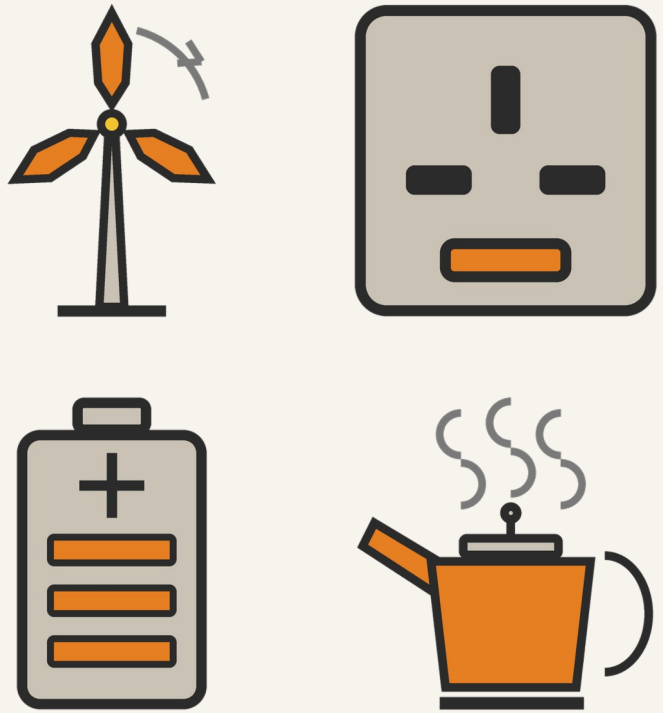
BOOKLET 2 · ENERGY AND EFFICIENCY

The Engineering Decision



Two designs, one budget. Let the numbers make the case.

National 5 Engineering Science

LEARNING INTENTION

To use efficiency calculations and other evidence to recommend an engineering choice.

Daily Review

SHOW ME BOARDS

1. A system takes in 800 J and wastes 200 J. How much is useful?
2. Now calculate the efficiency of that system.
3. A system is 40 % efficient and takes in 500 J. Find the useful output.
4. What does an energy audit show?
5. A 250 W motor runs for 1 minute. Calculate the energy transferred.

By the end of this lesson…

1. I can calculate the efficiency of two competing designs.
2. I can compare them using my own numbers, not my opinion.
3. I can give one economic and one environmental reason.
4. I can write a recommendation backed by a calculation.

Engineers Decide with Numbers

A recommendation is an argument, and the evidence is arithmetic.

CALCULATE

Work out the efficiency of every option before you say anything at all.

COMPARE

Put the figures side by side. State the difference, do not guess at it.

WEIGH IT UP

Cost to buy, cost to run, how long it lasts, how much it wastes.

RECOMMEND

One clear choice, backed by a calculation and one other reason.

The Lathe Motor Problem

The workshop needs a new motor for a small lathe. Here is the data.

	Motor A	Motor B
Input power	1 000 W	800 W
Useful output power	700 W	640 W
Cost to buy	£120	£180
Expected lifetime	5 years	10 years

Everything you need is on this table. The task starts with the efficiency of each motor.

Worked Example — Pump X

Pump X is supplied with 500 W of electrical power.

It gives out 300 W of useful power. Calculate its efficiency.

$P_{out} = 300\ W$

$P_{in} = 500\ W$

$\eta = ?$

$\eta = (P_{out} \div P_{in}) \times 100$

$\eta = (300 \div 500) \times 100$

$\eta = 60\ \%$

Worked Example — Pump Y

Pump Y is supplied with 400 W of electrical power.

It gives out 280 W of useful power. Calculate its efficiency.

$P_{out} = 280\ W$

$P_{in} = 400\ W$

$\eta = ?$

$\eta = (P_{out} \div P_{in}) \times 100$

$\eta = (280 \div 400) \times 100$

$\underline{\eta = 70\ \%}$

Writing the Recommendation

Five lines. Every one of them earns a mark.

- Lead with the numbers, never with a feeling.
- Say which design is more efficient, and by how much.
- Give one economic reason: cost to buy, run or replace.
- Give one environmental reason: less waste, less fuel burnt.
- Finish with one clear choice, in a full sentence.

Show Me — Compare

SHOW ME BOARDS

1. Motor P: 2 000 W in, 1 800 W useful. Calculate its efficiency.
2. Motor Q: 1 500 W in, 1 200 W useful. Calculate its efficiency.
3. Which motor is more efficient?
4. By how many percentage points?
5. Give one economic reason for choosing the cheaper motor.

Show Me — Compare Again

SHOW ME BOARDS

EXTRA PRACTICE

1. Lamp R: 40 W in, 34 W useful. Calculate its efficiency.
2. Lamp S: 25 W in, 20 W useful. Calculate its efficiency.
3. Which lamp is more efficient?
4. Which lamp wastes fewer watts? Careful — it is not the same answer.
5. Give one environmental reason for choosing an efficient lamp.

Task 1 — The Engineering Decision

Six questions, ending in a written recommendation.
Q1 and Q2 are the two efficiency calculations.
Q6 needs a calculation and one other reason.
14 marks in total, printed beside each question.

Booklet — “Engineering Decision Task”

Worked Example — Two Formulae, One Question

A motor draws 5 A from a 24 V supply for 40 seconds.
The motor is 75 % efficient. Calculate the useful energy output.

$V = 24\ V$

$I = 5\ A$

$t = 40\ s$

$\eta = 75\ \% = 0.75$

$E_{out} = ?$

$E_e = V\ I\ t$

$E_e = 24 \times 5 \times 40$

$E_e = 4\ 800\ J$

$E_{out} = \eta \times E_{in}$

$E_{out} = 0.75 \times 4\ 800$

$\underline{E_{out} = 3\ 600\ J}$

Task 2 — Efficiency and Energy Audits

Fourteen questions on efficiency and energy audits.
Q8 needs your answer to Q7. Q10 needs Q9.
Do them in order, SQA layout every time.
35 marks in total, printed beside each question.

Booklet — “PRACTICE: Efficiency and Audits”

Checkpoint

1. Design J: 600 W in, 480 W useful. Calculate its efficiency.

2. Design K is 90 % efficient but costs three times as much to buy.

3. What + why: which would you fit in a school workshop, and why?

Exam Practice — Past Papers

2021 Q10 — slow cooker: E_h, then E_e, then η (9)
2025 Q10(c)-(d) — lifeboat: E_p rearranged, then η (8)
SQP Q17(b)-(c) — lift: E_p, time, η, economics (11)
2025 Q12(a)-(b) — air fryer: economic impact, E_h (4)

Find the relationship in the data booklet

LOOKING AHEAD

Revision

Last lesson: prove every success criterion in the booklet.

Plenary — Prove Your I Can… Statements

SHOW ME BOARDS

1. Write the formula for percentage efficiency.
2. 600 W in, 450 W useful — calculate the efficiency.
3. Give one economic reason for choosing an efficient machine.
4. Now give one environmental reason.
5. What two things must every recommendation contain?

Plenary — More Quick Checks

SHOW ME BOARDS

EXTRA PRACTICE

1. State what η stands for.
2. 800 J in, 200 J wasted — calculate the efficiency.
3. Cheap and 50 % efficient, or dear and 90 %? Give a reason.
4. Name one thing an efficiency figure does not tell you.
5. Why must a recommendation quote a number?

Extension — If You Finish Early

1. Motor 1 takes 900 W and gives 720 W useful. Find its efficiency.

2. Motor 2 takes 600 W and gives 510 W useful. Find its efficiency.

3. What + why: Motor 1 gives more useful power. Which would you fit?

Extension — More Challenges

EXTRA PRACTICE

1. A 90 % efficient motor wastes 120 J. Calculate the input energy.

2. How much useful energy did that motor produce?

3. What + why: why does a more efficient machine often cost more to buy?

Extension — The Trade-Off

1. Machine A: £200 and 60 % efficient. Machine B: £500 and 90 %.

2. Which wastes less energy for every 1 000 J supplied, and by how much?

3. What + why: how much saving would justify the extra £300?

Extension — More Trade-Offs

EXTRA PRACTICE

1. A factory runs a 70 % efficient motor for eight hours a day.

2. Swapping to a 90 % motor cuts the input energy. What else does it cut?

3. What + why: name one cost of replacing a machine that still works.