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A case study identifying and mitigating the environmental and community impacts from construction of a utility-scale solar photovoltaic power plant in eastern Australia

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ABSTRACT

A case study on the construction of a utility scale solar PV plant is described highlighting how a range of environmental and community risks identified (i.e. predicted) at the planning stage, were not experienced in the field during construction, and those risks that did eventuate, were managed effectively. Logistics, fauna and biodiversity, noise, infrastructure and camp establishment issues, and the construction and operational environmental management plans, have the most planning approval requirements. Key learnings from the project are highlighted for each major impact area.

1. Introduction

Solar photovoltaic (PV) technology has become an increasingly important energy supply option globally. At the end of 2016, installed capacity worldwide exceeded 300 GW (Anonymous, 2016). A substantial decline in the cost of solar PV panels (or modules) has improved solar PV's competitiveness, reducing the need for subsidies and enabling solar to compete with other traditional power generation options in some markets. A recent estimate reveals that these price reductions have been as high as 80% from the period of 2006 to 2015 (Anonymous, 2016). While the majority of operating solar projects are in developed economies, the drop in prices coupled with unreliable grid power and the high cost of diesel generators has driven interest in solar PV technology in emerging economies as well (IFC, 2015). Assuming that PV technology prices continue to fall relative to competing sources of electricity, the market penetration rate of utility-scale solar energy (USSE) power projects can be expected to continue growing rapidly, including in emerging markets.

Solar PV installations have increased significantly in recent years in Australia. Although Australia represented only 2% of the global market share of solar PV in 2015, in the same year this represented a total installation of just over 1 GW of installed capacity. There are numerous regulatory issues that must be considered in the installation of new power generating sites including those generating solar PV (Oosterhuis, 1994; Outhred and Retnanestri, 2015). While the environmental and public health benefits of solar PV are extensive (Wiser et al., 2016), these regulatory issues need to be addressed and barriers to adoption overcome if the technology is to be integrated further into the economy and society, as has been the case with other environmental technologies and innovations (Guerin, 1999).

For USSE developments in New South Wales (NSW) (Australia), the range of legal requirements are identified in the environmental impact statement (or environmental impact assessment) stage of the developments as part of the preconstruction planning and approval. In New South Wales, Australia, the applicable laws range from climate laws, planning laws, local and state government laws to operational environmental law (Lyster et al., 2012).

2. Purpose

The purpose of this paper is to identify the risks pertaining to environmental and community issues expected during construction of a USSE photovoltaic power plant in the state of New South

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Wales, Australia, and then compare these to those identified in the field. The paper is presented as a case study.

3. Methods

The case study site is located in Central NSW, Australia. The USSE power plant has an installed capacity in excess of 100 MW. The project was constructed on entirely rural land and was located on one land parcel. Approximately 250 ha of land was required for the plant (Fig. 1). Along with the solar plant, the development included the installation and operation of a 132 kV transmission line, approximately 4 km long × 40 m (wide) to the main network interconnection. The solar plant consists of more than one million photovoltaic (PV) modules. The modules were mounted on steel post and rail (table) support structures up to 2 m in total height. Supporting infrastructure includes the installation of above and underground electrical conduits, construction of a substation, site office and maintenance building, provision of perimeter fencing, unsealed access road and the transmission line (Fig. 2). The planning and approvals process required the preparation of an environmental impact statement (EIS), and the consent conditions, approved by the state government, were based on this documentation and extensive consultation as required under the Environmental Planning and Assessment (EP&A) Act 1979 (Lyster et al. 2012). Prior to construction, the construction environmental management plan (CEMP), was prepared.

The case study and all large scale solar PV projects, have a common engineering concept (Dunlop 2012). Solar PV facilities utilise PV cells which are assembled to form PV panels or modules that are then lined up into solar arrays. PV cells convert sunlight into electric current using the photoelectric effect. The solar arrays use an inverter to convert the DC power produced by the PV panels into AC power. A solar PV facility comprises a series of PV panel arrays and inverters, mounts, cabling, monitoring equipment, substation and access tracks. In essence, USSE PV developments conform to construction methodologies common to earthworks, civil and structural, trenching, and electrical work scopes.

Solar PV plants can use either fixed-mount solar arrays (as in the current case study) or automated tracking systems that allow the solar arrays to follow the sun's daily path across the sky and optimise electricity production, though these require higher outlays of capital. Such tracking systems also have higher operating costs and require more land surface in order to avoid shading. On the other hand, they also give a higher power output which can reduce the required installed capacity. Subsequently, it is possible that tracking systems can offer lower levelised cost of energy (LCOE) than fixed array systems. An analysis of the pros and cons of such systems and their applications have been described previously (Campbell, 2011). The calculation of the LCOE provides a common way to compare the cost of energy across technologies, including types of panel mounting systems, because it takes into account the installed system price and associated costs such as financing, land, insurance, transmission, operation and maintenance, and depreciation, among other expenses (Dunlop, 2012).

For incident investigation and management, the 5-Why method of root cause analysis was used as previously described (Guerin 2015).

4. Results and discussion

The approvals process for the project led to a total of 296 consent conditions being applied to the project and the related facilities including the accommodation camp (Table 1). A construction environmental management plan (CEMP) for the project was prepared which included all the necessary subplans to address each of the consent conditions stipulated to be followed during construction. The CEMP subplans are summarised in Table 2.

A comprehensive assessment of all the operational health, safety and environment, and community (HSEC) risks were identified prior to construction, based on EIS and documents collected and or prepared during the planning stage, as well as knowledge gained from initial works at the site and the expertise of the newly assembled project team members (Supplementary Materials - A).

Logistics, fauna and flora management, visual impact, fire risks, soil, water and dust management and waste management and resource use impacts, were the key impact areas and are discussed in further detail as they related to the case study project. A summary of the targets and actual environmental and community outcomes during construction of the case study project is given in Table 3. Key learnings from each of these are highlighted under each impact area.

4.1. Transport and logistics impacts

Access to the solar plant site during the construction phase was via a main road. This main road (highway), access to which was located 1 km south from the site offices (Fig. 2), traversed east to west across a large portion of the central areas of NSW, and which is a sealed, single carriageway public road. The construction and operation of the solar plant did not have a significant or measurable impact on traffic flows on this main road, given that there was an increase in traffic volumes from both light and heavy vehicles during the 12-month construction period.

The 4 km long × 40 m wide 132 kV transmission line (from the solar plant's substation) crosses the main road at the site's entry but its installation did not disrupt traffic. This aspect of the works required consent from the Roads and Maritime Authority (in NSW) and the local council under s138 of the Roads Act (1993) (NSW).

The solar plant site was very flat, making drainage difficult due to the minimal fall able to be achieved. During the execution of the civil works, above average rainfall was experienced, which at times severely impacted the work's schedule and budget. Inclement weather was identified during the project planning phase of the project, however, the large volumes of rainfall (the impact of which was not planned for as it was the highest in the past 15 years and was not allowed for or anticipated in the construction plans) did have an impact on logistics, materials deliveries (both local and interstate), transportation, internal site road condition and development, laydown yard activities, and the ability to use heavy tracked equipment, trenchers and cranes. Rainfall affecting these activities resulted in delays until the saturated soil was able to dry out through standard dewatering and pumping activities (drying usually occurred within 24–48 h).

Within the project site, the civil works scope included construction of internal access roads on the perimeter of the site, around the array blocks, as well as internal alleys, along with car parks, laydown areas for storage of materials. All of these required maintenance through the timeline of the construction project. Maintenance requirements for civil works included grading, levelling, dust abatement, application of dust inhibitor (canola oil and calcium lignosulphonate were trialled). While longer lasting, these chemicals were ultimately less cost effective than water, and dewatering when localised flooding occurred (which was conducted on three separate occasions) after local flooding.

A Traffic Management Plan was developed as a subplan of the CEMP and implemented with only minor non-conformances observed (Table 2). During the 18-month period of construction, 600 road trains each loaded with 2 × 12 m shipping containers made deliveries to the project site delivering solar panels (modules) and related construction materials.