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Introduction to Electricity Industry II

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Contents

- AC/DC - History and Differences
- Types of Electric Current
- Voltage
- Power System
- Transfer and Distribution of Electricity

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Example II

You have a 2010 vacuum cleaner with the input of 1,500 We. Usually you use it once a week for an hour. In 2018 you decided to buy a new one, due to the EU regulations its output is only 750 We. Due to unexpected circumstances, you are forced to use the vacuum cleaner 5 times in a month for an hour. The price of electricity is 4 CZK /1 kWh. Are your monthly electricity expenditures lower than with the previous one? How much are they?

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Example II

2010 vacuum cleaner

4 hours a month x 1,500 We = 6,000 Wh = 6 kWh

6 kWh x 4 CZK = **24 CZK**

2018 vacuum cleaner

5 hours a month x 750 We = 3,750 Wh = 3.75 kWh

3.75 kWh x 4 CZK = **15 CZK**

Does it make sense to buy a new vacuum cleaner to save money on electricity?

Does it make sense to buy a new vacuum cleaner to save the environment?

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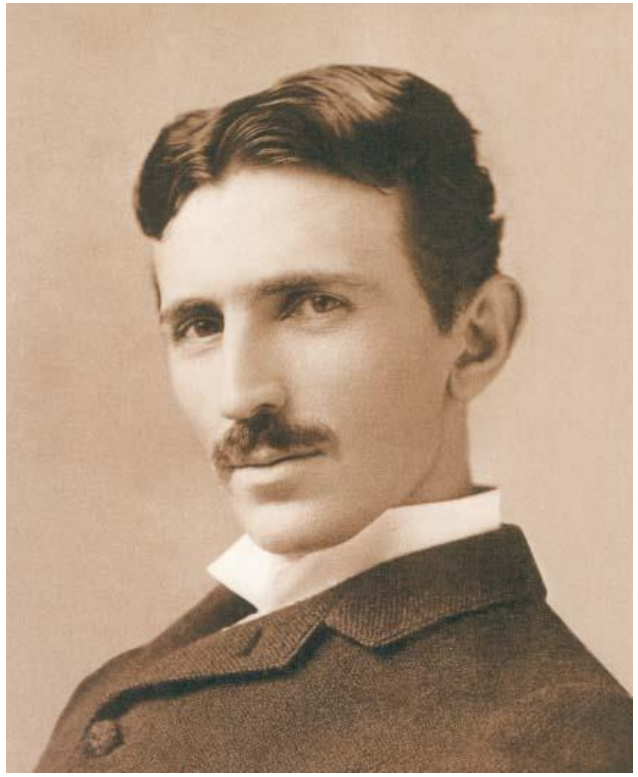
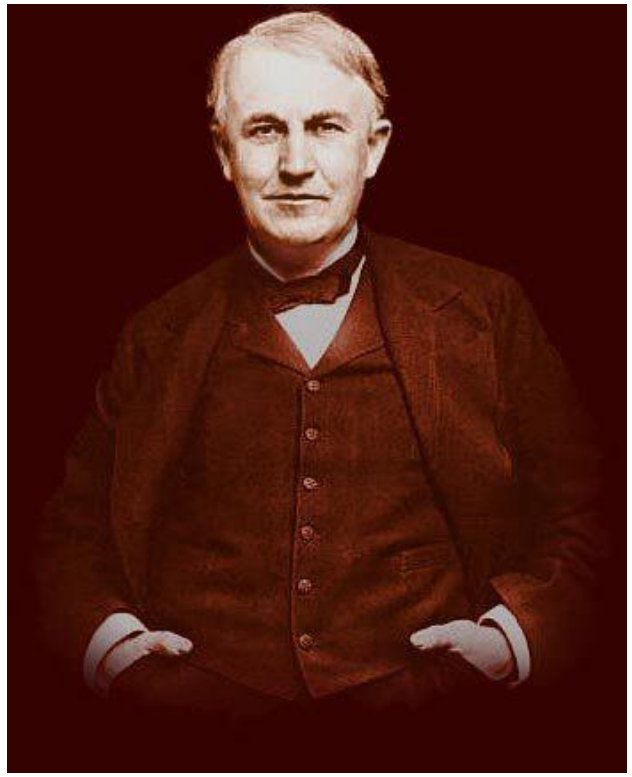
AC/DC – History and Differences



Nikola Tesla (1856-1943)



Thomas Alva Edison (1847-1931)

https://www.youtube.com/watch?v=NoKi4coyFw0

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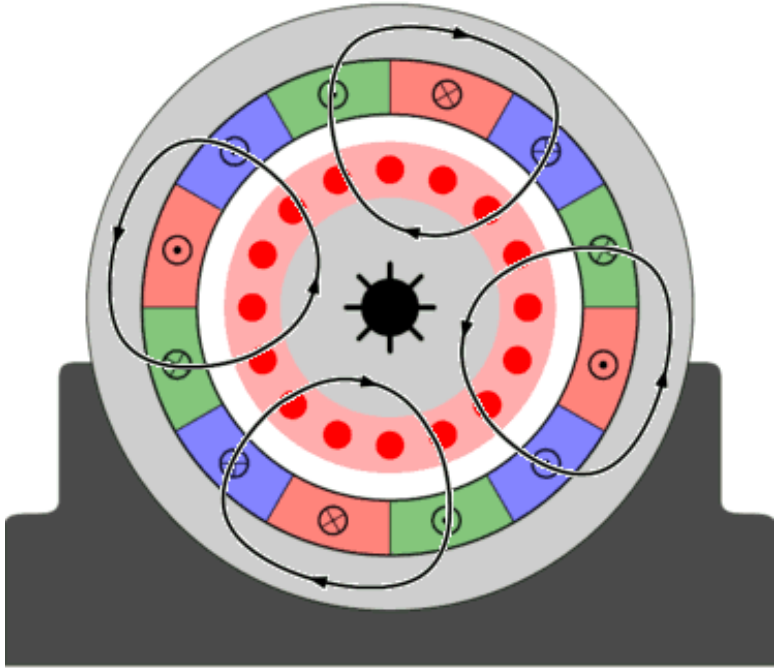
Tesla‘s AC Induction Motor



The AC power supplied to the motor's stator creates a magnetic field that rotates in time with the AC oscillations. The rotating magnetic flux induces currents in the windings of the rotor

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Types of Electric Current

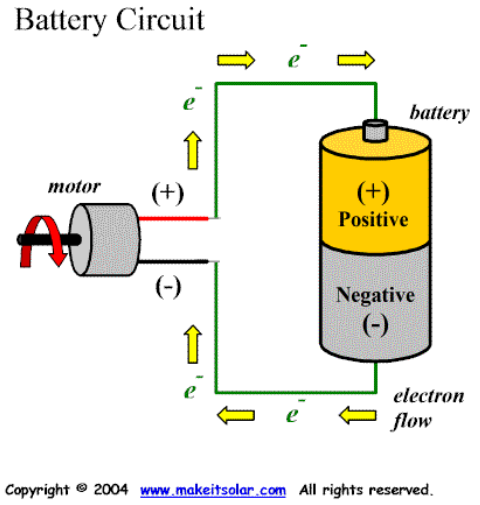
Direct vs. **Alternating** current

http://www.pbs.org/wgbh/amex/edison/sfeature/acdc.html

Direct Current (DC)

- Electrons flow only in one direction in a closed circuit; ie. DC has zero frequency
- The electrons in the circuit flow from "-" to "+"
- To get the energy of an electron to the appliance the electron must complete the whole way from a source to an appliance
- For longer routes (eg. already from 1 km) DC quickly loses its power and leads to huge losses in networks

- **What is the use of DC?**



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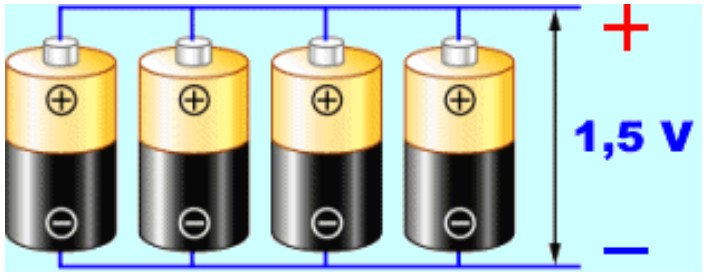
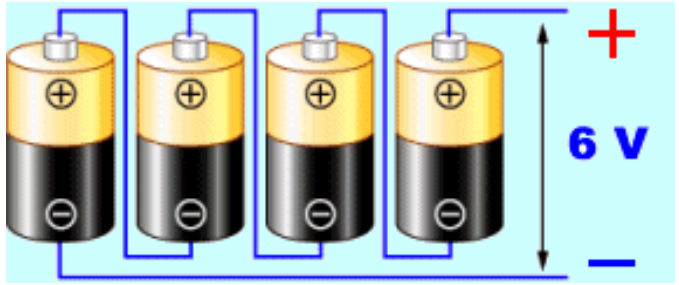
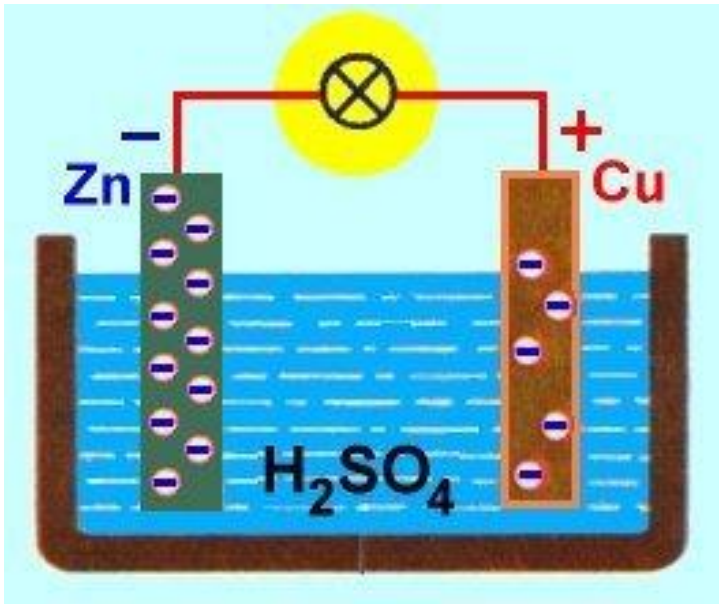
Direct Current (DC)

- It is used all around us, for example in batteries, rechargeable batteries, chargers, adapters, thermocouples, solar cells, transistors, etc..
- But even in trams, trains operation in the world (Decin-Praha-Ostrava), in most of the world's subways, etc..)
- It is also used by remote transmissions of large volumes of electricity, so called HVDC lines. The advantage is that it can interconnect systems on different frequencies as well as asynchronous systems.
- With very high voltages DC is more efficient at transporting electricity than alternating current
- However the changing of the voltage is complicated and expensive, and therefore a high-voltage DC power supply is used only during transportation over long distances (more than 600 km for overland lines).
- In practice the HVDC is used when connecting remote sources (typically dams and other renewable sources), or when connecting electrical systems with different frequency alternating current.
- "Natural" sources of DC are basically any non-rotating power plants (battery, solar cells, dynamo - exemption)

Direct Current (DC)







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Alternating Current (AC)

Alternating Current (AC)

- Electrons flow back and forth - periodically alternate
- Under network frequency of 50 Hz the current changes direction every 10 milliseconds
- Current is induced in the form of a sine curve
- Electrons almost do not wander through the conductor, they tap into the neighboring electrons and pass their charges, which gets from the source to the appliance
- Electrons move on much shorter routes, which leads to significantly lower losses in the network

- **What is the use of AC?**

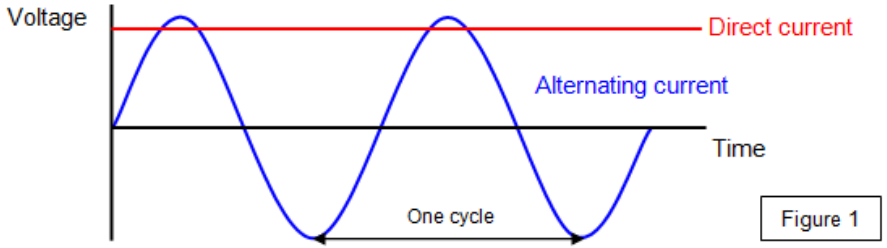

Figure 1

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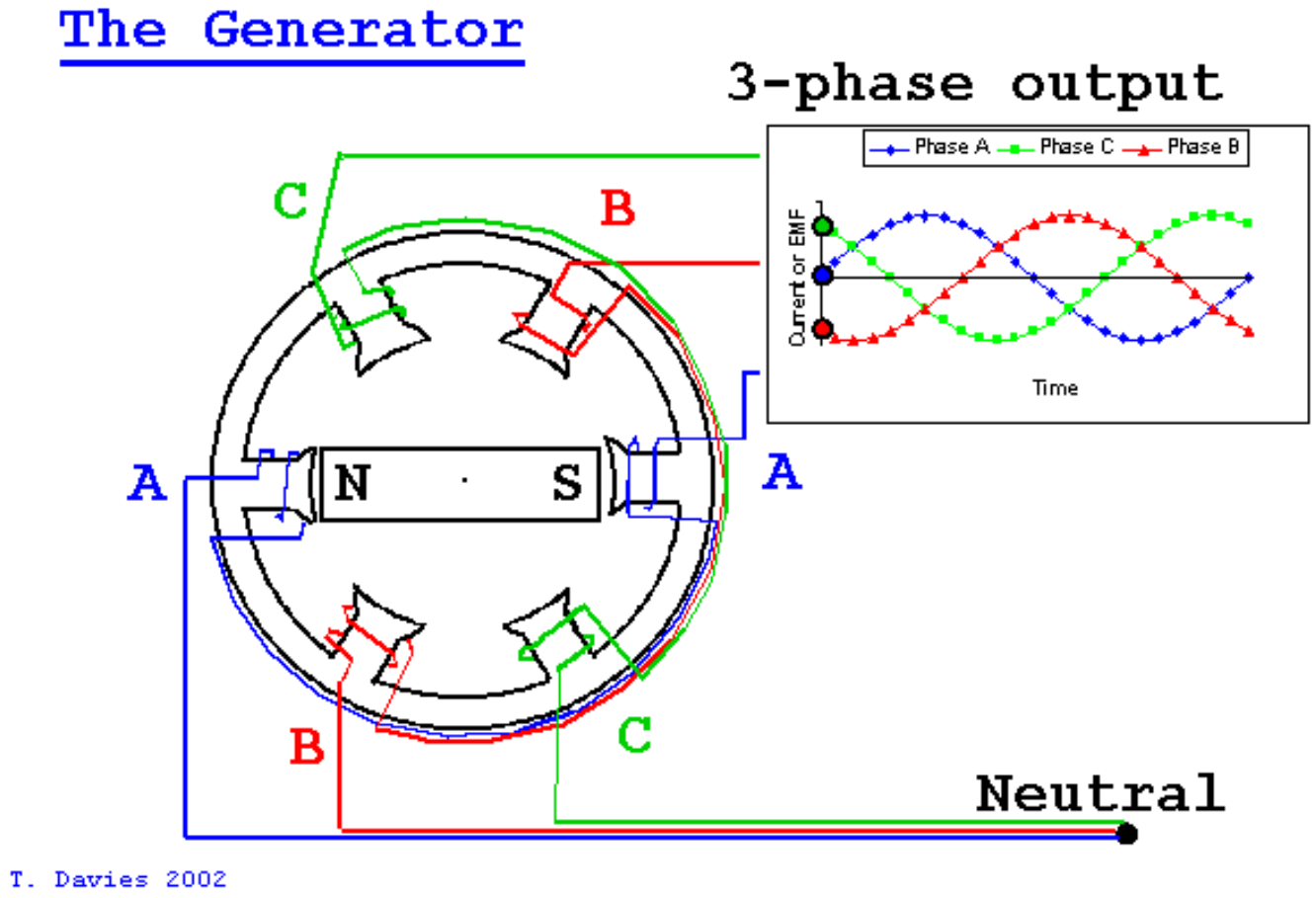
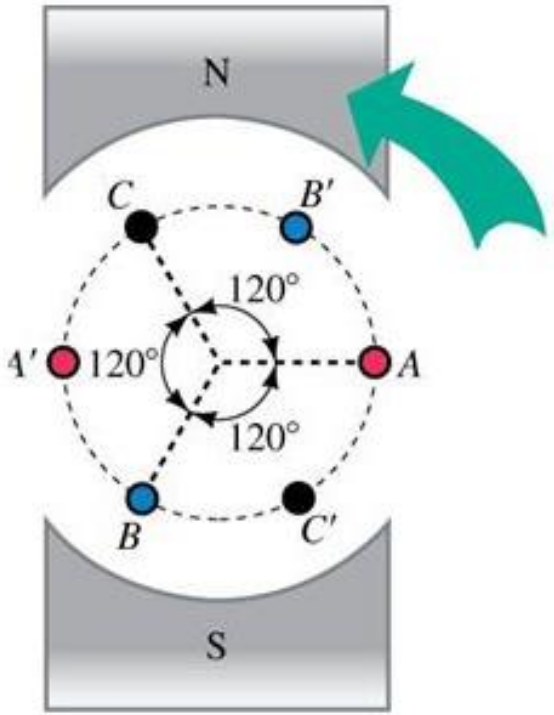
Alternating Current (AC)

- The main advantage of AC over DC is an easy increase and decrease of voltage and much cheaper industrial production and distribution
- It is used in mass production of electricity and for the transmission of power at a greater distance, with significantly lower losses that are achieved using higher voltages
- High voltage transport lines are used for remote supplies using easily transformable alternating current
- Very simple transformers are used for change in voltage, which consist of two coils wound around a common magnetic core. The proportion of the incoming and outgoing voltage is proportional to the proportion of the number of coil windings.
- The sources are all rotating motors, dynamos and nowadays mainly structurally simpler alternators
- The disadvantage of AC is the need to maintain a stable frequency network (i.e. to synchronize all connected generators)

Alternating Current (AC)





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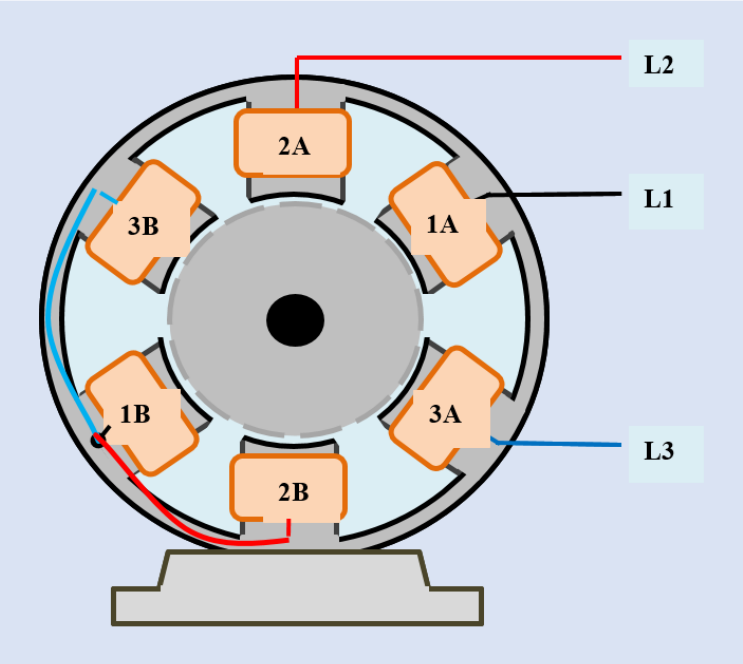
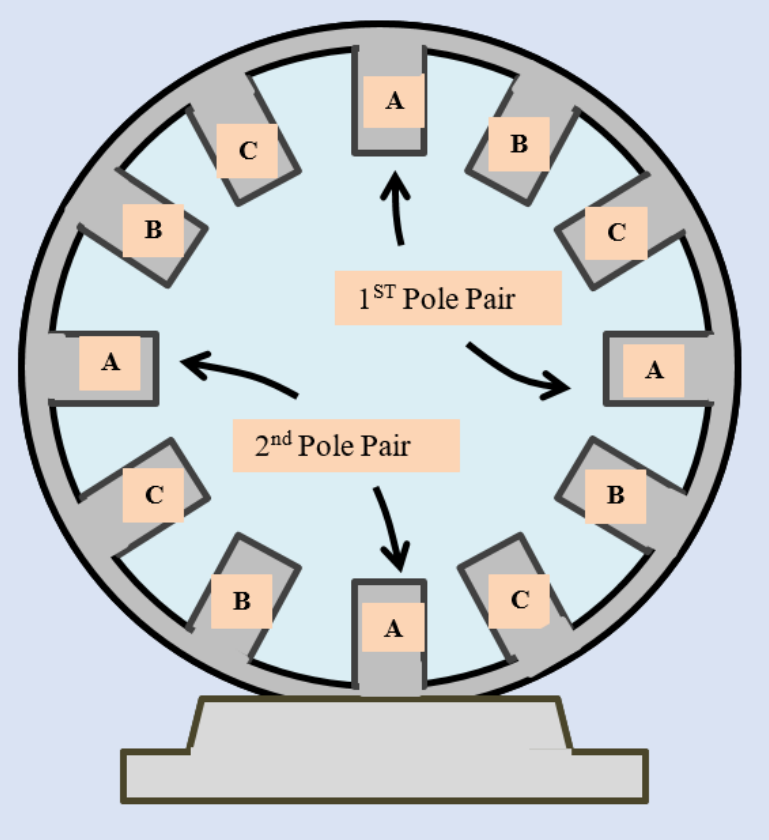
Three-Phase AC Generator Working

Three-Phase Two-Pole AC Generator

Three-Phase Four-Pole AC Generator





Synchronous rotor speeds for 3-phase 50Hz AC generators with different numbers of poles	
2 Poles	3000 rpm
4 Poles	1500 rpm
6 Poles	1000 rpm
8 Poles	750 rpm
10 Poles	600 rpm
Source: www.electricalacademia.com	

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Three-Phase AC Generator Working

Why multiple pole 3-phase AC alternators are used?

- in the case of a small engine the maximum output-producing rotation speed is higher than the synchronous rotation speed
- smaller engines thus can be used synchronously (can operate in a higher rotation speed range beyond the synchronous rotation speed)
- more silent operation by lowering the rotation speed
- the weight of a multi-pole generator is about a half of the weight of a two-pole generator

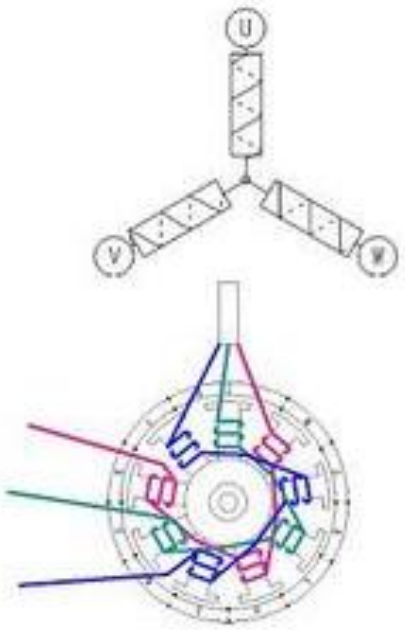
Why is an AC generator called an Alternator?

- an alternator is such a machine which produces alternation electricity. It is a kind of generator which converts mechanical energy into alternating electrical energy

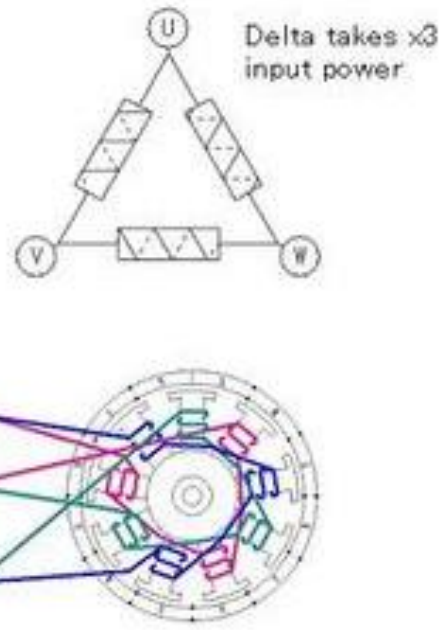
Why is an Alternator called a Synchronous generator?

- because it rotates at a constant (i.e.synchronous speed) no matter what the load on alternator is.F or instance if it is a 2 pole machine it will rotate at 3000 rpm to produce a frequency of 50 Hz (or 3600 rpm to produce 60 Hz).

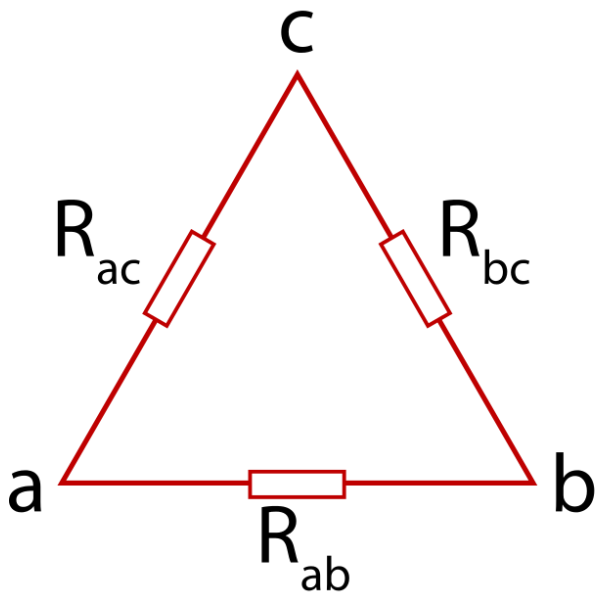
Production of Electricity and Voltage



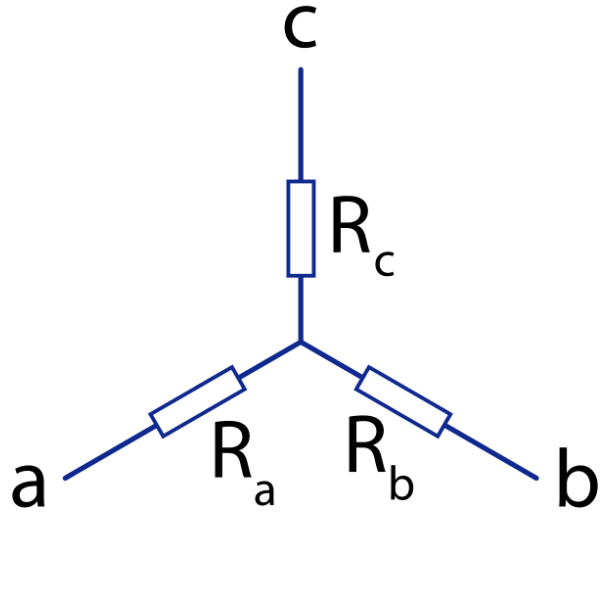
Star wiring
(phase conductors)



Delta wiring
(stranded conductors)



"Delta"



"Star"

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Production of Electricity and Voltage

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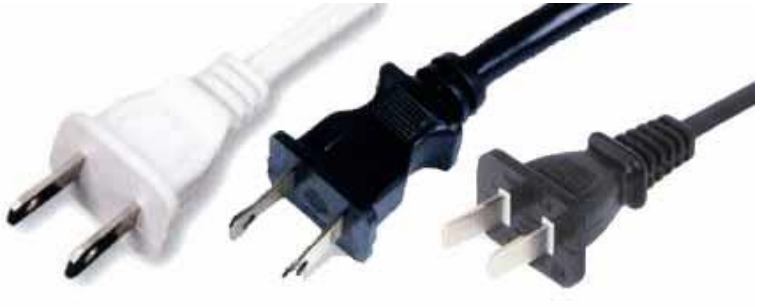
Types of Plugs/Sockets in the World



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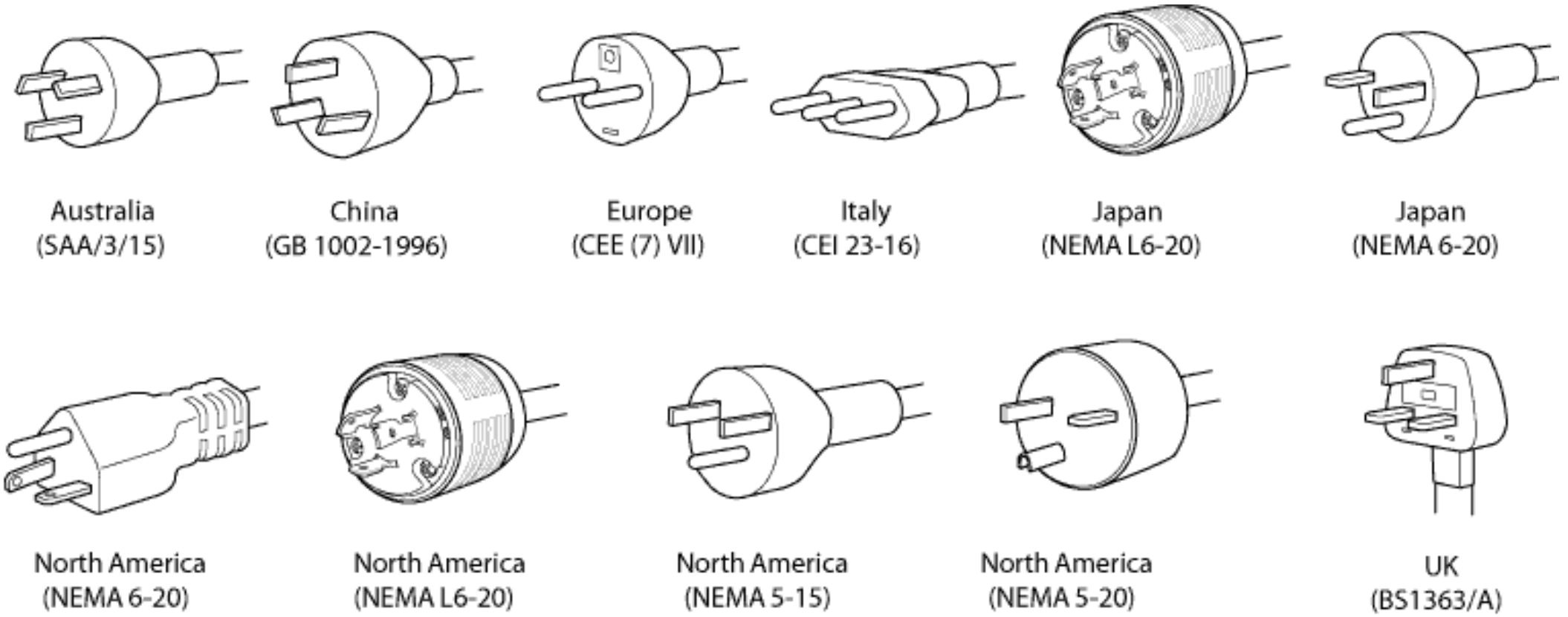
Types of Plugs/Sockets in the World



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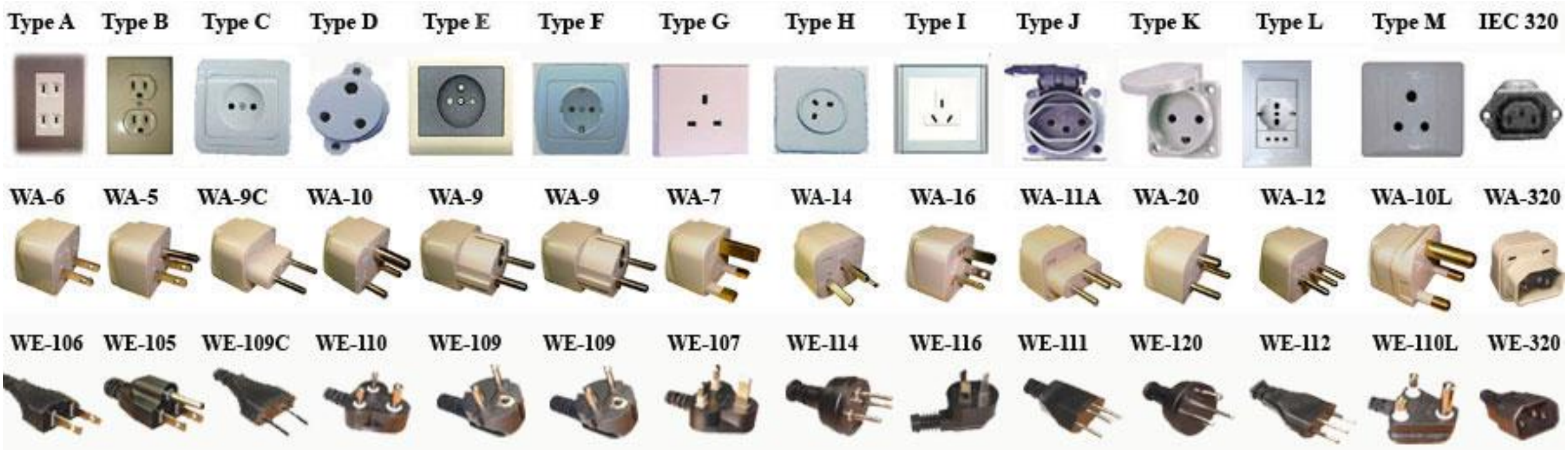
Types of Plugs/Sockets in the World



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Transmission and Distribution of Electricity

- **The power system** involves a process of electricity generation from different types of primary sources (fossil fuels, hydropower, wind, geothermal, nuclear, solar), qualitative transformation of the electric energy, transmission and distribution, and end use. All these processes are carried out through the electricity grid (transmission, distribution). They are dynamic - at any time must equal the energy consumed energy produced. Electrical energy is only a transitional form (carrier), it soon turns into light, heat, mechanical etc.

- **The transmission system** (distribution) is a set of interconnected devices that allow the transmission of electrical energy from the source to the consumer

Transmission and Distribution of Electricity

- **The power system** is an interconnected set of equipment for the generation, transmission, transformation and distribution of electricity, including electrical connections and direct lines, systems and metering, protection, control, security, information technology and telecommunications.

- The power system has several parts, namely:

- production
- power stations
- network
- power lines

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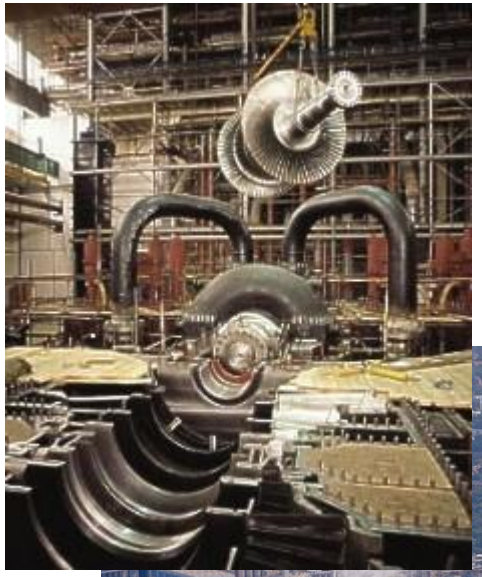
Transmission and Distribution of Electricity

- **Electric power plants** are installations that convert any energy into electricity.
- **Electric stations** is a complex of buildings and equipment, which enables the transformation, compensation, conversion or transmission and distribution of electricity, including the resources necessary to ensure their operation.
- Electric stations are *transformer stations* (used to change the voltage of electricity at the same frequency and its distribution), *switching station* (serving the same distribution of electrical energy without voltage transformation and without conversion), *converter stations* (used to convert the type of voltage or frequency) and *compensating stations* (used to compensate reactive components of alternating current, or line parameters).
- **Power grid/lines** is an important part of every device and allows transmission of electrical power and signals over distance. Electrical wiring is formed by conductors which serve to conduct electrical current and insulation separating the living part from the environment (except for bare lines). We distinguish four kinds of electric lines: lines of bare conductors (mainly outside), lead in pipes and rails, bridge line of wire and cable management.

Transmission and Distribution of Electricity



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Transmission and Distribution of Electricity

Switching station

Transformer station

Transformer

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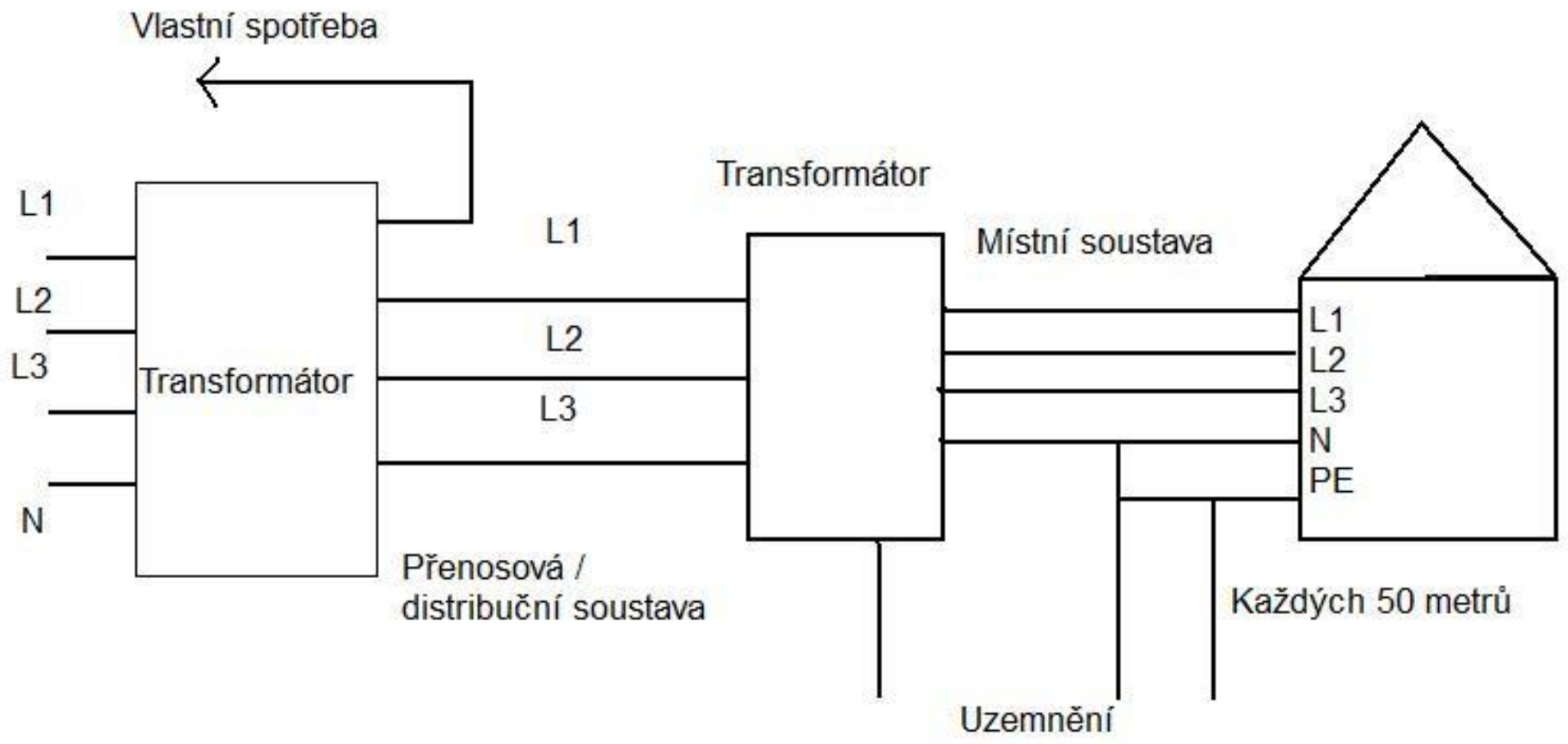
Transmission and Distribution of Electricity



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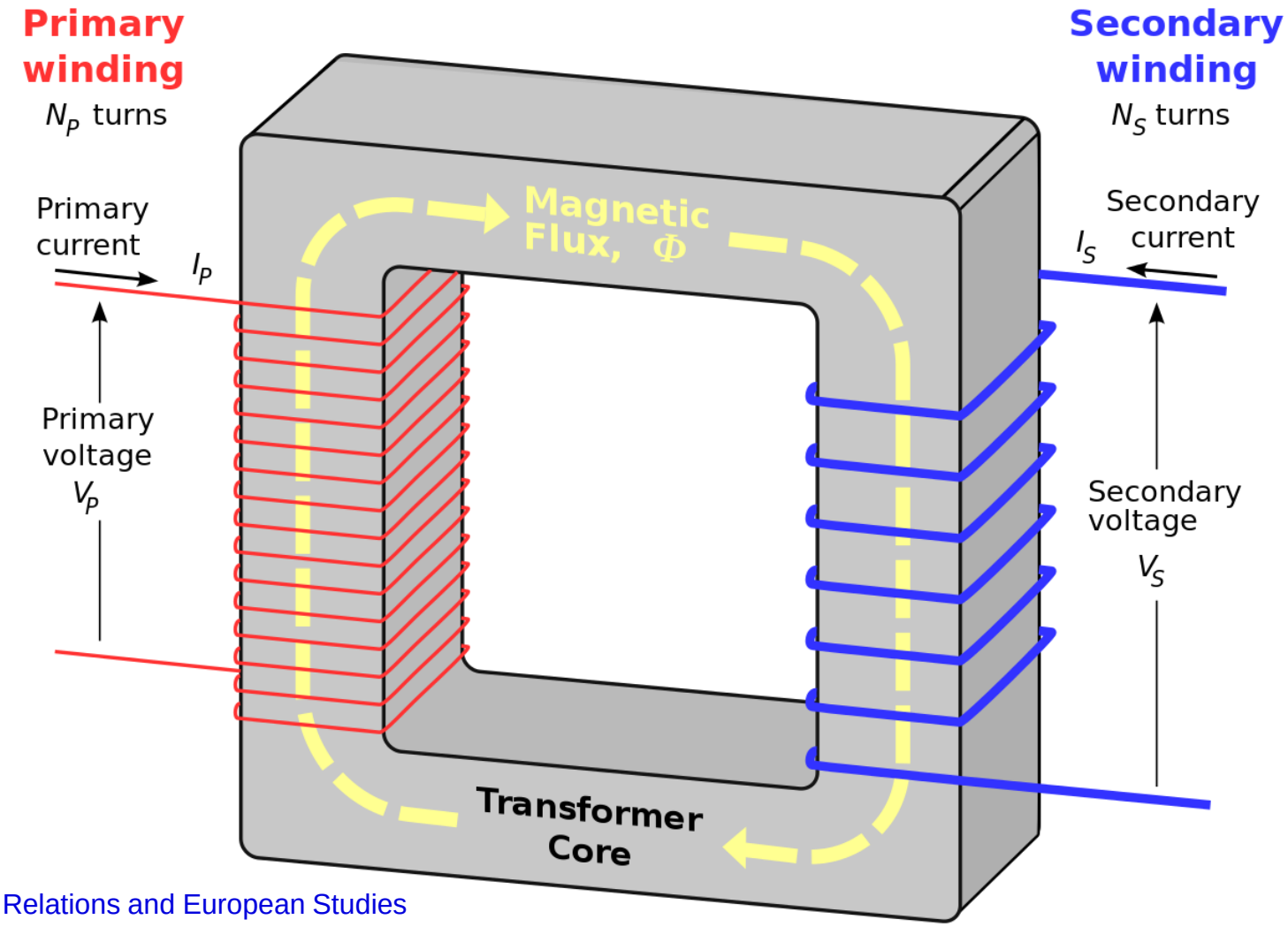
Transmission and Distribution of Electricity

- The produced electricity must be transported to the place of consumption, according to Kirchhoff's laws electricity has the advantage that it does not need any energy to this movement, because electricity flows naturally from higher voltage to lower voltage points.
- To change the voltage in electric power systems the transformers are used.
- Electricity thus enters the high-voltage transmission (parent system), then it is transformed to a lower voltage distribution systems (grid) and then to low voltage (local system).
- Electricity is eventually distributed either by phase conductors or stranded conductors.
- **Materials for outdoor or cable wires are copper cables and wires** (best electrical and mechanical properties, high resistance to external influences, but the high price and exceptional use), **or Al, Fe or Al alloys, bronze and steel**

Transmission and Distribution of Electricity



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Transmission and Distribution of Electricity

- **Electric lines** are part of the grid. It is a set of interconnected power stations and lines for the transmission and distribution of electric energy.

- **AC lines**
- UHV (800+ kV) Transmission
- EHV (230 – 800 kV) Transmission
- HV (69 kV to 230 kV) Transmission/Distribution
- MV (0,6 – 69 kV) Industrial/Distribution
- LV (50 V – 600 V) Local
- ELV (less then 50 V) -

Transported Capacity in Electric Grids	
Voltage	**Transported capacity**
230/400 V	3,55 kWe
22 kV	10,76 MWe
110 kV	268,9 MWe
220 kV	1 075 MWe
400 kV	3 555 MWe
Source: „*Elektroenergetika I,*“ n.d., s. 5.	

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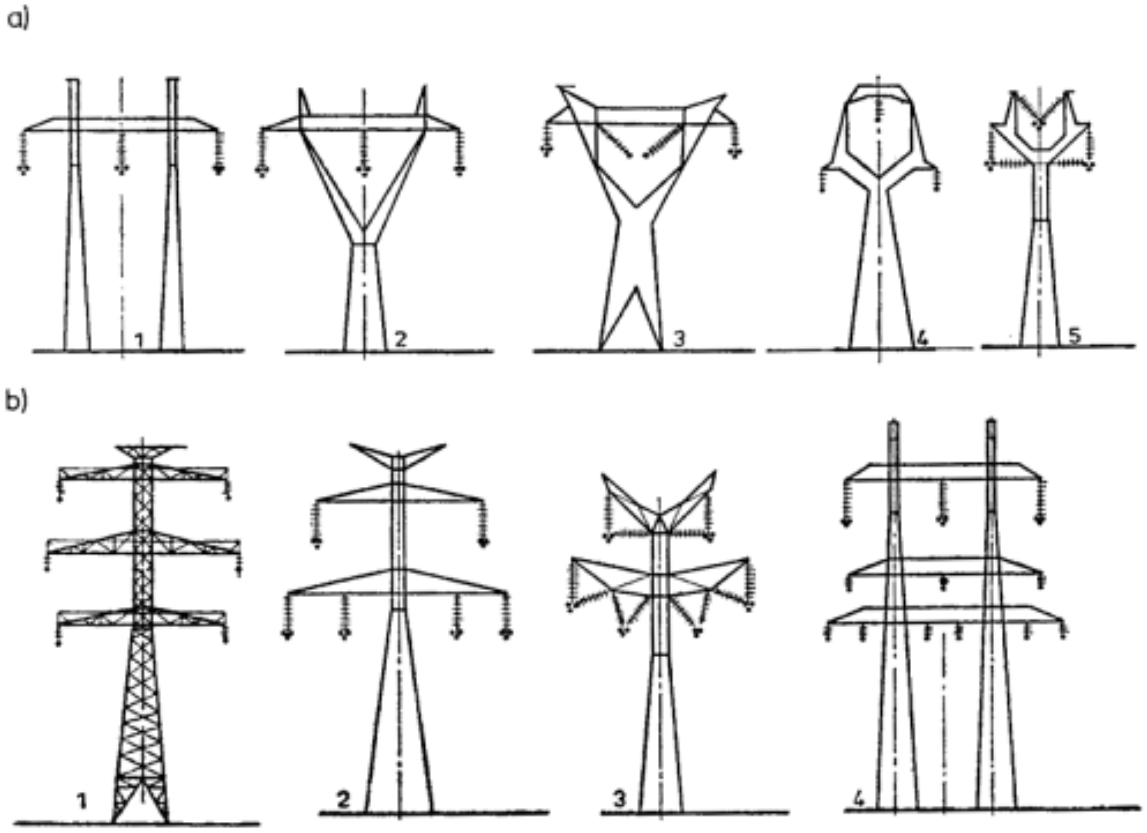
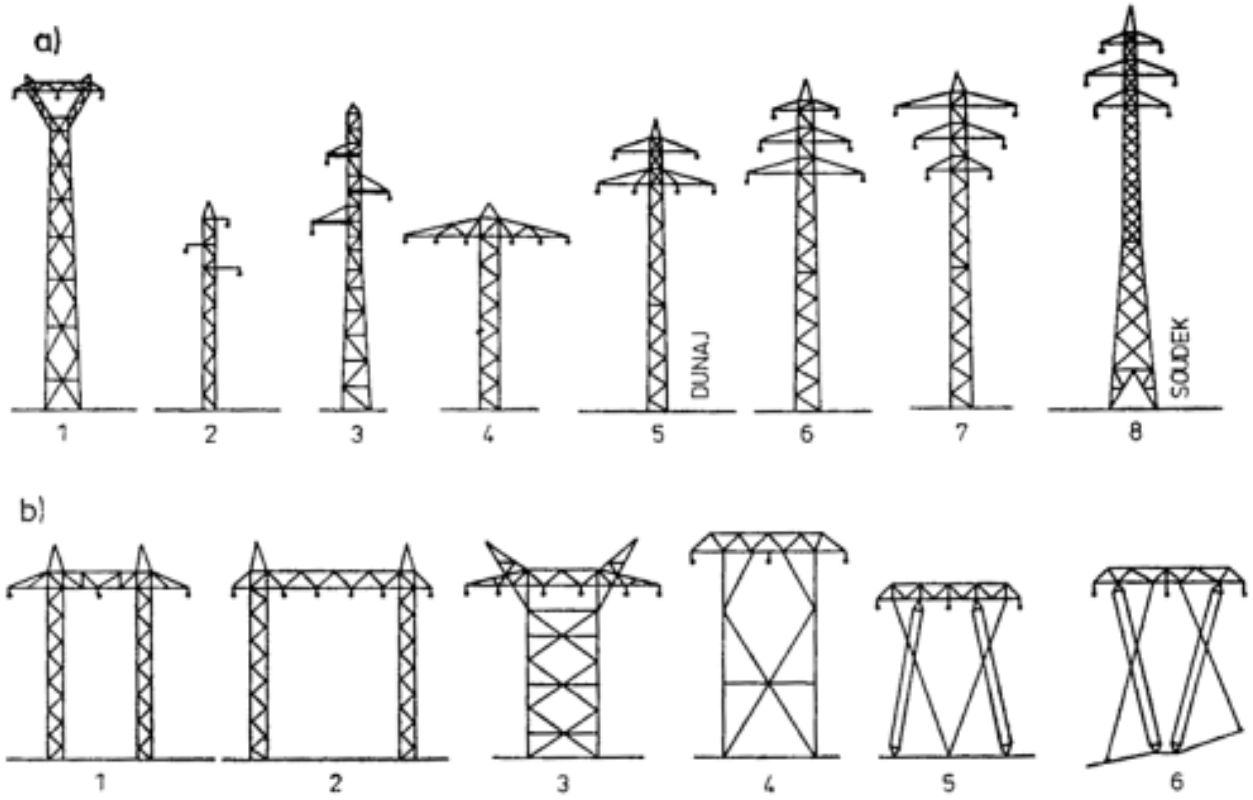
Transmission and Distribution of Electricity





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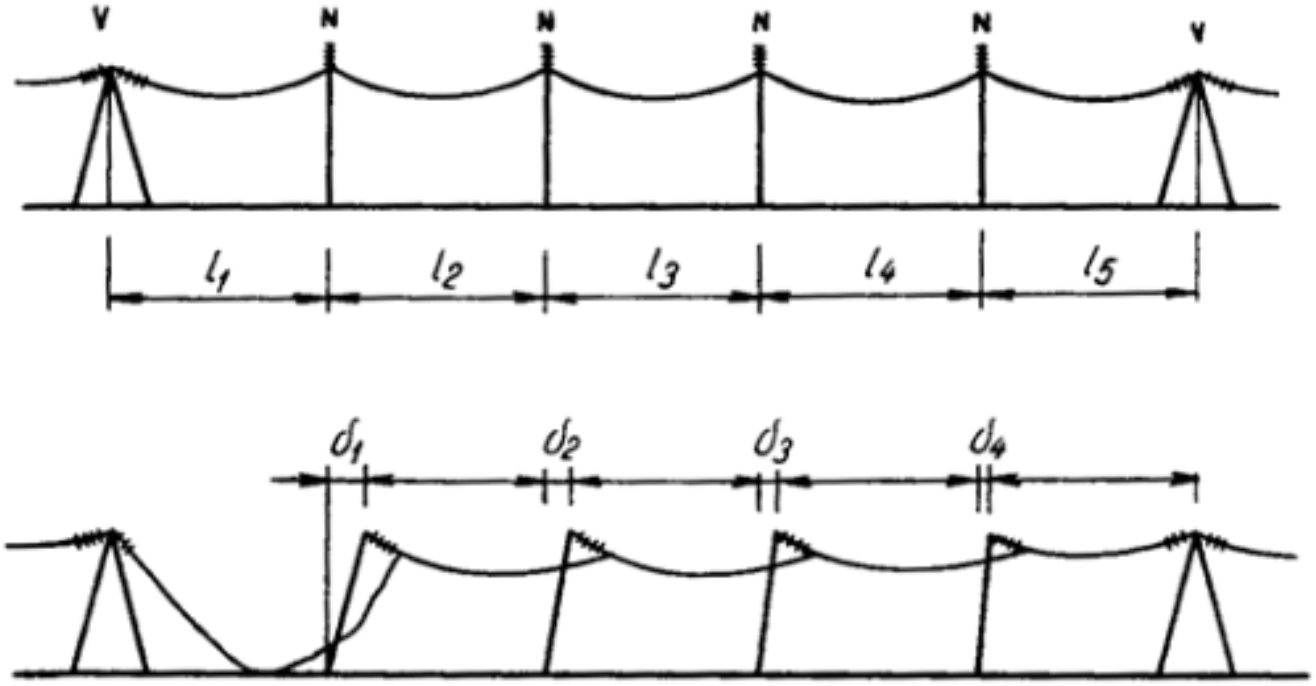
Transmission and Distribution of Electricity



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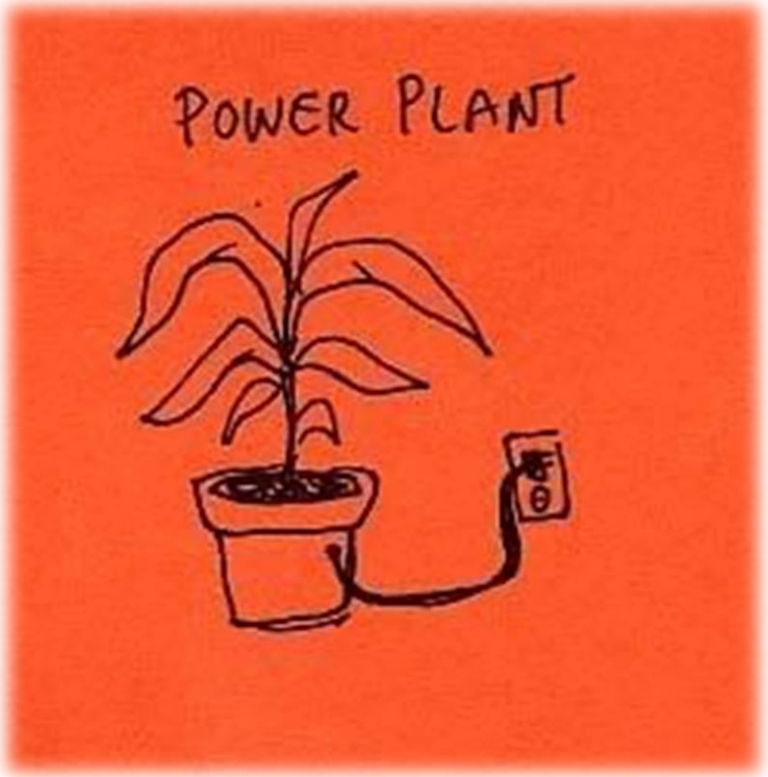

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