**Assignment on EE256: Rooftop Solar Plant Design and Analysis**

This assignment utilizes the JRC Photovoltaic Geographical Information System (PVGIS) design tool (https://re.jrc.ec.europa.eu/pvg\_tools/en/#PVP) to design and analyse a rooftop solar photovoltaic (PV) system for a hostel building. The tasks are structured to develop skills in solar plant design, resource assessment, energy output analysis, and financial evaluation.

**Task 1: Characterizing the Building and Rooftop Solar Plant Design [30 marks]**

**Objective**: Design a rooftop solar PV system for a hostel building based on site-specific data and engineering principles.

1. Site Assessment:

* Use Google Maps, Google Earth, or equivalent software to identify the hostel building assigned to you.
* Determine the approximately south-facing roof area (in square meters) suitable for solar panel installation. Account for obstructions and shading from nearby structures or trees.
* Provide a screenshot or diagram of the roof with annotations indicating usable area and any excluded sections.

1. Solar Plant Design:

* Using design techniques from the industrial lecture (e.g., panel sizing, spacing to avoid shading, and system capacity optimization), propose a suitable PV system.
* Select appropriate solar panels (specify type, efficiency, and wattage) and inverters (specify type and capacity) based on industry standards.
* Calculate the total system capacity (in kW) and the number of panels required, considering the usable roof area and panel dimensions.

1. Electrical Layout Diagram:

* Draw a single-line electrical diagram showing:
  + Arrangement of PV modules (series/parallel connections).
  + Inverter placement and connection to the grid.
  + Metering and safety devices (e.g., circuit breakers, disconnect switches).
* Use software like AutoCAD, SketchUp, or hand-drawn diagrams (scanned and uploaded).

1. Daily Energy Demand Estimation:

* Estimate the hostel’s daily electrical demand (in kWh) for weekdays and weekends.
* Divide the day into logical time periods (e.g., morning: 6 AM–12 PM, afternoon: 12 PM–6 PM, evening: 6 PM–12 AM, night: 12 AM–6 AM).
* Provide a table summarizing demand for each time period, considering typical hostel activities.
* Justify assumptions based on typical hostel occupancy and equipment usage.

**Task 2: Solar Resource Data Collection [10 marks]**

**Objective**: Gather and analyse solar resource data for the hostel’s location using PVGIS.

1. Location Details:

* Provide the hostel’s address and its precise latitude and longitude (use Google Maps or PVGIS for accuracy).

1. Data Collection:

* Using PVGIS, complete the following table for the hostel’s location:

|  |  |  |
| --- | --- | --- |
| Home address |  | |
| Parameter | Units | Home location |
| Latitude | 0 |  |
| Longitude | 0 |  |
| Annual global insolation (irradiation) on an optimally inclined plane | kWh/m2.year |  |
| Tilt angle for maximum annual insolation | 0 |  |
| Daily insolation (irradiation) in December at an optimum tilt angle | kWh/m2.day |  |
| Daily insolation (irradiation) in June at an optimum tilt angle | kWh/m2.day |  |
| Ratio of diffuse/global insolation throughout the year | % |  |

**Task 3: Solar Resource Visualization [15 marks]**

**Objective**: Visualize and interpret solar resource data to understand seasonal and daily variations.

1. Data Collection:

* Use PVGIS to extract monthly and daily solar irradiation data for the hostel’s location at the optimum tilt angle.

1. Graphical Analysis:

* Create the following graphs using software like Excel, Python (Matplotlib), or PVGIS’s built-in tools:
  + Graph 1: Monthly global insolation (kWh/m²) at the optimum tilt angle for all 12 months.
  + Graph 2: Average daily irradiance (W/m²) over 24 hours for March, August, and December at the optimum tilt angle.
* Ensure graphs are clearly labelled (title, axes, units, legend) and include a brief description of trends observed (e.g., seasonal variations, peak irradiance times).

1. Interpretation:

* Discuss how seasonal changes in insolation affect PV system design and performance.
* Highlight differences in irradiance patterns between March, August, and December, and their implications for energy production.

**Task 4: Grid-Connected PV Plant Performance [10 marks]**

**Objective**: Analyze the monthly energy output of the designed PV system and evaluate the impact of temperature.

1. Monthly Energy Output:

* Use PVGIS to estimate the monthly energy output (in kWh) for the grid-connected PV system designed in Task 1.
* Present the results in a table or graph, showing energy output for each month.

1. Temperature Impact:

* Obtain monthly average ambient temperatures for the hostel’s location using PVGIS or a reliable weather database.
* Compare the monthly PV energy output with the corresponding average temperature.
* Discuss the effect of cell temperature on PV panel efficiency and power output, referencing the temperature coefficient of the selected panels (typically -0.3% to -0.5% per °C above 25°C).

1. Analysis:

* Explain how temperature variations influence the system’s performance and suggest design considerations (e.g., ventilation, panel type) to mitigate efficiency losses.

**Task 5: Annual Revenue Calculation [15 marks]**

**Objective**: Estimate the financial benefits of the rooftop solar plant based on energy generation and consumption.

1. Energy Generation and Consumption:

* Use the annual energy output from Task 4 and the daily demand estimates from Task 1 to calculate:
  + Total annual energy generated by the PV system (kWh).
  + Total annual energy consumed by the hostel (kWh).
  + Net energy exported to the grid or imported from the grid (kWh).
* Assume net metering tariff (LKR/kWh).

1. Revenue Calculation:

* Calculate the annual revenue from:
  + Savings on electricity bills (energy consumed from PV instead of the grid).
  + Income from exporting excess energy to the grid (if applicable).

1. Discussion:

* Discuss factors affecting revenue, such as seasonal variations in generation and demand, or policy incentives.

**Task 6: Financial Analysis of the PV Project [20 marks]**

**Objective**: Evaluate the financial viability of the PV system over its operational life.

**Given Data**:

* Initial capital cost: LKR 100,000 per kW of installed capacity.
* Annual Operation & Maintenance (O&M) cost: LKR 50,000.
* Inverter replacement cost: LKR 400,000 after 5 years.
* Project lifespan: 15 years.
* Discount rates: 8%.

1. Project Timeline:

* Draw a timeline (e.g., using a Gantt chart or simple diagram) showing:
  + Initial investment (Year 0).
  + Annual O&M costs (Years 1–15).
  + Inverter replacement (Year 5).
  + Annual revenue from energy generation (Years 1–15).

1. Net Present Value (NPV):

* Calculate the NPV of the project
* Present cash flows in a table, including:
  + Initial investment (negative cash flow).
  + Annual revenue (from Task 5).
  + Annual O&M costs (negative cash flow).
  + Inverter replacement cost (negative cash flow in Year 5).
* Compute NPV and interpret the results.

**Submission Guidelines**

* Submit a single report (PDF format) including all tasks, calculations, diagrams, and graphs.
* Clearly label each task and sub-task.
* Include references for data sources (e.g., PVGIS, weather databases) and assumptions (e.g., tariffs, panel specifications).
* Ensure all calculations are shown step-by-step, and diagrams/graphs are of high quality.
* Word limit: 2,500–3,000 words (excluding tables, graphs, and references).

**Group Contribution Statement**:

* Include a section detailing the contributions of each group member. Assign the following roles to the five members:
  + **Project Engineer**: Oversees project coordination, ensures task integration, and manages report compilation.
  + **Design Engineer ( 2 – 3 Nos)**: Leads the solar plant design, including panel selection, system sizing, and electrical layout (Task 1).
  + **Solar Resource Analyst**: Manages data collection and visualization using PVGIS (Tasks 2 and 3).
  + **Performance Analyst**: Analyses energy output and temperature effects (Task 4).
  + **Financial Analyst**: Handles revenue calculations and financial analysis (Tasks 5 and 6).
* Provide a table or paragraph summarizing each member’s role, specific tasks performed, and estimated percentage contribution to the project (e.g., 20% per member for equal distribution or adjusted based on workload).