University of Canterbury

Wind Turbine Design for Onamalutu Lifestyle Block

ENEL664 - Renewable Energy System Design

Jamie Van de Laar – ID: 3472 3974
Ryan Taylor – ID: 4191 1824
Callum Stewart-Ward – ID: 3813 7025

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1 INTRODUCTION

This report is being undertaken in order to plan the design stages for a custom wind turbine design for a lifestyle block in Onamalutu, New Zealand.

Onamalutu is located in a hilly region West of Blenheim. The owner of the property would like to be able to detach from the grid - a wind turbine is suggested for the farm to this end. This report outlines the scope of the project in terms of what aspects of Onamalutu will need to be investigated, such as wind speed, power demand and topology. The requirements in order for this project to be feasible are outlined and the final deliverables to the client are specified.

In order to assist the design process, models of the prospective designs will be created using SolidWorks. These models will be tested using finite element analysis to test their structural properties and make improvements where necessary.

This report also outlines control solutions for the wind turbine. A modular electronic control system is described with the purpose of allowing remote braking and power regulation.

2 SCOPE

The turbine will be innovative in the fact that the nacelle will be able to slide down the tower. This first advantage of this is being able to easily undertake maintenance on the ground. This alleviates having to climb to the top of the tower or to use a scissor lift to perform maintenance. The second advantage is so that the turbine can be safely stored near the ground during high wind conditions/storms. This prevents the turbine being damaged due to strong turbulent winds. The turbine may also be stored behind a wall or in a small shed for further protection and also safety for nearby people if the blades are still spinning. This is an important feature of the design as the turbine will be able to be serviced by one person. Having maintenance being carried out on the ground allows for one person to work more safely, efficiently and conveniently as they have more space, and eliminates falling hazards from regular the maintenance procedure.

The turbine will also be innovative in the fact that it will employ both an eddy current brake and pitch control in order to control the speed of the turbine. The eddy brake uses magnetic forces in order to slow down the turbine, and has the advantage that it has no wearing parts, so will require little to no maintenance. The magnet will be actuated to allow finer control of its braking force. This can only slow down the turbine from high speeds, so the pitching system will also be employed to completely stop the turbine.

When designing a wind turbine one of the roadblocks can be that controls systems are expensive and a high level of expertise is needed to design one. To overcome this, a modular system will be designed to fit an array of different turbine configurations. The system will be split into two different sections, firstly the control side and secondly the inverter size. The control system will read in sensor inputs such as wind speed, wind direction, power of generator, and turbine angular velocity. This will give enough information about the turbine to control things such as yaw, pitch, and eddy brake. With the power requirements specified being AC or DC, according to type of generator and type of power required by the user, one of two modules will be needed. A module for DC to DC will designed, which will be interchangeable for DFIG type configuration for AC synchronisation. The DC to DC module will set the output voltage at 12, 24, and 48 volt.

2.1 Requirement Specifications

The general requirement specifications for the turbine are given below:

- The turbine nacelle must be able to be taken down within a period of 10 minutes - including time taken for the turbine to stop rotating.
- The turbine must able to last for at least 15 years with no more than two instances of servicing per year.
- The turbine must be within the budget specified by the farmer.
- The turbine must be able to be installed with only small crane assistance within one day.
- The turbine must be able to acquire legal consent and meet relevant standards for installation.
- The turbine size (kW) must be suitable for the farm requirement (when supplemented by micro hydro, solar PV).

2.2 Deliverables to Client

Deliverables to the client will include Solidworks CAD models of the final concept design for the mechanical components. A schematic for the eddy current brake and for the control system will also be supplied. A PCB will also be designed for the control system.

2.3 Models to Develop

Solidworks models will be developed for the tower and moving nacelle, including depiction of the eddy current brake and generator. The pitching mechanism will also be developed in Solidworks. Basic propeller blades may be designed, however detailed analysis into high efficiency blade shape will not be performed. It is assumed that such an investigation would have insufficient benefits to justify its cost for a small turbine.

2.4 Applicable Standards

The wind turbine must adhere to all AS/NZS standards as outlined in Section 7 of the New Zealand Small Scale Renewable Energy Standards Guide [1].

3 ROLES

3.1 Jamie Van de Laar

Jamie will work on the pitching mechanism, which will likely be implemented mechanically to reduce electrical complexity. The pitching mechanism allows for speed and thus power regulation of the turbine. In combination with the eddy brake this will allow the turbine to be slowed down in the event of high winds/storm conditions.

In collaboration with Callum, Jamie will also design the yawing mechanism to allow the turbine to constantly face the wind direction. This may prove complex due to the retractable nature of the turbine. FEA will also be performed by Jamie on the pitching and yawing mechanisms.

3.2 Callum Stewart-Ward

Callum will be responsible for the static structural elements of the tower. He will design the tower itself, including the sliding mechanism to bring the nacelle to the ground as well as the foundations for the tower. Callum will produce CAD models of these parts using SolidWorks along with finite element analysis of these to predict their stress and deformation due to wind and other forces. FEA will be carried out using Ansys Workbench software.

The sheltered area at the bottom of the tower for carrying out repairs will be designed. Jamie and Callum will also collaborate to integrate the sliding mechanism with a yawing mechanism for the nacelle.

3.3 Ryan Taylor

Ryan will be responsible for the embedded controls box and mechanical design of the eddy current brake. Ryan will produce an electrical schematic for the controls box, following this components will be sourced for the electrical design. A PCB will be laid out as a starting point for the first production run. Ryan will collaborate with Jamie to determine the type of inputs and outputs needed for the pitch and yaw control. Ryan will also specify the wind speed and wind direction sensors.

Ryan will calculate the dynamics of the eddy brake and design a system around these dynamics to allow easy control over the speed of the prop.

4 PROJECTED TIMELINE

The Gantt chart given in Figure 1 shows the timeline for the project, including how the project is broken up into subtasks. Scoping calculations will be performed in order to get an idea of the energy requirements of the farm, influencing the size of the turbine. Electrical design will primarily carried out by Ryan, whereas mechanical design will be carried out by Callum and Jamie. Post mechanical design, finite element analysis will be performed on the components and overall system to verify their strength. Finally the project report will be written.

A potential bottleneck may be the design of the tower and nacelle. This largely needs to be done by one person (i.e. Callum) as the tower and nacelle both share the sliding mechanism design.

Task Name	Duration	Start	Finish
Research	14 days	Fri 29/07/16	Wed 17/08/16
Scoping Calculations	4 days	Thu 18/08/16	Tue 23/08/16
Eletrical Design	**28 days**	**Wed 24/08/16**	**Fri 30/09/16**
Schematic	21 days	Wed 24/08/16	Wed 21/09/16
PCB Layout	7 days	Thu 22/09/16	Fri 30/09/16
Mechanical Design	**24 days**	**Wed 24/08/16**	**Mon 26/09/16**
Tower Design	14 days	Wed 24/08/16	Mon 12/09/16
Nacelle	14 days	Wed 24/08/16	Mon 12/09/16
Auto Pitch Mechanism	14 days	Wed 24/08/16	Mon 12/09/16
Yaw Mechanism	10 days	Tue 13/09/16	Mon 26/09/16
Eddy Current Brake	7 days	Tue 13/09/16	Wed 21/09/16
FEA	15 days	Tue 13/09/16	Mon 3/10/16
Report	7 days	Tue 4/10/16	Wed 12/10/16

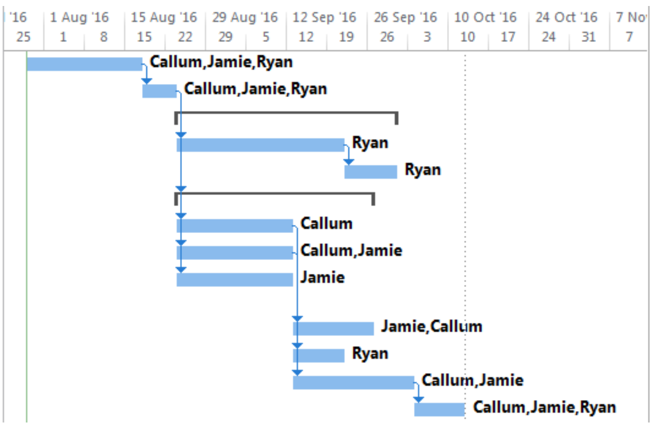

Table 1: Gantt chart showing project timeline.

5 RESOURCES REQUIRED

5.1 Design

Most of the design will take place on computer using software such as: Solidworks, Ansys, Altium, and Matlab. Communication and collaboration will be facilitated by Google Docs and regular meetings.

5.2 Data acquisition

Measurements of the landscape and power requirements of Onamalutu will be taken. The best location for a wind turbine will be the most exposed area of land near the homestead that is convenient. This information will be taken from Onamalutu itself. A summary of the required resources is given by Table 1 below.

Table 2: Summary of resources required for project.

Resource	Reason	Source	Expense ($)
SolidWorks	CAD design of physical components	University Computer Labs	0
Ansys	Modelling of effects of wind on structure	University Computer Labs	0
Altium	Electrical schematic	University Computer Labs	0
Matlab	Calculations for various component values	University Computer Labs	0
Onamalutu Trip	Understanding landscape and wind	Provided by Andrew Lapthorn	$50 per person
Anemometer	Measuring wind speed at Onamalutu	Borrow from University	0

6 REFERENCES

[1] *http://www.seanz.org.nz/files/file/20/Standards+101+Version+1.1.pdf*