Benha University

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Undergraduate Course

Solar Cells Fundamental

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Lecture (10)

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How to Design Solar PV System?

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Solar PV system sizing

1. **Determine power consumption demands**

The first step in designing a solar PV system is to find out the total power and energy consumption of all loads that need to be supplied by the solar PV system as follows:

a) Calculate total Watt-hours per day for each appliance used.

b) Calculate total Watt-hours per day needed from the PV modules.

2. **Size the PV modules**

To determine the sizing of PV modules, calculate as follows:

a) Calculate the total Watt-peak rating needed for PV modules.

b) Calculate the number of PV panels for the system

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3. Inverter sizing

- An inverter is used in the system where AC power output is needed.
- The input rating of the inverter should never be lower than the total watt of appliances.
- The inverter must have the same nominal voltage as your battery.
- For stand-alone systems, the inverter must be large enough to handle the total amount of Watts you will be using at one time.
- For grid tie systems or grid connected systems, the input rating of the inverter should be same as PV array rating to allow for safe and efficient operation.

4. Battery sizing

- The battery type recommended for using in solar PV system is deep cycle battery.
- Deep cycle battery is specifically designed to be discharged to low energy level and rapid recharged or cycle charged and discharged day after day for years.
- The battery should be large enough to store sufficient energy to operate the appliances at night and cloudy days.

$$\text{Battery Capacity (Ah)} = \frac{\text{Total Watt-hours per day used by appliances}}{(0.85 \times 0.6 \times \text{nominal battery voltage})} \times \text{Days of autonomy}$$

5. Solar charge controller sizing

- The solar charge controller is typically rated against Amperage and Voltage capacities.
- Select the solar charge controller to match the voltage of PV array and batteries and then identify which type of solar charge controller is right for your application.
- Make sure that solar charge controller has enough capacity to handle the current from PV array.

Example

A house has the following electrical appliance usage:

1. One 18 Watt fluorescent lamp with electronic ballast used 4 hours per day.
2. One 60 Watt fan used for 2 hours per day.
3. One 75 Watt refrigerator that runs 24 hours per day with compressor run 12 hours and off 12 hours.
4. The system will be powered by 12 V_{dc}, 110 W_p PV module.

Answering

1. **Determine power consumption demands**

Total appliance use = (18 W x 4 hours) + (60 W x 2 hours) + (75 W x 24 x 0.5 hours)
= 1,092 Wh/day

Total PV panels energy needed = 1,092 x 1.3
= 1,419.6 Wh/day.

2. **Size the PV panel**

2.1 Total Wp of PV panel capacity needed = 1,419.6 / 3.4
= 413.9 Wp

2.2 Number of PV panels needed = 413.9 / 110
= 3.76 modules

Actual requirement = 4 modules

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3. **Inverter sizing**

Total Watt of all appliances = 18 + 60 + 75 = 153

For safety, the inverter should be considered 25-30% bigger size.

The inverter size should be about 190 W or greater.

4. **Battery Sizing**

Total appliances use = (18 W x 4 hours) + (60 W x 2 hours) + (75 W x 12 hours)
Nominal battery voltage = 12 V
Days of autonomy = 3 days

$$\text{Battery capacity} = \frac{[(18\ W \times 4\ hours) + (60\ W \times 2\ hours) + (75\ W \times 12\ hours)] \times 3}{(0.85 \times 0.6 \times 12)}$$

Total Ampere-hours required 535.29 Ah
So the battery should be rated 12 V 600 Ah for 3 day autonomy.

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5. **Solar charge controller sizing**

PV module specification

$P_m = 110\ W_p$

$V_m = 16.7\ V_{dc}$

$I_m = 6.6\ A$

$V_{oc} = 20.7\ A$

$I_{sc} = 7.5\ A$

Solar charge controller rating = (4 strings x 7.5 A) x 1.3 = 39 A

So the solar charge controller should be rated 40 A at 12 V or greater.

- **Note:**

Adjusting the generation factor for different climates.

- The amount of energy from the panels will be greater than our estimate if the climate is sunnier than a tropical coastal climate.
- The energy from the panels will be less than our estimate if the climate is cloudier than a tropical coastal climate.
- For the sunnier climate, use a Panel Generation Factor of **3.86**
- For the tropical coastal climate, use a Panel Generation Factor of **3.43**.

Guarantee Certificates

1- Product warranty certificate against industry defects.

2. Certificate of Performance Assurance.

3 - Certificate of transit guarantee from customs.

4- Certificate of guarantee of the country of origin.

Example (1):

Solar Panels

10-year warranty against industry defects.

25-years Certificate of guarantee of performance.

90% for the first ten years and 80% for 25 years.

Tests for Certificates

1. Safety test
2. Electromagnetic compatibility test
3. Test the connection to the public electricity network
4. Energy quality assessment
5. Energy efficiency test
6. Test compatibility with the environment
7. Functional safety assessment
8. Performance testing
9. Reliability Test

Routine Tests.

- Partial Type Tests.
- Completely Type Tests.

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IEC62446

- This standard is concerned with the minimum documentation, tests and test criteria for solar cell stations, especially those related to the public electricity network.
- The objective of this standard is to ensure the good work of solar cell systems, and these specifications serve all relevant to the field of designers and implementers and operators of solar cell systems.
- Compliance with this standard is a prerequisite for the implementation of solar cell systems projects.

Occupational Safety and Health

Is a branch of science that is interested in providing safe working environments free from the causes of accidents or injuries to preserve human and property.

What are the goals of following the rules of occupational safety and health ??? !!!

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Safety, safety and occupational safety rules within the workplace

What are the procedures that must be followed within the workplace from your point of view ??? !!!

1. Preserve the dry environment of work.

2 - Do not hang things on a low level to prevent collisions.

3 - not to put any things in the course of the movement not to stray.

4- Ensure that all electrical wiring is isolated.

5 - Ensure the proper delivery of measuring devices.

6 - Ensure the safety of work equipment and use the correct methods.

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The dangers of electricity to humans

م	شدة التيار (ملي أمبير)	التيار المتغير	التيار المستمر
1	1.5 - 6	بداية الشعور برجفة خفيفة في الأصابع	لايشعر به
2	2- 3	رجفة في الأصابع	لايشعر به
3	5 – 7	رجفة في اليدين	شعور بالحرارة
4	8 – 10	شعور بالألم في الأصابع وعظام اليدين ويستطيع المصاب التخلص من مصدر الصدمة بسهوله	شعورزائد بالحرارة
5	20 - 25	عجز اليدين عن الحركة وعجز المصاب عن التخلص من مصدر الصدمة وشعور بضيق في التنفس	شعورزائد بالحرارة
6	50 - 80	توقف التنفس واضطراب في الدورة الدموية قد يسبب الوفاة	تقلص وصعوبة في التنفس
7	90– 100	توقف التنفس ويتوقف القلب بعد 3 ثوان وتحدث الوفاة	توقف التنفس
8	100 - 200	توقف القلب وحدوث الوفاة بشكل مؤكد	حدوث الوفاة
9	أكثر من 200	توقف التنفس والقلب وحدوث حروق كبيرة	حدوث الوفاة

The risks of electricity to installations and materials

What are your expectations for accidents of misuse and security of electrical energy ??? !!!

Watch a video of some electrical accidents

Causes of accidents caused by misuse of electric power are:

1. Overload.

2 - Palace in the circle.

3 - Touching electrified parts and not connecting devices and equipment to the ground.

4. Use of damaged electrical equipment or equipment.

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How to apply safety and security rules in the solar station

1- Leave a work area around the electrical appliances.

2 - Marking clearly to distinguish the sources of public nutrition and electrical loads and equipment to disconnect the power supply.

3. Wear electrical shock protection equipment such as insulating gloves, protective glasses, head and foot protectors.

4. Ensure that all protection devices are working properly.

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How to safely maintain and repair the solar plant

1 - Ensure the separation of power supply.

2. Ensure that the ground system is connected.

3 - Marking clear signs of the existence of maintenance work in this place or electrical device.

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How to deal safely with solar station batteries

1. Ensure that all electrical connections are sound.

2 - Ensure that there is no form of short circuit on the batteries.

3. Do not unplug the battery again.

4. Do not overload the batteries.

5. Do not place batteries in a bad working environment.

Do not use batteries of the same type.....

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Common risks

1 - The electrical components of the damage of rodents and mice.

2 - not sure to connect the electrical connections properly.

3. Uncovered electric covers.

4 - Passage of electrical wiring inside corridors or metal pipes.

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Examples of what can happen to solar panels

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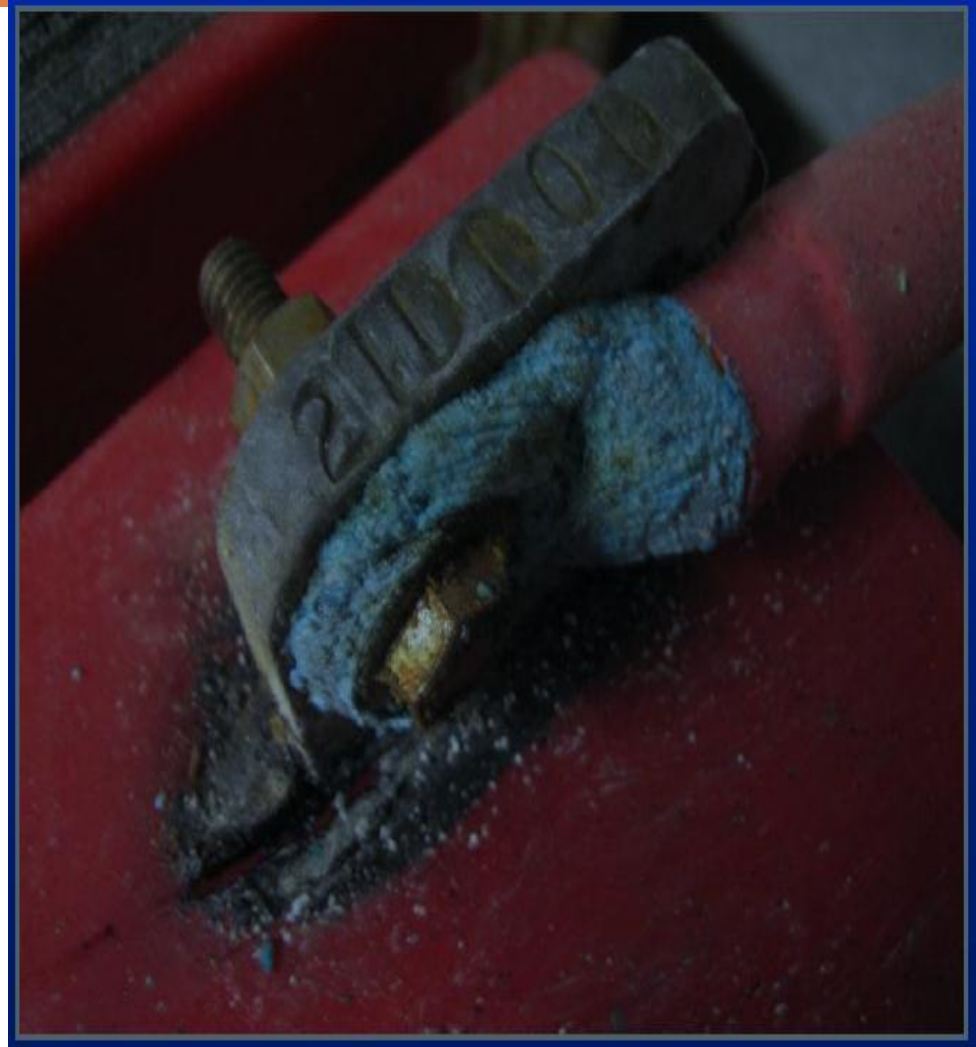
Examples of what can happen to solar panels

Examples of what can happen to solar batteries



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Steps to be taken before starting a solar cell system

1. Ensure that all components are properly installed.

2. Verify that all electrical and metal installations are carried out safely.

3 - Ensure the devices of separation of current in the position of separation with the presence of a sign that clearly indicates it.

4 - Inspection of all components and ensure the safety of all connections.

5. Identification and completion of missing parts.

6 - Ensure that there are signs in the correct places.

7- Ensuring that all pre-numbered values of the current, charger and other tasks are adjusted and prepared.

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Pre-operating tests of solar cell systems

1 - Test the resistance of the circuit to ensure that there is no path open circuit.

2 - positive and negative polar test.

3 - Test the voltage and current to make sure the matrix of solar cells for the desired values.

4. Ground resistance test.

5 - Performance test to ensure that the output of the system came according to the design.

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