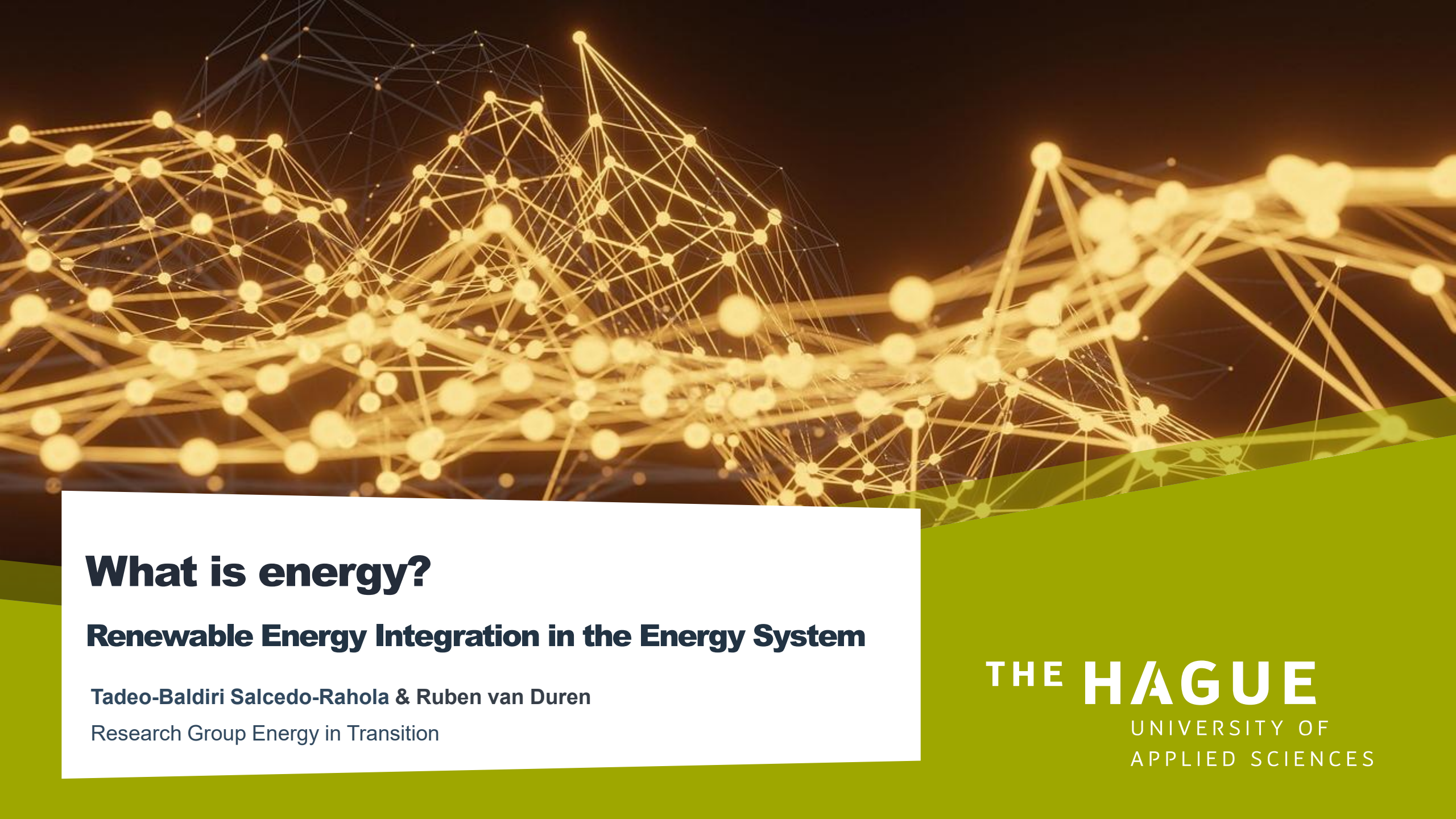




What is energy?

Renewable Energy Integration in the Energy System

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What is energy?

Energy is the ability to do work.

Energy is the capacity of a system to produce heat, radiation, motion, or matter.

Energy is everything



Energy forms

Potential energy

Chemical energy

Mechanical energy

Nuclear energy

Gravitational energy

Kinetic energy

Radiant energy

Thermal energy

Motion energy

Sound energy

Electrical energy



Chemical energy



Chemical energy



Mechanical energy



Nuclear energy



Gravitational energy



Radiant energy



Thermal energy



Motion energy



Sound energy



Electrical energy



Energy forms

Chemical energy

$$E = m \cdot H_0$$

Gravitational energy

$$E = m \cdot g \cdot H$$

Nuclear energy

$$E = m \cdot c^2$$

Thermal energy

$$E = m \cdot c_p \cdot \Delta T$$

Motion energy

$$E = \frac{1}{2} \cdot m \cdot v^2$$



Energy units

Joule [J]

Calorie [cal]

$$1 \text{ [cal]} = 4.184 \text{ [J]}$$

Kilowatt hour [kWh]

$$1 \text{ [kWh]} = 3.6 \text{ [MJ]}$$

Cubic meter of gas [m³ gas]

$$1 \text{ [m}^3 \text{ gas]} = 35.17 \text{ [MJ]} = 9.76 \text{ [kWh]}$$

Tonne of oil equivalent [toe]

$$1 \text{ [toe]} = 41.8 \text{ [GJ]}$$



Unit prefix

10^n	Prefix	Symbol	Name	Decimal equivalent
10^{15}	peta	P	billiard	1000 000 000 000 000
10^{12}	tera	T	billion	1000 000 000 000
10^9	giga	G	milliard	1000 000 000
10^6	mega	M	million	1 000 000
10^3	kilo	k	thousand	1 000



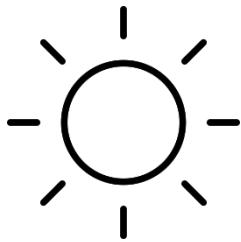
Energy sources



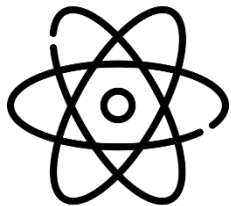
Geothermal heat



Tidal movement



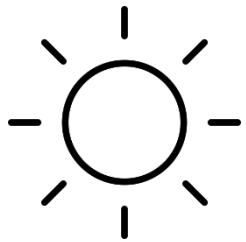
Sunlight



Atom nucleus splitting heat



Energy sources



Sunlight

Sunlight

Earth's surface and
atmosphere heat

Wind

Evaporation and
precipitation

Biomass

Fossil fuels

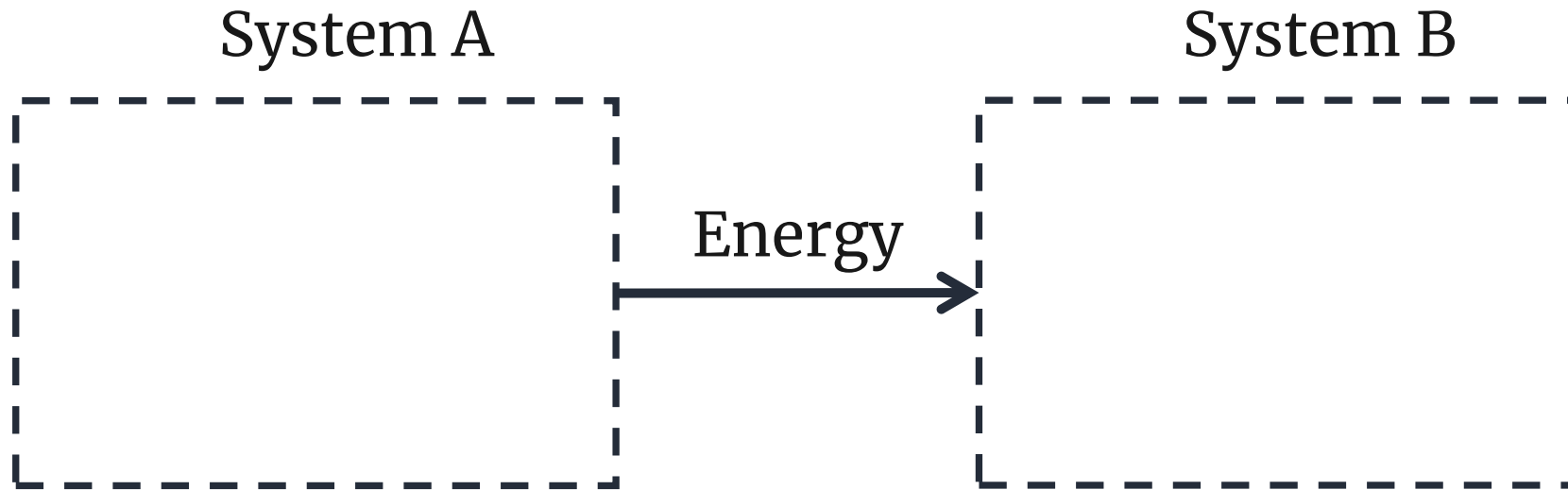
Conservation of Energy

“Energy can neither be created nor destroyed; energy can only be transferred from one place to another, or converted from one form to another.”

Law of conservation of energy, also known as first law of thermodynamics

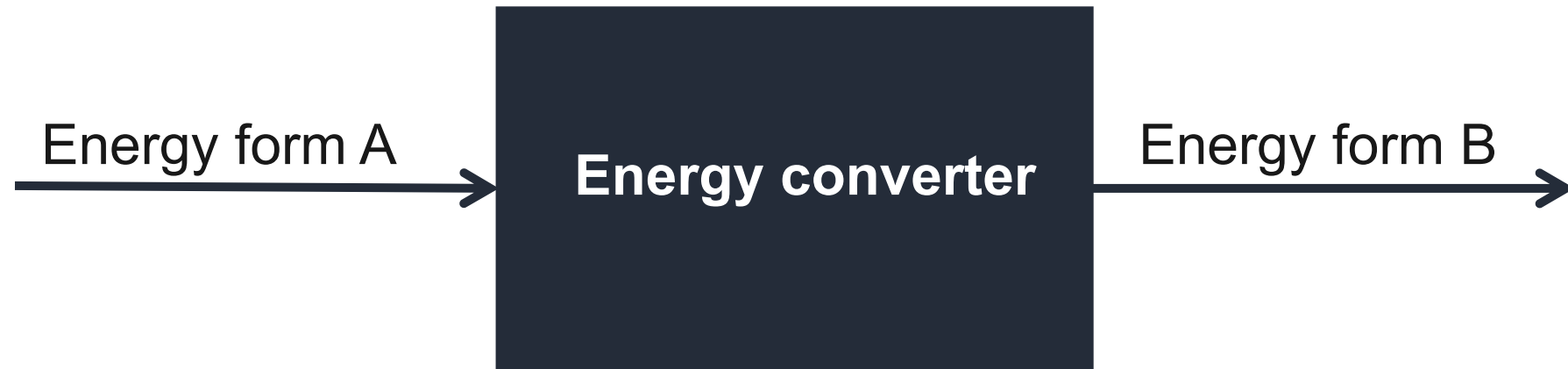


Energy transfer





Energy conversion



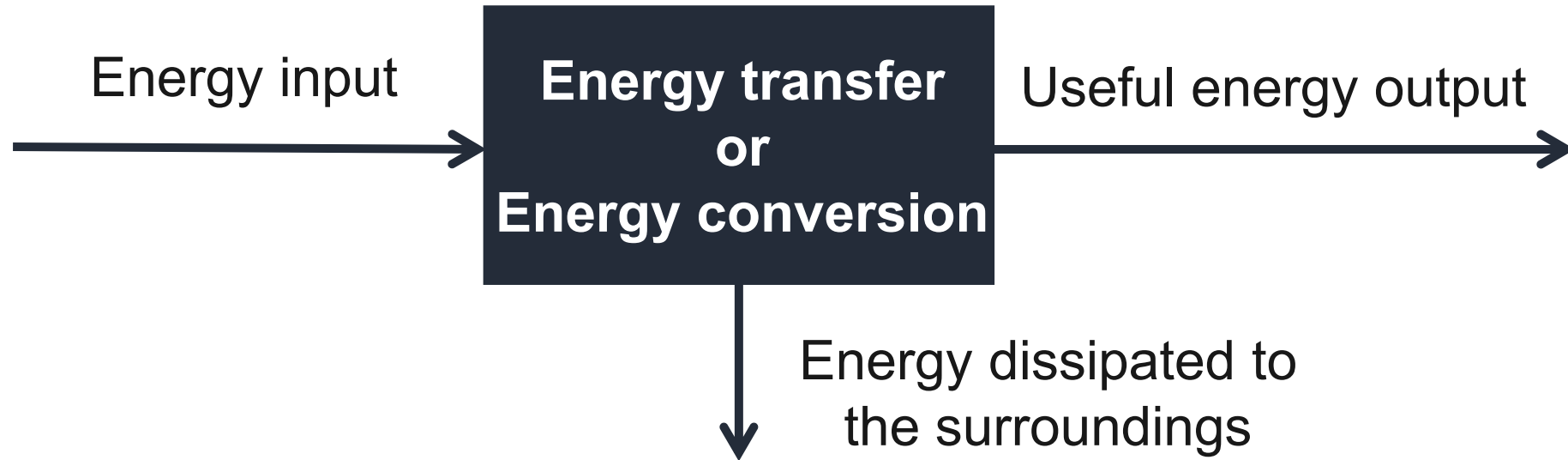


Energy converter examples

Input	Converter	Output
Chemical energy	Human Body	Motion energy
Chemical energy	Combustion engine	Motion energy
Chemical energy	Gas boiler	Thermal energy
Electrical energy	Electric boiler	Thermal energy
Wind energy	Wind turbine	Electrical energy
Solar energy	PV panel	Electrical energy



Energy efficiency



$$\eta = \text{efficiency} = \frac{\text{useful energy output}}{\text{energy input}}$$

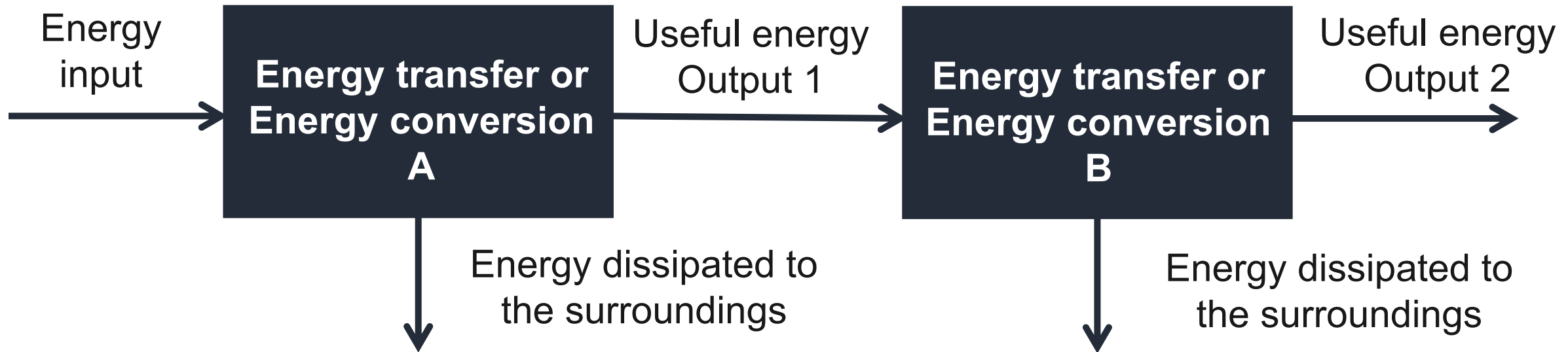


Energy converter efficiency

Converter	Average efficiency
Human Body	25%
Combustion engine	20%
Gas boiler	92%
Electric boiler	99%
Wind turbine	30%
PV panel	18%



Energy efficiency



$$\text{useful energy output 2} = \text{energy input} \cdot \eta_A \cdot \eta_B$$



Energy vs. Power

$$Power[W] = \frac{Energy[J]}{time[s]}$$



$$P_{light_bulb} = 100[W]$$

$$t = 3600[s] = 1[h]$$

$$E = P \times t = 100 \times 3600 = \mathbf{360000 [J]} = 100[Wh] = 0,1[kWh]$$



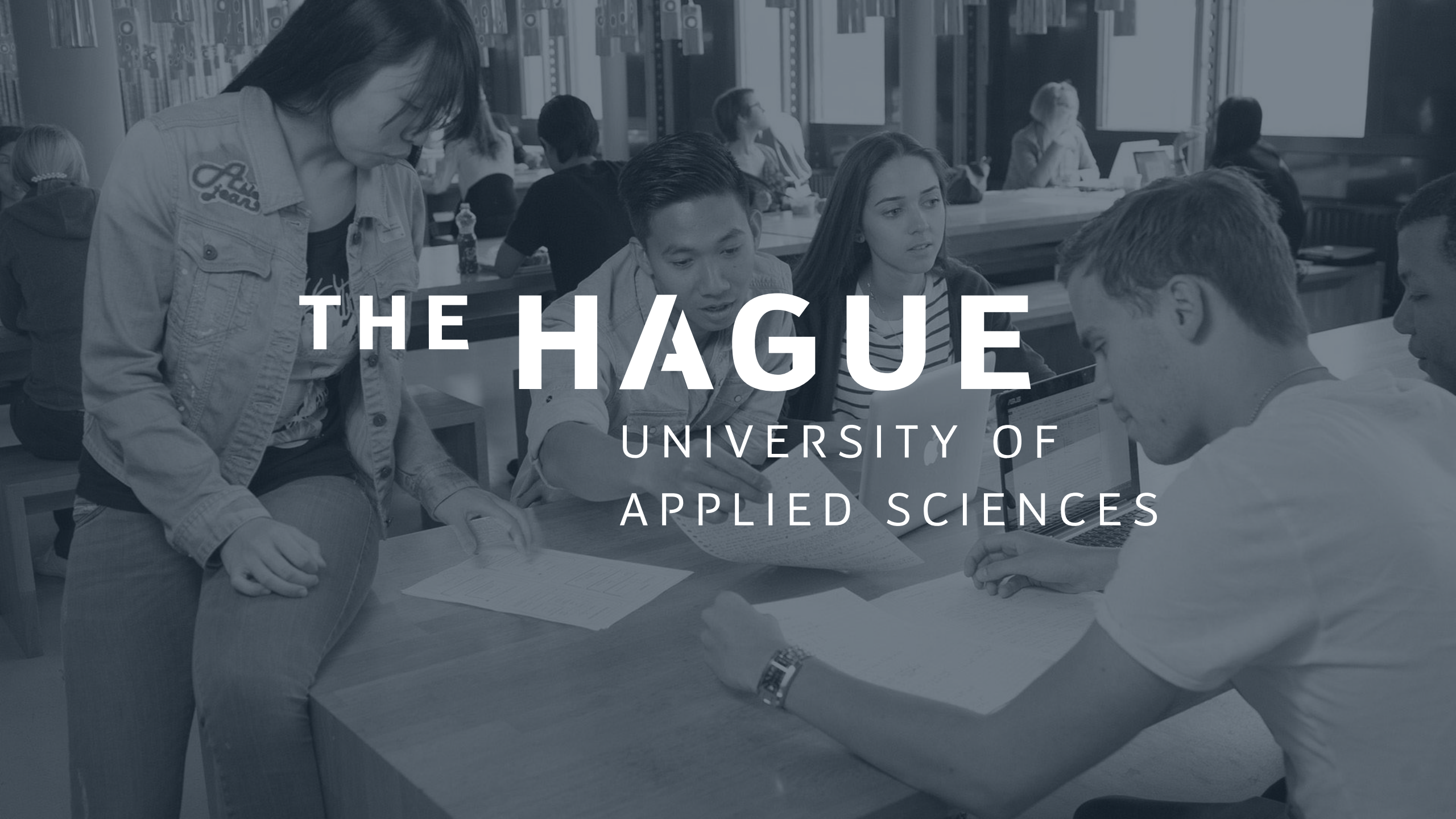
Power units

Watt [W]

Horse power [hp]

$$1 \text{ [hp]} = 745,7 \text{ [W]}$$



A grayscale photograph of a classroom or study hall. In the foreground, a group of four students are gathered around a table, looking at papers and a laptop. A young woman on the left is leaning over the table, pointing at a document. A young man next to her is also looking at the papers. Behind them, another young woman is looking at a laptop. To the right, a young man is sitting at the table, looking at a laptop. In the background, other students are visible, some sitting at tables and others standing. The room has large windows and a modern, open-plan design.

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Content references

[What is energy?](#) U.S. Energy Information administration

Books

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Ouwehand, J., Trynke, P., Gilijamse, W., Geus, J. de (2017) Duurzame energietechniek, Boom, Amsterdam.

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