Electricity storage is increasingly entering the picture of everyday discussion. By storing electrical energy, it would be possible to ensure more efficient use and reliable availability of energy produced from renewable energy sources.

Storing electrical energy directly as electrical energy is very difficult. Therefore, electrical energy is stored as another type of energy:

- Electric energy is stored as chemical energy in batteries, as well as in hydrogen fuel cells;
- Potential energy storage opportunities are typical through the use of water resources.

The main determinant of battery capacity is the combination of chemical compounds used in batteries for energy storage. The ability of batteries to store energy is given by a quantity called energy mass density (symbol e'). This quantity shows how much energy we can store in one unit of battery mass. If, for example, the mass of the battery $m_{battery}$ = 10 kg, and the amount of energy $E_{battery}$ = 40 Wh can be stored in it, the energy mass density of this battery is:

$$e' = \frac{E_{battery}}{m_{battery}} = \frac{40}{10} = 4Wh/kg$$

- The lead-acid battery has been known for centuries, for example modern car batteries are lead-acid batteries. It is technologically easier to produce compounds with lead, and its charging and use are very simple. However, lead is very dense and makes batteries heavy.The energy density of a lead-acid battery is expected to be around 50 Wh/kg.
- Lithium-based batteries are lightweight, but more expensive and difficult to manufacture. In addition, they have stricter restrictions on charging and use, thus requiring protection circuits. The use of lithium batteries has accelerated only after the year 2000, when the technologies related to them have become cheaper. The energy density of a lithium based battery is expected to be around 230 Wh/kg.

Systems with lithium batteries for storing large amounts of energy are found, for example, in electric cars, where the mass of the battery is of critical importance.

Calculation of storage capacity of batteries

The storage capacity of batteries is often measured in terms of their charge capacity $Q_{battery}$, which is measured in Ah. It basically shows the time during which the battery would provide a current of 1 A. Since 1 A = 1 C/s and 1 h = 3600 s, there is a total charge in the battery:

$$Q = Q"_{battery} \times 3600s = 1Ah \times 3600s = 3600C$$

We can get the energy stored in the battery if we know the value of the battery's terminal voltage. The unit "volt" represents energy: 1V = 1J/1C (joule per coulomb), so we can find the total energy capacity of the battery by calculating:

$$E_{battery} = Q"_{battery} \times 3600s \times U_{battery}$$

For example, a car battery with a terminal voltage $U_{battery}$ = 12 V, with a charge capacity of 50 Ah, holds a total of energy:

$$E_{battery} = 50Ah \times 3600s \times 12V = 2\ 160\ 000J$$

If we want to store 2 kWh of energy in the car battery, the capacity of the car battery required is:

$$Q_{battery} = \frac{E_{battery}}{3600s \times U_{battery}} = \frac{2kWh}{3600s \times 12V}$$
$$= \frac{2000 \times 3600s}{3600s \times 12V} = 167Ah$$

For this storage capacity, in the case of a lead-acid battery, the total mass of the battery required is:

$$m_{battery} = \frac{E_{battery}}{e'_{battery}} = \frac{2kWh}{50Wh/kg} = \frac{2000Wh}{50Wh/kg} = 40kg$$

Energy storage through hydro energy

Hydropower is often used to store larger amounts of energy. Namely, a very large mass is required for efficient energy storage. The energy stored through potential energy is found as:

$$E_{potential} = m \times g \times (h_{upper} - h_{lower})$$
$$= m \times g \times \Delta h$$

Here, g is the gravitational constant, h upper is the level height of the upper position, and h lower is the level height of the lower position; Δh is the difference between them. m is the mass of the substance used for storage, found from the density as

$$m = \rho \times V$$

SPECIFICATION regarding the 11-12 grade task. The increase in the height of the water reservoir from the amount of water added to it should be considered equal to 1 m. In this case, it is not necessary to take into account the addition of the height difference of the water reservoir, since Δh >> Δh water level.

Energy efficiency when storing

In every conversion transaction involving energy, there is some level of energy loss. This means that less energy is returned from the storage than the amount of energy that was put into it. Such energy lost during storage can be estimated through the storage energy efficiency. Its calculation resembles the efficiency calculation, where

$$\eta_{ES} = \frac{E_{out}}{E_{in}}$$

For example, the storage efficiency factor η_{es} = 60% means that if 10 kWh of energy was input into the storage, then from the storage was returned

$$E_{out} = E_{in} \times \eta_{ES} = 10kWh \times 0,6 = 6kWh$$

If we want to get 15 kWh back from another storage with η_{es} = 50%, then we have to enter into the storage

$$E_{in} = \frac{E_{out}}{\eta_{ES}} = \frac{15kWh}{0,5} = 30kWh$$

Hints for solving tasks:

- 1 Wh = 3600 J; 1 kWh = 3,600,000 J. It is better to do the calculations in kWh or Wh units as they give simpler numbers.
- The battery capacity of an electric car can be found by multiplying the energy consumption of the electric car by the distance traveled.
- The number of batteries cannot be a number with a decimal point, because the batteries are in pieces.
- When calculating the volume, 1m can be taken for the increase in the water level of the reservoir throughout the entire reservoir.