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

<table>
<thead>
<tr>
<th>Country</th>
<th>Renewable energy applied</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sine Moussa, Senegal</td>
<td>PV-Wind turbine-Battery- Diesel generator</td>
<td>5.2 kWp PV array, 5 kW wind turbine, 120 kWh battery bank and a 8.5 kVA diesel genset</td>
</tr>
<tr>
<td>Abdou, Thiès, region, Senegal</td>
<td></td>
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</table>

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].
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].

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 H2; (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.

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