USE OF INTEGRATED RENEWABLE ENERGY SOURCES.

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Annatatsion. Today, the world is experiencing a global energy transition. Countries are seeking to increase their renewable energy capacity to reduce dependence on unpredictable and highly unsustainable non-renewable energy resources (conventional energy sources such as coal, oil, and natural gas).

Keywords. photovoltaic systems, batteries, helium batteries, solar panels.

According to the IEA report, the world's renewable energy capacity is expected to exceed 8 percent in 2022 [4-5]. In addition, solar energy accounts for 60 percent of this growth. China currently leads the world in solar power generation with more than 300 gigawatts of capacity [6]. However, many countries have set ambitious targets for solar energy in the future and are building large scale solar power plants to meet their energy needs [7-8].

Currently, the largest solar photovoltaic power plants in the world are:

Bhadla Solar Park (India)

Bhadla Solar Power Plant is the world's largest solar power plant with a capacity of 2.25 GW, located in Bhadla, Jodhpur district, Rajasthan, India, on a total area of 10,000 acres (40 km^2). Rajasthan has the highest solar radiation of 5.72 kWh/m^2 per day, making it the most favorable location for setting up a solar power plant [9-10]. The project was launched in 2015 with an investment of 1.4 billion dollars. The solar power plant was developed by several companies in 4 stages [11]. Since this region receives good radiation throughout the year, 10 million solar panels have the capacity to generate 2245 megawatts of electricity. Solar panels are cleaned by robots and monitored by humans [12-13].

(Huanghe Hydropower Hainan Solar Park (China)

Huanghe Hydropower Hainan Solar Park is located in the remote Qinghai province of China [14]. It is the largest solar facility in the country and the second largest solar power plant in the world with a capacity of 2.2 GW. Huanghe Hydropower Hainan Solar Park is located in the remote Qinghai Province of China [15-16]. It is the largest solar facility in the country and the second largest solar power plant in the world with a capacity of 2.2 GW.

Pavagada Solar Park (India)

Pavagada Solar Park is located in the Tumkur district of the Indian state of Karnataka, a 2.05 GW solar photovoltaic power plant covering an area of 13,000 acres (53 km^2) and has been developed by the Karnataka Solar Power Development Corporation (KSPDCL) [17-18] . Construction of the solar power plant began in October 2016, and the first section with a capacity of 600 MW was commissioned in January 2018. With the commissioning of the last

100 MW of the solar project by SB Energy in December 2019, the world's third largest solar power plant by installed capacity is fully operational [19-20].

Storage of electricity produced by photovoltaic systems. AGM,

The following types of lead-acid batteries are recommended for installation in photovoltaic systems:

- sealed (non-repairable VRLA GEL and VRLA AGM);
- open type (liquid, repairable).

Other types of batteries such as NiCad or 36 V batteries can be used with TriStar controllers with appropriate computer programming of certain charging algorithms.

Closed-type batteries are a class of lead-acid batteries that regulate the exhaust gases with a valve (VRLA - Valve Regulated Lead - Acid) [21]. The main characteristics of batteries of this category are the internal immobilization of the electrolyte and the recombination of oxygen. When the battery is charged, the released oxygen is recombined within the cells to prevent water loss [22].

There are 2 types of sealed batteries used in solar systems: AGM and GEL batteries.

AGM (Absorber Glass Mat) batteries

In these batteries, the electrolyte is contained in fiberglass capsules between the lead plates. A charging voltage of 14.7 V is recommended for some new AGM batteries. The recommended charging voltage for these batteries is usually 14.4 - 14.5 V.

It is not recommended to equalize this type of battery, because the gas coming out through the valves is not filled. In addition, at extremely high temperatures, the electrolyte can leak, and operating these batteries at temperatures above 33°C can reduce their life by up to 50% [23].

For these types of batteries, their ability to recombine oxygen should not be exceeded. The optimal operating temperature is from 5 to 35 ° C.

GEL batteries

Helium batteries are generally similar to AGM. In helium batteries, special silicon-based additives are added to the electrolyte to reduce its fluidity. It is important not to exceed the charging voltage for helium batteries [26-28]. When installing the system, refer to the recommended charging parameters given in the instructions. Typically, the charging voltage for helium batteries is 14.1 - 14.5 V. Helium batteries are sensitive to overcharging [24].

An important operating condition for both types of batteries is 100% recombination of gases inside the battery. This prevents water loss [25]. Equalization is not performed, but a short "shock" charge may occasionally be useful to balance the potentials between individual cells.

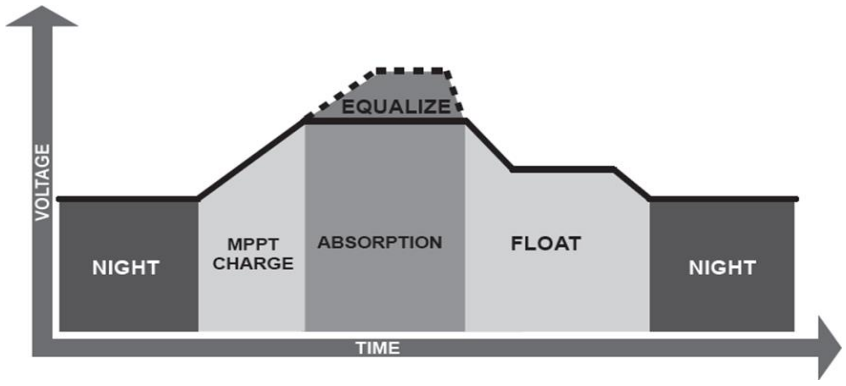

Figure 1. Optimal charging algorithm

TABLE 1.

Stage	GEL	closed type	AGM	open type
absorption	14.0 V	14,1 V	14,3 V	14,4 V
Charging	13.7 V	13,7 V	13,7 V	13,7 V
Charging time	3 hours	3 hours	3 hours	3 hours
Voltage	no	no	14,5 V	14,9 v
leveling	no	no	3 hours	3 hours
Equalization time	no	no	28 days	28 days
Periodic smoothing	15V/30V	15V/30V	15V/30V	15V/30V
Maximum charge voltage	11.5V/11.0V	11.5V/11.0V	11.5V/11.0V	11.5V/11.0V
Cut-off voltage	12.6V/12.1V	12.6V/12.1V	12.6V/12.1V	12.6V/12.1V

[1] *By uncompensated temperature.*
[2] *Set by switch, not temperature compensation.*

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