Advanced Energy Resources

# PROJECT 2018/ARP153: Advanced Energy Resources – Wind, Solar and Battery Project at Port Gregory

# "Port Gregory Microgrid"

## KNOWLEDGE SHARING FINAL REPORT

This Project received funding from ARENA as part of ARENA's Advancing Renewables Program

August 2022

# Contents

# DISCLAIMER

The views expressed herein are not necessarily the views of the Australian Government, and the Australian Government does not accept responsibility for any information or advice contained herein.

# 1 PROJECT BACKGROUND

## 1.1 Project Overview

The Port Gregory Microgrid is a groundbreaking project, representing a new generation of medium size fringe-of-grid microgrids. This new generation of microgrids can deliver reliable and affordable clean energy to fringe-of-grid customers in Western Australia by using a novel inverter connection topology.

AER's 'back-to-back' inverter topology maximizes customer side renewable penetration (up to 100%) and gives the customer an Uninterrupted Power Supply (UPS) service by being connected to the grid (via a grid-side inverter) while supplying the load from a separate grid-forming inverter (connected to the grid-side inverter via a DC link with integrated battery storage).

The microgrid represents an advanced, state of the art step forward in the management and operation of grid connected microgrids. The operation of the microgrid is fully automated by an advanced control system developed in-house by AER's engineers. The control system is constantly reviewed and optimized to increase the renewable contribution and reliability of the system.

Reducing customer energy costs by almost 50% over the life of the project and abating more than 100,000 tonnes of carbon emissions over the term of the power purchase agreement between AER and GMA, this represents significant savings for GMA Garnet and a sound business case for the $12m investment.

This project would not have been possible without the $3 million funding from ARENA under ARENA's Advancing Renewables Program.

The Port Gregory microgrid provides:

- 60% to 70% of the customer's electricity requirements.
- For surplus renewable energy to be exported to the Western Power network.
- Smoother operation, and higher reliability power quality to the customer's wet plant (GMA Garnet).
- In the event of short grid outages or disturbances, the customer's power supply is uninterrupted.

The Port Gregory Microgrid comprises a 2.5MW wind farm, 1MW solar farm, and a Battery Energy Storage System (BESS) incorporating 2x 2.2MVA back-to-back inverters and 0.5MWh battery providing transient stability and generation smoothing functionality to ensure the reliability, security, and power quality to the customer (GMA Garnet) is maximised.

***"Fringe-of-grid communities in mid-west Western Australia suffer from network outages, so this is a great step forward in creating a template for other electricity users in similar conditions, to replicate and reduce electricity costs and improve reliability and stability"***

***Darren Miller, CEO of ARENA***

## 1.2 Major Components

***2.5 MW Wind Farm***

The wind farm consists of five AER-refurbished Enercon wind turbines.

**Model:** Enercon E40
**Rated Power:** 500kW
**Type:** inverter-based, variable speed
**Rotor Diameter:** 40m
**Hub Height:** 65m
**Cut-in wind speed:** 2.5m/s

***"In Europe, there is a significant market for refurbished wind turbines, as wind farms increase their capacity by upgrading smaller turbines for larger, more powerful ones. Now, AER has brought experience from the European market to enable us to give these turbines a second life in Western Australia." Luca Castelli, Managing Director of AER***

***1 MW Solar Farm***

The solar farm is composed of 12 SolarEdge 82.8kW string inverters with optimisers implemented on the solar array for increased efficiency.

A solar plant room located adjacent to the solar farm accommodates all string inverters plus the required interconnection switchboards and automation and communication equipment.

***2.2 MW, 0.5 MWh BESS***

The BESS is made of 2 x 2.2MVA Siemens utility scale battery inverters (Sinamics S120 series) in a back-to-back topology interconnected to a 0.5MWh 2C rate Kokam battery system equipped with advanced Battery Management System (BMS).

The BESS building is located 3.5km from the wind/solar farm on the GMA Garnet Wet Plant site. This facility incorporates control, protection, and auxiliary equipment in addition to batteries and battery inverters.

## 1.3 Expansion

AER is currently developing an expansion to the project which will see the addition of up to 4MW of wind and solar generation capacity and increased energy storage capacity.

## 2 HOW THE PROJECT OUTCOMES WERE ACHIEVED

ARENA contributed significant funding to the Port Gregory Microgrid and AER is delighted to be able to deliver the outcomes specified as part of the Funding Agreement between ARENA and AER:

| Goals | Delivered |
|---|---|
| **Demonstration that the project's grid connection design can**<br>○ **overcome challenges associated with connecting to a weak grid, provide back-up power; and**<br>○ **facilitate high penetration of customer-side renewable generation.** | ☑ |
| **increased awareness and understanding of the challenges, impacts and opportunities from using secondhand wind turbines in the project for future replication, especially shorter-term projects.** | ☑ |
| **increased understanding of the challenges and opportunities of installing customer-side renewable generators in a fringe-of-grid location.** | ☑ |
| **increased understanding through sharing information on the project as outlined in the Knowledge sharing plan** | ☑ |

The following sections illustrate how these outcomes were achieved, the challenges faced, and the lessons learnt.

## 2.1 Weak Grid and Backup Power

Grid-side power is supplied by Western Power to GMA Garnet's Port Gregory wet plant via a 120km 33kV feeder from Geraldton which suffers from erratic and frequent outages (planned and unplanned), and grid voltage instability; basically, a typical weak grid by all definitions.

The grid outage and instability issues are caused by environmental factors (coastal), the feeder's length (120km) and remoteness (maintenance difficulties). Grid instability has a major impact on customer revenue; for instance, GMA Garnet's mining wet plant incurs lost production every time there is an outage or grid instability, both for the period of the grid outage and during the time required to return the plant to service and into steady state operation.

AER's novel back-to-back topology of BESS inverters in combination with the high-speed advanced control system now allows the wet plant to ride through grid interruption events following the completion of the project.

A sample of how the BESS rides through a grid event is illustrated in the below figures (this page). Despite the grid side circuit breaker (CB1) being tripped due to an overvoltage event, the battery took up the load fast enough that power supply was not impacted. During the grid recovery time (until CB1 is closed again), the battery compensated for the lack of the grid supply. The battery is then recharged at a controlled rate after the event where it is again ready to respond to the next supply interruption.

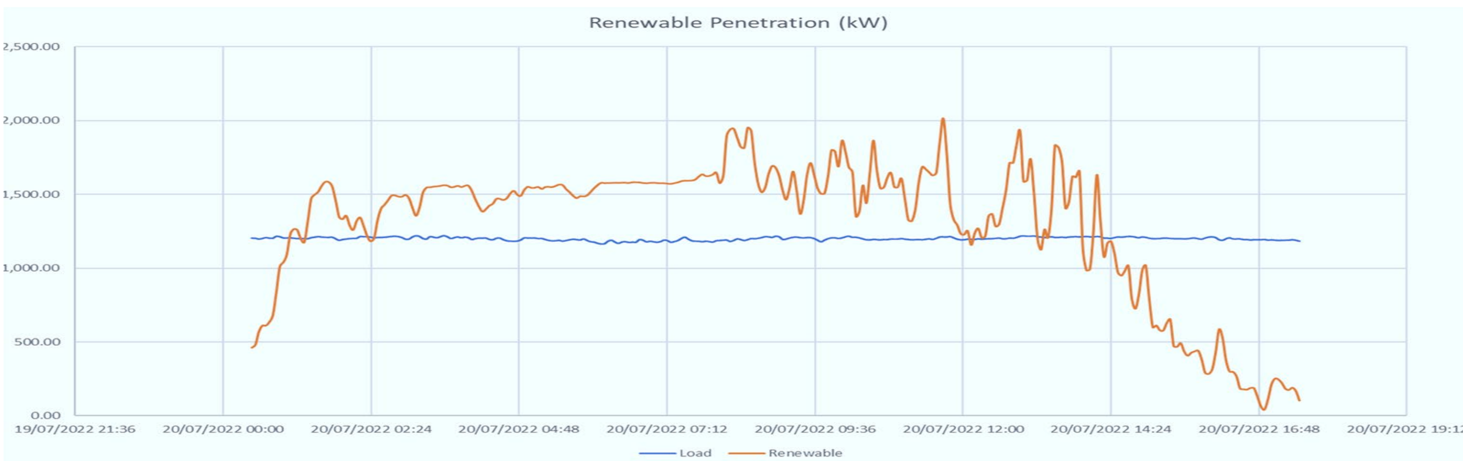
## 2.2 High Penetration of Customer-side Renewable Generation

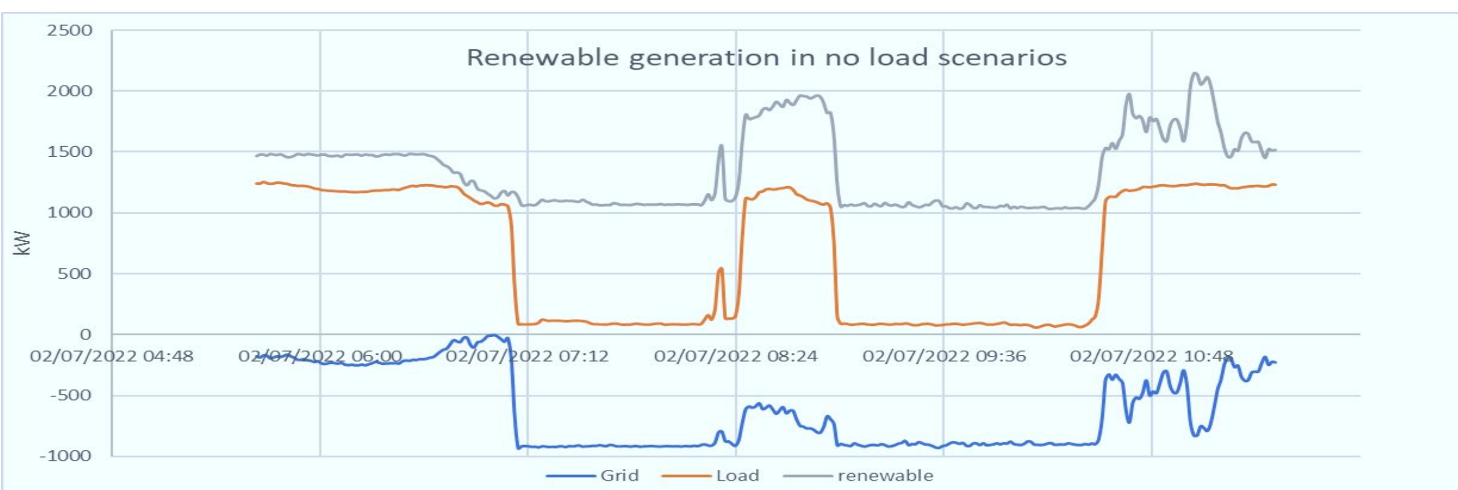
The back-to-back inverter topology is a game changer for allowing over 100% renewable penetration.

This cannot be achieved in off-grid stand-alone systems for technical reasons (such as increased O&M costs due to low thermal plant loading). Currently it is not commercially viable to increase the size of battery storage on microgrids to enable complete reliance on renewables.

Present off-grid solutions result in a reduction in possible renewable penetration, however at Port Gregory this problem has been addressed. Port Gregory Microgrid has been able to generate renewable energy in excess of demand and then export back to the grid, thereby achieving repeated events in which the system delivers 100% renewable energy penetration for sustained periods of time.

Even if the mine site is not using energy, renewable generation still can continue to export up to any export limits imposed by the network operator.



## 2.3 Refurbished Wind Turbines

AER's refurbished wind turbines are delivered at a significantly lower capital cost than new alternatives, making otherwise unfeasible projects possible (including the Port Gregory microgrid).

The Port Gregory microgrid's wind farm was delivered for an approximately 50% lower capital cost than an equivalent new wind farm.

Further, it is now difficult to find wind turbines of the size required for small microgrids. Port Gregory utilized 500kW wind turbines for a number of reasons including:

- Lower capital cost
- Redundancy during scheduled and unscheduled outages
- Reduced transport and logistics costs
- Increased flexibility in crane selection

Modern wind farms are currently utilizing wind turbines which are at least 3 - 4MW each in capacity. These are not suited to small-scale microgrids with loads of up to 3MW.

Currently AER is developing a very similar project near Moora (WA) where two refurbished wind turbines (2 x 1.8MW) will be used as the heart of the generation of the Microgrid.

AER is also planning to expand the existing Port Gregory wind farm with additional refurbished wind turbines.

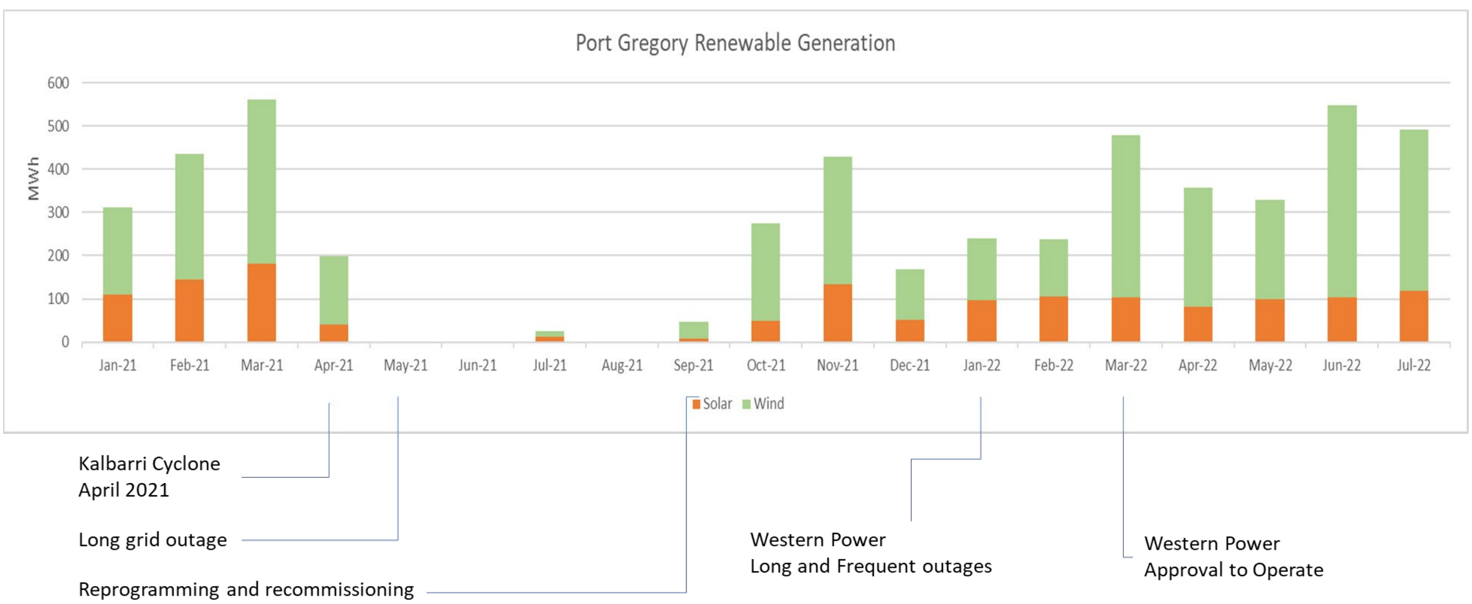
“ ***Europe has an active and established second-hand wind turbine market - typically, Australian equity investors are not familiar with the refurbished wind turbine market due to its infancy in Australia. However, day by day the significant value-add of second hand wind turbines – which in most cases is the defining factor of the project's existence – is starting to become understood by the Australian energy market.*** ” **Luca Castelli, Managing Director of AER**

# 3 MICROGRID PERFORMANCE

AER is constantly monitoring the performance of the microgrid using an advanced control system (high resolution data, seconds to millisecond resolution), metering data (30 minute intervals), and regular onsite inspection, measurement, and testing. This includes (but not limited to) generation outputs, control system response times, generation performance, curtailment efficiency, equipment level performance, power quality and more.

Although there have been very challenging situations and barriers along the way – such as Tropical Cyclone Seroja, COVID pandemic, grid outages, and poor delivery and legacy defects left by a key EPC contractor, Port Gregory is now generating close to its forecasted output and performing above expectations following the implementation of AER's new microgrid control system. A snapshot is represented below, as can be seen output generation for renewables is a function of environmental and seasonal impacts.

AER is continuously optimizing the Port Gregory microgrid's control system to increase the efficiency and reliability of the microgrid.



| MONTH | Solar (MWh) | Wind (MWh) | RES excl. export | RES incl. export | Renewable Energy Penetration |
|---|---|---|---|---|---|
| Jan-21 | 856.9 | 109.8 | 283.4 | 311.0 | 36.3% |
| Feb-21 | 782.2 | 145.4 | 375.2 | 435.1 | 55.6% |
| Mar-21 | 830.2 | 180.9 | 457.4 | 560.6 | 67.5% |
| Apr-21 | 228.0 | 41.5 | 150.4 | 199.9 | 87.7% |
| May-21 | 538.9 | 0.0 | 0.0 | 0.0 | 0.0% |
| Jun-21 | 779.2 | 0.0 | 0.0 | 0.0 | 0.0% |
| Jul-21 | 769.0 | 11.5 | 19.5 | 25.8 | 3.4% |
| Aug-21 | 815.9 | 0.0 | 0.0 | 0.0 | 0.0% |
| Sep-21 | 696.6 | 7.2 | 44.8 | 47.3 | 6.8% |
| Oct-21 | 591.8 | 48.3 | 189.1 | 274.0 | 46.3% |
| Nov-21 | 326.3 | 134.0 | 163.4 | 428.8 | 131.4% |
| Dec-21 | 576.9 | 51.8 | 121.8 | 168.4 | 29.2% |
| Jan-22 | 513.2 | 97.0 | 154.2 | 240.5 | 46.9% |
| Feb-22 | 475.5 | 105.7 | 182.5 | 238.8 | 50.2% |
| Mar-22 | 382.4 | 104.2 | 239.7 | 478.2 | 125.0% |
| Apr-22 | 392.4 | 81.2 | 209.2 | 356.8 | 90.9% |
| May-22 | 484.2 | 98.3 | 216.6 | 329.9 | 68.1% |
| Jun-22 | 301.3 | 103.5 | 165.7 | 547.8 | 181.9% |
| Jul-22 | 769.4 | 119.5 | 415.3 | 491.7 | 63.9% |

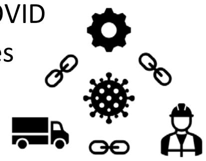
## 3.1 Output Generation and Challenges

### 3.1.1 Tropical Cyclone Seroja

The major challenge affecting the facility's generation was tropical cyclone Seroja, a Category 3 tropical cyclone, bringing heavy rain and hurricane-force wind gusts (max. 170km/h recorded near Kalbarri) which impacted the Port Gregory Microgrid and surrounding areas in April 2021. The Kalbarri cyclone caused significant and widespread damage to critical infrastructure including roads, telecommunication, and electricity distribution networks which left some 30,000 homes and businesses without power for several months. This imposed a significant burden on the network operator (Western Power) to recover a grid which was greatly impacted and damaged from the cyclone. As a result, there was significant grid disruption to the immediate electricity distribution network for almost 4 months in 2021.

The Port Gregory microgrid itself was impacted by the cyclone and suffered some damage to the wind and solar farms. The private 33 kV power line also required minor repairs.

### 3.1.2. Pandemic



Like many businesses and projects the COVID 19 pandemic and its consequences (including supply chain issues, border closures and regional travel restrictions) elevated the complexity of the logistics for maintenance and recovery activities for the Port Gregory microgrid and Western Power grid. Issues included limited access to technical service support personnel for wind turbines, battery inverters, and batteries which slowed down the process of fault finding and diagnosis.

There were also significant difficulties and lead times to obtain critical spare and replacement parts which caused further delays to fault finding, repair and maintenance activities.

### 3.1.3. Contractual dispute

Sub-contractor non-performance with a key EPC contractor was a key issue for the project.

Despite AER's wind and solar farm being practically complete and ready to enter commissioning in June 2019, the project's BESS was not handed over until the second half of 2020.

The BESS is a key component of the project which delayed the commissioning of the wind and solar farms by over 12 months.

In addition to the significant delay to the project by the EPC contractor's heavily delayed works, part of the dispute revolved around insufficient visibility of the supplied control system which provided limited ability for AER to determine the causes and outcomes of the many contingency events experienced by the BESS following handover, which allowed no ability for AER to resolve BESS issues and improve the control system.

A significant issue was experienced following tropical cyclone Seroja in which the lack of access to the control system prevented the system's battery from being charged by alternative means to the electricity grid (Eg. Diesel generators). As a result, part of the system's battery suffered damage.

Operationally, the control system delivered by the EPC contractor did not optimally control power flows in the system.

To manage the technical risk and commercial impact being suffered by the poorly performing control system and a significant list of defective work items, AER's in-house engineering team developed an improved control system which enabled performance optimization and improved operational visibility.

The project's control system was successfully recommissioned in September 2021, approximately 4 months after the cyclone.

AER's new control system provides added functionality including:

- Automated system contingency response capabilities
- Improved system stability
- Optimised power curtailment algorithms
- Grid/microgrid fault ride-through capability
- Load shedding
- Improved operability

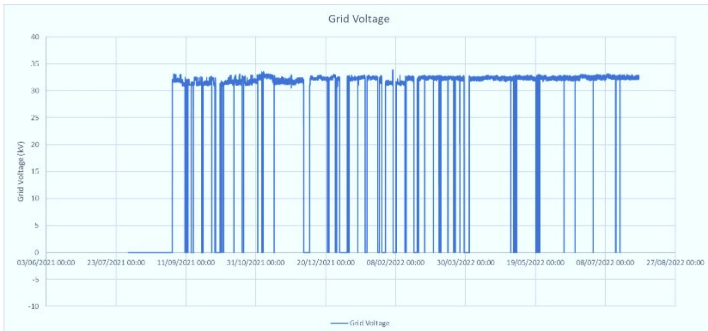
The BESS' availability has increased from approximately 60% with the EPC contractor's control system to over 97% availability once AER's new microgrid control system was implemented. An availability target of 99.5% is currently being worked toward.

### 3.1.4 Network Operator Approval to Operate

Due to the impact of the cyclone and the focus on restoring service to the grid, an unusually long timeline to receive approval to operate from the network operator resulted in significant revenue loss.

### 3.1.5 Grid Availability

Grid availability and power quality are a significant challenge for fringe-of-grid microgrids. The severity of the grid outages at Port Gregory is demonstrated in the average recorded voltage (5 minutes intervals) over a year as presented below.




Grid issues can be categorized into:

- Short-term outages (less than 30 minutes)
- Long term outages (30 minutes to weeks), and
- Low power quality (voltage fluctuations).

The Port Gregory microgrid is capable of riding through short term outages and network power quality events.

Long-term outages represent a different challenge. Long term outages impact on the ability to deliver power consistently as well as make it challenging to guarantee that the required load can be consistently catered for. Whilst the addition of diesel or gas generators (or even a pumped-hydro plant) to the system could resolve this issue, it is cost prohibitive at present.

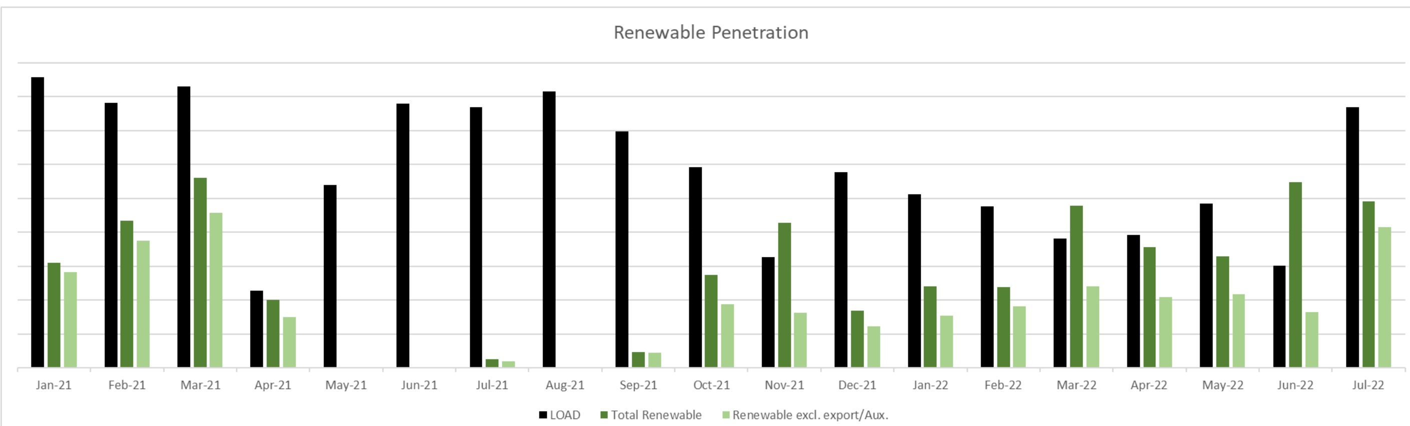
To tackle the challenge of long-term grid outages, AER has given visibility of real-time generation of renewables and network information to GMA plant operators so they are able to reduce demand during grid outages which results in black outs being avoided, and drastically improved plant recovery times.

If sufficient renewable energy is available, GMA's operations are able to continue operating through a short and long term power outage.

Should insufficient renewable energy generation or battery power be available, the main process can be ramped down, however, auxiliary loads can continue to operate during long outages which allows plant maintenance activities to continue and preparation of the plant for restart immediately following an extended outage. Administrative duties can also continue during network outages.

## 3.2 Renewable Penetration

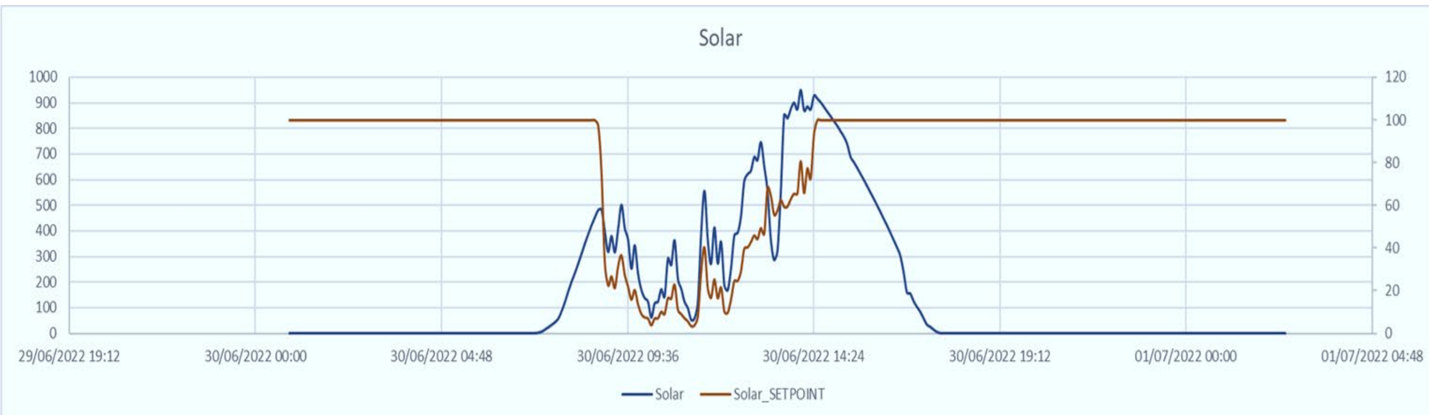
As per the generation output records presented, it is evident that the penetration of renewable energy is high. AER's back-to-back inverter topology allows the microgrid to have renewable penetration of greater than 100% meaning excess renewable energy can be exported to the electricity network when there is a surplus of renewable generation. Even if export and auxiliary loads of the microgrid are excluded, the renewable penetration remains significantly high. Approximately 70% is achieved when all 5 wind turbines are operating and a minimum of 44% when 2 out of 5 wind turbines are under maintenance. At present the full capability of the system has not been explored as renewable energy production is lower in the winter months due to low wind and reduced solar farm output.




### 3.2.1 Renewable Curtailment

Power curtailment is inevitable due to the grid export limit (1MW), load events, and operational constraints (such as battery state of charge). AER are constantly optimizing the power curtailment algorithm within AER's new control system to maximize the generation output while keeping the microgrid stable. Key curtailment decisions including response times of generation plant and constraints such as minimising mechanical stress on wind turbines during generation shedding events. An example of a curtailment event is shown below.


Load vs grid export
2000
1500
1000
500
0
-500
-1000
-1500
29/06/2022 19:12
30/06/2022 00:00
30/06/2022 04:48
30/06/2022 09:36
30/06/2022 14:24
30/06/2022 19:12
01/07/2022 00:00
01/07/2022 04:48
Grid
Load


Solar
1000
900
800
700
600
500
400
300
200
100
0
120
100
80
60
40
20
0
29/06/2022 19:12
30/06/2022 00:00
30/06/2022 04:48
30/06/2022 09:36
30/06/2022 14:24
30/06/2022 19:12
01/07/2022 00:00
01/07/2022 04:48
Solar
Solar_SETPOINT


WT1
500
450
400
350
300
250
200
150
100
50
0
29/06/2022 19:12
30/06/2022 00:00
30/06/2022 04:48
30/06/2022 09:36
30/06/2022 14:24
30/06/2022 19:12
01/07/2022 00:00
01/07/2022 04:48
WT1
WT1_Power_Capability
WT1_Power_Limit

## 3.3 Generators Availability

### 3.3.1. Solar farm

It can be expected that every 1 kW of installed solar capacity generates at least 4kWh per day (120kWh per month) on average during a year if there is no curtailment. After the cyclone and deployment of the new control system, this performance metric has been met even with the existence of the curtailment.

AER also required optimized parametrization of the solar farm's inverters to suit the specifics of the microgrid power system. In particular, typical network operator settings may not operate appropriately within a microgrid.

Consideration will be given by AER in future toward the accessibility of parameters of any solar inverter to reduce the need for OEM intervention and to reduce fault response times.

### 3.3.2. Wind Turbines

Since commencement, the wind farm has contributed approximately 60% of the total renewable generation within the Port Gregory microgrid, with an average of 4 out of 5 available wind turbines. This is increasing as generator reliability and system stability improve.

AER has a highly competent team of trained technicians (both inhouse and external) for maintenance of wind turbines and a network of turbine specialists based in Europe, ensuring that repair and maintenance time is minimized. This is an essential resource to have available for the reliable operation of refurbished wind turbines.

A refurbished wind turbine typically does not operate reliably at its capacity rating without significant refurbishment works.

Current experience at Port Gregory is that the wind turbines run very reliably at up to 85% of their peak power rating. Operation at full load has occurred for extended periods, however, an increase in outages and corresponding maintenance costs was evident.

To date, the turbines have been performing well and in line with expectations.

Environmental factors, primarily moisture and airborne salt (due to being only 6km from the coast) has been the largest contributor to wind turbine downtime. As a result, AER recently undertook an intensive refurbishment of the generator (stator, rotor and excitation system) in each wind turbine which has significantly improved turbine availability.

On average, the wind farm has achieved 92% availability since the system was recommissioned in September 2021 (the highest performing wind turbines have achieved 98% availability). The downtime was primarily due to supply chain challenges following the COVID pandemic.

Work is now commencing on improving the availability of the wind farm which includes the training of additional technical staff, increased inventory of critical spares parts and targeted proactive maintenance.

Availability in recent months (to September 2022) is now above 94%.

# 4 KEY LESSONS LEARNED

## 4.1 Network Integration and Approvals

Western Power (network operator) Approval to Operate was extensively delayed – approval was given by the network operator 20 months after the successful commissioning of the project. Numerous reasons have been given as to the causes of the delay including: network unavailable due to Tropical Cyclone Seroja, network operator being understaffed, network operator internal staff changes, lack of access to and deficiency in documentation issued by a key EPC contractor, and network connection regulation and policy changes in 2022 adding more delays to the process. In addition to these reasons, it should be noted that fringe-of-grid projects like Port Gregory are occurring in areas of the grid that already considered as weak, therefore increased scrutiny from the network operator is typically to be addressed such as higher sensitivity to harmonics and voltage stability.

For future projects, much longer timelines are planned into the project. Additionally, AER is now preparing all necessary documentation internally to reduce lead times.

## 4.2 Long Network Outages and UPS drainage

Long network outages cause not only loss of revenue, but technical issues which impact the microgrid. Previously, outages over 2 hours required AER to attend site to recover the system, which relied on technician availability, safety co-ordination with the mine site and travel time to site, resulting in significant additional cost and downtime. However, this issue is resolved after deployment of the AER's new control system which has dramatically reduced downtime keeping the microgrid running in a stand-alone mode during network outages and recovering automatically when grid supply is restored.

The black-start of a simple microgrid can be automated to a reasonable extent, however, the Port Gregory microgrid is evolving to be a complex and sophisticated microgrid.

## 4.3 Complexity of Microgrid operations

The operation of microgrids requires the management of technical, safety, reliability and commercial considerations all of which carry an increased degree of risk and requirements for specialized and appropriately trained operators.

AER's new Moora Microgrid will be an immensely more complex microgrid than Port Gregory due to the multiple number of electricity offtakers, multiple network-facing connection points and the presence of multiple generation technologies (solar, wind and biogas).

As a result, AER is currently assessing the requirements for added technical resources and contingency planning to facilitate the reliable operation of the Moora Microgrid.

AER's experience at Port Gregory has been instrumental in understanding the challenges and requirements for operating a microgrid.

Microgrids are inherently complex for several reasons, and the resources required to operate them should not be underestimated.

## 4.4 Microgrid Control System Topology and Control Strategies

Considering the typical size of fringe-of-grid applications, (which in many cases can be between 1 – 3MW) solar string inverters are a cost-effective and reliable alternative to centralised inverters. As a result, the number of devices that needs to be communicated with for solar generation management can be between 12 to 36 devices. Although solar inverter communications gateways can be used to decrease the number of communication points, power control response times increase significantly.

This leads to an important consideration which is the speed of control systems and related control system topology in microgrids. For maximum reliability and to reach the upper limits of renewable energy penetration, AER has designed its communication network to have high speed (predominately fibre optic based) and operates on a distributed control strategy.

The distributed control strategy utilizes a solar farm and wind farm controller which are separate to the microgrid controller. This allows higher speed decision making, and control strategies which optimize renewable energy production.

For example, AER's wind farm controller (which is part of AER's new microgrid control system) manages wind farm power curtailment by optimizing power setpoints individually for each wind turbine based on its particular constraints and operating data. For example, in certain wind directions, particular wind turbines may perform at lower power than other machines in the wind farm due to wake losses and microsite-specific impacts (Eg. Wind flow over terrain). As a result, power setpoints are optimized so that wind turbines that are capable of delivering more power are allowed to do so while still meeting the microgrid controller's maximum global wind farm setpoint.

## 4.5 Design Improvements

AER undertook a number of design improvements when designing its new Moora Microgrid by applying its learnings from Port Gregory which were gained through both the construction and operations phases of the project.

Key improvements include:

- Optimised layout of BESS inverters and battery (including top entry cabling to all switchboards and power conversion devices)
- Simplified high-speed communications network
- Optimised HV switching and isolation points to allow added flexibility during maintenance and to minimize lost renewables generation
- Improved redundancy of remote monitoring and communication systems
- Revised control philosophy to increase renewable energy penetration and system reliability

## 4.6 Microgrid Power Quality

Power electronics are a major feature of modern-day power systems. Loads are particularly likely to contain a large array of inverter based devices (typically variable speed drives). Due to their distributed design, microgrids are also likely to have a significant number of inverters which connect the various generation sources to the microgrid.

The presence of power electronic based devices can inject considerable levels of harmonics into a microgrid's power system. AER has faced this issue at Port Gregory and the management of both load and generator harmonics has been an important aspect of the optimization process.

When the control system was redesigned, the previous EPC contractor's settings were removed from the BESS' grid-facing and grid-forming microgrid inverters (both are Siemens S120 units) and replaced with AER's system optimized settings. This allowed increased flexibility to unlock the various features of the S120 inverters to boost microgrid performance and reliability and also optimize microgrid power quality.

The BESS inverter settings are being optimized frequently in order to refine the performance of the inverters to the microgrid's specific operational landscape.

AER is currently working to minimize power system harmonics by utilizing active filtering capabilities in the drives and also prepare the system to provide support to the weak grid if required by Western Power (network operator).

# 5. CONCLUDING REMARKS

The Port Gregory Microgrid project has been a groundbreaking project in many aspects and has proven to feasibly deliver low cost, high penetration renewable energy in a fringe of grid area.

The project is currently undergoing additional upgrades and trialing new functionality to improve the capabilities of the system and increase resilience of both the microgrid and the local network.

The project's success has given AER the comfort to implement the key parts of Port Gregory Microgrid's design at AER's Moora Microgrid which includes a BESS with the back-to-back inverter topology, refurbished wind turbines and an improved control system.

The Moora Microgrid will include a number of design improvements to provide increased reliability, simplified operations and also promote increased renewable energy penetration through more effective generation management and load control capabilities.

AER sees immense opportunity for the adoption of the dual converter design and the installation of refurbished wind turbines, particularly in grid-connected applications. Additionally, as energy markets evolve and distributed generation becomes more widespread, the ability for AER's microgrids to operate independently of the network while also having the ability to provide network support carries immense value in modern power systems, locally and elsewhere.

AER is currently progressing with the connection of several new microgrids using the dual converter technology and intends for the technology to be a key part of its microgrid installations going forward as increasing customer enquiries are received and new and evolving network connection challenges are encountered.

# 6. ACKNOWLEDGEMENTS

AER would like to thank ARENA for making this project possible and contributing to the future of renewables in Western Australia.