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Demands on energy storage for renewable power sources

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ABSTRACT

The article deals with the issue of energy storage facilities for renewable energy sources. Due to the ratio between power delivery and take-off, the energy storage system is a key element in these systems. It is useful to divide the energy storages into short, long and backup energy storage. Based on an analysis of the energy consumption of an apartment or habitable unit, it is possible to define the properties of each type of storage.

1. Introduction

Like other systems, renewable energy systems must also include energy storage. These storages are crucial to ensure the continuous operation of a home or residential unit. Short-term or long-term energy storage can compensate the differences between income and outcome energy.

The Renewable Energy Sources (RES) use the direct transformation of solar radiation through solar cells, concentrators, solar collectors, as well as the indirect use of solar radiation through biomass, water sources, heat pumps, wind power plants, the use of marine energy and so on, … [4–6]. The geothermal resources have a specific position in RES.

The RES systems may contain various types of energy storage such as: electrochemical accumulators, superconductors, superconducting units, rotary, air-pressurized and others. These types of storages are referred to as short-term. Except this option, long-term storages can be used, but they work on different principles. Long-term storage tanks have to keep their energy supply for a period of years. These are, for example, biofuel containers.

Electrochemical accumulators [1–3,7,8] are currently the best available to the user. It is also necessary to design the size of the battery assembly for the short-term energy storage of the required amount of electricity. Long-term energy storage bases are principally functional, but not yet technologically finalized for the stage of general use.

2. Definition of RES

Renewable energy sources (RES) on the Earth's surface can be defined as the technical means that collect the available energy within range, modify it and deliver it to the user for consumption.

Energy collection is subject to availability of energy in the area. Accessibility has a different time profile. Collection of energy from direct or diffused solar radiation is limited by the daily cycle and meteorological situation in a particular location on the Earth's surface, entering the ground level. Wind energy collection is limited by the regular or irregular occurrence of the wind with the necessary force. Geothermal energy collection is relatively stable, but it can also be variable in time. The energy gain from the tidal wave is regular, but it has phases when the energy is available, or there is a change between tides and waves. The energy of the sea waves depend on the stormy situation over the sea. The energy from the water depending on the actual water flow or the water reservoir over that source.

The most energy form conversion is from the solar energy into electrical or thermal energy. It may also be changed to positional, pressure and other type of energy. Energy conversion is also associated with its storage in buffer dispensers to reduce disproportion between collection and energy consumption.

The consumer needs to have the available electrical and thermal energy constantly, but the time profile of consumption may vary. For example, heating will be approximately constant, we need a stable room temperature. However, the hot service water is discharged irregularly. Usually in the morning and evening, as a regular the withdrawal. Over the day, according to the current activity, resumption is irregular.

A key element for the continued operation of such a RES system is the energy storage.

3. Reservoirs of energy in RES

The form of available and consumed energy can be the same or different. Getting heat and heating energy is a good combination, but it needs a stack to offset timeless processes.

In the case of different forms of available and consumed energy, a

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reservoir is also needed, also to offset the time-lagging processes of energy generation and consumption. For example, acquiring electricity from direct sunlight and its consumption on mechanical motion may also be uncoordinated. The combination of the form of collected and consumed energy can be a great deal.

It should be noted that in the RES we need to have an energy reservoir included due to the continuous operation of RES.

However, by energy manipulation, the fact is that to increase the efficiency of energy use, it is necessary to use the devices as simply as possible or without reservoirs. For example, to pump water into the reservoir, we can use an electric pump that is powered by photovoltaic panels through an electric accumulator. Here the electric accumulator acts as a compensating element for the optimal operation of the electric drive of the pump. However, it is also possible to use a mechanical method where the blade is driven by the wind and the mechanical motion of the pump drives the water to the tank. Obviously, the second, easier way of direct use of mechanical energy is more efficient and reliable.

If it is not possible to use a more straightforward method of direct use of the form of energy, it is necessary to use the RES system with a defined form of energy to carry out all the necessary activities.

For island RES systems, oriented to use for residential units of citizens, two forms of energy need to be delivered: thermal and electric. Therefore, the reservoirs should store either directly or indirectly the form of thermal and electrical energy, or the form of stored energy must be readily reversible to the two forms.

Keystones for residential units of citizens are storage tanks for heat and electricity. The user needs to store energy at three-time levels:

- for immediate use (short-term storage),
- for use in periods of lack of energy (long-term storage),
- for use in emergency situations (backup power sources).

3.1. Short-term storage

The principle of short-term storage of heat and electricity is similar. The energy obtained is stored in this form and, if necessary, withdrawn from the container.

Heat energy is obtained from the surrounding environment via a solar collector, heat pump, electric spiral from the electrical system, this heat energy is stored in the reservoir so as to heat the heat medium. Heat transfer is usually via the primary circuit from the source to the stack and back. The medium is often liquid, sometimes fixed or combined. Sometimes heat is stored in the form of a change in the heat carrier medium. Heat collection is only carried out using a secondary circuit with heat transfer fluid from the tank to the appliance. The appliance may be a heater, like a central heating system.

Electricity is obtained from the surrounding environment in photovoltaic panels, fuel cells, wind generators, water generators, DC electricity is fed into the storage tank, which is the most common chemical accumulator. The battery is recharging, energizing and storing in a chemical reaction. In addition, the accumulator may consist of an energized flywheel, superconductor, or other device. Electric energy is taken immediately by connecting an electrical appliance. Then the battery is discharged, the chemical energy is released in a chemical reaction. From the flywheel, we get the electric power so that the engine running will change to the generator.

These storages have the advantage that we can take the electricity instantly as needed. If the charging is at the same time, the battery only covers the difference between take-off and charging. If the subscription is small, only the battery charge is reduced by this value.

But they also have drawbacks. Although the thermal container is heat-isolated to reduce heat loss, losses cannot be reduced to zero. After a few days, the media temperature drops considerably in the energy storage. Similarly, the electric accumulator is gradually self-biasing. Over time, the amount of stored electricity will be reduced.

Short-term energy storages must be recharged at every opportunity. They enable power delivery at the point of time when the power cannot be recharged. The amount of energy stored overlays only a short period, the order day. For overclocking for several days, the stack increases considerably, or it may need to be folded from several standardly stocked energy storages. This is a disadvantage of short-term storage.

3.2. Long-term storage

The principle of long-term storage of energy is in a form that is stable over a long period of years.

Often it is about hydrogen. This is one of the perspective ways of long-term energy storage. The water is decomposed by means of electric energy by the electrolysis method, for example, in the fuel cell. Hydrogen and oxygen should be stored in a way that eliminates leakage and mixing. A great advantage is its non-toxicity in the event of leakage into the atmosphere. At the same time, the hydrogen reaction with oxygen generates water which is also capable of repeated decomposition. The disadvantage is, however, in its considerable explosiveness. Solving this problem is a technological issue. This problem is expected to be solved in the future.

Long-term storage of energy is principally in fact, that we acquire and store energy at a time when it is surplus and is not consumed. It is then stored for a long time. In a period of shortage of energy, these stocks are again used to re-release the stored energy. An essential condition is the requirement to save energy for a long time. The re-release of the stored energy can be started with a delay and hours without disturbing the continuous operation of the RES system.

3.3. Backup resources

Back-up power sources are in the RES system exclusively for emergency purposes. Then there will be a failure or failure of the RES systems, or in particularly adverse meteorological situations, the energy has been exhausted in both short and long-term stores.

Back-up resources can be ecological. These are, for example, the production and drying of wood pellets for use in winter and in emergency situations. However, the possibility of combustion of fossil fuels (natural gas, diesel) to produce heat or the use of a diesel power plant is also always available.

The preparation of backup energy sources is appropriate at a time when all the necessary steps can be taken regardless of the meteorological situation. The purchase of diesel is totally independent of the availability of energy in the RES system.

4. Approach to dimensioning short-term energy storage

The short-term energy storage is designed for daily energy consumption with a certain reserve. However, meteorological conditions will sometimes get worse enough, that we must save energy for several days. No energy can be added during this time. After that the size of the short-term storage increases algebraically. This process can also increase the cost of purchasing components.

The heuristic method is based on the results of individual insolation observation during each day. The assessment of the degree of insolation shall consider:

- The length of the day is variable after the year, in summer it is about 18 h, in winter about 7 h,
- In the case of a clear day, insolation in the summer is approximately three times, which is given by the length of the day and the angle of sunshine during the day,
- Also, the degree of insolation is determined by considering whether the air is clean or the amount of water vapor and smog present,
- The numerical representation of the insolation rate for a given day is subjective and expressed in 5% increments.