

Design Challenge: A Solar Still That Runs on the Water Cycle

Learning target: I can analyze test data from several solar still prototypes, combine their best features into an improved design, plan the next test, and justify my choices with the criteria, the constraints and the science of evaporation, condensation and gravity.

Transfer and design

About 50 min

Pairs

MS-ETS1-3 · assesses

MS-ETS1-4 · practice

MS-ESS2-4 · supports

engineering design

data analysis

writing

Name _____

Date _____

Period _____

Directions

Read the design brief and the test report. Answer Part A using the data table; show every calculation. In Part B, design your improved still by combining the features that the data say work, draw it, and plan the next test. In Part C, justify your design against the criteria and constraints and explain the water-cycle science that makes it work. You are not building anything today; your job is to think like the engineer who decides what to build next.

You will need: This worksheet, Pencil and ruler, Calculator, Colored pencils for the drawing

The design brief

A school in a dry coastal town wants a small **solar still** for its emergency kit: a device that uses only sunlight to turn salty or muddy water into clean drinking water. A solar still is a shallow basin of dirty water under a clear cover. Sunlight warms the water, water vapor rises, the vapor condenses on the cooler underside of the cover, and the drops run down the cover into a clean trough. Salt, mud and most germs stay behind in the basin.

Criteria and constraints — Criteria (what a good design does): C1: produces at least **400 mL** of clean water per sunny day. C2: is easy to carry: mass **1.5 kg or less**. C3: is simple enough for a student to set up in five minutes. **Constraints (limits that cannot be broken):** K1: materials cost **\$12 or less**. K2: uses **no electricity or fuel**. K3: fits in a box 60 cm × 40 cm × 30 cm. K4: the water never needs to boil (no flame and no boiling-hot parts).

The test report

Last year's class built six prototypes and tested them side by side on the same clear day, each starting with 2.0 L of salt water spread about 1 cm deep in a shallow basin. The clear covers were thin plastic film. The output is the clean water collected from sunrise to sunset. The warmest basin water measured all day, in prototype D, was **58 °C**.

Solar still prototypes tested on one clear day (teaching dataset)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Prototype	Basin liner	Cover	Cover tilt	Insulation under basin	Output (mL/day)	Cost (\$)	Mass (kg)
A	white plastic	clear film	flat (0°)	none	180	6	0.8
B	black plastic	clear film	flat (0°)	none	310	7	0.9
C	black plastic	clear film	20°	none	390	8	1.0
D	black plastic	clear film	20°	foam board	460	11	1.3
E	black plastic	clear film	45°	foam board	410	12	1.4
F	black plastic	black (opaque) film	20°	foam board	40	11	1.3

Simulated data for teaching. The pattern (dark basin, tilted clear cover and insulation each raising output; an opaque cover killing it) matches how real small stills behave; actual outputs vary with weather.

Part A: Analyze the tests

1. Check each prototype against criterion C1, criterion C2 and constraint K1. Write yes or no in each cell, then yes or no in the last column.

C1: 400 mL or more?	C2: 1.5 kg or less?	K1: \$12 or less?	Meets all three?
A			
B			
C			
D			
E			
F			

2. Prototypes A and B differ only in the basin liner. Calculate the increase in output from A to B in mL and as a percent of A's output. Explain why a black liner helps, using the word *energy*.

3. Compare the pairs B and C, then C and D. For each pair, name the one feature that changed, the change in output in mL, and a reason the feature helped. (Think about where the drops go on a flat cover, and where the basin's energy goes without insulation.)

4. D and E differ only in cover tilt, yet the steeper 45° cover produced **less** water. What does this tell you about 'more of a good thing'? Suggest one physical reason the steeper cover might have hurt.

5. Prototype F is identical to D except that its cover is opaque, and it produced only 40 mL. What does F prove about where the still's energy comes from? What second job does the clear cover do besides letting light in?

6. The warmest water in any basin was 58 °C, yet prototype D produced 460 mL of clean water. Explain the three water cycle steps inside the still, naming the driver of each (the sun's energy, cooling, or gravity), and explain why the salt does not travel with the water.

Part B: Combine the best features and plan the next test

7. Draw your improved still as a side view. Label the basin liner, the cover and its tilt, the insulation, the trough, and the collection container. Add arrows for sunlight, rising vapor, condensation on the cover, and drops running down to the trough, and label each arrow's driver (S, C or G).



8. List the features you kept from the tested prototypes and say which prototype's data justifies each one. Then name **one new change** you want to try that was not tested (ideas: a thicker or clearer cover, a shallower water depth, a reflector, a darker basin, a drip edge on the cover). Predict its effect and give a reason.

9. Plan the next test as an iterative test. State: the one variable you will change, the levels you will try (at least three), everything you will keep the same, how many days you will test, what you will measure and record, and what result would make you keep the change or drop it.

Part C: Justify the decision

- 10.** Write a recommendation to the school. Say which tested prototype you would build today if there were no time for more testing, and why, checking it against every criterion and constraint. Then explain what your improved design (Part B) would add, what risk comes with it (cost, mass, or untested features), and how the next test would reduce that risk. End with one sentence on how the still depends on the same two drivers as Earth's water cycle.

Read the table in pairs

The table is built so that most neighboring rows differ by exactly one feature: A to B changes only the liner, B to C only the tilt, C to D only the insulation, D to E only the tilt angle, D to F only the cover's clearness. When two rows differ by one thing, the change in output is caused by that one thing. Work down the table one pair at a time and write the feature and the output change in the margin before answering q2 to q5.

Cloudy-day budget

The town averages 230 clear days a year. Suppose prototype D makes 460 mL on a clear day and about a third of that on an overcast day. Estimate the yearly output of one D still in liters, then calculate how many stills the school would need to supply 2 L a day for each of 30 students during a 5-day emergency, if the stills had been collecting into storage for the previous 30 days of mixed weather. State every assumption and explain why a fog net might be a better partner for a solar still in a coastal town.