Diffuse Energy: Reliable and resilient wind energy for off-grid telecommunication towers

Diffuse Energy's test microgrid at Stanhope, NSW

LESSONS LEARNT REPORT 3

Project Details:

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Reporting Period	10 June 2021 to 10 September 2021

This Project received funding from ARENA as part of ARENAs Advancing Renewables Program.

EXECUTIVE SUMMARY

The Covid 19 pandemic has once again been causing havoc in Australia over the past 3 months, with lockdowns occurring across New South Wales, Victoria, Queensland, South Australia and the Australian Capital Territory, and border closures in Western Australia. This has been having a very significant impact on logistics and freight, both on a national and international level and has resulted in delays on manufacturing and delivering our systems to customers outside of our ARENA project.

Exacerbating the supply chain issue is that there is a global shortage of semiconductors, a key component in the computer chips utilised in our wind turbine controller and remote monitoring systems. This shortage is impacting many companies, including our customers, and presents a very serious challenge to not just Diffuse Energy but the broader economy if the shortage continues.

A technical lesson learnt during the period is the effect that our turbine can have on the system voltage of a small microgrid system under certain conditions. The settings of our wind turbine controller allowed a situation where our wind turbine can cause the system voltage to oscillate, which is potentially detrimental to the longevity of our system and reduces the amount of useful energy that can be stored. We have developed and tested an update for the controller firmware to rectify this and are providing it to our project partners.

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KEY LEARNINGS

LESSON LEARNT NO.1

Our turbine can cause system voltage to oscillate in certain conditions for systems with small batteries.

Category: Technical

Objective: Operation of wind turbine systems

Detail Learning:

There are 2 methods that our control system utilises to slow or stop our wind turbine:

- Applying an extra electrical load on the turbine in the form of dump resistors (the brake).
- Shorting the windings of the generator within the turbine.

The brake can be gradually, or rapidly, applied and can result in the turbine slowing to the point of aerodynamic stall, which is sufficient in many situations to limit the power output of the turbine. However, in situations where the brake alone isn't sufficient to stop the turbine, the controller will short the generator, which brings the turbine to an almost instantaneous stop.

Our controller monitors the voltage of the system to ensure the wind turbine does not overcharge and damage the battery. The maximum system voltage is set at 58 V and is configurable within our controller. When the controller sees the system voltage is at 58 V, the controller shuts down the wind turbine. At present, the controller shuts down the turbine for 1 second before applying full brake and releasing the short.

What we have seen during field operation of our microgrid test system at Stanhope NSW (which has a small AGM battery system with 8 kWh storage), is that in strong winds when the battery is approaching full capacity the turbine can drive up the system voltage to 58 V, causing the controller to think that the battery is full and shut down the wind turbine system through shorting the generator. The short is released with the brake at first fully applied and then decreasing, at which point the turbine starts spinning and producing significant current and pushing up the voltage once again, and the cycle is repeated until the wind speed reduces to a point where the output of the turbine isn't sufficient to push the system voltage to 58 V.

An example of this behaviour is shown in Figure 1 which is from the dashboard of our test microgrid located in Stanhope, NSW.

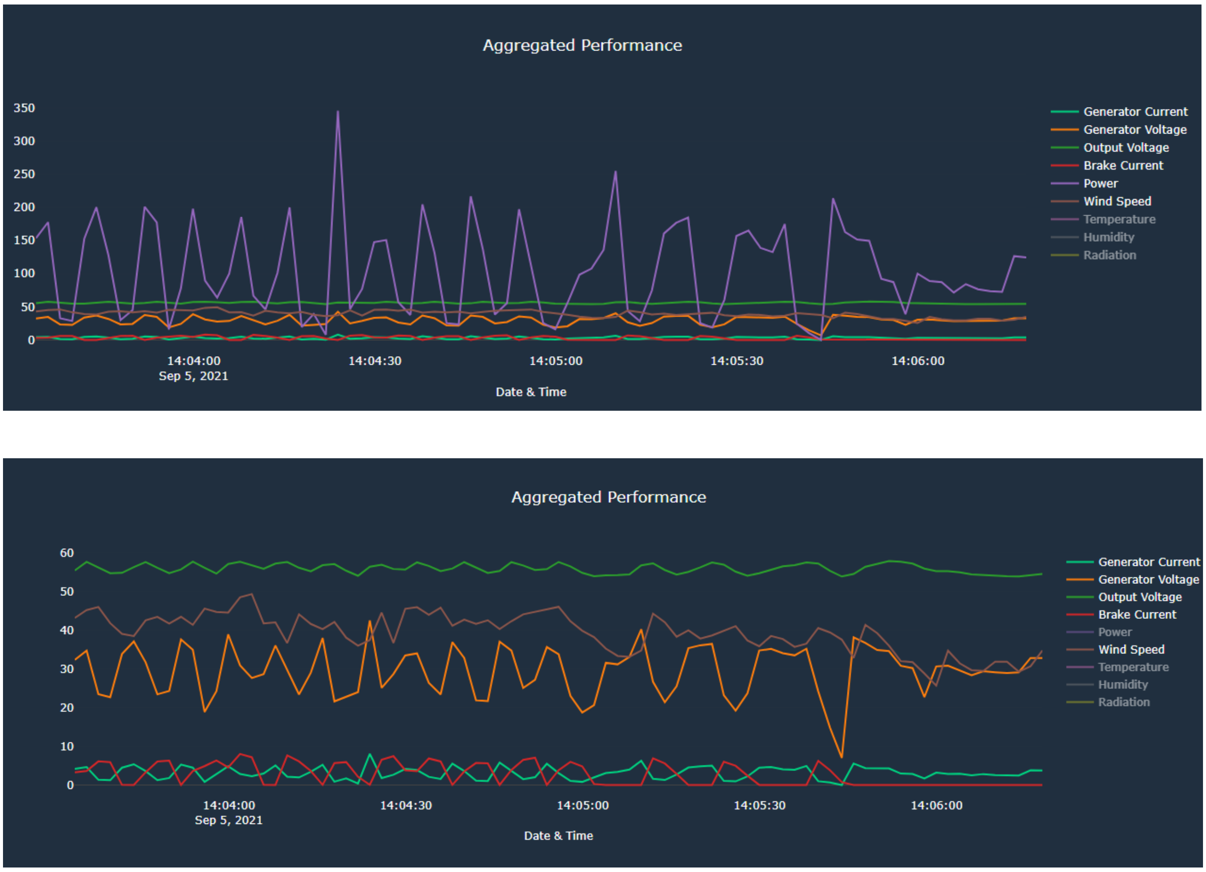

Figure 1. Screenshots of our dashboard from Stanhope, NSW with power output displayed (top) and without, for clarity of the other readings (bottom).

From Figure 1 the cycling of the turbine shorting can be clearly seen. The wind speed is over 40 km/h during this period and the system voltage (labelled Output Voltage in the figure) is oscillating between 56 V and 58 V. It can also be seen that once the wind speed drops below around 35 km/h, the system continues to operate as normal.

This situation isn't particularly harmful to the battery, but it does increase the mechanical and electrical fatigue on our wind energy system (turbine and controller) and reduces the amount of useful energy that can be extracted from the wind and stored in the battery.

The solution we have developed to resolve this is to have the brake come on earlier and ramp up to divert the current to the dump resistors that would otherwise push the system voltage up. This will in effect trickle charge the battery as it approaches the battery full limit, operating similar to the absorption mode for solar controllers. We have also increased the limits within the controller, after a lot of testing, so that the maximum current that can be sent to the dump resistors is 15 A with the result that the controller will only need to short the turbine at a much higher wind speed (or when the battery is actually full) and have increased the shutdown period of the turbine to 15 minutes.

This issue only affects the latest version of our controller hardware (the Mk II controller), and we have updated the firmware of our new controllers and are sending them to our project partners.

LESSON LEARNT NO.2

National and international freight is once again being impacted by Covid and lockdowns

Category: Commercial

Objective: Milestone 3b – installation of wind turbines and associated systems

Detail Learning:
During the period of this report, we have had numerous cases of delays of freight to and from our facilities. This has occurred for both national and international freight and impacts us twofold as we have had delays in receiving components to our workshop to assemble our systems, and then suffered delays when shipping our systems to our customers. The most egregious delay has been for a turbine delivery to Sydney from our workshop in Newcastle, which would normally be an overnight delivery (Newcastle is a 1.5 hr drive from Sydney) but instead took 12 days as a Sydney-based distribution centre for our freight company was shut down due to a Covid outbreak while our turbine was at the centre. We have also had deliveries to Brisbane taking 14 days, when during normal times they would take 3 days at most.

The delays differ in length, but on average has increased delivery time by two weeks, which has the potential to affect our ability to meet our customer's project timeframes. We are actively managing this by regularly communicating with customers with time-sensitive projects to keep them abreast of expected delivery times.

LESSON LEARNT NO.3

A global semiconductor shortage is creating manufacturing challenges for our controller and remote monitoring system.

Category: Commercial

Objective: Milestone 3b – installation of wind turbines and associated systems

Detail Learning:

There is currently a global shortage of semiconductors, a key component in computer and electrical equipment. The shortage started in 2020 and has been caused by a confluence of events:

- The worst drought in 50 years occurring in Taiwan which is a major supplier of the world's semiconductors. Semiconductors require vast amounts of water to produce, and the drought has caused shortages of water allocations to the semiconductor manufacturers, constraining production.
- The indirect impacts of Covid (people in lockdown and working from home ordering more electronic equipment and hence increasing demand for computer chips.
- Companies hoarding/stockpiling chips which has been further exacerbated by US-China trade tensions, with Chinese companies stockpiling chips in anticipation of trade sanctions.

The resulting shortage has caused delays in producing the latest version of our control system and is also delaying the build of our remote monitoring systems, as sourcing the components has been very difficult. We are certainly not alone in this regard, with some of the largest companies on the planet facing supply chain issues resulting from the chip shortage (Ford Motor Co., Toyota, Apple, Sony and Microsoft have all announced product delays, product shortages and plant shutdowns).

We are actively managing the situation by communicating with the contract manufacturer building our systems to source components, pre-purchasing critical components as they become available and working with our customers to identify measures to resolve, or at the least mitigate, the impact on their projects.

This shortage, combined with freight delays as detailed in Lesson Learnt No.2, is resulting in uncertainty around delivery timeframes for our customers and there is the potential for this to impact our ARENA project. While we don't anticipate that the impact on the project will be significant, it will create serious challenges for us in the longer term if Covid continues to create supply chain issues and the semiconductor shortage is not resolved.