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Advanced Energy Storage Technique and its Conversion

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Abstract*: Energy storage is an important aspect of the conservation of energy such as the energy releases from solar radiations using different energy storage in an efficacious way of renewable energy. Hydrogen is considered as a precious model for energy storage and energy carrier for the future scope and it can acquire by low-temperature water electrolysis, high-temperature water electrolysis, and carbon assisted hydrogen production. Electrochemical energy storage is a favourite zone of the modern era because of its adorable properties such as site versatility, static structure and modularity. Redox flow battery and lithium-ion batteries are most popular in energy storage because they have the most appreciable feature as the depth of discharge, which decides the lifespan of the batteries and signifies the maximum number of the cycle for which the capacity of batteries does not undergo the nominal capacity. Lithium-ion batteries enrolled all the aspects such as size range, capital cost, efficiency and found that the Redox flow battery and lithium-ion batteries have major potential to store energy for an off-grid renewable source.

***Index Terms*: Redox flow batteries (RFB), Hydrogen Cell, depth of discharge (DOD).**

I. INTRODUCTION

Energy storage provides the vision for renewable energy as an alternative to other fueling options. Energy storage has the primary focus to advance the clean energy which provides a cost-effective green energy source, which is eco-friendly also. For the sake of sustainable development and fulfill the requirement of energies, the scientists work on the alternative of non-renewable energy and their storage system. Because non-renewable energy has many bad marks such as they are limited and their uses lead to increasing the greenhouse gas emissions and many other afflictions for the environment. Therefore, time demand is to emerge out the efficacious alternative of the non-renewable energy that is solar, wind and other renewable energies. The main perplex with renewable energy especially solar and the wind is their storage and conversion. Worldwide, the work to develop the efficient and eco-friendly energy storage system has been going on [1]. Energy storage has many generalizations, for instance, thermal energy storage, electrochemical, mechanical, biological and magnetic energy storage. This stored energy can be converted into chemical, electrical, kinetic, potential and thermal forms as per the requirement and demand. The electrochemical energy storage system is in trend because electricity is a basic need of daily life and electrochemical energy storage is an efficacious way to fulfill this need up to a certain scale. Redox flow batteries (RFB) represent one of the most recent technologies and most favorable choice for stationary energy storage [2, 3]. The most conspicuous part of a redox flow battery is long durability, fast responsiveness, scalability and flexibility, high round-trip efficiency, independent sizing of power and energy, less environmental effect [4]. Such features make it practical for generating electricity from non-conventional energy resources because of its vast operational power and discharge time. Consequently, electrochemical energy storage is going to be a revolutionary change in the field of electricity generation using renewable energy which enhances the low-cost electricity. Renewable energy has tremendous availability; therefore, it will be going to be an important factor to maintain the growth of developing countries. Many countries encourage their research and development field for non-conventional energy to decrease the dependency on conventional energy resources. Therefore, many wide types of research have been enrolled for improvisation of desired properties of all generalization of energy storage and its compatibility. For the sustainable development of this competing era, the energy is not only required to fulfill the basic or comfort needs but also in various other fields also for instance in defense sectors. This year the article has been published by U.S government for the waste of precious energy sources such as nuclear energy waste, many countries preferred to use this energy for their defense sector which is indirectly the waste of precious energy. With this rate of consuming these non-renewable energies we will not have a secure future in the field of non-renewable energy sources, we have to search for effective and long-term alternatives as renewable energy with their efficient energy storage for the wide range of applications. An important term for energy storage is its efficiency which shows the power quality and energy management which formerly referred to charging and discharging process [5]. Energy storage such as mechanical, electrochemical, biological, thermal energy has different power discharge duration as shown in figure 1.

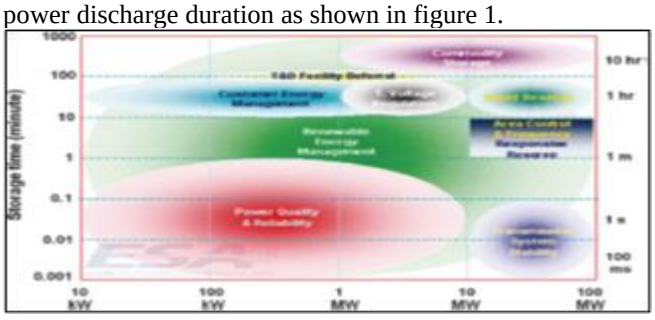

Figure 1: Power discharge duration diagram for different energy storage requirement [3]

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Today's daunting scenario forces us to use sustainable energy technology and its conservation. At present, there is a continuous decrement with conventional energy resources by time and searching for alternative forms of energy as non-conventional energy resources, but there are many perplex with the storage of non-conventional energy like solar energy, wind energy and more. Further, the energy storage is categorized which gives many new streets in research fields and enhance the way of developing the energy storage system.

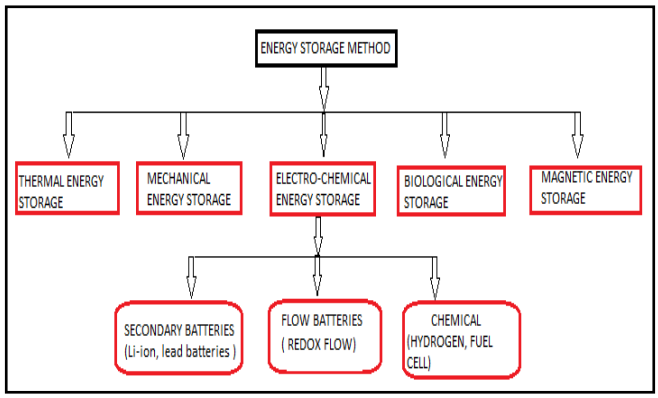

Figure 2: Different type of energy storage system

The thermal energy storage system is used to accumulate the solar thermal energy as sensible heat and latent heat with the help of PCM which has a very wide range of applications in storing energy. Mechanical energy storage has few modes of storing energy that is kinetic energy for linear and rotational motion, potential energy for elevation, as strain energy for an elastic material. In mechanical storage devices, we are generally a concern with the storage system that is compressed-air storage, flywheel, and hydro-storage [6].

The biological process is another generalization of the storage system which stores the energy in the chemical form by pursuing the biological phenomenon. It has merit for storing the energy for the long periods of time. In magnetic field storage systems, energy is stored by means of a magnetic field which is developed in the surrounding of the magnets. The electrochemical energy storage system is in trend because electricity is a basic need for daily life and electrochemical energy storage is an efficacious way to fulfill this need.

II. PRODUCTION OF HYDROGEN

Hydrogen is considered as a precious model for energy storage and energy carrier for the future scope. Hydrogen is taken out generally from water molecules which are a huge source of hydrogen element but there are many other ways such as low and high-temperature water electrolysis and carbon assisted hydrogen production. It offers sustainable energy assimilates with renewable energy such as solar, wind etc. Hydrogen when consuming with renewable energy it provides a clean energy source which helps in reducing the greenhouse gas emission as shown in figure 2. It can store the renewable energy at the time of their availability such as sunlight and convert the stored energy into power in the combustion chamber or in a fuel cell with the demand of the load.

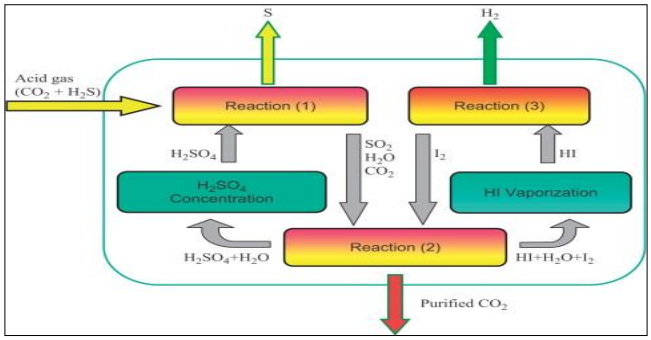

Figure 3: Schematic representation of the H_2S-splitting cycle for hydrogen production [7]

III. ELECTRO-CHEMICAL STORAGE SYSTEM

The electrochemical storage system is the most preferable and leads runner energy storage system because it can be able to store the energy for short and long time ambitions because of its site versatility, static structure and modularity [8]. Electrochemical storage system store the energy in the form of kinetic and vibration after reacting with the chemical composition, this mechanism is generally found in batteries such as Li-Batteries, Aluminum-ion batteries, lead-acid batteries and many more. In batteries, the most measurable feature is the depth of discharge (DOD) which decides the lifespan of the batteries. The maximum number of the cycle for which the capacity of batteries does not undergo the nominal capacity is termed as lifespan [9]. Recently a survey has been performed to check out all the aspect such as size range, capital cost, efficiency and found that the lithium-ion batteries have major potential to be energy storage for off-grid renewable energy. The lithium-ion battery has vast lifespan than other technologies with their high power density and energy [10] and because of this; it can be implemented in many applications such as in defense sector, automobile sector, power grid and in the medical industry also. It can bring a new revolution in automobile sectors because using it in vehicles integrate many advantages like less noisy, less costly, no use of fuels such as petrol and diesel and most important it is eco-friendly which help to reduce the percentage of carbon level in the atmosphere. Many other batteries are also available like lead-acid, Ni-Cd, NiMH but lithium-ion batteries are dominating because of the same reason higher energy and power density [11]. From table 1 few data has been searched out for the comparison of different batteries with the lithium-ion battery. The direct connection renewable energy sources like sun or wind cannot be provided to the grid because of the issue of stability of networks and sometimes its cause's failure [12]. In order to avoid these drawbacks, the battery energy storage system is used to get the non-fluctuating output of renewable energy sources. There are many other applications of lithium-ion batteries for small grids and also for the consumption of renewable energy in the grid. There are many factors which make the lithium-ion battery most favorable in every field with renewable energy sources but one of the most important factors is the depth of discharge [13].

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In the area of deep discharge, lithium-ion batteries have an incomparably higher number of cycles (above the nominal capacity) than other batteries.

Table – I Specification of Different Elements

Specifications	Lead acid	Ni MH	Ni Cd	Li-ion		
				Cobalt	Manganese	Phosphate
Specific energy density (Wh/kg)	31-52	47-85	62-125	152-195	105-134	95-115
Life cycle(80% discharge)	210-305	1050	310-495	495-1050	495-1100	1100-2100
The cutoff voltage of charge (V/cell)	3.40 Flot 3.26	Full charge detection by voltage signature		4.25		3.50
Toxicity	high	high	Low	Low		
Peak load current	6C	22C	5C	>3C	>30C	>30C
Self-discharge/month (room temp.)	6%	22%	35%	<12%		
Cell voltage (nominal)	2.2 V	1.4 V	1.5 V	3.9V	3.7 V	3.2 V
Internal resistance (mU)	<100	100-300	200-300	150-300	25-75	25-50

IV. BATTERY MANAGEMENT SYSTEM

In vehicles, the large number of the lithium-ion batteries are arranged in the series-parallel mode which causes perplexes like durability, uniformity and imposes a wall for widening the application of lithium-ion batteries. The battery management is must be required for the safe and reliable function by making the number of modules of different lithium-ion batteries. The system managed the battery by auditing the estimation of battery state, reporting the data, balancing and protecting the battery [14]. The battery management system takes the input to manage the batteries from sensors like current, voltage, temperature sensor and manage the output from capacitors, circuit contactor, heater, fan and many more. Redox flow batteries (RFB) are the advanced technology in the field of electrochemical system and become the first choice for stationary energy storage [15]. RFB is often used to convert the huge amount of electrical energy into chemical energy and vice versa, as per the requirement. RFB assimilate the couple of electrodes which is dipped in the solution of two electrolytes (positive electrolyte and negative electrolyte) which contains ions of metals in which one electrode release the electron and this process is termed as reduction and released electron get recombines with the second electrode (oxidation process) through the solution of electrolyte. The electrolyte solution in RFBs is separated by the membrane called ion-exchange membrane as shown in figure-4.

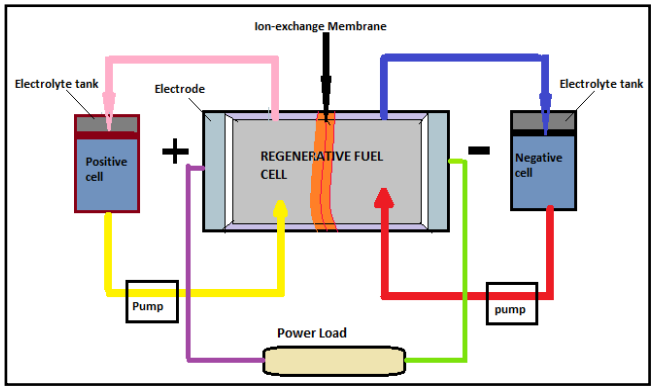

Figure 4: Schematic diagram shows the working of Redox Flow Batteries.

The flow of electrons from the anode to the cathode electrode in the two electrolytic solutions through the ion-exchange membrane, this phenomenon is called an electrolyte interface phenomenon. There are many RFBs has been developed after 1949 (first RFBs invented in Germany) such as Fe-Cr system, VRB system, V-Br cell, V-O2 cell and many more. RFBs become the first choice because of its merits of a long –lifetime, less response time, low self-discharge, high efficiency and the most one is tunable power and storage capacity.

V. RESULT AND DISCUSSION

The present work is based on a comprehensive review of Electro chemical storage devices such as Redox Flow Batteries. Electrochemical energy storage is a favorite zone of the modern era because of its adorable properties such as site versatility, static structure and modularity. RFBs are satisfied for large scale applications due to their design adaptability, high cycle life and independence between energy stored and rated power. The exemplary applications for RFBs are those in which the volume and weight are not limiting factors, such as load levelling, Uninterrupted Power Supply (UPS) and support to renewable energy sources such as solar and wind. RFBs might certainly contribute to the viability of the mass selection of overflowing, yet alternate renewable energy sources, providing an energy shield which allows the power output to adjust itself to the prompt grid demand. The performance of RFBs depends on various factors, namely on the technology involved. It will also depend on the performance of each one of their components, which in the present study.

VI. CONCLUSION

Energy storage and conversion have provided many new streets in research fields which takes a revolution in the era of Eco-development (development of individuals or countries by keeping the atmosphere safe). As electrochemical system becomes a first in every sustainable development which can fulfill the need of electricity and it can be enhanced in much other application like in automobile sector,

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which can bring a new reformation in this sector along with battery management system, by manufacturing the automobile which has zero carbon emission by the use of lithium-ion batteries. With the increment in uses of batteries in the automobile sector, it reduces the dependency on fossil fuels like petrol, diesel which reduces the cost as well. The first generation energy storage system in redox flow batteries is based on vanadium technology which brings a vigorous change in commercial exploitation. Hydrogen development technology provides precious energy storage media, which stores the energy at the off time and supply it at the peak time and also have an enormous contribution to reducing the greenhouse gas emission.

VII. FUTURE SCOPE

Energy storage and conversion are going to be a pillar for sustainable development all across the worldwide. It can bring a revolution in the defense sector and the automobile sector. In the defense sector, it can be used for the application of fully electric propulsion. For the high level of safety, lithium-ion sulfate in a lithium-ion battery is generally used. In the automobile sector, the uses of lithium-ion battery and redox flow battery reduce the greenhouse gas emission which is Eco-friendly and also reduces the dependency on fossil fuel like petrol and diesel. The arrangement of batteries and its functionality is managed by the battery management system. It can be enhanced by developing new technology in a different field which reduces the dependency on non-renewable energy.

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