1. **Describe an overview of the world's available energy sources: renewable / non-renewable sources and how we can use them to cover our energy needs.**

Solid fuel / oil /natural gas / nuclear heat/ biomass/ geothermal energy / solar energy / wind energy / hydro power /… we can use them for create heat or electricity.

2. **Which energy sources are most common in primary energy consumption in the world and describe what all affects the energy balance from primary to final consumption.**

Oil, coal and gas.

What affect the energy balance is the supply chain, the energy conversion rate and how the source of energy is consumed.

3. **Describe the types and characteristics of the use of renewable energy sources: hydropower, water power, biomass, wind, solar, geothermal, hybrid power plants**

Hydropower (HPP) water is converted into mechanical energy and then into electricity.

- run of river
- reservoir

Water power:

- TIDAL ENERGY, use of ocean tide rise and fall;
- WAVE ENERGY, the aim is to drive a turbine that generates electricity.
- OSMOIC ENERGY uses the salt concentrated in seawater to produce electricity.
- HYDROKINETIC ENERGY uses the flow of the river in the river or in the ocean.

Biomass can be produced from various feedstocks, including forest residues, agricultural and livestock waste, etc. We burn them to create vapor that run a turbine.

Wind energy: wind turbine transforms the energy of the wind into electricity through a generator

Solar energy,

- directly produce electricity: photovoltaic panel
- concentrated the sun energy, to create heat

Geothermal exploit heat stored in very deep rock formations

Hybrid power plants, combine those solutions into one power plant

4. Describe the types and characteristics of the use of non-renewable energy sources.

Coal / oil / natural gas / nuclear fuel are non-renewable energy because they come from limited resources.

All of these fuels are used in thermal power plants. TPP is a generating facility that uses the heat given off by combustion of biomass or a fossil fuel or by nuclear reaction**.**

5. Explain the abbreviations EPBT, EROI and what all affects their value.

EPBT = Energy payback time

- life span
- annual electricity production
- operation and maintenance

EROI = Energy return on investment

- life expectancy
- net energy conversion efficiency
- utilization

6. What does the energy potential of a watercourse mean and in what terms do we describe and determine, such as: gross/technical/economic potential….

- *Energy potential of a watercourse*: potential energy of a water quantity on a certain river section, which is converted into electricity in an observed period of time
- *Gross energy potential*: energy of the total water quantity that drains in one year on a certain section of the watercourse.
- *Technically exploitable energy potential*: amount of energy that can be used with known technical solutions.
- *Economically exploitable energy potential*: potential that can be exploited with positive economic effects.

7. Explain the concept of electric power system and which energy sectors it combines.

Consists of electric power facilities that operate in coordinated manner and are systematically interconnected with the aim to achieve a high level of operational reliability and quality of electricity supply.

Combines the capacities of 3 branches of electricity industry:

- electricity generation (power plants)

- long-distance energy transmission (HV transmission line connections)

- distribution of electricity to users (LV distribution network)

8. Explain the concept of interconnection and what are the advantages of connecting individual systems at this level.

Interconnection is useful to achieve greater operational reliability, fault tolerance and mutual assistance to overcome the difficulties if one part of the system is in trouble.

Advantages:

- smaller production capacities and system reserves

- provision of frequently stability

- continuity of voltage

- optimal operation of capacities

- lower generation costs

9. Explain the hydrological characteristics of watercourses in the Alpine area, which are characterized by a runoff regime: snow regime / snow-rain regime / rain-snow regime in the specific case of Slovenia.

- *Snow regime:* characterized by high flows in summer and low flows in winter (Drava and Mura).

- *Snow-rain regime:* rivers in higher alps regions are characterized by high flows in spring and autumn and low flows in summer and winter (Sava, Soca)

- *Rain-snow regime:* in lower pre-alpine area rivers (Sava and Soca) are characterized by high flows in spring and autumn.

10. Describe and explain the basic characteristics of hydropower plants.

- *Investment:* high investment costs, long depreciation period, relatively long construction time

- *Operation*: relatively long operating costs thanks to the possibility of operating autonomy

- *Long duration:* long live reduces impact of investment on energy price and raises competitiveness compared to other sources of production

- *Environmental costs*: contributes as compensation for the exploitation of natural resources, which burdens the price of energy

- *Risks:* production depends on hydrological or weather conditions, which cannot be reliably predicted, so it is not possible to determine precisely and in advance the costs of electricity production

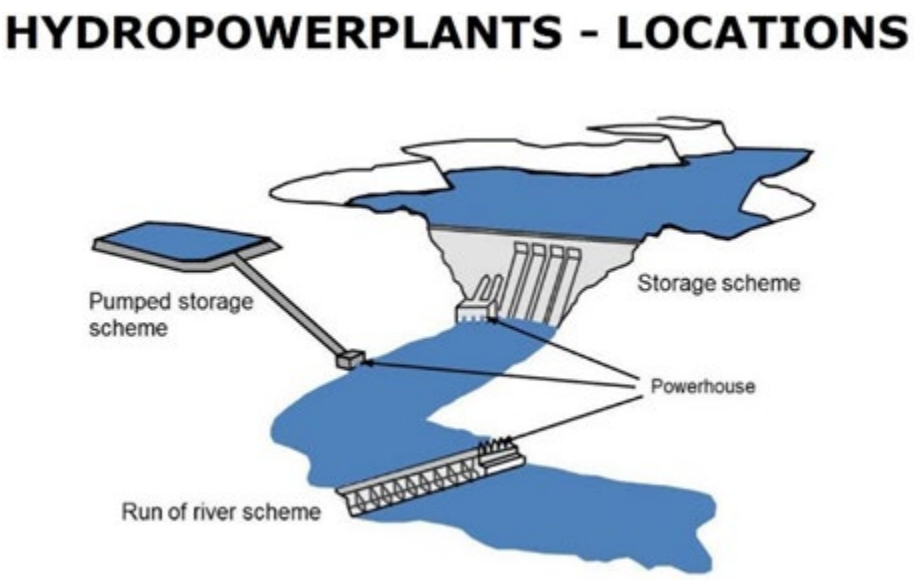
- *Operational independence:* do not depend on energy sources

- *Flexibility:* enabling the absorption of fluctuant in the energy system, and in this way balance the load of thermal power plants and significantly contribute to reducing costs

- *Multipurpose:* enabling the use of the reservoir for other purposes

- *Self-sufficiency:* Slovenia has sufficient knowledge and experience for the implementation of HPP projects almost entirely, with the exception of individual technological units

11. **Describe and sketch the basic types of hydropower plants and where they are usually located by location.**

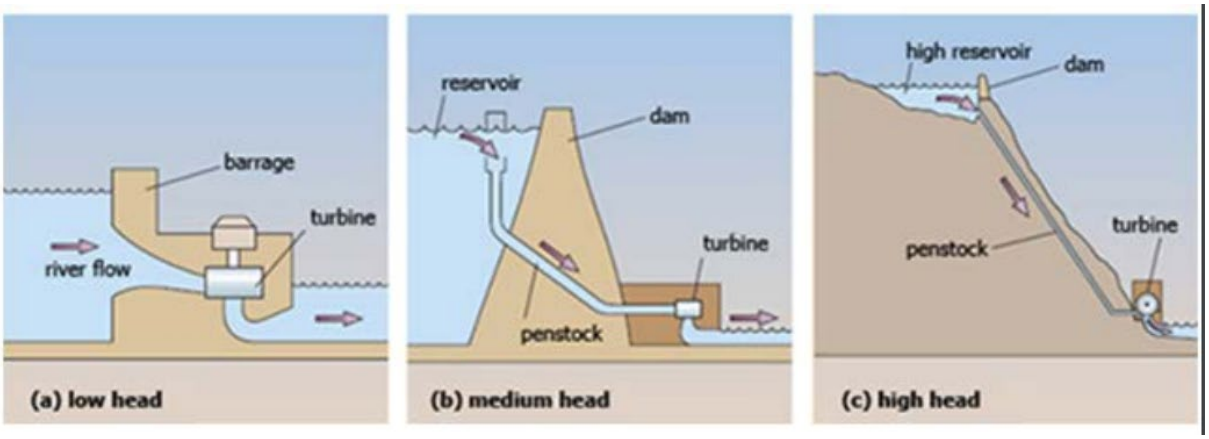


12. **Describe and sketch the classification of hydropower plants by hydraulic head.**

Low Head: (Hb<25m)
- allows a maximum of daily or weekly flow balance
- located in low and middle river section
- no special conditions for construction, due to low height of dam
- not a lot of possibilities to place hydropower component
- canal-type : diversion hpp or run-off-river hpp

Medium Head: (Hb<50m)
- allow for daily to seasonal flow balances
- all types of electrical and mechanical equipment are suitable
- the dam built is more strict because it's higher
- in middle and higher sections of rivers
- most typical types: tunnel diversion hpp and impoundment hpp

High Head: (Hb>50m)
- allow large annual or multi-year balancing of flows
- in upper river sections
- variability of disposition is very limited
- most typical type: tunnel diversion hpp and impoundment hpp
- foundation more demanding at higher dams


barrage
turbine
river flow
(a) low head
reservoir
dam
turbine
penstock
(b) medium head
high reservoir
dam
penstock
turbine
(c) high head

14. Describe the classification of hydropower plants by size and purpose of the reservoir.

Run-of-river hpp without reservoir:
- production depends only on installed capacities and varies with seasonal flows
- annual production availability is 70% to 90% of the total annual water volume

HPPs with daily balanced storage

HPP with weekly balanced storage
- compensation basin required

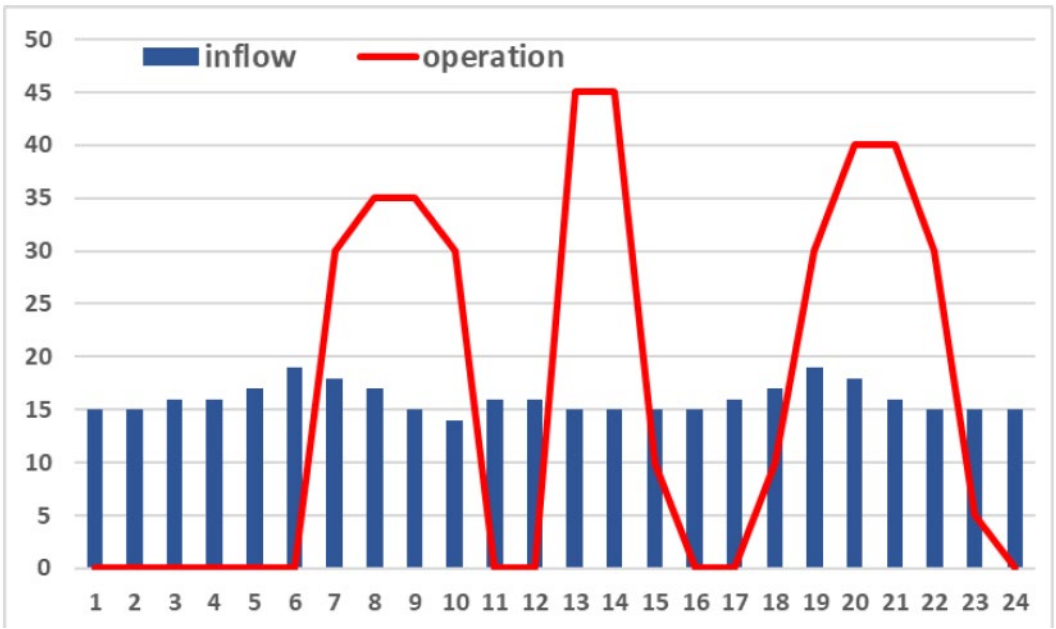
HPP with seasonal balanced storage
- compensation basin required

HPP with annual or multi annual balanced storage
- sufficiently large reservoir is required
- compensation basin required

Cascade/Run-of-river HPPs with balanced storage
- operate in closed chain of HPPs à use of reservoir to balance flow
- first and last HPP has largest reservoir
- intermediate HPPs operate as run-of-river HPPs as minimal fluctuation

Pumped storage HPPs
- water pumped from lower reservoir to higher reservoir when price for energy is lowest (night)
- economical if use of natural lake or existing reservoir is possible

16. Describe and sketch a typical daily consumption diagram and with which production capacities we usually cover it.



17. **For which type of electricity production are suitable pumping power plants, storage power plants and run-off-river power plants - justify with a daily operating diagram.**

When there is an immediate and punctual demand for electricity, this type of hydropower plants is suitable for this demand. They can be easily switched on and off and deliver energy when the network needs it

18. **Describe the possibilities of construction types of hydroelectric power plants to establish a hydraulic head.**

- *impoundment*: hydropower plant -the power house is located within the dam structure or adjacent to the dam. Used with high flows and small riverbed slopes.
- *diversion*: hydro power plant -the hydraulic head is created by diversion tunnel or diversion canal-the powerhouse is located outside the dam area
- *combination* of a diversion and a dam, the powerhouse is located outside the dam area
- *excavation* of the riverbed downstream of the powerhouse if slope of riverbed is large enough

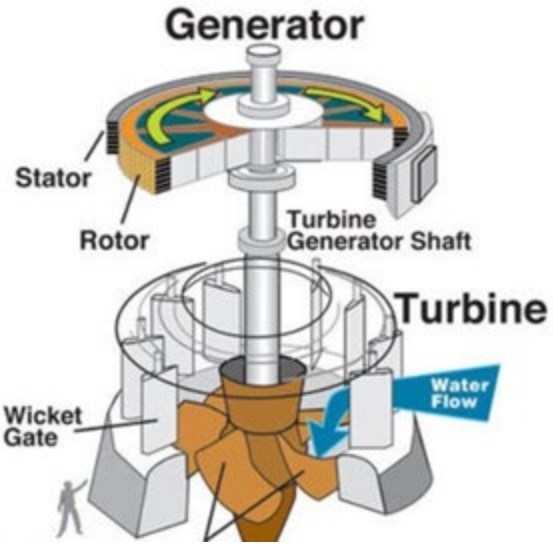
22. **Describe and sketch the Scandinavian/Italian/Swiss underground powerhouse type and what is characteristic of it.**

Scandinavian type: (powerhouse upstream)
- consists of short supply tunnel without surge tank
- build underground in cavern
- no surge tank required if the tunnel operates as free surface flow

Italian type: (intermediate located powerhouse)
- headrace tunnel and tailrace is under pressure,
- pre-turbine valves in are installed in separate cavern to reduce length of powerhouse & for safety in case of breakdown

Swiss type: (powerhouse downstream)
- most common example
- headrace tunnel is under pressure with surge tank, tailrace tunnel shorter
- advantages: easy access to engine room; easier installation and transport of equipment; simpler operating
- disadvantages: long headrace tunnel à water hammer effect; geological structure dictates design

23. What makes up an operating unit in a hydroelectric plant?



24. Describe and sketch how action/impulse turbines work and list the most typical types.

- Operate with their runners in air and convert water pressure energy into kinetic energy of jet that impinges onto runner buckets to develop torque .
- No draft tubes required because the runner must be located above the maximum tail water to permit operation at atmospheric pressure.

Types: Pelton, Turgo, Banki

25. Sketch a vertical Kaplan/Francis turbine with all the key elements and for which heads is it suitable?

- Kaplan turbine: for heads up to 75 m à reachable power: 200 MW
- Francis turbine: for heads from 40 to 750 m à reachable power: 820 MW

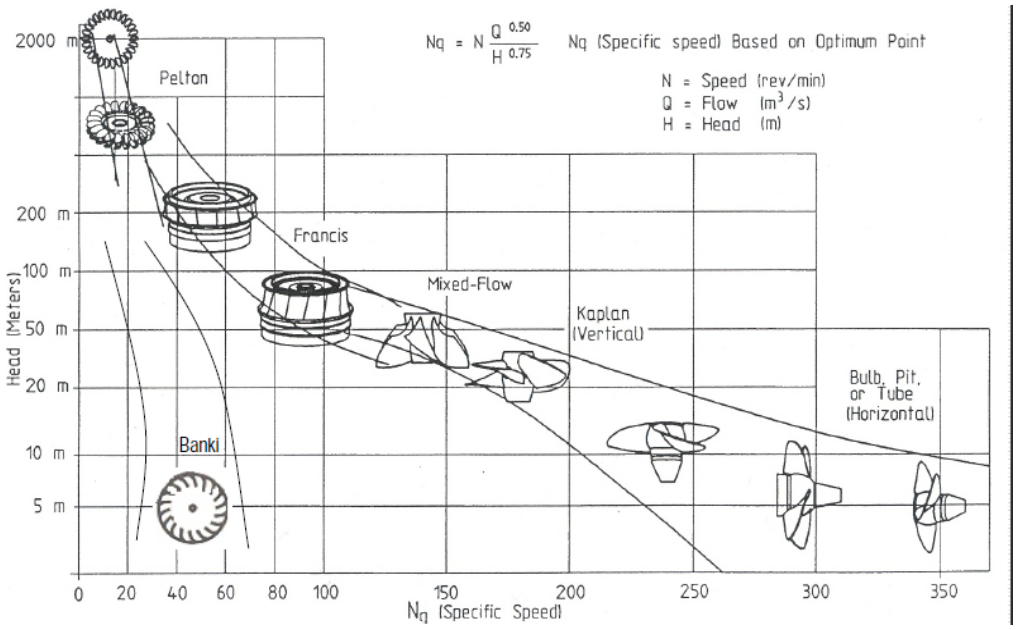
26. Sketch a vertical/horizontal Pelton turbine with all the key elements and for which heads is it suitable?

- Pelton turbine: for heads from 200 – 2200 m à reachable power: 400 MW

27. Define the characteristic number specific speed and what it represents.

- to compare different turbines à defines the operating range and range of application of an individual turbine
- based on head and flow rate (determined on usually on flow-based (N_q) & power-based (N_s) system)

28. Compare the operating range for the main types of turbines and which factors may influence the appropriate choice of turbine.



Nq Pelton < Nq Francis < Nq Kaplan

2 mains factors influence the choice of turbine are net head (m) and flow (m3/s)

29. What do the terms maximum power input, gross and net electricity production mean?

- Maximum power output = power output that the power plant enables when the optimal operating parameters are achieved (head, flow, efficiency, availability, …)

- Gross electricity production = maximum electricity output an electricity generator can produce under specific conditions

- Net electricity production = the amount of gross electricity generation minus the electricity used to operate the power plants

30. What do the terms active power, reactive power, apparent power and power factor mean?

- *Active power*: is the power that continuously flows from source to load in an electric circuit
- *Reactive power*: is the power that flows continuously from source to load and returns back to source in an electric circuit
- *Apparent power:* product of voltage and current or adding active and reactive power only if both have same phase difference
- *Power factor:* ratio of active power absorbed by the load to the apparent power flowing in the circuit