

A Survey Study on Hybrid Photovoltaic System: Technical and Economical Approach

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ABSTRACT

Solar energy is one of the main important of renewable energy in Iran. According to The reliability and performance of photovoltaic systems, the number of applicants of these systems is added every day. Due to the periodic nature of these systems in the utilization of solar energy, they cannot supply the load during the day lonely and require a backup system. The purpose of this paper is technical and economic assessment of hybrid photovoltaic power plant is. In this regard, the structure of hybrid photovoltaic systems, as main system and other systems such as wind, fuel cell, diesel and battery system began as backup system are compared with considering economic and technical aspect. Research shows that the construction of solar power is not economical currently. If the hybrid system hasn't energy storage (battery), the cost and reliability of energy is reduced and in this system wouldn't be economically justified. Hybrid system with battery is preferred without the battery.

KEY WORDS: Hybrid systems, wind generators, fuel cells, diesel generators, photovoltaic systems.

1. INTRODUCTION

The use of new energies attracted attention of planners and technical intellectuals in the world. In our country, by considering the growing need for energy, lowering fossil energy resources, the necessity of maintaining a healthy environment, reducing air pollution, limitation of electricity and fuel supplies for remote areas and villages, the using of new energies such as wind, solar, hydrogen, micro turbines, biomass and geothermal is very important. Iran is on the world's solar belt and is one of the countries that have good sunlight with appropriate the power. This country has suitable regions take the advantages of this energy.

Distributed generator can be categorized as renewable and nonrenewable type including solar systems (Photovoltaic and thermal), wind, geothermal, ocean, combined cycle, combustion turbines, micro turbines and fuel cell. Renewable systems have many advantages such as significantly reduction the production and emission of greenhouse gases.

Different systems including wind turbines, photovoltaic systems or biomass systems separately has performed as pilot projects in different places of country. Supplying electric energy in rural areas, grid-connected solar power plants, and street lighting are some of the implemented projects in the field of Photovoltaic. But designing and developing of methods for the use of hybrid systems is not achieved in the country.

2. Photovoltaic systems

Electricity production by the emission of light and without the use of driving mechanisms is named photovoltaic phenomena and a system that uses this phenomenon is named photovoltaic systems. overview of this system is shown in Figure 1. Photovoltaic systems are one of the most widely used system and these systems were installed with different capacities (0.5 W to several MW) in large and small units and also connected or not connected to network in the all of world. According to the reliability and performance of these systems are added numbers of applicants every day. With series and parallel state, we can give appropriate flow of electricity. Name of series and parallel of cells is panel. These cells are generally composed of silicon and silicon is produced by the sand that is available in the desert regions of the country. Therefore, there is no shortage to supply the raw material of these cells in Iran.

2-1- Photovoltaic systems: advantages and disadvantages

One of the major problems is that the potential of solar energy received on the ground level is very low. By assuming ridge of sun is at sea level, the solar energy will be received only about one watt per centimeter square that it results more expensive equipment. For Photovoltaic systems cost is high, power is low, but investment in solar

energy is inevitable because of producing electricity without fuel, no need to much water, no pollution, low depreciation and long life, no need to professionals, little need to spare, the limited supply of fuel, concerns about climate change and energy security.

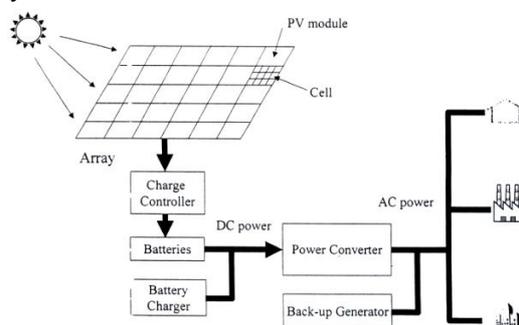


Figure 1: Block diagram of a photovoltaic system

2-2- Economic Evaluation of Photovoltaic Systems

Based on reports of the New Energy Organization of Iran, every kilowatt of electricity produced by solar energy in Iran is estimated to give about 500 to 1900 rails. Other method of energy production gives less than 200 rails per kw [21]. Despite of high the potential of energy in this method, producing solar energy for remote areas that have small populations has an effective option.

Today, in investments of solar systems not only consider cost of it, but also consider its benefits. Despite all the issues, we can find some of location in country that using solar energy is economical. For example, in remote areas using of Photovoltaic cell is appropriate.

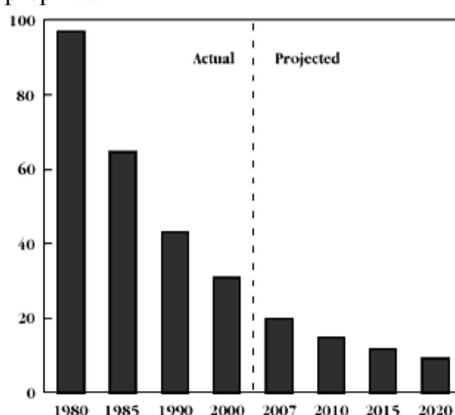


Figure 2: Trend of cost reduction for PV systems from 1980 to 2020.

3. Hybrid Energy Systems

Diversifying sources of energy, we can use a renewable system in the shape of power plan. By combing different source of energy we can cover weakness of them. In this way, the energy of resources such as wind, biomass, hydrogen and etc combine with each other. Appropriate hybrid system can be determined based on different climatic.

One of the potential advantages of these systems is using renewable resources according to climate. By considering different implemented plans of renewable energy in Iran, it is necessary to study these systems. This causes according to greatest potential of region, the most economical plan for hybrid system is selected. Selecting of the appropriate size for the hybrid system can be considered a good ratio between cost and performance. Therefore, selection of appropriate hybrid system is very important.

In regions with extreme weather changes that receiver attracts small solar energy, to feed the load, photovoltaic systems must be large or should be equipped with a battery that is possible for limited quantities. Despite these limitations, photovoltaic systems cannot provide the loads of the network lonely and we need a hybrid system. In the hybrid systems, a system uses renewable resources considered as the main system and other systems is considered as a backup. Backup system typically increases system reliability. In set of this paper, hybrid systems are surveyed.

3-1-Photovoltaic Hybrid Systems - Diesel

According to the properties of the photovoltaic systems, these systems cannot provide the required loads a region during the day alone; therefore, it is necessary to combine of this system with other systems. Figure 3 shows hybrid photovoltaic system - diesel without the battery. During of day that there is required emission, the PV can provide necessary electricity and during of night and when whether is cloudy, the diesel generators are also used. Using hybrid systems, we can provide necessary electricity in any time, but this system has some disadvantages as follows.

One of goals in the hybrid system is elimination of environmental contaminants, but using diesel generator can increase air pollutant gases. Due to lack of energy storage systems, the surplus energy that can be stored during the day is wasted. Diesel generator fuel cost is high and hence the production cost also increases. In addition, using diesel generators and the need of their maintenance can reduce system reliability.

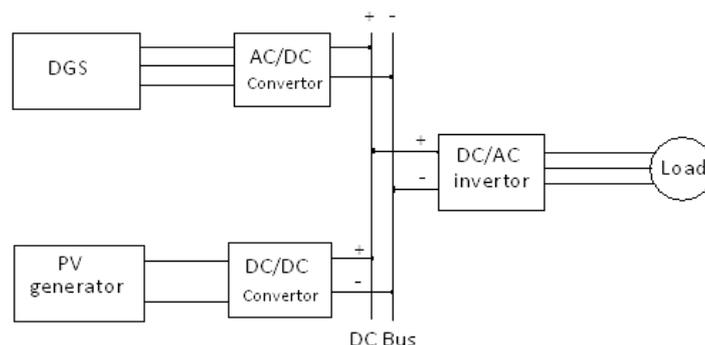


Figure 3: The Hybrid Photovoltaic Systems - Diesel

PV and DGS have Supplementary features to each other, so that the investment cost of PV is more than diesel generator but the performance cost of PV is less than DGS. The maintenance cost of PV is less than DGS. PV energy is available in all of times but it is depends on radiation. In other words, DGS works in all times but since the efficiency is low, it cannot provide electricity completely. Cost of fuels indicates that during the PV system is able to supply consumers electricity, it don't to be used the DGS. This frequent practice led to exhaustion. It can be seen this hybrid system that haven't a source for excess energy storage, energy costs will not be economically justified [10].

3-2-Photovoltaic hybrid system - Diesel - Battery

In the previous section, we saw that a hybrid system without saving energy must be have an enough Spinning Reserve to provide sudden load peak or dropping in production of PV. therefore, researchers studied using of batteries for energy storage. Figure 4 shows this system In the sometimes of the day, the surplus energy is stored in batteries and in sometimes such as peak times and in night, this energy is used. Using of batteries for energy storage will have the following advantages.

Fuel storage potential increases, fluctuations will have more consistent form, the time for performance of diesel generator decreases, system reliability increases and energy shortages in certain conditions are supplied. Since using of batteries can reduce the cost, it may be to prefer using of batteries.

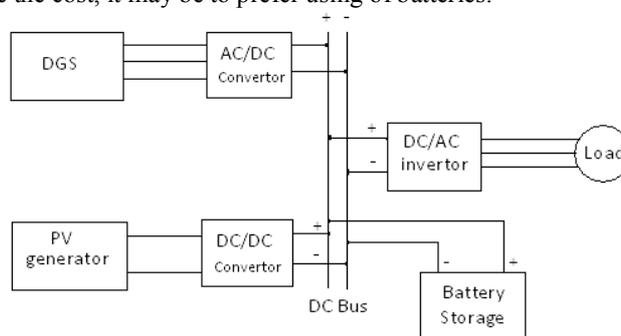


Figure 4: Hybrid photovoltaic system - Diesel - Battery

3-3-Photovoltaic Hybrid Systems - Wind

For a long time in order to supply the necessary energy for regions that are out of the national network, diesel generators were used. But today, some of problems such as high fuel costs; transportation problems and needs

for continue maintenance of generators is caused to use renewable resources. According to the Opposing characteristics of wind and solar seems hybrid system can solve our problems. Figure 5 shows the structure of this system observed.

During the day that there is enough radiation PV system provides energy. If the wind be blowing also, the wind generator can produce energy too. The surplus energy is stored in batteries and during peak times or in situations like night can be used. In addition, wind generators also will work at night to generate energy for storage of the batteries

As an economic view point, it is necessary to consider several issues. The optimum dimensions of the system depends on the potential radiation and wind in the desired location. To enhance the reliability of system design dimension will be slightly larger than expected dimension, therefore the revenant cost increase also. It also increased. Storage capacity of the batteries has a great impact on the cost of the system. Therefore, to reduce energy loss, it is necessary to use a large cost.

It seems that this plan hasn't economic justification for very low energy but with increasing of necessary load, it may be appropriate [11].

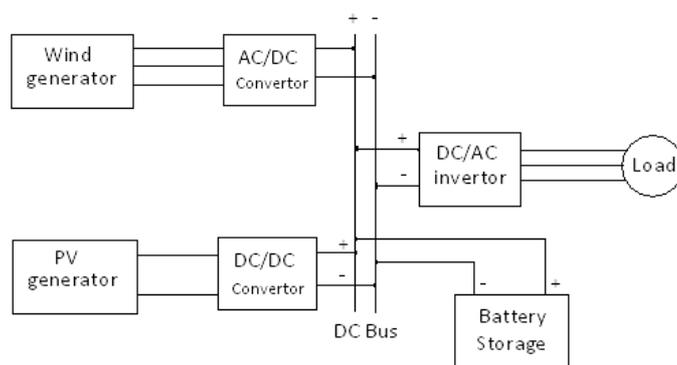


Figure 5: the structure of hybrid systems Photovoltaic - Wind - Power

3-4-Hybrid system of photovoltaic - fuel cell

This section describes arrangement of a hybrid photovoltaic-fuel cell (PVFC) That includes a photovoltaic generator, a proton exchange membrane fuel cell, an electrolyzer, a strong capacitor, and a gas storage unit and a the power converter unit that are is shown in figure 6. The only fuel required for this model is the hydrogen that is free of greenhouse gas emissions. Load is fed by the photovoltaic generator that works with the fuel cell is in parallel. When surplus PV energy is available, using electrolyzer, energy is converted to hydrogen in fuel cell for next use. To address the problem of lack of sunlight during the day and night and long-term energy storage, battery is used. But as it was mentioned, it also is possible only in limited quantities. Another way is to convert electrical energy to hydrogen using electrical decomposition of water with electrolyze and hydrogen storage for fuel cell. The main characteristics of fuel cells are high efficiency, low emission (about zero) and low nose. In this type of hybrid system, if the sun be high enough, the PV array is fed the load. Otherwise, the fuel cell to compensate the shortage load will feed load.

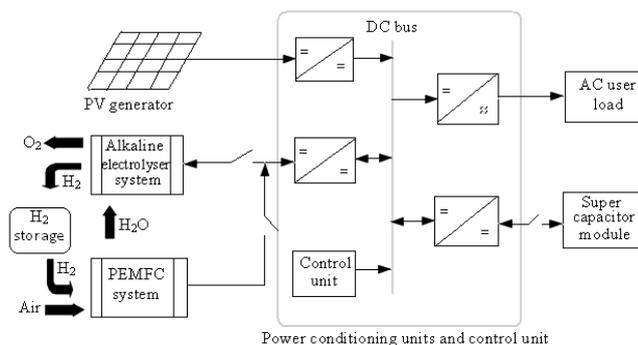


Figure (6) hybrid system of photovoltaic - fuel cell

3-5-Hybrid system of photovoltaic - fuel cell - air

In this section, the hybrid photovoltaic - fuel cell - air has been studied. In these systems according to the periodic nature of wind and solar, energy storage is needed. Usually, acid batteries are used for this purpose. But using these batteries has the environmental consequences, so researcher has been devised to find better solutions. A solution is using fuel cell and electrolyzer for hydrogen production and hydrogen storage tank. Figure 7 shows the structure of this system.

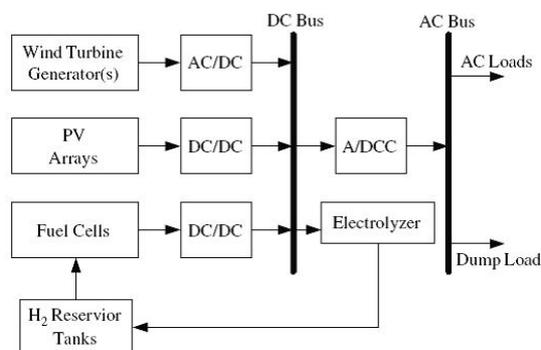


Figure (7) hybrid system of photovoltaic - fuel cell – air

Electrolyzer uses the surplus energy that is produced by wind turbines or solar panels to produce hydrogen and store it in a tank of hydrogen. After filling the tank of hydrogen, at the time fuel cell increasing with hydrogen, it provide the required energy. Researches and simulations show that energy storage in batteries is more economically than fuel cell. In this model, even if the cost of fuel cells are considered zero, however the batteries will be more saving [16].

3-6-Hybrid system of photovoltaic - fuel cell - battery

Figure (8) shows the structure of a hybrid photovoltaic - fuel cell – battery. The first arrangement (8a) includes a photovoltaic generator, a battery and a hydrogen fuel cell which is fed by an external supplier system in crisis times. In the second arrangement (8b), batteries aren't used for energy storage. But electrolyzer that is fed by PV, electrolyze rainwater and produce hydrogen to storage for fuel cell. Figure (c 8) illustrate that how two previous arrangement are combined the energy will be saved using the battery and electrolysis.

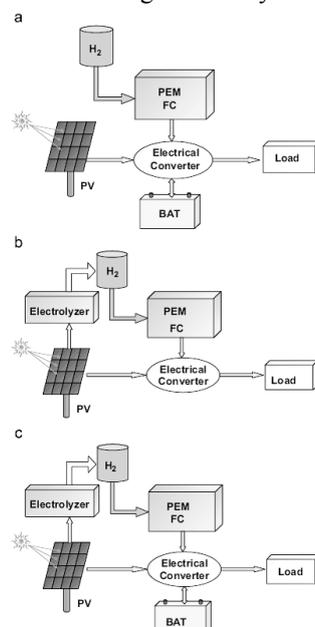


Figure (8) – a: photovoltaic generator, battery, fuel cell which is fed by an external hydrogen source; b: generating photovoltaic, fuel cell, hydrogen source electrolyzer; c: photovoltaic generators, batteries, fuel cells, electrolyzer and a hydrogen source.

3-7-Hybrid system of photovoltaic - fuel cell - air - diesel - batteries

Figure (9) shows the structure of a hybrid photovoltaic - fuel cell - air - diesel - battery installed for electricity generation. In these systems three factors charges, emissions and pollution must be considered simultaneously that are contradiction together when one of them is improved, the other will be worse.

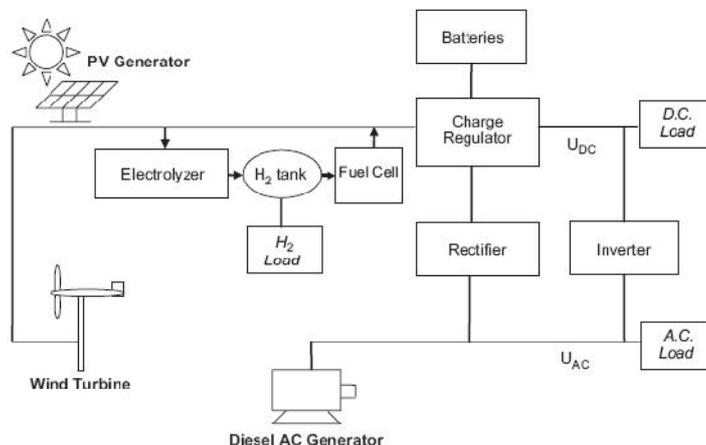


Figure (9) Hybrid system of photovoltaic - fuel cell - air - diesel - batteries

4. Conclusion

Researches show the high dependency of photovoltaic systems to the intensity of radiation cannot supply energy during the day. On the other hand, construction of independent solar power plants is not cost effective. therefore, photovoltaic systems are combined with other resources that were studied in this research and the results is as follows: The use of backup system can increase efficiency and reliability photovoltaic systems. The cost of the project depends on the type of hybrid system and output power. In the hybrid systems, If energy storage (battery) is not used, cost and reliability is reduced. This system wouldn't be economically, but it has less environment consequents. Since the cost has risen dramatically in this system and it cannot be easily passed. The hybrid system including a battery is preferred.

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