REVERSE OSMOSIS PLANT POWERED BY PV HYBRID SYSTEMS IN HOTEL SECTOR BY USING EUROPEAN INSTALLATION (EIB)

Angeliki Markolefa
N&C GOLIOPOULOS S.A.,
94, Kifisias Ave.,
GR-115 26, Ampelokipi,
Tel: +30 1 6919 011,
FAX: +30 1 6981273
E-mail: kgoli@tee.gr

Panayiotis Romanos, Stathis Tselepis,
Center for Renewable Energy Sources,
19th km. Marathonos Ave.,
GR-190 09, Pikermi, Greece,
Tel: +30 1 6039 900,
FAX: +30 1 6039 905,
E-mail: troman@cres.gr

ABSTRACT: The aim of this paper is to present the study of a reverse osmosis plant powered by a hybrid system that consists of PVs, fuel cells and battery inverter. The work was partially supported by the European Commission, under the Research Directorate General, Non-Nuclear Energy Programme, CRAFT-JOULE JOE3-CT98-7018 “Development of an Energy Management System for Hotels using standard sensor/actuator components and the European Installation Bus”. The study is concerned with the creation of a model, which can be used in the hotel sector. The flexibility and modularity of EIB technology and the availability of compatible component by a growing number of large manufacturers are some of its major assets. In a hybrid modular system, electricity generators, such as PV, wind turbines, small hydro, and storage units are coupled on the established single or three-phase AC grid. Compatibility of components is achieved by using EIB standard interfaces. The advantages of this solution are high reliability, simple expandability as well as simple installation, use and maintenance. The application of such energy management systems seems viable for stand-alone and grid connected energy supply systems for one house/user or small communities. The energy supplying units and loads are simply connected to the AC energy grid, as well as to communication bus (twisted pair or power line couplers) via standard EIB interface components. The EIB technology provides the convenience to control and assign tasks to the various components, defining the energy management strategy and the supervision and safety functions. A case study for the installation of a reverse osmosis plant powered by hybrid systems in hotel sector by using European Installation Bus (EIB) is examined in an island hotel in Greece.
Keywords: Munich Conference – 1: Reverse Osmosis Plant - 2: Grid-Connected

1. INTRODUCTION

Several hotels, mainly in remote Greek islands, yearly buy large quantities of water (transported by ships), in order to cover their demands in water consumption. Taking into account the increasing demands in water of these hotels especially in summer, the reverse osmosis desalination plants can give a solution to the problem. However, desalination plants require extensive amount of energy. The integration of renewable energy sources into the local power systems can cover the increase of energy demand caused by the desalination process, without causing additional pollution.

The modularity and high reliability of PV modules are great assets that have to be used in the design of the systems technology. Modularization of components can lead to a significant cost reduction. Modular systems technology is based on coupling generators, such as PV, pint-sized fuel cells, diesel gensets etc., and storage units on the established single or three phase AC grid. The communication compatibility of components may be achieved by using EIB. The advantages of this solution are the availability of volume production of hybrid components, high reliability, simple expandability as well as simple installation, use and maintenance.

In this way, expandable hybrid systems can be constructed, forming AC grids of high quality and availability by transforming and storing different kinds of renewable resources. Different systems can be tailored to the specific supply conditions by selecting appropriate electricity generation units. Supply systems can be installed, with a few energy sources feeding in, by connecting them to the AC energy bus. The supervisory control unit, sets the Reference State of the power supply system and receives the information about the actual state of each component.

More than 100 companies, of the electric industry in Europe, have joined into only one technology for building Control components that is E.I.B. The use of E.I.B. technology opens the way for compatibility of products from different manufacturers of PV components and Home Automation, opening the market in both directions. The EIB technology for the control of heating, cooling and lighting has already been installed at the case study hotel. The expansion of the system, that will include the RO plant, will reduce the installation cost.

2. THE CASE STUDY

A case study for the installation of a reverse osmosis plant was examined in an island hotel in Greece. According to the information provided by the hotel, there was a comparison of the monthly consumptions of the years 1997 and 2000, as presented in figure 1. The maximum difference was between June 2000 and June 1997. This maximum difference was used in order to size the appropriate RO plant that would meet the hotel's needs. This difference in water consumption was caused by the increase of the hotel’s water demands in watering. A 30% was added to the maximum difference in order to cover future increases. Figure 2 depicts the comparison of water consumption differences. Therefore, the RO plant is called to cover exactly this difference.

The daily water production of the RO plant was estimated in 1020m^3/day and its electric power in 220KW.

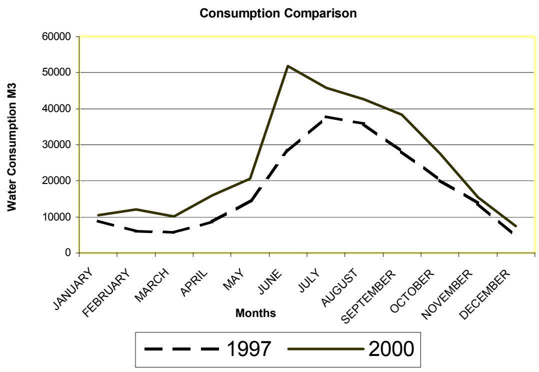

Figure 1: Water consumption comparison between 1997 and 2000

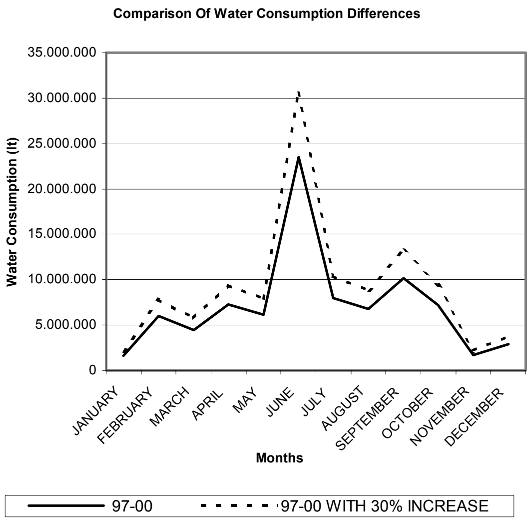

Figure 2: Comparison of water consumption differences

3. LOAD PROFILE

According to the measurements taken, a typical daily power consumption profile of month October of the hotel was created (figure 3). October was chosen as a month with an average load profile for this hotel. In addition, a typical daily power consumption profile for the RO plant of month October of the hotel was created. The addition of these two profiles created the hotel's final load profile (figure 4).

The electric loads of the hotel will be covered by the hybrid system. The average power, which is depicted in figure 4, is 834 KW. The average power will be covered by a diesel genset and a battery inverter. The diesel genset, will operate as a backup only when the battery inverter will not be able to cover the load demand. Moreover the peak will be covered by PVs. According to our experience the diesel genset and the battery inverter has to be 1000 KW each, the batteries' capacity 87.000 Ah with a 3-days autonomy and the PVs 47.000KWh.

In order to examine the system's behavior we used the experimental pilot plant at CRES. We took an experiment by creating a correspondence between the experimental pilot plant at CRES and the estimated sizes of the hotel's hybrid system. There was a subdivision of the estimated sizes of the hotel by using a 1:100 scale.

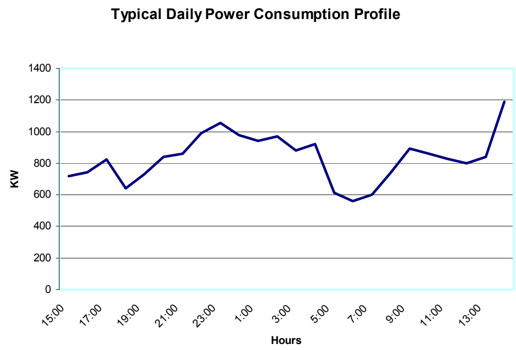

Figure 3: Typical daily power consumption profile

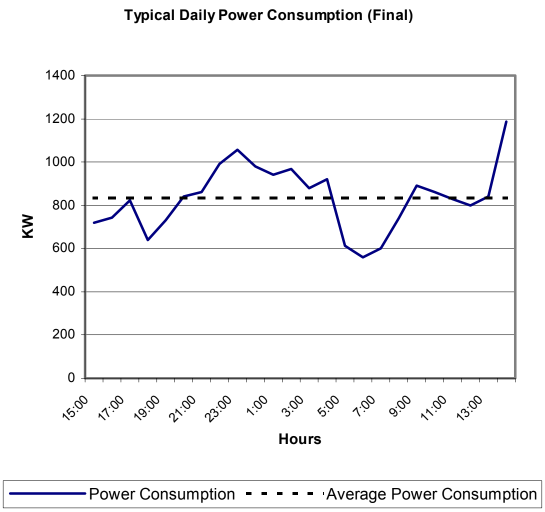

Figure 4: Typical daily power consumption profile including RO plant

4. THE EXPERIMENTAL PILOT PLANT AT CRES [1]

A pilot plant serving all the options of the Control Strategy is necessary. For realistic simulation and testing purposes CRES has set-up a Hybrid system at its premises with energy producing and load units connected to an AC grid. All components are connected to a single twisted pair wire bus. The system includes of a 4.4 kWp PV array mounted on one axis sun tracker, 3KW PV inverter from TOTAL ENERGIE, a 9 kVA four quadrant battery inverter (CEBS, 96 VDC-220VAC) from ANIT, a 12 kVA Diesel electricity generator, ohmic, capacitive and inductive loads and a wind simulator. An operational control unit, which communicates with the local control units, controls voltage, frequency and power and operates as a data acquisition unit.

Interbus-S has been chosen for the communication between the units of the experimental plant at C.R.E.S.

A software prototype has been developed at this stage, based on LabVIEW, as presented in figure 5.

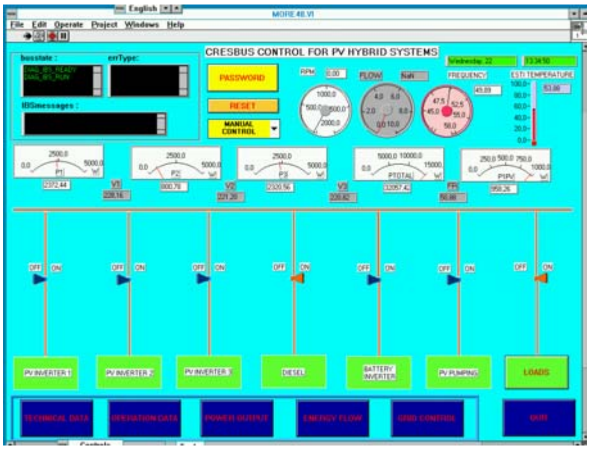

Figure 5: Supervision and Automation Control of Stand-alone Hybrid Systems

Figure 6 depicts the distribution board of Interbus-S modules for the load simulator.


Figure 6: Distribution board of Interbus-S modules for the load simulator

In order to experiment on the energy management of the hybrid system two different strategies are examined. The idea of the first experiment was to inject power from the battery inverter during the period of the peak load demand, therefore reduce the maximum power generated by the diesel generator. The batteries are charged during the period of low load demand, using the same amount of energy that they injected to the grid. The daily load demand profile used to simulate the power consumption of the grid, which is depicted in figure 7, is exactly the same in the two cases. Notice that the first three hours of the day are not shown on the diagrams. The following figures depict the experiments for strategy 1.

The figure 8 diagram shows how the cover of load demand is distributed between the diesel genset and the battery inverter, as well as the batteries charging and discharging time periods. The chart 9 shows the diesel fuel flow.

Figure 7: Daily load demand profile.

Strategy 1:

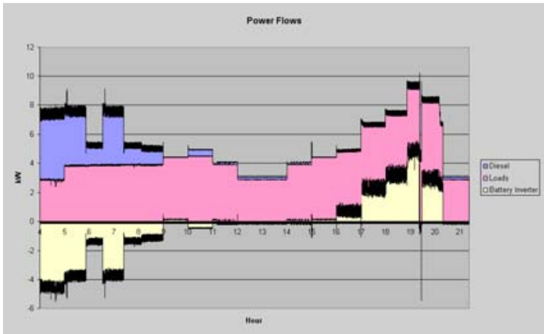

Figure 8: Power flows of the diesel generator, the battery inverter and the load demand.

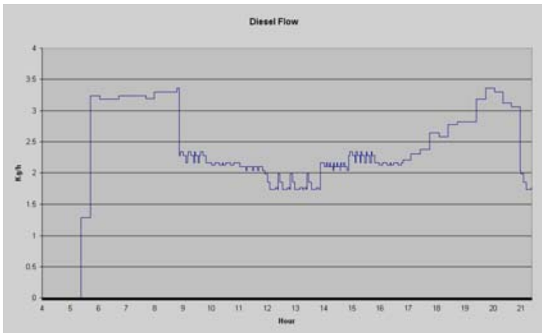

Figure 9: Fuel power flow of the diesel genset (kg/h)

The idea of the second experiment was to use the batteries to cover the whole load demand during a period of base load demand, while the diesel genset is switched off. Then again we charge the batteries using the same amount of energy that they injected to the grid. The results of the experiments are demonstrated in the following charts in the same order as in strategy 1.

Strategy 2:

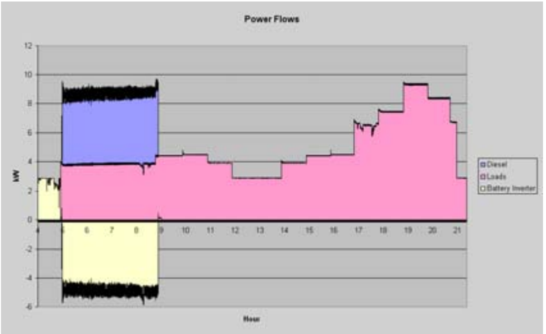

Figure 10: Power flows of the diesel generator, the battery inverter and the load demand.

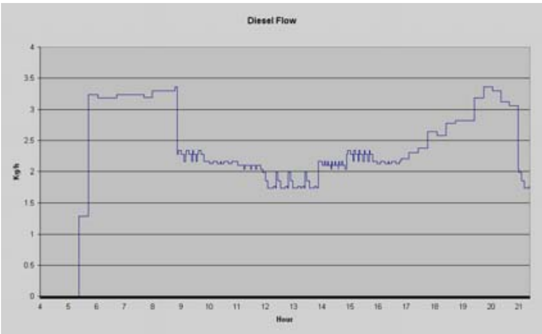

Figure 11: Fuel power flow of the diesel genset (kg/lt)

The total fuel consumption was measured 53.56 Kg or 64.16 lt, when strategy 1 was implemented. In the second case, the consumption was 44.21 Kg or 52.96 lt. This means that 17.5% fuel saving can be achieved applying the second strategy. In general, maximum energy saving can be obtained when an accurate load prediction is attained. Notice that the load profile that is used in the experiments includes the energy, which is produced by PV and Wind Inverters.

Notice also that measurements for the frequency of the grid were also taken, yielding high Power Quality. During the experiments the frequency variation range was less than 0.004 per unit.

5. CONCLUSIONS

The PV hybrid system, gives us the ability to cover reliably the hotel's load, including the reverse osmosis plant. However, depending on the size of the total load, the PV hybrid system could cover part of the load or only the reverse osmosis plant, taking advantage of the fact that the hybrid system could be connected to the grid.

The EIB technology is the key for the efficient and low cost energy management of the PV hybrid system with reverse osmosis plant.

REFERENCES

[1] T. Romanos, S. Tselepis, G. Goulas, VB2.17, Proceedings of 17th European Photovoltaic Energy Conference, 22-26 October 2001, Munich, GERMANY.