Solar Energy Integration Project: Comprehensive Load Assessment and PV Array Sizing for a Commercial Building

Site Overview and Energy Requirements

The project involved the design of a photovoltaic (PV) system for a commercial office building located on a 220-square-meter plot. The building operates during standard business hours, from 7 AM to 6 PM, Monday through Friday, with occasional weekend usage. The structure is a single-story building that accommodates office spaces, meeting rooms, and essential services. The site benefits from an average of 4.4 peak sunlight hours daily, totaling approximately 1606 sunlight hours annually. This solar irradiance data was crucial in determining the optimal size of the PV system.

Electrical Load Calculation and Efficiency Enhancements

A comprehensive audit was conducted on the building's electrical appliances, including office equipment such as computers, printers, lighting systems, HVAC units, and other essential devices. Power consumption estimates were based on actual usage data or drawn from credible industry sources. Each appliance’s daily and annual energy consumption was calculated in kilowatt-hours (kWh), considering the typical business operation hours.

Key areas for energy efficiency improvements were identified, with proposed enhancements including the transition from fluorescent lighting to energy-efficient LED systems and optimization of HVAC operation schedules. These improvements successfully reduced the building's daily energy consumption from 36.585 kWh to 34.02 kWh, and the annual energy usage from 7552.425 kWh to 6655.95 kWh.

PV Array Sizing and System Configuration

The optimized energy profile of the commercial building informed the calculation of the necessary power output for the PV array. A 25% system loss was accounted for, considering inefficiencies during energy conversion and potential shading effects. The PV array was designed to deliver approximately 5.53 kW, sufficient to meet the building’s energy demands.

A high-performance photovoltaic module was selected, with a rated power of 330 W, a maximum power voltage (Vmp) of 36.8 V, and a maximum power current (Imp) of 8.97 A. To achieve the required output, 17 modules were configured in series, producing a total output of approximately 625.6 V and 8.97 A. The chosen modules were sourced from a reputable manufacturer, ensuring the system's efficiency and reliability for commercial operations.