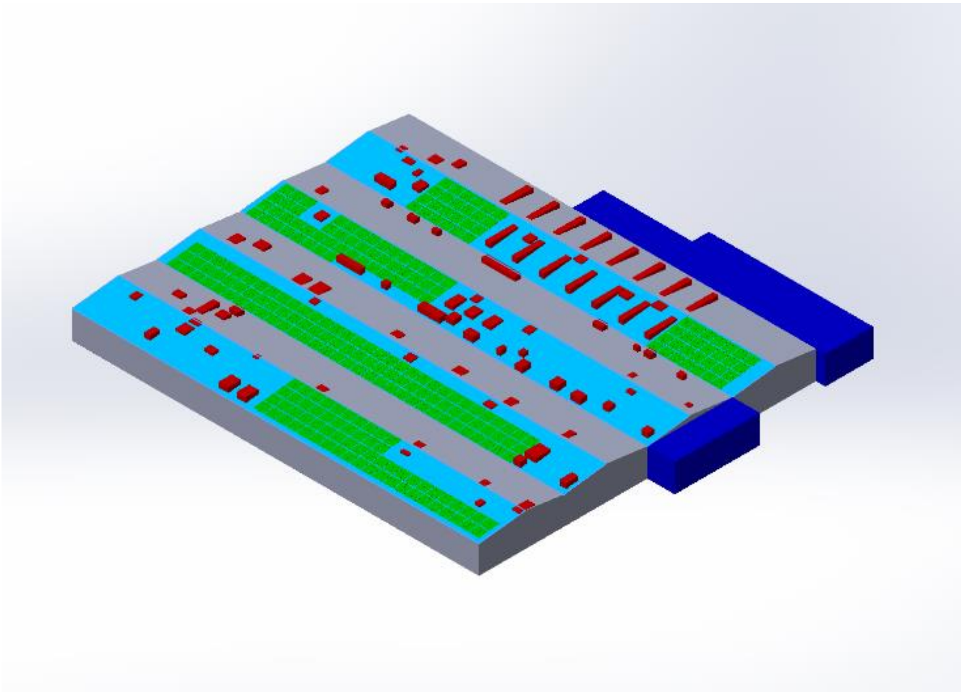
EMS761U/P - Solar Energy Engineering 2025/26

Individual Written Report:
Formula 1 Media and Technology Centre (M&TC) in Biggin Hill



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1. Design brief:

The selected location for the study is the Formula 1 Media & Technology Centre located in Biggin Hill, Kent (approximately 51.320° N, 0.030° E)[1]. Due to its massive scale and large rectangular commercial roof area, Biggin Hill was recognized as an ideal location to install a rooftop photovoltaic system; and due to the operational needs of Formula One's broadcasting and media operations, there are operational electricity demands that could be both high and constant throughout the year.

The building has also been selected as suitable due to its operational purpose. Formula 1 have stated that their Media & Technology Centre in Biggin Hill provides the central hub from where they transmit live coverage to over 180 countries/territories worldwide[2]. A major broadcast and media processing centre such as the one described is likely to be equipped with extensive IT, communication and data processing systems, thereby generating a significant electrical load profile. Therefore, the opportunity for on-site PV generation is maximised through the application of local renewable energy generation to mitigate daytime electrical demands associated with the building's media and broadcasting activities.

The literature provides support for selecting buildings of this nature. Approximately twenty percent to forty percent of the total final energy consumed by developed nations can be attributed to the built environment, with commercial and office buildings being a significant portion of non-domestic energy demand [3]. Office-type buildings in the UK represent a considerable portion of total energy consumption in offices, including relatively minor electrical loads that together account for in excess of 20% of total energy usage [4]. Therefore, a media and technology facility, such as the one described above, increases the likelihood of having sufficient electrically intensive loads to justify local renewable energy generation.

Based upon the above factors, PVGIS indicated that an approximately 152 kWp crystalline silicon PV system installed at Biggin Hill would have produced approximately 132,905 kilowatt-hours of electricity per annum [1], and as a result of combining viable available rooftop space, possible high operational loads and credible solar energy production capacity, the Formula 1 Media & Technology Centre is considered to be a good candidate for the case study building.


Fig 1 & 2. Front of F1 media building/ Sapphire House Biggin Hill (left) [5] and aerial view from Google earth (right) [6]

2. System design:

2.1 Primary feasibility assessment

The Google Earth built-in solar design tool was utilized at the beginning stages of the design process as the first level of feasibility assessment to determine suitability of the rooftops for PV installation. The tool indicated an extremely high degree of rooftop solar potential for the building. The design tool output was used solely for a preliminary evaluation of the building's suitability for PV installation.

The final design was subsequently developed by hand to enhance its practicability, and the rooftop obstacles (such as HVAC units), the access zones, the areas of broken or interrupted roofs and other extensions were excluded from the design. Therefore, the design adopted utilizes the most space efficient and feasible method of installing the PV array using only the preferred south-west sloping roof areas with all safety considerations made for the inspection, installation and maintenance of the equipment.

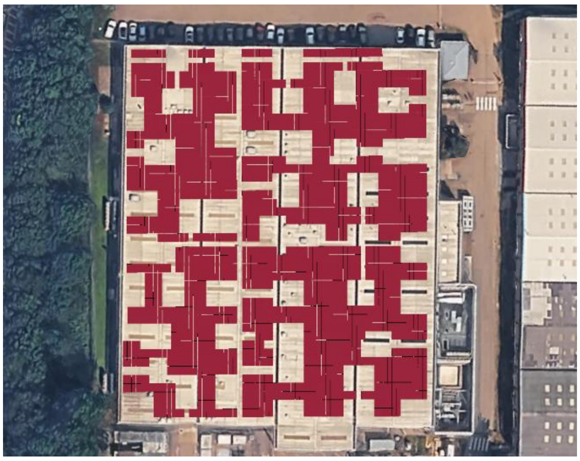

Fig 3. Google Earth inbuilt solar design tool for the chosen location [6]

2.2 System Design Concept

This Final Proposal will be a grid connected rooftop Photovoltaic (PV) installation for the Formula 1 Media & Technology Centre located at Biggin Hill. The proposed system utilizes the available roof space that was determined in section 1 of this report. The available roof space will ensure that safe access is maintained and roof obstructions are avoided.

The building roof can be considered as a rectangular shape with an approximate size of 94.42m x 78.57m providing an approximate total floor area of 7,417.8 m². A fixed tilt crystalline silicon solar panel array is to be fitted only to the southwest aspect of the roof surface. The roof has a compass bearing of 233° from North. This equates to an azimuth angle of 53° as defined by the PVGIS module [1]. The chosen roof pitch is 7.5°. This is very similar to the 8° pitch used in the PVGIS performance model [1].

2.3 Selection of Technology

Monocrystalline / Crystalline Silicon was selected due to the fact that the roof area available is limited and thus a higher efficiency technology would be best suited for this application. The PVGIS model used for this study is based on crystalline silicon and indicates excellent performance at the site selected [1]. Additionally, numerous studies have demonstrated that crystalline silicon PV systems are well-established for grid-connected rooftop applications and can demonstrate strong technical, environmental and economic performance during the operational lifetime of the system [7][8].

Due to the constraints associated with a commercial rooftop, thin film technologies including amorphous silicon, CdTe and CIGS were not considered as options for the PV array. Lower efficiency modules are less efficient for making use of the available installation area for a constrained commercial rooftop application.

2.4 Choice of Fixed-Tilt Mounting Methodology

Fixed tilt mounting was selected over solar tracking due to the simplicity and reliability of the design and the limited geometrical characteristics of the roof area. Solar tracking systems require additional mechanical components and higher maintenance costs, and are generally used for larger scale, ground mounted installations rather than commercial rooftop installations.

2.5 Basis of Performance Estimates

The final performance estimates for the system are based on the PVGIS grid-connected simulations for 51.320° N, 0.030° E. For a 151.96 kWp crystalline silicon system, PVGIS predicts 132,904.52 kWh/year with 1128.45 kWh/m² per year of in-plane irradiance, 14% system loss and 22.5% total calculated loss [1]. The reported losses include 4.31% from the angle of incidence and 7.39% from temperature and low irradiance [1]. As the final design is identical to the PVGIS installed capacity, these performance predictions provide a consistent performance estimate.

2.6 Inverter Strategy

Grid-tied string inverters are required to convert DC electrical energy generated by the PV array into AC electrical energy for consumption within the building and/or for export to the electrical grid. A suitable commercial reference inverter is the Huawei SUN2000-100KTL-M2, providing 100 kW nominal AC power, 10 MPPT trackers, 98.6% maximum efficiency, IP66 protection, and the necessary integrated protection and monitoring functions to support a commercial rooftop PV system [9].

2.7 Final Array Layout

The final layout includes 262 modules, each having a rating of 580 W[10]; thus providing a total covered area of about 691.9 m² and a total installed DC capacity of:

Eq 1. Total installed DC capacity

$$P_{DC} = \text{Total pannels} \times \text{rated power} = 262 \times 580 = 151{,}960W = 151.96kWp$$

The capacity of this installation is based upon that assumed in the PVGIS model for the location you have selected [1]. The module placement was determined using a typical commercial rooftop layout on the preferred roof faces (with the modules being placed in such a way to avoid protrusions and roof extensions that are not available for installing). Placement of modules in such a manner makes it easier to install, route cables, inspect and perform future maintenance.

Table 1. Pannel placement CAD considerations

Parameter	Value
Roof-edge setback	1.0 m
Panel-to-panel spacing	30 mm
Maintenance corridor	600 mm after every two rows
Module placement	Only on the 233° roof faces
Rooftop protrusions	Treated as exclusion zones with retained clearance

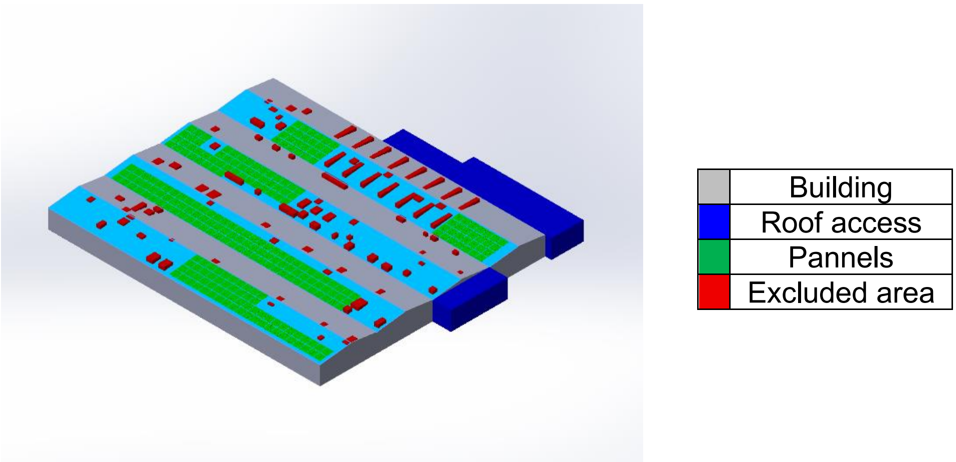

Fig 4. CAD with panel array (right) and legend (right) [12][13]

Dark blue sections in the final model depict reserved zones for accessing roofs and were intentionally left uncovered with modules to allow for realistic design of roof movements, inspections and maintenance. Therefore, the installation described here is less than the potential maximum capacity but represents a technically acceptable design.

3. Cost estimate:

The final system size is 151.96 kWp, (262 modules) @ 580W/module. [1][10]. At this point, the cost estimate is being taken as a preliminary feasibility study estimate. It has yet to be established as a contractor’s quote. This is acceptable, as it is intended that the study will determine if the proposed PV system is technically & economically viable.

Eq 2. Total installed DC capacity

$$C_{(total)} = P_{DC} \times \text{Cost rate} = 151.96 \times 800 = £121{,}568$$

A planning level installed cost of £800/kWp is assumed as a stated cost for a UK commercial rooftop PV system. Therefore, the total installed cost is estimated to be £121,568. The estimated cost is made up of the modules, inverter kit, mounting system, electrical balance of systems components, labour & contingency allowance.

This method of estimating cost is in line with commercial PV costing where the total project cost is dependent upon the full installed system rather than the module price alone. [8] A simplified breakdown of the costs associated with the mid-point total of the costs are shown below in table 3.

Table 2. Indicative cost breakdown for the proposed PV system

Component	Share	Estimated cost (£)
Modules	45%	54,706
Inverters and electrical equipment	15%	18,235
Mounting system	15%	18,235
Labour / installation	15%	18,235
Design / contingency / miscellaneous	10%	12,157
Total	100%	121,568

The final layout of 262 panels uses only the preferred 233° SW facing roof planes. It also excludes protrusions, access areas & all other awkward roof sections. This results in reduced installation complexity, reduced cabling, improved maintenance access & is superior to a layout that achieves a maximum fill.

4. Available Solar Resource

The available solar resource was taken from the PVGIS site-specific simulation at 51.320° N, 0.030° E.For the final crystalline silicon system, PVGIS reported a yearly in-plane irradiation of 1128.45 kWh/m². This figure is applicable since it represents the amount of solar energy that will be incident upon the tilted module surfaces.

PVGIS modeled a slope angle of 8°, an azimuth angle of 53°, and system losses of 14% [1] for their final system. Therefore, the PVGIS data represent a suitable performance basis for the final proposed layout, which utilizes only the 233° south-west-facing roof planes and has a roof pitch of 7.5°.

Monthly PVGIS output illustrates the expected seasonal variation with the highest generation occurring during the latter part of the spring through the summer months, while the least amount of generation occurs during the winter months [1].

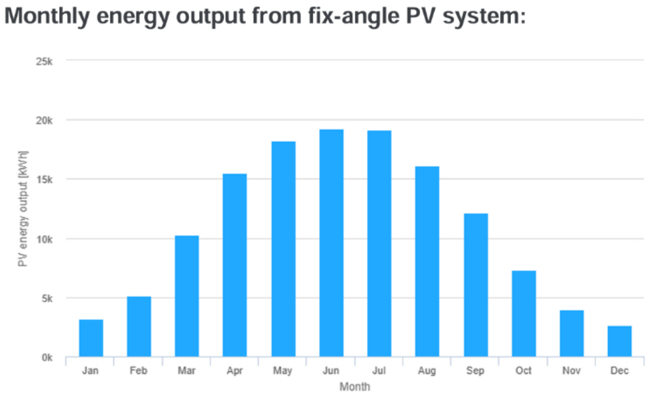

Fig 5. Monthly energy output from fix-angle PV system for the location [1]

5. Expected System Output

Since the expected output is derived from the PVGIS grid connected simulation, the output should include all site-specific information, along with practical loss factors. For a final installed capacity of 151.96 kWp, PVGIS estimates that the yearly electrical production will be 132,904.52 kWh/year [1]. Since the final array capacity of 151.96 kWp corresponds to the PVGIS model, this value may be used without modification.

In addition to the 14% system loss applied by PVGIS, they report a total calculated loss of 22.5%, which includes a 4.31% loss resulting from the angle of incidence and a 7.39% loss resulting from both temperature and low irradiance [1].

The specific yield is approximately 874.6 kWh/kWp/year. This is a reasonable value for a fixed-tilt commercial rooftop system located in southeast England. However, it is less than what could be achieved by an ideal due-south array, as the actual design reflects the physical constraints of the roof geometry and only utilizes the 233° south west facing roof planes.

Therefore, the proposed PV system is expected to produce approximately 132.9 MWh/year when operating under normal conditions [1].

6. Financial payback time:

The Simple Financial Payback Time was calculated using the installed cost of the system and the annual output of the PV system. The simple payback time calculation does not take into consideration the discounted cash flow (DCF) of the output or the PV system's performance over its expected lifetime; nor does it account for the replacement cost of inverters, potential degradation, operation and maintenance costs, or the potential to sell excess power back to the utility company. Therefore, the simple payback time is used as a first cut assessment of whether or not the PV system is feasible.

$$Saving\ (annual) = 132{,}904.52 \times 0.267 = £35{,}485.51/year$$
$$Payback\ period\ = 121{,}568/35{,}485.51 = 3.43\ years$$

PVGIS estimates the annual output of the 151.96kWp system will be 132,904.52 kWh /year. Based upon the non-domestic electricity tariff rate of 26.70p/ kWh (£0.267 per kWh), the total annual savings from the PV system will be £35,485.51/year.

Based upon the mid-point estimate of the installed cost of the system (£121,568), the simple payback period will be 3.43 years. This is an excellent result for a commercial roof mounted PV system and is indicative of both the systems expected annual output and the value of displacing expensive utility supplied electricity [1][2][11].

It should be noted that this result needs careful interpretation. The calculation assumes that 100% of the energy produced by the PV system is consumed at the full retail tariff price. As such, the true payback of the system will depend on how much energy is actually consumed onsite versus exported, the cost of operation and maintenance, and the long-term replacement cost of components. However, the calculation is indicative that the proposed roof top PV system is financially viable at the feasibility phase.

7. Energy payback time

Also, an estimated Energy Pay-Back Time (EPBT), should be taken into consideration. The published review data show that photovoltaic systems, as a rule, have an EPBT from approximately 1.0 up to 4.1 years [14]. Therefore, for the proposed, at the feasibility stage, modern crystalline silicon rooftop system an approximate value of EPBT equal to 2 years, could be assumed [14]. It means that, during its operation, the system will pay back the amount of energy, which was used for its manufacturing and installation.

8.CONCLUSION:

The work in this project produced a grid connected rooftop photovoltaic system for the Formula 1 Media & Technology Centre, Biggin Hill. The location was chosen based upon the large surface area of the roof, the high potential of electrical load and the credible solar irradiance available [1]. The final design of the system utilises 262 monocrystalline modules each having a rating of 580W which gives the installed capacity as 151.96kWp and covers a total area of 691.9 m² with modules [1]. As part of the design process, the layout was designed conservatively by only using the preferred roof planes facing in a south west direction (at an angle of 233 degrees) and excluded all protrusions from the roof plane and also excluded all restricted roof areas and access zones in order to improve the buildability of the system, allow for easier maintenance access and improve the commercial viability of the system.

Using site specific data provided via the PVGIS model, it has been predicted that the annual electrical output of the system will be 132,904.52kWh per year. Therefore, it can be concluded that the system will provide a substantial amount of renewable electricity to the building site [1]. Using the costs identified during the estimation process (£121,568), a simple financial payback period of 3.43years has been identified [1][11]. Additionally, there are published studies indicating that an approximate energy payback time of circa 2 years exists for modern crystalline silicon systems [14].

Therefore, overall, the proposed system is both technically viable and commercially viable and suitable for the selected commercial rooftop application.

9. RECOMMENDATIONS:

It would be recommended to consider part of the site car park as an additional area for installation of a solar canopy shuttle bus charging station. The aerial photograph of the site suggests that there is sufficient external space available to install this type of system. The system would enable an increase in on-site renewable generation, shaded car parks and also low emission transport [15].

References:

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Appendix:

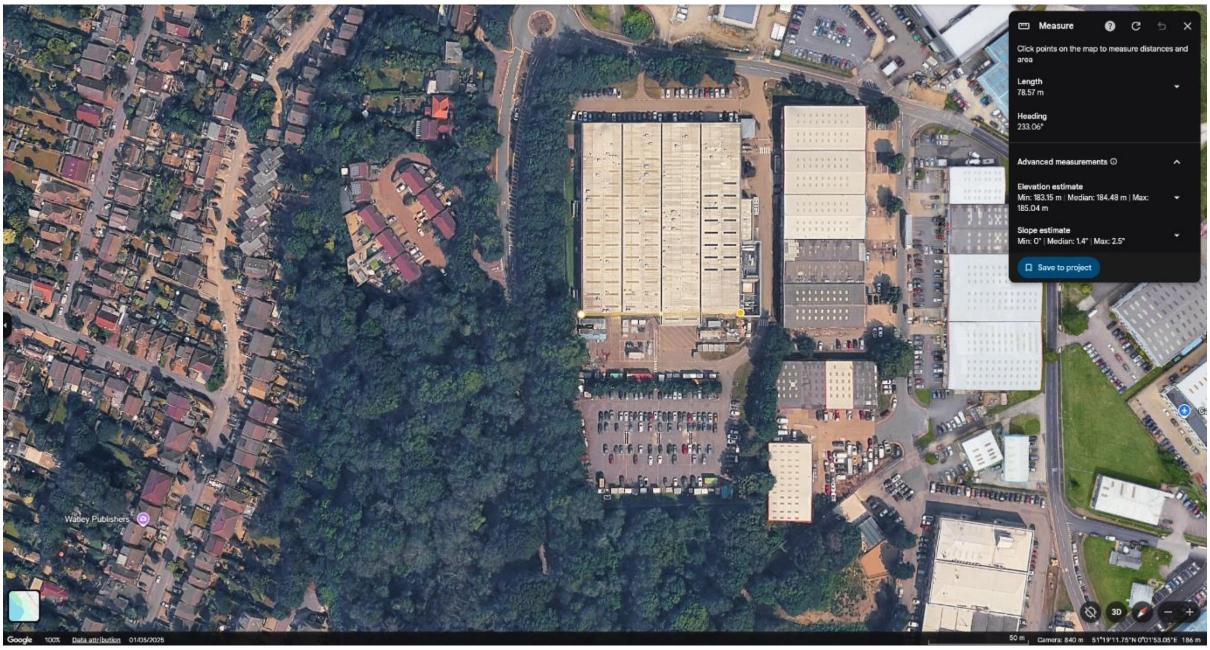

Fig 6 & 7. Top view Google earth [6]

Fig 8 & 9. Orthogonal and side view Google earth [6]

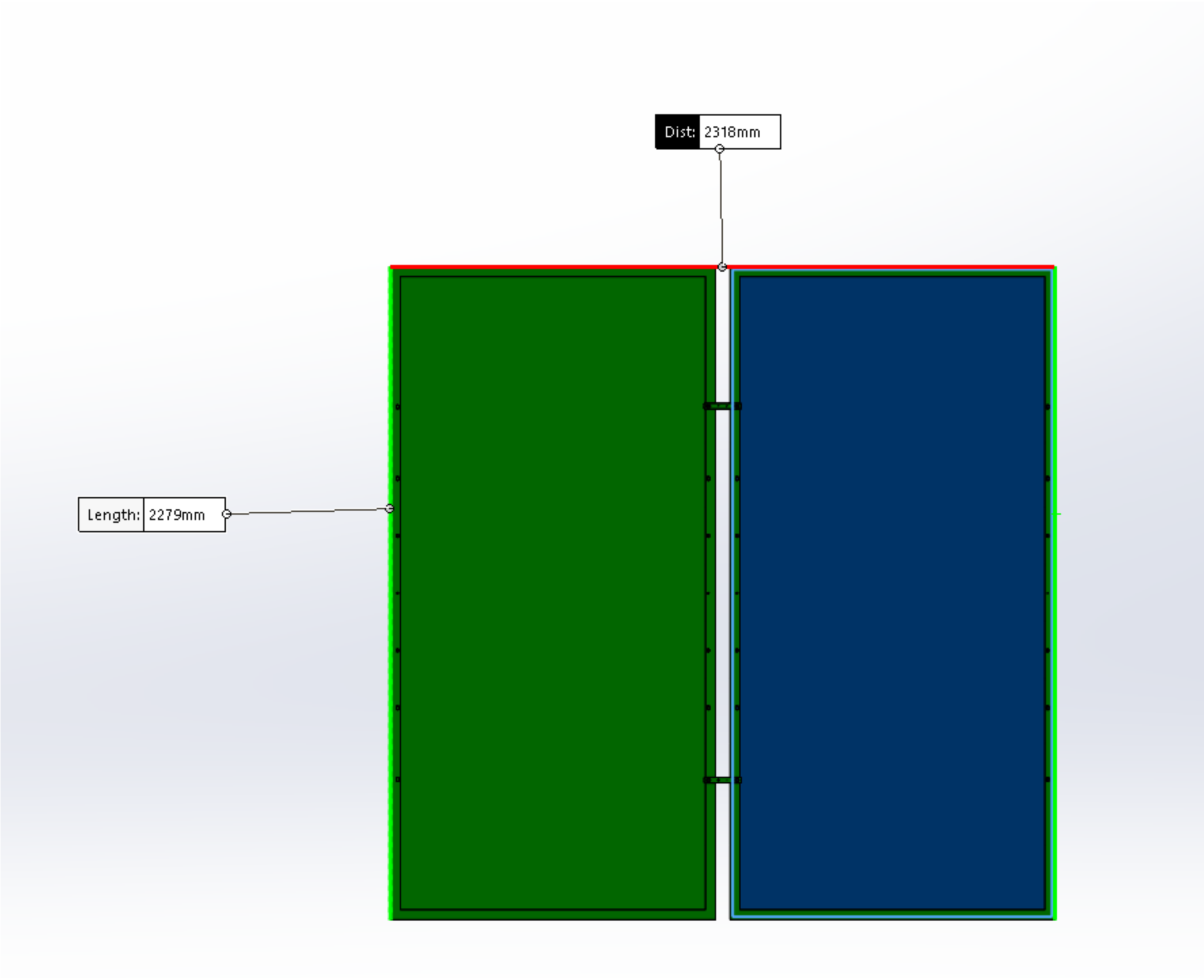

Fig 10. Pannel model and size [12][13]

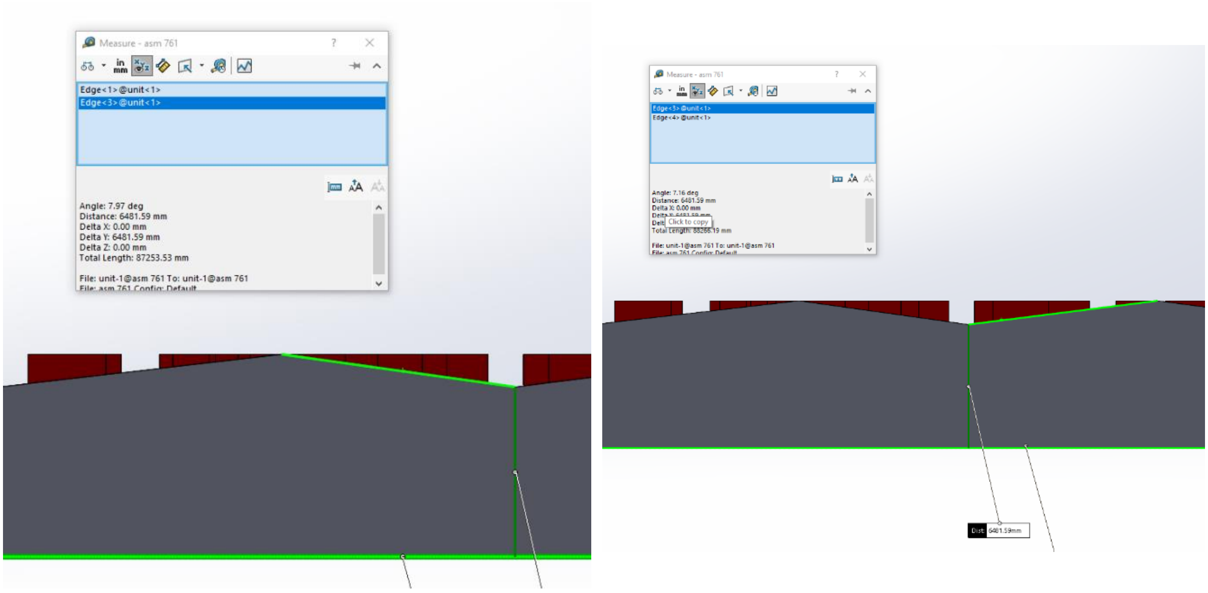

Fig 11 & 12. Approximated roof slope measurement [12]