Efficiency and energy audits

LEARNING INTENTION

We are learning to calculate efficiency and carry out an energy audit of an electronic product.

SUCCESS CRITERIA – I CAN

- ☐ calculate efficiency from energies or powers
- ☐ express efficiency as a decimal or a percentage
- ☐ complete an energy audit diagram with losses
- ☐ suggest how to improve efficiency

Efficiency

No device turns all its input energy into useful output. Some is always **lost**, usually as heat or sound.

Efficiency (η) compares the useful output with the input. It has no unit. Multiply by 100 for a percentage.

DATA BOOKLET page 4

$\eta = E_{out}/E_{in} = P_{out}/P_{in}$
efficiency

$E_e = VIt$
electrical energy

$P = E/t$
power

$P = VI$
electrical power

WORKED EXAMPLE Efficiency of a fan motor

1 GIVEN	2 FIND	3 FORMULA	4 SUBSTITUTE	5 ANSWER + UNIT
P_{in} = 60 W P_{out} (useful) = 45 W	η	$\eta = P_{out}/P_{in}$	$\eta = 45 \div 60$	**η = 0.75** = 75%

Efficiency has no unit. It can never be more than 1 (100%).

SHORT CIRCUIT

× WHAT EXAMINERS SAW

Efficiency answers above 1 (or 100%), usually from dividing input by output.

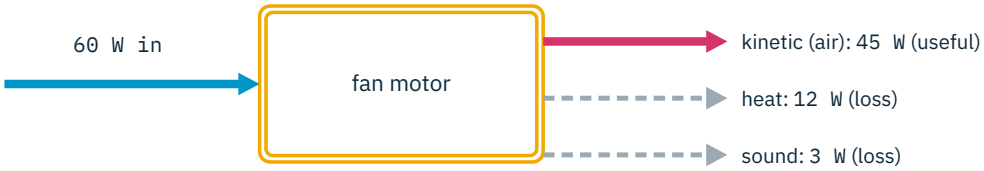
✓ THE FIX

Efficiency = useful OUTPUT ÷ INPUT. Sense check: it must be less than 1 (less than 100%).

Common error in efficiency calculations.

Efficiency and energy audits

Energy audits



Energy audit for a 60 W fan motor

An **energy audit** shows where every joule (or watt) goes. The **law of conservation of energy** says energy cannot be created or destroyed, so the outputs add up to the input.

WORKED EXAMPLE **Energy audit: missing loss**

1 GIVEN	2 FIND	3 FORMULA	4 SUBSTITUTE	5 ANSWER + UNIT
E_{in} = 2000 J light = 400 J sound = 50 J	heat loss	E_{in} = sum of outputs (conservation of energy)	2000 = 400 + 50 + heat heat = 2000 − 450	**heat = 1550 J**

Energy is never destroyed: every joule in must come out as something.

SHORT CIRCUIT

× WHAT EXAMINERS SAW

Energy audits that listed the losses but did not make the energies add up to the input.

✓ THE FIX

Conservation of energy: E_{in} = useful E_{out} + all the losses. Check the sum before you finish.

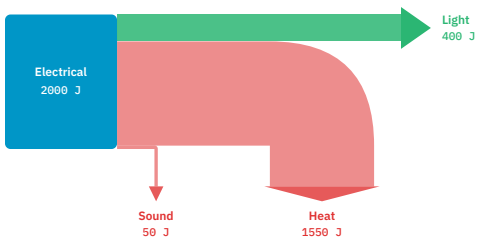
Spec: law of conservation of energy; energy audits.

Overall efficiency

When devices are joined in a chain, multiply their efficiencies: a 0.9 efficient charger feeding a 0.8 efficient motor gives 0.9 × 0.8 = 0.72 overall (72%).

Efficiency and energy audits

Energy audits as a flow diagram



Lamp: 2000 J in, 400 J light out

The width of each band shows how much energy goes that way. Useful output goes straight on. Wasted energy turns away.

All the outputs add up to the input: energy is conserved.

EFFICIENCY IN FOUR STEPS

1	2	3	4
E_{in} = 2000 J	light 400 J	400/2000 × 100	η = 20 %
Input energy	Useful output	Divide and × 100	Efficiency (no unit except %)

WORKED EXAMPLE Efficiency from energies

1 GIVEN	2 FIND	3 FORMULA	4 SUBSTITUTE	5 ANSWER + UNIT
E_{in} = 2000 J useful light = 400 J	η	$\eta = E_{out}/E_{in} \times 100$	$\eta = 400/2000 \times 100$	**20 %**

WORKED EXAMPLE Useful output from efficiency

1 GIVEN	2 FIND	3 FORMULA	4 SUBSTITUTE	5 ANSWER + UNIT
P_{in} = 500 W η = 80 %	useful P_{out}	$P_{out} = \eta \times P_{in}$	$P_{out} = 0.8 \times 500$	**400 W**

Efficiency and energy audits

WRONG

$$\eta = 2000/400 = 5$$

Upside down: efficiency can never be more than 100 %.

RIGHT

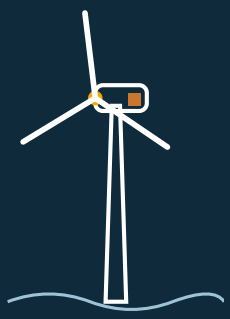
$$\eta = 400/2000 \times 100 = 20\ \%$$

Useful output over input.

REAL ENGINEERING · FIRTHWIND ENERGY TURBINE

A Firthwind (fictional) turbine nacelle loses energy in the gearbox (heat) and generator. Engineers audit each stage.

Better cooling and lubrication raise efficiency, so more of the wind's energy reaches the grid and less fossil-fuel generation is needed.



PROBE · QUICK CHECKS

1. Unit of efficiency? _____
2. P_{in} = 100 W, P_{out} = 80 W. η? _____
3. Can efficiency be 120%? _____

EXAM READY · 8 MARKS

1 An LED lamp takes in 3.0 W and gives out 2.4 W of light. **Calculate** its efficiency. [2]

2 A hair dryer is 90% efficient and has an input power of 2.0 kW. **Calculate** its useful output power. **[2]**

3 A motor takes in 500 J. It gives 400 J of kinetic energy and 30 J of sound. **Calculate** the heat lost. **[2]**

4 **Explain** one way to increase the efficiency of a motor. **[2]**