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Generating Electricity using PV/FC Hybrid System

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***Abstract*— A reliable electrical energy supply is a prerequisite for improving the standard economic and quality of life levels in a country. As is the case in many countries, it is uneconomical to connect these villages to the existing grid, the installation of stand-alone electrical power generators has become common practice. As a result, diesel stand-alone power generators see widespread use in these remote locales, which, whilst fit for their intended purpose, unfortunately suffer from several drawbacks, including instability in regards to everyday oil prices and a number of environmental issues. The implementation of a PV/FC hybrid power system could be one potential alternative to help solve these problems. Therefore, this paper presents PV/FC system control strategies. This study is especially important in terms of envisioning the future energy supply needs. By using HOMER the proposed control strategies and suggested components of a PV/FC system would be able to produce a satisfactory outcome.**

Keywords—photovoltaic; fuel cells; HOMER; hybrid power system; remote area; diesel generator

I. BACKGROUND

There are many remote villages that are located far away from the utility grid. Connecting such villages to the existing grid is certainly both impractical and inefficient. Therefore, in order to fulfil the electrical energy demand in those particular villages, the installation of standalone generators is a normal practice.

However petroleum costs keep increasing, with the fluctuations in price often being unpredictable. As such, the use of diesel as a fuel source for standalone generators in remote areas can no longer be considered reliable. In addition, since its consumption releases significant pollutants, such as $CO2$, CO, NOx and $SO2$, diesel is unfriendly to the environment [1, 2].

As a result, the best option for remote areas would be to install standalone electrical generators, which utilise a renewable energy supply. Under similar conditions, there are some renewable energy sources and technologies that are available for use, which have already been applied, as shown in **Error! Reference source not found.**.

TABLE VIII. APPLICATIONS OF RENEWABLE ENERGY IN SOME COUNTRIES

Country	Renewable energy applied	Capacity
Sine Moussa Abdou , Thiès region ,Senegal [3]	PV-Wind turbine-Battery-Diesel generator	5.2 kWp PV array, 5 kW wind turbine, 120 kWh battery bank and a 8.5 kVA diesel genset
Kimprana-Mali [3]	PV- Battery- Diesel generator - local grid	72 kWp, PV array, 1185 kWh, 175 kVA diesel genset, 400 V DC, Sunny Mini Central
Conselice, Italy [4]	Palm oil	50 MWel (engines) + 6 MWel (steam turbine)
Angonia, Tete, Mozambique [5]	Hydropower	280 kW
Maguga Dam, Swaziland [6]	Hydropower	19.2 MW

One potential renewable energy source is a hybrid photovoltaic (PV) and fuel cell (FC) system. Regarding the green energy concept, these are both excellent renewable energy sources. PV/FC power plants have been successfully operated in many countries, including Germany, Italy, Finland, Japan, Spain, Saudi Arabia, Switzerland and the USA [7].

Even though many efforts have been made towards simplifying the design of PV/FC systems, so far researchers have been unable to agree on a definitive optimum design process for such a system. There is a real need to explore optimum sizing of component selection, operational control strategies and performance-related issues in this area.

In order to obtain an optimal design, which includes the sizing of components, hourly-based operating states and the operational control strategy, four main components of a PV/FC hybrid power system requires to be examined, namely PV, the electrolyzer, hydrogen storage tanks, fuel cells as well as other accessories. The stored hydrogen and oxygen furnish the fuel cells in a controlled fashion without interruption when the PV system cannot supply sufficient power to the electrolyzer and accessories during off-solar days.

II. SYSTEM DESCRIPTION

A hybrid-type power generation system consists of a PV module equipped with a controller that is used to attain maximum power-point trackers, a pressurized storage tank for $H2$ storage, fuel cells, inverter (DC-AC) and electrolyzer for $H2$ production as shown in Figure 1. The whole system can be designed using HOMER as shown in Figure 2. Furthermore, several component prices for this study will be obtained from previously published papers [8, 9].

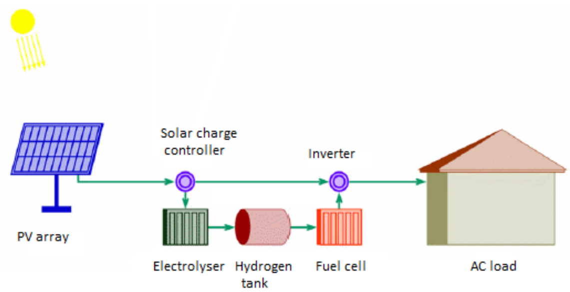

Fig. 7. The configuration of a PV/FC hybrid power generation system.

III. HOMER SOFTWARE

The Hybrid Optimization Model for Electric Renewable (HOMER) is software that is used to perform comparative economic analysis on distributed generation power systems. The data inputted into the HOMER software will perform an hourly simulation for every possible combination of the components. These inputs are used to rank the systems according to user-specified criteria, such as cost of energy (COE) or capital costs. Furthermore, HOMER simulations can perform 'sensitivity analysis', in which the values of certain parameters, such as cost of fuel cells, are varied in order to determine their impact on the COE [10].

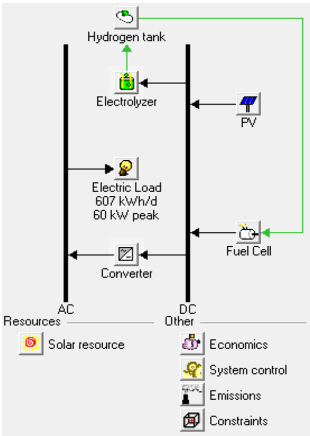

Fig. 8. The configuration of a PV/FC hybrid power generation system in HOMER software

The simulation can be carried out based on a 25-year-long projection period and 6% annual real interest rate. The aim was to ensure the highest levels of reliability in terms of supply security, efficiency of the stand-alone PV/FC system and to properly define the operational strategy needed to maintain the generator, all of which can be summarized as follows:

(a) The first scenario was the PV system supplies the electricity immediately to the load demand. In this scenario the power of the PV system was equal to the load demand (P Load); (PV supply = P Load).

(b) The second scenario was if the power of the PV system exceeds the P Load. In such a situation, the PV system would immediately supply the P Load as well as distribute the excess power from the PV system to the electrolyzer in order to produce H_2; (PV supply > P Load).

(c) Another scenario was that the PV system provides less electrical power than the P Load. In this scenario, the P Load would be supplied by both the PV system and the FC; (PV supply < P Load).

(d) Finally, if solar irradiation is unavailable, electricity might be supplied from the FC to the load demand; (PV supply = 0).

Furthermore, experiments were conducted in order to find the optimum values of each decision variable size, with the possible decision variables being (1) PV array, (2) fuel cell generator, (3) converter, (4) electrolyzer and (5) hydrogen storage tank.

IV. CONCLUSION

A feasibility study regarding the use of PV/FC hybrid power systems for remote locations could be carried out comprehensively by using the HOMER software. Based on the simulation results, the control strategies and the performance of the system components are acceptable for implementing. The PV/FC system operates completely independent from world fossil fuel price fluctuation (which is likely to only increase in the years to come). As an additional benefit, no harmful pollutants such as CO2, CO, NOx and SO2 will be released into the environment. Considering varieties in load profiles and meteorological conditions, the proposed method could be safely implemented for the optimization of hybrid PV/FC power systems.

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