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Implications of applying solar industry best practice resource estimation on project financing

Romeo Pacudan *

Brunei National Energy Research Institute (BNERI), Brunei

HIGHLIGHTS

- Best practice solar energy resource estimation uses multiple datasets.
- Multiple datasets are combined through measure-correlate-predict technique.
- Correlated data have lower uncertainty and yields superior high-confidence energy production.
- Best practice case yields debt-service coverage ratios (DSCRs) that surpass the benchmark rates.
- Best practice case accommodates high debt share and have low levelized cost of electricity.

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ABSTRACT

Solar resource estimation risk is one of the main solar PV project risks that influences lender's decision in providing financing and in determining the cost of capital. More recently, a number of measures have emerged to mitigate this risk. The study focuses on solar industry's best practice energy resource estimation and assesses its financing implications to the 27 MWp solar PV project study in Brunei Darussalam. The best practice in resource estimation uses multiple data sources through the measure-correlate-predict (MCP) technique as compared with the standard practice that rely solely on modelled data source. The best practice case generates resource data with lower uncertainty and yields superior high-confidence energy production estimate than the standard practice case. Using project financial parameters in Brunei Darussalam for project financing and adopting the international debt-service coverage ratio (DSCR) benchmark rates, the best practice case yields DSCRs that surpass the target rates while those of standard practice case stay below the reference rates. The best practice case could also accommodate higher debt share and have lower levelized cost of electricity (LCOE) while the standard practice case would require a lower debt share but having a higher LCOE.

1. Introduction

Solar PV power generation has started to emerge recently in the national energy mix of a number of ASEAN countries due to the improvement of solar PV cost competitiveness at the international market and the introduction of policies and regulatory frameworks that promote the deployment of renewable energy technologies. This is particularly evident in countries that have introduced reforms allowing private sector participation in the generation segment of the power industry. Also, due to increasing sizes of solar PV projects being planned and implemented in some of these countries, project financing or non-recourse financing has been increasingly used as one of the main mechanisms to finance utility scale solar PV projects.

There exist however a number of project risks inherent to solar PV project planning, construction and operation that inhibit the full development of solar energy resource potential in these countries. These risks as perceived by lenders and investors could influence their decision in providing project financing and in determining the cost of financing. Solar PV projects are currently subject to high financing costs due to the higher perception of risks associated in project development (Lowder et al., 2013).

As the solar PV industry started to mature, risk management strategies have emerged and various measures to mitigate solar PV project risks have been identified. A key question raised in this paper is how these measures and management practices have contributed in attracting financing and in lowering solar PV energy production costs. This paper aims to evaluate the impact of a specific risk mitigation measure or management practice on project financing and how it contributes to attracting favourable financing and reducing energy generation cost.

* Corresponding author.
E-mail address: romeo.pacudan@bneri.org.bn

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Solar PV project risks are numerous and could be classified into technical and non-technical and could be further subdivided into development stage risks and operational risks. Among these risks, the study focuses on solar resource estimation risk, a technical risk at the development stage that affects the calculation of the expected annual production of electricity at the pre-construction stage of the project – the stage where mobilization of financial resources is crucial. This risk mainly comes from the uncertainty in solar resource estimates. The expected annual production could be possibly overestimated and that failure to achieve the target production compromises the project's ability to meet its debt obligations.

A standard practice in solar PV industry is that project developers often rely on satellite-derived solar irradiation data in their feasibility studies due to lack of available ground measurement data near identified project sites. High resolution satellite data have however high uncertainty due to difficulties in integrating key atmospheric parameters in the radiative transfer models (McMahan et al., 2013; Vignola et al., 2013; Stoffel et al., 2010). Banks and investors providing financing to solar PV projects on the other hand require higher production probability (higher level of confidence on actual energy production) to ensure the project's ability to service its financing obligations.

On-site measurements which provide site-specific data with known technical details and management scheme are the source of accurate solar data for project analysis. Also the level of uncertainty of on-site data is relatively low (Stoffel et al., 2010; Vignola et al., 2013). Most on-site measurements have however shorter record period and do not capture the long-term historical climate trend. As a measure to mitigate risks in resource estimation and to address the data accuracy concerns, the use of multiple data sources instead of relying solely on satellite data or short-term on-site measurement data in resource estimation is emerging as the best practice in the solar energy industry. One of the methods in combining various sources of solar data is the measure-correlate-predict (MCP) approach which correlates short term data measurements with long-term reference datasets (Vignola et al., 2013; Schnitzer et al., 2012).

Applied on a specific case study in Brunei Darussalam, the study evaluates the implications of employing the industry's best practice of using multiple sources of data in resource estimation on financial structuring of projects. The study compares the expected energy production and high-confidence level energy generation from both the standard practice and best practice in resource estimation. The study investigates and compares capital structuring of these two cases by simulating combinations of project debt to equity ratio to satisfy the debt-service coverage ratio (DSCR) targets set by lenders and credit rating agencies for high-confidence energy estimates.

The case study used in the analysis is the identified expansion project of the Tenaga Suria Brunei (TSB). TSB is 1.2 MWp Solar PV Power Generation Demonstration Project jointly implemented by the Government of Brunei Darussalam and Mitsubishi Corporation (MC). The project is situated in Seria, Belait District with global coordinates of 4.61°N, 114.34°E and altitude of 4.6 m above mean sea level. The Brunei National Energy Research Institute (BNERI) has carried out a study to assess the potential expansion of the TSB project. The study has identified a total land area of more than 24 ha in 3 adjacent plots and within close proximity to the site that are suitable and available for solar PV development. Using polycrystalline solar PV modules, a minimum of 27 MWp capacity could be potentially developed and added to the existing TSB project (Pacudan, 2015b).

This paper is structured as follows. Section 2 presents the data and the methodology used in establishing energy resource estimates for both the standard and best practice case studies, the uncertainties associated with these datasets and the methodology used in estimating energy production. Section 3 presents the energy production results and discusses the impacts of these results on financing. Section 4 presents the conclusion and policy implications of the study results.

2. Methodology and data

The estimation of energy production from solar PV power plant is influenced by the accuracy of solar irradiation datasets and the energy generation simulation model. The uncertainties in energy production determine project risks and financing costs. High confidence energy production levels which are the basis for financing decisions are derived using the uncertainties related to the solar irradiation datasets as well as the uncertainties in energy production estimation.

This section describes and derives the solar irradiation datasets and their associated uncertainties, and presents the methodology in estimating energy production from the 27 MWp solar PV power plant in Brunei Darussalam. Section 2.1 presents the irradiation datasets used in the standard industry practice case and establishes the datasets for best practice case through measure-correlate-predict methodology while Section 2.2 describes and determines the measurement uncertainties of these two datasets. Section 2.3 describes the energy simulation model used on the study as well as the uncertainties in the estimation of the overall energy production. Energy production uncertainties are wide-ranging and encompass solar measurement uncertainties.

2.1. Solar irradiation datasets

The radiant power from the sun is known as the total solar irradiance (TSI) which is estimated at the mean Earth–Sun distance to be 1366 ± 7 W/m^2 with the variation attributed to the 11-year sunspot cycle while on the other hand due to the Earth's elliptical orbit, the solar radiation reaching at the top of the atmosphere also varies annually between 1415 W/m^2 to 1321 W/m^2 (Stoffel et al., 2010; Paulescu et al., 2013). The solar irradiance that is available at the top of the Earth's atmosphere is known as the extra-terrestrial solar radiation (ETR). When the solar radiation passes through the Earth's atmosphere, its spectral distribution is modified by absorption and scattering processes, and separated into different components (Stoffel et al., 2010). The direct normal irradiance (DNI) is the part of the solar radiation that directly reaches the Earth's surface and normal to the sun's position; the diffuse horizontal irradiance (DHI) is the part of the radiation scattered in the atmosphere as measured on a horizontal surface. The sum of the direct and diffuse irradiation is known as the global horizontal irradiance (GHI). Energy production from solar PV power facilities are estimated using global horizontal irradiance (GHI) datasets (Coimbra et al., 2013; Stoffel et al., 2010).

At present, there are various sources of GHI data used by project developers in solar PV project preparation stage, and these are: (i) modelled data, (ii) reference station data, and (iii) on-site data. Modelled data consist of a combination of satellite-modelled, numerically modelled and back-filled datasets, reference station data are datasets collected from international, national, regional and state level surface-based measurements while on-site data are those collected through on-site solar measurement and monitoring campaigns (Schnitzer et al., 2012; McMahan et al., 2013).

On-site measurements are the source of most accurate dataset for project analysis which provide site-specific data derived from known technical details and management scheme (Stoffel et al., 2010; Vignola et al., 2013). Most on-site measurements have however shorter record period and do not capture the long-term