THE INSTALLATION DESIGN OF SOLAR PANELS FOR VILLAGE HOUSES HK WITH OPTIMIZATION-BASED EFFICIENCY FOR S USTAINABLE ENVIRONMENTAL

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ABSTRACT

The primary objective of this project is to provide a meaningful contribution towards the sustainable development of rural communities via the facilitation of solar panel installations on residential houses in Sai Kung Village, located in Hong Kong. Additionally, the project aims to build a comprehensive framework for the sale of excess power generated from these solar panels to CLP. The suggested system aims to fulfill the electrical requirements of the designated household, so making a valuable contribution towards the sustainable and economic development. This installation design using optimization of the energy and financial efficiency with sustainable environmental protections.

KEYWORDS

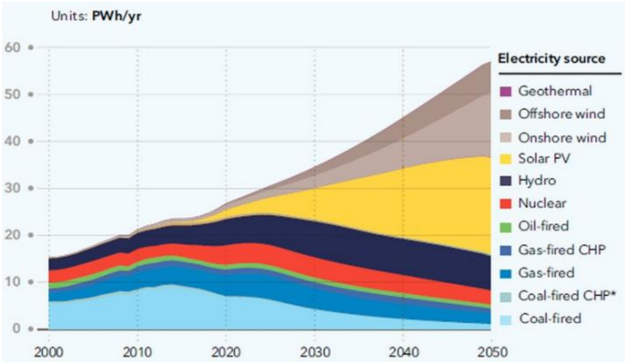
Sustainable Environmental Protections, Optimization, Energy Efficiency, Financial Efficiency.

1. INTRODUCTION

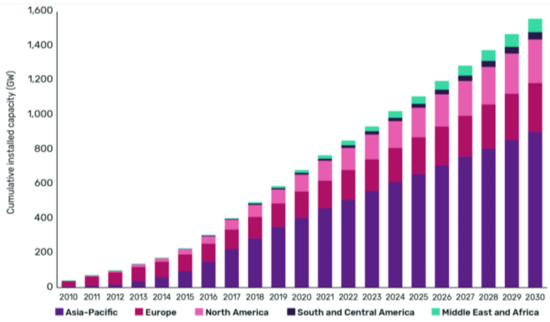
Sustainable energy sources and environmental protection have been increasingly prominent topics of discussion on a global scale in recent years. The adoption of renewable energy solutions has become the primary focus in responding to climate change and the rapid depletion of finite fossil fuel resources. Among all these options, solar energy stands out as a viable option for Hong Kong, especially in its rural areas where village houses are common.

Solar energy's widespread availability, inherent durability, and high cleanliness make it an indispensable component of the renewable energy revolution. In 2019, solar energy accounted for 4.1 EJ of consumption, or 1.1% of global energy consumption [1,2]. Given that Earth receives 4 million EJ of solar energy yearly [2], it still has considerable application potential. Photovoltaic (PV) power generation continues to be the most important way to utilize solar energy, notably on rooftops of buildings, as a result of the huge drop in battery costs [3].

DOI: 10.5121/ijcsit.2024.16605



With an annual growth rate of approximately 40% [4], the global installed capacity of PV power generation is expected to reach 760 GW by 2020 [1]. The total installed capacity of wind and solar power in China is projected to rise to more than 1200 GW by 2030 [5]. China has contributed around 253.4 GW of cumulative PV installed capacity. Roof-mounted solar photovoltaic (PV) systems are becoming more and more popular because they can fulfil the distributed energy demand of a building and reduce transmission and conversion costs. Whether installed as a component of a building or as a retrofit facility, they also conserve land and require little upkeep [6,7].



The landscape of Hong Kong is characterized by a distinctive fusion of urban development and rural areas, featuring village houses concealed in scenic land areas. Many people in Hong Kong rely on these village houses for housing, which are a unique part of the city's cultural heritage. But unlike urban regions, rural areas frequently lack modern energy infrastructure. Typically, village houses rely largely on traditional house electricity, which may be less dependable and ecologically unsustainable. In addition, due to their remote locations, they frequently encounter difficulties in obtaining economical and dependable energy sources.

Rooftop solar photovoltaic (PV) systems are a major focus of energy system development in rural areas, and an awareness of PV power generation's spatial distribution is essential to the creation of rural microgrids. There are few shelters, consistent house types, low population densities, low energy building levels, low floor area ratios, and a large percentage of single-family homes in rural areas. All these factors integrate effectively to make PV systems ideal.

Since its introduction, microgrid systems have been the primary application technique for roof-mounted solar PV systems, which have greatly enhanced the quality of life for rural households in developing countries [8]. A microgrid is a system that communicates between houses and interacts with the local municipal power grid at the village level to enhance PV power consumption rates [9]. The microgrid not only meets the demands of house occupants but also offers renewable electricity for irrigation pumps, small businesses, and other uses [10]. However, a reliable and sustainable energy source is still an issue for many of these villages. In order to satisfy their energy needs and further the greater objective of switching to renewable energy sources, this research investigates the benefits of solar panel installations on the village house rooftops.

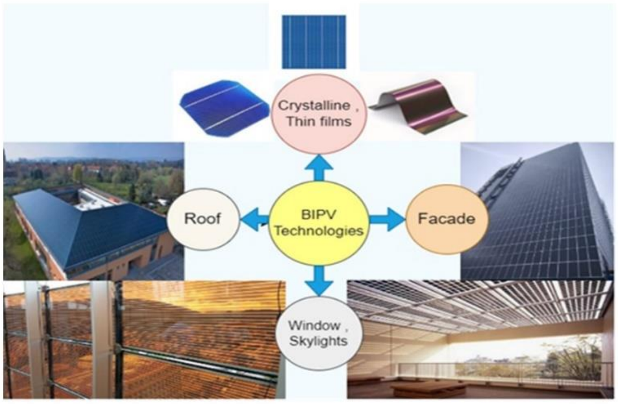
2. LITERATURE REVIEW C

2.1. The Design Aspects

According to [11], for solar panel installations in village houses to be functional and integrate with the current infrastructure, their design is essential. Many design factors should be taken into account:

- System Configuration: The construction and size of village houses differ; thus, the system configuration needs to be customized to the amount of rooftop space that is available and the energy needs. Rooftop arrays, ground arrays, and solar tracking systems that monitor the sun's path for maximum energy output are common combinations.

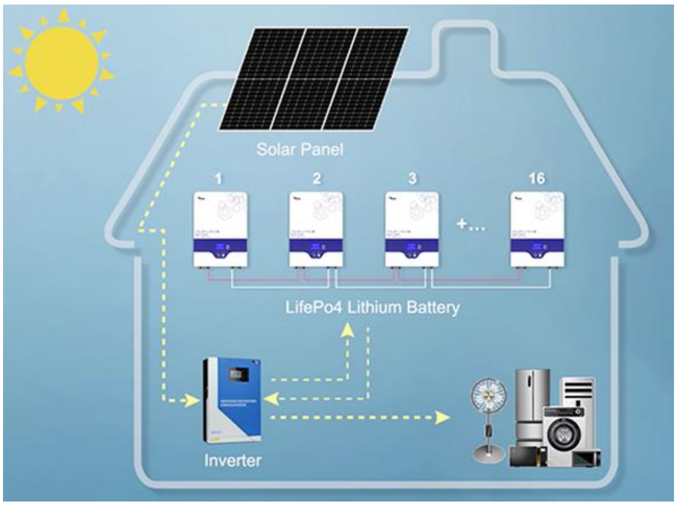
- Integration into the Building: Aesthetic integration of solar panels into the building is crucial since it affects the system's efficiency and attractiveness from an aesthetic perspective. Solar panels incorporated into roofing materials or utilized as shade structures are known as building-integrated photovoltaics, or BIPV. BIPV systems produce clean energy and enhance the aesthetic of the houses.



Innovations in Solar Panel Efficiency and Integration

The efficiency of solar panels has been steadily rising. Higher energy conversion rates have been achieved recently, particularly in monocrystalline panels. Some advanced technologies can increase energy output by capturing sunlight from both sides, such as bifacial solar panels.

Since they enable the storing of excess energy for later use, energy storage systems are becoming a necessary component of solar panel installations. Residential energy storage is increasingly using lithium-ion batteries, similar to those used in electric vehicles. This method increases the financial advantages of solar energy integration while also guaranteeing a steady power supply during cloudy periods [12].



In order to ensure grid stability and effective energy distribution, smart grid integration is a major area of concern. To monitor and control energy flows, it makes use of sensors, communication networks, and sophisticated metering. To optimize energy usage and maintain grid stability, smart grids enable two-way communication between the grid and solar installations.

2.2. Performance Aspects and Grid Integration

Particularly in the presence of variable weather, performance assessment of solar panels is crucial. Factors like sunlight intensity, panel, and shading may all have an impact on the output and efficiency of solar panels. To determine how reliable solar panels are in supplying energy on cloudy or low sunlight days, it is essential to evaluate how they function. Modern solar panels can still produce power, albeit at a slower pace, even in situations with partial shading or poor lighting, according to studies. This data guarantees a steady supply of energy and helps grid operators and homeowners better prepare for times when solar energy output is lower [13].

Concerns about grid stability and dependability are critical when discussing distributed solar energy. Grid operators have difficulties due to the intermittent nature of solar energy generation, as variations in power supply can impact the stability of the grid. To ensure grid dependability, integrating solar energy into the current infrastructure needs careful design. In order to overcome these obstacles, grid management techniques like energy storage and demand-side management are essential. To reduce grid load and improve stability, excess solar energy may be stored in batteries and released at times of peak demand [14].

AI and machine learning have become important instruments for optimizing solar energy output and use. With the use of these technologies, predictive modeling may be done using historical data, weather forecasts, and real-time sensor data. Homeowners and grid operators may make educated decisions about energy use and storage thanks to machine learning algorithms' high accuracy forecasting of solar energy output. AI-driven demand response systems may also be used to maximize self-consumption and reduce dependency on the grid by coordinating energy usage with solar output peaks [15].

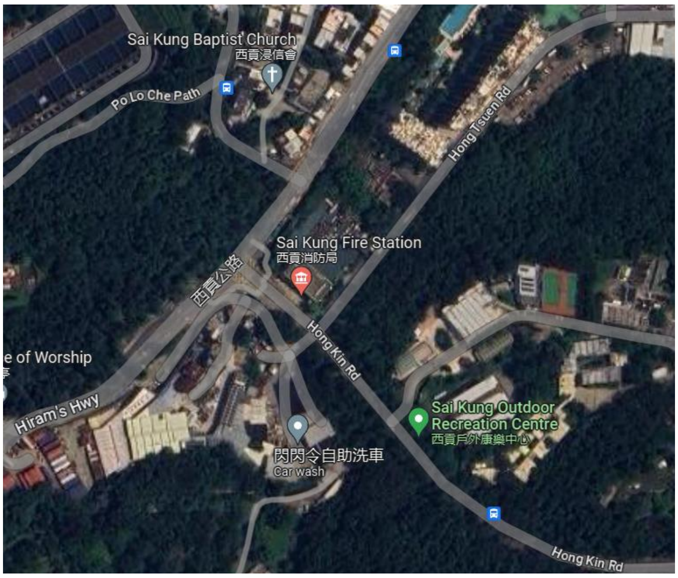
AI is used by advanced grid management systems to instantly balance supply and demand, increasing grid stability. When solar energy output is insufficient, AI algorithms can regulate how much energy is released from batteries to provide a steady supply of power to residences. Furthermore, machine learning can proactively detect and fix technical problems with solar installations, cutting down on maintenance expenses and downtime.

3. METHODOLOGY

3.1. Location of Case Study

The household selected for the case study resides in Sai Kung Village, in the Sai Kung District of Hong Kong. Sai Kung Village is located in the eastern part of the New Territories and is around thirty kilometers distant by car from Hong Kong's central business district. Sai Kung Town, a popular destination renowned for its quaint beach town and breathtaking landscape, is nearby.

The closest metropolitan hub, Tseung Kwan O, is around 9 kilometers away by road from the settlement, which is readily accessible by a number of transit options. Sai Kung Village is located in the subtropical zone of southern China with coordinates of around 22°22'30.0"N, 114°16'30.0"E (latitude: 22.375000; longitude: 114.275000).



Sai Kung Village is distinguished by its balance of modern and traditional design features, which combine the area's rich cultural legacy with recent advancements. Sai Kung is renowned for its picturesque splendor, coastline scenery, and close proximity to the Sai Kung Country Park. However, precise population statistics may differ.

Sai Kung Village features a subtropical environment with distinct seasons. Summertime temperatures are hot and humid, frequently reaching above 30 degrees Celsius (86 degrees Fahrenheit). Winters are mild, with an average temperature of around 10 degrees Celsius (50 degrees Fahrenheit). The monsoon influences the region's climate, with the rainy season often lasting from May to September. Typhoons do occasionally impact Sai Kung, although during this period the majority of the region's annual precipitation falls.

The South China Sea and the surrounding hills are beautifully seen from the settlement. Sai Kung's natural surroundings, which include lovely beaches and hiking trails, make it a well-liked vacation spot for both residents and visitors looking for outdoor activities. The coastal position also results in fluctuations in wind patterns, which enhances the appropriateness of wind power production on a small scale.

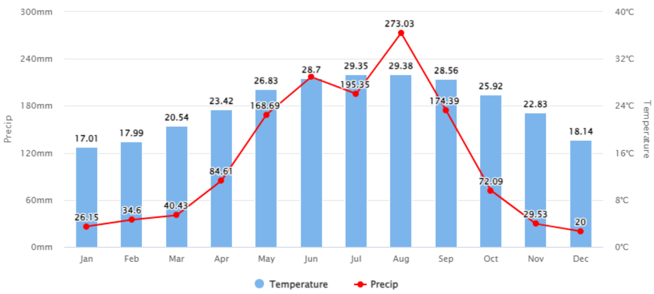


Figure 11: Mean monthly temperature and precipitation of Sai Kung
Source: https://weatherandclimate.com/hong-kong/sai-kung

Among the city's noteworthy middle-class neighborhoods is Sai Kung Village. The village is distinguished by a mix of business and residential buildings, including large residences that showcase a variety of architectural designs. Sai Kung Village's population is seen to be financially stable, representing a middle-class group that is often more open to embracing renewable energy projects. Large roof areas are a common feature of the buildings in Sai Kung Village, which makes it easy to install solar photovoltaic (PV) systems. There is a chance that people may choose renewable energy alternatives, including home solar PV systems, given their financial security. By reducing the effects of growing grid power costs, these technologies may help create a more ecologically friendly and sustainable energy environment.

The decision to use Sai Kung Village as a case study took the locals' financial situation into account. This involves evaluating their living circumstances, level of property ownership, and possession of different luxuries including homes, cars, and appliances. The viability and success of suggested renewable energy projects in the region are greatly influenced by the citizens' financial capacity.

3.2. Data Collection

In order to conduct this study, it is necessary to get some precise data, such solar insolation levels, the geographical location of the site (Village), and the electrical demand. The data pertaining to various residential structures in Sai Kung village, including details about roof types and orientations, was obtained via a comprehensive site study.

3.2.1. Solar Insolation Data

The National Aeronautics and Space Administration (NASA) website and the Hong Kong Observatory were the two trustworthy sources of solar insolation statistics for Sai Kung Village. Using on-site equipment, the Hong Kong Observatory measured solar radiation on the ground. NASA satellite data, which was used in the RETScreen Software, was also taken into account for validation and comparison.

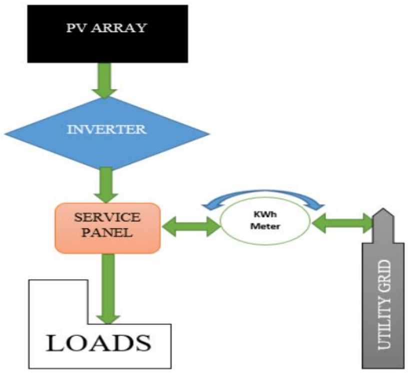
It was decided to size the solar photovoltaic (PV) system using NASA data after a careful examination of the sun insolation data. Environmental data that is essential for different investigations is carefully collected and archived by the Hong Kong Observatory. This includes typical daily temperatures and sun insolation, which are essential variables for the solar energy research that is carried out in Sai Kung Village.

To make it easier to include the solar insolation data into the design and size of the solar PV system, the Hong Kong Observatory converted the data from Watt-hours per Square Meter (W/m^2) to Kilowatt-hours per Square Meter (kWh/m^2). Notably, the criteria used to choose NASA data was whether or not it met the goals of the study and complied with accepted international norms.

The historical data used in this study, which was gathered from the Hong Kong Observatory and covered a two-year period, was consistent with the methodology employed by other researchers. Fan Jiang et al. (2007) conducted a study to investigate the availability of solar photovoltaic (PV) resources in tropical regions with unique weather patterns. The writers conducted their research over a similar period of time. Research conducted in the meantime by scientists like Xiao Jian Ye et al. and Zakaria Anwar et al. utilized temperature and solar insolation data over 8 and 30 years, respectively, tailored to the specific requirements of their investigations (Ye, et al., 2009). The choice of the data period in Sai Kung Village considered factors such as the study's duration, type, and the distinction between standalone or grid-connected systems, mirroring the diverse methodologies employed in solar energy research worldwide.

3.3. Solar PV Electricity Generation System

The solar PV array, net metering, and inverter are the three main components of a solar photovoltaic (PV) power generating system. Selecting appropriate proportions for the solar photovoltaic (PV) array was the first stage in the design and sizing process. This conclusion was reached by taking into account both the amount of solar radiation that was available and the load needed. After the array's dimensions have been determined, the next item to measure is the DC to AC inverter, whose size frequently depends on the customer's peak power.



Selecting a metering device to be put within the system is the final item that has to be decided. To accurately measure the quantity of electricity that is imported and exported, an energy meter must be placed between the building distribution board and the grid. Several design and sizing-influencing aspects have been taken into account at every stage of the system's design. Selecting the appropriate size for an array requires careful consideration of several crucial factors. Among these factors are the type of module being used, the connection method, the array's tilt angle, the impacts of shadow, and the effects of temperature and irradiance.

3.4. System Design Software

This section gives a summary of the software that was used to create the solar photovoltaic (PV) system for the case study. Based on the information acquired, a variety of solar PV design software options were investigated as part of the inquiry to ascertain which software would be most beneficial for this specific research. A solar photovoltaic array's (PV) output fluctuation is also affected by a number of dynamic derating characteristics, including as the surrounding temperature, sun irradiation, shadow, and a few other factors. Consequently, the solar photovoltaic (PV) array's output will vary based on how frequently the parameters are changed. This suggests that producing a precise design that satisfies requirements requires more than just using human computations.

The recommended approach was examined using Natural Resources Canada's RETScreen Clean Energy Project Analysis Software. The purpose of this program is to carry out feasibility studies for various renewable energy projects. Pre-existing data on solar radiation and climate for several locations, including Sai Kung in Hong Kong, is included into the software. Additionally, it incorporates system specifications from several suppliers. The system's capabilities span the complete project lifespan, allowing for the modeling of technical and financial aspects of renewable energy systems.

To precisely calculate energy production, RETScreen needs individual photovoltaic (PV) module data in addition to climate data. Through the use of semiconductor-based solar cells, photovoltaic

(PV) technology converts solar radiation into direct current (DC) power, or electrical energy. Each module in an array is a collection. Achieving the necessary energy production is the basis for choosing how many modules to include in the system. The RETScreen specialist maintains an up-to-date database with a variety of module brands and the accompanying input data that is required for the RETScreen software to work properly. The Chine Sunergy Polysilicon-CSUN 300-72P modules are used in the construction of the suggested photovoltaic (PV) system. The specific technical specifications of these.

Characteristic	Standards
Maximum Power at STC (Pmax)	300W
Optimum Operating Voltage (Vmp)	35.9V
Optimum Operating Current (Imp)	8.36A
Open Circuit Voltage (Voc)	44.5V
Short Circuit current (Isc)	8.83A
Module Efficiency	15.50%
Operating Module Temperature	-40^0C to $+85^0$C
Maximum System Voltage	1000VDC (IEC)
maximum Series Fuse Rating	20A
Power Tolerance	0/+5%
Size	1.94 m^2

3.5. Financial Analysis

The project's economic analysis was evaluated through the application of Net Present Value (NPV) and straightforward payback period computation techniques. Financial techniques are commonly employed in the evaluation of renewable energy projects since they are a reliable means of determining the viability and bankability of various producing sources. Comparing the total discounted cash inflows to the project's present value with all project-related costs yields the project's net present value, or NPV. The given equation represents the net present value (NPV) formula. A project with a positive net present value (NPV) indicates that the financial expert may be able to make more money from it.

$$\boldsymbol{PV} = \sum \left\{ \frac{\boldsymbol{Net\ Period\ Cash\ Flow}}{(\mathbf{1}+\boldsymbol{R})} \right\} - \boldsymbol{Initial\ investment}$$

Where:

Initial Investment =Initial Cost + Replacement Cost

R= Discount Rate,and
T= Lifetime of the proposed project,for the proposed system is thought to be 25 years.

The intended solar photovoltaic (PV) system underwent a financial study to evaluate the project's possible advantages and costs. The application of RETScreen software packages made the work easier to finish. In addition to having features that make it easy to use, the application can simulate both simple payback times and net present values. It can also calculate the potential greenhouse gas reductions that renewable energy plants might provide over the course of their entire operational lives. A project's viability and feasibility may be evaluated using two important financial metrics: net present value (NPV) and simple payback period. Below is the formula for figuring out the payback period (PBP):

$$BP = \frac{Initial\ Cost}{Operating\ cost\ (Base\ Case) - (Operating\ Cost\ (Current\ System)}$$

It's crucial to do both an economic analysis and a financial feasibility assessment to determine a project's viability. The project's feasibility may be evaluated using the payback period. In most circumstances, it is probable that the project won't be deemed economically feasible if the payback period is longer than a given threshold.

3.6. Data Collection

This investigation encompasses an examination of many residential properties located in Sai Kung village, situated in the region of Hong Kong. The residential units are dispersed across Sai Kung Village and together have a gross floor area (GFA) of 73 square meters. The residential structures include floor layouts that are designed in the form of a double cross.

Figure 14: Typical village house in Sai Kung
Source:https://a-p-u.hk/architectural-design-build-for-sai-kung-village-house

The windows of the houses in the village have a total size of 8 square meters, resulting in a window-to-floor ratio of 0.11. The dwellings are built using medium-weight concrete, including walls that are 100 mm in thickness. The following table provides a comprehensive overview of the operational activities pertaining to the village dwellings.

4. Results and Discussion

4.1. Analysis of Data

In order to aid in the design of a grid-connected photovoltaic (PV) system for the selected case study, an analysis of the horizontal solar radiation data and load data is presented in this section.

4.1.1. Radiation of Solar

It is necessary to have precise and comprehensive data regarding solar radiation in order to determine the appropriate dimensions for a photovoltaic system or any other solar energy-based system intended for the conversion of solar radiation into electricity or other forms of energy. The responses of various types of solar photovoltaic (PV) systems to variations in the ambient operating temperature are distinct. It is widely known, meanwhile, that as temperatures rise, solar photovoltaic (PV) systems become less effective. Extremely high temperatures affect the solar cell's ability to generate electricity, which lowers the array's output voltage and causes thermal impacts on the cells. The chosen community experiences few changes in temperature and other.

Table 7: Climatic parameters data for Sai Kung village houses

	Air temperature °C	Relative humidity %	Wind speed m/s	Atmospheric pressure, kPa	Earth temperature, °C	Precipitation (mm)
January	19.9	70.4	2.3	85.6	20.7	81.54
February	20.7	66.5	2.4	85.5	21.9	63.93
March	20.2	76.1	2.2	85.5	21.4	113.23
April	19.7	78.4	2.2	85.5	20.6	89.55
May	20.6	62.8	2.6	85.7	21.8	60.56
June	21.1	49.9	3.1	85.8	23.1	15.51
July	21.3	45.1	2.8	85.8	23.9	19.28
August	22	46.4	2.7	85.8	25.1	43.3
September	21.7	56	2.4	85.7	24.2	70.89
October	20	74.9	2.1	85.6	21.4	89.37
November	19.2	81.4	2	85.6	20.2	111.56
December	19.3	78.1	1.9	85.6	20	75.38
Annual average	**20.5**	**65.5**	**2.4**	**85.6**	**22**	**834.11**

4.1.2. Results of Load Data

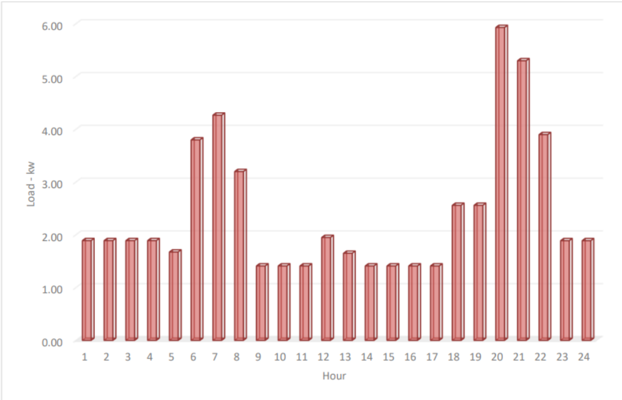
Determining the ideal size of the photovoltaic (PV) system was largely dependent on the energy consumption profile of the village dwellings. The aforementioned profile was essential in accurately estimating the chosen household's daily energy use. The load data linked to the chosen residence, owned by a middle-class household, includes a variety of electrical and technological gadgets, as the table illustrates. By examining the available data, the selected residential unit's daily power usage was ascertained. The photovoltaic (PV) system's design and dimensioning were made easier with the usage of this data. The specific daily usage of 8.36 kWh was determined for a single middle-class family.

Table 8: Available active appliances in Sai Kung village for a typical family house

S/N	Equipment	Number in use	Rated Power W	Using time in hour/d	Total energy consumption in kWh/d
1	Refrigerator	1	-	24	1.41
2	Iron	1	1200	1	1.20
3	Television	1	150	5	0.75
4	Compact fluorescent lamps for rooms	6	12	6	0.43
5	Compacts fluorescent lamps for outside	2	30	8	0.48
6	Home theater	1	60	6	0.36
7	Laptop Computer	2	100	7	1.40
8	Digital Video Disc (DVD)	1	16	5	0.08
9	Mobile Phone	4	6	6	0.14
10	Blender	1	500	0.15	0.08
11	Electric Cattle for boiling water	1	1800	0.5	0.90
12	Toaster	1	850	0.5	0.43
13	Microwave	1	1000	0.7	0.70
Total					**8.36**

The graphic displays the daily load curve that was created by examining daily consumption data for a single middle-class home in Sai Kung village. The graph shows that the selected household's peak power consumption demand, measured at 8 PM, was around 5.93 kWp. Moreover, the average demand will always be at least 1.41kWp since the refrigerator will continue to maintain a continuous connection.

The average home uses about 3.1 megawatt-hours (MWh) of electricity annually. Throughout the whole design process, the load curve has displayed a constant pattern and had a steady profile all year long. The suggested method will efficiently meet the village's needs for energy usage. Any excess energy generated will be exported or traded to the electrical grid through a net metering arrangement during the peak solar radiation period. On the other hand, users would turn to importing power from the electrical grid in circumstances where the electricity produced by solar sources is insufficient to meet the necessary energy consumption.



A load profile is a representation of the electrical load, or consumption, over time. It is important to note that the load demand fluctuates throughout the day due to the fact that not all appliances are used simultaneously. The aforementioned curve has significant significance in the organization of the energy provision, as it provides crucial insights for determining the requisite amount of power necessary to ensure its availability at any given moment.

4.2. System Sizing of Solar Photovoltaics and Simulation Results

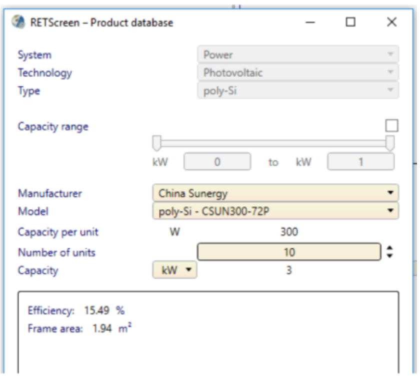
The RETScreen Clean Energy Project Analysis Software, developed by Natural Resources Canada, was one of the advanced methodologies used to assess the size of the photovoltaic (PV) system in a selected dwelling in Sai Kung Village. Using this application is essential to doing in-depth analyses of sustainable energy initiatives. It was used to determine the best specifications for Sai Kung Village's photovoltaic (PV) system.

During the first phases of the investigation, the "Location and facility" part of the RETScreen program performed a pivotal role. The determination of the climatic zone for Sai Kung Village included the consideration of both localized climate data unique to Sai Kung and more extensive climate data including the larger Hong Kong region, with special emphasis on the Kowloon area. This methodology provided an accurate depiction of the ecological factors under which the research was carried out.

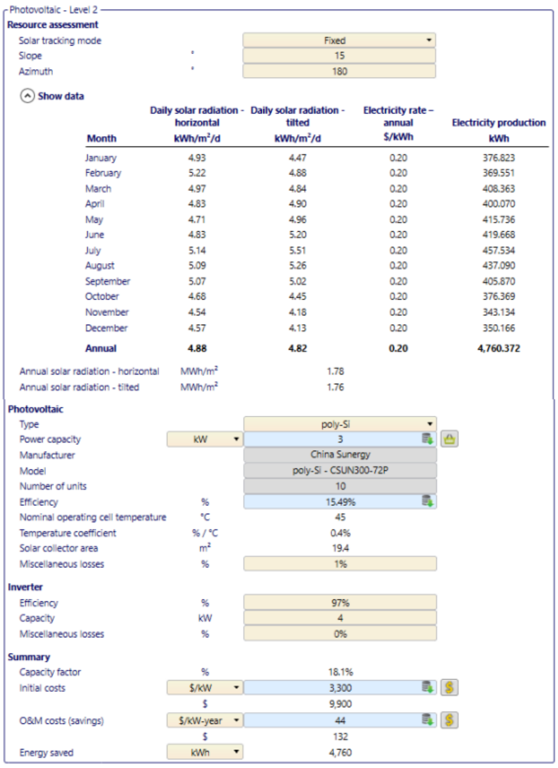
4.3. Analysis of Energy

The software program RETScreen Expert was utilized to carry out the previously described component. Finalizing the energy sheet included in the feasibility section followed the first round of data collection and networking model development. With RETScreen's energy component, users may select between two different levels to find the one that best suits their preferences and requirements. Because Level 2 required more information on the azimuth and horizontal solar panel inclinations, it was chosen for this simulation because of its increased accuracy. Following that, suitable arrangements for the photovoltaic (PV) system were developed.

The selection of the optimal azimuth and tilt for solar panels in Sai Kung Village has considerable significance in maximizing energy efficiency. Considering the geographical location of Sai Kung in the northern hemisphere, it is recommended to choose an optimal azimuth angle that orients the solar panels towards the south, in order to face the equator. It has been ascertained that the design slope that yields the most beneficial results is a latitude +150 tilt. Furthermore, it was observed that arrays oriented towards the north get an average annual global horizontal irradiance of 4.8 kWh/m2/day. The determination of the suitable photovoltaic (PV) technology relies on the collection of data on solar radiation levels at the designated location, as well as the daily power consumption measured in kilowatt-hours (kWh) or the particular kinds of electric load. This document presents an overview of the methods used by RETScreen Expert for the aforementioned objective. The figure below depicts an illustration showcasing the number and technical characteristics of the photovoltaic (PV) panels that have been selected for examination.



Once the kind of solar PV system and the required number have been determined, the software determines the remaining values of the other field based on the suitability of the energy model design.



Month	Daily solar radiation - horizontal kWh/m²/d	Daily solar radiation - tilted kWh/m²/d	Electricity rate – annual $/kWh	Electricity production kWh
January	4.93	4.47	0.20	376.823
February	5.22	4.88	0.20	369.551
March	4.97	4.84	0.20	408.363
April	4.83	4.90	0.20	400.070
May	4.71	4.96	0.20	415.736
June	4.83	5.20	0.20	419.668
July	5.14	5.51	0.20	457.534
August	5.09	5.26	0.20	437.090
September	5.07	5.02	0.20	405.870
October	4.68	4.45	0.20	376.369
November	4.54	4.18	0.20	343.134
December	4.57	4.13	0.20	350.166
Annual	**4.88**	**4.82**	**0.20**	**4,760.372**

The photovoltaic (PV) system's output of electrical energy is contingent upon two primary factors: the level of solar radiation at the designated site and the PV panel's efficiency. As indicated in the table, the number of panels depends on the power output needed to sufficiently meet the daily energy needs. The user gathers information on a chosen household's mean gross power load, particularly for middle-class households. This information is gathered through the use of an interview and a questionnaire that concentrate on the details of the utilized equipment in the home. After that, the data is input into RETScreen expert. The application also asks for details regarding the grid's desired load ratio and the PV technology that has to be preserved or safeguarded. In order to do a thorough cost analysis, the application incorporates the costs per kilowatt of electricity using the current exchange rates.

When dust or sand particles collect on the surface of a photovoltaic cell, a process known as "soiling," the power-generating capability of the system may be severely diminished. The effects of soiling on photovoltaic (PV) cells have been the subject of several research. Sandstorms have the potential to deposit dust and sand particles on photovoltaic (PV) cells, which makes the previously stated phenomenon extremely important in dry habitats. Based only on the impacts of dust, as demonstrated by earlier studies, a 1% reduction in dust's impact on yearly productivity is expected. The accounting for the integration of reduced energy production on solar cells. Additionally, it is believed that any losses that may occur in the inverter or other power conditioning components are insignificant. The selected inverter has been confirmed to operate within a power range of 1 to 4 kW. It has an inverter efficiency of 97%, which signifies the percentage of DC energy that is successfully converted to AC.

The export of electricity reached a significant peak in July, with a production output of 457,534 MWh. The seasonal shift, which has been shown to negatively affect solar cell performance, might be the cause of the drop in power production observed between September and December.

5. CONCLUSION

5.1. Conclusion

The aim of this project is to design a grid-connected solar photovoltaic (PV) system that can supply electricity to a middle-class Sai Kung Village home. Numerous research projects carried out throughout the world have pinpointed certain problems with the existing systems, which have been successfully tackled in the proposed design. This research's study has successfully tackled each specific goal on its own, indicating a thorough examination of the main objective. This implies that the goals were clearly stated at the beginning and have been carefully considered. Once selected, the case study was carried out. Following the case study's selection, a few elements were judged essential to achieving the study's goal. For the chosen region, load data analysis and solar resource evaluation have been carried out using the methods described in Chapter 3. Sai Kung receives an average sun irradiation of around 4.88 kWh/m2/day and 5.2 kWh/m2/day, respectively, according to statistics provided by NASA and RMA.

Following examination, the collected data were put to use in the creation of a typical solar photovoltaic (PV) energy producing system for the community of Sai Kung. A three kilowatt (kW) grid-connected photovoltaic (PV) system was designed with middle-class families in mind. The system consists of 10 separates 300 watt (W) photovoltaic (PV) panels. The project would require 19.4 square meters of roof area in total. The photovoltaic (PV) system must be oriented northward in order to absorb sun energy to its fullest. A comprehensive evaluation was conducted during the process of choosing solar photovoltaic (PV) components by getting in touch with both domestic and foreign retailers. The primary selection criteria were the components' cost and performance. The research's conclusions highlight the practicality and potential benefits of installing solar panels on homes in Hong Kong's communities, along with the chance to sell any extra energy to the CLP grid. The findings of our investigation demonstrate a significant impact on the production of energy at the local level, accompanied by a simultaneous decrease in reliance on conventional energy sources. The solar insolation data gathered at the selected site supports the feasibility of using solar electricity in many applications, establishing a strong basis for implementing similar systems in comparable environments.When examining the financial components, the extensive financial analysis undertaken demonstrates a favorable return on investment over the duration of the project. Although the initial expenditures associated with installation may be a significant obstacle, the potential money derived from the sale of energy, in conjunction with the enduring sustainability of solar power, provides a compelling rationale for the economic feasibility of this undertaking. In addition, the environmental advantages resulting from a less carbon footprint contribute to the broader socioeconomic and ecological significance of shifting towards renewable energy sources.

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