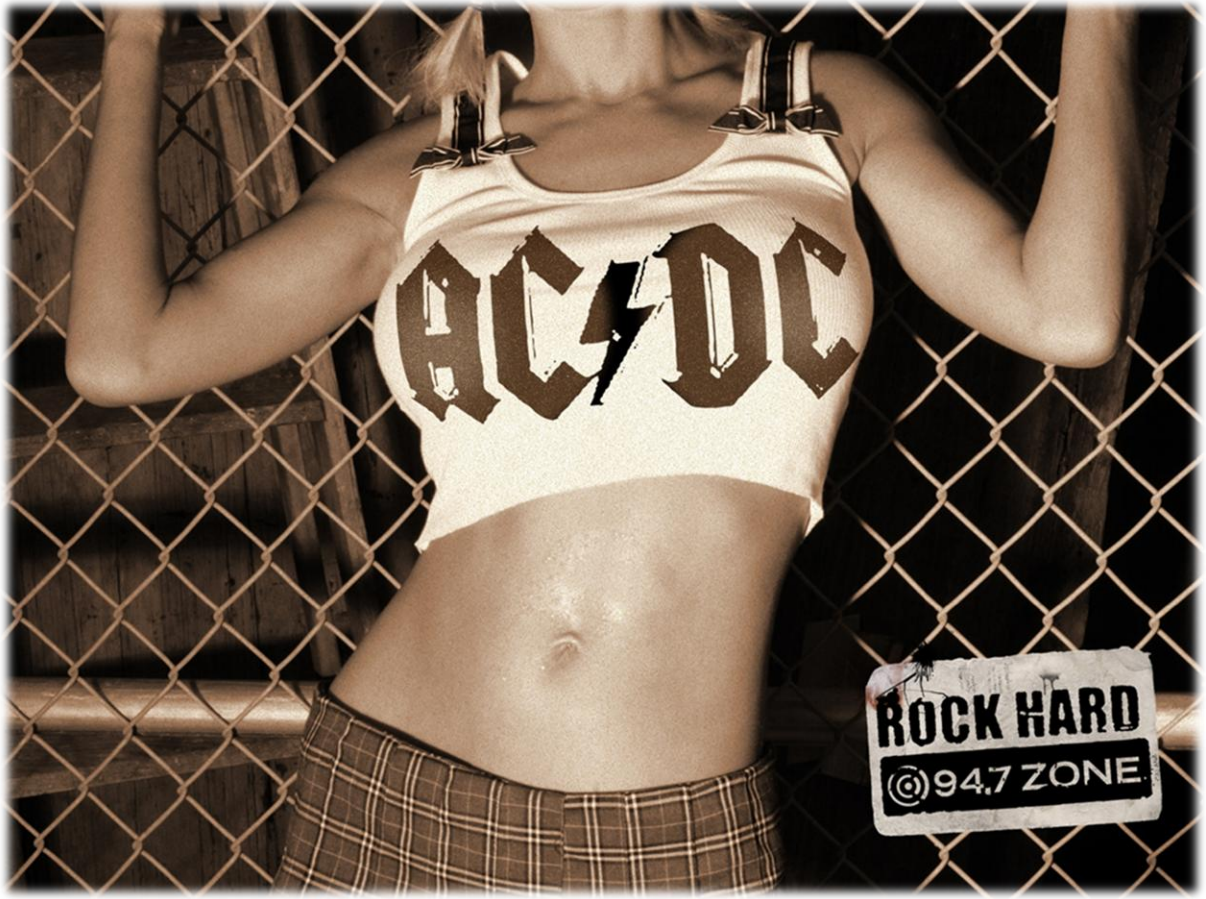
Introduction to Electricity Industry



PhDr. Tomáš Vlček, Ph.D.

International Relations and Energy Security

Department of International Relations and European Studies

EVROPSKÁ UNIE

esf

MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY

OP Vzdělávání pro konkurenceschopnost

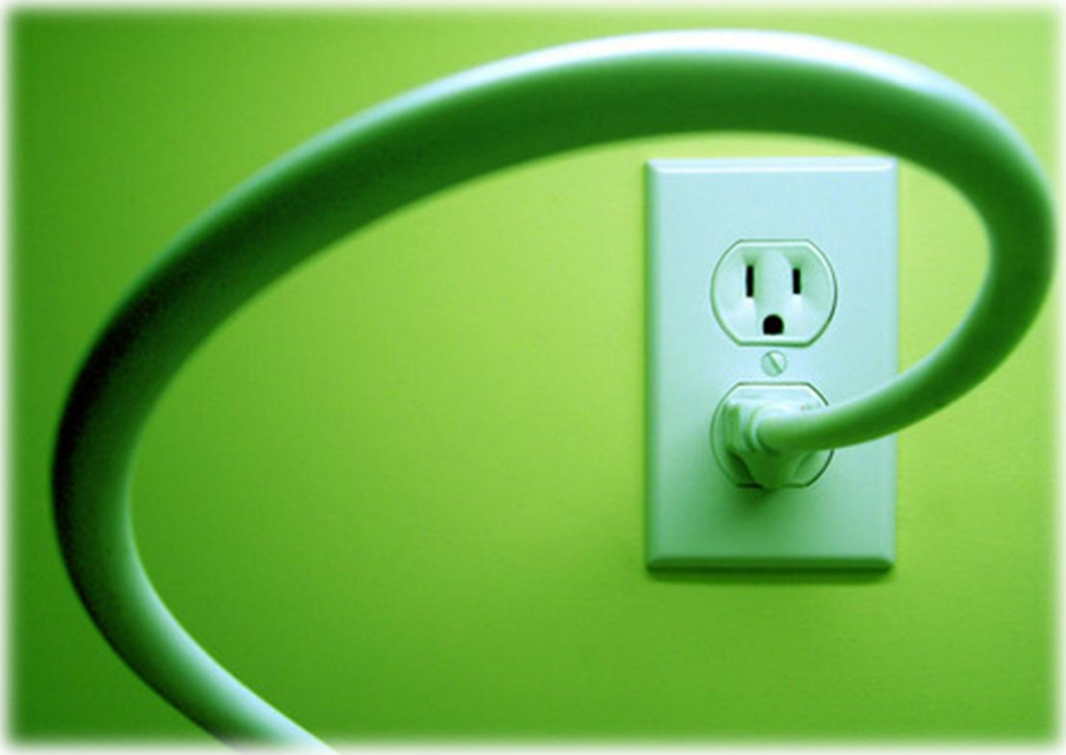
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Content

- Basic Quantities and Units
- Energy Transformation
- Basics of Electricity
- Electricity System
- AC/DC - History and Differences
- Transfer and Distribution of Electricity
- Pricing and Market
- Regulation of Electricity
- Electricity Trading

What is Electricity?

http://www.youtube.com/watch?v=8gvJzrjwjds



What is Electricity?

Electricity has many advantages

- easy to handle
- simple transfer
- it is clean and non-polluting
- it is elegant and inexpensive

Basic Quantities and Units

• Voltage	U (V)	unit 1 volt
• Current	I	unit 1 ampere
• Resistance	R	unit 1 ohm (Ω)
• Installed capacity	P	unit 1 watt
• Energy / work	E	unit 1 joul (Ws), j Wh
• Frequency	f	unit 1 hertz
• Efectivity	η	dimensionless quantity (%)

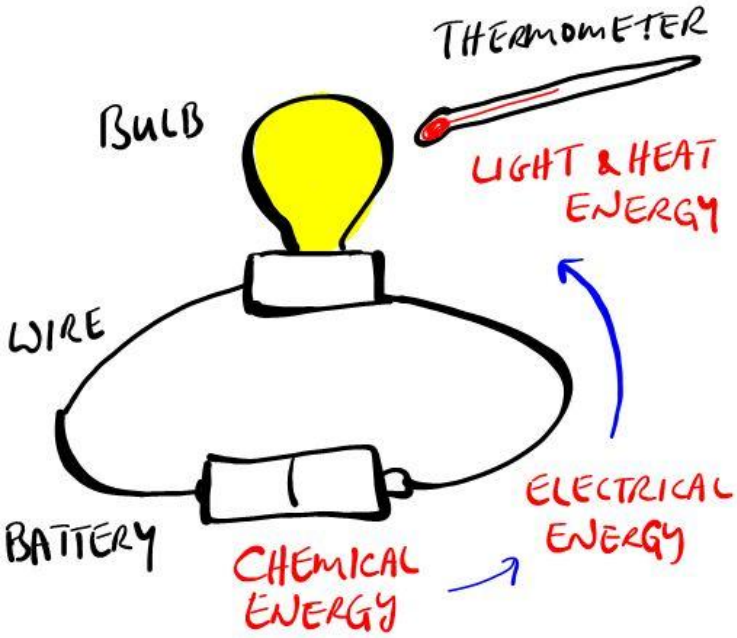
Basic Quantities and Units

- fluorescent lamp 8–25 W
- lightbulb 25–200 W
- laptop (sleep) 12 W
- laptop 20 W
- PC + LCD monitor 80 W
- colour TV 100 W
- washing machine 500-2,000 W
- iron 1,000 W
- el. pan/hot-plate 1,200 W
- toaster 1,200 W
- dishwasher 1,500 W
- vacuum-cleaner 1,000–2,000 W*
- tea-kettle 1,200–2,000 W
- electric locomotive 2 MW
- electric induction furnace 40 MW

* 9/2014 1,600+ W banned in EU; 1/2017 900+ W banned in EU

Basics of Electricity

- Installed Capacity
- Electricity Production (work)
- Capacity Factor
- Efficiency and Energy Transformation



Installed Capacity in the Electricity Grid on 31 December 2012

Type of Power Station	Installed Capacity (MWe)	Percentage (%)
Thermal Power Station	10644	51.9
Gas Combined Cycle Power Station	521	2.5
Gas Fired Power Station	750	3.7
Hydroelectricity	1069	5.2
Pumped-storage Hydroelectricity	1147	5.6
Nuclear Power Station	4040	19.7
Wind Power	263	1.3
Solar Power	2086	10.2
Geothermal Power	0	0
Total	20520	100

Source: Energetický regulační úřad, 2013, s. 11.

Gross Electricity Production in 2012

Type of Power Station	Electricity Production (GWh)	Percentage (%)
Thermal Power Station	47 261.0	53.9
Gas-fired and Gas Combined Cycle Power Station	4 435.1	5.1
Nuclear Power Station	30 324.2	34.6
Hydroelectricity (incl. Pumped-storage Hydroelectricity)	2 963.0	3.4
Wind Power	417.3	0.5
Solar Power	2 173.1	2.5
Total brutto production	87 573.7	100
Total netto production	81 088.4	92.6% of brutto production

Source: Energetický regulační úřad, 2013; percentages by T. Vlček.

Capacity Factor in 2012

Type of Power Station	Potential Eletricity Production (GWh)	Electricity Production (GWh)	Capacity Factor (%)
Thermal Power Station	93 241.4	47 261.0	50.7
Gas-fired and Gas Combined Cycle Power Station	11 133.9	4 435.1	39.8
Nuclear Power Station	35 390.4	30 324.2	85.7
Hydroelectricity (incl. Pumped-storage Hydroelectricity)	19 412.2	2 963.0	15.3
Wind Power	2 303.9	417.3	18.1
Solar Power	18 273.4	2 173.1	11.9

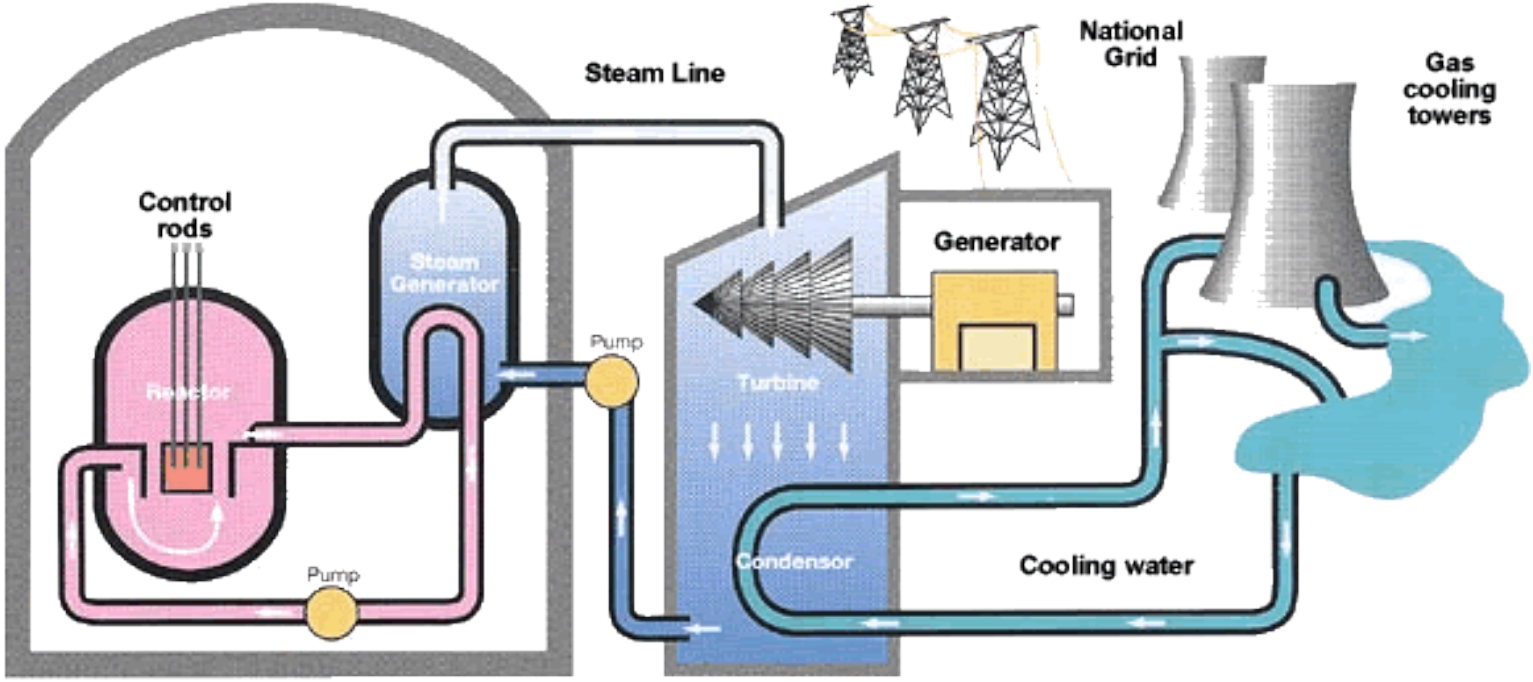
Source: Energetický regulační úřad, 2013; percentages by T. Vlček.

How did I calculate the Potential Electricity Production?

Boiler variants of Coal-fired power plants			
Type	**Pressure (MPa)**	**Temperature (° C)**	**Efficiency (%)**
Sub-critical	12 – 20	510 – 560	35 on average
Critical	23 – 25	510 – 560	35 – 47
Super-critical	25 – 36	580 – 600	up to 47
Ultra-super-critical	25 – 36	600 – 700	up to 54
Source: Kolat, Roubíček, & Kozaczka, 2008, s. 20.			

Technical aspects of electricity production in different power stations		
Type of Power Station	**Capacity factor (%)**	**Conversion efficiency (%)**
Thermal	50 – 80	32 – 47
Nuclear	80 – 95	27 – 33
Gas Combined Cycle Power Station	11 – 60	38 – 60
Solar	5 – 20	12 – 14 (25, 34)
Wind Turbines	15 – 28	20 – 45
Pumped-storage Water	10 – 15	85 – 95
Water-flow	45 – 70	85 – 95
Source: author		

Energy Transformation and Efficiency



Nuclear Energy

stored in the nucleus of an atom and released as nuclei are split

→

Heat Energy

produced from the fission as kinetic energy of the fragments of the fission and the KE of free neutrons

→ used to heat water and produce steam that under pressure causes turbine blades to turn

Kinetic Energy

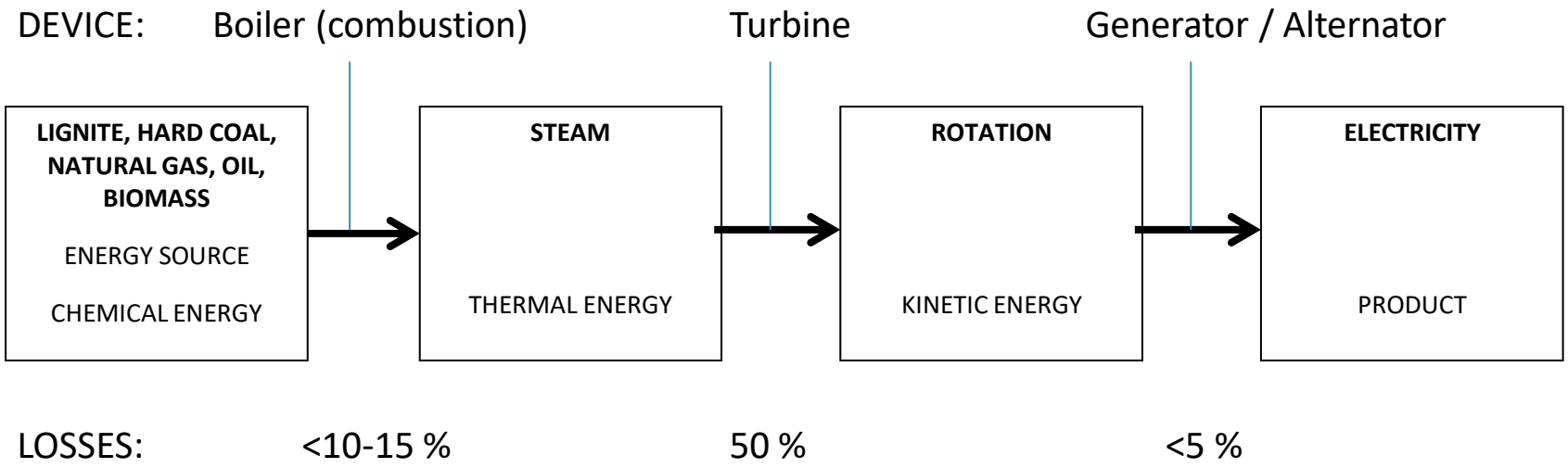
The turning of the turbine makes the coil of wire turn in a magnetic field

→

Electrical Energy

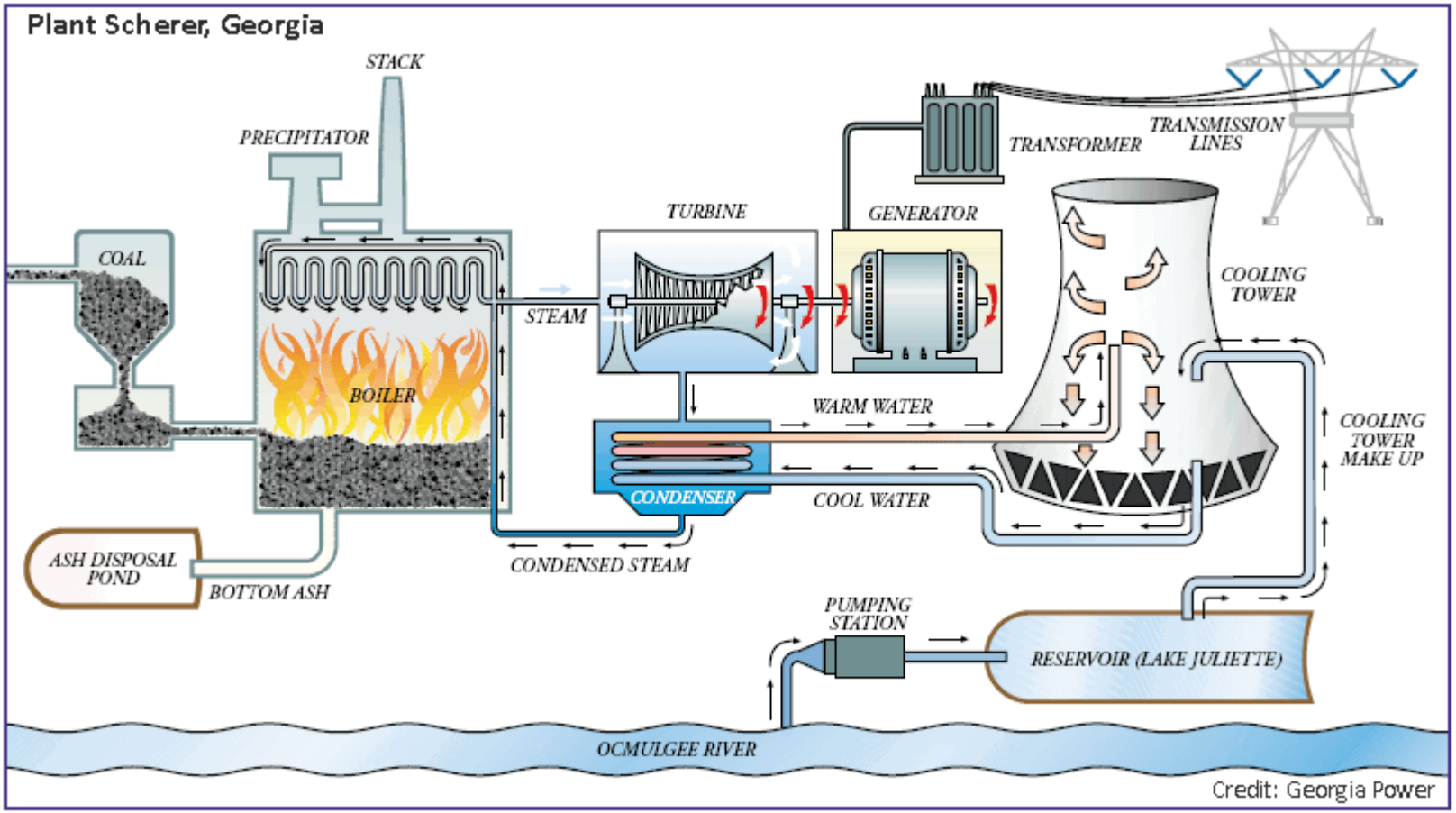
Produced by electromagnetic induction and then tranmitted to the National Grid to be transported around the country.

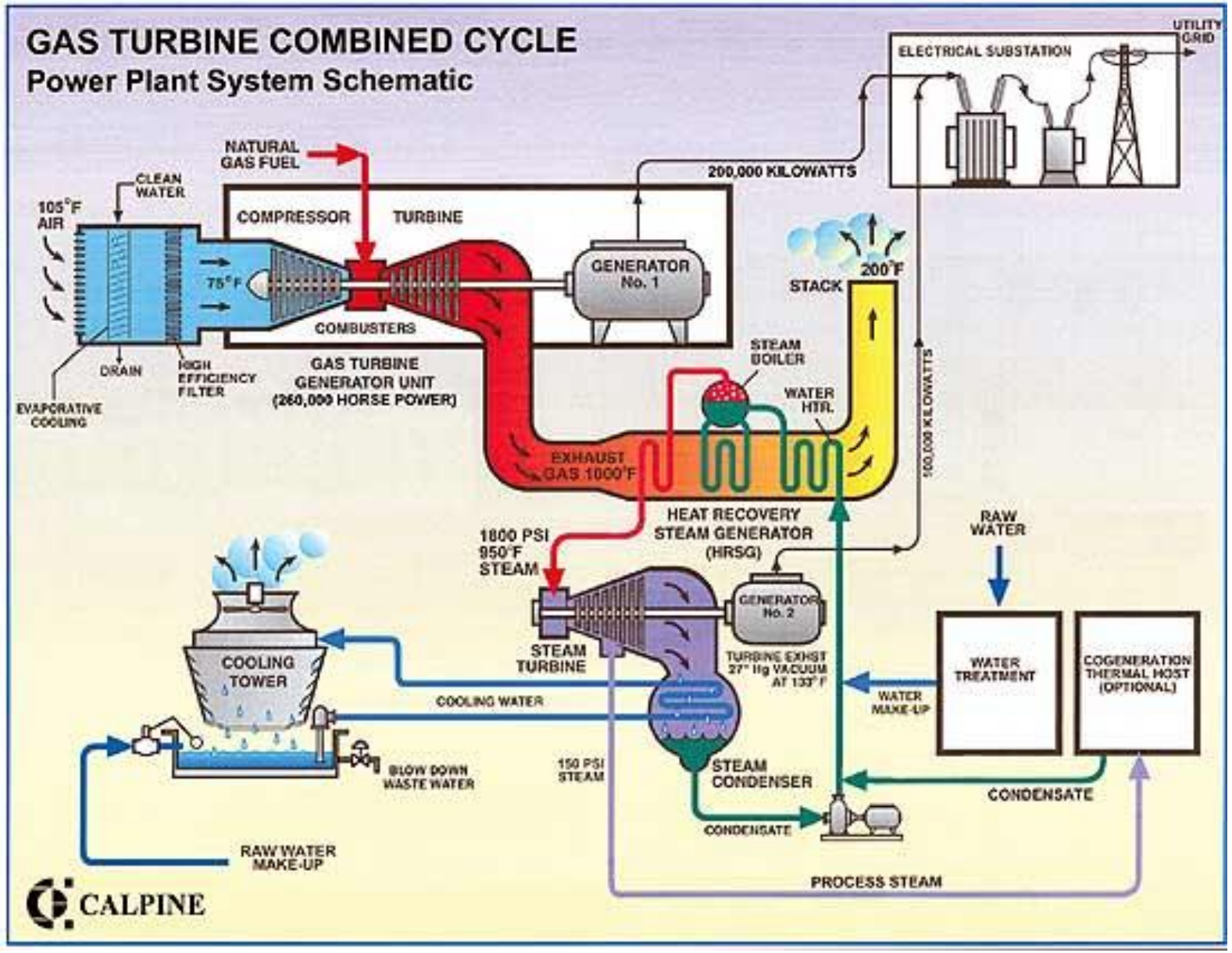
Energy Transformation and Efficiency



EFFICIENCY is the sum of effectivity of all energy transformation processes, in the picture above it is calculated as 100 x 0.85 x 0.5 x 0.95 = 40.375%

ELECTRICITY is an intermediate form of energy, we do not use electricity, but heat, light, mechanical energy = effectivity (losses) of downstream appliances is also in play


Plant Scherer, Georgia
STACK
PRECIPITATOR
TRANSFORMER
TRANSMISSION LINES
TURBINE
GENERATOR
COAL
COOLING TOWER
STEAM
BOILER
WARM WATER
COOLING TOWER MAKE UP
CONDENSER
COOL WATER
ASH DISPOSAL POND
BOTTOM ASH
CONDENSED STEAM
PUMPING STATION
RESERVOIR (LAKE JULIETTE)
OCMULGEE RIVER
Credit: Georgia Power


GAS TURBINE COMBINED CYCLE
Power Plant System Schematic
UTILITY GRID
ELECTRICAL SUBSTATION
200,000 KILOWATTS
NATURAL GAS FUEL
CLEAN WATER
105°F AIR
COMPRESSOR
TURBINE
GENERATOR No. 1
75°F
COMBUSTERS
DRAIN
HIGH EFFICIENCY FILTER
EVAPORATIVE COOLING
GAS TURBINE GENERATOR UNIT (260,000 HORSE POWER)
200°F
STACK
STEAM BOILER
WATER HTR.
100,000 KILOWATTS
EXHAUST GAS 1000°F
HEAT RECOVERY STEAM GENERATOR (HRSG)
1800 PSI 950°F STEAM
RAW WATER
GENERATOR No. 2
STEAM TURBINE
TURBINE EXHST 27" Hg VACUUM AT 133°F
COOLING TOWER
COOLING WATER
WATER MAKE-UP
WATER TREATMENT
COGENERATION THERMAL HOST (OPTIONAL)
BLOW DOWN WASTE WATER
150 PSI STEAM
STEAM CONDENSER
CONDENSATE
CONDENSATE
RAW WATER MAKE-UP
PROCESS STEAM
CALPINE

How much will I pay for 2 litres of tea, if I have a 1 l electric teapot (P = 1,500 We)? It takes 5 minutes to boil the water in the teapot and the electricity costs 4 CZK /1 kWh.

How much will I pay for 2 litres of tea, if I have a 1 l electric teapot (P = 1,500 We)? It takes 5 minutes to boil the water in the teapot and the electricity costs 4 CZK /1 kWh.

The teapot is used twice for 5 minutes

= 10 minutes

= 1/6 * 1,500 We

= 250 Wh

= 0.25 kWh = 1 CZK

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?

2010 vacuum cleaner

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

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

2018 vacuum cleaner

5 hours in 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?