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The electric energy storage management
Zarządzanie magazynowaniem energii elektrycznej

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Abstract: One of the fundamental aspects of the organization management is determination of appropriate strategy for the adoption of development directions and organization areas that needs improvement in the context of existing opportunities and threats based on the organization strengths. The aim of the paper is analysis of the strengths and weakness of E-Guides of European universities in the context of its applying in Erasmus+ programme. Paper is a result of scientific international cooperation of Polish Erasmus coordinator with Turkish Erasmus student.

Streszczenie: Zwiększenie udziału odnawialnych źródeł energii w produkcji energii elektrycznej ze względu na ich zależność od pogody, zmienne zapotrzebowanie na energię w czasie, a także ochrona środowiska wymusza zmianę podejścia do zarządzania systemem elektroenergetycznym i wprowadzanie nowych rozwiązań. W artykule przedstawiono możliwości zarządzania energią i jej efektywniejszego wykorzystanie poprzez zastosowanie magazynów energii. Omówiono kryteria magazynowania i wybrane formy magazynowania energii elektrycznej. Zwrócono uwagę na niektóre istotne wady i zalety wymienionych magazynów energii elektrycznej. Podkreślono, iż nie istnieje jedna, uniwersalna metoda magazynowania energii elektrycznej i równolegle należy rozwijać różne technologie magazynowania, by odpowiadały na zróżnicowane potrzeby.

Key words: energy storage, electric energy, energy management

Słowa kluczowe: magazynowanie energii, energia elektryczna, zarządzanie energią

1. Introduction

An important issue related to the production of electricity and its transmission is to ensure a balance between supply and demand. Due to the development of technologies for capturing energy from renewable energy sources (RES) is a problem appropriate management of the power system. System, in which the energy is generated from renewable sources is unstable system because the energy supply depends on changing weather conditions.. Another problem is daily fluctuation. It is important to eliminate these difficulties that can be supported by electricity storage systems. They will allow for better use of produced energy, limiting losses [1,2].

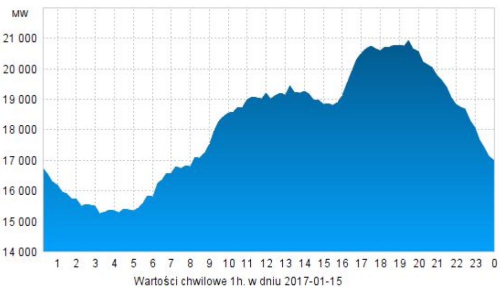

Fig. 1. The daily demand for electricity per selected day [3]

2. Criteria of the energy storage

Aspects that are taken into account in classifying energy storage are following [4]:

- used conversion of the energy carriers:
  - intermediate storage - the accumulation of energy in a different form than desirable, which get in the way of change in the system storage, for example fossil fuel (chemical energy) storage to the desired time,
  - direct storage - the storage of energy in the form in which it is used, optionally in the energy storage source to the process of the direct-conversion, e.g. in the electrochemical energy source,
  - intermediate storage - the accumulation of energy in another form than desirable, obtained in the storage system changes e.g. fossil fuel (chemical energy) are stored to the desired time to get them by burning heat .
- multiplicity of charge cycles:
  - disposable storage - the warehouse has only one charge cycle, e.g. galvanic primary,
  - cyclical storage - storagewith multiple possibility of loading according to the magazine, its number can vary from a few to several hundred thousand, e.g. car batteries,
- timing of storage (time between the loading phase and the phase of energy consumption):

- short-term storage that includes: a temporary storage (in the range of seconds to several mi-nut), periodic minute (from a few to 60 minutes) and the periodic time (from 1 to 24 hours),
- storage medium - storage from 1 to 30 days,
- long-term storage –a season storage (from 1 to 6 months) and long (six months to several years).

A very important aspect related to the energy storage is a density of the stored forms of energy, as well as the efficiency of the cycle, the working temperature, the impact of the energy store on the environment, investment and operating costs. A suitable magazine is chosen having regard to the criteria outlined above, as required, as there is no universal storage technology [4,5].

3. Methods of the electric energy storage

Methods of the electricity energy storage are presented in Figure 2.

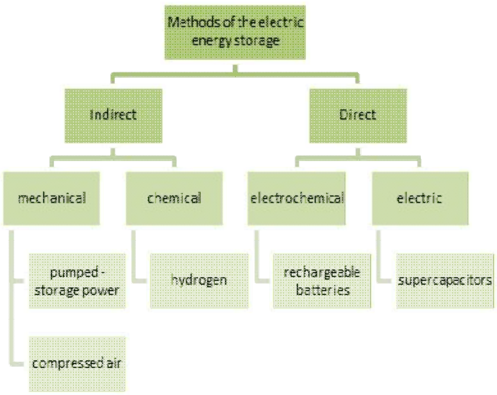

Fig. 2. The division of the electric energy storage due to the form of energy storage examples [5].

Pumped-storage hydroelectricityare currently the only developed form of energy storage on a large scale. Their name is associated with the principle of operation. At the time of peak demand for the energy, water stored-on in the upper tank is directed to a turbine driving a generator - the potential energy of water is converted into electrical energy. In the off-peak time, the excess energy produced at the time of the thermal power to pump water from the lower reservoir to the upper back is used (Fig. 3) [7].

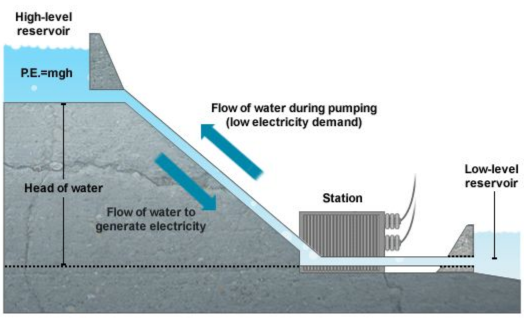

Fig. 3. Schematic construction and operation of hydro - pump [6]

An alternative to hydro - pumping systems are pneumatic energy storage - CAES (Compressed Air Energy Storage), the operation of which is in some ways is analogous to pumped storage systems, except that in this case the working medium is an air, not water. At the time of low energy demand, the band compressor fills the tank (usually under-gas, used for this purpose exploited mines-not or natural caves) with an air at a pressure of 100 atmospheres. During the peak energy released from the air tank is used to produce electricity by conventional turbines burning fuel [7,8].

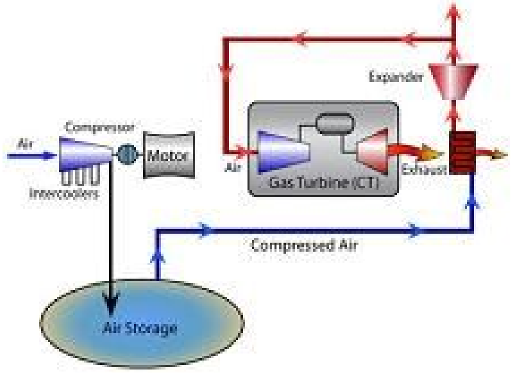

Fig.4. Schematic construction and operation of energy storage system using compressed air [9].

Another way to use the excess energy when the supply exceeds the demand is the use of the energy for the production of fuels such as methanol, methane and very promising hydrogen and at peak demand is recovered, usually by burning. Hydrogen because of its high calorific value (in pure form is about 120 MJ/kg) and the availability, it appears to be the fuel of the future. Unfortunately, despite its universality, hydrogen does not occur on Earth in its pure form, but there is developed a number of methods that allow it. Hydrogen is obtained inter alia in the process of electrolysis of water, gasoline reforming or steam methane reforming. The advantage of this fuel is the lack of harmful emissions during the combustion process - the product of combustion is only water.At the moment, the hydrogen storage is used, inter alia, special containers, where it is stored as a compressed gas or chemical metal hydrides. This method involves storing hydrogen in the form of chemical compounds, i.e. KH (sodium hydride), NaH (sodium hydride) $NaBH_4$ (sodium borohydride) that, when the need to break down by supplying a chemical-no water and a catalyst [10].

A common (and at the moment the most developed) in everyday life storage of electricity is a battery (Fig. 5), which is used to power all kinds of portable electronic devices like laptops and cell phones, but also in the automotive industry or as an emergency power buildings. The battery pack is made up of two different electrodes immersed in an electrolyte. As a result of chemical reactions between these elements, on one of the electrodes there is an excess of electro-moon, and on the other a shortage - the chemical energy is converted into electrical energy. Despite the high efficiency and universality of such a solution, the batteries have a significant drawback - the most commonly used in these environmentally harmful substances, such as acids or heavy metals [6, 10].

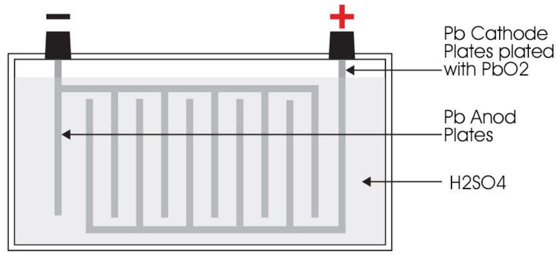

Fig. 5. Scheme of the battery on the example of lead battery [11]

Although electrochemical methods are classified as direct methods of energy storage, is among the examples presented here warehouses, only super capacitors store the energy in the form of the final product or electricity. This device combines the features of a traditional battery as well known and widely used capacitor.

Super capacitor is composed of two non-reactive to the porous electrode-electrolyte between which a voltage is applied (Fig. 6). The principle is based on the collection of goods by attracting ions to the electrodes (positive ions to the negative electrode, the negative ions to the positive electrode - the magazine is loaded), resulting in the formation of two layers separated charges. The capacity of the super-capacitor is proportional to the electrode area and inversely proportional to the distance between them. The prefix "super" device owes its properties, including very rapid charging and discharging, through which achieve high power density. Recent super capacitors nominal characterized by high durability. They can withstand up to a million charge cycles. Their big advantage is small size, because it can store more energy than conventional capacitors.

Although electrochemical methods are classified as direct-means of energy storage, only super capacitors store the energy in the form of the final product or electricityamong the examples presented storages. This device combines the features of a traditional battery as well known and widely used capacitor. Super capacitor comprises two electrodes of non-reactive porous electrolyte between which a voltage is applied (Fig. 5). The principle is based on collecting goods-device by attracting ions to the electrodes (positive ions to the negative electrode, the negative ions to the positive electrode - the magazine is loaded), resulting in the formation of two layers separated charges. The capacity of super capacitors is proportional to the post-surface electrodes and inversely proportional to the distancebetween them. The prefix "super" device owes its properties, including very rapid charging and discharging, through which achieve high power density. Recent super capacitors nominal characterized by high life - they can withstand up to a million charge cycles. Their big advantage is small size, because it can store more energy than conventional capacitors [4, 6, 10].

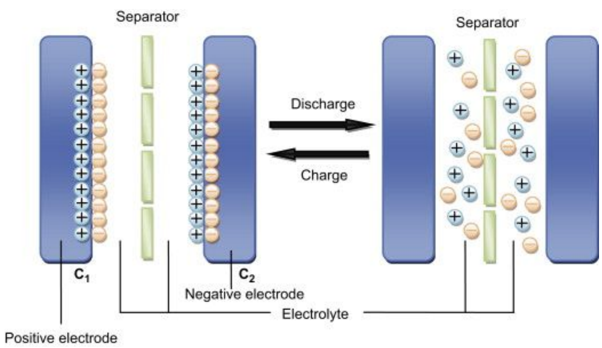

Fig. 6. Schematic diagram of the super capacitor and principle of its operation[12].

4. Conclusion

The energy storage is a response to the growing awareness of the need to care for the environment and the rational management of produced electricity. It allows minimizing and in the future can quite eliminate fluctuations in demand compared to the supply of electricity at the time, caused varying energy needs of the time and the instability of the system of power, which is result of the renewable energy share increase in total electricity production, that are dependent on changing weather conditions.

The article presents just a few of the developed energy storage technologies. Taking into account the different issues, it can be stated that there is no universal method of the energy storage. They can differ among themselves in know-many aspects. Despite the high cost of using the described techniques should be developed in parallel because of the different properties of storage (Table 1).

Table 1. Performance of some storage technologies [13]

Storage type	Power (MW)	Discharge time	Efficiency (%)	Lifetime (yr)	Capital cost (USD/kW)
Pumped Hydro	250-1000	10h	70-80	<30	2000–4000 (100-300) b
CAES	100-300	3-10h	45-60	30	800-1000 (1300-1800) c
Super Capacitors	10	<30s	90	$5*10^4$ cycles	1500-2500 (500) d
Lead battery	3-20	10s-4h	75/80 DC 75/79 AC	4-8	1500-2000

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