CMR INSTITUTE OF TECHNOLOGY

USN

Internal Assesment Test - III

| Sub: | Operation And Maintenance of Solar Electric Systems | | | | | | | Code: | 17EE832 |
|---|---|---|---|---|---|---|---|---|---|
| Date: | 17/06/2022 | Duration: | 90 mins | Max Marks: | 50 | Sem: | 8 | Branch: | EEE-B (17scheme) |
| Answer All FIVE FULL Questions | | | | | | | | | |

| | | Marks | OBE CO | OBE RBT |
|---|---|---|---|---|
| 1a | What is feed in Tariff. What are the two different ways of feed in tariff. Give important features of feed in Tariff. | [6] | CO5 | L2 |
| 1b. | State the method to calculate upfront cost and simple payback method | [4] | CO5 | L1 |
| 2 | Why voltage drop is a crucial issue in PV system. Calculate voltage drop if the length of the cabling route is 18 meters from PV array to inverter. Resistivity of copper cabling is0.0183Ω/m/mm$^2$ is used with a cross sectional area of 2.5 mm$^2$. It must carry a current of 5 A. | [10] | CO4 | L2 |
| 3 | Briefly explain the testing of PV system | [10] | CO5 | L2 |
| 4 | List and explain strong barriers and positive attributes of PV Technology. | [10] | CO5 | L1 |
| 5 | What system documents are to be supplied to the owner after completion of PV installation | [10] | CO4 | L2 |

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| 2 | What are the risks involved with installing PV systems. How the risks are classified | [10] | CO4 | L3 |
| 3 | Explain the interconnection of PV array with utility grid using net metering and gross metering arrangements. | [10] | CO4 | L2 |
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## Feed-in tariffs

A Feed-in tariff (FiT) is a monetary reward for feeding electricity generated by PV into the grid. It can either be equal to the retail electricity rate or greater than this rate (known as an enhanced FiT). FiTs are usually financed by a levy added to all electricity bills. Small-scale PV is generally most successful in locations that have FiTs, such as Germany; however, it is important for these FiTs to be stable in order to encourage sustainable growth in the industry. In

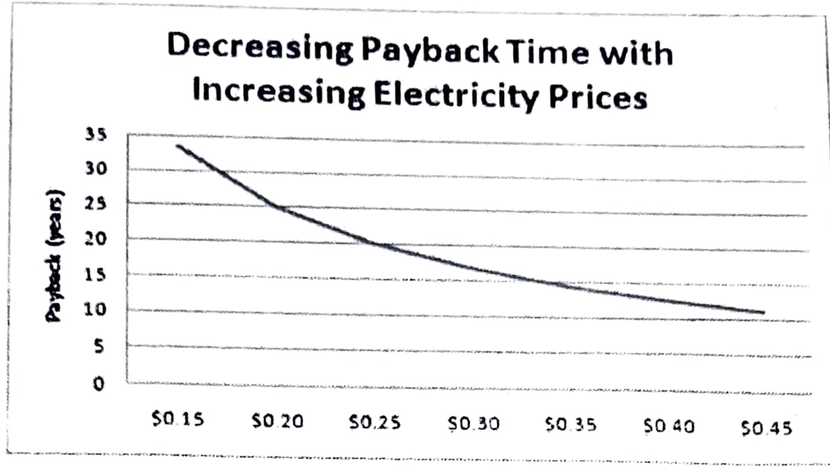


**Figure 13.4** Payback times will decrease with the inevitable rise in electricity prices even if PV system prices do not decrease

both Spain and Australia there have been recent cases where an FiT was introduced by the government but removed within a year. FiTs can be structured in two different ways:

- Gross FiT: All electricity generated, regardless of whether it is used in the customer's house or not, receives the FiT.

or

- Net FiT: Only electricity that is exported to the grid receives the FiT. Some net FiTs are time-of-use FiTs, i.e. if the customer is away from home during the day while the PV system is producing electricity, then the customer receives the FiT (even if they use more energy at night than they produced during the day). Other net FiTs go by the total amount of energy produced vs. the amount consumed; i.e. when it was consumed is irrelevant.

- Capital costs: The upfront purchase of all system equipment including PV modules and balance of system equipment makes up approximately 80 per cent of total system costs. The modules are the most expensive item by far, but inverters can still be costly; grid-interactive inverters range from US$500/kW to US$2000/kW. Smaller inverters generally used in residential applications are in the more expensive end of the spectrum because they are smaller. In areas where utilities are obliged to offer free net metering (as is the case in most US states) to customers with a PV system a new meter can be acquired free of charge, but in areas where the policy does not exist (i.e. Australia) it is often necessary to purchase a new meter with the system. The remaining 20 per cent of system cost is for the actual installation (excluding a small ongoing maintenance cost).
- Maintenance costs: 1 per cent of

## Simple payback

The simplest method for examining the economics of PV grid-connected systems is the *simple payback* method. People are often interested in the payback period of the installation. This is calculated using the following formula:

$$\text{Time (years)} = \frac{\text{Capital cost (\$)}}{\text{Savings from avoided electricity purchase (\$)}}$$

Example:

## Testing

Following a visual inspection of the system, testing should be undertaken in accordance with the prevailing national codes. National codes may require installers to ensure that the following points are compliant prior to system testing:

- There is no voltage at the output of the PV array (and at the output of each string if there is more than one). This may be achieved by leaving one of the module's interconnects disconnected/unplugged.
- Any fuses have been removed and all circuit breakers are in the 'off' position.
- The AC and DC main disconnects/isolators are in the 'off' position; local codes may also require them to be tagged or locked for the duration of the testing procedure.
- All components, i.e. the inverter, are switched off.

After the safety requirements outlined in the local codes have been fulfilled, testing may be undertaken. Each component is switched on and each isolator closed individually, beginning at the array and ending at the loads (i.e. appliances). Testing is done in this order for safety; it reduces the risk of hazards and equipment damage should any problems occur. At each step the system is tested by measuring the system parameters using meters and the displays on various components (i.e. the inverter display will show important data about the system). If at any stage the system begins to operate outside the expected parameters then electricians must identify the problem and address it before testing can continue. Common parameters that are tested include:

- continuity between adjacent system components;
- resistance of cable insulation;
- measurement of array and string open-circuit voltage (a large difference in the open-circuit voltage of identical strings or an open-circuit voltage very different to that expected may indicate a problem;
- measurement of array and string short-circuit current (hazardous – see box below);

- measurement of voltage drop across string fuses;
- verification of polarity of installed components;
- grounding/earthing of the system, often including impedance loop test or ground electrode test for which a ground tester is required.

- PV is reliable and low-maintenance; it contains no moving parts and the modules are robust, often coming with a 20–25 year guarantee.
- PV is good for the environment. Some people may suggest that a PV system cannot generate enough energy in its lifetime to equate to the amount of energy required in its production; this is not accurate. The energy required is retrieved in 2–7 years, depending on the system components, design, installation and its location. In addition this energy is clean and renewable, and will further reduce greenhouse gas emissions. PV modules are also recyclable.
- Grid-connected PV systems are easy and quick to install. PV's modular nature also makes it very easy to work with, installations can be of any size without any major manufacturing changes and modules can usually be added or removed during the lifetime of the installation.

- PV can represent a good investment: a system can add value to the building where it is installed and many of the financial incentives available such as FiTs are legislated for a certain period of time.
- PV is useful as a public demonstration of commitment to sustainability and reducing greenhouse gas emissions. This may be desirable for a company marketing itself as green because PV is an easy and highly visible way to make a statement and reduce a company's carbon footprint.

Despite these positive attributes there are still some strong barriers to PV technology, these include:

- High capital costs: the high capital cost of a system can be a major deterrent for investment or render a PV system unattainable for some people. Rebates and green loan programmes are attempting to address this.
- Lack of public knowledge and advertising: there are many myths surrounding PV such as it being too expensive to even consider putting on a home and that the amount of energy produced by the system is less than the energy consumed in its manufacture. The PV industry needs to be proactive about education to dispel these myths.
- Lack of industry: The grid-connect PV industry is still very much in its infancy in most parts of the world. There are a limited number of companies providing training and installation, and standards and regulations are still being developed.
- Lack of planning: As already discussed the amount of solar radiation a module receives is strongly affected by its orientation, but the installation is often governed by the orientation of the roof. When many towns were planned and built the roof orientation was not considered with respect to future PV installations.
- Utility regulations based on mains supply: Most electricity markets are unaccustomed to dealing with distributed generation, i.e. small-scale PV. Sometimes people seeking to install a small rooftop PV system have been required to complete the same paperwork as those planning to connect a large-scale coal-fired power station to the grid. Over time utilities are becoming more accustomed to dealing with distributed generation and streamlining the process of interconnection.
- Well-integrated fossil fuels: Well-established systems that favour fossil fuels are a key barrier to PV. Despite PV's numerous advantages, fossil fuels remain a more cost-effective option. Policies that put a price on the environmental damage of fossil fuels, such as emissions trading schemes and carbon taxes intend to drive up the price of fossil-fuel-generated electricity, making PV and other renewable energy sources more competitive.

## System documentation

At the completion of the installation the owner should be supplied with a system manual that includes information on the system. Local codes generally specify the documentation that should be provided; however, a general guide is given below.

- List of equipment supplied: the system manual should include a full itemized list of all the components that have been installed including PV modules, inverters, array frames, PV combiner boxes, string isolators, fuses or circuit breakers and the DC and AC main disconnects/isolators. The list should include the quantities of equipment items used.
- System diagrams: a basic circuit diagram and a wiring diagram should be included in the manual. Architectural drawings or the site plan showing the major components are also useful.
- System performance estimate: the manual should include the expected yield of the system as calculated by the designer. It may also include information on local financial incentives (see Chapter 13) and what these mean for the system in terms of income and/or savings on electricity bills. It is also important to emphasize that this is purely an estimate and some variation from year to year is common.
- Operating instructions for the system and its components: the manual should include a brief overview of the system, the function of each of the main components and how the system operates. Any information important to that particular system should be included in the manual. It is important to explain to the owner that the system will turn off when the grid fails, i.e. when there is no power available from the grid.
- Shutdown and isolation procedures for emergency and maintenance: the manual should include procedures for maintenance and emergency. Depending on the size of the system, maintenance procedures might not involve the complete shutdown of the system.
- Maintenance procedure and timetable: Chapter 12 details the maintenance requirements for a grid-connected PV system, including tables that should be included in maintenance logbooks. This information should be incorporated into the system manual.
- Installation and commissioning records: these should be all signed and included in the system manual.
- Monitoring of system: a section of the manual should advise the system owner how to monitor the system to ensure that it is operating correctly. Many inverters have monitoring capabilities. If the inverter includes these features, instructions on how to use them should be provided. If a separate monitoring unit has been supplied with the system, the manual must include information on its operation.
- Warranty information: a grid-connected PV system comprises individual products connected together by a system installer to create the system. There are four types of warranties applicable to such a system, these are:
  1. product warranties covering defects in manufacture;
  2. product warranties related to output performance over time;