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Automatically Monitoring System of Renewable Energy Sources

Constantin Stoica

Petroleum – Gas University of Ploieşti, 39 Bucureşti Blvd., Ploieşti, ROMÂNIA
e-mail: cstoica@upg-ploiesti.ro

Abstract

This paper describes hardware and software infrastructure developed by the author for monitoring the electricity provided by two sources of renewable energy, wind and solar. The devices in question are represented by a wind generator and four photovoltaic panels. These are located in the research laboratory for the study of renewable energy in the Hydraulics, Thermotechnics and Reservoir Engineering Department. Monitoring is the first step that precedes the final goal of the author: the efficient allocation according to the requirements of the energy supplied by renewable sources. This represents the author's PhD thesis main objective.

Key words: *renewable energy sources, data acquisition, monitoring, databases*.

Introduction

At present, one of the fundamental world problems is supplying energy for human daily activities. Achieving energy independence involves both knowledge and efficient use of classical energy resources, especially identification of new renewable energy sources and increasing the efficiency of their use [4].

Using the potential of renewable energy gives real prerequisites for achieving strategic goals for increasing security of energy supplying, by diversifying sources and reducing the imports amount of energy, the sustainable development of the energy sector and environment protection[1].

Efficient use of energy resources and especially the renewable ones requires optimal allocation according to their existing requirements. For an efficient use, renewable resources need to be studied and known and must take into account their random appearance. Resource availability is not constant over time.

A first step towards using and resource allocating according to requirements means effective monitoring of parameters characterizing the renewable energy sources.

In this paper the author describes the hardware infrastructure and the software applications developed for automated monitoring of renewable energy sources. These activities were developed in the research laboratory for the study of renewable energy sources. The laboratory belongs to the Hydraulics, Thermotechnics and Reservoir Engineering Department.

The author's main objectives presented in this paper are:

- monitoring and storing of radiation that reaches solar panels;
- parameters monitoring and storing of energy supplied by photovoltaic panels;
- monitoring and storing of air currents from the wind generator;
- parameters monitoring and storing provided by wind generator;
- visualizing the history of requested parameters.

Hardware infrastructure of monitoring system

In the laboratory mentioned above are studied solar, wind and geothermal energy sources.

The monitoring system described in this paper focuses on electric energy obtained from solar and wind sources.

Solar energy is captured and converted into electricity using four photovoltaic panels Shell S75[1]. Specifications of one Shell S75 panel are shown in Table 1. Shell S75 panel consists of 36 solar cells, 125 x 125 mm, series connected. They can generate a maximum power of 75W at a voltage of 17.6 V.

Table 1. Technical specification for Shell S75 panel

Rated power	P_r=75W
Peak power	P_{mpp} =75W
Peak power voltage	V_{mpp}=17.6V
Open circuit voltage	V_{OC}=21.6V
Short circuit current	I_{SC}=4.7A
Minimum peak power	$P_{mpp\ min}$=71.25W
Tolerance on peak power	±5%
Outside dimensions	1220 x 580 mm
Weight	10 kg

Wind energy is captured and converted into electricity using a wind generator HWG-400. Technical specifications of the wind generator are presented in Table 2. Wind generator HWG-400 reaches the maximum generated power (450W) around the 13.5 m/s wind speed.

Table 2. Technical specifications of wind generator HWG-400

Rotor diameter	1.4 m
Start up wind speed	2.4 m/s
Cut-in wind speed	3.0 m/s
Rated wind speed	12.5 m/s
Turbine rated output	400W
Survival wind speed	60 m/s
Battery voltage	12 V
High voltage protection	15.2 VDC
Low voltage protection	10.0 VDC

[1] www.shellsolar.com

The amount of electricity produced in a given period of time depends of several factors, some of them being the geographical area where wind power generator is located, the strength of air currents acting on the turbine blade and so on.

Photovoltaic panels and wind generator are connected to consumers through a monitoring and control panel (fig. 1).

Fig. 1. Monitoring and control panel.

The electricity generated by photovoltaic panels and wind generator is loaded via control panel to a group of batteries (fig. 2). This group consists in two M16 VARTA batteries of 12V and 180Ah.

Additionally, for cases when electricity isn’t available (from renewable sources or from the battery group), the consumers are connected to the energy grid.

As it can be seen from figure 1, monitoring and control panel is equipped with nine measuring and parameters display devices. The measured and displayed parameters are:

- electric current, voltage, energy and electric power from photovoltaic panels;
- electric current, voltage, energy and electric power from wind power generator;
- electric current, voltage, energy and electric power from the network grid;
- electric current, voltage, energy and electric power from the batteries group;
- solar radiation from photovoltaic panels area and wind speed from wind generator area;
- current date and time.

The measuring and displaying devices architecture have integrated ATmega8[4] microcontroller, produced by ATMEL. ATmega8 is an 8 bits CMOS[2] low-power microcontroller, based on AVR RISC[3] architecture. By running some powerful instructions in a single clock cycle, ATmega8 reach performance of 1 MIPS[4] per MHz.

ATmega8 important features:

- 8K Bytes of In-System Self-programmable Flash program memory;
- 512 Bytes EEPROM;
- 1 KB SRAM;
- 23 programmable I/O lines;
- 3 timers/counters with separate prescaller, compare mode and capture mode
- three PWM channels;
- programmable serial USART;
- 8-channel ADC with 10-bit accuracy;
- programmable watchdog timer;
- five sleep modes: idle, ADC noise reduction, power-save, power-down and standby.

Each device has assigned an own address and is connected to a RS485 communication network, based on a master-slave communication protocol. Table 3 presents a message request to a device and a correspondent answer message from the interrogated device.

Table 3. Example of request - response message

Message	**Description**
request: **&V1g**	**& -** START character **V1-** addressed device **g –** STOP character
response: **res=:A=1,I=+0005,U=+0144**	**res=: -** response A=1 **-** device 1 **I=+0005 –** electrical current +0,5 A **U=+0144 –** electrical voltage 14,4 V

Software architecture of monitoring system

The monitoring system was implemented by the author using Visual Studio 2005 development environment. Microsoft Visual Studio is an IDE (Integrated Development Environment) offered by Microsoft.

Visual Studio is used to develop console applications, graphical user interface (GUI), stand-alone Windows application (Windows), web sites, web applications or web services.

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[2] Complementary metal-oxide semiconductor

[3] Reduced instruction set computing

[4] Million instructions per second

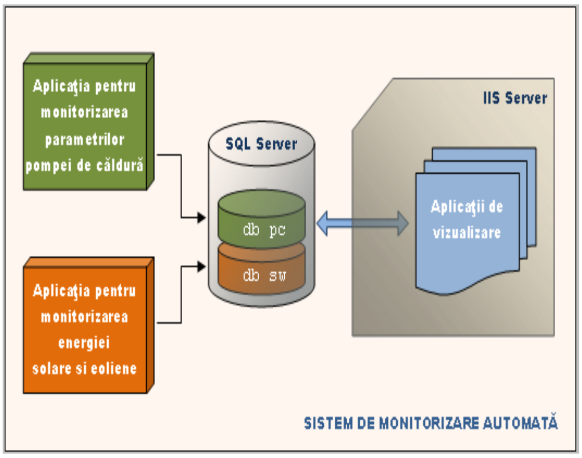

Fig. 2. Monitoring system architecture.

In figure 2 is presented the architecture of the monitoring system developed by the author. It consists in the following software entities:

- application for wind and solar energy monitoring;

- application for parameters monitoring of heat pump;

- MSQL server database;

- ASP web applications for viewing stored parameters, which runs on IIS web server.

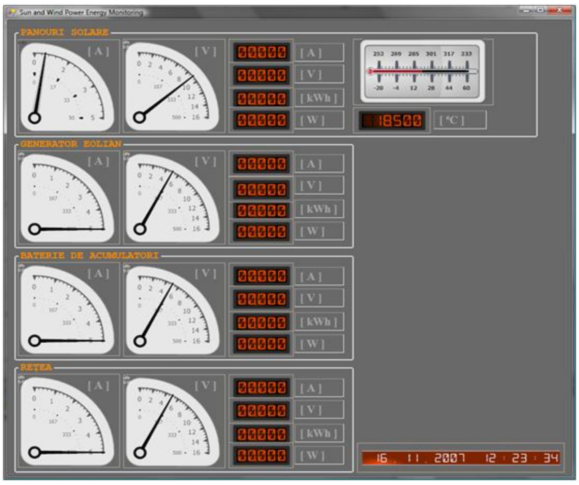

Fig. 3. Graphical user interface of monitoring application.

The first application (wind and solar energy monitoring) has the graphical user interface shown in figure 3. The source code is written in Visual C#.NET [2]. The application interrogates successively each of the nine measuring devices, displays the results and sends them to the database related to MSQL server.

The other application (for heat pump parameters monitoring) is the next future research direction of the author. The scheme from figure 2 contains this application to illustrate how it will be integrated into the final monitoring system of renewable energy.

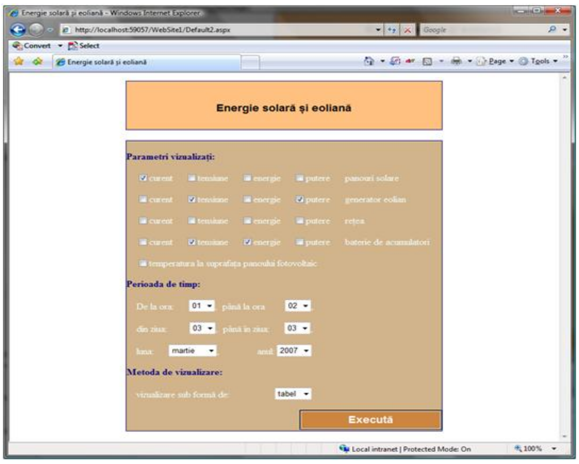

Fig. 4. Web user interface for visualization application.

For its capabilities, as database server for storage of acquired data Microsoft SQL Server 2005 [3] was selected. It contains two databases (one for each monitoring applications): **db_sw -** to store parameters of energy produced by photovoltaic panels and wind generator, **db_pc** - designed for the heat pump monitoring application.

The **db_sw** database consists in a number of tables in which names are formed from the current month and year (example: january2009, february2009, etc.). The tables are created automatically at the beginning of every month.

Each table contains fields for storing the current, voltage, power and energy from solar panels, wind generator, network grid, and the group of batteries. Supplementary the surface temperature of solar panels, solar radiation, wind speed and current date and time are saved.

The visualization applications, shown in fig. 4 (on previous page), are implemented using Visual Web Developer 2005 which is another Microsoft Visual Studio 2005 product.

The programming language used for applications development is Visual C #.NET, same as for the monitoring application. Visualization applications are run by the web server IIS (Internet Information Server).

Figure 4 presents the graphic user interface of one visualization application. The application gives the user the possibility of selecting between various saved parameters and certain period of time, the results being displayed as tables or charts when the **Execute** button is pressed.

Conclusions

Efficient use of energy supplied by renewable sources cannot be achieved without a good knowledge of these sources. Their study and use must take account of their random appearance – their availability being not constant over time. In this way, the author has implemented an automated system for renewable energy resources monitoring. Parameters characterizing the monitored electricity produced by photovoltaic panels and wind generator are acquired. The values of parameters can be displayed either in real time (through the measuring and displaying equipment, or through the software monitoring application) or from server database through a web interface.

Future research will be continued by the author for monitoring resource allocation according to the existing consumer’s requirements.

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Sistem de monitorizare automată a surselor regenerabile de energie

Rezumat

Lucrarea de faţă prezintă infrastructura hardware şi software dezvoltată pentru monitorizarea energiei electrice furnizate de două surse regenerabile de energie, eoliană şi solară. Dispozitivele în discuţie sunt reprezentate de un generator eolian şi de patru panouri fotovoltaice, amplasate în laboratorul pentru studiul surselor regenerabile de energie din cadrul catedrei Hidraulică, Termotehnică şi Inginerie de Zăcământ. Monitorizarea este etapa precedentă în vederea alocării eficiente funcţie de cerinţe a energiei furnizate de aceste surse regenerabile, acest lucru fiind obiectivul tezei de doctorat a autorului.