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Evaluating expected and comparing with observed risks on a large-scale solar photovoltaic construction project: A case for reducing the regulatory burden

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A R T I C L E I N F O

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A B S T R A C T

The overwhelming benefits of building solar power plants instead of fossil fuel powered sites for new generation capacity outweigh the less significant risks, some of which are identified in this study on the construction stage of a utility-scale solar energy (USSE) project. This project confirmed and clarified the nature of environmental and community risks to be expected on Australian construction sites. Expected risks from desk top studies and related planning requirements captured the majority of those risks actually experienced in the field during the construction phase. The large number of approval conditions (set by the relevant regulatory authorities; state and local) for the construction stage of the project, are arguably excessive compared with the risk profile of the project, and the overall positive benefits to the environment, economy and local community. The environmental and community risks of greatest concern (including dust control, optimising vegetation growth under the panels, waste management, a lack of common understanding of expectations for local job opportunities), while planned and eventually managed, could have been more efficiently addressed by further upfront investigations, and questioning and enhancing the governance processes by the engineering procurement construction (EPC) entity (or constructor). For example, managing the end-of-life packaging materials (EOLPMs) was a specific unexpected risk on the project during the construction stage, which can be overcome on future remote location projects by enhancing the design and execution of project-level contracts and securing partners such as resource recovery companies or other end users (of EOLPMs) at the earlier, planning stage. Recommendations for regulators include to reduce approval constraints on new low-emissions electricity developments, particularly at the state and local government level. These should be considerably less onerous than building new fossil fuel electricity generation infrastructure. A sharper focus on regulatory red tape reduction will enhance USSE project adoption.

1. Introduction

1.1. Establishment of renewable energy industry in Australia

Australia's National Strategy for Ecologically Sustainable Development (ESD) launched in 1992, encouraged federal, state/territory and local governments to pursue ESD, with climate change being identified as a threat to a sustainable future. With energy (electricity) production being the primary source of Australia's emissions, governments at all levels are recognising the need to reduce greenhouse gas (GHG) emissions. The development of low or zero GHG emission energy technologies such as solar, wind and other sources of renewable energy plants, is essential to achieving significant reductions in national GHG emissions.

1.2. Regulatory incentives

The Australian Government's Mandatory Renewable Energy Target (MRET) scheme was established in 2001 to expand the renewable energy market and increase the amount being utilised in Australia's electricity supply. The Renewable Energy Target (RET) scheme is an expansion of the MRET and has been established to encourage additional generation of electricity from renewable energy sources. In February 2011, the Enhanced Renewable Energy Target (ERET) was also introduced which consisted of the Small-scale Renewable Energy Target (SRET) and the Large-scale Renewable Energy Target (LRET). This was done to provide greater certainty for households, large-scale renewable energy developments and installers of small-scale renewable energy systems like solar panels and solar water heaters. Currently the total installed capacity of solar PV (including all forms) is 2% of the

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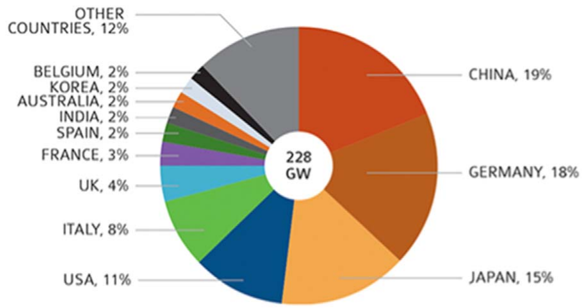

Fig. 1. Cumulative solar PV installed in Australia as a proportion of world total (Source: IEA PVPS 2017).

global installed capacity (Fig. 1).

1.3. Growth of photovoltaic (PV) solar in Australia

Only in the past decade have solar PV systems come to the fore in meeting Australia's energy and emissions reduction challenge [1–3]. Utility scale systems are relatively new to the Australian energy landscape with the emergence of 10–20 MW installed systems being constructed in the past 5 years. An indicator of this is the trends in employment in renewable energy activities including employment activities related to all solar power systems with an installed capacity of 40 kW or greater (referred to as large scale in Fig. 2). In practise, large scale solar includes two broad types of solar power infrastructure. The first is a larger version of roof-top solar PV installations, typically sited on the roof of commercial operations such as shopping centres, hospitality clubs or factories. The owner of this type of infrastructure is usually seeking to defray a significant electricity expense. The second type of large scale solar infrastructure is a dedicated solar farm, or power station, allowing the electricity producer to supply electricity to the grid for sale to third-party customers. In Australia, this type of infrastructure will allow its owner to gain accreditation under the LRET. In both cases, employment in renewable energy activities relates to those direct employment activities needed to carry out the installation of the large scale solar, such as site preparation, system design, system installation, project management and administration. In principle, it also includes employment related to the ongoing operation and maintenance of large scale solar power infrastructure (Fig. 3) [4]. During the period shown, employment growth has been slow in the large scale solar sector with full time equivalents (FTE) growing from 10 to 800 FTE.

1.4. Environmental and community impacts and risks

There is little known of the impacts of large scale solar systems on the environment or the communities in which they are constructed and/or operated in, particularly from the published literature from Australia. Environmental impacts of utility scale solar energy (USSE) systems occur at differential rates and magnitudes throughout the project's lifespan (i.e., construction, operation, and decommission) of a power plant, which varies between 25 and 40 years [5]. Such impacts relate to biodiversity, water use and consumption, soiling and dust, human health and air quality, transmission corridors, and land-use and land-cover changes reported for international studies [6–8]. Other comprehensive studies include those also by a range of international researchers [9–14].

Treyer and Bauer [9] recognise in the middle east, from LCA analysis studies, that the practical way forward to reduce carbon emissions will include a mix of low emissions energy approaches. Scognamiglio [10] argues that ground-mounted large photovoltaic (PV) arrays are the least-cost design solution for installing PV, they account for the majority of the solar power installed to date. With the increase of both the number and size of installations, the attention to their impacts in terms of land-use and land-transformation is growing, as well as concerns about landscape preservation and possible losses of ecosystem services. Scognamiglio [10] argues the current fixed mount design is generally straight-forward and is aimed to maximise energy generation given a certain land area and brings forward the holistic idea that PV systems should be designed as an element of the landscape they belong to, according to an 'inclusive' design approach that does not focus only on the overall energy efficiency of the system, but extends to other additional ecological and landscape objectives.

An overview of the current status of CdTe solar cells and modules with respect to life cycle management of raw materials is provided, and is an important part of considering USSE system risks [15,16]. Actively managing raw materials throughout the product life cycle can help to manage cost and conserve resources for large-scale PV deployment. Among the various materials management strategies, a primary factor influencing the material intensity of PV systems is module conversion efficiency. Material and energy usage across life cycle stages (module manufacturing, balance of systems, collection and recycling) have been documented in life cycle inventories. An example of life cycle materials management is water management, where specific strategies include minimising electricity use in PV module manufacturing, improving PV module efficiency, deploying tracking systems, developing a water balance for PV manufacturing facilities, minimising grading during construction, using dry brush cleaning methods during operation, and recycling end-of-life systems. Due to low life cycle water usage, solar PV provides a potential path forward for addressing the energy–water nexus with solar desalination as an example application [15].

1.5. Limited published experience in Australia

In Australia there are now several USSE systems in the construction as well as the operations and maintenance stage. There is a lack of

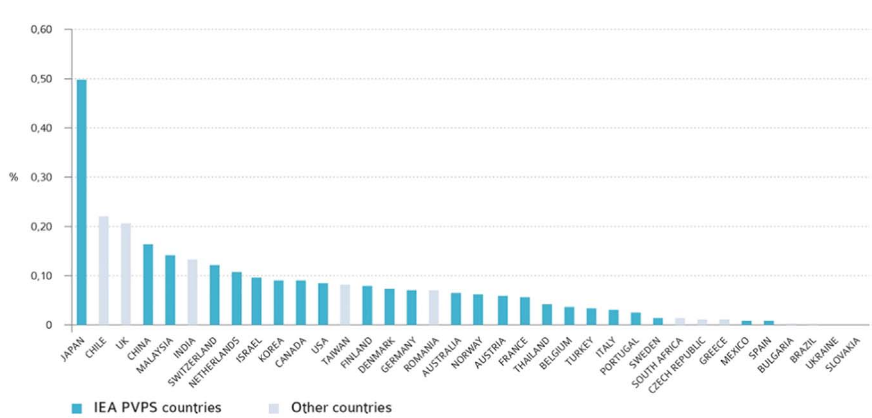

Fig. 2. The size of business of the PV market as a proportion of country GDP (Source: IEA PVPS 2017).