3. Solar Design

Designing with the Sun
Lesson Outline

Chapter 3: Solar Design

- Solar Energy
- Solar Design Principles
- Solar Around the World
- Activities
- Links & Resources
Solar Energy
Designing with solar panels

Designing with solar panels starts with determining the **size of the system** based on how much **sunlight** you will receive and how much **energy** you plan to use.
Solar Irradiance

To determine the size of the system, you will measure the daily electrical usage you need and divide it by your solar radiance.

Solar Irradiance is the amount of sunlight that hits the earth, which changes depending on the time of the year / location.
Peak Sun Map: US in July

Insolation maps rate locations by their average daily peak sun hours.

Image: “Photovoltaic Systems” by James P. Dunlop
Peak Sun Map: US in January

Image: “Photovoltaic Systems” by James P. Dunlop
Solar Design Principles
A *South* facing solar array is the best position to absorb the most sunlight for the northern hemisphere.

The sun’s angle changes +15° in the summer and -15° in the winter.

[Source](siamagazin.com/40ft-shipping-container-off-grid-family-home/)
The angle at which a solar panel is set to face south the towards sun varies based on the location's latitude.

In the winter the angle should be 15° more and in summer 15° less or fixed based on the location's latitude.
A Solar Pathfinder device is used to analyze exactly where the shadows will be at different times of the day or year so that the solar array is placed in the best spot.

Image: livingindryden.org
PV systems can be tied to the Utility grid

Grid-tied Photovoltaic System

Circuit Diagram

Solar Panel → Utility-Interactive Inverter → AC Power Distribution Panel → Utility Grid

Designing with the Sun
Solar panels can directly power DC appliances like a fan during the day without a battery.

Examples:
circulation fan, water pump, calculator
PV systems can use a battery to power a load (like LED lights) during the night.

Circuit Diagram
Off-Grid Solar Charging Station

735 Watts of Solar

Charge Controller

Battery Bank 300 Amp hour 24 volts

Inverter 2500 Watts

AC Load

DC Load
PV systems can use a DC to AC inverter to run common household AC appliances.

**Batteries** can be used for energy storage at night and during cloudy weather.

The **solar panels** recharge the **batteries** when sunny weather returns.

An **inverter** converts (DC) electricity produced by solar panels into alternating current (AC) electricity used in buildings.
Grid-tied solar system

Energy produced by the **PV system** can be used directly in your home or business.

**Extra energy** can flow through the building's meter to the grid and be sold to your neighbors in states with solar buy back policies.
Solar Around the World
Solar Decathlon

Teams from all over the world participate in the Solar Decathlon Design Challenge and propose creative solutions for real-world issues in the sustainable building industry.
Floating Solar Powered School

Bangladesh

buildabroad.org/2016/09/16/floating-schools-solution-flooding-across-globe/
Beddington Zero Energy Development
London, United Kingdom

It has 8,360 sq ft of solar panels for housing and offices

Off-grid Solar Tiny House
Byron Bay, Australia

Solar Tiny House, Byron Bay, New South Wales, Australia
Solar electricity, solar hot water, rainwater collection, biogas stove
Make Glow India

A foldable cardboard solar lamp in India
We Care Solar designs portable Solar Suitcases that power critical lighting and medical devices in low resource areas without reliable electricity. wecaresolar.org
Build a DIY Solar Bag:

Tools and Supplies

https://learn.adafruit.com/solar-charging-handbag/tools-and-supplies
Designing with the Sun

Use your imagination! Design and sketch your own solar powered object or building:

- Where will your design be used?
- Who will use it? How?
- Will it have special features?
- Will you integrate photovoltaic (PV) panels? If so, how?
- What materials will you use?
## Solar Charging Station Design Steps

<table>
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<tr>
<th>Step Number</th>
<th>Instructions</th>
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<tr>
<td>1. Concept Development</td>
<td>Use your imagination! Design and sketch your own solar charging station.</td>
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<tr>
<td>2. Problem Statement</td>
<td>How will your project be used? Where will it be located? Who will use it? What size will it be? Will it have special features? What materials will be used? What will it charge? Will it have furniture or bike racks?</td>
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<td>3. Concept Sketch</td>
<td>Hand sketch multiple ideas (pencil, markers). Develop best iterations with detailed use notes (Photoshop, Procreate.art).</td>
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<tr>
<td>4. CAD Model</td>
<td>Design project structure to scale with CAD software (Rhino, Fusion 360).</td>
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<td>5. Solar Design</td>
<td>Create a parts list (PV panels, battery, inverter, outlets, LEDs, electrical enclosure). Size the equipment to meet the needs of the items you want the station to charge. (Use an off-grid solar calculator for help.) Example: <a href="https://www.altestore.com/store/calculators/off_grid_calculator/">https://www.altestore.com/store/calculators/off_grid_calculator/</a></td>
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<tr>
<td>6. Prototype</td>
<td>Build a to-scale prototype (3D print, laser cut, or hand cut matte board).</td>
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<tr>
<td>7. Poster</td>
<td>Include: title, description, digital renderings, material, fabrication plan, prototype photo, CAD model with dimensions: side, front, top, isometric</td>
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## Solar Design Considerations

<table>
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<th>Design Feature</th>
<th>Considerations</th>
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<tr>
<td><strong>Site Placement</strong></td>
<td>South facing (Northern Hemisphere), free of shade obstacles (tree, building).</td>
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<td><strong>Structure</strong></td>
<td>Roof should be angled to the south approximately equal to the location's latitude. Example: Austin, TX: 30° angle to maximize solar gain.</td>
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<tr>
<td><strong>Solar Electronics</strong></td>
<td>PV panels, battery, inverter, outlets, LEDs, electrical enclosure. Battery capacity depends on system load (what you want to charge and for how long). Off-grid solar design calculators can be used.</td>
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Solar Charging Station Equipment

- Solar Panel
- Charge Controller
- Battery
- Inverter
- Meter
- Load

Circuit Diagram

Off-Grid Solar Charging Station

- 735 Watts of Solar
- Charge Controller
- Inverter 2500 Watts
- Battery Bank 300 Amp hour 24 volts
- DC Load
- AC Load
Student Examples
Campus Solar Charging Station

This is a solar charging station at the University of Texas at Austin
Build a Solar Wagon

Part List

- 60 Watt Solar Panel (20-60 watts are best)
- 12 Volt 35 AMH Sealed AGM Battery
- USB outdoor socket
- Sun Saver MPPT 15 Amp charge controller
- Sun Saver 300 Watt inverter
- Morningstar Sun Saver remote meter
- Breakers / bus bar for the solar panel, battery, and inverter (load)
- LEDs
- Black and Red wire

Learn More


NASA Climate Kids [https://climatekids.nasa.gov/greenhouse-effect/](https://climatekids.nasa.gov/greenhouse-effect/)


The Solutions Project [thesolutionsproject.org/](http://thesolutionsproject.org/)
Designing with the Sun
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