Name:_____ Teacher:_____

S3 Engineering Science
2 – Energy in Engineering?

#	Success Criteria	R / A / G
1	I can name different forms of energy.	
2	I can describe energy transfers in engineered systems.	
3	I can identify useful energy and wasted energy.	
4	I can draw a simple energy transfer diagram.	
5	I can calculate simple percentage efficiency.	
6	I can explain why engineers try to improve efficiency.	
7	I can describe how energy use affects cost and the environment.	
8	I can explain my ideas using what + why.	

What is Energy?

Energy is what makes things happen. Engineers think about energy whenever they design something that moves, heats up, lights up or makes a noise.

Energy is measured in joules (J). Larger amounts are measured in kilojoules (kJ) or megajoules (MJ).

Why do engineers care about energy?

- Almost every machine, vehicle or building uses energy.
- Energy costs money.
- Wasted energy can damage the environment.
- Better designs use less energy and work better.

Quick Match — Energy in everyday things

Match each object to the main form of energy it uses or produces.

Electrical **Kinetic** **Chemical** **Light** **Heat**

Sound **Elastic** **Gravitational potential**

Object / system	Main form of energy
Kettle boiling water	
Wind turbine spinning	
Battery in a phone	
LED torch shining	
Car engine running	
Speaker in a phone	
Stretched elastic band	
Skier at top of a hill	

Engineers use different forms of energy to make systems work. Here are the main ones you need to know in S3.

Energy	Simple meaning	Example
Chemical	Energy stored in fuels, food and batteries	petrol, gas, AA battery
Kinetic	Energy of movement	moving car, spinning fan
Gravitational potential	Energy stored when something is high up	ball on a shelf, water in a dam
Electrical	Energy carried by moving charge in a circuit	phone charger, plug socket
Heat	Energy that makes things hotter	kettle, oven, radiator
Light	Energy carried by light	lamp, sun, LED
Sound	Energy carried by vibrations	speaker, alarm
Elastic	Energy stored when something is stretched or squashed	elastic band, spring

Sort it — Forms of Energy

For each item below, write down **all** the relevant forms of energy.

Object	Forms of energy
moving train	
torch	
stretched bow	
hot oven	
charging phone	
loud drum	
tin of beans	
book on a high shelf	

Energy Transfers

Engineered systems take in one form of energy and change it into another. We call this an energy transfer.

Three important words:

- **Input energy** – the energy that goes into the system.
- **Useful output energy** – the energy that does the job we want.
- **Wasted energy** – energy that does NOT do the job we want (often heat or sound).

Energy Transfer Diagram

A simple energy transfer diagram looks like this:

INPUT → SYSTEM → USEFUL OUTPUT + WASTED OUTPUT

Worked example — Electric kettle

Input energy	Useful output	Wasted output
Electrical	Heat (in the water)	Heat (lost to the kitchen) and sound

Your turn — Energy Transfer Diagrams

Fill in the table for each engineered system below.

System	Input energy	Useful output	Wasted output
Phone charger			
Light bulb			
Electric motor (e.g. drone)			
Petrol car			
Wind turbine			
Loudspeaker			

Efficiency

Efficiency tells us how much of the input energy ends up as useful output energy.

A more efficient system wastes less energy.

The Efficiency Formula

efficiency = useful output energy ÷ total input energy × 100

Example

A kettle uses 200 J of electrical energy. 160 J is used to heat the water. The rest is wasted as heat and sound. Calculate the efficiency.

efficiency = useful output ÷ total input × 100

efficiency = 160 ÷ 200 × 100

efficiency = 0.8 × 100 = 80%

the kettle is 80% efficient.

A motor uses 500 J of electrical energy. 350 J is changed into useful kinetic energy.

efficiency = useful output ÷ total input × 100

efficiency = _____ ÷ _____ × 100

efficiency = _____ × 100

efficiency = _____ %

Practice — Efficiency Calculations

1. A light bulb receives 100 J of electrical energy. 60 J is changed into useful light energy. Calculate the efficiency.

2. A motor receives 500 J of electrical energy. 200 J is changed into useful kinetic energy. Calculate the efficiency.

3. A fan receives 1000 J of electrical energy. 750 J is changed into useful kinetic energy. Calculate the efficiency.

4. An electric heater receives 2000 J of electrical energy. 1600 J is changed into useful heat energy. Calculate the efficiency.

5. A machine receives 8000 J of electrical energy. 1200 J is changed into useful output energy. Calculate the efficiency.

Challenge Questions

1. An old light bulb takes in 60 J of electrical energy. Only 6 J is given out as useful light.

   (a) Calculate the efficiency.

   (b) A new LED bulb takes in 10 J and gives out 8 J of useful light. Calculate the efficiency.

   (c) Which bulb is more efficient and why? Use your numbers in your answer.

2. An engineer improves a machine.

   The original machine takes in **1000 J** and produces **400 J** of useful energy.
   The improved machine takes in **1000 J** and produces **650 J** of useful energy.

   (a) Calculate the efficiency of both machines.

   (b) How much has the efficiency increased by? Give your answer in percentage points. (e.g. 40% → 60% is an increase of 20 percentage points)

Saving Energy and Sustainability

When engineers improve efficiency, good things happen:

- less energy is wasted
- running costs go down
- less fuel is burned
- less pollution is produced
- the environment is better protected

How Engineers Improve Efficiency

Method	How it helps
Better materials	Lighter, stronger or better at conducting / insulating heat or electricity
Insulation	Stops heat being lost from buildings, ovens, pipes, etc.
Reducing friction	Smooth surfaces, bearings and oil reduce wasted heat in moving parts
Better design	Streamlined shapes, smaller engines, smarter layouts
Sensors and control systems	Switch things off when not needed (lights, heating, motors)
Using suitable energy sources	Renewables like wind, solar and hydro reduce harmful waste

Quick Task — Match the improvement

Suggest ONE engineering improvement for each problem.

Problem	Engineering improvement
A house loses lots of heat through the walls.	
A car wastes too much fuel on the motorway.	
A school leaves lights on in empty rooms.	
An old motor gets very hot and noisy.	
An office wastes heat through old single-glazed windows.	

Working Like an Engineer — Energy Audit

Aim: Work in a team to investigate a classroom, area of the school or everyday device. Find out where energy is being used, where it might be wasted and how it could be saved.

You will work like a real engineer:

1. Identify where energy is used.
2. Decide where energy is being wasted.
3. Suggest improvements.
4. Explain why your improvements would help.

Team Roles

Role	Main job
Project Manager	Keeps the team on task, manages time, leads discussion.
Energy Investigator	Looks for energy use, asks questions, makes observations.
Recorder	Writes down ideas, results and improvements clearly.
Improvement Lead	Leads the team in suggesting better designs or ideas.

Our team roles:

Project Manager	
Energy Investigator	
Recorder	
Improvement Lead	

Equipment / Materials

- Pencil and pupil booklet
- Clipboard or iPad for notes / photos
- Thermometer or simple meter (if available)
- Tape measure (optional)

Safety and Common Sense

- Do NOT touch wiring, plugs or hot equipment.
- Stay in your audit area. Do not disturb other classes.
- Move sensibly. Take photos only where you are allowed.
- Ask before opening cupboards or moving anything.

Step 1 — Plan your Audit

Audit area / device:

What questions will your team try to answer?

Step 2 — Record Where Energy is Used

List up to 6 places where energy is being used. Note what type of energy and what it is for.

#	Where? (item / location)	Form of energy	What is it being used for?
1			
2			
3			
4			
5			
6			

Step 3 — Useful and Wasted Energy

For each item, identify the useful and wasted energy.

#	Item	Useful energy	Wasted energy
1			
2			
3			
4			
5			
6			

Step 4 — Suggested Improvements

Choose your three biggest energy-wasters. Suggest an engineering improvement for each one.

#	Problem	Improvement	Why would it help?
1			
2			
3			

Step 5 — Thinking About Impact

Tick the boxes that apply for your suggested improvements.

Improvement	Lower cost	Better for environment	More comfort	Safer

Team Conclusion

As a team, write a short conclusion. Use the sentence starter.

Our audit showed that the biggest waste of energy was … We think the best engineering improvement would be … because …

Individual Reflection

Tick the statements you can do.

- I helped my team during the audit.
- I identified at least one example of wasted energy.
- I suggested at least one improvement.
- I explained one of my ideas using what + why.

One thing I did well:

One thing my team could do better next time:

Local Engineering Link — EDF Torness Power Station

EDF Torness Power Station is a large energy site near Dunbar in East Lothian. It employs many engineers from across the Borders and Lothians.

Engineers who might work at a power station

Role	Possible job
Electrical engineer	Designs and maintains generators, wiring and control panels.
Mechanical engineer	Looks after turbines, pumps and moving parts.
Control engineer	Designs and checks the systems that monitor and control the plant.
Maintenance technician	Inspects equipment and carries out repairs.
Environmental engineer	Monitors emissions, water and impact on local wildlife.
Safety engineer	Makes sure systems and procedures protect people and the environment.

Research / Discussion Questions

Use a trusted source (school iPad, careers website) to help answer these. Short notes are fine.

1. What kinds of engineers might work at a power station?

2. Why is energy efficiency important in power generation?

3. What safety and environmental issues might engineers need to think about?

4. What skills would an employer at a power station look for?

Challenge / Extension

Challenge 1 — Compare two designs

Two heaters use the same amount of electrical energy each minute (1 200 J).

- Heater A turns 900 J into useful heat in the room.
- Heater B turns 720 J into useful heat in the room.

Calculate the efficiency of each heater. Which heater would you recommend, and why?

Challenge 2 — Trade-offs

A new wind turbine design is more efficient but costs much more to build.

Discuss as a pair: should the company use this design? Think about cost, efficiency and the environment.

Challenge 3 — Sensors and Control

Suggest TWO ways that sensors or control systems could reduce wasted energy in a school. Explain each one using what + why.

Challenge 4 — Design Brief

Sketch and label a design for a more efficient version of one of:

- a classroom
- a kettle
- a school corridor

Knowledge Organiser — Energy in Engineering

Forms of energy

Form	Quick reminder
Chemical	Stored in fuels, food, batteries
Kinetic	Energy of movement
Gravitational potential	Stored when something is high up
Electrical	Carried by moving charge
Thermal / Heat	Makes things hotter
Light	Carried by light
Sound	Carried by vibrations
Elastic	Stored when stretched or squashed

Energy in a system

INPUT → USEFUL OUTPUT + WASTED OUTPUT

- Useful energy = does the job we want.
- Wasted energy = does NOT do the job (often heat or sound).

Efficiency

efficiency = useful output ÷ total input × 100

Mini example: 100 J in, 60 J useful → 60 ÷ 100 × 100 = 60% efficient.

Key words

Word	Meaning
Energy	What makes things happen. Measured in joules (J).
Transfer	When energy changes from one form to another.
Useful energy	Energy that does the job we want.
Wasted energy	Energy that does NOT do the job we want.
Efficiency	How much input energy ends up useful (as a %).

Sustainability	Using energy in a way that protects the future.
Insulation	Material that slows the loss of heat.
Friction	A force that wastes movement energy as heat.

Quick reminders

- Efficiency is always a percentage (%).
- Efficiency can never be more than 100%.
- Engineers improve efficiency to save energy, money and the environment.
- Always explain using what + why.

End of Topic Self-Check

Answer each question. Use full sentences where you can.

1. Name FOUR different forms of energy and give an example of each.

2. Describe the energy transfer in an electric kettle. Use the words input, useful and wasted.

3. A light bulb gives out useful energy and wasted energy. Identify each one.

4. A motor takes in 400 J of electrical energy. 300 J is changed into useful kinetic energy. Calculate the efficiency.

5. Engineers try to make systems more efficient. Explain ONE way they do this. Use what + why in your answer.

Well done. Update your Success Criteria R/A/G on the front page.