



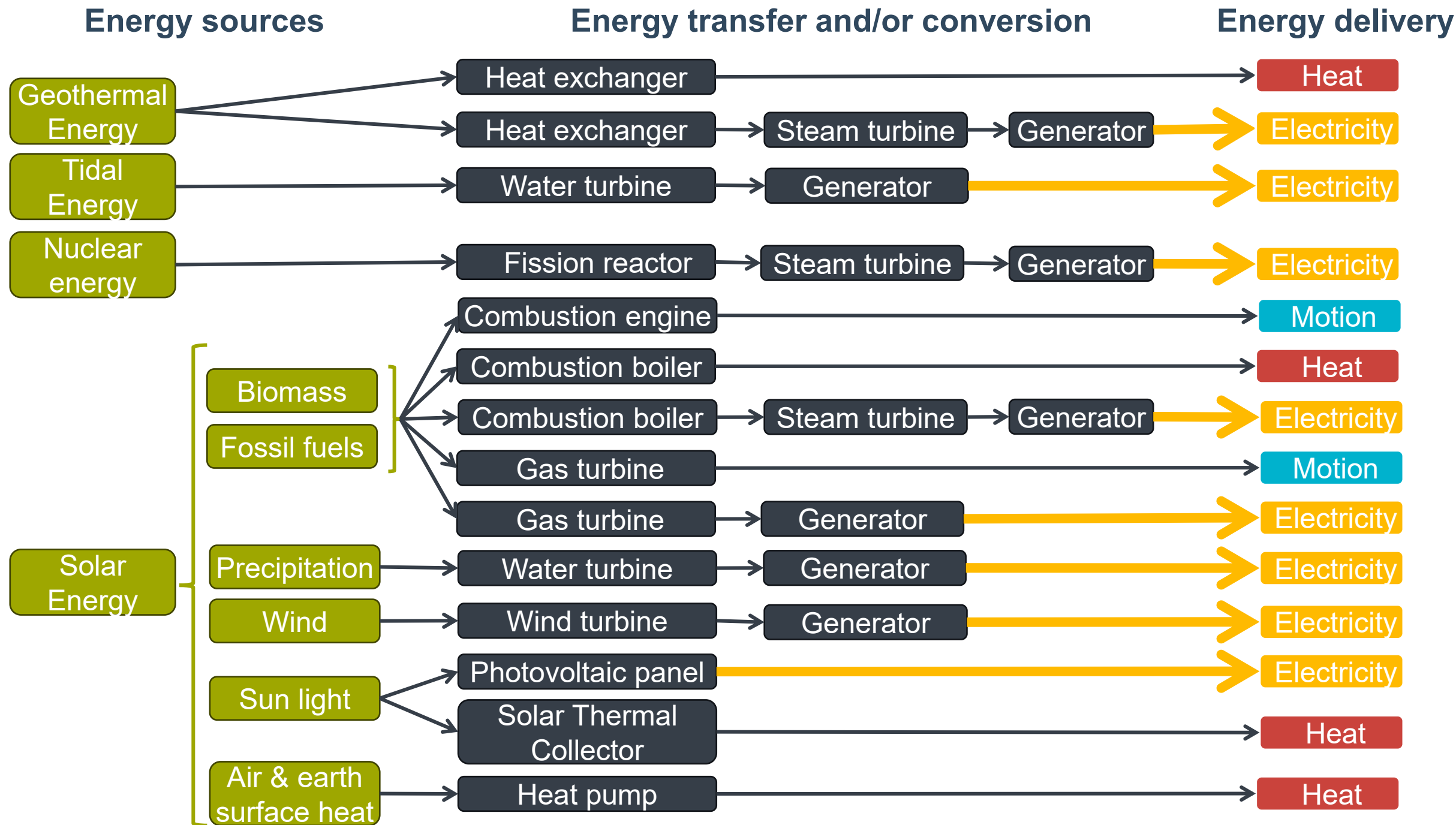
Electricity Delivery

Renewable Energy Integration in the Energy System

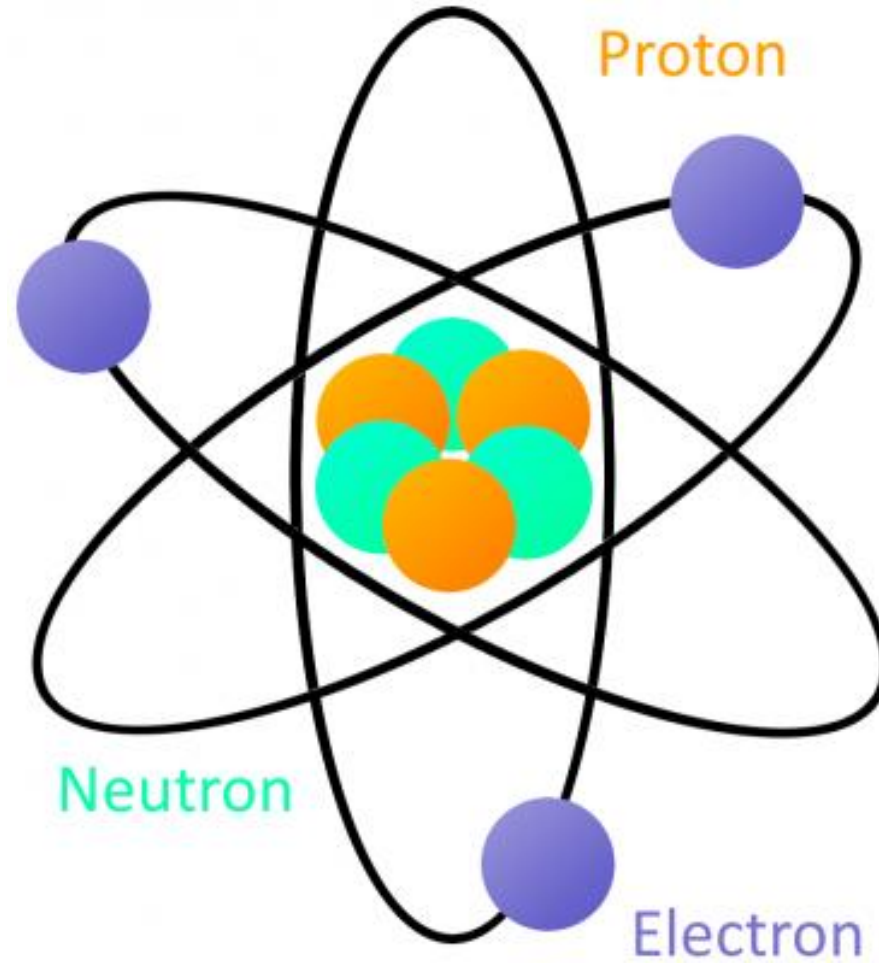
Tadeo-Baldiri Salcedo-Rahola & Ruben van Duren

Research Group Energy in Transition

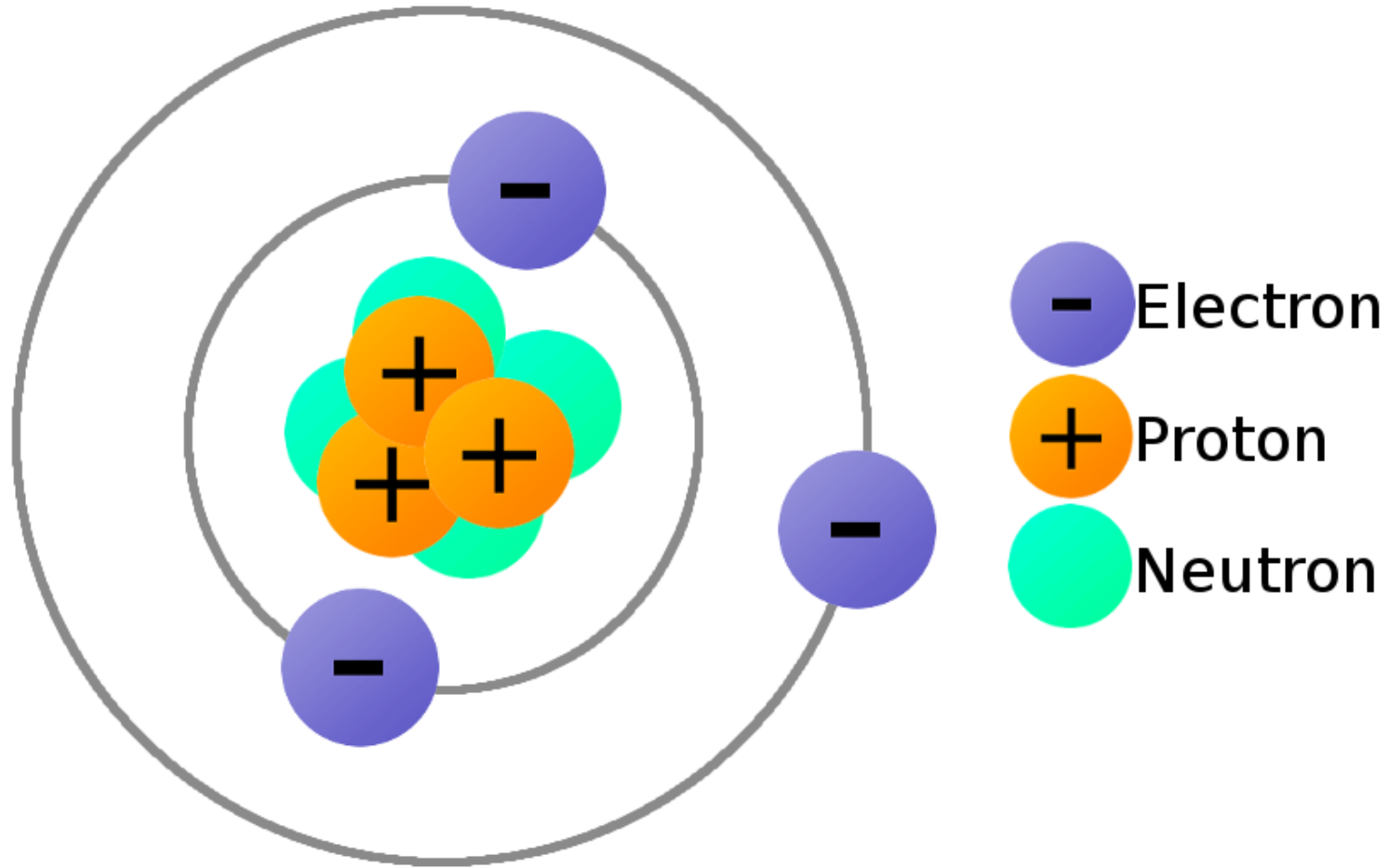
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What is electricity?

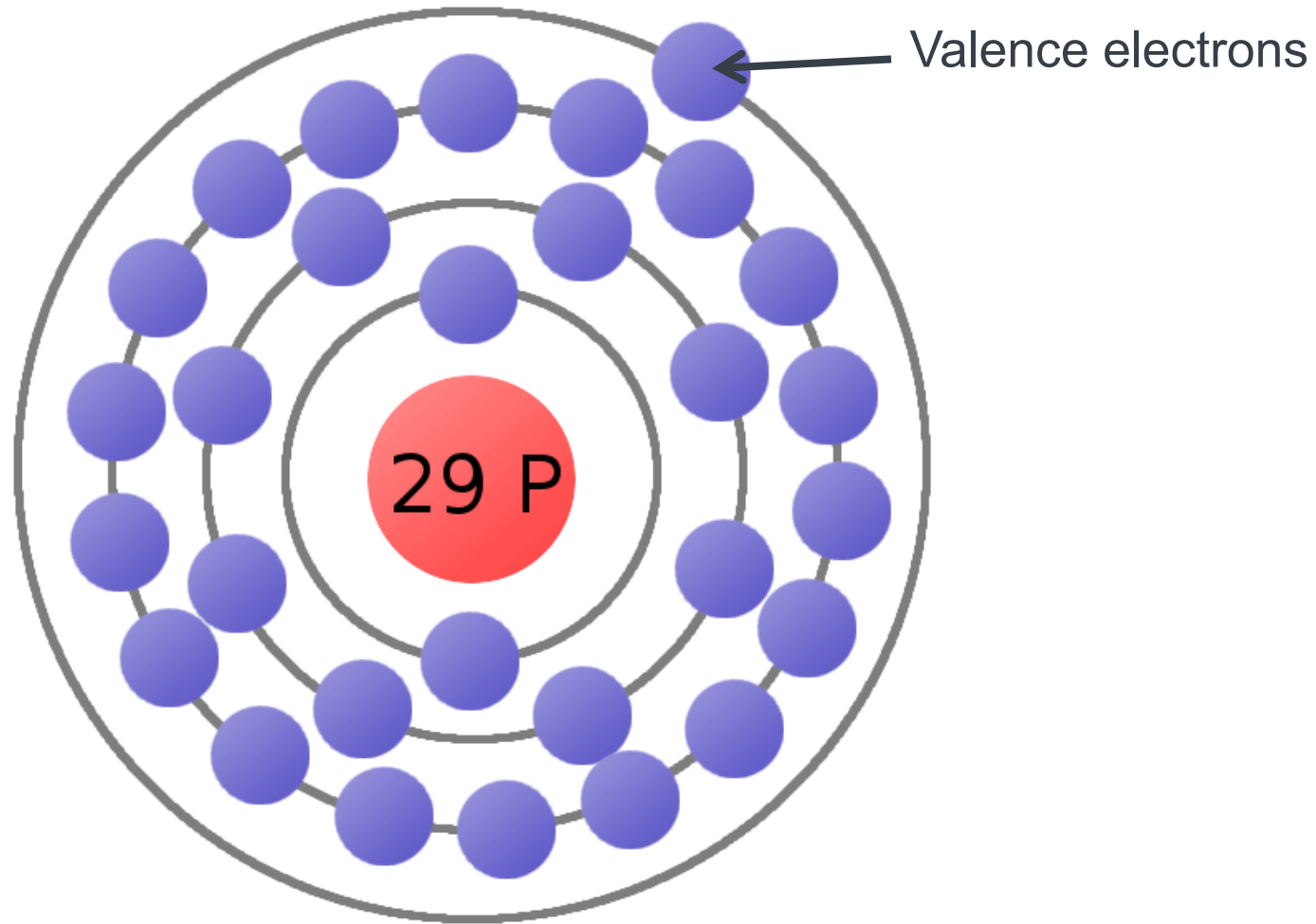


What is electricity?

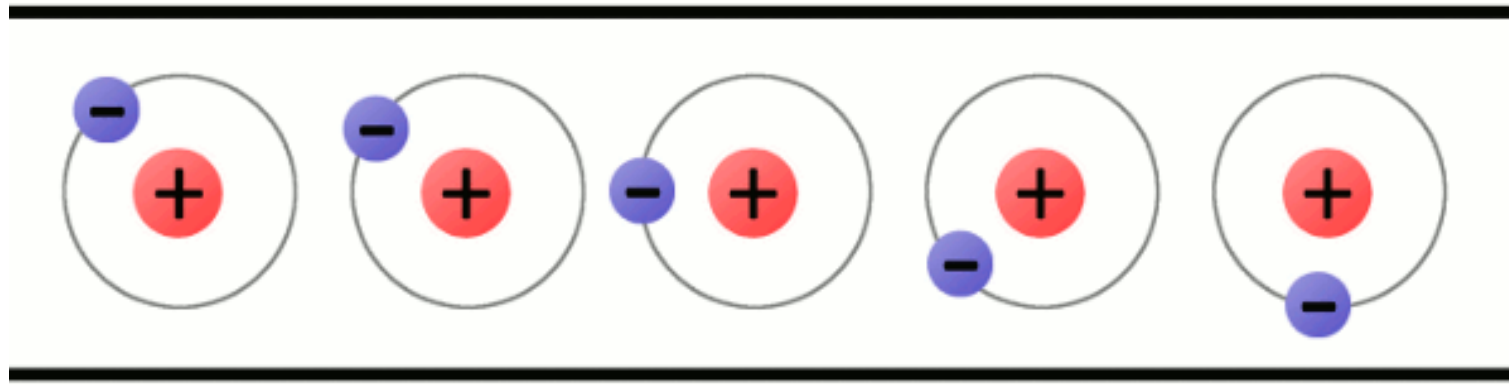


What is electricity?

Copper atom



What is electricity?



Electric conduction and insulation

Electric conductor

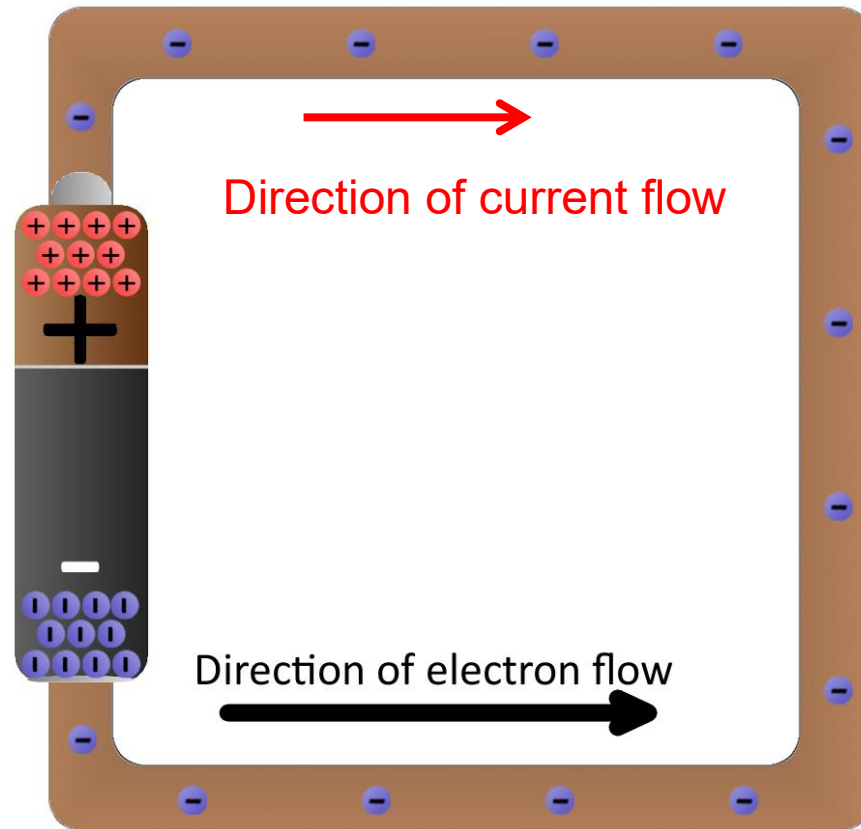
- Silver
- Gold
- Copper
- Aluminum

Electric insulator

- PVC
- Glass
- Air
- Ceramic

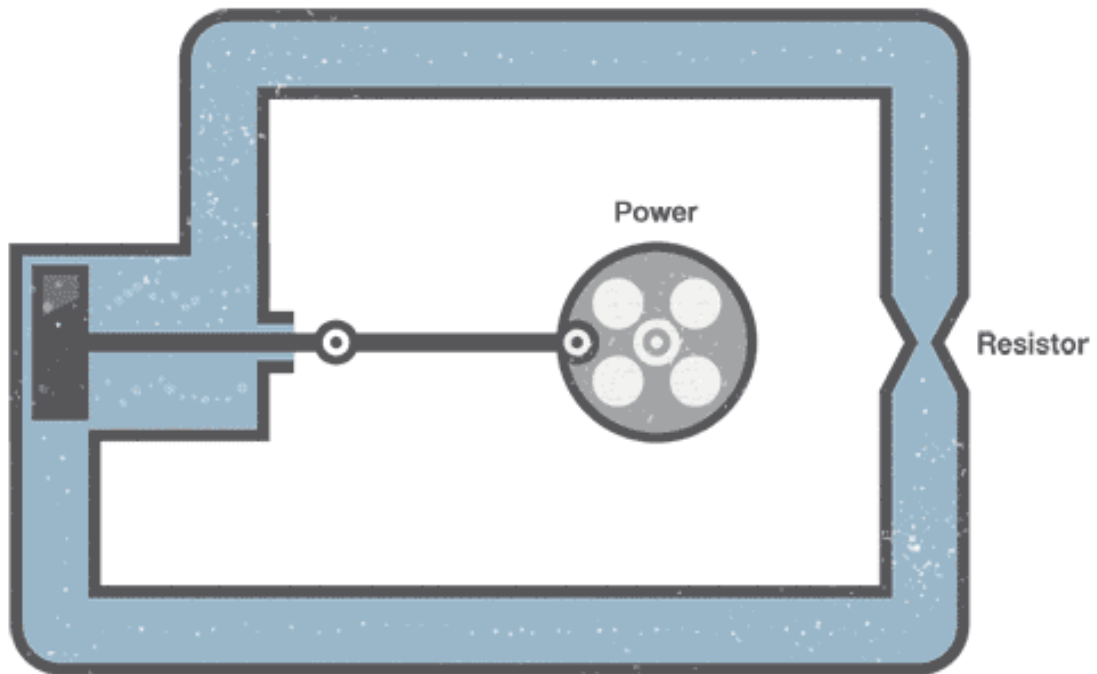
Electric current

Electric current needs a circuit: a closed, never-ending loop of conductive material.



AC / DC (Alternate current/Direct current)

Alternating Current: The Water Analogy



Direct Current



Ohm law

The voltage is the difference in charge between two points.

The current is the speed at which the load flows.

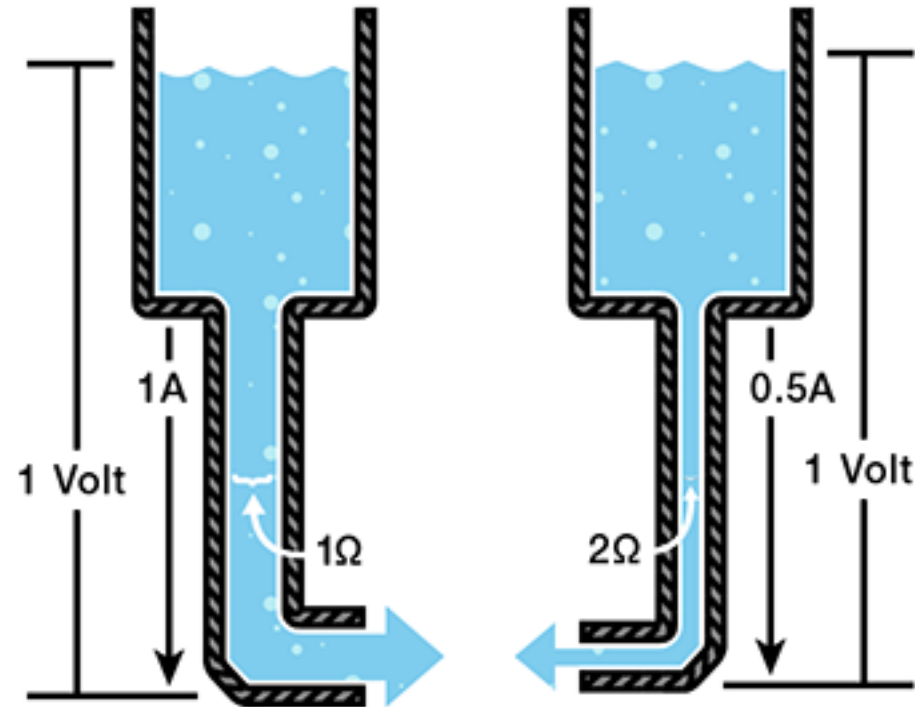
The resistance is the tendency of a material to resist the electric current.

$$V = I \times R$$

$V = \text{Voltage}[V]$

$I = \text{Current}[A]$

$R = \text{Resistance}[\Omega]$



Electric power

$$P = V \times I$$

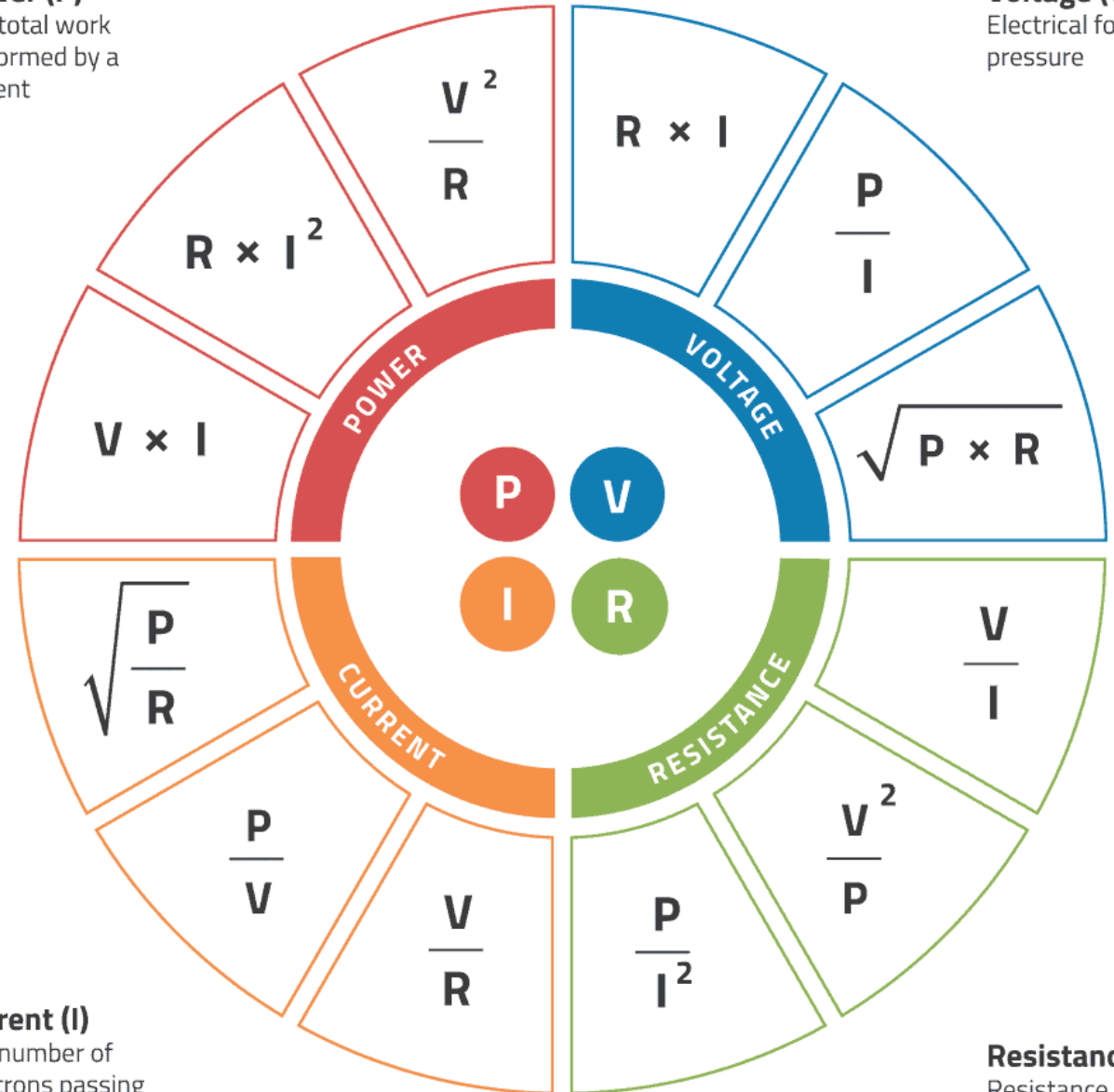
$$P = \text{Power}[W]$$

$$V = \text{Voltage}[V]$$

$$I = \text{Current}[A]$$

Power (P)
The total work
performed by a
current

Voltage (V)
Electrical force or
pressure



Current (I)
The number of
electrons passing
in a single point

Resistance (R)
Resistance to the
flow of current

Voltage



5V



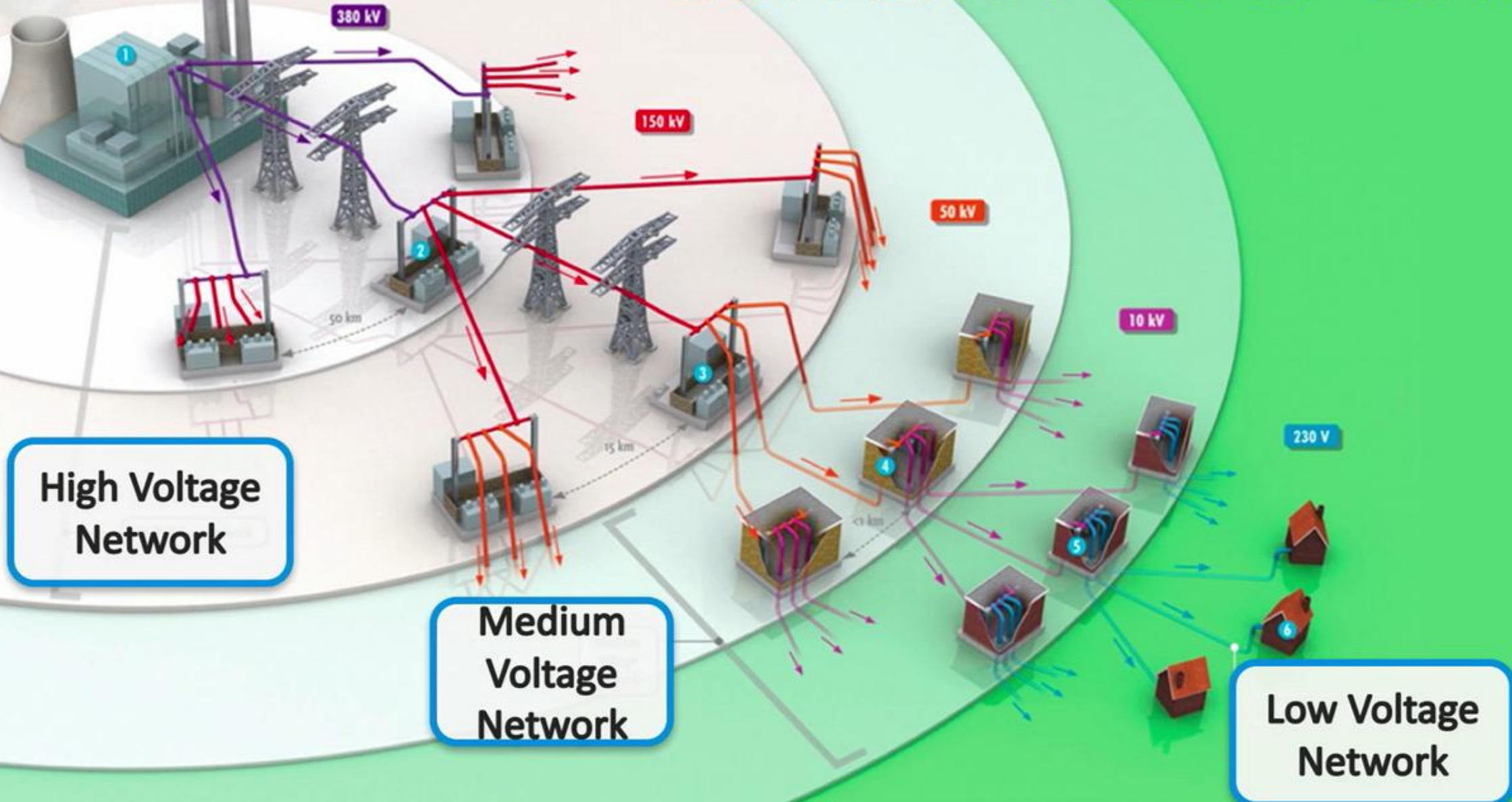
19,5V



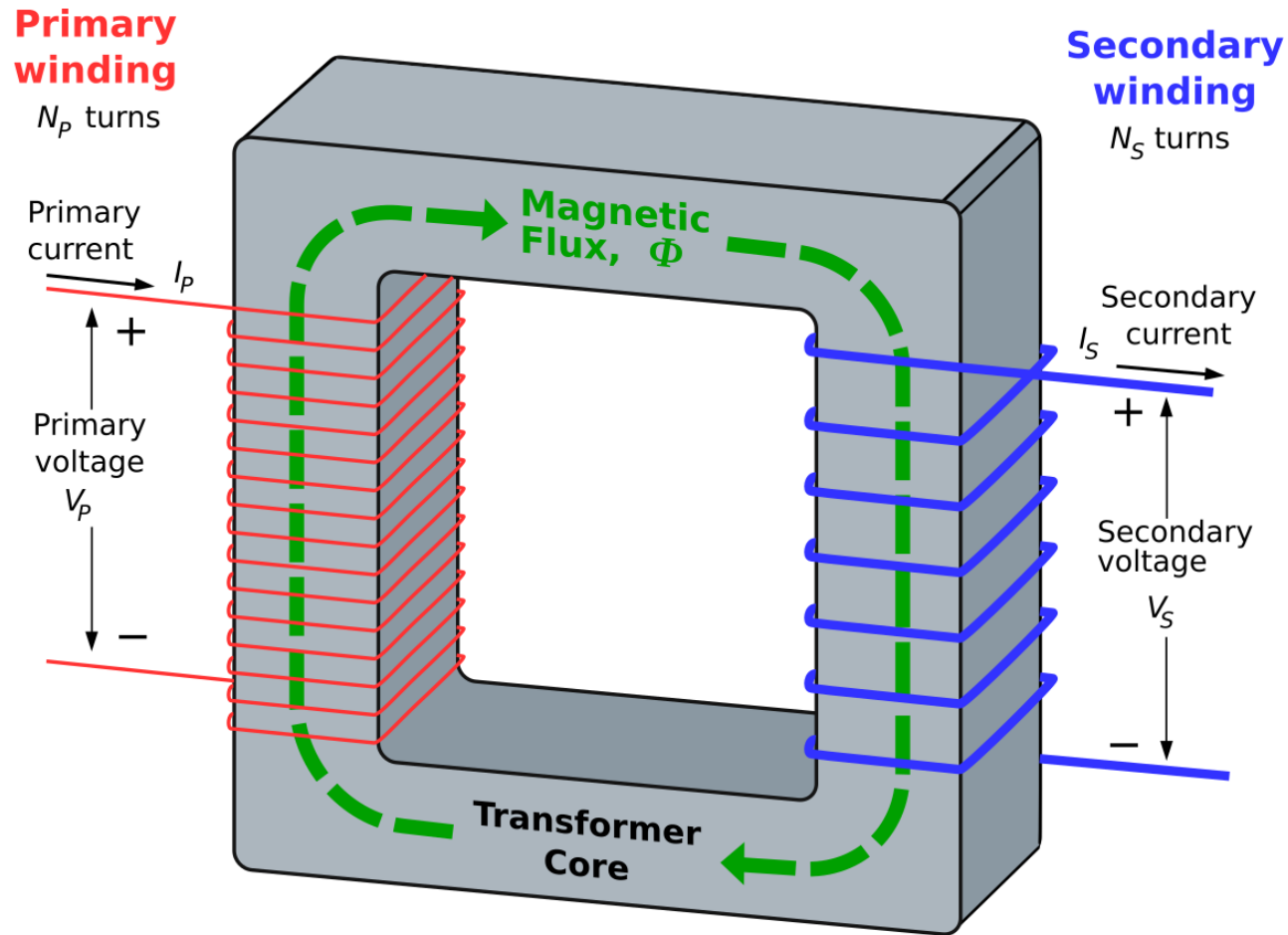
12V or 24V

Voltage

Current Power Grid

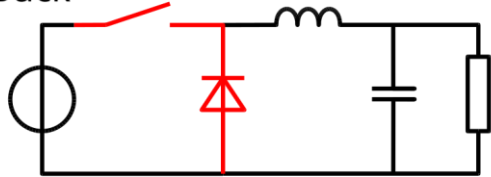


AC Transformer

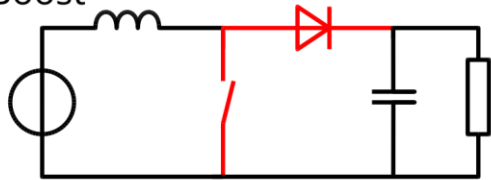


DC-to-DC converter

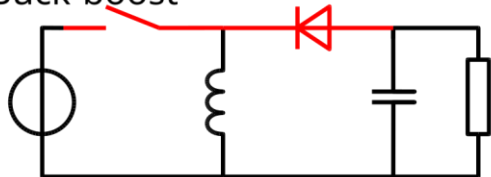
Buck



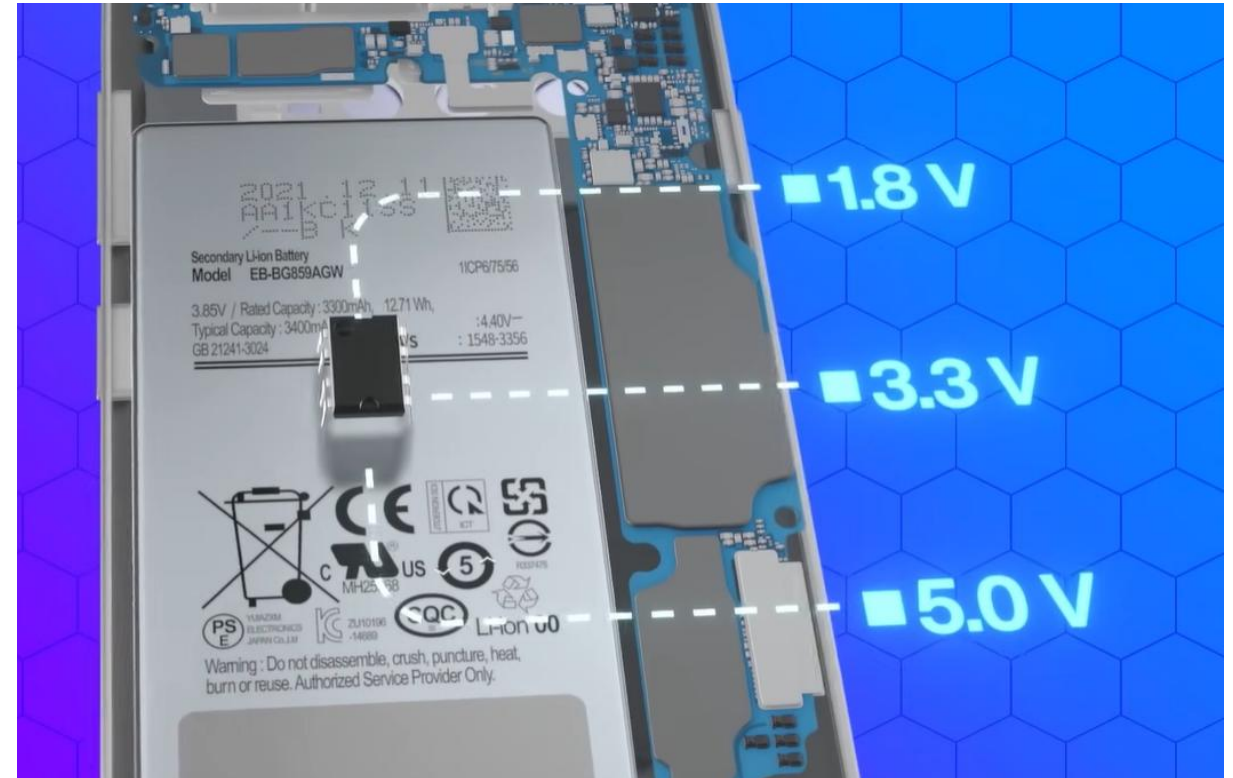
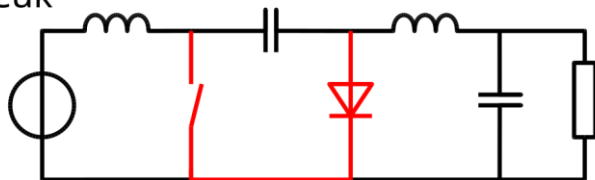
Boost



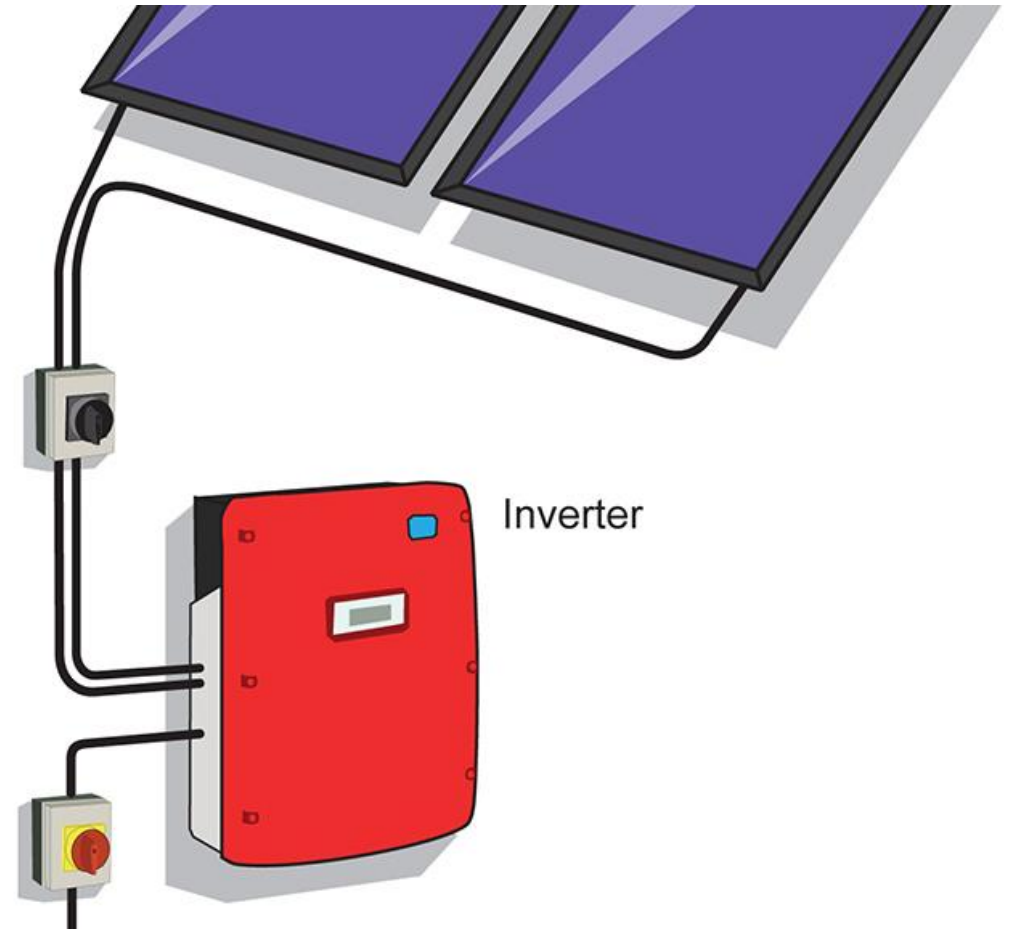
Buck-boost



Cuk

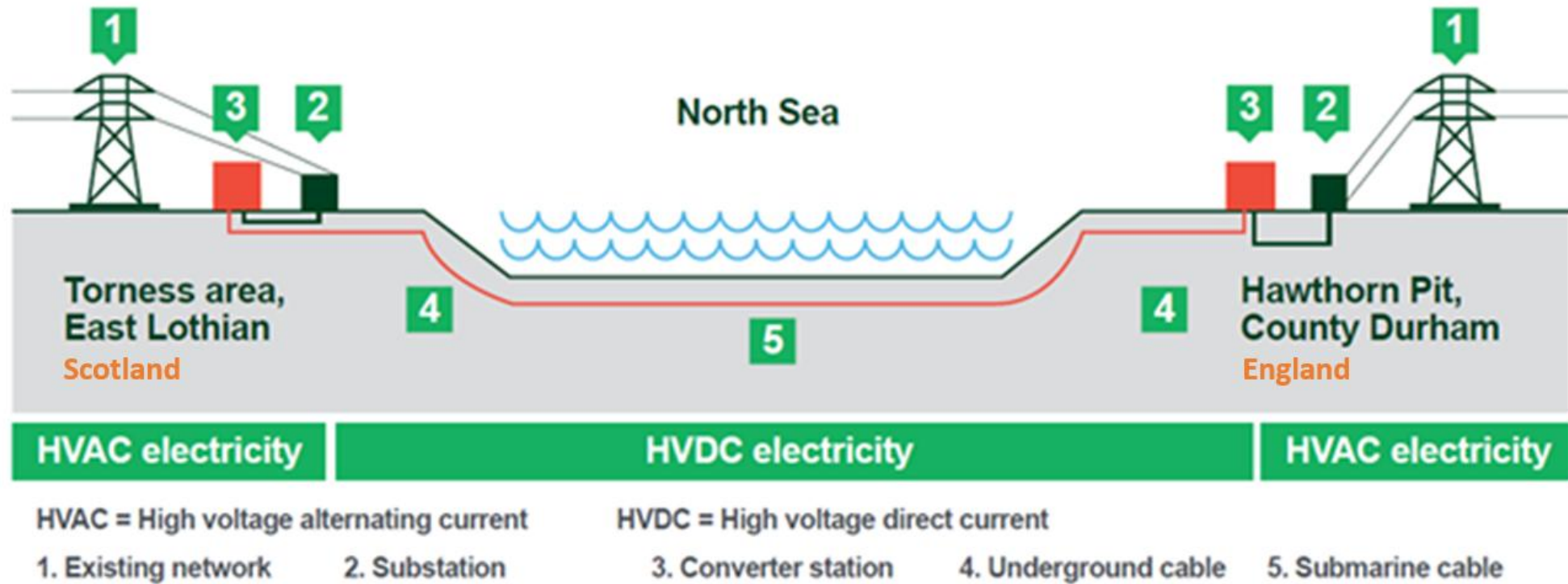


AC-to-DC Converter / DC-to-AC Inverter

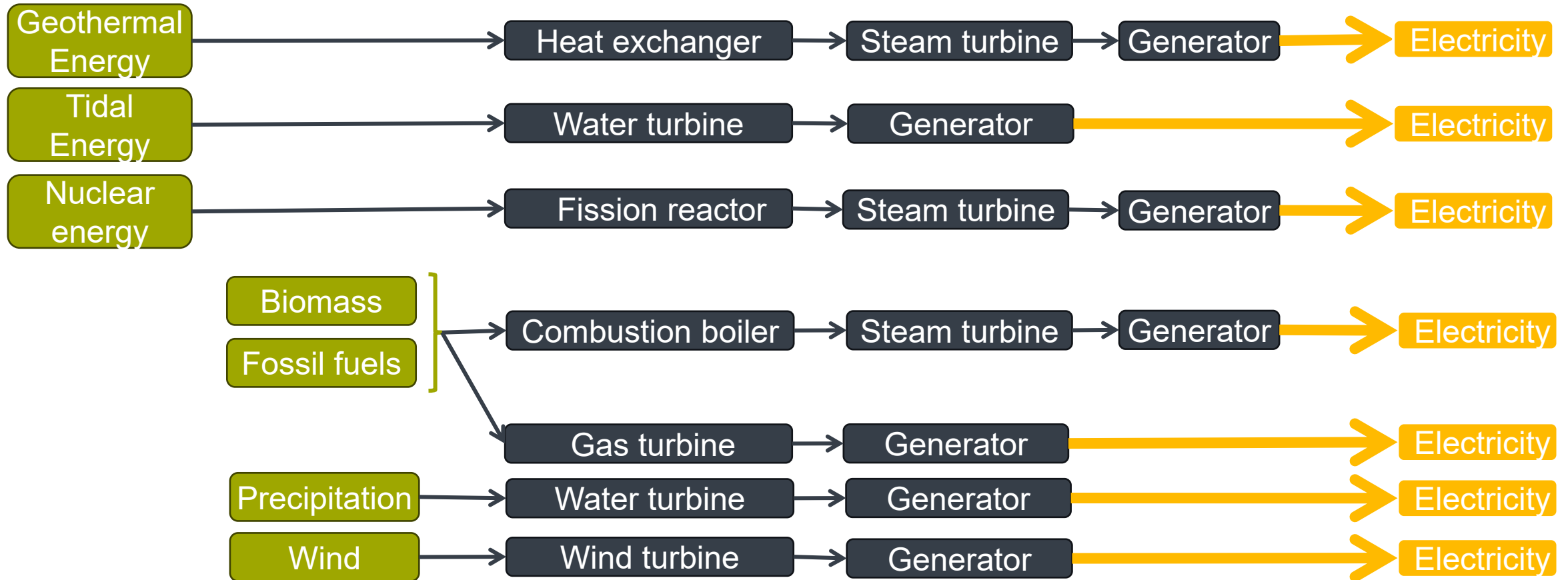


HVDC transmission

How EGL1 will work

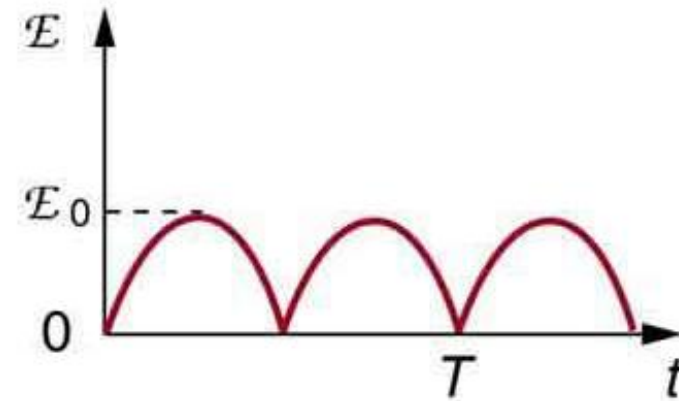
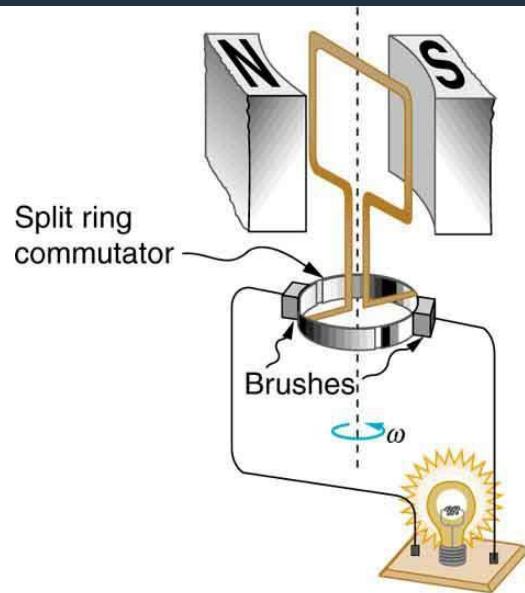


Electrical generator

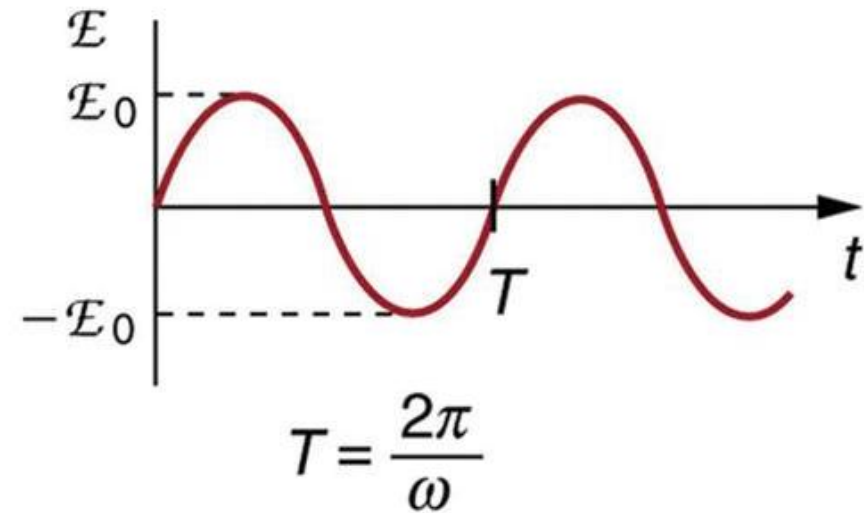
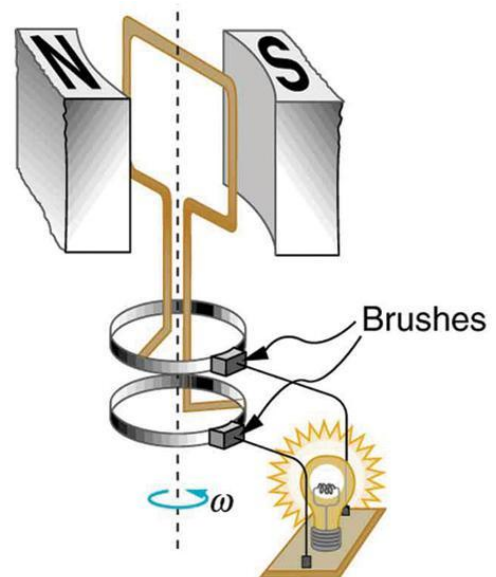


Electrical generator

DC

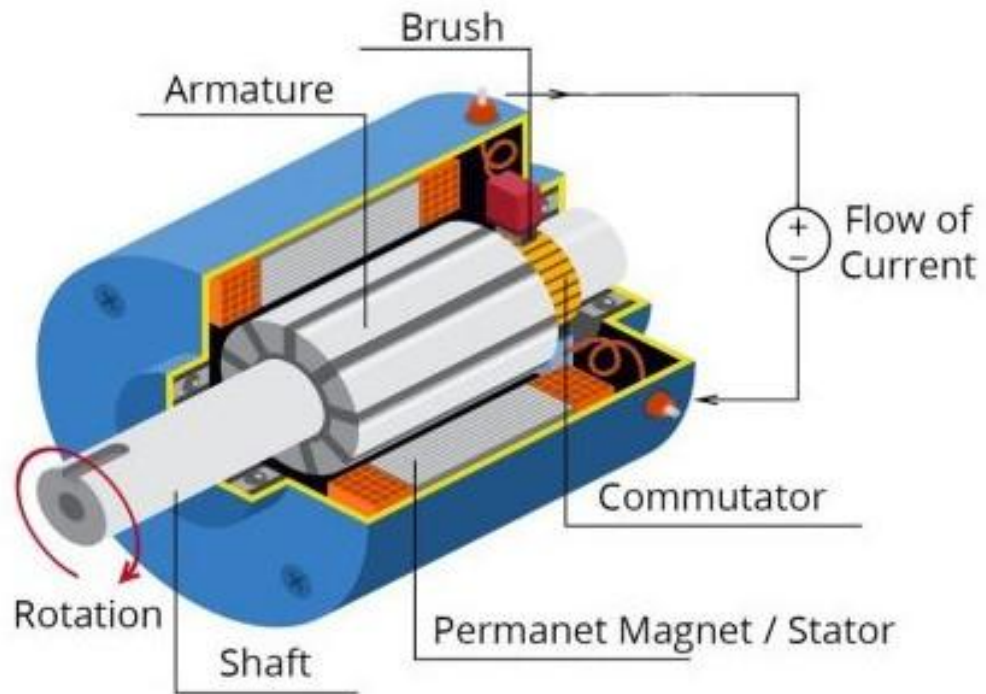


AC

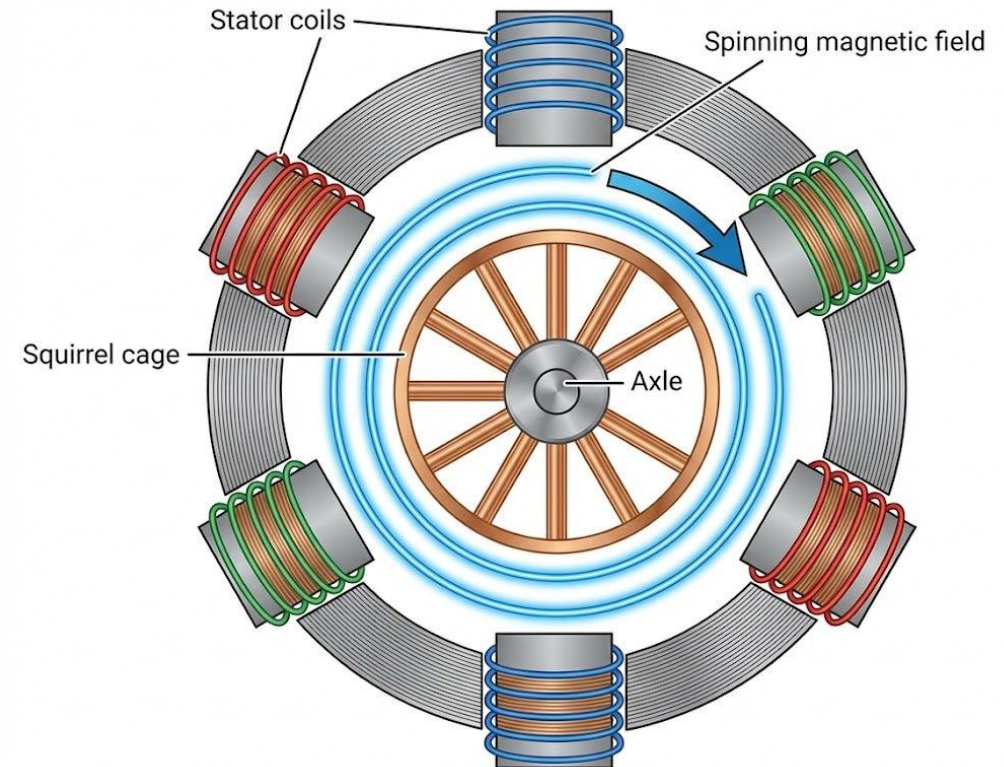


Electrical motor

DC



AC



Electrical motor advantages vs disadvantages

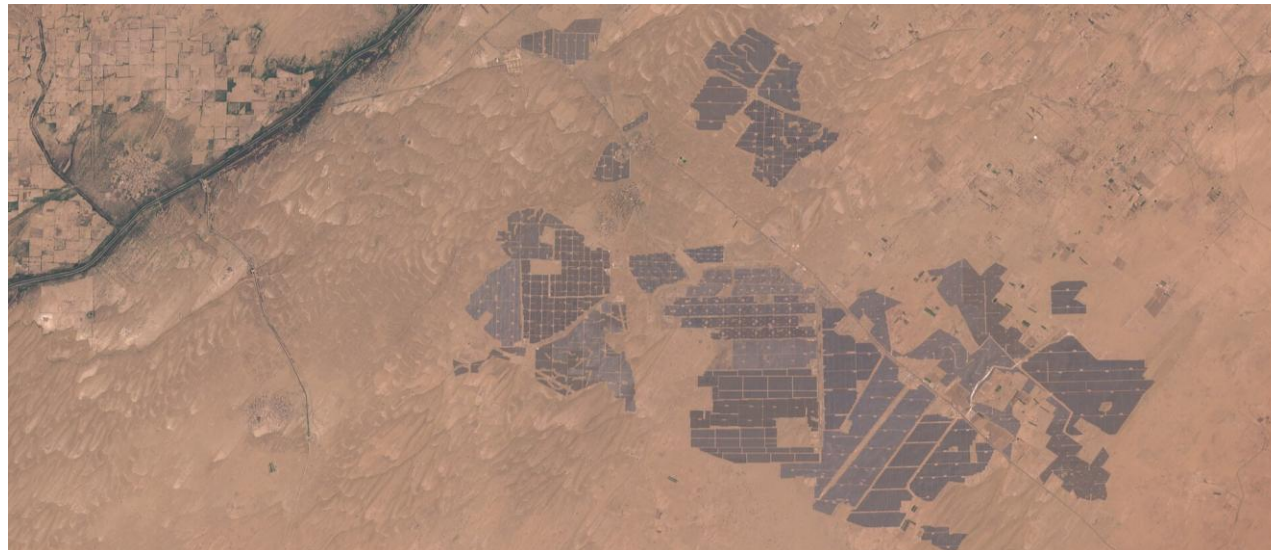
- High efficiency (less energy lost as heat)
 - Instant torque and quick start
 - Quiet operation
 - No direct emissions (environmentally friendly at use)
 - Precise control of speed and position
 - Reliable with long lifespan
 - Low maintenance (fewer moving parts, especially AC motors)
- Dependence on electricity supply
 - Batteries can be heavy, costly, and limited (for portable use)
 - Some types (e.g. brushed DC) require maintenance
 - Higher initial cost in some systems
 - Requires control electronics (adds complexity)
 - Can overheat without proper cooling

PV Solar Panel

Sun light

Photovoltaic panel

Electricity



https://en.wikipedia.org/wiki/Solar_panel

https://en.wikipedia.org/wiki/Floating_solar

https://en.wikipedia.org/wiki/Bhadla_Solar_Park

PV Solar Panel

Solar photovoltaic panel prices

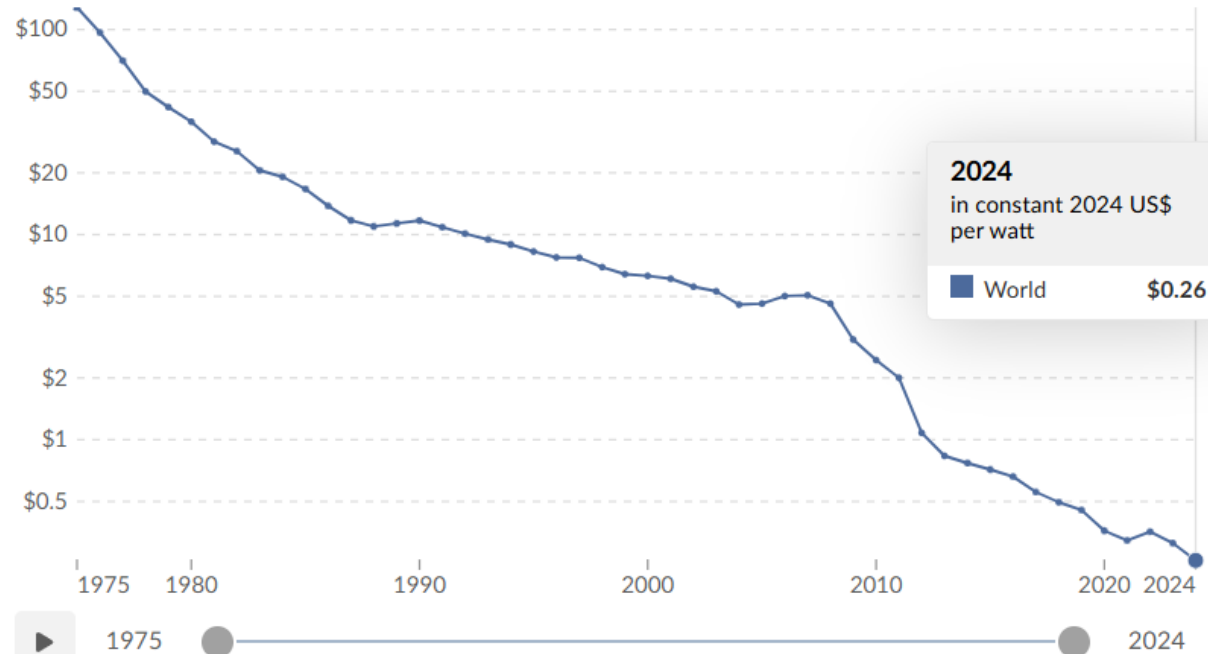
Average price of solar modules, expressed in US dollars per watt, adjusted for inflation.

Our World
in Data

Table

Chart

Settings

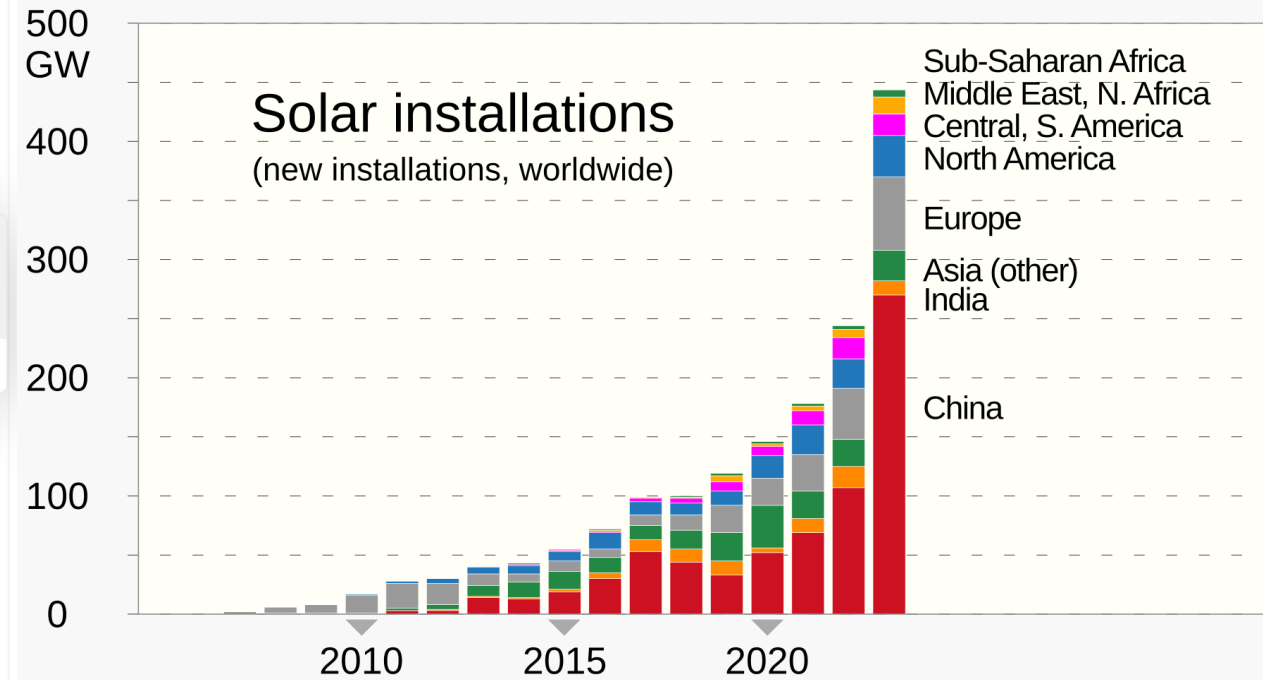


Data source: IRENA (2025); Nemet (2009); Farmer and Lafond (2016) – [Learn more about this data](#)

<https://ourworldindata.org/grapher/solar-pv-prices>

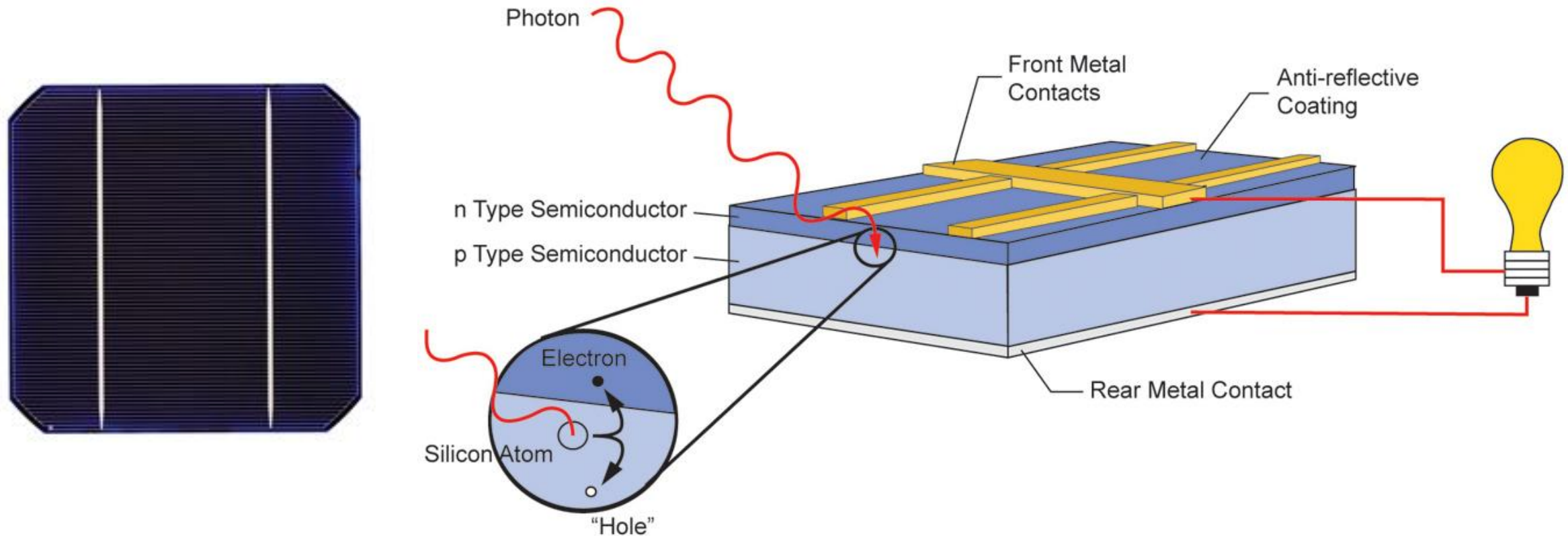
Solar installations

(new installations, worldwide)



https://en.wikipedia.org/wiki/Growth_of_photovoltaics

PV Solar Panel



PV solar panel advantages vs disadvantages

- Renewable energy source (sunlight)
- No direct emissions during operation
- Low maintenance (no moving parts)
- Scalable and flexible installation
- Reduces electricity bills
- Increases energy independence

- Dependent on sunlight (weather and day/night cycle)
- Requires storage or backup systems for reliability
- High initial installation cost
- Limited efficiency (not all sunlight converted)
- Requires space for installation
- Environmental impact from manufacturing and disposal

Do you want to know more?

This is a selection of Youtube videos that extend the content offered in this module

[How electricity works - working principle](#) - The Engineering Mindset

[How does a Transformer work](#) - The Engineering Mindset

[What is a DC/DC Converter?](#) - Mouser Electronics

[Electricity Across Oceans: Is HVDC the Future?](#) - Engineering with Rosie

[AC Electrical Generator Basics](#) - The Engineering Mindset

[Working Principle of DC Generator](#) - Chrvoje_engineering

[How does an Electric Motor work?](#) (DC motor) - The Engineering Mindset

[Induction Motor Basics](#) (AC motor) - The Engineering Mindset

[Generate Electricity - How Solar Panels Work](#) - The Engineering Mindset

[Overview of electric power systems - Sustainable Energy](#) - TU Delft

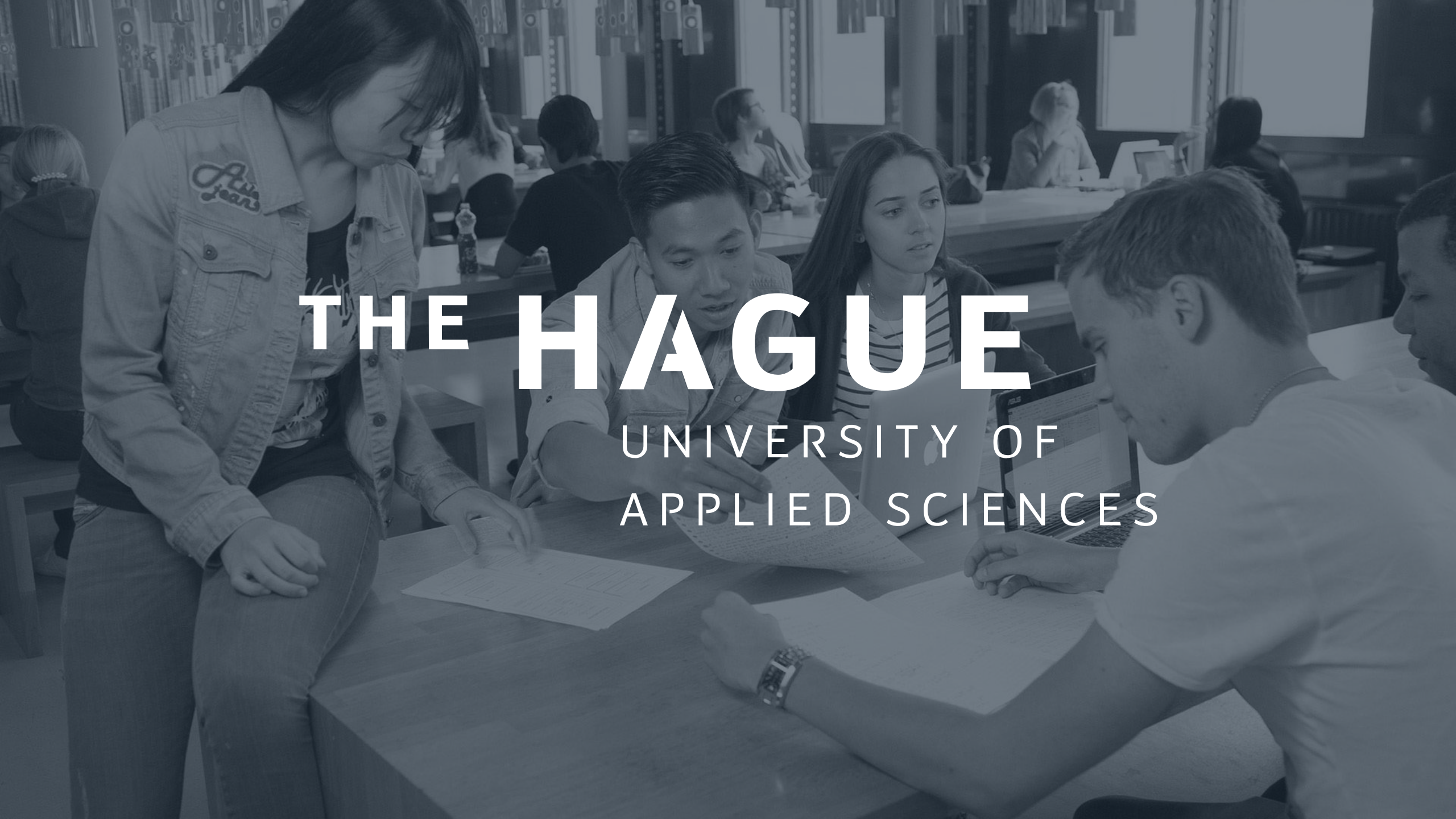
References

The references are accredited in each slide of the presentation.

General books used as reference are:

Ouwehand, J., Trynke, P., Post, E., Taal, A. (2012) Toegespaste Energietechniek, Sdu, Den Haag.

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

A grayscale photograph of a modern 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 bright, airy feel.

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