S. A. Alkaff, N. H. Shamdasania, G. Y. Ii and V. K. Venkiteswaran, “A Study on Implementation of PV Tracking for Sites Proximate and Away from the Equator,” *Process Integration and Optimization for Sustainability,* vol. 3, pp. 375-382, 5 March 2019.

This article studies the effect of geographical location on sunlight exposure and evaluates the effectiveness of single-axis and dual-axis trackers for photovoltaic systems. It claims that for locations nearer to the equator, single-axis tracking system provides 19% more energy output relative to fixed photovoltaic systems while dual-axis tracking system provides an additional 4% over the single-axis trackers. However, despite the dual-axis trackers generating more energy output than the single-axis trackers, the article indicates the additional drawbacks of implementing dual-axis trackers over single-axis trackers (requiring more power and more complicated). Hence, it might not be ideal for locations near the equator to deploy dual-axis trackers over sing-axis trackers.

This article is published in 2019 which is relatively recent. As our report is based on Singapore which is near the equator, this source article is relevant to us as it also studies the tracking systems in locations near the equator. Checking up on the researches, it is found that they are from School of Engineering and Physical Sciences, Heriot-Watt University, Putrajaya, Malaysia. According to ORCID (Open Researcher and Contributor ID), many of the researchers have the relevant qualifications and experience such as holding a PHD in the engineering field or being an assistant professor in the university for extended period. Cross-referencing with SERIS (Solar Energy Research Institute of Singapore), the claims made by the source article such as the increased energy output for single-axis trackers and dual-axis trackers agree with SERIS.

This article justifies our choice of installing single-axis tracking systems over the dual-axis tracking systems as a solution. It is seemingly paradoxical to install single-axis tracking system when an upgraded counterpart (dual-axis trackers) exists that harvests greater energy output which addresses the problem in our report. However, this article considers the additional drawbacks of dual-axis trackers over the single-axis trackers, and compares them with the limited benefits it brings due to the geographical location of Singapore, providing data to support our choice of single-axis trackers over the dual-axis trackers.

A. Quek, A. Ee, A. Ng, and T. Y. Wah, “Challenges in Environmental Sustainability of renewable energy options in Singapore,” *Energy Policy*, vol. 122, no. August, pp. 388–394, 2018.

This article examines the environmental sustainability of renewable energy in Singapore given its geographical limitations. It presents geographical and demographic data such as the land area of Singapore (710km2) and the amount of space required for sufficient PV panels (158km2) to meet the large energy demand of the high population density country.

This source is published in 2018 and the data used are relatively updated, citing from other credible sources such as 2017 data from Energy Market Authority (EMA) and 2016 data from National Environmental Agency (NEA). The researchers are from the University of Singapore (NUS) and according to ORCID, they have much relevant experience in this field of study. This source is relevant as it studies our target location of our report ­­– Singapore; and obtains data from the local organisations that are credible and updated. With reference to an article published by The Business Times in December 2018, entitled “Singapore goes underground to boost land use”, Ler Seng Ann, a group director at the Urban Redevelopment Authority (URA) acknowledges the land scarcity in Singapore and the implication of it on the country’s future development.

This source provides us with the evidence and data to support our claim that land scarcity is a pressing issue undermining Singapore’s ability to meet its demand for green energy. It presents the extent of the land scarcity’s implication on solar energy deployment and serves as a basis for our choices of proposed solutions.

Our second proposed solution is the installation of non-tracking planar concentrators which act as mirrors to redirect solar energy onto specific areas with PV panels installed. As some areas have consistent and good exposure to the sun, but the restricted space due to urban infrastructure impedes the installation of PV panels, planar concentrators which require lesser space (and cost) than the PV panels can be installed. These concentrators resolve the intermittency in solar generation by redirecting solar energy from these consistently high sunlight exposed areas with limited panels installation space onto locations with lower or inconsistent sunlight exposure but with available space for PV panels installations. According to a report by Solar Energy Research Institute of Singapore (SERIS), PV cell can only be installed in the upper part of high-rise buildings due to mutual shading [40]. In addition, PV cells can only be installed at places out of reach of the residents or homeowners as they might sabotage the PV cells due to the unappealing aesthetics [40]. Hence, as these concentrators are smaller in size and less impactful to the overall aesthetic of the location, they can be installed at these areas while PV cells can be installed at areas affected by mutual shading of the buildings, thereby redirecting the sunlight from the region within reach of saboteurs onto areas with limited sunlight exposure due to mutual shading. Since these concentrators requires lesser space to install, they are also able to boost the energy output of the PV cells more space efficiently. According to a Bi-Directional Reflectance Function (BDRF) Based Modelling done by Queen’s University and Michigan Technological University, installation of non-tracking planar concentrators can increase PV system performance by up to 30% [41]. This means that these concentrators can increase the energy output while occupying relatively lesser space than installing additional PV panels.

In conclusion, Singapore’s high energy demands is an urgent call for Singapore to increase its renewable solar energy production. Our paper has identified that the main causes limiting Singapore’s solar generation is its land scarcity and unstable weather, leading to lower deployment areas and intermittent solar power, and that current measures in plan can mitigate this limiting factor, but may have other undesired implications. As such we have proposed \_\_\_ to be used in conjunction with current measures to effectively \_\_\_ and meet the high energy demands of Singapore.