Estimation of Optimum Orientation for Solar Panels mounted on Buildings in Sri Lanka

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1. Introduction – The government of Sri Lanka has shown keen interest in the generation of electricity by renewable energy replacing the carbon-intensive sources. Accordingly, a nationwide program called 'Battle for Solar Energy' was initiated in the year 2016 that encourages, among others, the installation of grid connected small-scale roof-top solar PV units. This has created a huge turning point in the Sri Lankan electricity sector with a total solar generation exceeding 200 MW to date, which even surpasses the government's own Nationally Determined Contributions (NDC) target of 105 MW in solar. With the success of this program, the Sri Lanka Sustainable Energy Authority (SLSEA) is looking towards the feasibility of setting up solar panels on the roofs and walls of buildings without major change in orientation to minimize the cost of mounting arrangements. This research is carried out with the guidance of SLSEA to appraise the above concept by formulating a numerical model for the characterization of energy performance of solar panels mounted at different azimuth angles (α) and mounting angles (β).

2. Methodology – The model presented in this paper uses global horizontal irradiance (GHI), direct horizontal irradiance (DHI) data from ground stations and basic solar geometries to calculate the annual solar irradiance falling on solar panels mounted in 32,400 different orientations by varying α from 0 to 90° and β from 0 to 360° in 1° increments. Direct normal irradiance (DNI) is derived from available GHI and DHI values. The only geographical region in Sri Lanka that has both GHI and DHI data for a complete year was found to be Hambanthota and therefore the model was used for this region. The results are compared with the data model found in the solar atlas of Sri Lanka (SASL) published by SLSEA.

3. Results and Discussion – The results of the analytical model are displayed in figure 1, which shows the distribution of annual solar irradiance falling on a solar panel with varying α and β, with a peak value of 2079 kWh/m^2 at the optimum angles of α = 63° and β = 10°. The optimum angles reported in SASL are α = 0° and β = 7°. Yet the difference between the annual solar irradiations predicted through the present model at the above two set of optimum angles is only 1.0%. Another notable result from the model is that the annual solar irradiance at orientations with varying angles of β from 0 to 14° and α from 0 to 126° has values within 98% of the peak value, stressing the possibility of mounting solar panels at a wide range of orientations without lessening the energy production. Further, the panels mounted on vertical walls (α = 0°), will have considerably lower energy potentials, with a maximum value of 1004 kWh/m^2, a 51.7% reduction from the overall peak value.

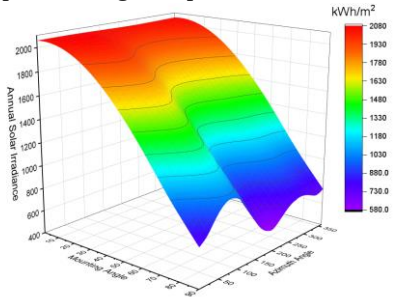

Figure 1: Annual Solar Irradiance

4. Conclusions - The numerical model can be used to predict the variation the annual solar irradiance falling on the surface of a solar panel successfully. The optimum α from the model can be seen to have a significant difference from the optimum value reported in the national solar map, thought the difference between the annual solar irradiations is less than 1.0%. The reductions of solar irradiance falling on a vertical solar panel are significant and therefore should be considered when deciding the applicability of the concept on buildings.