Contents

	Page
WELCOME, RENEWABLE ENERGY ENGINEER!	**4**
YOUR RENEWABLE ENERGY JOURNEY	**5**
SOLAR ENERGY	
WIND ENERGY	
HYDROPOWER	
BIOMASS ENERGY	
ENERGY-EFFICIENT SMART HOMES	
THE CLEAN-ENERGY CONNECTION	**8**
Build a Solar Oven System	**9**
Build Your System	**10**
Test and Record Your Results	**13**
How It Works (Science Background)	**13**
Improve Your Design	**15**
Troubleshooting	**17**
REFLECT & EXPLAIN	**18**
Build a Wind-Powered Generator System	**20**
Build Your System	**21**
Test and Record Your Results	**25**
How It Works (Science Background)	**26**
Improve Your Design	**27**
Troubleshooting	**29**
REFLECT & EXPLAIN	**30**

💦 **Build a Hydropower Generator System**	**32**
🛠️ Build Your System	**33**
🔍 Test and Record Your Results	**36**
🔬 How It Works (Science Background)	**38**
🛠️ Improve Your Design	**40**
🔧 Troubleshooting	**42**
📄 REFLECT & EXPLAIN	**43**
🌱 **Build a Mini Biogas Energy System**	**45**
🛠️ Build Your System	**46**
🔍 Test and Record Your Results	**47**
🔬 How It Works (Science Background)	**49**
🛠️ Improve Your Design	**51**
🔧 Troubleshooting	**53**
📄 REFLECT & EXPLAIN	**55**
CAPSTONE PROJECT 🏠 **Build an Energy-Efficient Smart Home**	**57**
🛠️ Build Your System	**58**
🔍 Test and Record Your Results	**65**
🔬 How It Works (Science Background)	**67**
🛠️ Improve Your Design	**69**
📄 **REFLECT & EXPLAIN — ANSWER KEY**	**70**
⭐ Your Next Engineering Mission	**72**

WELCOME, RENEWABLE ENERGY ENGINEER!

ARE YOU READY TO POWER THE FUTURE?

Plan → Build → Test → Measure → Improve

Energy is all around you. Sunlight warms the ground. Wind moves tree branches. Flowing water pushes rocks and turns wheels. Plants and food waste contain stored energy. Homes use energy every day for heating, cooling, lighting, and appliances.



But how can we capture energy without using up fuels that may run out?

How can we turn natural resources into useful heat or electricity?

How can we design homes that waste less energy?

These are the kinds of problems that renewable energy engineers solve.

In this book, you will not simply read about renewable energy. You will build systems that help you see energy in action. You will:

- ☀️ **Capture sunlight and convert it into heat.**
- 🌬️ **Use moving air to generate electricity.**
- 💧 **Use flowing water to power a generator.**
- 🌿 **Model how biomass can produce gas.**
- 🏡 **Design a smart home that uses energy more efficiently.**

Each project is a complete engineering challenge. You will plan a system, build it, test its performance, collect evidence, solve problems, and improve your design. Your first attempt may not work perfectly. That is not failure. That is the engineering process.

YOUR RENEWABLE ENERGY MISSION

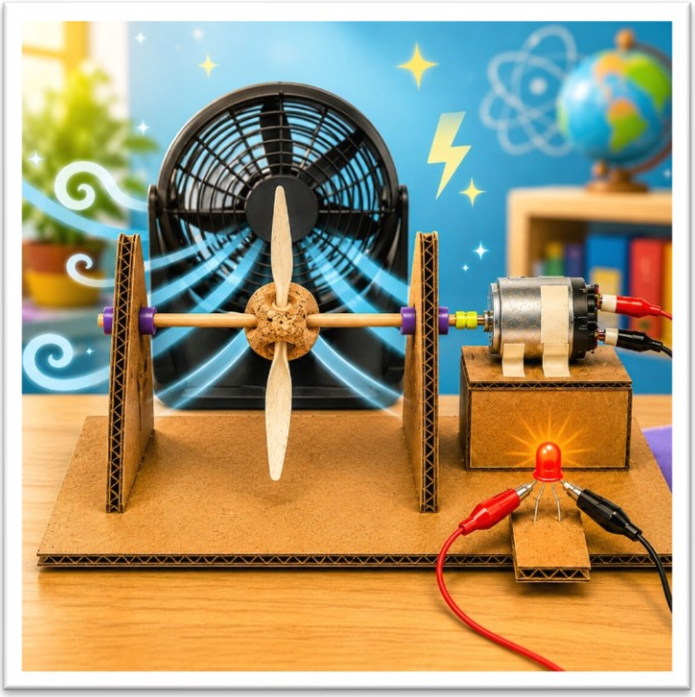
Complete all five engineering projects and discover how renewable energy can help power a cleaner future. During your mission, you will:

1. Capture Energy
Collect energy from sunlight, moving air, flowing water, and biomass.

🌬️ Build a Wind-Powered Generator System

Get ready to think like an engineer and build your own **wind-powered generator system**! In this activity, you will design and build a system that **captures** moving air (wind) **and transforms it into** electricity.

Instead of using batteries or plugging into electricity, you will use the **power of moving air to spin turbine blades and generate electrical energy**. By designing turbine blades, building a spinning system, and connecting a motor and LED, you will investigate how engineers **capture and use** renewable wind energy **to solve real-world problems**.



❓ What problem are we solving?

Imagine a world without renewable energy systems...

- 🚫 No wind-powered electricity
- 🚫 No wind farms generating clean energy
- 🚫 Greater dependence on fuels that can run out
- 🚫 More pollution from traditional energy sources
- 🚫 Fewer ways to create clean electricity
- 👉 Engineers design systems that help us use clean energy from nature.

💡 Challenge

How can we design a system that uses moving air to:

- 👉 capture wind energy
- 👉 spin turbine blades efficiently
- 👉 generate electricity
- 👉 Create the **strongest, most effective wind-powered generator possible?**

💦 Build a Hydropower Generator System



Get ready to think like an engineer and build your own hydropower generator system! In this activity, you will design and build a system that captures the energy of moving water and transforms it into electricity.

Instead of using batteries or plugging into electricity, you will use flowing water to spin a water wheel turbine and generate electrical energy. By designing turbine blades, building a spinning system, and connecting a motor and LED, you will investigate how engineers capture and use renewable water energy to solve real-world problems. When moving water pushes against the turbine blades, the wheel begins to spin. This spinning motion turns a motor, which works like a generator to produce electricity. As electricity flows through the system, it can power an **LED light**.

❓ What problem are we solving?

Imagine a world without renewable energy systems...

🚫 No hydroelectric dams generating electricity

🚫 Greater dependence on fuels that can run out

🚫 More pollution from traditional energy sources

🚫 Fewer ways to create clean electricity

🚫 Less access to renewable power from rivers and flowing water

👉 Engineers design systems that help us use **clean energy from nature**.

💡 Challenge

How can we design a system that uses moving water to:

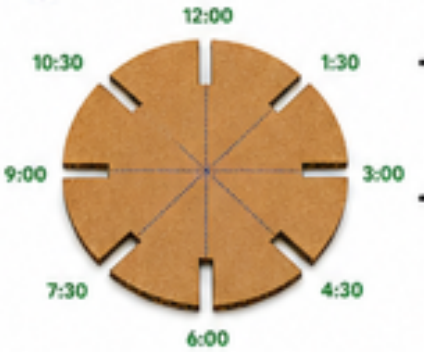
👉 capture water energy

👉 spin a turbine wheel efficiently

👉 generate electricity

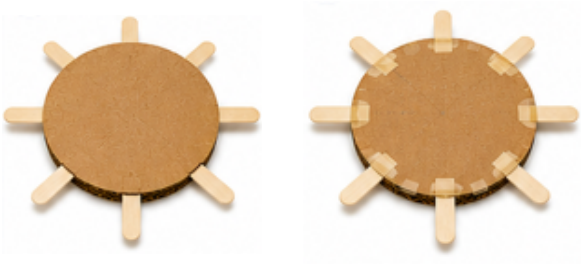
👉 and create the **strongest, most effective hydropower generator possible?**





→ Slide **8 craft sticks** into the slots to create paddles. Make sure the paddles are **evenly spaced** and stick out by a similar amount.

Make sure the paddles are inserted straight and evenly. Uneven paddles can make the wheel wobble



→ Place the **second cardboard circle on top** to trap the paddle ends between the two circles like a sandwich.

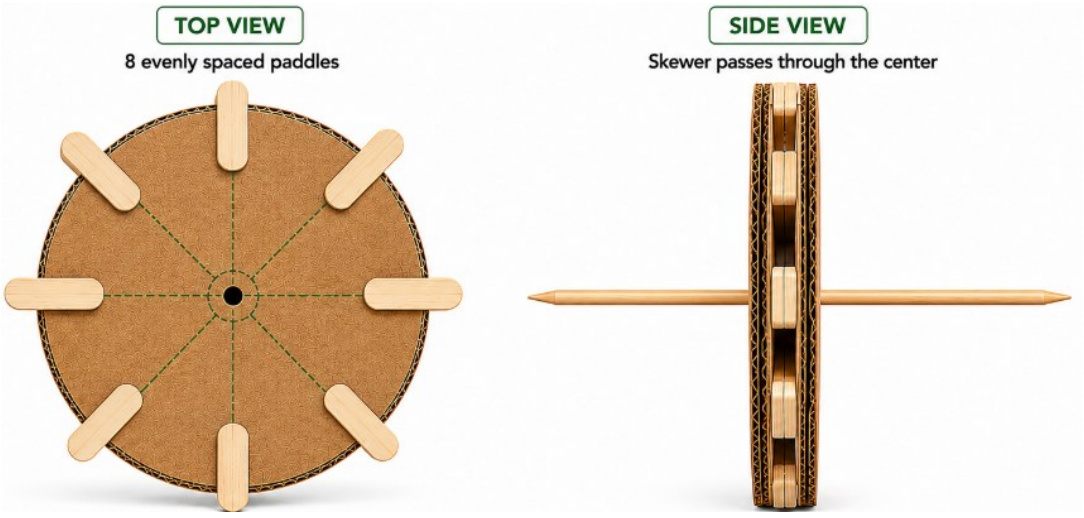
→ Tape or glue the wheel firmly so the paddles stay secure during spinning.

👉 **The paddles will catch moving water and help the wheel spin.**

● Step 2 — Add the Axle

→ Push a wooden skewer through the center of the water wheel
→ Keep the skewer as straight as possible
→ The wheel should rotate with the skewer
→ Gently spin the wheel with your fingers to test it

👉 **The axle transfers spinning motion from the wheel to the generator.**



REFLECT & EXPLAIN

① **Energy Transformation**: Which pathway correctly describes the hydropower system?

☐ A. Electricity → Water → Motion → Light
☐ B. Water → Motion → Electricity → Light
☐ C. Water → Heat → Motion → Electricity
☐ D. Motion → Water → Electricity → Light

---

② **Water-Wheel Paddles**: What is the main job of the paddles?

☐ A. Store electrical energy
☐ B. Capture moving water and rotate the wheel
☐ C. Hold the generator in place
☐ D. Measure the water volume

---

③ **Motor-Generator**: Why is the DC motor important?

☐ A. It creates the water flow
☐ B. It reduces splashing
☐ C. It converts rotation into electrical energy
☐ D. It keeps the paddles evenly spaced

---

④ **Calculate Estimated RPM**: A water wheel completes **17 rotations in 10 seconds**.

Estimated RPM = Rotations in 10 Seconds × 6

☐ A. 23 RPM ☐ B. 60 RPM ☐ C. 102 RPM ☐ D. 170 RPM

---

⑤ **Match Each Part to Its Function**: Write the correct letter beside each component.

Component	Answer	Functions
1. Water-wheel paddles		A. Shows an observable electrical response
2. Skewer axle		B. Transfers rotation from the axle to the generator shaft
3. Straw bushings		C. Captures moving water and creates rotation
4. Straw coupler		D. Converts rotational motion into electrical energy
5. DC motor-generator		E. Supports the axle while reducing friction
6. LED		F. Transfers the wheel's rotation through the system

⑥ **Fair Testing**

Which investigation is the fairest test of **paddle shape**?

☐ A. Change paddle shape and pouring height together.
☐ B. Change paddle shape while keeping all other conditions the same.
☐ C. Change paddle shape, paddle number, and water volume.
☐ D. Use a different pouring container for each design.

🌱 Build a Mini Biogas Energy System



Get ready to think like an engineer and build your own **mini biogas energy system**! In this activity, you will design and build a system that shows how organic materials can produce gas.

Instead of using batteries, sunlight, wind, or moving water, you will explore how **biomass energy** can come from once-living materials. You will use a simple mixture of warm water, sugar, and yeast inside a plastic bottle. Then, you will place a balloon over the bottle opening to collect the gas that forms. As the yeast uses the sugar, gas is produced inside the bottle. This gas moves upward and inflates the balloon. The balloon helps you see evidence of gas production, even though the gas itself is invisible.

❓ What problem are we solving?

Imagine a world without renewable energy systems...

- 🚫 More food waste sent to landfills
- 🚫 Greater dependence on fuels that can run out
- 🚫 More pollution from traditional energy sources
- 🚫 Fewer ways to create clean energy from waste
- 🚫 Less use of natural energy sources around us

👉 **Engineers design systems that help us use energy from nature and reduce waste.**

💡 Challenge

How can we design a model biomass-energy system that:

- ☑ uses a biomass food-source model;
- ☑ supports microorganism activity;
- ☑ produces visible gas;
- ☑ collects the gas safely;
- ☑ measures how much gas is collected;
- ☑ and models how real biogas systems store renewable energy?

Biomass → Microorganisms → Gas → Balloon Inflation → Stored Gas Energy

🛠️ 5. Improve Your Design

Engineers change a system, measure the results, and compare performance.

⚖️ Keep It Fair

For Levels 1 and 2, change only the named variable. Keep the following the same:

150 mL water; 1 teaspoon sugar; identical bottles and balloons; sealing method; observation time; circumference-measuring method.

👉 Build a **new bottle for every test condition**. Never reopen a sealed bottle to add ingredients.

🟢 Level 1 — Test Yeast Amount

Challenge: Test how the amount of yeast affects gas production.

Prepare three new systems:

Bottle A	Bottle B	Bottle C
½ teaspoon yeast	**1 teaspoon yeast**	**2 teaspoons yeast**

Keep the water temperature and all other conditions the same.

Measurement	½ tsp Yeast	1 tsp Yeast	2 tsp Yeast
Starting water temperature(°C)			
Circumference at 10 min (cm)			
Circumference at 20 min (cm)			
Bubbles/Foam	☐ None ☐ Some ☐ Strong	☐ None ☐ Some ☐ Strong	☐ None ☐ Some ☐ Strong
Seal quality	☐ Tight ☐ Leak	☐ Tight ☐ Leak	☐ Tight ☐ Leak

Which yeast amount produced the greatest balloon circumference after 20 minutes?

What evidence supports your conclusion?

🔧 6. Troubleshooting

🚧 Problem	🔧 What You Can Do
⚠️ Balloon does not inflate	✓ Check that the balloon is sealed tightly around the bottle opening ✓ Make sure yeast was added to the mixture ✓ Make sure sugar was added as food for the yeast
⚠️ Balloon inflates very slowly	✓ Check that the water was warm, not cold ✓ Give the system more time ✓ Make sure the yeast is fresh and active
⚠️ Balloon falls off the bottle	✓ Stretch the balloon opening before attaching it ✓ Pull the balloon farther down over the bottle mouth ✓ Use a rubber band or tape to improve the seal
⚠️ Gas leaks from the bottle opening	✓ Check for gaps around the balloon seal ✓ Press the balloon tightly around the bottle neck ✓ Use a new balloon if the first one is loose or torn
⚠️ Mixture does not bubble	✓ Check that the water is warm enough ✓ Make sure sugar and yeast were added ✓ Use fresh active dry yeast
⚠️ Mixture foams too much	✓ Do not fill the bottle too high ✓ Use less mixture next time ✓ Keep the bottle on a tray or paper towel
⚠️ Bottle tips over	✓ Use a wider or heavier bottle ✓ Place the bottle on a flat surface ✓ Keep the bottle in a tray for stability
⚠️ Balloon size is hard to measure	✓ Use the same measuring method each time ✓ Use a string around the widest part of the balloon when measuring circumference ✓ Do not squeeze the balloon
⚠️ Different tests produce different results	✓ Check that each group used the same water amount ✓ Check that each group used the same sugar amount ✓ Compare yeast amount, water temperature, seal quality, and observation time

🏠 Build an Energy-Efficient Smart Home



Get ready to think like an engineer and build your own **energy-efficient smart home model**! In this activity, you will design and build a home that uses smart design choices to **reduce energy waste**, **hold energy longer**, and **include renewable energy features**.

Your smart home will include design features such as insulated walls, sunlight-facing windows, a dark, energy-absorbing floor, an inclined solar panel on the roof/ceiling area, battery storage, a wind turbine, a biomass/biogas system, and a water collection system.

You will test your home by warming it with **direct sunlight or a small lamp**, then observing how well it holds heat as it returns to room temperature.

❓ What problem are we solving?

Imagine a world where homes waste a lot of energy...

- 🚫 Heat escapes quickly through walls and gaps
- 🚫 Homes need more electricity or fuel to stay comfortable
- 🚫 More energy comes from fossil fuels
- 🚫 More pollution is created from traditional energy sources
- 🚫 Renewable energy is not used efficiently

👉 **Engineers design homes that use energy wisely and reduce waste.**

💡 Challenge

How can we design a smart home that captures useful energy, reduces heat loss, and uses energy more wisely?

💡 System Model

👉 **Reduce Energy Waste → Capture Renewable Energy → Store/Use Energy → Build a Smarter Home**

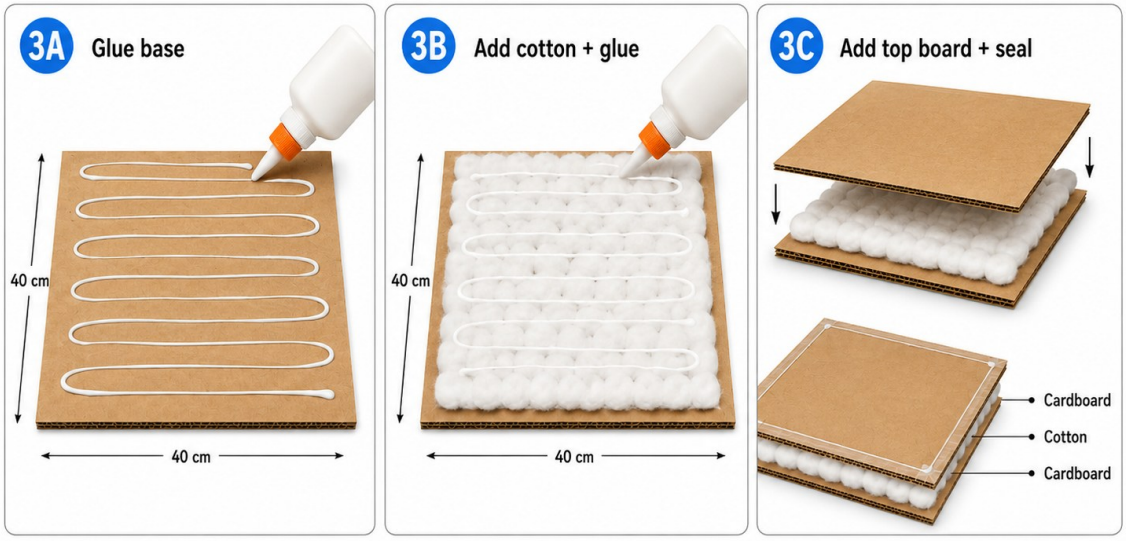
🔴 Step 3 — Build the Insulated Cardboard Sandwich

→ Take two large square cardboard boards, each at least **40 cm × 40 cm**. If available, use **42 cm × 42 cm** to allow extra cutting margin
→ Place **one cardboard board flat** on the table. This will be the **bottom board**
→ Add glue to the **bottom board**
→ Spread **cotton balls or cotton pads** across most of the board surface
→ Try to cover the board evenly, but do not make the cotton too thick
→ Leave a small space near the outer edges so the boards can be glued or taped together more easily
→ Add glue over the cotton to help hold the cotton in place
→ Place the **second 40 cm × 40 cm cardboard board** on top
→ This will be the **top board**
→ Press the two boards together gently
→ Tape or glue around the edges so the insulated sandwich stays together
→ Do **not** crush the cotton too much — the cotton should stay fluffy inside
→ Keep the full insulated board flat, because you will cut the wall panels from it in the next step

👉 This creates one large, insulated cardboard sandwich:

cardboard → cotton insulation → cardboard

👉 In the next step, you will cut the **front, back, and side wall panels** from this insulated board.

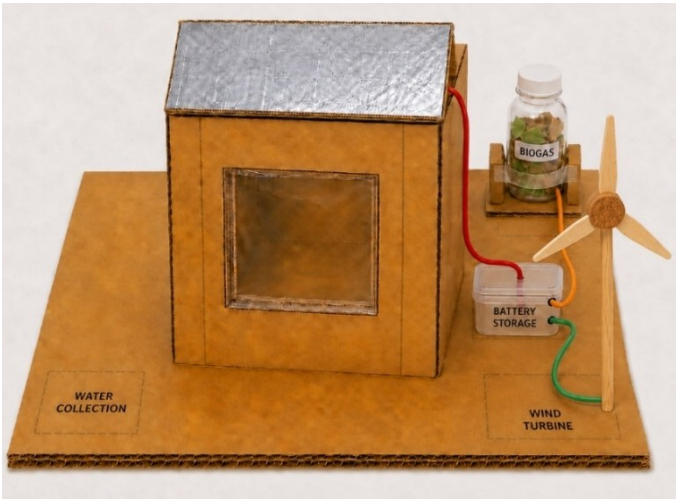


🟣 Step 4 — Cut the Insulated Wall Panels

→ Take the large, insulated **cardboard sandwich** you built in Step 3
→ Make sure it is dry enough and strong enough to cut
→ Use a ruler and pencil to mark four square wall panels

✅ Final System Check

☐ Solar panel connects to battery storage
☐ Wind turbine is stable and connects to the battery
☐ Biomass/biogas energy pathway is clearly shown
☐ Rainwater pipe leads toward the collection container
☐ All components are firmly attached
☐ No feature blocks the window, thermometer, or testing area



Your finished model now combines: **Energy Efficiency + Renewable Energy + Energy Storage + Water Management**

🔍 3. Test and Record Your Results

Engineers measure how much energy a home captures and how slowly it loses heat.

→ Place the thermometer inside the home in the same location for every reading.
→ Face the clear window toward the sunlight or lamp.
→ Keep the lamp distance and warming time the same for every test.
→ Check that the walls, window, and ceiling are sealed.

Test Condition	Record
Heat source	☐ Sunlight ☐ Lamp
Distance from lamp (cm)	
Window facing the light?	☐ Yes ☐ No
Seal condition	☐ Tight ☐ Some gaps
Warming time	10 minutes

🌡️ Measure Temperature Change

→ Record the starting temperature.
→ Warm the home for 10 minutes, record the temperature immediately after warming.
→ Remove the heat source or move the home away from it.
→ Record the temperature after 5 and 10 minutes of cooling.

Test Stage	Temperature
Starting temperature (°C / °F)	
After 10 minutes of warming (°C / °F)	
After 5 minutes of cooling (°C / °F)	

4. How It Works (Science Background)

Your smart home is a connected system: **Capture Energy → Reduce Energy Loss → Store and Manage Energy → Use Energy Wisely**

Capturing and Holding Heat

The clear window allows light to enter. The dark floor absorbs some of that light and warms the inside of the home.

Insulated walls slow heat transfer, while tight seals around the window, walls, ceiling, and base reduce air leakage.

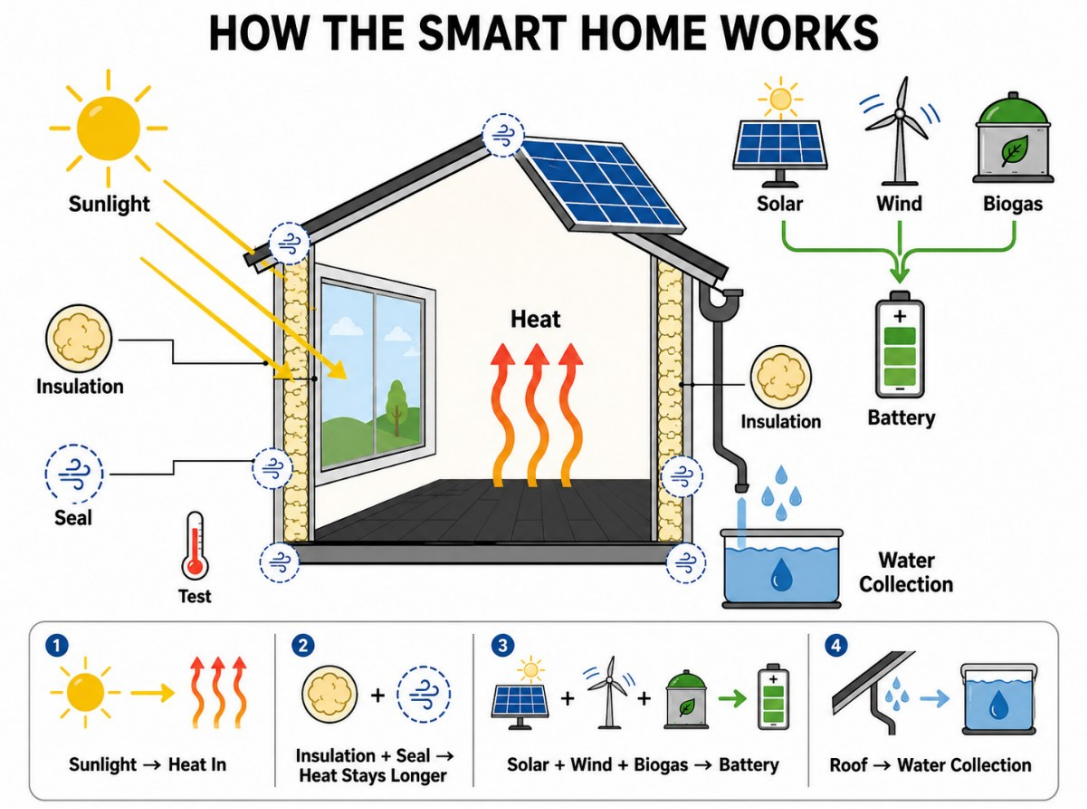
Window + Dark Floor = Heat Capture

Insulation + Sealing = Slower Heat Loss

A well-designed home should warm under the light source and cool more slowly afterward.

The Complete Energy System

Energy efficiency reduces how much energy a home needs. Renewable systems provide cleaner energy for the remaining demand.



REFLECT & EXPLAIN — ANSWER KEY

☀ ACTIVITY 1 — SOLAR OVEN SYSTEM

① **B** ② **B** ③ **B** ④ **A — 15°C**

⑤ **Matching:** 1–E 2–B 3–D 4–C 5–A

⑥ **B** ⑦ **A** (The temperature increases were 13°C, 14°C, and 14°C, so the oven produced similar results).

⑧ **Improved Oven**. It produced a **19°C increase instead of 12°C**, and the test item **softened instead of only warming**.

⑨ **Correct checks:** ✓ Adjust the reflector so sunlight reaches the black surface. ✓ Check for gaps around the plastic window.

⑩ **Suggested Response:** Sunlight strikes the aluminum foil and is redirected by reflection into the oven. The black paper absorbs the light and changes it into heat. Clear plastic allows sunlight to enter while reducing heat loss. As useful heat builds inside the oven, its temperature increases.

🌬 ACTIVITY 2 — WIND-POWERED GENERATOR

① **B** ② **B** ③ **C** ④ **C — 126 RPM**

⑤ **Matching:** 1–C 2–D 3–E 4–F 5–G 6–A 7–B

⑥ **B** ⑦ **B** (The turbine performed consistently: it completed 18, 19, and 18 rotations, and its motion remained smooth).

⑧ **Redesigned Turbine**. It produced **23 rotations instead of 16**, reached **138 RPM instead of 96 RPM**, produced a steady LED response, and rotated smoothly.

⑨ **Correct checks:** ✓ Reverse the LED connections. ✓ Check whether the motor shaft is turning.

⑩ **Suggested Response:** Wind pushes the turbine blades and creates rotation. The axle and coupler transfer that motion to the motor-generator. The motor-generator changes rotational motion into electrical energy, which travels to the LED and may cause it to light.

💧 ACTIVITY 3 — HYDROPOWER GENERATOR

① **B** ② **B** ③ **C** ④ **C — 102 RPM**

⑤ **Matching:** 1–C 2–F 3–E 4–B 5–D 6–A

⑥ **B** ⑦ **A** (The system performed consistently: it completed 15, 16, and 15 rotations, and the wheel remained smooth).

⑧ **Redesigned Paddles**
They produced **21 rotations instead of 14**, reached **126 RPM instead of 84 RPM**, produced a steady LED response, and rotated smoothly.