LESSON

Introduction to Types of Solar Systems

BIG IDEA(S)

It is important to be able to accurately describe all the necessary components of any type of solar system.

OBJECTIVES

Students will be able to:

- Identify and describe the 3-4 kinds of solar systems
- Describe the components of each kind of system
- Explain how systems/configurations are best suited for specific situations
- Describe Grid Direct, Stand-Alone, and Hybrid systems are configured
- Explain the pros and cons of building integrated systems

BRIGHT SOLAR FUTURES

SOLAR

TOPIC OF STUDY

Solar Project Management and Design

2 HOURS

TASK LIST SUBCATEGORY

401 Identify solar mechanical and electrical components

402 Select appropriate components to design a solar system

405 Identify the factors related to system sizing and production

406 Differentiate the design of grid-tied, storage and off-grid systems

OVERVIEW

There are three basic types of solar systems: grid direct, stand lone (off grid) and hybrid that this lesson explores. Some grid-tied have battery back-ups. For most people, a grid-tied solar system is a solid investment that provides security and predictability for their business, farm or home. The payback for a grid-tied solar system is shorter and there are fewer components that could need to be replaced in the future. An off-grid solar system is a good option for some cabins and more isolated areas, however at this time, off-grid systems struggle to compete with the payback and ROI of a grid-tied system.

KEY TERMS

PV direct
DC standalone
grid-direct
grid-tied with battery back-up
batteries
AC load
stand-alone with AC loads
stand-alone with back-up
hybrid
building integrated solar

STANDARDS

PA/SDP

3.4.10.A1. Illustrate how the development of **technologies** is often driven by profit and an economic market.

3.4.10.A2. Interpret how **systems** thinking applies logic and creativity appropriately in complex real-life problems.

3.4.10.B2. Demonstrate how humans devise **technologies** to reduce the negative consequences of other **technologies**.

3.4.12.A2. Describe how management is the process of planning, organizing, and controlling work.

3.4.12.B2. Illustrate how, with the aid of **technology**, various aspects of the environment can be monitored to provide information for decision making.

3.4.12.C2. Apply the concept that engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.

INSTRUCTIONAL

TEXTS/REFERENCES

Solar Electric Handbook, SEI, 2013. Pp. 55-79

Solar Photovoltaic Basics, Sean White, 2019. Pp. 83-90

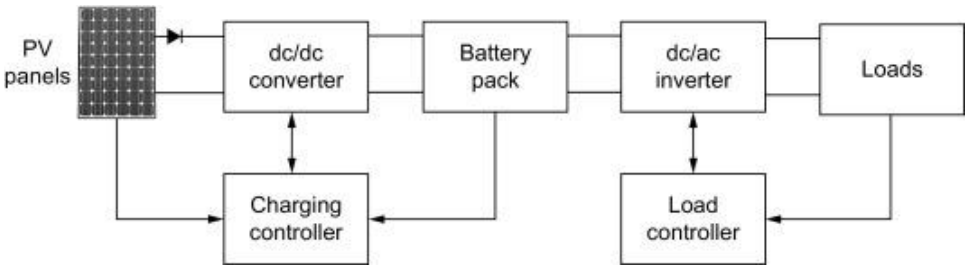
IMPLEMENTATION (LESSON PLAN)

ENGAGE

What do you think all PV systems have in common? Why would different systems have different components? Discuss with students to assess background knowledge. They should at least understand that photovoltaic modules are what all systems have in common.

EXPLORE

1. There are many types of solar systems. However, there are 3 systems that are most common:
    a. **Off Grid -** These systems require batteries or some other form of energy storage. The house is not connected to a power grid so all electrical power is generated from the solar system.
        - In this simple topology, the dc/dc converter between the battery and the PV panel is used to capture all the available power from the PV panel. In this system, battery pack acts as an energy buffer, charged from the PV panel and discharged through the dc/ac inverter to the load side. The charging controller determines the charging current of the battery, depending on the MPP of the PV panels at a certain time.
        - House have ac loads so the inverter is used to convert to ac from the PV panel



Alireza Khaligh, Omer C. Onar, in Power Electronics Handbook (Fourth Edition), 2018

https://www.sciencedirect.com/topics/engineering/stand-alone-photovoltaic-systems

    b. **Utility Interactive (Grid Tied or Grid-Direct) -** This is the most typical type of solar system. The homeowner stays connected to the utility grid and, when the solar is producing more electricity than the home needs, can feed electricity back to the grid. When the solar is not producing energy the home uses power produced by generation sources on the grid. There is no charge controller or batteries, and the grid must always be present.
        - **Net metered** systems are the most common type of grid direct. The single utility meter tracks the amount of energy purchased from the utility and the surplus PV energy sold back.

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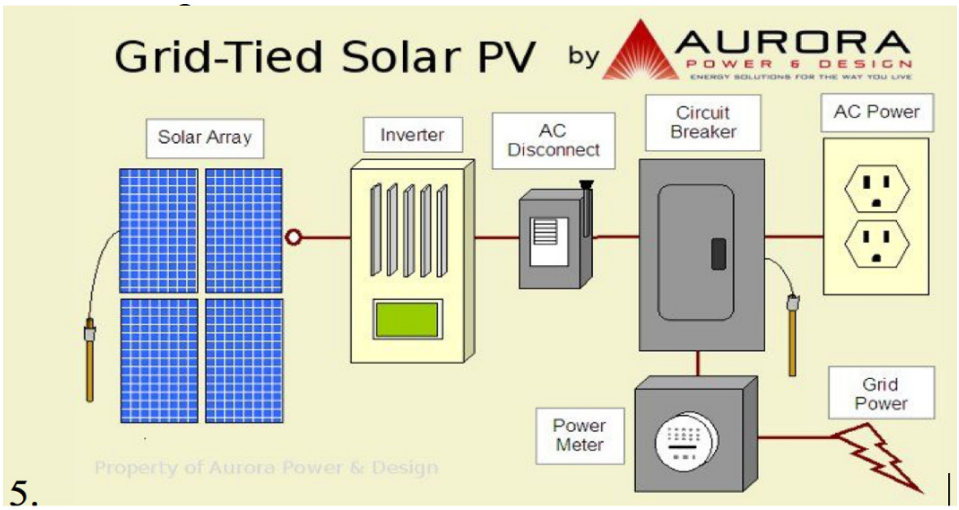
IMPLEMENTATION (LESSON PLAN) - CONTINUED

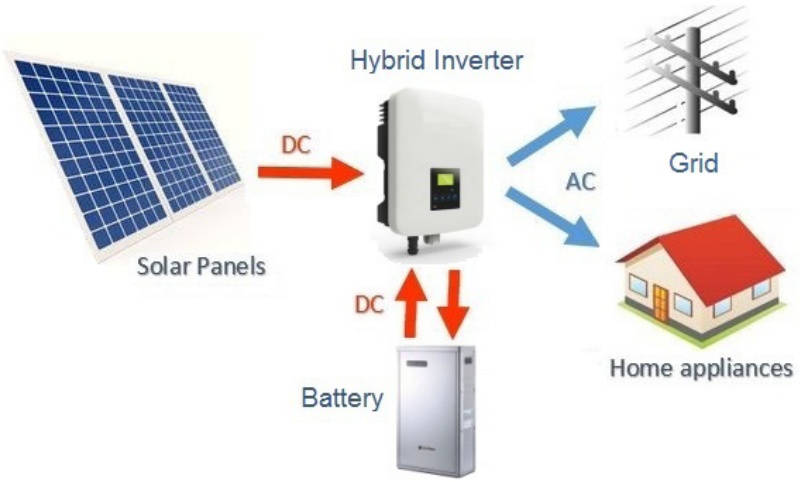
- **Feed-in tariff** systems include a second, utility style meter and is used to track all power that is generated by the PV system. A separate rate structure (incentive) applies to the energy that is sold vs. energy purchased from the utility.



5.

https://www.google.com/search?client=firefox-b-1-e&q=Grid-connect+solar+system+design#cobssid=s

c. **Hybrid systems -** This is the most complicated type of solar system. It involves solar and multiple power sources plus storage. For example, a house may be grid connected, with generator back-up, battery storage, and solar. These systems typically involved complex programming to ensure proper operation.



EXTEND

1. For most people, a grid-tied solar system is a solid investment that provides security and predictability for their business, farm or home. The payback for a grid-tied solar system is shorter and there are fewer components that could need to be replaced in the future. An off-grid solar system is a good option for some cabins and more isolated areas, however at this time, off-grid systems struggle to compete with the payback and ROI of a grid-tied system.

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IMPLEMENTATION (LESSON PLAN) - CONTINUED

2. Grid-Tied Pros and Cons
    a. Pros
        i. Grid-tied systems tend to be the less expensive option, due to not needing batteries and other equipment
        ii. This type of system is great for those who don't have the room or financing to install a solar system big enough to cover 100% of their energy usage. You can continue to pull electricity from the grid if needed
        iii. Net metering allows the electricity generated by a solar system to offset the electricity used from the grid during the night or cloudy days
        iv. The grid becomes your cost-effective, reliable storage solution
        v. In some regions, Solar Renewable Energy Credits (SRECs) allow owners of a grid-tied system to receive extra income by selling the SRECs their system produces
    b. Cons
        i. If the grid goes down your system will shut off, leaving you without power. This is required to prevent energy from back feeding into the grid to keep utility workers safe. Your grid-tied system will automatically shut off when the grid goes down, and will also automatically turn back on when power is restored
        ii. You're not completely independent from the grid
3. Off Grid-Solar System Pros and Cons
    a. Pros
        i. Completely independent from the grid
        ii. A great solution for remote locations and underdeveloped communities
    b. Cons
        i. They are more costly
        ii. Batteries are required to deliver electricity consistently throughout the day and night
        iii. It could require a lifestyle change to reduce energy consumption
        iv. Surplus energy production could go to waste
        v. Cannot rely on the grid at night or on cloudy days
        vi. Batteries require maintenance, have a relatively short lifespan, and degrade rapidly
4. Hybrid System Pros and Cons
    a. Pros
        i. Continuous power supply – The hybrid solar systems provide power continuously, without any interruption, as the batteries connected to them store the energy. So, when there is an electricity outage, the batteries work as inverters to provide backup. This is also the case during the evening or night time when there is no sun and energy is not being generated; batteries provide the back-up and life goes on without any interruption.
        ii. Utilize the renewable sources in the best way – Because the batteries are connected to the system to store the energy, there is no waste of the excess energy generated on bright sunny days. So, these systems make use of renewable energy in the best way, storing energy on a good day and utilizing the stored power on a bad day. The balance is maintained.

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IMPLEMENTATION (LESSON PLAN) - CONTINUED

iii. Low maintenance cost – The maintenance cost of the hybrid solar energy systems is low as compared to the traditional generators which use diesel as fuel. No fuel is used and they do not require frequent servicing.

iv. High efficiency – The hybrid solar energy systems work more efficiently than your traditional generators which waste the fuel under certain conditions. Hybrid solar systems work efficiently in all types of conditions without wasting the fuel.

v. Load management – Unlike traditional generators, which provide high power as soon as they are turned on, most hybrid solar power systems manage load accordingly. A hybrid solar system may have technology that adjusts the energy supply according to the devices they are connected to, whether it's an air conditioner requiring high power or a fan which requires less.

b. Cons

i. Complicated controlling process – With different types of energy sources in use, the systems require some knowledge. The operation of different energy sources, their interaction and coordination must be controlled and it can become complicated.

ii. High installation cost – Although the maintenance cost is low, the initial investment for the installation of a hybrid solar energy system is high as compared to a solar system.

iii. Less battery life – The batteries connected to the system may have a lower life as they are often exposed to natural elements like heat, rain, etc.

iv. The number of instruments connectable is limited – The number of devices you can connect to a hybrid solar energy system is limited and vary from system to system.

EVALUATE

Working in 3 groups, have students create a drawing of each of the three kinds of solar systems.

HOMEWORK

Do some research to find out what the most popular solar systems installed. Determine if choices are influenced by weather, wind, other natural resources,days of sun per year, etc.

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