ENERGY STORAGE AND MULTIPLE USES OF RENEWABLE ENERGY SOURCES

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The increasing use of renewable energy sources requires solving problem of the effective redistribution obtained energy for the agreement two processes – energy generation and consumption. For this purposes energy storage devices are needed. At present day world total energy storage capacity is about 112 GW-h. In large and middle scale applications proposed pumped and pneumatic storage systems, hydrogen and electrochemical batteries. Multiple use different renewable energy sources in common hybrid system, can significantly decrease need in energy storage. The most effective multiple use of renewable energy provided by union with hydropower station.

Renewable energy sources, energy storage systems, hydroelectric power plant, wind power station hybrid system

The reform of power sector of Russia realizes new principles and mechanisms of state support and promotion of use of renewable energy sources. Under these conditions, the accumulated energy of renewable energy sources gives the possibility to leave for the new electricity markets. However with the increasing use of renewable energy sources, problem of the effective redistribution obtained energy in time become more important.

As is known, generation of renewable energy bears stochastic nature, simultaneously the process of consumption is also uneven and depends on the rhythm of the life, type of energy consumption etc. For the agreement of these two processes in general case (with or without electricity grid) energy storage devices are needed.

At present day energy storage devices gain increasing interest and even become essential with regard to higher shares of renewable power generation.

For the perfect fit to individual conditions different energy storage systems can be proposed (Fig. 1)

The most well established energy storage system through the years is pumped storage. Pumped storage is large-scale and has 99% (110 GW-h) share from world electric energy storage capacity. The basic motivation for the large-scale storage of electrical energy is the saving of excess energy that is created in basic load power stations in times of light load, as well as through delayed dynamic dumps as high-load energy in times of increased demand. Further possible applications are secondary regulation (capacity frequency regulation) and the supply of swiftly deployable energy reserve capacities to increase the operational reliability of the of the electricity network.

In the middle-scale energy storage systems presented by electrochemical batteries: well established lead acid batteries and innovative NaS and Flow-batteries. Instead lage-scale storage on pumped hydro or caes electrochemical batteries mobile and independent from specific site. This allows to create smart standalone energy systems. On the other hand capital costs of this energy storage systems proportional growth with storage capacity (Fig.2). Also electrochemical batteries have limit cycles of life.

Other way to solve problem with stochastic nature of renewable energy sources is their multiple use. Multiple use different renewable energy sources in common hybrid system, can significantly decrease need in energy storage. The expediency of union of Renewable energy sources outflows from the analysis of meteorological data,

confirming character of arrival of wind, solar, and hydro energy occurring at different times that allows energy sources in hybrid system effectively to supplement each other (Fig. 3). Further hydro energy sources gives possibility for energy storage.

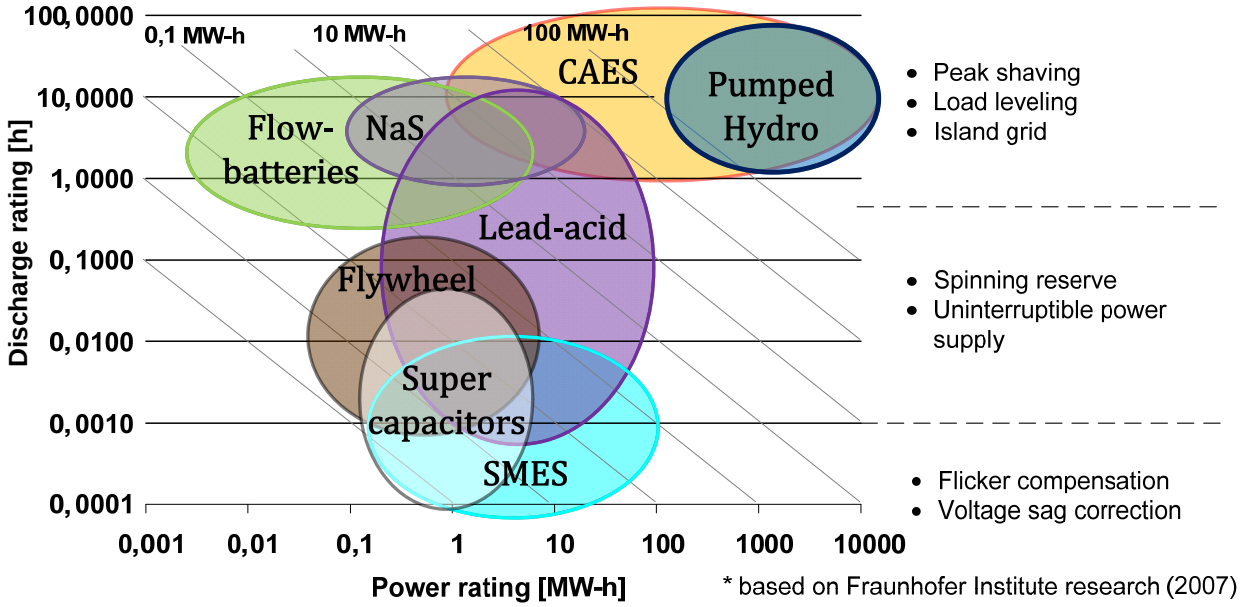

Fig. 1 Scope of electric energy storage systems

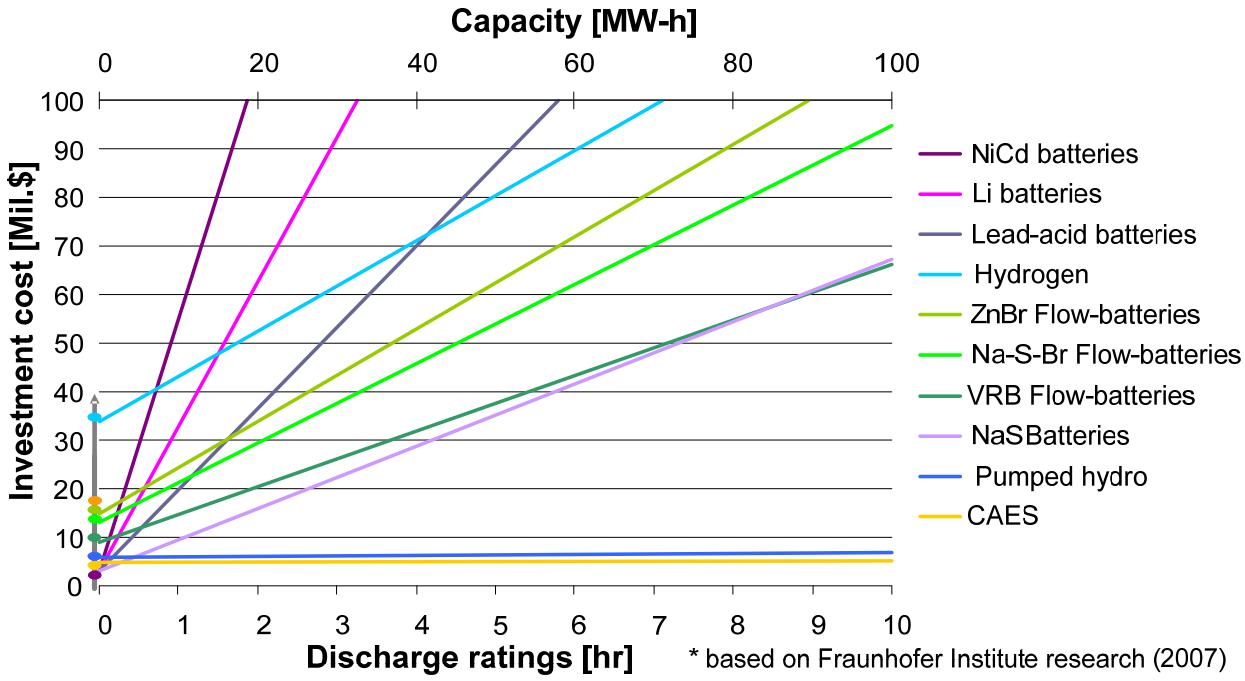

Fig. 2 Investment costs of energy storage systems

The widely utilized at present energy storage systems provide for the retention of end product, i.e., electric energy or another already produced energy. Primary energy storage is more economical and efficient because there are no energy losses for transformation and overflow. Hydroelectric power plant (HEPP) with reservoir can be storage system of this type. In this case it proposed to create enclave or stand-alone energy solutions with hydro power station and other power stations on renewable energy sources, for example wind power station. Interconnection in one power supply

system (hybrid system) will provide the guaranteed power supply of the consumer with hydro energy storage. Thus this hybrid system provides sustainable renewable energy and reduces fuel's influence on an environment.

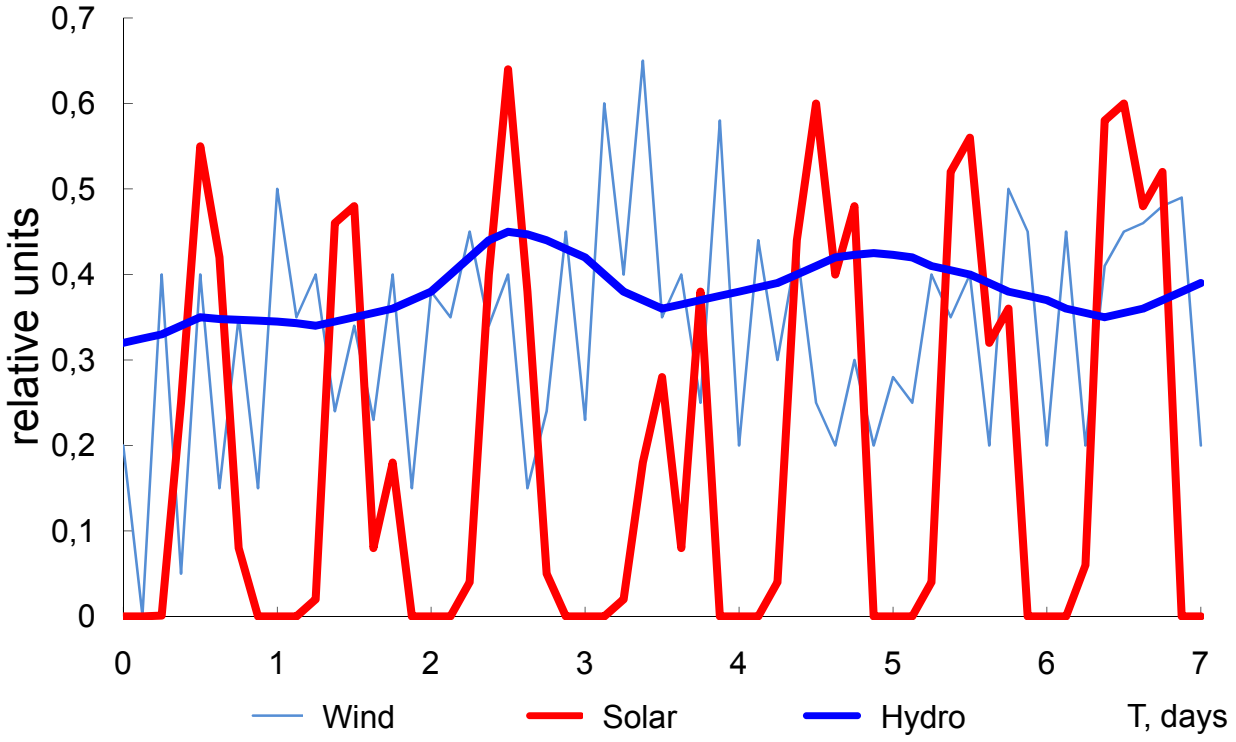

Fig. 3

An example of such solution may be hybrid system with wind and hydropower stations. Wind Power can be managed by Hydro Power through proper plant interconnection. Availability of the storage reservoir of annual, seasonal or daily regulation makes it possible to ensure the work of wind power plant operation with maximum energy output. For this purpose, special operating mode has to be installed on part or on all hydraulic units, which depends on wind flow's characteristics and wind turbine operating mode. Wind power stations (WPS) and Hydroelectric Power Station linked together by communication and electric connections with common control center. In this case, the Hydroelectric Power Station and Wind Power station work in parallel (Fig. 4). The reservoir provides energy storage without transformation losses on input and can establish electric energy storage with high efficiency. Long storage time and high energy capacity of hydro accumulation provides successful use for energy management and decouple in time, providing guaranteed output and smoothing load peaks on site.

Using storage capacity hydroelectric power station reservoir, knowing and varying its parameters we have a possibility to calculate and base firm yield of wind turbine (which is independent of environmental conditions) in specified (estimated) time. The operating mode of the compensation for underproduction in the period of wind-power calms is one additional complex regime, which requires the maximum storage capacity of reservoir. At the same time this operating mode as the most critical, makes it possible to base the installed capacity of the wind-power station with firm yield ensuring. In this case, the installed capacity of the wind-power station is selected from the condition of the possibility of coating the load curve taking into account the additional discharge of water from reservoir and power production on HEPP.

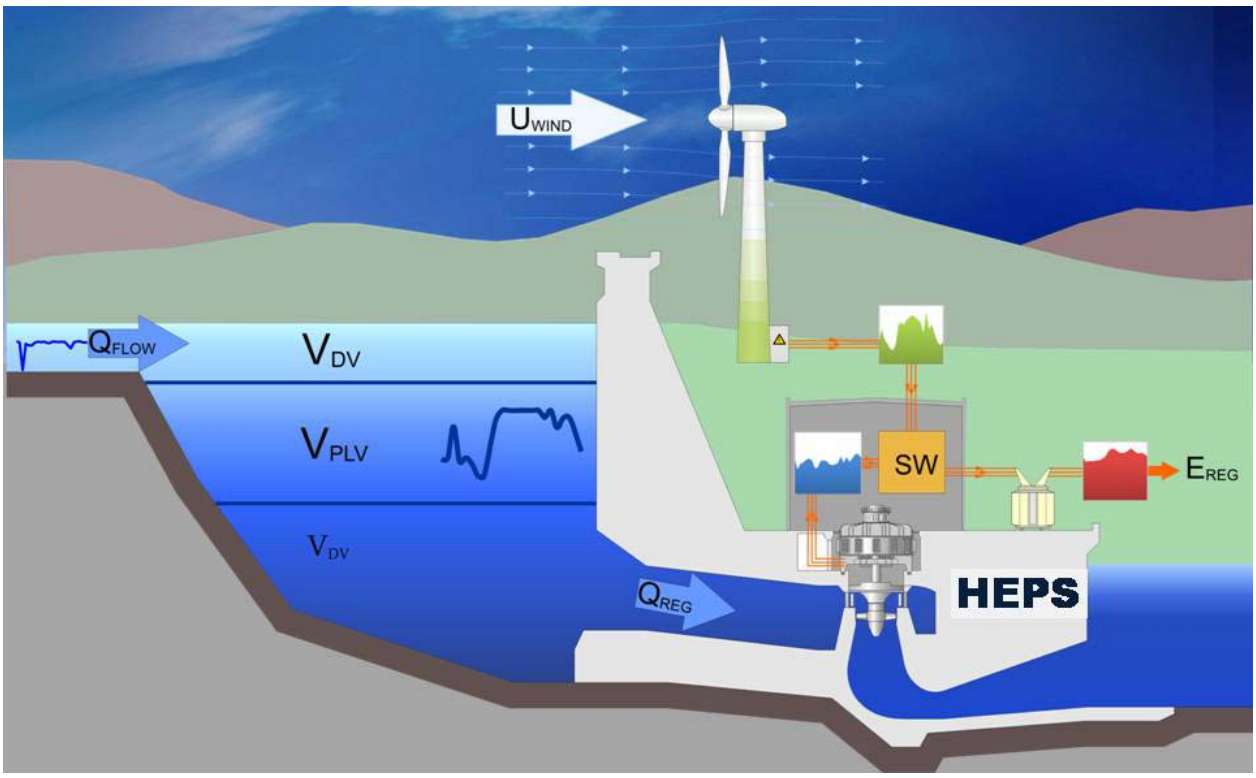

Fig 4. Scheme of the hydroelectric power station and wind power station joint operation

Such hybrid system allows reserving the electric energy produced by Wind Power Station in the form of potential energy of water in the reservoir and in a necessary time to convert it back through hydraulic units of HEPS. Thus, there is no double transformation of energy that causes high efficiency and storage time practically beyond all bounds (Fig 5).

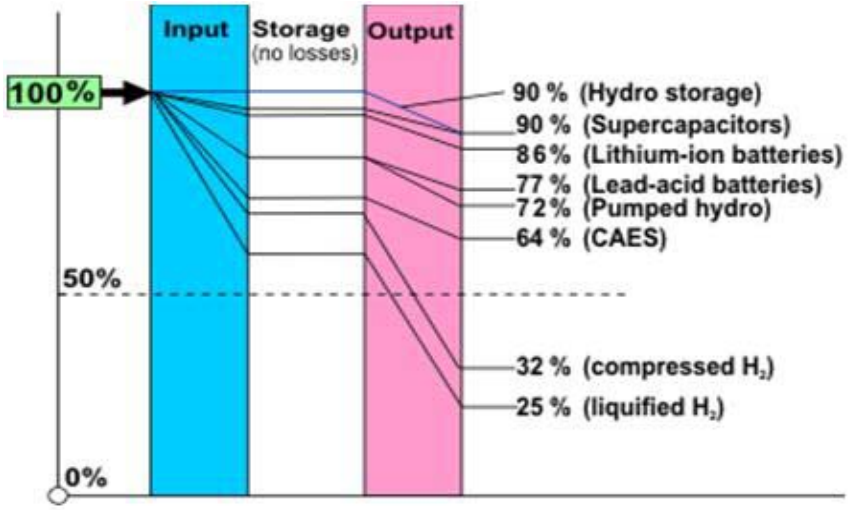

Fig. 5 Energy storage transfer losses

As part of the program wind energy development in Russia, one of the first planned is reconstruction Zapolyarnaya (1.5 MW) wind power station, consisting of 6 HWT with a capacity of 250 kW, constructed in early 90-ies in the Republic of Komi, 30 km from the Vorkuta city. There is a water reservoir of the Uca river near WPS with

capacity of 16 million cubic meters, where, water is pumping by 5.1 MW Pumping station to Vorkuta city. To ensure energy for pumping station and other local consumers it is supposed to build a small hydro power plant with Wind power station joint operation and thus to create an autonomous hybrid system with hydro storage of energy produced by the WPS. Hydraulic units of HEPS assumes place in the regulation system of pumped station. The head of HPS is 10.46 meters, installed capacity of 4.2 MW. During the reconstruction of the WPS is proposed to mount the new Units – 4 HWT with installed capacity of 1 MW each, adapted for operation in cold climatic conditions. (eg, WWD-1) Renewed wind power station will have electrical and data connection with hydroelectric power station creating the stand-alone hybrid system, which is capable to generate electric energy for a pumping station. For compensating wind energy fluctuations, hydro power plant units operate in sharply variable modes, ensuring the fitting of energy production and consumption. The capacity of the reservoir is sufficient for a monthly management and change slightly in the daily mode. The average efficiency of the system in the daily cycle regulation was - 89.6%. Common yearly output of hybrid system — 26,3 MWh including hydroelectric power station output 18,1 MWh and wind power.

Calculations indicates that efficiency of hydraulic energy storage based on HEPS is one of the best among the other storage systems and can be amounted to 90% including operation losses 1-2%.

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