Design a Roof:

Roof Orientation & Solar Yield Analysis

A CENVAR SOLAR SCIENCE EXPERIMENT FOR GRADES 9-12

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Description

Students evaluate real or sample buildings to determine which roofs are best for solar panels based on orientation, tilt, and shading. They then estimate the annual energy output of a planned solar array using basic solar resource data, connecting math and mapping to real-world solar project planning.

Age/Grade Level:

Grades 9-12, Intro College STEM

Time:

1-2 Class Periods plus extension depending on depth of analysis.

Objectives:

- Determine roof orientation and tilt from maps, satellite imagery, or onsite observations.
- Use solar resource data (irradiance) to estimate annual energy output of a rooftop solar system.
- Communicate a data-based recommendation for the best location and size of a rooftop solar array.

Vocabulary

- **Solar Energy:** Energy from the sun.
- **Heat:** A form of energy that makes things warmer.
- **Melt:** To change from a solid to a liquid because of heat.
- **Reflect:** To bounce back light or heat.
- **Solar panel (PV panel):** A device that turns sunlight into electricity.
- **Kilowatt-hour (kWh):** A unit for measuring electrical energy used or produced over time.
- **Carbon emissions:** Gases released when fossil fuels are burned, contributing to climate change.
- **Azimuth:** The compass direction a surface faces (e.g., south-facing roof).
- **Tilt:** The angle of a roof surface measured from horizontal.
- **Irradiance:** The amount of solar power received per unit area, typically in watts per square meter.

Materials

- Access to satellite maps (e.g., printed Google Maps views of the school and nearby buildings)
- Protractor, ruler, and compass rose overlay
- Simple solar irradiance tables or online solar resource estimates for your area (printed for offline use).
- Calculator or spreadsheet for energy calculations

Safety Precautions

- If taking observations outdoors, follow school safety rules and stay clear of roof edges and restricted areas.

Implementation (Teacher Script)

1. Show students an image of a school with solar panels installed on the roof.
2. Ask: “What makes a roof ‘good’ or ‘bad’ for solar panels?” Collect ideas like direction, shade, and size.
3. Explain they will act as solar designers, using real building data to choose the best roof surfaces for a solar array.
4. Divide students into small teams and give each team a house footprint and a set of solar panel cutouts.
5. Instruct teams to design two versions of the roof:
   a. Roof A: Standard roof (no solar panels).
   b. Roof B: Roof with solar panels arranged wherever they think they would work best (e.g., on the “south-facing” side of the drawing).
6. Have teams count how many panel cutouts fit on Roof B and use the data handout to estimate:
   a. How many kWh per year the solar system might produce.
   b. How much of the home’s electricity use that could cover.
   c. How much carbon emissions could be avoided.
7. Ask teams to list 3–5 pros and cons for each roof design (appearance, cost, maintenance, energy independence, environmental impact).
8. Each team prepares a short pitch recommending either Roof A or Roof B for their client, using their calculations and pros/cons as evidence

Procedure

- Provide each student group with a printed satellite view of your school and at least one nearby building (e.g., gym, library, neighborhood home).
- Have students:

    - Identify roof sections and mark approximate orientations using a compass rose.
    - Estimate roof tilt (e.g., pitched vs. flat) using photos and basic assumptions.
    - Note nearby shading sources (trees, taller buildings, equipment).
- Using irradiance data for your location, have students estimate annual energy output:
    - Step 1: Approximate usable roof area (in square meters) for panels on each surface.
    - Step 2: Assume a standard panel power rating and power density (e.g., about 1 kW per 6–8 square meters).
    - Step 3: Apply annual kWh per kW of installed capacity for your area (from irradiance tables or a solar calculator printout).
- Students record estimates of annual kWh for each potential roof surface and note any losses due to tilt/orientation and shading.
- Each group chooses their “best” roof for solar and writes a short justification including data, assumptions, and limitations.

QUESTIONS TO PROMPT INQUIRY:

- How did roof orientation and tilt affect your energy estimates?
- Which mattered more in your case: shading, roof size, or orientation?
- How might your recommendations change for a home vs. a large school roof?

Conclusion (Key Takeaway)

Solar designers must analyze roof orientation, tilt, shading, and available area to predict how much energy a rooftop system can produce. These factors are critical inputs in deciding where and how big a solar array should be on a school or home.

Activity Extensions

    - Layer in real or sample electricity bills to estimate how much of the building’s usage the solar array could offset.

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