PV HYBRID BUILDING SYSTEM USING EIB

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ABSTRACT: The use of renewable energy sources (R.E.S) will increase rapidly, as fossil fuel resources are being used up. Apparently, the consumers are encouraged not just to use R.E.S., but also to do as much energy saving as they can. Buildings with PV Hybrid systems in combination with E.I.B. (European Installation Bus) installation seems to be an alternative solution, in order to reduce fossil fuel consumption and greenhouse gas emissions.
The control and the supervision of the PV Hybrid building system is done by means of LabVIEW in combination with B-CON program. Via these programs' environment it is relatively easy to manage the loads and the energy offered by the PV Hybrid System in such a way, so as to reduce the electricity bill of the building. This work was partly supported by the European project JOR3-CT98-0244.
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1. INTRODUCTION

The penetration of the photovoltaic systems in buildings increases rapidly. European Union and European governments have financed the installation of PV systems in buildings, which are connected to the grid, or not. For example, German government announced in 1998, a program to subsidise the installation of 100.000 grid connected PV systems in buildings. Furthermore, the Greek government announced this year a program to subsidise by 70% the installation of PV systems in buildings, in Crete. The estimated installed power will be about 2 MWp in the following year.

On the other side, many buildings can not be connected to the grid in an economic way even in highly industrialised countries like Germany and Norway. As an example, more than 100.000 solar home systems (SHS) have been installed in Scandinavia on a commercial basis. These systems are mostly used to supply weekend-houses with electricity during the summer session. In the Alps, more than 30 PV-diesel hybrid systems have been set up to power alpine huts very reliably [1].

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, wind turbines, small hydro, diesel gensets etc., and storage units on the established single or three phase AC grid [2]. The communication compatibility of components may be achieved by using European Installation Bus (E.I.B.) The advantages of this solution are the availability of volume production of EIB 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 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, which 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.

2. LOAD MANAGEMENT SYSTEM

The electric loads of the house can be considered as loads of the Hybrid System. Some companies have produced EIB modules for Load Management, achieving the maximum energy saving. Such Load Management Systems for houses are currently available. They could control the household electric devices, during heating/cooling and lighting periods, in order to reduce the peak power consumption by 50% of the average prior state. Moreover, the energy consumption of these houses is expected to be reduced by 20-25%. This leads to a significant reduction of emissions by decreasing the fossil fuel consumption.

E.I.B. technology is selected because different manufacturers produce a large variety of compatible modules to control the building appliances. EIB is compatible with other building automation systems (e.g. SICLIMAT X) and recently it was introduced as a communication bus to energy producing units, such as PV grid connected inverters and Battery inverters.

E.I.B. modules provide the opportunity to:

- control automatically and visualise the PV Hybrid and building systems
- optimise the energy management of the PV Hybrid System so as to cover all the energy needs of the building with the lower cost
- save energy

Today, there are not sufficient energy management installations in houses. One reason is that residents do not appreciate the importance of energy management, because they do not know when they are exceeding the desirable energy consumption and how they are going to save energy. Another reason is that the owners, without thinking in long term, are interested in low cost installations when they are building their houses.

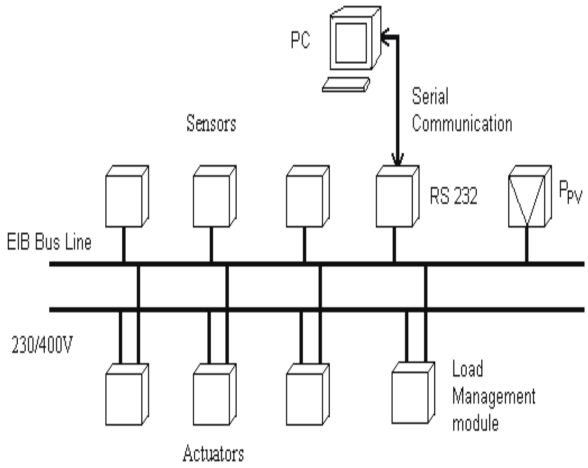

Figure 1: Typical PV Hybrid Building System Structure Using EIB

In Figure 1 is shown a typical PV Hybrid building system structure using EIB technology. Sensors and actuators depict all building appliances that use EIB modules. The control and the supervision of the PV Hybrid building are achieved via an RS 232 EIB module, which communicates serially with a PC. The P_{PV} module depicts an EIB module that measures the power of PV in order to succeed the optimum energy management.

The Load management module helps to avoid excessive power consumption during peak periods (Figure 2) by temporarily deactivating subordinate loads. The loads are switched decentralized via EIB. It is noted that sometimes it is preferred not to switch off a load for a small period of time, because it may require more electrical power when it is turned on than if it was working normally during this period of time.

Standard components for controlling heating/cooling and lighting, which are available with the EIB interface, are able to reduce energy costs considerably.

There are three main reasons to apply EIB: easy installation, increasing comfort and energy savings.

Some scenarios that can be considered in order to achieve energy saving are:

- If the outdoor brightness is sufficient for room illumination, decrease the light intensity without compromising the effectiveness of lighting.

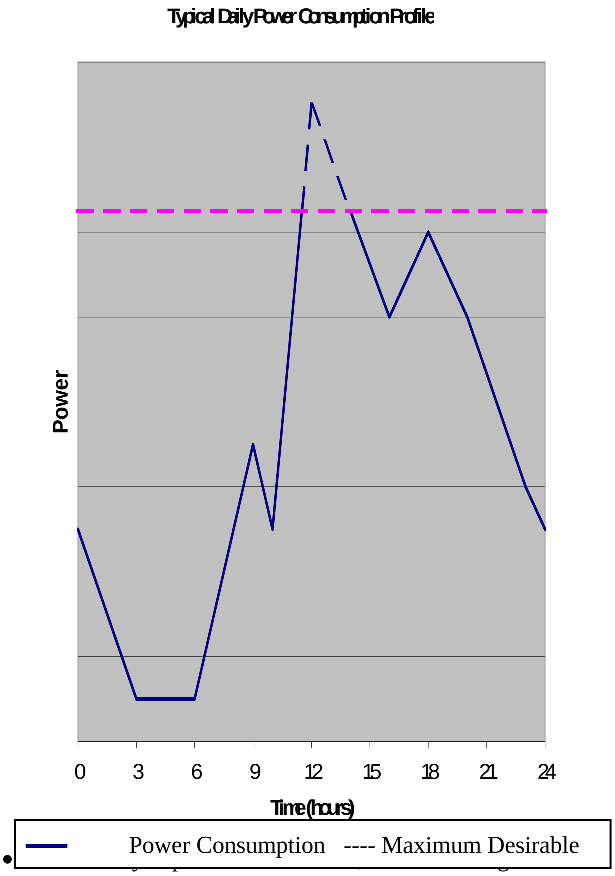

Figure 2: Typical Daily Power consumption

- If a window or a door is open, turn off the heating/cooling.
- If nobody is present in the house, turn heating in the comfort temperature program.
- If the maximum desired level of the power consumption is exceeded, deactivate subordinate loads temporarily by the load management modules.

3. THE PRICING MODEL [1]

The control strategy, which should be used, will choose when energy should be bought from the energy supplier and when should be sold to him, depending from the cost of KWh and the contract between the user and the energy supplier. In general, an Energy Management System for a complex system like a building has to control the components in accordance to the needs, especially comfort needs, of the occupants and it has to guarantee a minimised energy consumption. At the same time it should reflect to the user his actual consumption in a comprehensive way, a fact that it is ignored in conventional building management systems (BMS), where the occupant has no influence and no information at all due to the lack of interactivity. The proposed controller, based on EIB, includes also an easy and intuitive dialogue between user, energy customers, energy suppliers and Energy Management System (EMS) as well as visualisation of actual energy flows and costs. The innovation of the visualisation unit is its orientation for an educational use. It will mainly influence the user via a price information to a more energy saving behavior as the price represents a comprehensive information for all users, even those without technical background.

Through energy management system (EMS), PV Hybrid Systems can be operated in such a way that reliable power supply for all consumers becomes possible. The key element of the EMS is an information system in combination with variable pricing of the electricity. Under this type of EMS the actual electricity price is calculated according to the actual supply demand, which forms an energy market.

The actual price is also influenced by the actual state of charge of the battery, the electric contribution of the auxiliary generator and the probabilistic future profiles for power production and demand. This system guarantees optimal use of PV energy because for periods of sunshine electricity is offered at a cheaper price. By contrast, at times of high power demand or during bad weather periods the electricity price will be raised, resulting in a reduced consumption.

The system described above needs special metering, in which the actual power is being multiplied at each moment by the actual electricity price. Transmission of the actual price from the power plant (market) to consumers can easily be performed through the power line. With this way the EMS could convince the user for example, to switch off the kitchen now and to postpone the cooking for some later time, depending the prediction for the load demand and the weather.

4. THE EXPERIMENTAL PILOT PLANT AT CRES

A pilot plant serving all the options of the Energy Management 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 may be composed of a 4.4 kWp PV array, mounted on one axis sun tracker, a 9 kVA four quadrant battery inverter (96 VDC-220VAC), a 12 kVA Diesel electricity generator, ohmic, capacitive and inductive loads.

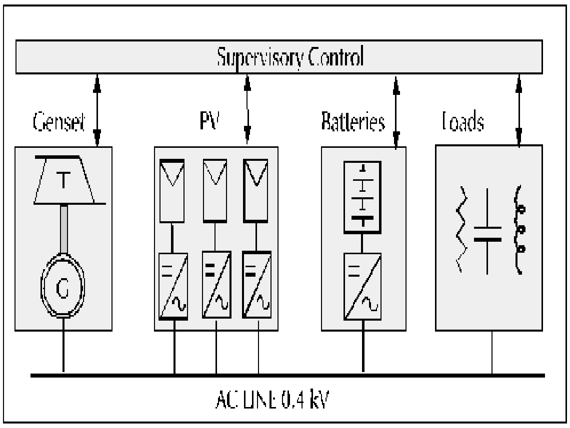

Figure 3: The block diagram of the Experimental Pilot Plant at CRES

An operational control unit which communicates with the local control units, controls voltage, frequency and power and operates as a data acquisition unit. The block diagram of the Experimental Pilot Plant layout is shown in Figure 3.

The aim of the experimental application was a standardized applicable system technology which will allow a variety of different hybrid buildings to be covered. Combined with a standard communication bus for operational control, a basis is defined for future development of a set of fully compatible units, which can be integrated into various hybrid systems in buildings. [2]

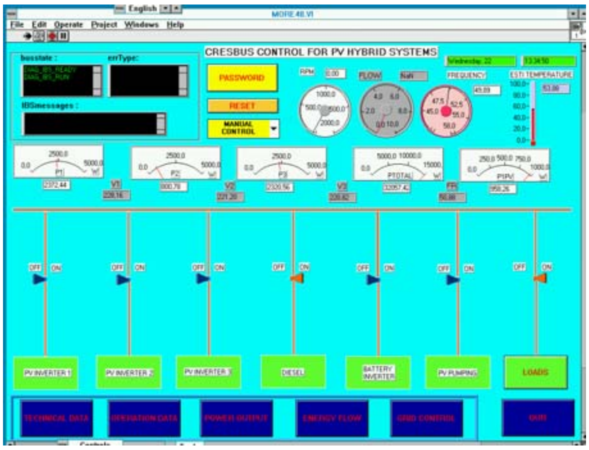

Figure 4: Supervision and Automation Control of Grid-connected PV Hybrid Systems

EIB 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 4. The Energy Management System can be tested on this pilot plant.

The central supervisory control unit sets the reference state of the power supply system and receives the information about the actual state of each component. The communication between EIB modules and LabVIEW was successful via B-Con.

5. DATA TRANSMISSION VIA EIB POWER LINE

Because the installation of the EIB components is practically impossible in buildings whose their electrical installation has been installed, it is essential the examination of the harmonic analysis of every of these buildings and afterwards, the examination of the power line data communication's reliability with the EIB components. For this reason, we developed a simulation, with the aid of MATLAB-SIMULINK programs, which is presented below (Figure 5).

The simulation model consists an EIB-Transmitter Block, which modulates the digital sequences of the information and overlap the modulated signal to the main signal of 220V/50Hz.

In the Communication Channel Block there are the models of the EIB-PowerLine Medium and a Noise Generator, which produces interference. If the noise is measured then the reliability of the Communication via Power Line can be examined.

The next two models are parts of the receiver, where the demodulation is taking place and the extraction of the data.

The last Block is an Error Meter, which is used for the observation of the results.

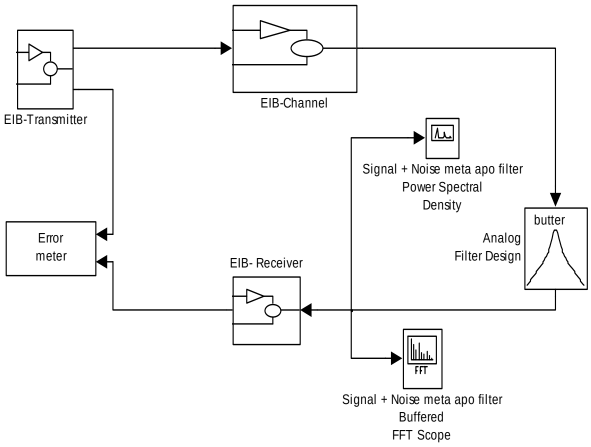

Figure 5: EIB Power Line Simulation

An advantage of the use of the power line medium as the only communication channel is the reduced cost in buildings, which their electrical installation has already been fulfilled.

6. CONCLUSIONS

EIB technology seems to be the optimum choice for communication interface between the units of the hybrid system, because it can combine the operational control in Hybrid Systems with home automation. This way peak saving is achieved through Load Management by the EIB modules. Furthermore, a Simulation tool, in MATLAB is developed in order to examine the communication of the EIB modules via Power Lines. In this way the penetration of the Hybrid PV Systems in buildings with an existing electrical installation would be smoother and more rapid.

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