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TENDER REPORT

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Revision Log

Revision Number	Release Date	Description
1.0	13/03/24	Initial Draft of the Scoping Document for Buddy Marking, outlining all initial requirements, planning and budgeting.
1.1	20/03/24	Testing metrics and schedule added. Document ready to be buddy marked.
2.0	1/04/24	Revisions made to key sections taking feedback from buddy marking.
2.1	20/04/24	Testing metrics updated in preparation for Final Tender release.
3.0	18/05/24	Draft Tender for peer assessment.
4.0	29/05/24	Updated design reviews, schematics, and formulated plans for environmental considerations.

Student Statements

Member	Contribution to Tender Document	Student Statement
Devin Rajakaruna	Project Objectives, Deliverables, Testing, Sensors	I am currently studying Mechatronic Engineering and utilising my degree I brought my skills and knowledge of sensors, technical writing, working

		on larger projects, as well as keeping up to date with technical documents.
Shardul Kamat	Interfacing Requirements, TPM's, Reflection, Environmental Design Specifications, Testing	I am studying Mechatronics Engineering. For this unit I have brought my knowledge of wiring, sensors, schematics along with report writing skills and techniques I have acquired throughout my degree.
Gurinder Singh	Scope of Works, Background Research	I am studying Mechanical Engineering. For this unit, I have brought to the table my knowledge of structural and mechanical design. This includes but does not limit to CAD, mechanical and structural analysis as well as report writing.
Colin Yin	Justification, Project Schedule, Reflection	
Sharlet Merin Sunny	Functional Requirements, Cost Breakdown, and Conclusion,Electrical services, Electrical Distribution	I am undertaking a Bachelor of Engineering degree with a focus on the Mechatronics Stream. I contributed to this project through my knowledge in electrical systems and power distribution as well as sensors, which helped me to provide the schematics and understand the key electrical components needed to make our system function.
Jiangbo Wen	Figures and Tables, Inclusions and Exclusion, Glossary of Definitions, Abbreviated Terms, Electrical services, and Electrical Distribution	I am studying Electrical and Electronic Engineering, focusing on circuit design, embedded systems, and power electronics. I have worked on projects developing power systems and communication networks, while improving my technical writing and staying updated with industry advancements.
Nikki Sherpa	Problem Statement, Project Constraints, Document Structure, Design Review, Structures	I am a final year civil engineering student, focusing on the structural elements in this project. As a bridge & road design intern, I am tasked with writing many technical reports at work. I have leveraged that aspect of my work experience to also write the problem statement & design review of this project.
Zarin Tasnim Isra	Document Structure, Introduction, Performance Requirements, Environmental Design Specifications and recommendations, Reflection	I bring my knowledge of software and technology systems from my Software Engineering degree to this group project. I also bring my skills in technical writing and teamwork.

Nicholas Simos	Requirements, TPM’s, Document Structure, Reflection	

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Glossary

Terms	Definition
EIA	Environmental Impact Assessment
IoT	Internet of Things
distro	distribution
TPM	Technical Performance Measures
IFR	Interface Requirements
UD	Unit Deliverables
PO	Project Objectives
FR	Functional Requirements
PR	Performance Requirements
TSF	Time Since Failure
TSR	Time to System Repair
PC	Project Constraints

1 Project Overview

1.1 Abstract

This document will outline the development of our solution to the selected United Nations Sustainable Development Goals (SDGs). The distributed wind and solar energy farm system will aim at providing widespread power across New South Wales (NSW) to support these goals, specifically goal seven, “ensuring access to affordable, reliable, sustainable, and modern energy to all”. The system also aims to provide support in furthering other SDGs such as “building resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation” and “make cities and human settlements inclusive, safe, resilient and sustainable. The document will provide detail to the project's scope, objectives, requirements, and design of the solution.

The primary purpose of this project is to significantly develop NSW’s renewable energy capabilities and distribution of energy to cities and rural areas, reducing reliance on fossil fuels and helping environmental sustainability. Included within the scope are the methodologies used in site selection for widespread wind farms, the effective integration of solar energy panels into existing infrastructure, an assessment of energy output potential and the environmental impact that the new system will have. The system aims to ensure sustainable energy supply for both rural and urban areas with limited environmental impact.

The scoping document will serve as a foundation for the planning and implementation of the developed solution offering critical insight to ensure the project's success.

1.2 Introduction

As global energy demands continue to rise there is an urgent need to develop solutions to support current fossil fuel based energy sources which can in future provide a sustainable alternative. The system aims to harness the wind and solar resources available in both rural and urban areas to increase the share of renewable energy in the state's power grid, providing a sustainable energy supply that will enhance the quality of life for its residents. Currently an average of 39% of Australia's electricity is generated from renewable energy sources predominantly from wind and solar power but the overall usage of land in generating such power is significantly small in comparison to what is available for use while still limiting the environmental impact. Additionally only 28% of suitable urban areas are used for solar energy, the introduction of our distributed energy solution aiming to reach the lower benchmark of 45% states within Australia can reduce their reliance on fossil fuels by a considerable 40%.

On behalf of our client Macquarie University Faculty of Science and Engineering (FSE) we introduce our solution to the United Nation Sustainable Development Group Goals (UNSDGs), The Distributed Urban solar and rural wind farm project. The system will further NSWs current power grid by providing advanced energy storage and distribution centres with machine based learning algorithms for energy redirection to higher demand central hubs while still providing sustainable energy supply to rural areas.

The purpose of this document is to provide stakeholders with a clear understanding of what the system will address and deliver, as well as a qualitative analysis of its performance. The purpose of the project is to bridge the gap in energy access and consumption, through a decentralised system operated by the state.

1.3 Background

With wind energy and solar contributing to a total of 27% of the power consumed in 2022, it only makes sense that a hybrid of the two, implemented in cities, is the future for renewable sources of energy. Australia has a network of highly-developed and complex power grids which is supported by multiple power sources including natural gas, coal, wind and solar energy. If we break the percentages down, we find that wind power is the largest contributor at 12.8% with domestic rooftop solar coming in second with a strong 9.3%. These two figures show that wind and solar are imperative to the growth of renewables in Australia.

With wind and solar energy becoming increasingly significant in supporting our power grids in recent years, renewable energy sources have been a focal point for state policies and our aims to develop greater technologies to further their contribution and reduce Australia's reliance on carbon emission producing sources.

Wind farms have been implemented in a number of NSW’s highlands, these wind farms include, the silverton wind farm, capital wind generation fields and the sapphire wind farm. The placement of these wind farms allow for power generation in core segments of the state to help provide effective power distribution while still minimising power loss over distance.

Solar energy contributed to the state power grid through two main sources, residential power generation from solar panels installed on users roofs that directly feed into the users own residence and then back into the power grid or through major solar farms. The decentralisation of solar energy generation through residential areas has seen a significant increase of the past 5 years and this increase has allowed for dramatic decreases in overall costs. This cost reduction significantly increases the effectiveness of solar generation and NSW state policies are continuously being reviewed to improve the affordability and encourage growth.

1.4 Problem Statement

This project highlights the necessity for the transition towards statewide renewal energy distribution as the current world is faced with the adverse effects of climate change. This document discusses comprehensive development goals for transition to a renewable energy distribution system, through integrating monitoring & control mechanisms. Ultimately adopting this transition is imperative to mitigate climate change.

The engineers plan to address the problem by integrating state available renewable resources in the form of solar and wind power. The concept design includes optimising wind energy for commercial use whereas solar is used for residential use. These renewable elements define themselves as a promising solution however, effective utilisation is cornered by various technical and operational challenges. Wind & Solar generated power were significantly consumed in 2022, with solar at 9.3% and wind at 12.8%. However, several technical & operational challenges related to effective utilisation were faced (Australian Energy Update, 2023). These figures underscore the imperative role of wind & solar energy in Australia. Policies like Renewable Energy Target (RET) aimed for 33,000 Gwh of renewable energy generation by 2020 however this was not met (NSW Government, 2022).

Residential and Commercial demands tend to be constantly fluctuating, leading to challenges in equal energy supply of solar and wind power generation. As a result, the design of an unattainable monitoring and control system capable of adjusting energy distribution to accommodate changing energy demand is required. Other serious challenges such as adverse weather conditions also indicate unreliability of the grid system, posing threats to grid management and mechanism. This condition will require a dynamic & advanced grid management system to gain control of the mechanism to fully integrate seamless operation. Moreover, optimal utilisation of the resource is necessary to effectively harness solar and wind; however, precise forecasting as well as coordination is required to do so. In this instance, engineers must develop a dynamic system so that; the economic viability & environmental benefits of the renewable energy system are not compromised. This new design system must also possess evolving characteristics & capabilities to address the ever-changing patterns of renewable energy sources.

The primary objective of this report is to approach a multidisciplinary plan to address these challenges; eventually developing & implementing a statewide renewable energy distribution system. This system will have dynamic integration monitoring & control mechanisms to efficiently & effectively manage uneven energy distribution. This project aims to revolutionise the current sustainable energy field through infrastructure development to create a low-carbon future.

1.5 Justification

A statewide distribution of energy enables diverse efficiency of renewable energy sources across different regions by integrating solar and wind power for statewide consumption. This can help with the reduction of greenhouse gas emissions, monitoring to ensure compliance with environmental standards, and promoting cleaner and more sustainable energy systems that ensure long-term viability.

The renewable energy sources are based on the weather conditions, whereas cloudy days affect solar panels while calm days impact wind turbines. In this case, a distribution system balances uneven generation by integrating multiple sources and control mechanisms to ensure a stable supply even during fluctuations. Moreover, monitoring systems track energy demand patterns by analysing data that can implement load management strategies, control systems adjust energy flow, prevent the grid congestion, and maintain stability during peak demand or sudden changes. This energy can maximise overall generation capacity by monitoring and control systems enabling real-time adjustment to match energy production with demand and minimising wastage. This energy can also help reduce the transmission losses based on the region where there is no need to get energy from elsewhere.

1.6 Project Objectives

The goal of this project is to develop and deploy a statewide renewable energy distribution system. The systems will have integrated monitoring and control mechanisms, with the objective of even and efficient energy generation, as well as distribution. The project will be undertaken by a diverse group of engineers, spanning multiple disciplines including electronics, mechatronics, mechanical, civil and software engineering. The project will commence upon government approval, with a clear timeline established for completion. The project will be focused statewide, spanning across all regions and sectors within the state.

The main benefits of this project include advanced monitoring and environmental sustainability. With the addition of state-wide renewable energy, to achieve even generation as well as even distribution of energy, control systems are required to be in place. These control systems will be in place in both the generation stage and distribution stage of the system and will aid in improving reliability and producing a more even energy system. Another benefit of this project is the push for environmental sustainability. The project would aid immensely in reducing the carbon emissions of the targeted area, while also reducing the reliance on fossil fuels. This will aid in the push for sustainable energy practices and can promote more green infrastructure. Additionally, as time goes on, while fossil fuels will start to rise due to limited supply, infrastructure that uses renewable energy will have a higher chance of maintaining a more stable cost.

The costs of this project include expenses and transition challenges. Expenses refer to both the initial investment required, but also the ongoing expenses for maintenance, monitoring and system management. The expenses for this project will be incredibly high at first, during the initial investment. The undertaking that is proposed aims to replace the previous energy system with renewable energy. The energy generation systems, such as solar systems as well as wind farms will be incredibly expensive, however over time, will reduce their cost as fossil fuels will become more depleted and increase in cost as time goes on, while renewable energy will not increase as much. Transition challenges refer to the problems that may arise such as grid relation issues, regulatory hurdles and stakeholder resistance. As the project commences, regulatory hurdles will have to be carefully managed and navigated through. Additionally, extra manpower, processes and control systems would be needed initially due to the possible grid regulation issues that could arise due to utilising the same grid structure, but with differing energy generation sources.

Despite these costs, the long-term benefits of the solution, including environmental preservation, energy security, and economic prosperity, justify the investment and provide a compelling case for its implementation.

1.7 Project Constraints

Table 1. Project Constraints

ID	Description
P.C.1	Budget Limitations: A pre-decided budget constraint is a limitation for the project, requiring careful allocation for resources & budget-friendly solutions. This imposes constraints on the quality of the equipment bought, manpower quality & technologies compromising performance for affordability.
P.C.2	Time Constraints: The project must follow a strict timeline, making sure each milestone is reached on time. Any delays in project timeline may compromise the quality of the product as well as significant cost overruns. Moreover, customer relations may be affected.
P.C.3	Resource Availability: Several factors may lead to unavailability of skilled labour, manual labour, equipment, materials & renewable resources. This may cause significant effects in project timeline, efficiency, product viability & management strategies.
P.C.4	Technical Limitations: The integration of this project is mainly reliant on technological use which poses a risk on product reliability. In cases of technological performance issues, there are Renewable energy technologies are widely subject to technological limitations restricting flexibility leading to requirements for selective design phases. Moreover, issues related to inter connection between the grid connection & the distribution system may arise which may challenge the logistics

	and stability of the project.
P.C.5	Regulatory Limitations: The design of this project must follow all the relevant Australian guidelines and standards such as compliance to environmental regulations, safety standards etc. It must also strictly adhere to any regulatory guidelines set out by the client as well as all the stakeholders.
P.C.6	Geographic Constraints: The status & availability of the renewable resources being used for this project significantly depend on various geographical factors such as climate, terrain, land mass etc. These factors must be taken into consideration during site selection to ensure mitigation impacts.
P.C.7	Stakeholder Concerns: Approval of local councils, communities, land owners & industry clients are essential for the success of this project. These stakeholders' concerns must be met; it must be understood that their decisions may influence the outcome of this project.

2 Requirements

2.1 Functional Requirements

This section defines the expected features and functionalities of the proposed solution.

Table 2. Functional Requirements

ID	Description	Related TPM
FR.1	Environmental monitoring protocols for assessment of environmental impact (EIS System)	TPM6
FR.2	Cybersecurity measures to protect system from unauthorised access and cyber-attacks	TPM7
FR.3	Metering infrastructures for accurate measurements of power generation and consumption. Proper distribution of generated electricity to residential, commercial, and industrial consumers through the grid infrastructure, including transformers, substations, and distribution lines	TPM5
FR.4	Remote monitoring capabilities allow operators to track performance, diagnose issues, and adjust settings as necessary for optimal operation and maintenance.	TPM8
FR.5	System scalability to meet growing power consumption needs.	TPM1

	Designing the grid to accommodate future expansion of solar and wind capacity and adapt to changes in energy demand and technological advancements.	
FR.6	The primary function of a wind turbine system is to convert wind energy into electrical power efficiently. Wind turbine systems for commercial power grid utilisation.	N/A
FR.7	The system should incorporate safety mechanisms to protect against over-speeding, extreme weather events, and potential hazards to both the turbine and surrounding environment	TPM10
FR.8	The primary function is to effectively convert solar radiation into electrical energy through photovoltaic (PV) panels or concentrated solar power (CSP) systems. Solar energy systems designed to distribute power for residential purposes.	N/A
FR.9	The turbine must seamlessly integrate with the electrical grid, including systems for power transmission, voltage regulation, and grid stability.	TPM3
FR.10	Components must withstand the stress of continuous operation in various weather conditions, ensuring long-term reliability	TPM4
FR.11	The system must adhere to relevant industry standards and regulations governing safety, environmental impact, and grid interconnection	TPM3
FR.12	Incorporation of safety measures to protect against electrical faults, overloads, and grid disturbances, ensuring the safety of both the grid infrastructure and end-users.	TPM4
FR.13	Integration of energy storage solutions such as batteries to store excess energy generated during peak sunlight hours for use during periods of low or no sunlight	TPM2
FR.14	Ensuring seamless integration with existing electrical grids, including synchronisation with grid frequency and voltage levels for stable power supply	TPM3

2.2 Performance Requirements

This section specifies the criteria which determine how well the system performs and defines the standards it needs to achieve to be considered an efficient solution.

Table 3. Performance Requirements

ID	Description	Related Functional Requirement	Related TPM
PR.1	System availability should be at least 99.9% to ensure continuous power distribution.	FR.2	TPM4
PR.6	The system should respond to generation and load fluctuations within 50 milliseconds.	FR.2	TPM4
PR.2	Monitoring systems should detect faults and initiate responses within 100 milliseconds to maintain uninterrupted service.	FR.2	TPM4
PR.3	The system should be able to accommodate 20% increase in renewable energy generation capacity and load demand within five years.	FR.5	TPM1
PR.4	The system should provide user-friendly and secure interfaces for monitoring and control teams.	FR.3	TPM7, TPM8
PR.5	The system should ensure compatibility with existing infrastructure and future upgrades by adopting industry-standard communication protocols (e.g., IEC 61850).	FR.10	TPM3
PR.6	The queries used in the database system should be highly optimised to ensure fast storage and retrieval of data.	FR.2	TPM9
PR.7	The proposed software should be portable across key systems and operating systems used by monitoring and control teams.	FR.10	TPM8

2.3 Interfacing Requirements

This section specifies the conditions in which group systems will interface.

Table 4. Interfacing Requirements

ID	Description
IFR.1	Solar and Wind subsystems need to work together
IFR.2	Wireless data transfer for ease of monitoring and viewing system status remotely
IFR.3	System should work efficiently with minimal losses when harvesting and dissipating

	energy
IFR.4	All connections should be secure and easily serviceable
IFR.5	Use specific software for solar and wind to optimise power generated and dissipated in hybrid systems.
IFR.6	Compliance with national standards for connecting to existing power grids
IFR.7	Protocols for interconnections with existing utility infrastructures
IFR.8	Interfacing for connecting energy storage systems to balance supply and demand with battery energy storage systems
IFR.9	Communication protocols for monitoring, control and data exchange between power generation system, power storage system and grid operations
IFR.10	Power consumption monitoring system for
IFR.11	Integration protocols with distributed generation sources
IFR.12	Integration with with energy markets for scheduled participation in demand response programs
IFR.13	User-Interfaces for system operators to access real-time and historical data

3 Final Design Solution

3.1 Schematics

3.1.1 Electrical Distribution

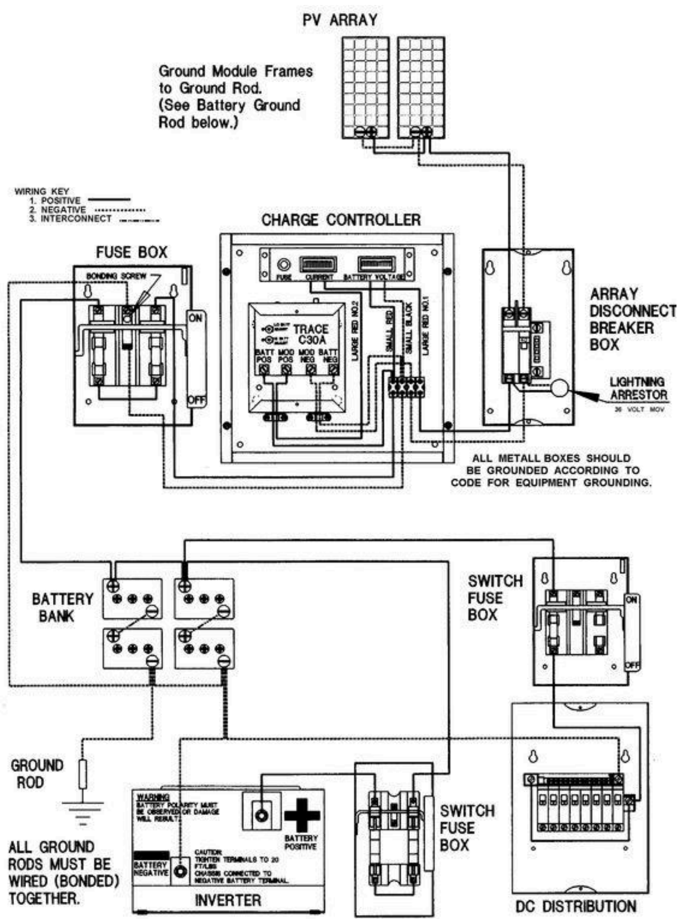

Figure 1. Solar panel to grid distribution [12]

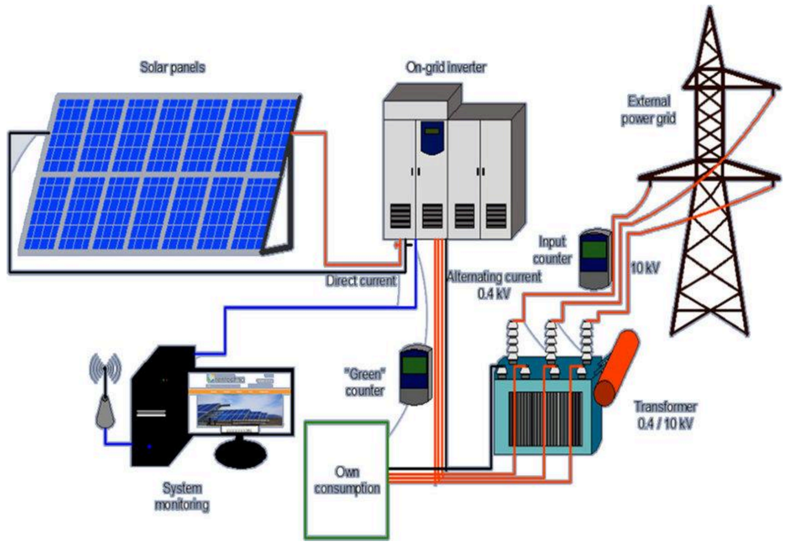

Figure 2. Visualisation of power distribution for residential power consumption. [11]

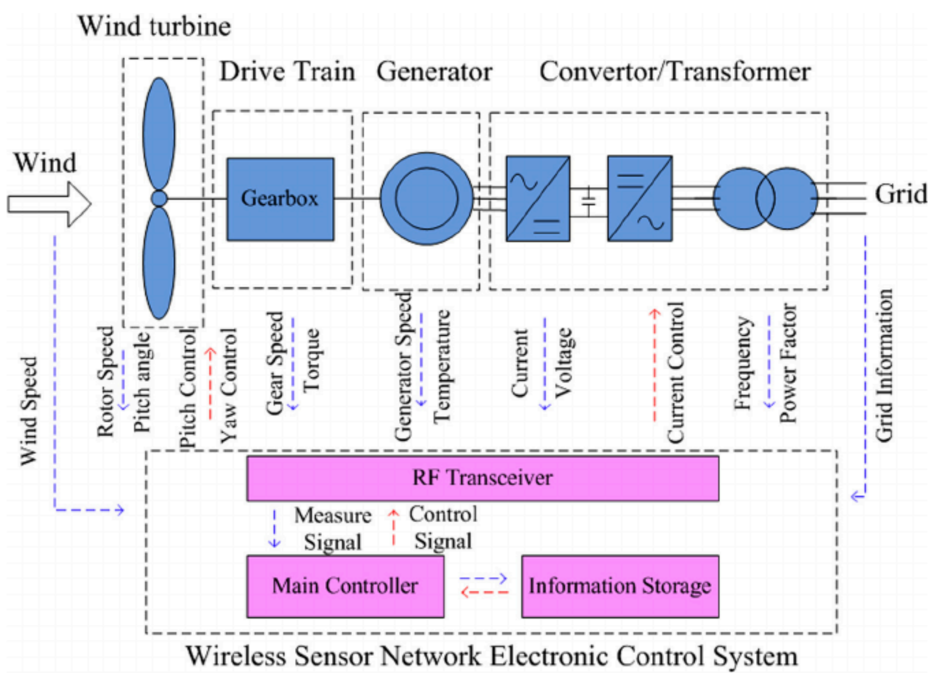

Figure 3. Wind Turbine Schematic [13]

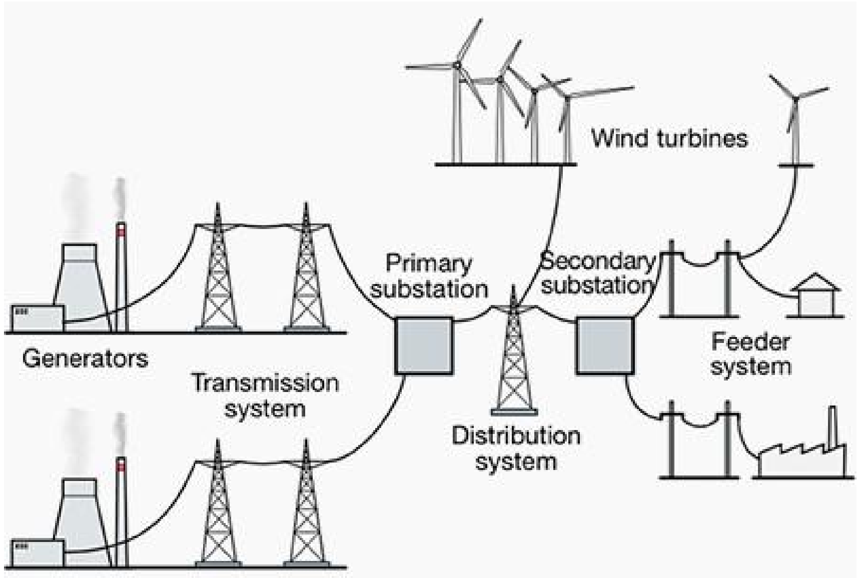

Figure 4. Wind Turbine grid distribution [14]

3.2 Subsystem Specifications

3.2.1 Structural

Solar Panels

Based on the manufacturing drawings provided in the Appendix, the solar panel array is designed with the following dimensions:

1. Dimensions: (Length) 5m x (Width) 4m x (Height) 1m
2. Angle (at tilt): 15 degrees
3. Location: New South Wales

15 degrees of tilt angle was selected to maximise sunlight capture in NSW.
The foundation that supports the solar panel array is a significant aspect of this design project. Several structural components were crucial for the design and some of them include:

- Galvanised Steel Frame: Galvanised steel frames are resistant to corrosion & offer long term durability. This frame will be constructed with dimensions 10m x 4m x 1m with a 30 degree tilt allowing maximum sun exposure & capture.
- Concrete Footing Foundation: These foundations are design at 0.2m x 0.2m each; which is a standardised size used for solar footings. These footings are concrete poured thereby acting as a solid base isolating each footing. This allows for even distribution of the weight/load therefore able to withstand strong wind forces.

Recommendations and specifications

- Optimal Positioning: The solar panels are positioned facing directly to the sun in order to maximise sun exposure.
- Robust Frame Design: The galvanised steel frame is constructed for adjusting solar panel together with a dimension of 5m *4m with a height of 1m from the ground and slope of angle 15 degrees.
- Secure Mount: The panels are mounted on a structure with brackets to withstand local wind loads and other environmental stress.
- Concrete Footing Specs: The concrete foundation dimensions to support the footing is 0.2m *0.2m for each foot.
- Material Specs: All the material specifications such as mounting frames and brackets are made from galvanised steel to prevent corrosion and ensure durability.
- Maintenance Access: Safe access point for maintenance to ensure the longevity and efficiency of the system.

Table 5. This is a cost estimation of the mounting structure and concrete footing for each blog.

Description	Estimated Cost Per Unit $	No of Units	Total Cost $
Mounting structure			
Galvanised steel rails	50	10	500
Adjustable tilt brackets	30	8	240
Mid clamps	5	16	80
End clamps	5	16	80
Screws and Fasteners	0.5	100	50
Concrete footing			
Concrete mix (20kg bag)	8.5	47	399.5
Rebar	10	10	100
Total estimated cost			1449.5

Wind Turbine

In designing the wind turbine there are several construction component keys that need to be considered to ensure stability, efficiency and longevity. The tower is made out of steel with the shape of tubular that has the height of 100m, base diameter of 5m and top diameter of 3m and the blade length of 50m. The blade shape is in aerofoil shape to maximise lift and minimise drag force. Moreover, the foundation is a type of gravity base foundation that is made out of reinforced concrete, has a diameter of 20m with depth of 3m and high strength steel rebar for reinforcement.

In this design there are three different loads that need to be considered such as aerodynamic loads, axial loads that come from the rotation of the blade and gravitational load. These loads are considered on the blade. For the load act on the tower are static loads of the machinery and rotor, dynamic load that come from wind load and operational loads and fatigue loads due to cyclic loading from wind variation and rotor movement. Finally, the load act at the foundation needs to be considered on bearing capacity based on soil type and load requirements and wind load resistance to prevent falling [9].

Recommendations and specifications

- The tower height is 100m with the bottom diameter of 5m and top diameter of 3m.
- There are 3 blades for each turbine machine that has a length of 50m.
- Machinery such as gearbox, generator and control system need to be mounted.
- Foundation is reinforcing concrete that has a diameter of 20m, depth of 3m with high strength steel rebar for reinforcement.

Table 6. This is the cost estimation for each wind turbine machine.

Description	Estimated Cost Per Unit $	No of Units	Total Cost $
Rotor and blades			
Rotor blades	150,000	3	450,000
Transportation and installation	30,000	1 set	30,000
Machinery	-	-	-
Gearbox, Generator and Control System	300,000	1	300,000
Assemble and Installation	70,000	1	70,000
Tower			
Steel tower	500,000	1	500,000

Transportation	50,000	1	50,000
Installation	100,000	1	100,000
Foundation			
Concrete (942m^3 @100/m^3)	100	942	94,200
Steel bar (200 tons @1,000$/ton)	1,000	200	200,000
Total estimated cost			1794200

3.2.3 Electrical

In order to provide an effective and sustainable energy supply, this design describes a fully integrated renewable energy distribution system that combines solar and wind. The main components of the system are high-efficiency monocrystalline silicon solar panels placed on top of residential and commercial buildings, designed to maximise photovoltaic conversion efficiency and expected to provide a stable output for at least 25 years; ground-mounted wind turbines deployed at state commercial facilities and in open areas, each rated at 2 megawatts (MW), with resistance to inclement weather and an expected lifespan of at least 20 years.

We have developed a sophisticated energy storage system that integrates lithium-ion batteries, supercapacitors for high-frequency charging and discharging, and superconducting magnetic energy storage (SMES) devices for large-scale energy storage. These energy storage options not only make energy use more flexible, but they also significantly improve the system's capacity to handle variations in output, guaranteeing the security and continuity of the energy supply. A state-of-the-art integrated energy management system (EMS) oversees the entire system. It is furnished with cutting-edge monitoring technologies and sophisticated algorithms that facilitate real-time analysis of energy output and consumption, optimization of energy flow and operation, and support for remote monitoring and troubleshooting to improve the responsiveness and manageability of the system. Using an integrated approach, our design not only contributes to environmental sustainability but also offers a stable, dependable, and effective energy supply solution that serves as a strong foundation for industrialization and urban growth. This helps to lower carbon emissions and stimulate economic growth while protecting our natural resources and guaranteeing energy security and diversity. To ensure the safety and dependability of the system, all components will adhere to Australian Electrical standards as well as the International Electrotechnical Commission's (IEC) performance and safety requirements.

Table 7. List of materials required for the proposed electrical services design.

Description	Estimated Cost Per Unit $	No of Units	Total Cost $
High-efficiency monocrystalline silicon photovoltaic panels	300/m^2	100m^2	30,000
Wind Turbine (minimum 2 MW)	2,000,000	2	4,000,000
Lithium-ion Battery	100/kWh	500 kWh	50,000
Ultra-capacitor	30/kWh	100 kWh	3,000
SMES system	500,000	1	500,000
Inverter (500kW to 1MW)	100,000	6	600,000
Circuit Breaker (100A to 250A)	100	10	1,000

High-efficiency monocrystalline silicon photovoltaic panels:

These solar panels have an energy conversion rate of at least 20% which makes them the ideal panel to use in terms of efficiency along with having low maintenance costs. These panels have an outstanding resistance to weather erosion allowing them to be ideally suited for both residential and commercial power distribution. The resilience of these panels guarantees dependability and sustainable functionality over harsh weather conditions.

Wind Turbine (minimum 2 MW):

The use of 2MW capacity wind turbines minimises operational noise and disruption to the surrounding environments. These turbines are designed to function steadily in various wind conditions, which makes them appropriate for large-scale power generation for commercial use. These turbines fulfil the needs of our design, with the benefit of being energy efficient which allows us to be environmentally sustainable.

Lithium-ion Battery:

The extended life cycle and high energy density of a lithium-ion battery enables the energy consumer base to have power support for 4-6 hours. Li-ion batteries are a popular option on the market and work well for devices that need to be charged and discharged frequently.

Ultra-capacitor:

The use of ultracapacitors in our systems helps greatly enhance system reactivity and prolongs the service life of the system. Our system demands to be quickly discharged at high loads, which makes use of the ultracapacitors appropriate for this function. The ultracapacitors increase grid stability and are well suited for valley levelling and peak shaving.

SMES:

Superconducting Magnetic Energy Storage (SMES), functions as a long-term storage solution for the energy produced that lowers the energy loss and elevates the overall system functionality and efficiency. They are appropriate for storing energy during times of low demand.

Grid-connected inverters:

Grid-connected inverters provide a direct interface to the grid compatible with solar and wind power systems. In order to minimise energy losses and provide remote monitoring, control, and smart grid activities like load management and demand response, they should have a minimum conversion efficiency of 98%.

Circuit Breakers:

The simplicity of installing and maintaining modular circuit breakers makes it ideal for use in our system for cutting off circuits when an electrical problem is identified. These circuit breakers would have an interrupting capacity of minimum 10kA and a current rating of 100A to 250A to interface with our system. They are ideally suited for systems with maximum loads as seen in residential and small business applications. The system will be further improved and protected using total overload and short circuit protection along with a ground-fault prevention system.

3.2.4 Sensors

For our proposed system, sensors play a major part in introducing renewable energy within the distribution grid and aiming for even distribution and generation of energy. With the help of sensors, we can monitor both the health and flaws of renewable energy production, as well as conduct asset maintenance by using sensors to produce information on important metrics, such as temperature, voltage output and other variables. This allows the team overseeing energy production to have a well rounded perspective of the energy generation, ability to alter inputs based off of outputs and produce closed-loop systems that can adjust differing parameters based on the goal of even energy production. With energy distribution, there is a proven track record of sensors used in major cities to assist with even energy distribution and allow for redistribution of energy. Shown below are the sensors required for even energy generation as well as distribution

Wind Turbines

- Vibration Sensors

Vibration Sensors are needed to detect misalignments or unexpected vibrations. For our system, our recommendation is to have both a Wired Condition Based Monitoring (CbM)

Evaluation Platform and ADcmXL3021 per wind turbine from Analogue Devices. This allows for a range of vibration sensors attached to the same platform. The cBM platform cost $235.4, and the vibration sensor cost $235.16.

- Temperature Sensors

These are required to monitor temperature for operational efficiency and air density effects. Companies such as Senmatic offer temperature and humidity sensors for the wind power industry. The sensor we recommend is the Type AMK Thermocouple, which costs about $400.

- Wind Speed and Direction Sensors

These are required to determine energy generation potential from wind speed and optimize turbine positioning for maximum energy capture. Brands such as Lambrecht sell sensors that provide for both functions, within a compact low energy and robust package. The ARCO SDI-12 Wind sensor is the sensor we recommend and has a cost of $3079.14.

- Barometric Pressure Sensors

Barometric Pressure Sensors are needed to measure atmospheric pressure that could affect wind patterns and energy production. Companies such as NRG Systems offer barometric pressure sensors modelled for remote wind and solar energy studies. The sensor we recommend is the NRG BP65 BAROMETRIC PRESSURE SENSOR, which costs $330.

- Strain Gauges

Strain Gauges are needed to assess mechanical stress within mechanical systems. Companies such as HITEC Sensors specialise in stress gauge sensors for wind turbines. The sensor we recommend is the NRG BP65 BAROMETRIC PRESSURE SENSOR, which has a cost of $330.

Solar Panels:

- Environmental Sensors

These are required to measure panel performance under various environmental conditions. Companies such as Solar Edge provide sensors to monitor irradiance, temperature, and wind velocity, and utilise these metrics to estimate and alter the performance ratio of the solar panel system. The sensor we recommend is the SE1000-SEN, which is an array of sensors. There are differing sensor modules such as irradiance sensors, ambient temperature sensors, temperature sensors and wind sensors. These cost about $500 per module, adding up to $2000 total.

- Inverter Sensors

Inverter Sensors are needed to monitor inverter efficiency and performance for optimal energy conversion. Companies such as SunGrow provide inverter sensors. The sensor we recommend is the SG8.0RS-ADA, which has a cost of $2145.

Battery Storage:

The battery storage sensors that are recommended are modelled off of a large solar power battery called the Hornsdale Power Reserve in South Australia. The sensors that are being used include temperature sensors, voltage sensors, current sensors and inertia sensors.

- Temperature Sensors

Temperature Sensors are important for monitoring the temperature of battery cells. We recommend the NTC thermistors because they are used for temperature sensing in battery packs. The Hornsdale Power Reserve is around a 200 MWh system. Assuming 1 temperature sensor per 10MWh, in total we would need 20 temperature sensors. With an approximate price of 75 dollars each, the total price is $1500.

- Voltage Sensors

Voltage Sensors are important for monitoring battery performance and grid stability. Our recommendation is to use a Hall effect voltage sensor, because of their accuracy and reliability. The Hornsdale Power Reserve is around a 200 MWh system. Assuming 1 voltage sensor per 10MWh, in total we would need 20. With an approximate price of 125, the total price is $2500

- Current Sensors

Current Sensors are important for monitoring battery performance and grid stability. Our recommendation is to use a Hall effect current sensor, because of their high precision and power to handle large flow ranges. The Hornsdale Power Reserve is around a 200 MWh system. Assuming 1 current sensor per 10MWh, in total we would need 20. With an approximate price of 125, the total price is $2500

- Inertia Sensors

Inertia Sensors are important to stabilise grid frequency, improve grid stability and prevent blackouts. Our recommendation is to use inertia measurement units (IMUs), because of their high precision, ability to manage large current ranges and ability to react dynamically to grid conditions. The Hornsdale Power Reserve is around a 200 MWh system. Assuming 1 IMU per 50MWh, we would need 4 IMUs. With an estimated price of 1000 dollars each, the price for current sensors would be $4000.

3.3 Environmental Considerations

In our design of a hybrid solar and wind solution to handle uneven generation and load of electricity, large pieces of land are required to house our generators, power collection systems, transformers, substations, and all other equipment. We, the engineers behind this project, recognise the environmental risks associated with the project, and have taken utmost measures to ensure that our systems are built in accordance with environmental policies (*Commencement of the Protection of the Environment Operations Amendment (Scheduled Activities) Regulation 2013*) and our sense of duty to the land.

Our state-wide renewable system aims to handle uneven load in an environmentally friendly and renewable way, however, as any other large scale construction project, our project can also pose environmental risks if not done properly. For this reason, we have formulated some strategies:

- Our sites for the project will be selected based on the results of Environmental Impact Assessments (EIA) performed as a State Significant Project under the NSW Environmental Planning and Assessment Act (1979). Prior to establishing our solar and wind farms, our team will perform these EIAs to scope out potential impacts on local ecosystems.
- Our aim is to prioritise areas with minimal ecological sensitivity, such as barren unused lands in western Australia. It is crucial to us that we avoid critical habitats, migratory paths, and protected areas. Our designs aim to optimise land use and preserve natural habitats such as rivers, waterways, wetlands, deserts, plains, forests, bush and coastal areas as much as possible in line with the *Environment Protection Act 1997*.
- Our strategy involves the implementation of deterrent systems (for birds, bats and more) around wind farms to reduce collision risks, and use bird-friendly turbine designs and operational strategies.
- Our engineers are opting for sustainable, recyclable, and low-impact materials in the construction of solar panels, wind turbines, and associated infrastructure. We will employ construction techniques that minimise soil disruption and erosion, such as ensuring vegetation buffers are protected, and restoring disturbed areas with native vegetation after construction works are completed. Where possible, our team will also attempt to employ our solar panels as canopies for existing vegetation.
- Design of our solar farms contain water-efficient cleaning systems. Dry cleaning methods or recycled water will be used for panel maintenance. We aim to ensure construction and operation activities do not contaminate the water bodies surrounding our sites by keeping strict protocols in place.
- We will be using environmentally friendly and recyclable batteries for energy storage, and ensure proper disposal and recycling of batteries to prevent contaminating the environment. Protocols will be followed for recycling and disposing of solar panels and wind turbines at the end of their lifecycle to minimise waste and environmental impact.
- Measures to reduce noise and light pollution from wind turbines and solar farms, such as noise barriers and down-shielded lighting, will be implemented.
- We will ensure that the construction and maintenance of energy facilities are conducted with machinery that meets emission standards.
- One of our strategies is to engage with local communities to understand their concerns and incorporate their input into project planning and execution, as well as offer employment and training opportunities. Developing programs to educate the public about the environmental benefits of renewable energy and promote sustainable energy practices is also part of our strategies.

- We will be implementing monitoring systems to track environmental parameters (e.g. wildlife activity, water quality etc) continuously, and use this data to make informed decisions regarding operations.
- Through these steps we aim to minimise the carbon footprint of the entire project lifecycle, from construction through to decommissioning.

4 Testing Schedule

4.1 Technical Performance Measures

TPM1 - Capacity and Scalability

Table 8. TPM1 - Capacity and Scalability

Purpose of TPM	To ensure that the system has enough capacity to handle 20% more than the energy coming in and going out.
What to be measured:	The vibrations, temperature and usability of the system during simulated tests of over 20% power, as well as uneven bursts of energy.
Method of measurement:	Monitoring using sensors on the system, such as vibrations sensors, heat sensors and power output sensors
Measure of success	The system can handle many variances of power and still be able to handle it efficiently
Measure of failure	If the system shuts down or cannot handle the power input.
Possible causes of failure	● Capacity being too small ● The power sent to the system being too much ● The subsystems connecting the system are not being strong enough.

TPM2 - Storage Efficiency

Table 9. TPM2 - Storage Efficiency

Purpose of TPM	Measure how well the plant is storing the energy that is being harvested
What to be measured:	The capacity of storage and how much loss is occurring in the process.
Method of measurement:	Using a sensor and algorithm to calculate how much energy we are losing and what the reason is for losing it.

Measure of success	The efficiency of the system is as close to the manufacturer's specifications.
Measure of failure	Any loss greater than 10% of what we have calculated in theory.
Possible causes of failure	● Inefficient connections ● The location or routing of the system can cause loss due to temperature/distance. ● The materials used are inefficient. ● The programming has flaws.

TPM3 - Grid Integration and Stability

Table 10. TPM3 - Grid Integration and Stability

Purpose of TPM	To ensure Solar and Wind power generation systems integrate seamlessly with existing power grids
What to be measured:	Grid support service performance including reactive power support and distribution
Method of measurement:	Monitoring and analysis of grid parameters including frequency and voltage and grid support service performance metrics through grid analytics tools
Measure of success	- Frequency and Voltage variations within nominal values - Effective provisions of grid support services
Measure of failure	- Frequency and voltage variations outside nominal values - Failure to provide adequate grid support when needed
Possible causes of failure	- Insufficient grid connection infrastructure - Inaccurate forecasting and energy management - Inadequate grid support

TPM4 - Reliability

Table 11. TPM4 - Reliability

Purpose of TPM	Monitor consistent and uninterrupted power support from solar and wind generation systems to connected power supply grid
What to be measured:	- System availability - Time between system failures - Time of system repair
Method of measurement:	Tracking of operational data of TSF and TSR and overall system availability metrics
Measure of success	- System availability time - High TSF - Low TSR

Measure of failure	- Low System availability times - Low TSF - High TSR
Possible causes of failure	- Equipment failures - Insufficient maintenance - Extreme weather conditions affecting system components

TPM5 - Load balancing Accuracy

Table 12. TPM5 - Load Balancing Accuracy

Purpose of TPM	Accurately match power generation with load demand to ensure efficient operation and minimise power imbalances
What to be measured:	Load balancing accuracy measured through accurate loads against power generation
Method of measurement:	Analysing deviations between load and generation forecasted against measurements over specified time intervals
Measure of success	A high accuracy when balancing the load and little to no power imbalances
Measure of failure	Unaccurate matching, if the power is too high or low on either end or if the operation is not efficient enough i.e. too much loss when balancing power.
Possible causes of failure	- Inaccurate load and generation forecasting - Sudden changes in generation capacity - Failure in demand response

TPM6 - Environmental Impact

Table 13. TPM6 - Environmental Impact

Purpose of TPM	Minimise environmental impact of solar and wind farm power generation systems while meeting power demands
What to be measured:	CO2 emissions, land use impact, wildlife and habitat stability
Method of measurement:	Analysis of CO2 emissions against conventional power generation method emissions. Land surveys before against after construction and environmental impact assessments
Measure of success	Making the system efficient enough to not need many generation systems especially for wind as it takes a lot of space on the ground. Making the setup process efficient to reduce emissions when building and assembling.
Measure of failure	The power generation is not strong enough from what we

	calculated. The ecosystems around the plant and generators are disturbed. Too many emissions from our project are harming the environment.
Possible causes of failure	- Construction and operation disruption on local ecosystems - Fluctuation in wildlife population and habitable land density

TPM7 - Cybersecurity

Table 14. TPM7 - Cybersecurity

Purpose of TPM	Measure cybersecurity risks on the monitoring system for power generation, load and distribution.
What to be measured:	System vulnerabilities, threat detection and response, access control, data integrity, compliance.
Method of measurement:	Penetration testing, log analysis and monitoring, access audits, compliance audits.
Measure of success	- Identification and remediation of criticals vulnerabilities within 30 days - Detection of all simulated threats during testing (99%) - No unauthorised access detected during audits - Successful completion of incident response drill
Measure of failure	- The system fails to identify and respond to incidents and threats - Frequent reports of unauthorised access - Failing to detect simulated threats
Possible causes of failure	- Outdated software or hardware - Inadequate security patches - Weak access control policies - Insufficient monitoring and logging - Human error

TPM8 - Monitoring System - User Interface

Table 15. TPM8 - Monitoring System

Purpose of TPM	Measure the effectiveness and usability of the user interface of the monitoring system.
What to be measured:	User experience, intuitiveness of the design, data readability, accessibility, system integration.
Method of measurement:	Surveys and feedback, usability testing, performance testing.
Measure of success	- Positive feedback from users and positive results of user

	stories testing - Accurate display of data - Error messages are clear and informative - UI integrates seamlessly with underlying systems
Measure of failure	Low user satisfaction, poor error handling, integration issues, non-compliance with accessibility standards.
Possible causes of failure	- Poor design of UI - Lack of user testing - Insufficient error handling - Limited user feedback - Inefficient design of backend processes resulting in incorrect or outdated display of data

TPM9 - Monitoring System - Queries

Table 16. TPM9 - Monitoring System

Purpose of TPM	Measure the optimisation of database queries to ensure high speeds to detect uneven generation, load and distribution effectively.
What to be measured:	Query execution time, resource utilisation, query complexity, index utilisation.
Method of measurement:	Performance profiling, query analysis tool (EXPLAIN, Query Store), index analysis, load testing.
Measure of success	- Queries execute within acceptable timeframes (~0.3 seconds) - Consistent return of accurate and reliable data - Consistent performance under varying loads during testing - Proper indexing in query execution
Measure of failure	Slow query execution, high query complexity, poor indexing, high resource utilisation, inaccurate data.
Possible causes of failure	- Lack of indexes - Inefficient design - Insufficient memory resources - Network latency - Software bugs

TPM10 - Wind Turbine Safety

Table 17. TPM10 - Wind Turbine Safety

Purpose of TPM	Measure the effectiveness of the safety system designed to protect wind turbines.
What to be measured:	Functioning of over-speed protection, extreme weather detection, monitoring structural integrity, emergency shutdown procedures, alarm and notification systems.
Method of measurement:	Simulation testing, sensor calibration and testing, stress testing, emergency drills, compliance audits
Measure of success	- Turbine over-speed conditions are prompt detected and mitigated by the system - Accurate and timely extreme weather detection - Continuous structural monitoring - Alarm systems function accurately and promptly
Measure of failure	Delayed over-speed mitigation, alarm systems failing time constraints during tests, failure to meet safety standards
Possible causes of failure	- Sensor malfunction - Software bugs - Hardware failure - Environmental interference - Human error - Lack of maintenance - Inadequate testing

5 Final Design Review

The final design review of this renewable energy integration project covers a meticulous evaluation of the strategies & proposed technologies aimed to effectively conclude this report. All components incorporated in the project have been carefully chosen to optimise renewable energy generation. Several significant factors such as: efficiency, reliability, scalability, environmental impact, cost & budget, council & government regulations etc were considered during the selection process. Monocrystalline silicon photovoltaic solar panels are to be used to generate renewable solar energy whereas, minimum of 2 MW wind turbines are to be used to generate renewable wind energy in this project. These elements are particularly selected to be used in this project for several reasons which are all highlighted in section 5.1. The integration of energy storage solutions include lithium-ion batteries, superconducting magnetic energy storage & ultracapacitors. They are considered for their assurance in grid stability & reliability however they are likely to be complex and are not cost efficient. Although they have some disadvantages, they offer great compatibility, safety & ease of maintenance. Additionally, incorporation of a variety of sensors for monitoring was critical to ensure a data driven decision system. However, integration requirements of several components may pose challenges during assimilation. Overall, although this proposed design offers notable benefits in terms of grid efficiency & energy utilisation, the identified critiques must be addressed carefully to ensure successful implementation of the project.

5.1 Justifications and Critique for Photovoltaic Solar Panels

Table 18. Justifications and Critique for Photovoltaic Solar Panels

JUSTIFICATIONS	CRITIQUES
Efficiency: Electricity production per unit area is effectively maximised due to monocrystalline panel’s ability to offer superior energy conversion rates.	Initial Cost: When compared to conventional solar panels, monocrystalline panels have a higher initial cost which can impact the project’s upfront investment.
Scalability: Monocrystalline’s scalability allows trouble-free expansion of their solar capacity and hence can easily meet energy demands.	Resource Intensity: Monocrystalline panels require high purity silicon & high energy intense processes to produce which raise ethical environmental concerns.
Reliability: These panels offer minimised downtime & maintenance cost. They have demonstrated their ability over time & have set records of reliability.	Nil.

5.2 Justifications & Critique for Wind Turbines

Table 19. Justifications and Critique for winds turbines

JUSTIFICATIONS	CRITIQUES
Efficiency: These wind turbines allow higher energy per unit area compared to conventional smaller wind turbines.	Due to restrictions and policies such as height restriction, environmental policies, larger turbines are prone to facing these sitting challenges.
Compared to conventional smaller turbines, the 2 MW turbines reduce the land footprint & the visual impact overall minimising the environmental disruption.	Larger turbines require complex maintenance hence adding to the overall cost.
They offer lower costs in the long term despite costing higher upfront investment.	Nil.

They allow better economies of scale.	

5.3 Alternatives

COMPLETED NICK

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Appendix A: Scope of Works

Site Assessment

- Conduct thorough site surveys to evaluate the feasibility of wind and solar energy installation.
- Assess local climate conditions, topography, shading, and structural integrity of buildings.
- Determine optimal locations for wind turbines and solar panels to maximise energy generation, prioritising solar for residential and wind for commercial.

Engineering Design

- Develop detailed engineering designs for wind turbine placements and solar panel arrays.
- Calculate energy production estimates based on site-specific factors and system configurations.
- Design electrical layouts, including wiring diagrams, inverters, and connection to the grid or battery storage systems.
- Integration with interworking systems and current grid, EMS and BMS Systems.
- Ensure compliance with Australian Standards and relevant building codes, zoning regulations, permitting requirements, etc.

Procurement

- Source wind turbines, solar panels, mounting structures, inverters, and other necessary components.
- Evaluate suppliers based on product reliability, performance, and warranty terms.
- Coordinate procurement activities to ensure timely delivery of equipment and materials.

Installation, testing and commissioning

- Ensure adequate skilled labour and equipment for the installation of wind turbines and solar panels.
- Conduct quality assurance inspections throughout the installation process to verify compliance with design specifications.

- Coordinate with utility companies for grid connection and necessary approvals.
- Perform functional testing of all components to ensure proper operation and performance.
- Conduct system integration tests to verify compatibility and efficiency.
- Optimise system settings for maximum energy output and reliability.

Documentation and Handover

- Prepare documentation, including as-built drawings, operation and maintenance manuals, warranty information.
- Compile performance and commissioning data for client's reference.
- Conduct final inspection and handover of the completed wind and solar power systems.

Project Schedule

In the table below is a project team milestone to provide information and progress of works to clients and team members.

State Wide Renewable Energy Distribution System Miles Stone														
Project Start	27/02/2024	Week												
Project End	28/05/2024	1	2	3	4	5	6	7	8	9	10	11	12	13
Investigate the lack in United Nations Sustainable Development Goals of the state wide renewable energy distribution system topic														
Survey anlysis on the topic to define the problems														
Look into possible improvement and developing to the issue														
Scoping document drafting														
Final scoping document														
Develop final solution														
Tender document drafting														
Final tender document														
Presentation of Project														

Deliverables

The below deliverables describe what items will be delivered to the customer. Documentation of the project is compiled and delivered when the scoping and requirements are set, when the design of the statewide energy generation system is confirmed, and when the testing data is available.

Table 20. Deliverables

ID	Description
D.1	Plans for Wind Farm construction, including costs and possible areas

D.2	Plans for Solar Energy Distribution, including costs and rebates for companies or residential homes that will include it
D.3	Ideas for Battery Storage for both Solar And Wind Energy
D.4	Control systems in place for individual energy farming sources, including safety measures for uneven generation
D.5	Plans for Energy Distribution
D.6	Control Systems for Energy DIstribution, including safety measures for uneven load
D.6	Cost Analysis for initial costs for energy generation and control systems, while also including maintenance costs, tax rebates for solar energy and other costs

Inclusions and Exclusions

This section outlines what work, activities, analyses, and objectives are covered by the report (i.e., what are inclusions) and what is excluded from the scope of this report (i.e., what are exclusions). This helps the reader understand the focus of the report, its limitations, and anything that is not expected. Below are the Inclusions and Exclusions for our project.

Inclusions

<u>Technology and methodology</u>

Table 21. Inclusions for Technology and Methodology

Name	**Description**
Hybrid renewable energy systems	Combining solar and wind to create hybrid plants to ensure stable supply by mitigating the intermittency of renewable sources.
Solar utilisation	Deploying solar panels on residential buildings, high-rises, and large commercial buildings. Utilising state-owned plants as central battery storage to support homes during low solar output periods.
Wind energy Distribution	Establishing wind farms dedicated to supplying electricity to state agencies, providing backup and additional power when solar output is low.
Interconnection and Load Balancing	Interconnecting solar and wind energy systems for efficient load management, redistributing stored solar energy during low wind periods to support commercial sites and vice versa.
Energy storage solutions	Implementing advanced energy storage technologies such as supercapacitors, SMES, and batteries to buffer and stabilise energy

	from variable renewable sources.

Monitoring and Management

Table 22. Inclusions for Monitoring and Management

Name	Description
Monitoring and control systems	Implementing advanced monitoring and control systems to manage uneven energy generation and load distribution across the state. Leveraging data analytics, IoT, and smart grid technologies for real-time optimization of energy distribution and storage.
Load management strategies	Developing dynamic load management strategies to ensure optimal energy allocation, usage, and supply stability.

Exclusions

Aspects Beyond Scope

Table 23. Exclusions for Beyond the scope of the Project

Name	Description
Non-renewable energy sources	The project aims to minimise reliance on fossil fuels for sustainability. Conventional methods will only be used to maintain grid stability temporarily.
Individual residential energy storage	While individual households may have personal solar panels, the project focuses on centralised storage solutions for efficiency and scalability.
Residential small wind turbines	Excludes the deployment of small residential wind turbines due to high costs, technical challenges, and space requirements.
Full upgrade of existing energy infrastructure	The project will align with existing infrastructure. A full system upgrade is beyond the current scope and budget constraints.

<u>Areas not covered</u>

Table 24. Exclusions for Areas not Covered

Name	Description
Detailed market analysis and business modelling	While the project promotes sustainability, a detailed market analysis and business model will be addressed in later phases of the project.
Detailed EIA	Although the project aims for sustainability, a comprehensive EIA is outside the scope of this report. A dedicated team will conduct this assessment in later project phases.

Appendix B: Reflection

This engineering project has brought together students from a multitude of engineering backgrounds to think about solving a real world problem and meet Sustainable Development Goals. It has made us all think about how each engineering decision affects certain aspects of our surroundings, from scientific, ethical, environmental perspectives. Through our research of our chosen project, we have delved deep into the world of renewable energy, and have felt the need for expansion of the industry like never before. Renewable energy is the only solution to inequalities in electricity access, especially in remote areas of Australia, and a state-owned and controlled system is the perfect way to achieve this in our opinion.

The project has also given us a taste of the real world of engineering, and how every little decision and design choice affects the final product. Brainstorming, problem solving, testing, and cost estimations have all been parts of our learning so far as young engineers, however, planning a large scale project has taught us skills such as accountability, conflict resolution, respectful confrontation and punctuality.