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Energy Storage Methods for Renewable Energy Sources

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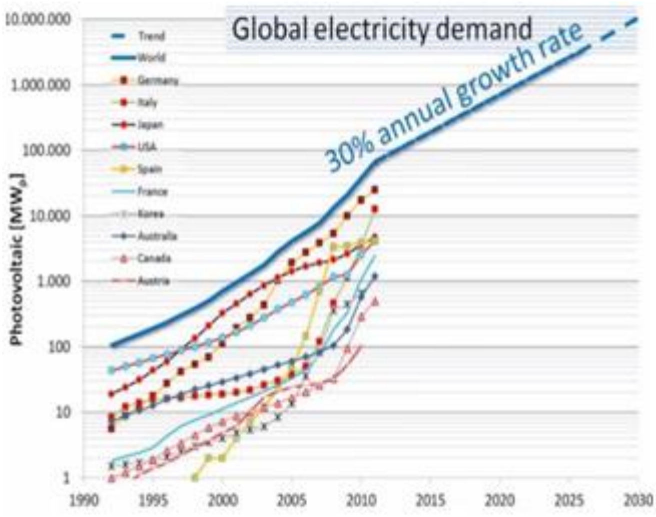
Abstract: ***Energy is an indispensable element for human survival. Most of the energy sources that we are currently using are non-renewable forms of energy. These sources are limited and are exhausting at a fast rate. For non-renewable sources we have oil, coal, petroleum to list some. In this scenario of scarcity of energy, renewable form of energy provides a better and more secure option. We need to use the renewable sources to their full extent in order to reduce the burden on the non-renewable sources of energy. But these sources do have some limitations. Solar energy is not available at night, wind energy depends on the intensity of the wind speed and hydro power plant's installation takes a toll on the environment as it damages the environment and its nearby habitat adversely. We have the technologies for the generation and implementation of these renewable sources of energy but we lack in the storage sector. The energy systems in India have an outdated storage method. We need some reliable storage methods in case we cannot use renewable sources for energy production. In order to completely switch over to solar form of energy we need to devise ways to store energy efficiently. The only problem limiting the use of renewable sources of energy is the storage. For storage we need to consider the factors like price, efficiency and footprints of the solution we choose. For solving the above storage problems we have the batteries., Power to gas conversion hydro power plant Hydraulic hydro storage self powering and storage. The main focus of this paper is to provide an efficient way to implement and provide some alternate implementation schemes for the above suggested methods. In 2030 the energy demand is expected to rise up to 10,000,000MW .Hence there is a critical need to shift our concentration on to the storage methods which can be used to explore renewable resources to their full potential. The authors have pointed the urgent need for implementation of the alternative storage schemes such as the use of Hydraulic hydro storage, Pumped hydro power plants, power to gas conversion and vanadium redox batteries***

Keywords: Renewable energy, solar energy, battery, hydro power

1. Introduction

The world's environment is facing a serious crisis. The earth is under threat from growing number of global-scale problems environmental problems such as global warming, deforestation, pollution, degradation of natural habitat. Many developing countries like USA, Japan, India against the backdrop of population explosion and rapid industrialization are accelerating deforestation and desertification and severe pollution.



1.1 Growth of Renewable Energy

In today's world where technology knocks the doors of every people we still have lack of energy resources to at least utilize them. This brings in a period of dormancy to the developing trends and as well degrades the quality of life.Energy play an important part for human survival. Hence we need to use it efficiently.There should be sufficient energy such that it meets the need of society. Energy conversation and efficient measures reduce the impact of energy development and can have the changes in economic costs and changes in environmental in the environmental effects.

There are various types of energies available. The basic classification is non-renewable sources of energy and renewable sources of energy. Non renewable energy sources are coming from the limited quantity present on the earth. These sources are exhaustible i.e they will run out after few years. Non-renewable sources of energy includes fossil fuels, coal, petroleum, nuclear fission, shale gas. These sources play an important role in meeting our energy demands. For eg, in 2005 around 81% of our energy needs were met by fossils. Similarly nuclear energy contributed to 5.7% of world's energy and 13% to worlds electricity in 2012. But these energy sources will eventually dwindle becoming too expensive or too environmentally damaging to retr0ieve.Hence there is a need for alternative energy sources which can be used again and again. Renewable sources of energy are those which is generated easily and they are practically limitless reserves. They include sources such as solar energy, wind energy are constantly replenished and will never rule out. Renewable energy provides a lot more benefits than non-renewable energy sources. The have a much lesser environmental impact than conventional energy technologies. Renewable energy also creates more jobs and improves the economy as a lot investments are made on materials and workmanship to build and maintain the facilities rather than on imports. But there are some disadvantages of using them too. Solar energy can only be used during day time, wind energy depends on the speed of the wind. Hence we need to store these energies so that they can be used again as the demand for energy is going to continuously. The need for energy storage is not new. People have devised many methods of storing energy over the years, however, the problem of storing large amounts of accessible energy lies in cost effective and efficient manner.Today, the advent of modern renewable energy sources greatly improves our ability to collect or harvest energy, but not to store what we gather. Modern renewable energy sources intensify the search for robust, cost effective means to store energy.The need to store the available energy from nature still exists, and is even more critical in today's world. Our continued dependence on fossil fuels causes pollution, health problems, climate change, and political unrest. While significant energy storage technology advances have been made in many areas, none have been successfully engineered to meet this storage challenge. No method of long term, high power energy storage has been shown to be cost-effective, efficient and flexible enough to inspire widespread use. For making best of the solar power, Germany has the best modules, Italy has the maximum number of the modules installed, and China has the highest production. U.S.A. has best cell efficiency and India has the highest potential for production. So this potential has to be changed into useful results. Hence we need to adopt new technology to make use of these benefits.

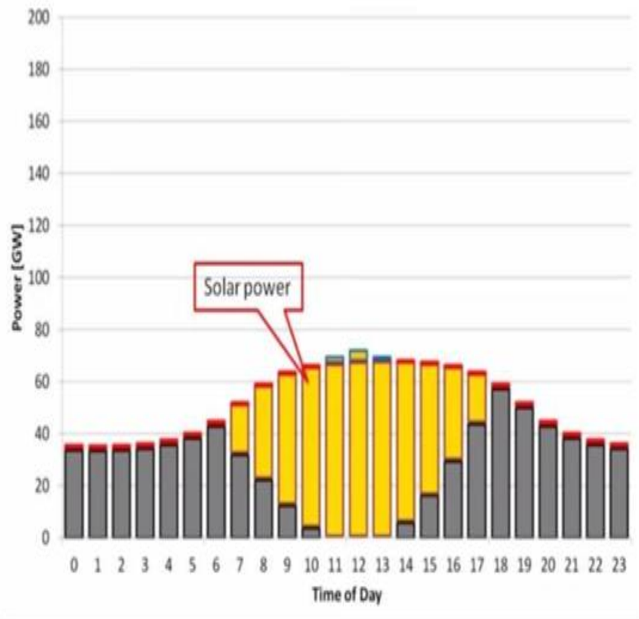


Figure 2: solar power consumption

Batteries, power to gas conversion, pumped hydro plants, Hydraulic hydro storage self powering and storage system are some storage methods that can be used for storage purpose. Batteries can be made as an efficient source of energy storage if we used proper electrolyte. Vanadium redox batteries can be used for storage purpose. There are clear benefits of using vanadium batteries over normal batteries. First, unlike conventional batteries, power output is independent from energy storage capacity—output depends on the size of the fuel cell stack, while the energy storage capacity depends on the size of the electrolyte tanks. VRBs, unlike many of their conventional counterparts, can be fully discharged without reducing life expectancy. In contrast, discharging a lead-acid battery more than 20–30% erodes longevity and also reduce toxicity than normal used batteries. t. orwer cotnversion is good but as it involves many steps, it results in a lower efficiency i.e. 25 percent. For pumped hydropower plant, the site for water reservoir should be chosen after considering every aspect such as deforestation, land fertility, wildlife etc. Hydraulic hydro storage is the presently the best option as it promises a profit of 160million US dollars with a high Efficiency and low cost.

2. Batteries

Rechargeable Batteries have long been used for storage battery.Nickel-Cadmium were initially used for storage battery for portable equipment. But they have been replaced by lithium-ion batteries.The energy density of lithium-ion is typically twice that of the standard nickel-cadmium. There is potential for higher energy densities. The load characteristics are
reasonably good and behave similarly to nickel-cadmium in terms of discharge. Lithium batteries also cause less harm when disposed. It is a low maintenance battery. There is no memory required and no scheduled cycling is required to prolong the battery's life. In addition, the self-discharge is less than half compared to nickel-cadmium, making lithium-ion well suited for modern fuel gauge applications.

But these batteries do have some disadvantages too. They require protection from being over charged and discharged too far.It is also dependent upon the number of charge discharge cycles that the battery has undergone. Another disadvantage of lithium ion batteries is that there can be certain restrictions placed on their transportation, especially by air. A major lithium ion battery disadvantage is their cost. When considering their use in mass produced consumer items where any additional costs are a major issue. Hence we need to overcome these drawbacks of batteries currently used.

A Vanadium redox batteries contains two different electrolyte solutions, each in a separate tank. In a charged VRB, one electrolyte is positively charged, and one is negatively charged. In order for the battery to provide power, the electrolytes flow through a fuel cell stack on opposite sides of a proton exchange membrane. Their opposite charges create a gradient that powers an external current.

Several characteristics unique to VRBs enable them to sustain utility-scale storage and power at potentially competitive prices. First, unlike conventional batteries, power output is independent from energy storage capacity—output depends on the size of the fuel cell stack, while the energy storage capacity depends on the size of the electrolyte tanks. Neither constrains the other, although the ratio of storage to power determines how long the batteries can run without recharging.

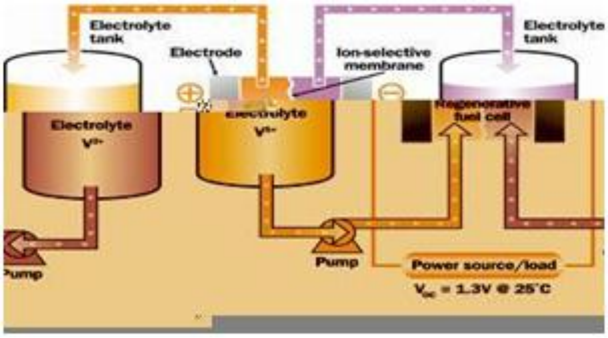


Figure 3: VRB circuit

VRBs, unlike many of their conventional counterparts, can be fully discharged without reducing life expectancy. In contrast, discharging a lead-acid battery more than 20–30% erodes longevity. Even under the best circumstances, lead-acid batteries are good for little more than 1,000 charge–discharge cycles. But a VRB in Sapporo has undergone around 14,000 cycles, says Dennis Witmer, director of the Arctic Energy Technology Development Laboratory at the University of Alaska, Fairbanks. The limiting factors are the proton exchange membrane and the pumps, both of which can be replaced. Discharged electrolyte can be replenished by running a current through the battery.

VRBs are far greener than other batteries, as they lack potentially toxic metals as lead, cadmium, zinc, and nickel, which can contaminate the environment at all phases of the conventional battery life cycle. VRBs' most toxic component is the sulfuric acid of the electrolyte, which is only one-third as acidic as that in a lead-acid battery. But unlike lead-acid batteries, the electrolytes in a VRB function indefinitely, eliminating the disposal problem.

Vanadium itself has very low toxicity, and the batteries are designed to contain electrolyte spills. "We have the best environmental footprint of any storage technology," says Simon Clarke, executive vice president for corporate development at VRB Power Systems.

For now, VRBs are not a viable option for cars. The energy density of gasoline equals 13,000 watt-hours per kilogram, while the typical VRB is still not much better than a lead-acid battery—about 40 watt-hours per kilogram. Lithium ion batteries, as used in the latest generation of hybrid vehicles, have an energy density of about 200 watt-hours per kilogram.

Other types of flow batteries under development, such as those using vanadium bromide, could double the density of storage, but probably would still be inadequate for cars. Developing a sufficiently energy-dense flow battery would solve the problem of how long it takes to recharge currently available batteries for electric vehicles. Hypothetical automotive flow batteries could be replenished in minutes by replacing discharged electrolyte with freshly charged electrolyte.

3. Hydropower

Pumped storage is an essential solution for grid reliability, providing one of the few large-scale, affordable means of storing and deploying electricity. Pumped storage projects store and generate energy by moving water between two reservoirs at different elevations. At times of low electricity demand, like at night or on weekends, excess energy is used to pump water to an upper reservoir. During periods of high electricity demand, the stored water is released through turbines in the same manner as a conventional hydro station, flowing downhill from the upper reservoir into the lower and generating electricity. The turbine is then able act as a pump. With an ability to respond almost instantaneously to changes in the amount of electricity running through the grid, pumped storage is an essential component of the nation's electricity network.

4. Power to Gas Conversion

Power to gas is a technology that can be used to convert electrical power to gas. It is one of the efficient method for storage purpose. There are three methods which are adopted to convert the power to gas. Firstly, we use the process of electrolysis to use electricity to convert water to hydrogen and oxygen respectively.

$$2\,H_2O(l) \rightarrow 2\,H_2(g) + O_2(g)$$

Now the hydrogen generated in the electrolysis equation is injected into the natural gas grid.The second method is to convert the hydrogen and carbon dioxide to methane gas by using sabatier equation.

$$CO_2 + 4\,H_2 \rightarrow CH_4 + 2\,H_2O + \text{energy}$$

The methane may then be fed into the natural gas grid.Then we make use of the output gas of a wood gas generator , after that biogas upgrader is mixed with the produced hydrogen from the electrolyzer, to upgrade the quality of the biogas,

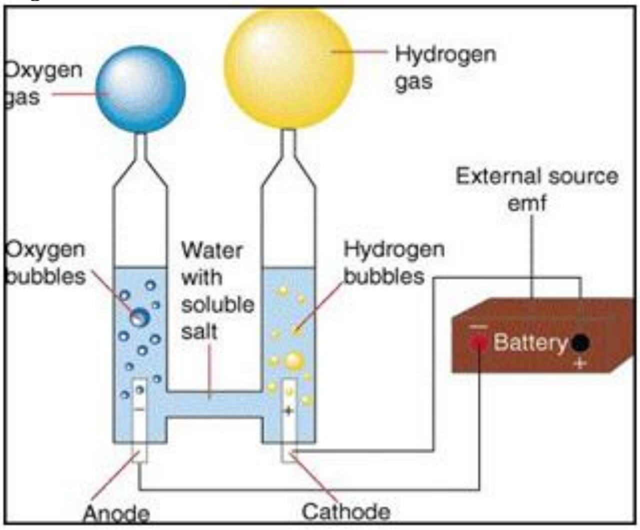


Figure 4: Electrolysis

Power to Gas as Storage

The power to gas can be used as adjuncts to wind power or solar power plants. The excess power generated by wind generators or solid arrays which may be used later time for load balancing in the energy grid. The german natural gas network has a storage capacity more than 200,000GW.h which is enough for several months of energy storage. The storage cost per kilowatt hour are estimated at €0.10 for hydrogen and €0.15 for methane.

5. Innovative Idea

Now all the above methods which are suggested above have their limitation too. The main consideration that should be taken up for energy storage is low price per kWh, high efficiency and small footprint. These three factors help in providing cost effective system for storage purpose and a environmental friendly system. The batteries have high efficiency which comes to 90 percent but has dis-advantages of low price per kWh which comes to $200/kWh and a small footprint. The power to gas conversion method provides advantages of a small footprint and also low price per kWh but the efficiency of it is very less as it comes to only 25%.The pumped hydropower system has advantages of low price kWh and a high efficiency but the have a small footprint. Hence we see that each of the above system has disadvantages along with their advantages. As the energy demand is continuously increasing, it is required that the dis-advantages of above system should be removed and a new system be adopted. Here we have a new system which can be adopted to provide a better energy storage equipment.

6. Hydraulic Hydro Storage Self Powering Storage System

Hydraulic hydro storage self powering and storage system is the one in which the renewable energy can be stored for a much longer time than we can at present. Present storage capacity is just half an hour. Which is much lesser than needed. Presently the systems we have can generate renewable energy for instant use only what our system is suggesting is making use of the energy generated for the instant use as well as storing it for a much longer time say even some days and the system has a provision for storing the energy generated and using it to power distant places. In this system we convert the electric energy to kinetic energy that will be stored as potencial energy and will be stored in high efficiency special batteries.

In this system we use the reversal of a hydro power plant. In hydro power plant we store the energy as potential energy in form of water which is stored uphill. this is highly efficient upto 80% but it has its foot prints on nature and the places nearby are completely disrupted.

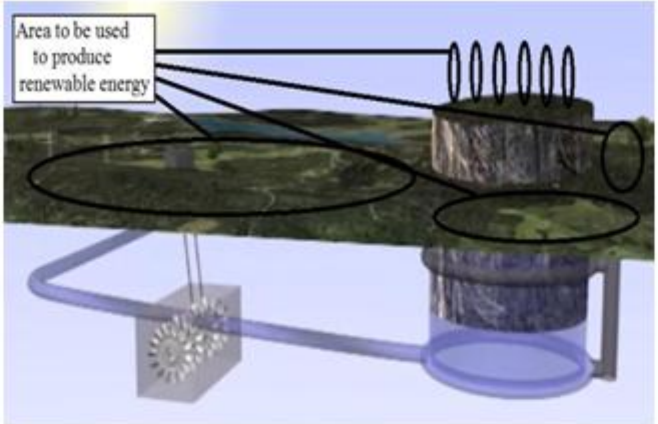


Figure 5: Proposed Idea

In hydraulic hydro storage system we will be storing the water underground rather than storing it uphill for this purpose an ground will be cut and the water through a turbine will take the water under the rock cut.and the water will uplift the land which has been cut so the land which comes up is the storing house now. Whenever we need power just take the cut mass of land down and it will re-power the water and power will be generated

So our system now is an mirror image of the hydro power systems. What we do is take an area that equivalent to the circle of 500mts and then we cut that area through rocks to the height of 1 km downwards. The mechanical system used to cut down the rocks is an advanced system causing no disruption to the area nearby. The cutting through the rock is done by using sawing strings. Before cutting through rocks we will place a shaft into the ground that goes into ground 1.1km deep and will have 2 tunnel systems. One tunnel will be placed at half the height and other will be near the ground. Tunnels will be used to hold the rock when it will be risen up.

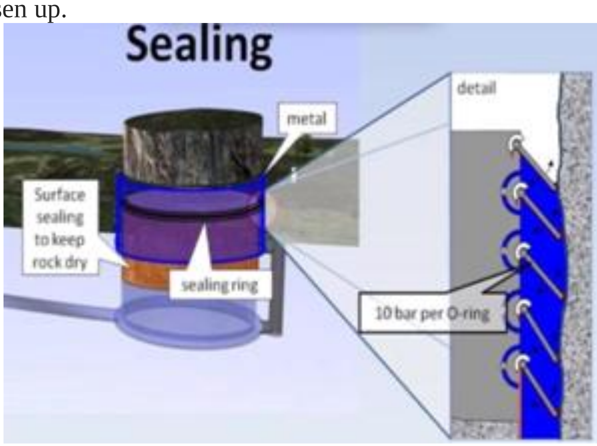


Figure 6: structure description

In this system we use an area of say 8 kilometres out of 8 km we use 1km for the storage of water. So the cut mass will basically have just two positions first will be when the water will be under the land mass and it will be held there by the tunnel system we are using. The tunnel system has a provision that it holds the land mass efficiently in its place where the water is under it. Then when the rock is left off move down and pumo uo the water through the external structure. Now again the same water structure is used to hold the land mass in the final place. The tunnel system has the extended rings in it which holds the land mass in its proper positions without fail. So the water will be sent under ground using the renewable energy through a pump so basically we use the renewable energy produced to pump water under the cut land mass. now whenever needed the rock will be allowed to move down freely which will start pushing uo the water through a turbine. Now here the working is same as that of a traditional hydro power plant.

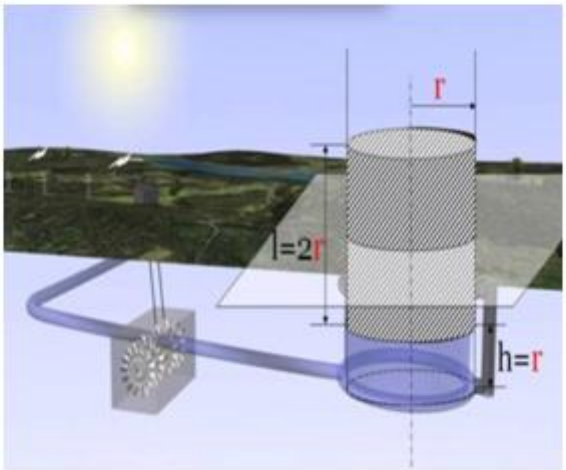


Figure 7: hydraullic hydro system

From where does the renewable energy will come. Well it will be coming from the around are which we are using to install solar cells and wind mills.In our system we are making the best use of our place which is present over the land mass cut. So this place will be used to place as many wind mills as possible. Whenever the landmass comes down or goes up making the wind mills to move and generate energy at there best rate. So the area we take under consideration is 8 km and out of it only 1 km is enough for the land mass system. The other 7km will be used for the renewable energy production. So our system is generating its own renewable energy and using it to set the power to store in form of potential energy under the cut mass land. We don't leave it here now this system will be capable of producing instant power in nights or any other time of crisis. But what about the daytime and the other free times. This system will be operating as frequently as possible but what will be we doing with the energy produced now? We will be storing all of that energy in the highly efficient above mentioned vanadium redox batteries. Now this system is generating its own renewable energy to be used, generating power whenever needed and providing the stored power in form of batteries.

So our system takes care of all the aspects necessary for it to be much better than any other present. Now why this system is better than what we have? Answer is that it provides us a method to store the renewable energy for any amount of time we need. preferred Location of our system would be barrened but even if it is not the barrened,it will just do fine. How efficient is this system? These are some relations to express the efficiency.

Mass (M) is proportional to (Radius(R) to the power3)
Height(H) is proportional to (Radius to the power 3)
That makes,
Energy is proportional to (Radius(R) to the power 4)

So, making the landmass to work in one full cycle will give an profit of atleast 160million$. This figure is enough to express the efficiency.

7. Limitations

The system is having a little more of an expensive installation cost but as soon as it starts working the expenditure would be regained again. Water storage area would be needed for the proper operation of the system but it won't be needing any special mountainous area. A natural water body will be fine and it won,t disrupt the functioning of the water body as measures for it can be applied easily. Proper care has to be taken while cutting through rocks and the tunnel structure to hold the landmass in its place has to be very precise and the engineering has to be done innovatively so the misshappenings can be avoided. but if everything is done as planned the structure would be as profitable as there never have been.

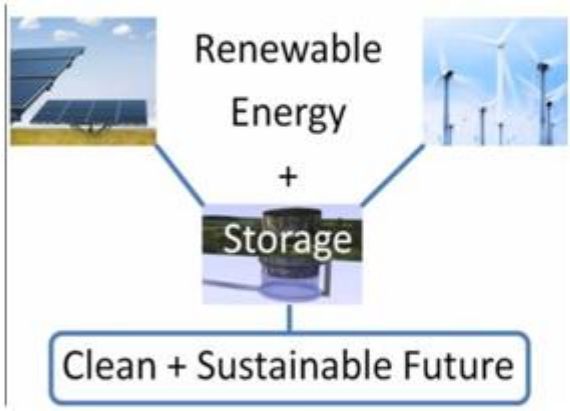


Figure 8: Descrition of idea

8. Conclusion

In 2030 the energy demand is going to increase to 10,000,000MW. Hence there is a crirical need to shift our concentration to storage systems of renewable energy systems. The main focus of this paper is to provide an efficient way to implement and provide some alternate implementation schemes for the above suggested methods. The authors have pointed the urgent need for implementation of the alternative storage schemes such as the use of Hydraulic hydro storage, Pumped hydro power plants, power to gas conversion and vanadium redox batteries. Energy is an indispensable element for human survival. Hence there is a need for better methods of energy storages and hydraulic hydro storage self powering storage system provides an efficient method of energy storage and needs to be adopted instantly.

9. Acknowledgement

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