Manildra Solar Farm

Lessons Learned in Development, Construction, Logistics and Network Connection

46.7 MWac Solar Photovoltaic Project
Manildra, NSW
Report Dated: 31 October 2019

First Solar®

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1 Project Overview

Manildra Solar Plant ("Manildra", "the Project") is a 46.7 megawatts ("MW") solar photovoltaic power generating facility occupying 120 hectares of land approximately 1 kilometer north-east of Manildra in New South Wales, Australia. The early stage development of the project was originally performed by Infigen Energy, with completion of development, financing and construction under ownership of First Solar. The Project was purchased by New Energy Solar ("NEW") at completion of construction and is now operational.

Manildra utilises more than 466,000 First Solar Series 4 thin film photovoltaic ("PV") modules, producing enough solar energy to power 14,000 homes and displace the equivalent of more than 91,000 metric tons of carbon dioxide emissions per year. The project sells power to EnergyAustralia ("EA") under the terms of a power purchase agreement ("PPA").

Manildra received funding from the Australian Renewable Energy Agency ("ARENA") via its Large Scale Solar ("LSS") competitive grant funding round in 2017. Manildra has been generating and exporting electricity into the National Electricity Market since April 2018.

This report has been prepared to support Manildra's knowledge sharing deliverables with respect to lessons learned by the project teams in the areas of:

1. Development Approval and Planning
2. Capital Costs and Construction
3. Logistics and Supply Chain
4. Network Connections

2 Development Approval and Planning

Although the current Project participants were not involved in the original development phase of the Project, the following is a general overview of the planning process undertaken. First Solar acquired the Project from Infigen Energy with a Development Approval in place, with the original approval confirmed in 2011, and two subsequent Development Approval modifications in 2015. The original planning documents for Manildra estimated the Project would have a capital investment of A$150 million, and as a result it was considered to be Major Infrastructure under Part 3A of the NSW Environmental Planning and Assessment Act 1979 (EP&A Act). The proposed solar farm at that time also had a peak generating capacity of 50 MW and was, therefore, also considered 'critical infrastructure' in accordance with Clause 75C of the EP&A Act.

The key steps in the Part 3A assessment process and timeline for Manildra were:

- 5 July 2010: The development was declared to be a Major Project by the Minister for Planning.
- 28 July 2010: The Project Application was submitted with a Preliminary Environmental Assessment to the NSW Department of Planning ("DoP").
- 1 September 2010: The Director General's Requirements ("DGRs") for the Environmental Assessment ("EA") were received from the DoP.
- September 2010 to March 2011:
    - Preparation of the EA was completed in consultation with stakeholders.
    - The EA was exhibited for public comment for a minimum of 30 days.
    - Public submissions were provided to the proponent. The proponent was then required to respond and/or modify the proposal and/or the Statement of Commitments ("SoCs").
    - The Director-General provided a report to the Planning Minister. If the Director-General recommends the project be approved, draft Conditions of Approval are attached to the report for approval (or rejection) by the Planning Minister.
- 3 March 2011: Development Approval was received from the Planning Minister.

3 Construction Costs and Analysis

3.1 Capital Cost

The completion of construction of the Manildra Solar Farm was impacted by the voluntary administration of the EPC Contractor, RCR O'Donnell Griffin Pty Ltd ("RCR"). This insolvency event has also impacted the project's ability to identify a breakdown of detailed actual construction costs under the EPC contract. Based on information available to Manildra, the following table provides a summary of the broad categories of construction costs as defined by ARENA:

Project Costs *(excluding financing and other non-construction costs)*	**Base Case**	**Actual at Completion (February 22, 2019)**
Delivery	$86,398,961	$81,163,355
Other Construction and Capital	$2,374,439	$2,039,340
Development	$14,988,467	$15,661,137

3.2 Construction Issues

During construction of Manildra a range of construction issues were experienced by RCR, impacting both construction cost and construction schedule. Following provides an outline of the more significant issues experienced:

- Cut and fill:
    - The amount of cut and fill required on site to meet single-axis tracker gradient tolerances was considerably larger than originally designed by RCR.
    - The additional cut and fill activity increased the quantity of exposed ground. SWMP sediment run-off calculations were not adjusted to allow for the increased cut and fill with the lack of groundcover increasing the risk of sediment run-off.
    - No hydrology issues experienced during construction.
- Groundcover establishment:
    - Replenishment of groundcover in cut and fill areas was impacted by the drought, with adequate coverage in re-seeded areas taking longer than expected.
- Resources and Scheduling:

- Provision of adequate water and shading during the day was identified early as a prime concern for workers, with shaded rest areas, supplies and rest periods mandated to ensure the health of workers.
- Staging materials at the end of the day to ensure installation teams were primed for the following morning start was found to be important for continuation of progress on a day-to-day basis.

3.3 Construction Schedule

Completion of construction of Manildra was significantly impacted by the voluntary administration of RCR. However, construction related issues did also impacted the timing of completion of the Project, as outlined below:

- Unfavourable Ground Conditions: The number of drilled piles (as opposed to directly driven piles) was higher than originally estimated. The number of drilled piles increased by a factor of 5 with >5,000 posts finally installed via drilling. Drill rig availability and additional time to install each pile resulted in this activity being delayed.
- Energisation: Delay to first energization of Manildra was impacted by the delay in construction as well as coordination with Essential Energy (the Network Service Provider, or "NSP") to confirm availability of resources to terminate the 11kV feeders.
- Commissioning and Testing Delays: Delays to the completion of commissioning and testing was due to ongoing assessment and testing to confirm the requirement of a harmonic filter to address the potential for excessive current harmonics. Although control of current harmonics is not required within the GPS, Essential Energy continued to push for a harmonic filter to be installed, however following extensive analysis and testing it was demonstrated that a filter was not required in order to meet the requirements of the connection application and the NER.

The following table provides a variance summary of delays in relation to key construction milestones:

Key Construction Dates	Baseline Date	Forecast / Actual Date	Variance (Early/Delayed)	Comment
Detail Design Completion	28-Jul-17	30-Dec-17	155	Critical design components were delivered with design not impacting on construction schedule
Commence Installation Works	29-Sep-17	19-Oct-17	20	
Substation Energisation	11-Dec-17	21-Dec-17	10	
Overhead Line Relocation Works	29-Sep-17	14-Jun-18	258	Delayed due to legal process
PVIS Commissioning Complete	18-Dec-17	12-Mar-18	84	General construction and commissioning delays
Installation Works Completion	7-Feb-18	14-May-18	96	

4 Logistics and Supply Chain

The major equipment used at Manildra is based on international technologies, with the procurement of project equipment and materials, including tracker posts, NexTracker single-axis trackers, First Solar photovoltaic modules, SMA inverters, AC and DC cables and switchgear, from international suppliers.

Where possible and cost effective, the EPC Contractor made use of the following Australian content and resources:

- Construction and installation labour
- Construction equipment
- Engineering and design services
- Minor consumables and operational needs
- Waste management services
- Environmental services

All materials that were shipped internationally arrived at Sydney port via seas. From Sydney port, it was determined that transportation via rail from Sydney to Parkes was the most economical, reducing road transport distance and the potential for road dilapidation maintenance requirements. Equipment was either stored in a facility in Parkes until required on site, or alternatively trucked to site for installation. This strategy reduced the overall laydown area requirement on site.

Containers arriving at Sydney port were de-stuffed at port and trucked as break bulk on trucks to site. This increased the handling requirements at the port but eliminated potential container demurrage fees. Failure by RCR to accurately track the break bulk materials resulted in material tracking issues; where in some instances, the packing lists were based on the original container content and de-stuffing converted materials to 'break bulk' across multiple loads for road and rail freight. This resulted in the need to reconcile deliveries at the Project site, which was inefficient and laborious for the EPC Contractor.

5 Network Connections

Manildra's network connection agreement was negotiated and executed by First Solar, along with an agreed Generator Performance Standard ("GPS") at financial close. RCR was responsible for the final negotiation of the GPS following completed design of the facility, and subsequent GPS compliance testing. As a consequence of RCR going into administration before completion of GPS compliance testing, First Solar and NEW were responsible for bringing the project to final completion.

Manildra benefited from both a low connection voltage and proximity to the adjacent Essential Energy substation, resulting in a simplified connection arrangement and lower cost connection. Dual AC feeders from two photovoltaic interconnection switchgear units connect directly to Essential Energy 11kV busbars, providing redundancy to the connection and lower cost connection infrastructure.

The process of taking the Manildra connection through negotiation, registration, and testing has resulted in a number of lessons learned by the various parties:

- Grid connection represents a significant risk to project schedule. This is driven by a number of interrelated factors:
    - Volume of connection enquiries and commissioning processes.
    - Equipment manufacturers not adequately understanding the performance requirements of the NER.
    - Differing interpretations of the meaning of aspects of the NER.
- The cause, allocation of responsibility and resolution of network harmonic issues needs to be more clearly understood by all in the energy industry. Manildra experienced protracted negotiations on whether a harmonic filter was required, leading to significant delays.
- Connection at 11kV can significantly decrease the cost and time of the connections in an increasingly constrained network.