PROJECT ONE: MILESTONE 1 – COVER PAGE

Team Number: Tues - 24

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

Full Name:	MacID:
Taaha Atif	AtifT
Yasmine Elkhouly	Elkhouy
Borna Sadeghi	sadegb1
Pritika Thevakanthan	thevakap

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

Team Number:	Tues - 24

You should have already completed this task individually <u>prior</u> 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: | Tues - 24

Please list Team Member that is submitting the memo.

Full Name: Borna Sadeghi	MacID: sadegb1

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

Introduction

Since the early 1970s, wind power has been regarded as an important world power source [1]. As oil prices increased steeply, Western nations realized that they were excessively dependent on foreign energy sources [1]. It was found that energy prices are closely linked to the economic health of nations, so measures were ultimately taken to reduce the dependency on foreign sources of energy, to develop alternative and renewable energy sources and to promote energy conservation and moderation [1]. To this day, scientists and researchers continue to develop new technologies that aid in efficiently converting kinetic energy from the wind to electrical energy for widespread use.

The Current State of Wind Turbine Technology

For millennia, it was obvious that the wind offered valuable energy to mankind. Humans have used it to guide sailboats and pump water long before electricity was discovered [1]. Wind turbines are the oldest devices engineered specifically to produce electricity using wind as an energy source [1]. There are many wind turbine designs, and overall, many ways to convert kinetic energy from an air stream into useful work [2]. Most modern wind turbines consist of a tower, generator, gears, and the rotor, as well as the axis system and speed control to adjust the turbine based on the weather conditions [1].

Design Factors

Generating power from airflow still presents a large variety of difficulties. The largest issue is inconsistency of the wind flow [1]. Wind can be inconsistent in force and direction and electrical energy must be stored when winds are too weak or too strong to capacitate a steady flow of energy from the turbine [1]. Additionally, horizontal axis wind turbines must be tall enough in order to allow for clearance of the blades and avoid obstructions for consistent airflow [1]. However, this means that maintenance must be done high above the ground [1]. On the other hand, horizontal axis designs (which consist of propellor blades) are superior in the way that the rotor speed and output can be controlled by adjusting the angle of the rotor blades [2]. The blades can take advantage of aerodynamic lift in order to optimize the power output of the generator [2].

Copy the references below (use IEEE format)

[1] D. Chamberland. “Wind power.,” *Salem Press Encyclopedia of Science*, 2019.

[2] E. Hau. *Wind Turbines - Fundamentals, Technologies, Application, Economics*. Munich: Springer, 2013.

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Please list Team Member that is submitting the memo.

Full Name: Yasmine Elkhouly	MacID: Elkhouy

Pre-project Research Memo

Introduction

A wind turbine is a technological device mounted in locations where there are favourable weather patterns to convert the wind's kinetic energy into electrical energy. Utilizing wind energy is vital for protecting the critically damaged environment and combating climate change. Wind turbines do not emit greenhouse gases or pollutants whilst generating electricity, and the global wind supply is abundant and inexhaustible; thus, the wind energy industry is experiencing explosive growth. Global wind capacity increased from 17,000 megawatts to more than 430,000 megawatts from 2000 to 2015 [1]. The common types of wind turbines are vertical axis wind turbines and horizontal axis wind turbines. Vertical axis wind turbines are characterized by an axis of rotation that is perpendicular to the ground, and their designs are derived from either Darrieus or Savonius [2]. The Darrieus design consists of two curved rotors with an airfoil section shape with lift-driven rotors [2]. The Savonius design consists of open cylindrical surfaces attached to a vertical rotating shaft with drag-driven rotors [2]. Horizontal axis wind turbines are lift-based designs characterized by an axis of rotation that is parallel to the ground [2]. This design has a higher coefficient of power and optimum tip-speed ratio in comparison to vertical axis wind turbines [2]. As a result, it is the most commonly used design configuration in modern wind turbines as it is more effective in extracting energy from the wind.

Design factors

When designing a wind turbine, several factors must be analyzed to ensure it operates at maximum efficiency. Wind speed, air density, and blade design primarily influence power output [3]. Turbines are designed to operate within the limit of the cut-in speed and cut-out speed [3]. Between this range is the rated speed, in which the maximum output capacity is reached [3]. At the rated speed, power output will increase cubically with wind speed [3]. At the cut-out speed, the turbine is shut down to avoid damage to the equipment [3]. This demonstrates the significance of accounting for wind speed during design processes. In addition, dense air exerts more pressure on the rotors, which results in increased power outputs [3]. Thus, local altitude, pressure, and temperature are key factors to consider. Furthermore, turbine blades experience lightning strikes and damaging surface erosion whilst operating. Leading-edge erosion decreases blade aerodynamic efficiency, requires costly maintenance, and limits tip speeds [4]. This degradation occurs due to rain, hailstones, sand dust, airborne particles, temperature oscillations, UV radiation, and long-term exposure to moisture, chemicals, and salt [4]. Leading-edge erosion can potentially lead to reductions of more than 5% in annual power output for a utility-scale wind turbine [5]. Blades are also subjected to a significant number of strikes during their lifespan, which cause scorching damage and cracking around the lightning attraction point and possibly spar rupture, separation, and surface tearing [5]. Also, the structural integrity of the blades is crucial to ensure the longevity of a wind turbine. As turbine sizes and blade lengths increase to maximize power output and become lighter to reduce manufacturing expenses, the issue of blade deflection arises [2]. These factors result in blades that are more susceptible to breakage as bending stiffness has decreased [2]. Excessive deflection may cause damage to the rotor or, in extreme cases, cause the blade to fracture [2].

Existing solutions to these issues include using composites for manufacturing wind turbine blades. Typically, electric-glass fibers are used as main reinforcement in these composites [5]. Carbon fibers are an alternative due to their higher stiffness and lower density, which allows for thinner, stiffer, and lighter blades [5]. However, their limitations include high costs and low damage tolerance, compressive strength, and ultimate strain [5]. Other alternatives include basalt fibers, which are 30% stronger, 15–20% stiffer and 8–10% lighter than electric-glass, and inexpensive [5]. Lastly, aramid fibers, that have high durability, but low compressive strength, low adhesion to polymer resins, absorb moisture and degrade due to the ultraviolet radiation [5].

References

1. "Wind Power," National Geographic [Online]. Available: https://www.nationalgeographic.com/environment/global-warming/wind-power/. [Accessed: September 26, 2020].
2. V. Nelson and K. Starcher, *Wind Energy: Renewable Energy and the Environment.* Boca Raton; CRC Press, 2019.
3. A. Campbell, "Wind Power," Energy Education [Online]. Available: https://energyeducation.ca/encyclopedia/Wind_power April 28 2020. [Accessed: September 26, 2020].
4. J. Bech, "Extending the life of wind turbine blade leading edges by reducing the tip speed during extreme precipitation events," Wind Energ. Sci. [Online]. Available: https://wes.copernicus.org/articles/3/729/2018/. [Accessed: September 26, 2020].
5. M. Leon, Materials for Wind Turbine Blades: An Overview. Materials Basel, 2017.

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Please list Team Member that is submitting the memo.

Full Name: **Pritika Thevakanthan**	MacID: **thevakap**

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

Introduction:

Wind energy is a renewable energy source that utilizes wind turbines to produce electricity. Wind turbines extract the kinetic energy from wind and convert it into mechanical energy, which is then converted electrical energy. Approximately 10% of the world's energy supply is wind energy [1]. Modern turbines can generate usable amounts of electricity over 90 percent of the time [1]. The optimization of wind turbine efficiency is determined by engineering designs [1].

Design factors:

Wind turbines are analyzed in accordance to how the blades of the turbine interact with wind and the orientation of the rotor axis to the ground [2]. The resultant wind from the aerodynamic interaction of the blades of wind turbines produces lift and drag forces [2]. There is a torque on the blade causing it to rotate [2]. This is due to the lift and drag forces on the blade which applied at a certain radius from an axis [2].

For the blade to spin faster and capture wind at lower velocities to increase turbine efficiency, the materials and shape of the blade must be optimized. The material of the blades enhances their aerodynamics [3]. The material of the blades fulfills the following criteria: "high stiffness for optimum aerodynamics, low density to reduce gravitational forces, and long fatigue life to reduce material degradation" [3]. Fibrous materials are a good choice for the blades of wind turbines. The strength and stiffness of fibers make them efficient for turbine blade materials [3]. Carbon fibers have great mechanical properties with high stiffness, high strength, and low density [3].

A horizontal axis wind turbine or a vertical axis wind turbine is allocated by the orientation of the rotor axis [2]. The rotational axis of horizontal axis wind turbines is parallel to the ground [4]. Majority of wind turbines consist of horizontal axis wind turbines [1]. The rotational axis of vertical axis wind turbines is perpendicular to the ground [4]. There are advantages and disadvantages for both types of wind turbines. An advantage with horizontal wind turbines is that this type of wind turbine can produce more electricity for a given amount of wind [4]. However, this type of wind turbine is generally heavier and does not perform well in turbulent winds [2]. An advantage of vertical axis turbines is that it is powered by wind coming from all directions and due to its versatility, it is ideal for this type of turbine to be installed in wind conditions that are inconsistent [4].

Copy the references below (use IEEE format)

[1] K. D. Decker, "How to Make Wind Power Sustainable Again," *Resilience*, 27-Jun-2019. [Online]. Available: https://www.resilience.org/stories/2019-06-27/how-to-make-wind-

power-sustainable-again/. [Accessed: September 27, 2020].
[2] V. Nelson, *Innovative wind turbines: an illustrated guidebook*. Boca Raton: CRC Press, Taylor & Francis Group, 2020.
[3] "Materials Used in Wind Turbines," *Matmatch*. [Online]. Available: https://matmatch.com/learn/material/materials-used-in-wind-turbines. [Accessed: September 27, 2020].
[4] C. Conner and A.M.Oke, "Vertical Axis Wind Turbines vs Horizontal Axis Wind Turbines," *Windpower Engineering & Development*. [Online]. Available: https://www.windpowerengineering.com/vertical-axis-wind-turbines-vs-horizontal-axis-wind-turbines/. [Accessed: September 27, 2020].

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Please list Team Member that is submitting the memo.

Full Name: Taaha Atif	MacID: AtifT

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

Introduction

In the present society, we consider electricity as a vital source required for most individuals to survive. However, as environmental issues such as pollution and global warming continue to harm the Earth, we continue to aspire in determine ways of harnessing sources of power. One common renewable energy source can be harvested through the use of wind. This type of energy is accumulated using wind turbines. These turbines are known to save billions of gallons of water annually, as “wind turbines require no water to produce electricity or cool power generating equipment.” [1]. This is exceptionally beneficial towards our already minimal water reserves. Using wind turbines also significantly decreases the emission of co2, which is a major contributor to air pollution. In Canada, it states that “a single installation of six 65 kW wind turbines in Newfoundland is expected to produce approximately 1 million kWh of electricity a year and reduce CO_2 emissions by approximately 750 tonnes.” [2]. Due to the multiple environmental benefits that wind turbines provide, it is undeniably one of the best ways to harness electricity.

Design Factors

Wind turbines are all connected to a generator capable of producing energy when the blades of the turbine rotate. For wind turbines to work efficiently, they “need to be in areas with a lot of wind on a regular basis, which is more important than having occasional high winds.” [3]. These wind turbines can be categorized into two separate groups, horizontal-axis, and vertical-axis. Horizontal-axis wind turbines are considered to be the most common type of turbines being used today. They have their rotor and electrical generator at the top of the tower and are pointed towards the direction of wind. Vertical-axis turbines are less common as they are known to produce less energy than horizontal-axis wind turbines. Vertical-axis turbines have their generator located at the base of the structure and “has blades mounted on the top of the main shaft structure, rather than in the front like an aircraft rotor.” [4]. Both turbines, however, have similar basic design factors being wind speed, air density, and blade radius. The wind speed corresponds to the electricity generated meaning greater wind speed concludes to a higher rate of electricity produced. The density of the air affects the spin of the rotors as denser air has a greater pressure on the rotors, which generates increased power. Finally, the blade radius affects the overall amount of energy collected as “Larger blades allow the turbine to capture more of the kinetic energy of the wind by moving more air through the rotors.” [3]. Furthermore, the aerodynamics and material of the blade is considered as a major factor when designing wind turbines. The blades are commonly made from “reinforced plastic composites with the most common composites consisting of fibreglass/polyester resin, fibreglass/epoxy, fibreglass/polyester and carbon-fibre composites.” [5]. These materials are used as they are cost efficient and effective. Finally, the shape of the blades correspond to the design of aeroplane wings and “As the blade cuts through the air, a wind speed and pressure differential is created between the upper and lower surfaces of the blade." [5].

References

[1] "Environmental Benefits," *AWEA*. [Online]. Available: https://www.awea.org/wind-101/benefits-of-wind/environmental-benefits. [Accessed: 29-Sep-2020].

[2] 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: 29-Sep-2020].

[3] A. Campbell, "Wind power," *Wind power - Energy Education*, 28-Apr-2020. [Online]. Available: https://energyeducation.ca/encyclopedia/Wind_power. [Accessed: 29-Sep-2020].

[4] T. Arcadia, "Vertical Axis Wind Turbines Advantages & Disadvantages," *Blog*, 27-Jul-2017. [Online]. Available: https://blog.arcadia.com/vertical-axis-wind-turbines-advantages-disadvantages/. [Accessed: 30-Sep-2020].

[5] Alternative Energy Tutorials, "Wind Turbine Design for a Wind Turbine System," *Alternative Energy Tutorials*. [Online]. Available: https://www.alternative-energy-tutorials.com/wind-energy/wind-turbine-design.html. [Accessed: 30-Sep-2020].

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

MILESTONE 1 (STAGE 1) – INITIAL PROBLEM STATEMENT

Team Number: Tues-24

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.**

During project one, our team will be designing a wind turbine blade component for one of the four assignment scenarios: renewable energy for a large population, engineers without border humanitarian aid mission, a roof generator, pioneer in clean energy. Our wind turbine blades must fulfill the design requirements associated with our assigned scenario. Generally, the wind turbine blades must be structurally integral and function with high aerodynamic efficiency, with regard to local wind speeds and air densities, to maximize power output whilst withstanding potential issues such as deflection, leading-edge erosion, and lighting strikes.

MILESTONE 1 (STAGE 3) – REFINED OBJECTIVE TREES

Team Number: Tues-24

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.

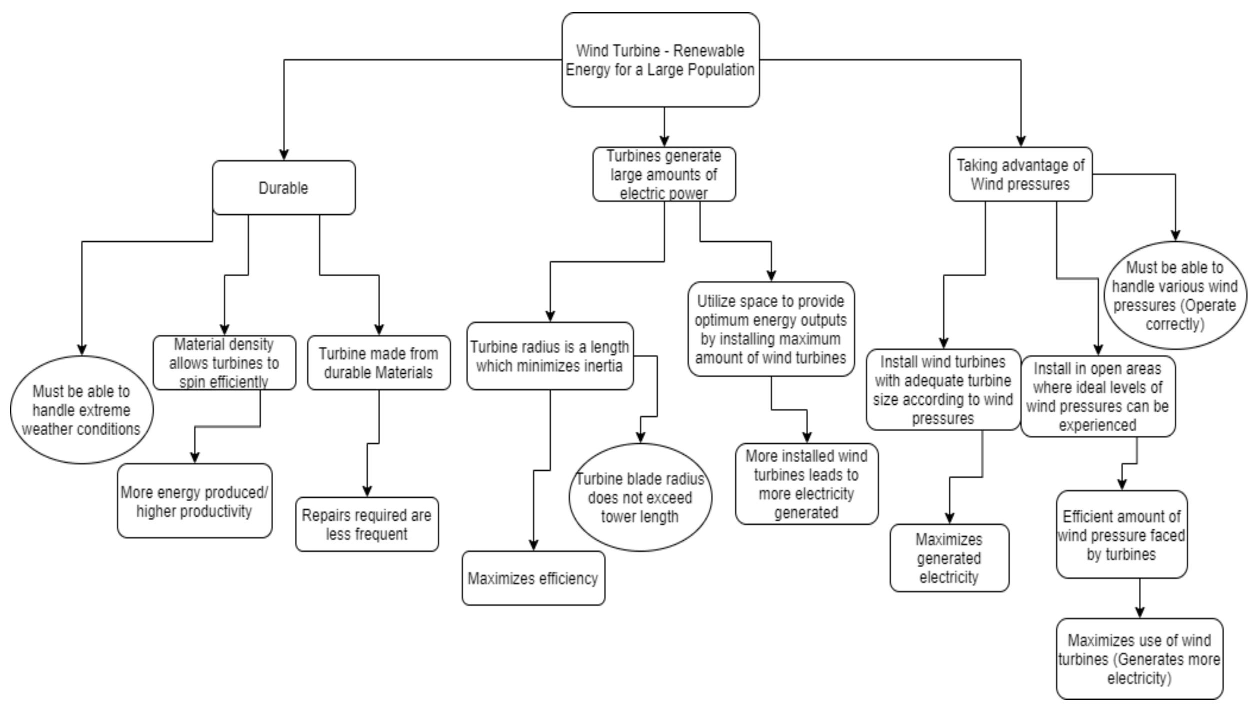
Engineering Scenario #1

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.



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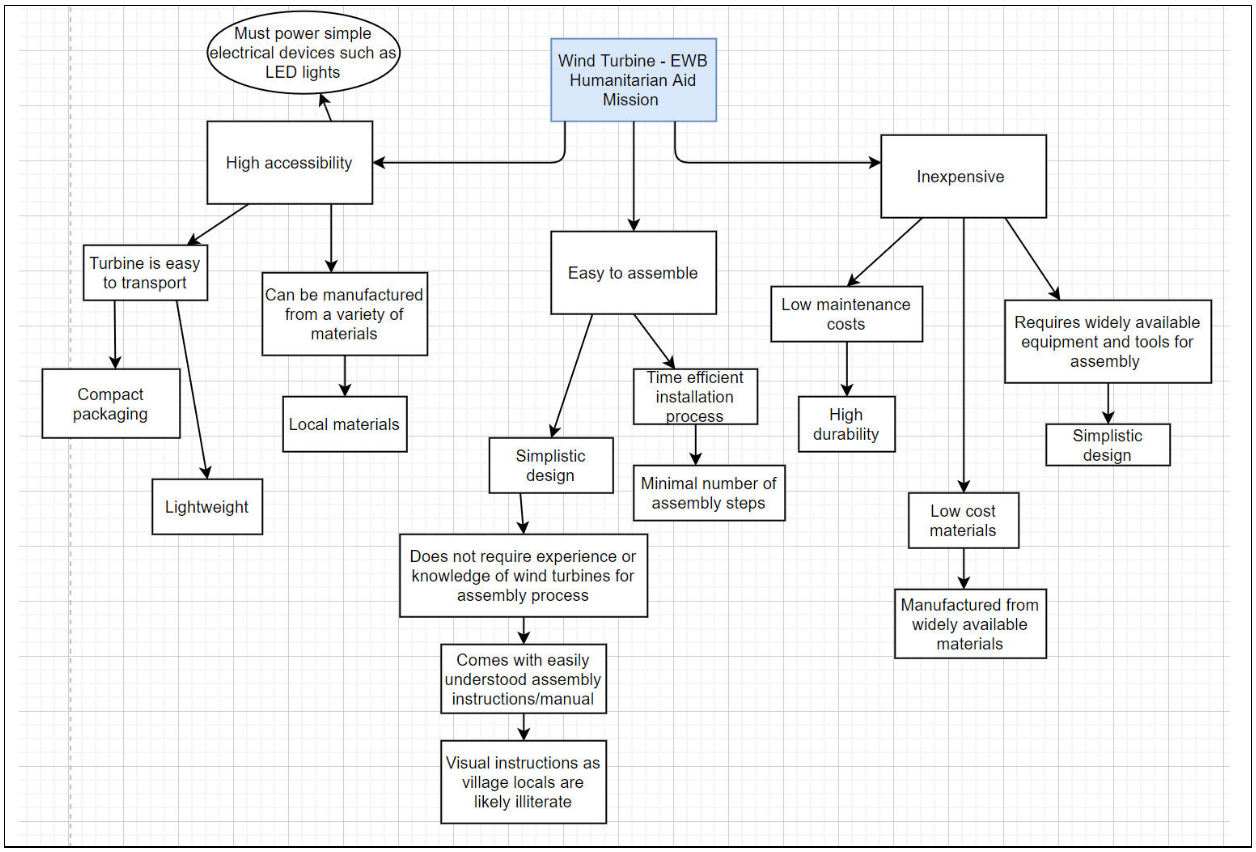
Engineering Scenario #2

The title of the scenario

Scenario 2: EWB Humanitarian Aid Mission

Team objective tree diagram for scenario #2

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



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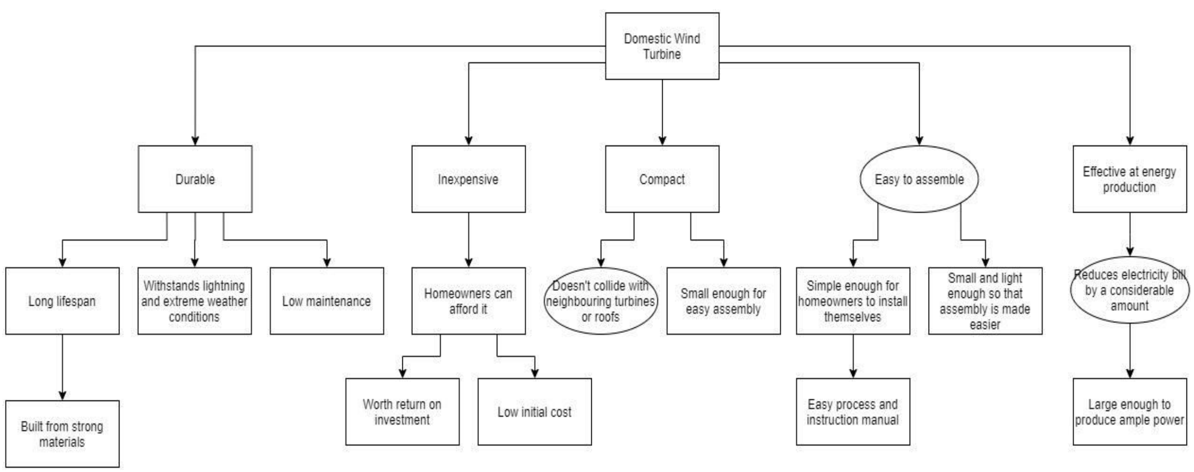
Engineering Scenario #3

The title of the scenario

The Roof Generator

Team objective tree diagram for scenario #3

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



Team Number: Tues-24

Engineering Scenario #4

The title of the scenario

A pioneer in clean energy

Team objective tree diagram for scenario #4

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