PGWF Pty Ltd

(Recipient)

and

Advanced Energy Resources Pty Ltd

(Lead Contractor)

PGWF Advanced Energy Resources Wind, Solar and Battery Project at Port Gregory.

LESSONS LEARNT REPORT

Recipient Name	PGWF Pty Ltd
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Reporting Period	9/5/2019 (financial close) to 31/7/2020 (commissioning date)

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EXECUTIVE SUMMARY

The Project was successfully commissioned in July 2020, approximately 6 months later than planned. There were several delays mostly relating to sub-contractor non-performance with a key EPC contract (BESS installation and commissioning). COVID-19 resulted in further challenges and there were some less anticipated delays such as land-use agreements and environmental approvals. These latter issues serve as a lesson not to underestimate the time to complete even seemingly trivial project tasks.

At this early stage of operations, the Project is generally performing to expectations, with some improvements still to be gained from the BESS. Due to reduced performance of the BESS relative to its capabilities, AER is currently developing an alternative control system to optimise the system's performance and also develop alternative applications such as UPS capability, ancillary services and network support functionality. We anticipate the Project objectives and outcomes contained in the ARENA funding agreement will be achieved and we look forward to sharing the results in due course.

PROJECT OVERVIEW

PGWF Pty Ltd signed a long-term Power Purchase Agreement (PPA) with the world's largest industrial garnet producer, GMA Garnet (GMA) in June 2017, which saw the construction of a 3.5MW wind and solar farm with battery storage. Advanced Energy Resources (AER) were responsible for the project concept, design, construction, and ongoing operations and maintenance (O&M) of the facility. The project site is located 3.5km from GMA's mine and wet plant processing operation in Port Gregory, 60km south of Kalbarri, WA.

The project uses a novel back-to-back inverter topology which decouples the load and renewable energy generation from the electricity network through a DC link while allowing the export of renewable energy into the Western Power network.

PROJECT SCOPE

Located at the northern fringe of the South-West Interconnected System in WA, 120km from the Western Power substation, the challenge was to design and construct a renewable energy system that could connect to the weak grid, facilitate high penetration of customer-side renewable generation and export surplus electricity to the Western Power network.

The project consists of:

- 2.5 MW wind farm: 5 x 500kW refurbished Enercon E40 wind turbines
- 1 MW (AC) solar farm: 1.12MW DC with 1 MW of Solar Edge string inverters
- Battery storage: 4.4MVA inverters (2 x 2.2MVA, DC coupled), 586kWh battery bank.

IMPLICATIONS FOR FUTURE PROJECTS

Advanced Energy Resources and PGWF Pty Ltd have been encouraged by the initial performance of the Project. There have been many challenges to overcome and numerous lessons to take from this experience. The project objectives are all being achieved, and the Project is proving to be a successful blueprint for other projects in our pipeline. AER is currently developing two new microgrids using the back-to-back inverter topology which will feature AER's revised BESS and Microgrid control system.

AER anticipates many aspects of these future Projects will be made easier and more cost effective as result of AER's experience with the Port Gregory project. AER has an intimate understanding of the back-to-back inverter topology and the integration of high penetration renewable energy in a microgrid setting.

AER has also conducted significant design optimisation following our learnings at Port Gregory and anticipates a reduction of at least 25% in project capital costs as a result of optimised BESS design and implementation and greater understanding of the wind turbine refurbishment and recommissioning process, in particular around logistics and technical recommissioning.

KEY LEARNINGS

Lesson Learnt No. 1 Network Integration

Knowledge Category:	Technical
Knowledge Type:	Network Integration renewables penetration
Project Objective:	Demonstration that the Project's grid connection design can overcome challenges associated with connecting to weak grids, provide backup power, and facilitate high penetrations of customer-side renewable generation.
Technology Type:	Wind/Solar/BESS
State/Territory:	Western Australia

Despite the successful commissioning of the Project in July 2020, AER is still awaiting 'approval to operate' from the network operator – Western Power. This is due to harmonic disturbances outside the designated parameters. Anecdotally we have learnt this is a common cause of delay in approvals by network operators elsewhere in Australia.

AER successfully installed and had the wind farm and solar farm ready for commissioning in July 2019. However, significant delays in the project schedule by a key EPC contractor caused the commissioning schedule of the project to be impacted by the COVID-19 pandemic. The impact of COVID-19 on the off-taker's business globally also resulted in a temporary disruption to their normal operations which required additional effort to coordinate some construction, commissioning and early operational activities.

Notwithstanding these issues the Project was successfully commissioned, with the refurbished wind turbines and solar array performing above expectations. The BESS is still to achieve optimal performance which we expect to achieve following the implementation of a revised BESS and microgrid control system which is being developed by in-house by AER.

Lesson Learnt No. 2 Delays

Knowledge Category:	Commercial
Knowledge Type:	Contingency Planning
Project Objective:	Increased understanding of the challenges and opportunities of installing customer-side renewable generators in fringe-of-grid locations.
Technology Type:	Wind/Solar/BESS
State/Territory:	Western Australia

Project commissioning was delayed by approximately 6-months due to several factors. Some of these delays were exacerbated by COVID-19. This required contract variations to extend the start date. It highlights the importance of:

a) contemplating such delays when drafting a PPA
b) flexibility and buy-in from various project stakeholders.
c) open and honest communication from all parties throughout.

Similarly, the importance of a sound agreement with sub-contractors cannot be understated. In this instance AER engaged credentialed and experienced contractors. However, we still encountered problems with performance and a lack of communication in relation to problems that arose.

AER notes that competency, experience, resourcing and the financial strength of appointed EPC contractors is imperative to successful and timely project delivery. AER has strengthened its due diligence processes in relation to the financial capacity of EPC contractors following our experience around EPC contractor appointment at Port Gregory.

Early consultation and stakeholder engagement are crucial to gain the support necessary to acquire land-use agreements. While land-use agreements did not contribute to any delays, land-use agreements were not yet finalised prior to execution of the projects PPA which heightens a potential financier’s perception of project risk. In future, AER intends to conduct land-use negotiations prior to PPA execution. Not achieving this buy-in can result in significant project delays and heightened project risk.

Lesson Learnt No. 3 Community Engagement

Knowledge Category:	Social
Knowledge Type:	Community relations
Project Objective:	Increased understanding of the challenges and opportunities of installing customer-side renewable generators in fringe-of-grid locations.
Technology Type:	Wind/Solar/BESS
State/Territory	Western Australia

In our experience, local landowners, business operators and local Government are very supportive of renewable energy initiatives in this region. In AER's experience, appreciation is even greater if local stakeholders are consulted early in the process and given the opportunity to express their views. An example of this was a representative visiting local residents and businesses to explain the Project. Perhaps not surprisingly, the sense of community in regional areas is strong and word-of-mouth is important and should be anticipated in both a positive and negative regard.

Lesson Learnt No. 4 Approvals

Knowledge Category:	Regulatory
Knowledge Type:	Planning requirements
Project Objective:	Increased understanding of the challenges and opportunities of installing customer-side renewable generators in fringe-of-grid locations.
Technology Type:	Wind/Solar/BESS
State/Territory:	Western Australia

There were some elements of gaining approvals that were not foreseen and were time sensitive (i.e. that flora surveys must be completed in spring when a rare orchid would most likely be visible), which could have resulted in delays for the project.

Lesson Learnt No. 5 Tyranny of distance

Knowledge Category:	Logistical
Knowledge Type:	Project management
Project Objective:	Increased understanding the challenges and opportunities of installing customer-side renewable generators in fringe-of-grid locations.
Technology Type:	Wind/Solar/BESS
State/Territory:	Western Australia

Port Gregory is located approximately 110km north of Geraldton, a large population centre. However, despite the seemingly short distance, the rural nature of the project location and the region generally restricts access to labour and materials.

Travel and accommodation costs can become significant.

Despite the small size of the wind turbine foundations, concrete supply came at a significant premium. The local concrete batching plant (located approximately 60km from the project site) did not have the capacity required to supply concrete at the required rate during foundation pours. The only plant with suitable capacity was in Geraldton, which is located 110km from the site – this created significant risks around concrete quality which were exacerbated at times of high ambient temperatures.

As a result, on-site concrete batching was required which added significant cost to the civil construction component of the project given the small scale of the wind farm.

Lesson Learnt No. 6 Expect the Unexpected

Knowledge Category:	Risk
Knowledge Type:	General
Project Objective:	Understanding the challenges and opportunities of installing customer-side renewable generators in fringe-of-grid locations.
Technology Type:	Wind/Solar/BESS
State/Territory:	Western Australia

No additional risks have been identified. However, COVID-19 created significant issues with a number of aspects including accessing the customer's site, unavailability of subcontractors and regional travel restrictions, which underscore the importance of fully considering force majeure provisions and contingencies in any PPA

Lesson Learnt No. 7 Network connection complexity

Knowledge Category:	Technical and Regulatory
Knowledge Type:	Network Connections
Project Objective:	Demonstration that the Project's grid connection design can overcome challenges associated with connecting to weak grids, provide backup power, and facilitate high penetrations of customer-side renewable generation.
Technology Type:	Wind/Solar/BESS
State/Territory:	Western Australia

Being a novel connection topology, the connection concept took significant engagement with the network operator to reach understanding and approval.

Early engagement was critical in order to understand the specific network constraints and was key in designing a system that was compatible with the weak network, but also ensured that the project had the support of the network operator.

The project utilises a back-to-back inverter topology that decouples the renewable energy generation from the Western Power network. Being located 120km from the substation and having generation capacity which is almost three times greater than the load, a grid-facing renewable energy system would have caused unacceptable power quality impacts during times of variable generation output.

The system uses a battery to smooth fluctuations in renewable energy generation that is passed through to the electricity network, which minimises power quality issues that could result from the high penetration of renewable energy that is capable of being exported to the electricity network.

Lesson Learnt No. 8 Funding

Knowledge Category:	Commercial
Knowledge Type:	Project financing
Project Objective:	Understanding the challenges and opportunities of installing customer-side renewable generators in fringe-of-grid locations.
Technology Type:	Wind/Solar/BESS
State/Territory:	Western Australia

Third party funding for the project was a significant challenge, in particular when approaching typical debt lenders (banks). A number of components of the project were considered high risk by typical lenders, including:

- The back-to-back inverter connection topology
- Refurbished wind turbines
- EPC, O&M and wind turbine refurbishment not being conducted by the original wind turbine manufacturer

Ultimately, AER provided a significant portion of the project's funding and included a number of experienced and like-minded individuals in the project's equity structure. A portion of the project's investors are experienced and well-credentialed renewable energy project developers and investors based in Europe who understand the complexities of microgrid and hybrid energy projects but also understand the risk and rewards associated with 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.

AER also provided debt to the project as part of a private consortium due to the extensive due diligence requirements imposed by traditional lenders (banks). Due to the perceived risk profile, the proposed due diligence costs were not commercially viable.

AER intends to refinance the project's debt following commissioning.

In AER's experience, small amounts of debt (<$10m) have been a challenge to source from banks, so innovative approaches to financing structures may be required from small scale developers.

Lesson Learnt No. 9 Wind Turbine Refurbishment and Re-Commissioning

Knowledge Category:	Logistical
Knowledge Type:	Project management
Project Objective:	Increased awareness and understanding of the challenges, impacts and opportunities from using second-hand wind turbines in the Project for future replication, especially for shorter terms projects.
Technology Type:	Wind/Solar/BESS
State/Territory:	Western Australia

AER undertook dismantling, logistics, shipping, import clearances and all inland transport between Germany and Australia for the decommissioned wind turbines. Upon arrival in Australia AER undertook an intensive refurbishment of the wind turbines' mechanical and electrical systems and all blades.

As an Australian first, AER encountered a number of challenges which were overcome, including:

- Lack of support from original equipment manufacturer – The wind turbine OEM had minimal desire or incentive to support AER in recommissioning the turbines at their end of life. As a result, AER was forced to develop in-house capabilities, procedures and quality control for the testing, refurbishment and recommissioning of the wind turbines following their dismantling

- Qualified staff were difficult to find, as most were based in Europe

- Recommissioning wind turbines almost 2 years after decommissioning is no easy task. A key learning: "Plan for the worst, expect nothing more." Recommissioning activities were at times frustrating and repetitive as the activities were not as straight forward as new machines. The process included not only methodical recommissioning, but generally each step was met with a requirement to fault find other issues that resulted from the time that the turbines were sitting dormant awaiting recommissioning. Some challenges included moisture in generator windings that required rectification to prevent long term reliability issues and failed components (switchgear, circuit boards, power electronics, etc).

- Lack of parts and documentation: The wind turbines were almost 18 years old when decommissioned. Many parts had been discontinued and documentation and schematics for the turbines was scarce. AER was required to develop internal repair procedures for many of the wind turbine components and undertook many hours of reverse engineering of componentry to develop suitable operational documentation.

- Patience, logic and an intimate understanding of the wind turbine is key to recommissioning. The process can't be rushed, and never underestimate the amount of time required to undertake recommissioning. One particular wind turbine fault tested the patience of some of the most experienced wind turbine technicians for almost four days in what was eventually identified as a faulty contactor which only faulted intermittently.

Despite the challenges of using refurbished wind turbines, AER has now developed the capability and experience to cost effectively implement the refurbished wind turbine model in Australian renewable energy projects. This has been achieved through the development of solutions to the key issues and risks associated with the implementation of this particular implementation model:

- Spare parts supply
- Component repair
- Refurbishment procedures – electrical, mechanical, blades
- Documentation
- Recommissioning procedures and capabilities

AER is able to provide a full turnkey service to developers and project owners wishing to source and deploy refurbished wind turbines, from the identification of suitable operating wind turbines to dismantling, shipping, inland transport, refurbishment, recommissioning and O&M. This provides a one-stop-shop for developers who can access significant cost savings while reducing project risk through partnering with a service provider who is experienced in the sector.