. In the state of problem, our group stated that "The function of a wind turbine is to spin, using wind to generate energy in a renewable way. Therefore, the amount of energy generated by the turbines is limited to the amount of wind and they must be sturdy and durable enough to withstand such pressures." This is also based on the conditions mentioned in Scenario 2 and the conclusion came to after the discussion. And on the contrary, cost constraints, lightweight and sturdy materials, as well as resistance to water were the overall results. Through the understanding and discussion of scenario 2, it can finally come to the conclusion that cost control will be the most important constraint, since if the wind turbine has too much expensive maintenance costs and assembly price, it will not be a suitable wind turbine, hence this is one of the important points we need to consider. So, this is one of the points our design needs to focus on.

Main Body

2: Justification of Technical Objectives and Material Performance Indices



In our objective tree, our group have set three main objectives, which are efficient(durable), affordable(economic) and safe (easy assembly), as the cost of the wind turbine must ensure low cost, that the materials used and the maintenance of the wind turbines should be low, as all the time ensuring sufficient efficiency in power generation. The cost of the wind turbine blades must be controlled, which means the use of materials and the maintenance cost of the wind turbine must be reduced. In addition to this, wind turbines should be durable and safe enough for long term use.

Weighted Decision Matrix - Template							
	Weighting	*Material 1: Medium Carbon Steel*		*Material 2: Wood, typical along grain*		*Material 3: Aluminum alloys*	
		Score	Total	Score	Total	Score	Total
Accessibility	3	3	9	4	12	5	15
Maintenance	5	4	20	2	10	3	15
Weather resistance	3	2	6	1	3	4	12
	TOTAL		35		25		42

In our weighted decision matrix we have chosen three materials which are medium carbon steel, wood, and aluminum alloys. By analyzing the different materials using Granta which have come up with the data shown in the graph. By analyzing the different materials using Granta, it came up with the data in the graphs and analyzed them based on the comparison of accessibility, maintenance, and weather resistance and finally our group chose aluminum alloys which had the highest score.

	Objective	MPI-stiffness	MPI-strength
Primary	Minimizing cost	$E / \rho C_m$	$\sigma_y / \rho C_m$
Secondary	Minimizing mass	E / ρ	σ_y / ρ

In this MPI table, our group set up two important criteria for reference, respectively, one is Minimizing mass (primary, $E / \rho C_m$) and the other is Minimizing cost (secondary, E / ρ). The reason why cost is a secondary choice is because reducing cost alone may also lead to some of our other objectives will be difficult to realize. For example, if our group chooses bamboo as the design material, then the durability may be much worse. So, our final material through these two MPIs. For the primary MPI, minimizing cost is important because the village is initially off the grid and will have less money and resources.

3: Conceptual design – Justification of selected material

As a team, each of us generated a material property chart for different MPI's. Our primary goal was to minimize cost, and our secondary goal was to minimize mass while considering the strength and stiffness of the materials. Each of us got a simulation on Granta regarding the materials.

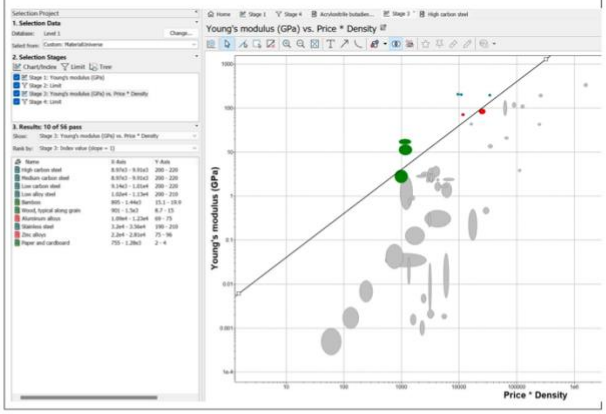
	Objective	MPI stiffness	MPI strength
Primary	Minimizing cost	Figure 2 E/ρ Cm	Figure 4 (5)σ_y/ρ Cm
Secondary	Minimizing mass	Figure 5 E/ρ	Figure 3 (4)σ_y/ρ

We then took each MPI ranking of the materials and put them into a ranking table. The material finalists were medium carbon steel, wood typical along grain, and aluminum alloy. In our specific project scenario, our wind turbine is in a remote location, with harsh climates, and required maintenance, so we needed a material specifically designed to withstand these challenges. Due to this, we decided to select aluminum alloy as it scored the highest on the weighted decision matrix (Figure 1) due to its accessibility, easy maintenance, and its ability to withstand the Guatemalan climate. Even though medium carbon steel was ranked higher in terms of maintenance, aluminum alloys ranked higher than both medium carbon steel and wood typical along grain on both accessibility and weather resistance.

	Weighting	*Material 1: Medium Carbon Steel*		*Material 2: Wood, typical along grain*		*Material 3: Aluminum alloys*	
		Score	Total	Score	Total	Score	Total
Accessibility	3	3	9	4	12	5	15
Maintenance	5	4	20	2	10	3	15
Weather resistance	3	2	6	1	3	4	12
	TOTAL		35		25		42

Figure 1. Weighted decision matrix

Material Property Chart		
Assigned MPI	**Functional Constraint**	**Objective**
MPI-stiffness (E /ρ Cm)	ρ Cm	Minimize the cost
Insert a screenshot of the material property chart with MPI guideline. Please clearly label the top 5 materials with their names in the plot.		



Material Ranking					
	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
Assigned MPI:	Steel	Zinc alloys	Aluminum alloys	Coppers alloys	bamboo

Figure 2. Young’s modulus (GPa) vs. Price * Density

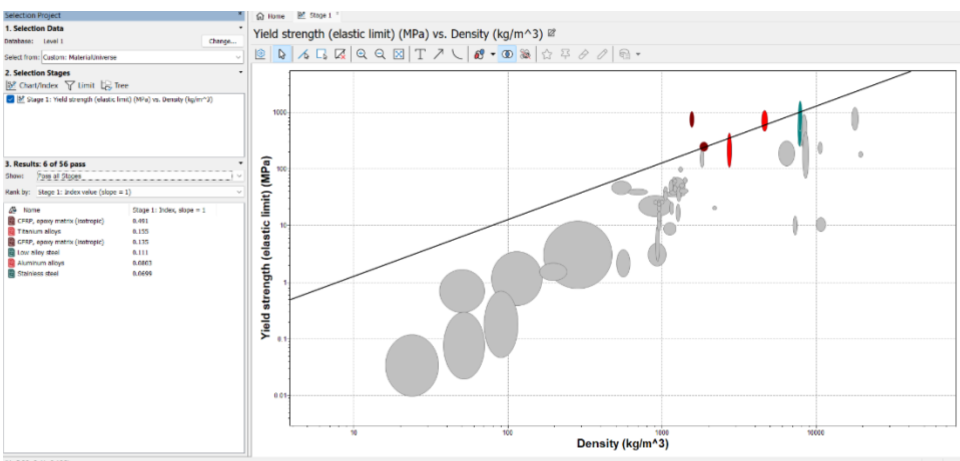


Figure 3. Yield strength (elastic limit) (MPa) vs. Density (kg/m^3)

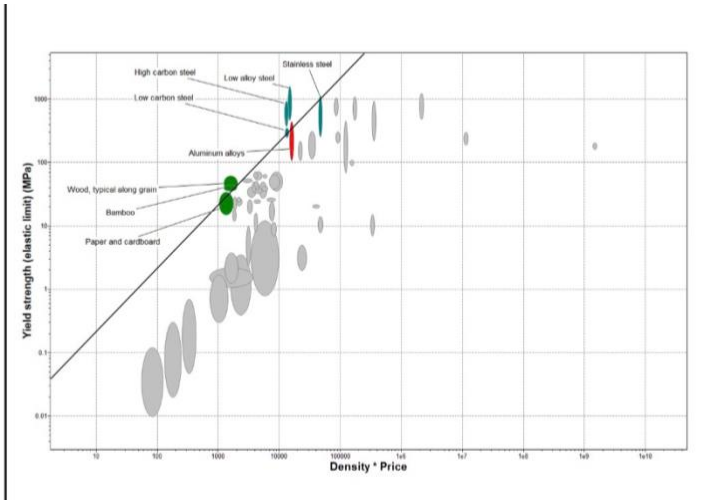


Figure 4. Yield strength (elastic limit) (MPa) vs. Price * Density

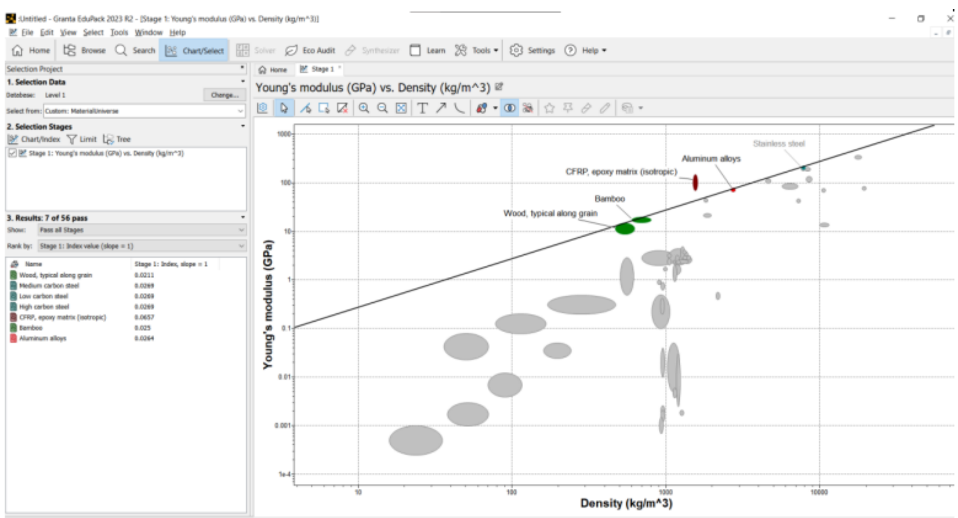


Figure 5. Young’s modulus (GPa) vs. Density (kg/m^3)

4: Design Embodiment – Justification of Solid (CAD) Modelling

With the chosen material being Aluminum Alloy, we conducted several tests to determine the optimal thickness, ensuring a maximum deflection of less than 10mm. We tested four different values: 15mm, 30mm, 50mm, and 150mm [1, pg. 40], which yielded the following results: 12.86mm, 10mm, 3.602mm, and 1.736mm, respectively. Following these tests, we concluded that the ideal deflection range falls between 15mm and 30mm. We continued experimenting with various thickness values until we identified the perfect thickness, which turned out to be 19mm and resulted in a deflection of 9.475mm (Figure 1) satisfying the constrained deflection of less than 10mm [1, pg. 40].

5: Discussion of Regulations

Our wind turbine was situated in a small off grid village in Guatemala. Due to this, we had to take some considerations into its properties. To start, we had to take the Guatemalan environment into consideration. The wind turbine must be constructed in an area such that it would not affect Guatemala's natural habitat. We decided that the wind turbine should be placed in open plains and on higher elevations. It would make more logical sense to place the wind turbine on an open plain as open plains are generally less ecologically sensitive than rainforests and other densely packed ecosystems. To add on, the wind turbine being on higher elevations would allow for more wind to be available allowing for more energy.

Furthermore, due to the socio-cultural expectations of the small village, the village should be provided with an affordable and safe flow of electricity. A problem of the wind turbine is that there is a risk of it breaking which poses a threat to the village as a part could harm someone. We can overcome this problem by placing the wind turbine far enough away from the village, but close enough such that the village can still receive a flow of electricity. Another socio-cultural expectation of the village is that they require peace and quiet. This expectation can be fulfilled, by placing the wind turbine at a far enough distance such that the wind turbine does not give any noise pollution to the village.

6: Discussion of Sustainable Choices

In our end-of-life considerations for the wind turbine project, we carefully evaluated the material choice, the turbine's location, and its construction. When selecting the material, our primary objectives were to ensure it was cost-effective for production and readily available on the land where the turbine would be installed. After thorough research and testing, we identified Aluminum Alloy as an ideal material due to its widespread availability in the Guatemalan village and its affordability, aligning with our material selection goals. The design and construction of the turbine were optimized to facilitate easy maintenance and repairs, recognizing that the villagers themselves would be responsible for maintaining the turbine in the long run.

7: Peer-Learning Interview

The other team that we discussed with was team #5, who were tasked with scenario one. Scenario one involved designing a durable wind turbine that would generating enough electric power for the large population of Kingston, Ontario. Because their wind turbines would be situated on an island this provided team #5 with certain limitations to their design. The two most pressing limitations they were faced with were size constraints due to transportation on and off the island, and an overall weight limit of 14 tons. The dimensions of the turbine are as follows: 80m in height, 50m across, 3m in diameter, and 1.5m wide at the tip of the turbine blade. The material chosen for the design of these wind turbines was carbon fibre reinforced plastic, which they argued in favour of for several reasons. Firstly, this material has a high Young's modulus making it inelastic and resistant to deformation when under large amounts of stress or pressure. Additionally, carbon fiber reinforced plastic is very lightweight and low maintenance option but does however have a higher cost than most other materials. Overall, their approach largely differed from ours due to their lack of concern with the overall cost of the wind turbines, which causes for several differences in the physical designs. For team #5 their main goal was durability, so the expensive cost of roughly two million dollars per turbine was worth it due to the little maintenance it will require in the long run. Having such a budget allowed them to make turbines with a more expensive and durable material than ours and allowed them to design turbines that were much bigger in size than ours. If there was one way our team would have changed the way this scenario was approached it would have been to pay more attention to the cost of the turbine, specifically when it comes to the cost of their chosen material as there are many options that would have still been both inexpensive and durable.

8: Concluding Remarks – Reality Check

This Project was one that was full of new experiences and unfamiliar challenges. It taught us how to use important software such as Granta for selecting the best material to use for our turbine, and Autodesk Inventor for creating a 3D model of our turbine which we could run tests and simulations on. In learning these new skills, we also majorly improved upon our preexisting thinking and collaboration skills. Choosing materials in Granta required us to use critical thinking to analyze our given scenario and select the factors which we would be prioritizing when creating our design from a materials perspective. Learning how to navigate Autodesk allowed us to appreciate the value in asking questions and recognize the importance of learning from one another. Overall, one of the most valuable take aways from this project was gaining the experience of working in a collaborative group. Not only did we learn how to lend our knowledge and share our skills, but we also learned how to step back and let others take the lead and learn how to trust others with certain responsibilities. Some engineering additional engineering considerations that might be worth exploring in the future, specifically related to our scenario, is the concept of creating a design that can be easily maintained and constructed by non-engineers, which enhances its practicality and usability.

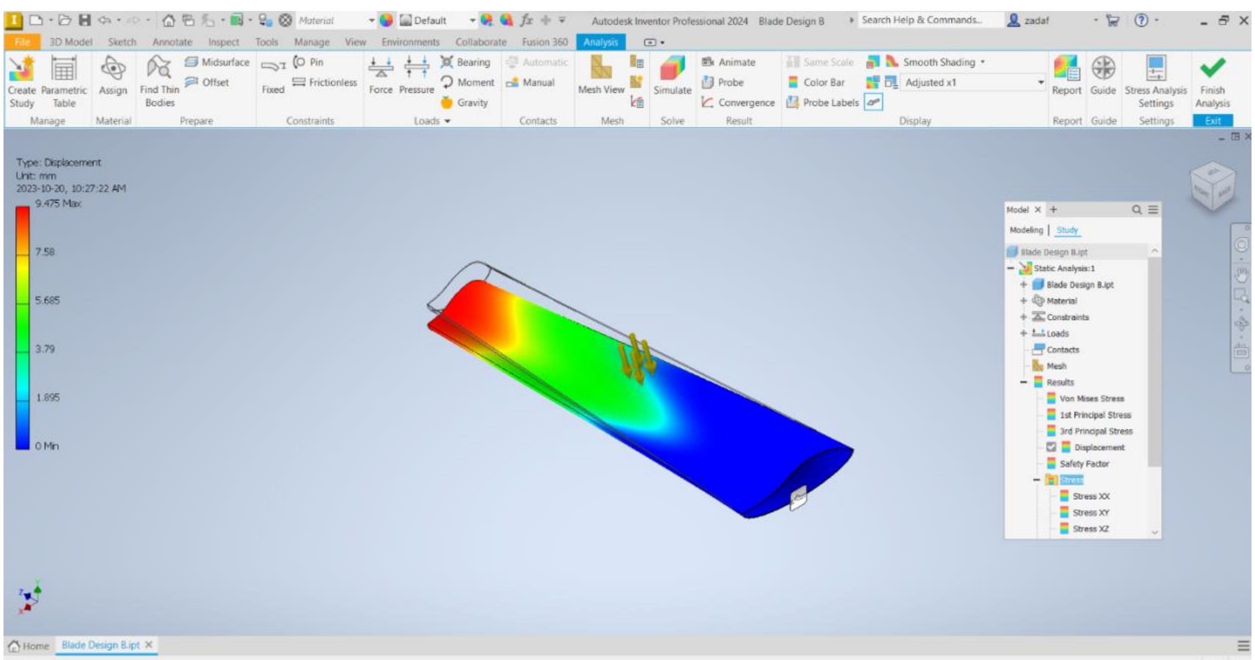
9: Summary of Contributions

Section Name	Group Member Name
Peer-Learning Interview (7) and Concluding Remarks (8)	Sofia Bedoya
Finalized Problem Statement (1) and Justification (2)	Xuanjin Chen
Conceptual design – Justification of selected material (3) and Discussion of Regulations (5)	Harsshan Sakilan
Design Embodiment (4) and Discussion of Sustainable Choices (6)	Fahd Zada
Reference List (10) and Appendices (11)	Shatha Jaddaa

10: Reference List

[1] "P1 Project Module," Class Notes for ENG 1P13, Department of Engineering, McMaster University, Fall, 2023.

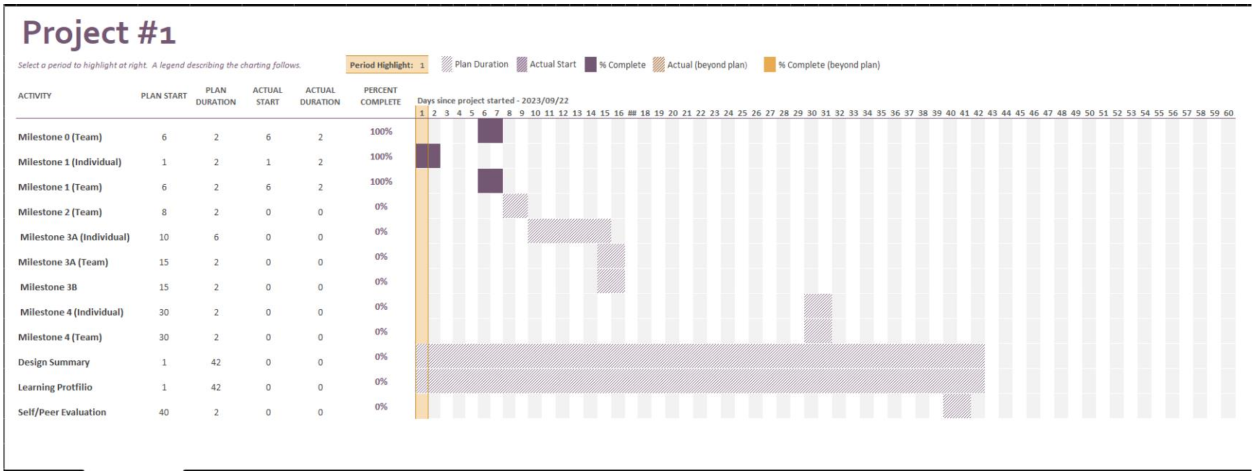
Figure 1. Autodesk Inventor final deflection simulation



11: Appendices

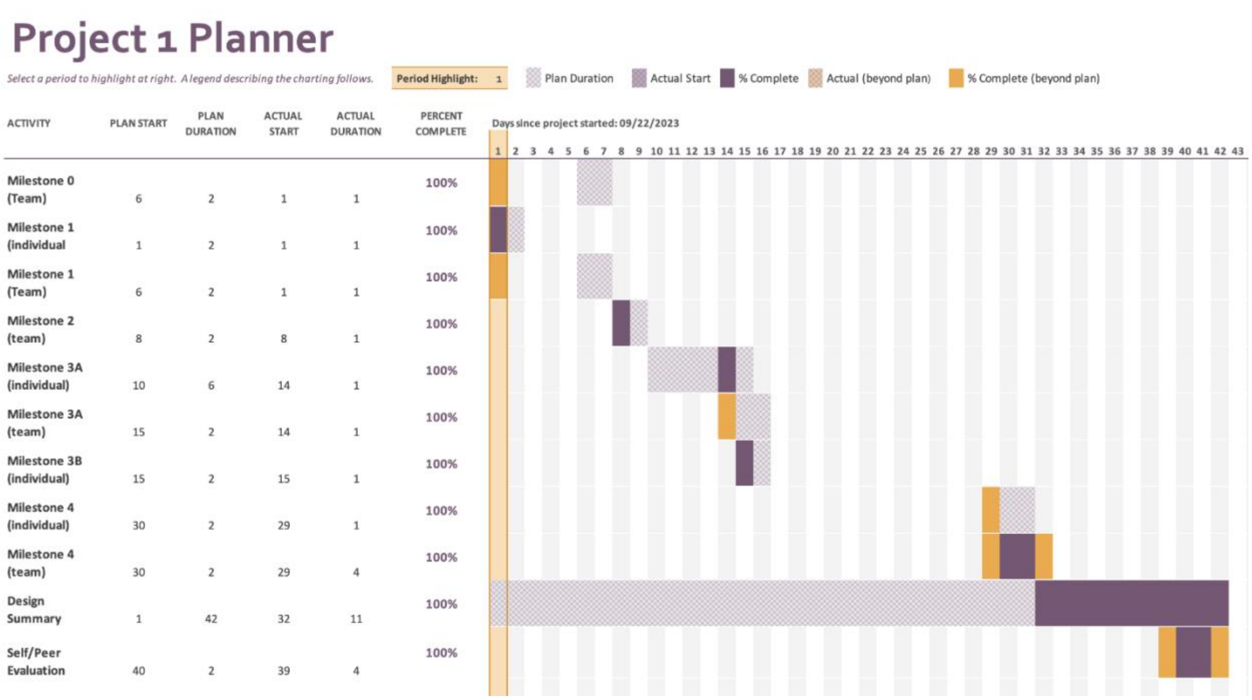
Appendix A: Project Schedule

Preliminary Gantt Chart:



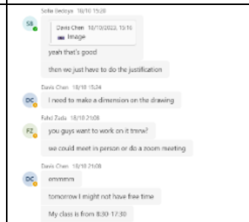
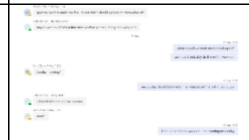
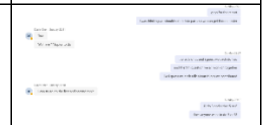
ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Milestone 0 (Team)	6	2	6	2	100%
Milestone 1 (Individual)	1	2	1	2	100%
Milestone 1 (Team)	6	2	6	2	100%
Milestone 2 (Team)	8	2	0	0	0%
Milestone 3A (Individual)	10	6	0	0	0%
Milestone 3A (Team)	15	2	0	0	0%
Milestone 3B	15	2	0	0	0%
Milestone 4 (Individual)	30	2	0	0	0%
Milestone 4 (Team)	30	2	0	0	0%
Design Summary	1	42	0	0	0%
Learning Protfilio	1	42	0	0	0%
Self/Peer Evaluation	40	2	0	0	0%

Final Gantt Chart:



ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Milestone 0 (Team)	6	2	1	1	100%
Milestone 1 (individual	1	2	1	1	100%
Milestone 1 (Team)	6	2	1	1	100%
Milestone 2 (team)	8	2	8	1	100%
Milestone 3A (individual)	10	6	14	1	100%
Milestone 3A (team)	15	2	14	1	100%
Milestone 3B (individual)	15	2	15	1	100%
Milestone 4 (individual)	30	2	29	1	100%
Milestone 4 (team)	30	2	29	4	100%
Design Summary	1	42	32	11	100%
Self/Peer Evaluation	40	2	39	4	100%

Logbook of additional meetings and discussions:

September 22, 2023	October 17, 2023	October 18, 2023	October 26-27, 2023	October 29, 2023
				
Short online discussion where Fahd requested the group to make changes to the objective trees and to insert them into the document.	The group discusses the project and the need to complete it. Group begins to plan the project completion.	The group plans an in-person meeting, however we decided that it would be better to work on it on our own.	The group begins to discuss the final report, and when to work on it.	The group discusses how to approach the project. We agreed that we should split it up to finish it efficiently.

Appendix B: Scheduled Weekly Meetings: N/A

Appendix C: Comprehensive List of Sources

Milestone 2 – Research Memo:

Harsshan Sakilan:

[1] "What is wind power?," WINDExchange, https://windexchange.energy.gov/what-is-wind [Accessed Sep. 29, 2023].

[2] A. E. Tutorials, "Wind turbine design for a wind turbine system," Alternative Energy Tutorials, http://www.alternative-energy-tutorials.com/wind-energy/wind-turbinedesign.html#:~:text=Rotor%20Blade%20Length%20–%20Three%20factors,is%20controlled%20by%20the%20weather. [Accessed Sep. 29, 2023].

Sofia Bedoya:

[1] "How Do Wind Turbines Work?", Energy.Gov [Online]. Available: https://www.energy.gov/eere/wind/how-do-wind-turbines-work

[2] "Wind Turbines: the Bigger, the Better", Energy.Gov [Online]. Available: https://www.energy.gov/eere/articles/wind-turbines-bigger-better

[3] C. A. Bardurek, “Wind Turbine”, Britannica [Online]. Available: https://www.britannica.com/technology/wind-turbine

Shatha Jaddaa:

[1] A. E. Tutorials, “Wind turbine blade design, flat, bent or curved,” Alternative Energy Tutorials, https://www.alternative-energy-tutorials.com/wind-energy/windturbine-blade-design.html [accessed Sep. 28, 2023].

[2] Group PLC, “How does a wind turbine work?” National Grid Group, https://www.nationalgrid.com/stories/energy-explained/how-does-wind-turbinework [accessed Sep. 28, 2023].

[3] Wind Energy Technology Office, “How a wind turbine works - text version,” Energy.gov, https://www.energy.gov/eere/wind/how-wind-turbine-works-textversion [accessed Sep. 29, 2023].

Xuanjin Chen

[1] C. A. Badurek, “Wind turbine | technology,” Encyclopædia Britannica. Nov. 15, 2015. Available: https://www.britannica.com/technology/wind-turbine

“Wind Turbine Blade Aerodynamics”,[Online],available

[2] “Wind Turbine Blade Aerodynamics,” Electrical Academia, Aug. 01, 2018. https://electricalacademia.com/renewable-energy/wind-turbine-blade-aerodynamics (accessed Sep. 29, 2023).

[3] “Wind Turbine Blade Shape: A Comprehensive Guide to Design and Efficiency -,” lambdageeks.com, Sep. 23, 2023. https://lambdageeks.com/wind-turbine-blade-shape/

Fahd Zada:

[1] “Wind,” IEA [Online]. Available: https://www.iea.org/energy-system/renewables/wind. [Accessed: September 28, 2023].

[2] Altenergytutorials, “Wind Turbine Blade Design,” Alternative Energy Tutorials [Online]. Available: https://www.alternative-energy-tutorials.com/wind-energy/wind-turbine-blade-design.html. [Accessed: September 28, 2023].

[3] Adam Johnston, “Wind Energy More Energy Efficient Than Fossil Fuels,” CleanTechnica [Online]. Available: https://cleantechnica.com/2012/07/18/wind-energy-energy-efficient-fossil-fuels-uk/. [Accessed: September 28, 2023].

[4] “The best in wind turbine blade design,” GE Renewable Energy [Online]. Available: https://www.ge.com/renewableenergy/wind-energy/leading-wind-turbine-blade-technology#:~:text=Factors%20such%20as%20wind%20turbine,extremely%20high%20degree%20of%20precision. [Accessed: September 28, 2023].

Milestone 4 – Turbine Justification:

[1] “Wind turbine blade sizes and transport: A guide,” Utility Dive [Online]. Available: https://www.utilitydive.com/spons/wind-turbine-blade-sizes-and-transport-a-guide/623444/. [Accessed: October 19, 2023].

[2] William J. Griffith, “Guatemala,” Britannica [Online]. Available: https://www.britannica.com/place/Guatemala. [Accessed: October 19, 2023].

[3] Altenergytutorials, “Wind Turbine Blade Design,” alternative-energy-tutorials [Online]. Available: https://www.alternative-energy-tutorials.com/wind-energy/wind-turbine-blade-design.html. [Accessed: October 19, 2023].

[4] “Bends, Twists, and Flat Edges Change the Game for Wind Energy,” Wind Energy Technologies Office [Online]. Available: https://www.energy.gov/eere/wind/articles/bends-twists-and-flat-edges-change-game-wind-energy#:~:text=Aerodynamic%20engineers%20wanted%20thin%20shapes,which%20are%20structurally%20more%20efficient. [Accessed: October 19, 2023].

Project Report:

[1] “P1 Project Module,” Class Notes for ENG 1P13, Department of Engineering, McMaster University, Fall, 2023.

Appendix D: Additional Documentation: N/A

Appendix E: Design Studio Worksheets

Milestone 0 (Team): Cover Page

Team ID: Fri-#6

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

Full Name:	MacID:
Fahd Zada Shatha Jaddaa	zadaf jaddaas
Sofia Bedoya	bedoyas
Harsshan Sakilan	sakilanh

Insert your Team Portrait in the dialog box below

Milestone 0 – Team Charter

Team ID: Fri-#6

Project Leads:

Identify team member details (Name and MacID) in the space below.

Role:	Team Member Name:	MacID
Manager	Fahd Zada	zadaf
Administrator	Shatha Jaddaa	jaddaas
Coordinator	Harsshan Sakilan	sakilanh
Subject Matter Expert	Sofia Bedoya	bedoyas
	Xuanjin Chen	chenx412

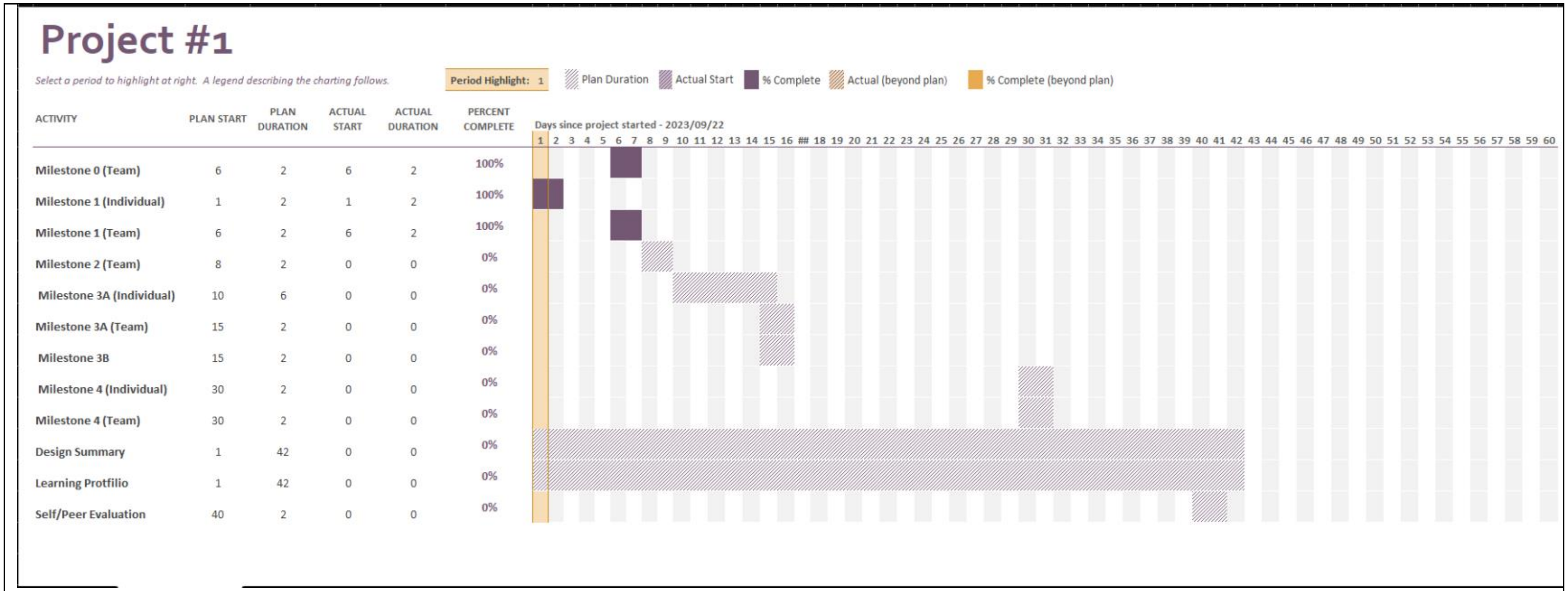
Milestone 0 – Preliminary Gantt Chart (team Manager ONLY)

Team ID: Fri-#6

Only the **Project Manager** is completing this section!

Full Name of Team Manager:	MacID:
Fahd Zada	zadaf

Preliminary Gantt chart



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Milestone 2 (Team)	8	2	0	0	0%
Milestone 3A (Individual)	10	6	0	0	0%
Milestone 3A (Team)	15	2	0	0	0%
Milestone 3B	15	2	0	0	0%
Milestone 4 (Individual)	30	2	0	0	0%
Milestone 4 (Team)	30	2	0	0	0%
Design Summary	1	42	0	0	0%
Learning Protfilio	1	42	0	0	0%
Self/Peer Evaluation	40	2	0	0	0%

Milestone 1 (Team) – Cover Page

Team Number: Fri-#6

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

Full Name:	MacID:
Fahd Zada	zadaf
Shatha Jaddaa	Jaddaas
Harsshan Sakilan	sakilanh
Sofia Bedoya	bedoyas
Xuanjin Chen	chenx412

Any student that is ***not*** present for Design Studio will not be given credit for completion of the worksheet and may be subject to a 10% deduction to their P-1 grade.

Milestone 1 (Stage 1) – Initial Problem Statement

Team ID:	Fri-#6

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 this initial problem statement, you should be focusing on the main function(s) of the wind turbine.**

The function of a wind turbine is to spin, using wind to generate energy in a renewable way. Hence, the amount of energy generated the turbines is limited to the amount of wind and they must be sturdy and durable enough to withstand such pressures.

Milestone 1 (Stage 3) – Refined Objective Trees

Team ID: Fri-#6

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.

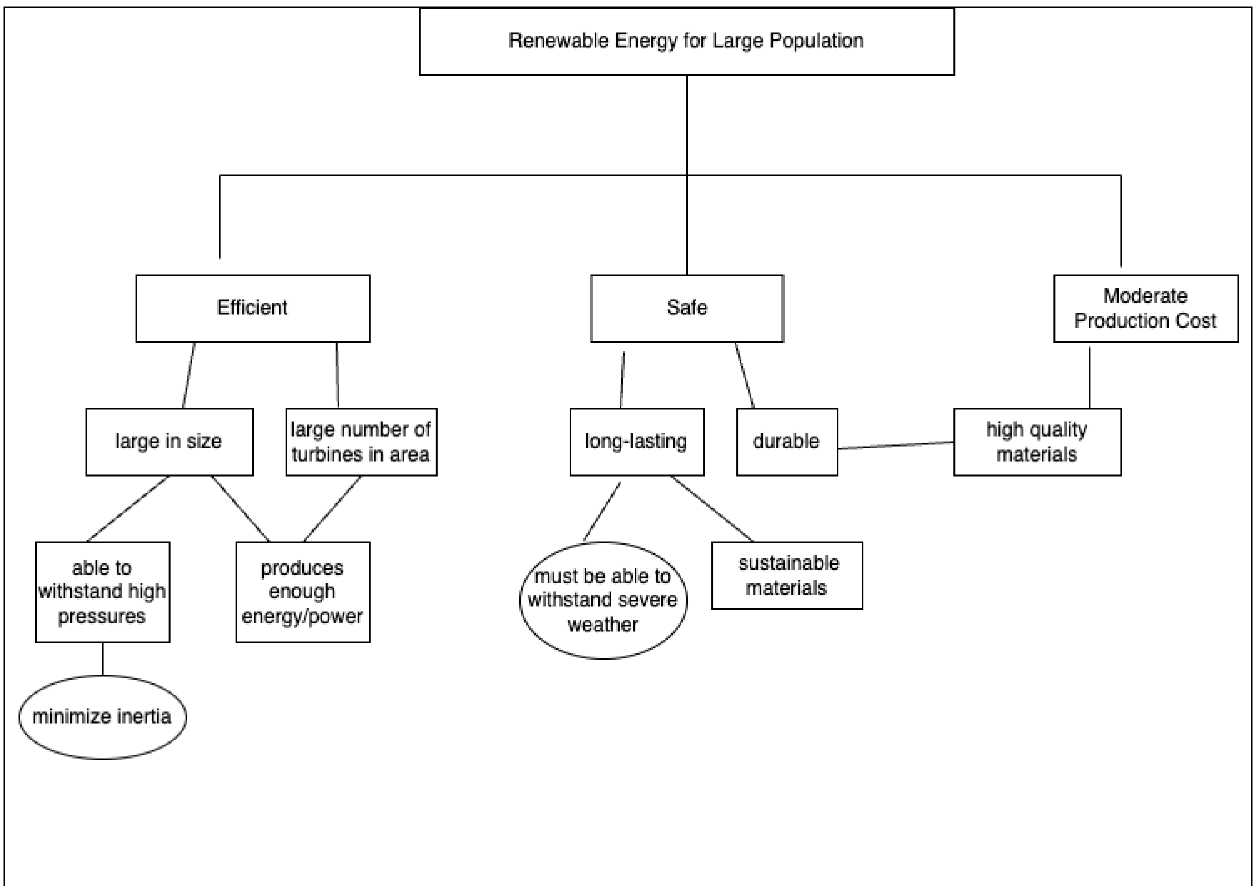
Engineering Scenario #1

The title of the scenario

Renewable Energy for a Large population

Team objective tree diagram for scenario #1

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



Team ID: Fri-#6

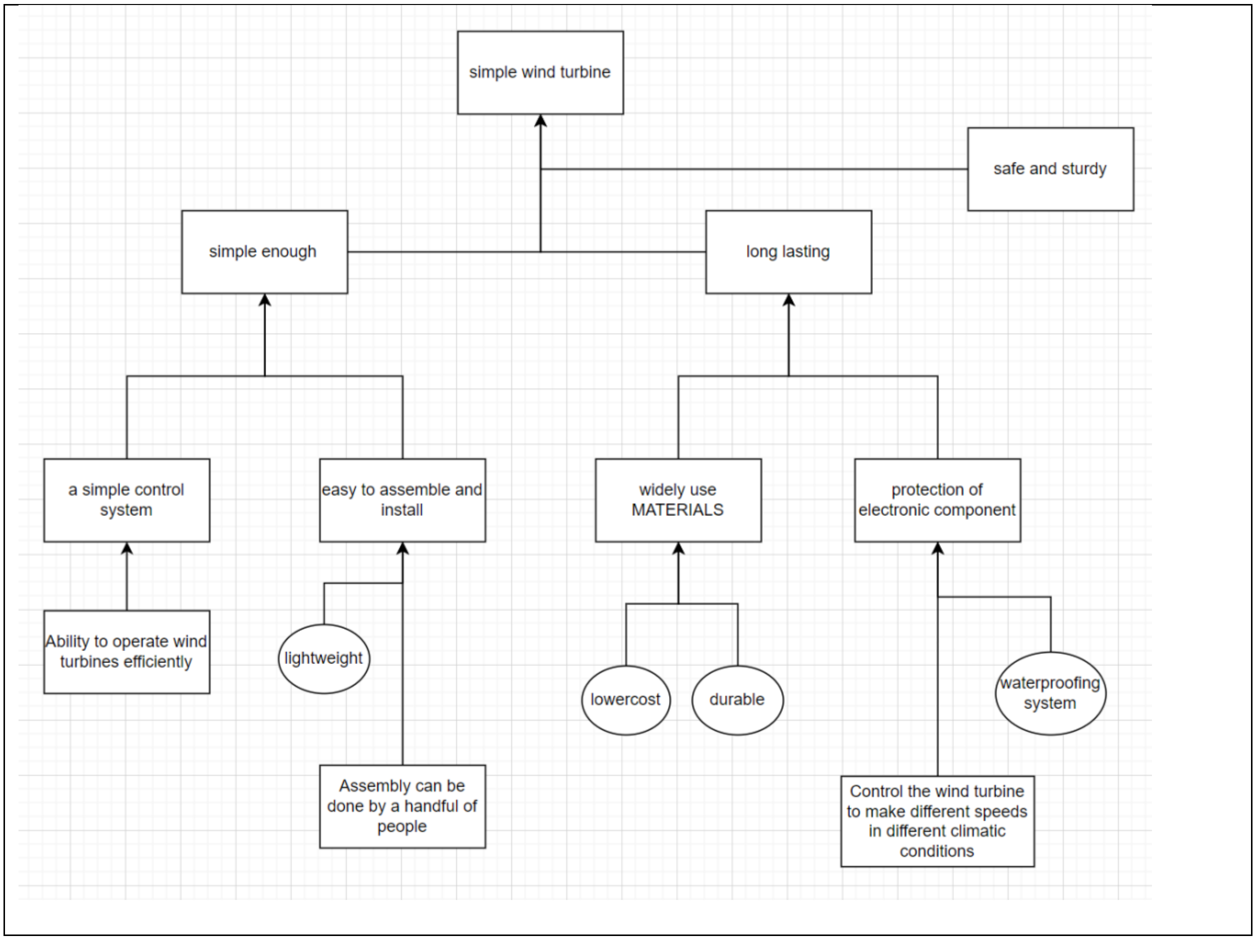
Engineering Scenario #2

The title of the scenario

Simple to use and easy to assemble wind turbine

Team objective tree diagram for scenario #2

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



Team ID: Fri-#6

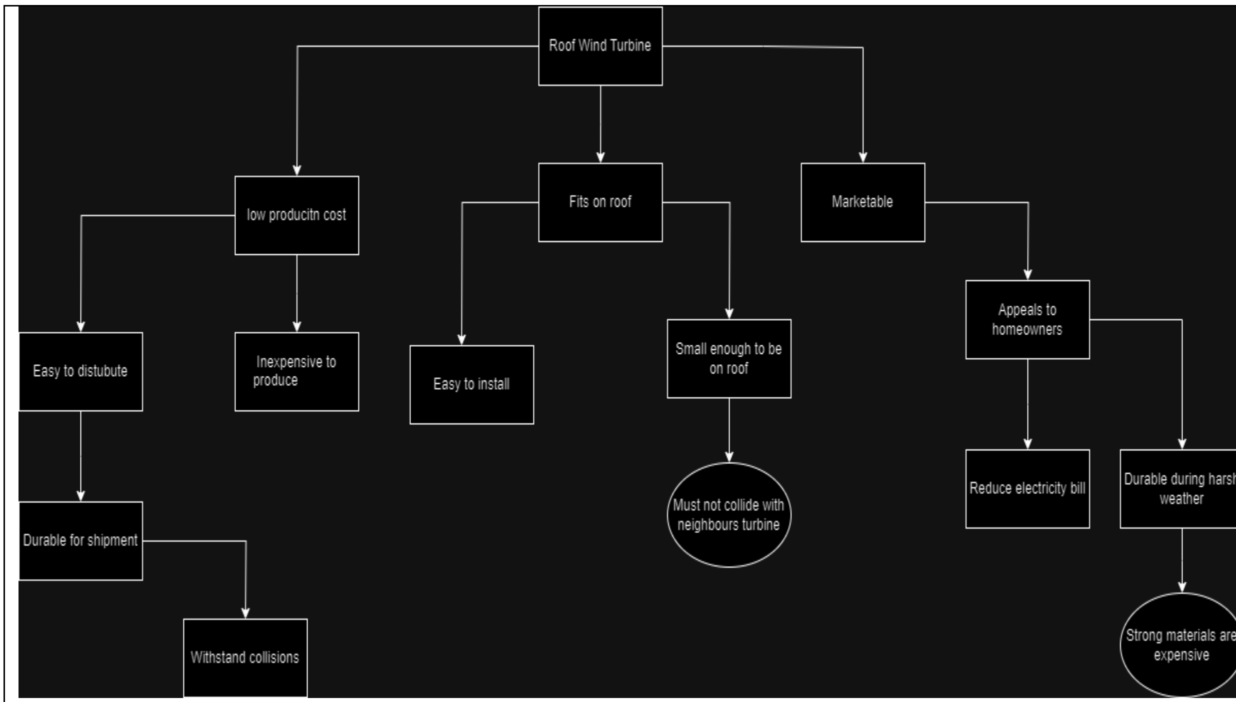
Engineering Scenario #3

The title of the scenario

The Roof Generator

Team objective tree diagram for scenario #3

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



Team ID: Fri-#6

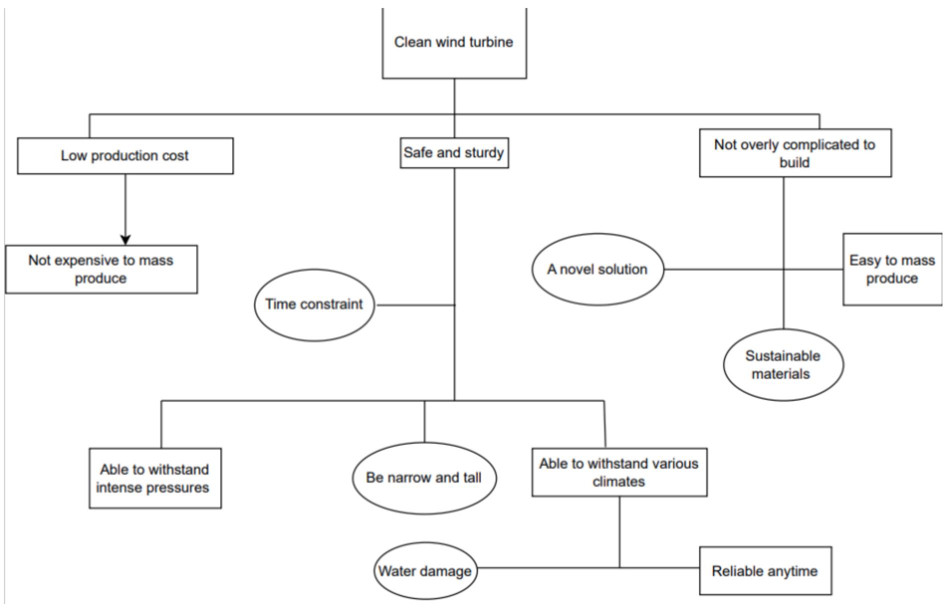
Engineering Scenario #4

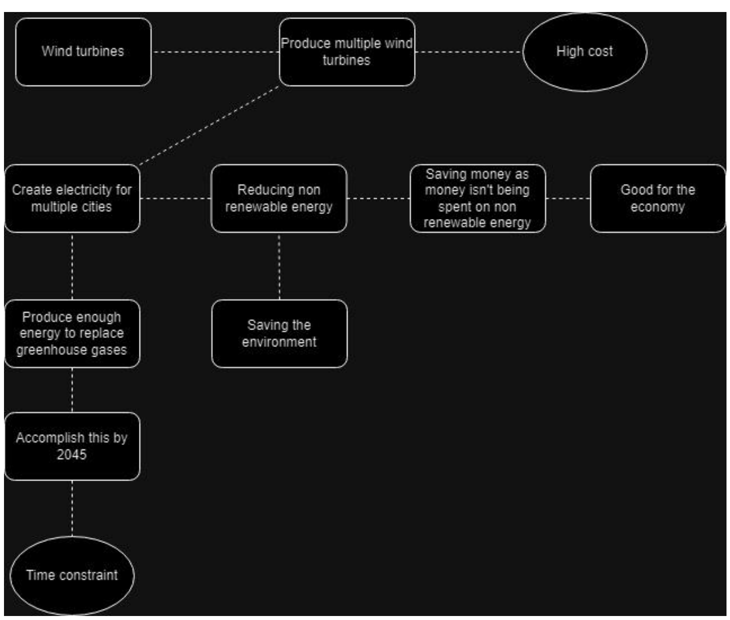
The title of the scenario

A Pioneer in Clean Energy

Team objective tree diagram for scenario #4

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





Milestone 2 (Team) – Cover Page

Team Number: Fri-#6

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

Full Name:	MacID:
Shatha Jaddaa	jaddaas
Harsshan Sakilan	sakilanh
Sofia Bedoya	bedoyas
Fahd Zada	zadaf
Xuanjin Chen	chenx412

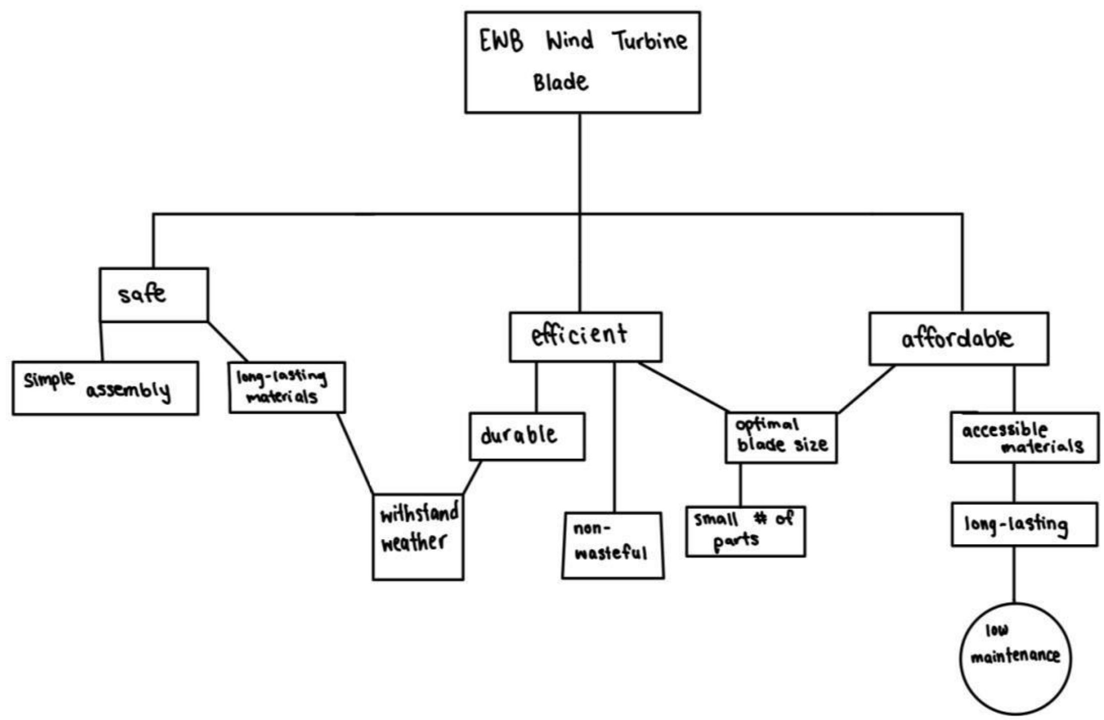
Any student that is ***not*** present for Design Studio will not be given credit for completion of the worksheet and may be subject to a 10% deduction to their P-1 grade.

Milestone 2 (Stage 1) – Design requirements for A turbine blade

Team ID: Fri-#6

Objective Tree of turbine blade for assigned engineering Scenario

→ Please insert a copy of your team objective tree for the design of a turbine blade based on your assigned engineering scenario.



Turbine Blade Problem Statement:

→ Write a complete problem statement for the design of a turbine *blade* based on your assigned engineering scenario.

The blades must be durable and able to withstand the Guatemalan climate and be an optimal size which can generate significant amounts of energy while still having a relatively simple construction process. The three primary factors that should be taken into consideration include, the affordability, the efficiency, and how easy it is to assemble. The clients in this scenario are the people of a village in Guatemala. The wind turbines must be situated in areas with higher amounts of wind, generally on the top of hills, open plains, and mountain gaps that intensify the winds. It should also be constructed in an area such that it will not affect Guatemala's natural environment. The rationale for this project is to provide the village with a renewable source of energy.

Milestone 2 (Stage 2) – Selection of Top Objectives for a Turbine Blade

Team ID: Fri-#6

List the top three objectives of a turbine blade for your assigned engineering scenario

1: Affordable
2: Efficient
3: Easy Assembly

Include a rationale for selecting each of these objectives

→ Write *maximum* 100 words for each objective

Objective 1: Affordable

Rationale:

The blade is being built for a village that could not necessarily afford the prices of a wind turbine technology. To overcome this problem, the materials being used must be affordable and widely used, while maintaining efficiency.

Objective 2: Efficient

Rationale:

The blade must be efficient and durable, by being able to withstand bad climate and extreme weather. The design of the blade must have an aerodynamic such that it could extract energy from the wind and efficiently produces wind power. Meaning the blade must not allow wind to pass through without it being used for energy production.

Objective 3: Easy Assembly

Rationale:

Because it will be the villagers assembling and keeping up with any required maintenance of the blades, they must have an easy assembly so that the blades will continue to be functional and impactful in the long run.

Milestone 2 (Stage 3) – Metrics

Team ID: Fri-#6

For your selected top three objectives fill out the table below with associated metrics (including units) for each objective.

Objective 1:	Affordable
Unit/Metric:	CAD Dollars ($)

Objective 2:	Efficient
Unit/Metric:	Amount of energy per hour (J/hr)

Objective 3:	Easy assembly
Unit/Metric:	The number of parts required, and the assembly rate per hour Progress/hour (%/hr)

Milestone 2 (Stage 4) – Regulations

Team ID: Fri-#6

Insert your group discussion below

- Obtaining materials used for the production of the blades must be done in a way that is mindful of and preserves the surrounding environment of the village.
- The wind turbine must be close enough to send energy to the village but at the same time must be far enough such that it does not pose a threat to the village. Must be at least 2 km away from homes, and roadways.
- Wind turbine must not be a significant contributor to noise pollution.
- Does not pose a threat to the natural surrounding environment.
- When siting wind turbines it is important to site wind inlets and outlets in larger basins, wind inlets and outlets in larger ocean lakes, etc. to ensure that there is enough wind to maintain power generation efficiency.

Milestone 3A (Team) – Cover Page

Team Number: Fri-#6

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

Full Name:	MacID:
Fahd Zada	Zadaf
Harsshan Sakilan	sakilanh
Sofia Bedoya	bedoyas
Shatha Jaddaa	jaddaas
Xuanjin Chen	chenx412

Any student that is ***not*** present for their scheduled Lab-B session will not be given credit for completion of the worksheet and may be subject to a 10% deduction to their P-1 grade.

Milestone 3A (Stage 1) – Material Selection: Problem Definition

Team ID: Fri-#6

1. Copy-and-paste the title of your *assigned* scenario in the space below.

EWB Humanitarian Aid Mission

2. MPI selection
   - → List one primary objective and one secondary objective in the table below
   - → For each objective, list the MPI
   - → Write a short justification for your selected objectives

	Objective	MPI-stiffness	MPI-strength	Justification for this objective
Primary	Minimizing cost	E /ρ Cm	σ y /ρ Cm	Minimizing cost is important when considering the fact that the village is initially off the grid and will have less money and resources.
Secondary	Minimizing mass	E /ρ	σ y /ρ	The mass of the blade is important due to the fact that villagers are going to be building the wind turbine.

Milestone 3A (Stage 3) – Material Selection: Material Alternatives and Final Selection

Team ID: Fri-#6

Document results of each team member's materials selection and ranking on the table below.

- All different types of steel (carbon steels, alloy steels, stainless steels) have very similar Young's moduli. **For this stage in Project 1, please group all variations of steels into one family as "steel"**. Please put **steel** in your material ranking list only once and indicate in a bracket which steels made the top ranks.

Consolidation of Individual Material Rankings					
	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
MPI 1:	Wood, typical along grain	Steel(Medium carbon, Low carbon, High carbon)	CFRP, epoxy matrix (isotropic	Bamboo	Aluminum alloys
MPI 2:	CFRP, epoxy matrix (isotropic)	Titanium alloys	GFRP, epoxy matrix (isotropic)	Low alloy steel	Aluminum alloys
MPI 3:	Steel （Medium carbon, High carbon, Low carbon, Low alloy, Stainless)	Bamboo	Wood, typical along grain	Aluminum alloys	Zinc alloys
MPI 4:	Steel (Low alloy steel, high carbon, medium carbon)	Wood, typical along grain	Bamboo	Paper and cardboard	Aluminum alloys

As a team, fill out the table below and narrow down the possible materials for your assigned scenario by choosing the 3 materials which showed up the most across all MPI rankings in the table above.

- For this stage in Project 1, if **"steel"** is one of your three material finalists, please specify which steel your team chose to continue with, based on which showed up the most in your team's consolidated table.
- Remember to save the datasheets of all 3 material finalists

Narrowing Material Candidate List to 3 Finalists	
Material Finalist 1:	Medium carbon steel
Material Finalist 2:	Wood, typical along grain
Material Finalist 3:	Aluminum alloy

Team ID: Fri-#6

As a team, compare material alternatives and make a final selection based on either a simple decision matrix or a weighted decision matrix (up to your team to decide)

→ As a team, consider *at least* 3 additional criteria that are relevant to your assigned scenario and discuss your 3 materials finalists for each criterion
- Feel free to pause at this stage and do some quick research on the materials finalists
- You may refer to the material finalists' datasheets for any relevant information that will enable your discussion.
- To help you come up with your additional criteria, below are some question prompts that you may consider. Please note that you are not limited to these suggestions, and they may or may not be relevant to your assigned scenario

Additional Criteria	**Possible question prompt**
Ease of access to material	Is the material easy to source in the country, are there tariffs due to international trade policy?
Chemical, weather and/or corrosion resistance	Will the material degrade over time (e.g. due to chemical resistance, corrosion resistance, fatigue resistance)?
Ease of maintenance	Consider maintenance if the part got damaged. Based on the material, is it easy to fix or will the entire part need replacement?

→ Remember that:
- Your MPI ranking takes into consideration both material and mechanical properties relevant to the objectives of your assigned scenario.
- Your additional considerations should not include previously evaluated objectives e.g. If minimizing the carbon footprint was either your primary or secondary objective, then it should not be an additional criterion

→ Compare the material alternatives and make a final selection based on either a simple decision matrix or a weighted decision matrix (up to your team to decide)
- *Applies to a weighted decision matrix only:* choose a range for the weighting (e.g., 1 to 5) for each criterion. The higher the number on the weighting, the more important that criterion is.
- Choose a range for the score (e.g., 1 to 5) for each material on each criterion. Give each material a score based on how successfully it meets each criterion. The higher the score, the better the material is for that criterion.
- Add additional rows as needed.
- Add up the total score for each material alternative.

Weighted Decision Matrix - Template							
	Weighting	*Material 1: Medium Carbon Steel*		*Material 2: Wood, typical along grain*		*Material 3: Aluminum alloys*	
		Score	Total	Score	Total	Score	Total
Accessibility	3	3	9	4	12	5	15
Maintenance	5	4	20	2	10	3	15
Weather resistance	3	2	6	1	3	4	12
	TOTAL		35		25		42

→ State your chosen material and justify your final selection

Justification	
Chosen Material:	Aluminum alloys
Aluminum alloy was chosen as the final selection because it scored the highest on the weighted decision matrix due to its widely accessible nature, its ability to be easily maintained, and its ability to withstand the Guatemalan climate.	

Summary of Chosen Material's Properties

Material Name	Average value
Young's modulus E (GPa):	69-75 GPa
Yield strength σ_y (MPa):	109-439 MPa
Tensile strength σ_{UTS} (MPa):	186-510 MPa
Density ρ (kg/m^3):	2.64e3-2.81e3 kg/m^3
Embodiment energy H_m (MJ/kg)	99.8-117 MJ/kg
Specific carbon footprint CO_2 (kg/kg)	7.47-8.59 kg/kg

Scenario Specific Turbine Blade Design (Team) – Cover Page

Team Number: Fri-#6

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

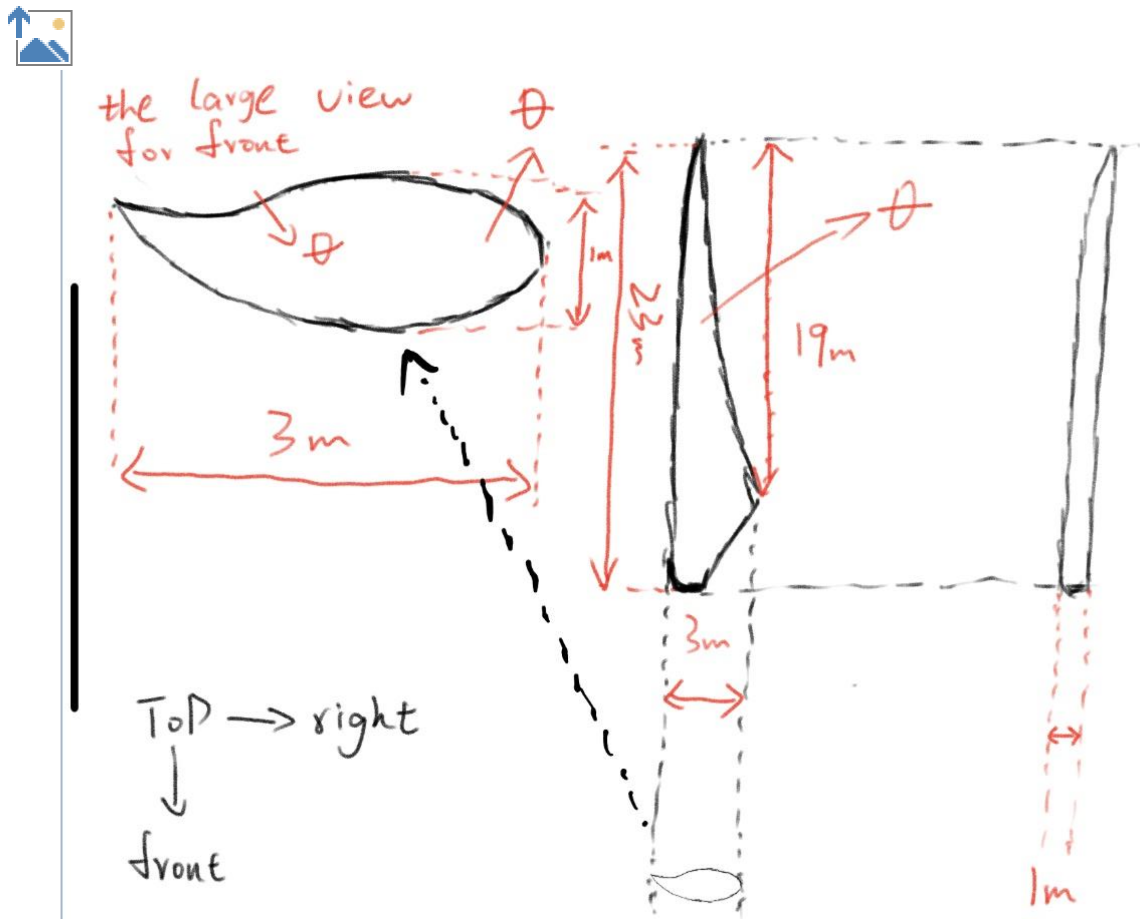
Full Name:	MacID:
Xuanjin Chen	chenx412
Fahd Zada	zadaf
Harsshan Sakilan	sakilanh
Sofia Bedoya	bedoyas
Shatha Jaddaa	jaddaas

Multiview Turbine Blade Sketch and Justification

Team ID: Fri-#6

1. Sketch of Turbine Blade

Insert a multiview sketch of your team's scenario specific turbine design. Multiview sketch must include front, top, and right-side view.



2. Justification of Turbine Blade

Our blade is going to be 46 meters long because this is the average size used for wind turbines in use for a community [1]. The size of the blade allows for a more extensive capture of wind energy, which results in more electricity. A large blade like ours is going to have the advantage of capturing wind energy at a lower wind speed, making it more efficient. This could be especially beneficial for a place like the Guatemalan village, which experiences a dry season between November and April [2]. The blade's design is going to be straight and narrow, making it thinner from the blade root to the tip, resulting in producing as much power as possible from the turbine [4]. Another reason for the design being shaped this way is that these types of blades (flat) have "significant benefits for DIY enthusiasts" [3], meaning that this wind turbine blade, compared to other designs, is easy and cheap to produce. This is our primary goal when attempting to design and make the blade. Adding to that, these blades are "the easiest to understand, requiring fewer design and construction skills" [3], which is another goal we are striving to achieve, as the villagers will be building the wind turbine. In conclusion, the size of the blade allows for more captured wind energy, the straight and narrow design of the blade is meant to make it produce energy efficiently, and the flat design of the blade provides an advantage to the villagers, as they are the ones building the wind turbine.

References:

[1] "Wind turbine blade sizes and transport: A guide," Utility Dive [Online]. Available: https://www.utilitydive.com/spons/wind-turbine-blade-sizes-and-transport-a-guide/623444/. [Accessed: October 19, 2023].

[2] William J. Griffith, "Guatemala," Britannica [Online]. Available: https://www.britannica.com/place/Guatemala. [Accessed: October 19, 2023].

[3] Altenergytutorials, "Wind Turbine Blade Design," alternative-energy-tutorials [Online]. Available: https://www.alternative-energy-tutorials.com/wind-energy/wind-turbine-blade-design.html. [Accessed: October 19, 2023].

[4] "Bends, Twists, and Flat Edges Change the Game for Wind Energy," Wind Energy Technologies Office [Online]. Available: https://www.energy.gov/eere/wind/articles/bends-twists-and-flat-edges-change-game-wind-energy#:~:text=Aerodynamic%20engineers%20wanted%20thin%20shapes,which%20are%20structurally%20more%20efficient. [Accessed: October 19, 2023].

Milestone 4 (Team) – Cover Page

Team Number: Fri-#6

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

Full Name:	MacID:
Harsshan Sakilan	sakilanh
Sofia Bedoya	bedoyas
Xuanjin Chen	chenx412
Fahd Zada	zadaf

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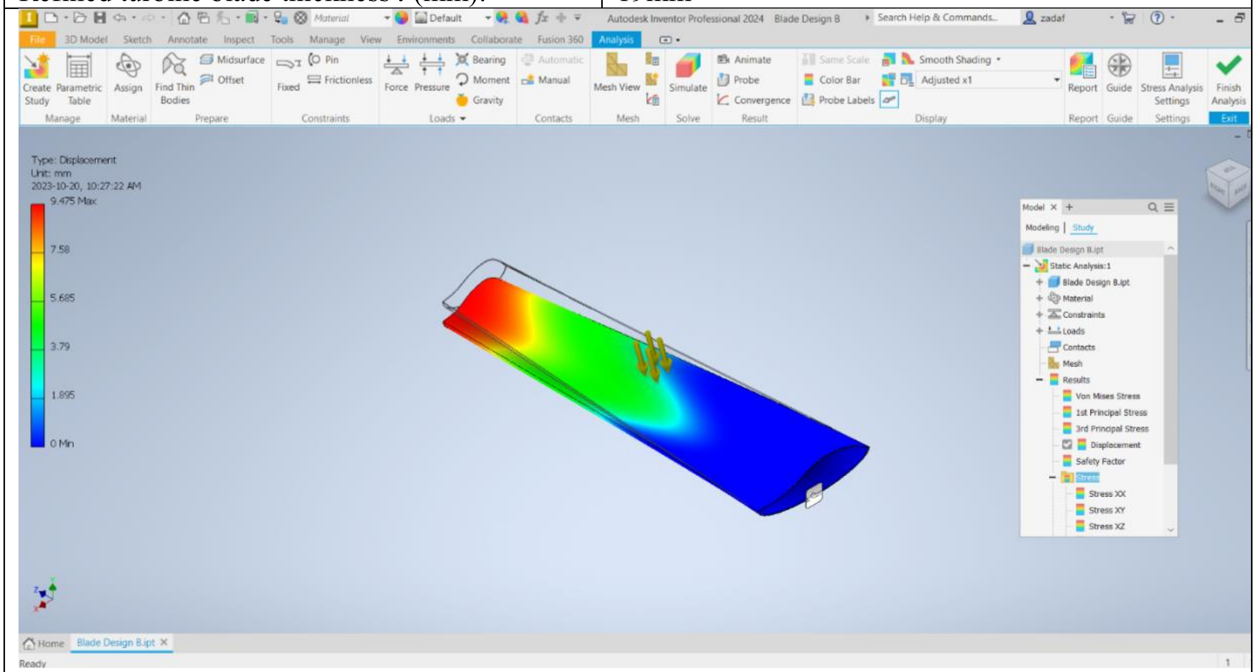
Milestone 4 (Stage 2) – Refine Thickness Requirement

Team ID: Fri-#6

1. Refine Thickness Requirement to Satisfy Deflection Constraint

Refined turbine blade thickness *t* (mm):	19mm



Milestone 4 (Stage 3) – Peer Interview

Team ID: Fri-06

→ Meet another team with a different scenario
- Discuss differences in your design process
- Compare:
  - Primary/secondary objectives
  - Chosen materials, thickness, etc.
- Discuss the relevance of your scenario-specific turbine blade design to your assigned scenario and any design challenges you have encountered.

1. Peer Interview Notes

Scenario 1
- Providing to an island which presents limitations
  - Due to limitations of getting to the islands, limitations of size exists.
  - 14 ton weight limitation

80m long, 50m across, 3m diameter, 1.5 m across at the tip
Material: Carbon fiber reinforced plastic (due to high youngs modulus), also the material is very light. It is expensive but it has lower maintenance costs, this is due to it being on an island.

Each blade is $2,000,000

Main goal was durability (so the expensive cost is worth it due to the little maintenance it will require in the long run)

- We believe that choosing carbon fiber as the material used is not the best option out there since it is way more expensive than other materials.