



RENEWABLE ENERGY SOURCES HYBRID SYSTEM

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Abstract: Nowadays, many countries are starting to turn their attention to renewable energy sources. This is particularly acute issue due to the fact that scientists are warning so strongly on the climate changes, which could have catastrophic results to our planet. One of solution to this problem is use of renewable energy sources (RES), like wind and solar energy. This paper presents practical realization of a hybrid renewable electrical energy source, based on wind and solar energy. In order to implement that kind of system it is important to know energy potential of the natural resource. Therefore, at the beginning of the paper the wind and solar energy potential for the territory of AP Vojvodina is presented. The realized system has been tested in the Laboratory for RES at the Faculty of Technical Sciences in Novi Sad.

Key Words: Renewable energy sources / wind & solar energy / hybrid system.

1. INTRODUCTION

The majority of renewable energy systems used for producing electrical energy qualify period, variety, discontinuity, and unpredictability. Because of this features, using hybrid system of renewable electrical energy sources in remote buildings such as households, farms, cottages, is the most suitable solution. Hybrid system of renewable electric energy offers a wide range of possibility in combination of many types of renewable sources concerning hydro-energy, wind-energy, solar radiation as well as fuel cells. The most appropriate hybrid system, concerning type of energy, consists of devices for exploiting wind energy and solar radiation [1]. Before installing such system it is important to know the amount of available renewable energy in the area. Designing hybrid renewable energy systems is not possible without that kind of information.

2. ENERGY OF SOLAR RADIATION

The quantity of global solar radiation, among else, depend upon the season of the year, which is consequence of the grade of cloud lines [2]. In winter months there are the fewest sunny days while in summer months are opposite. The average number of sunny days during the year in AP Vojvodina is represented on picture 1. The yearly sum of sunny hours for the territory of Vojvodina is in amount of 2050 hours.

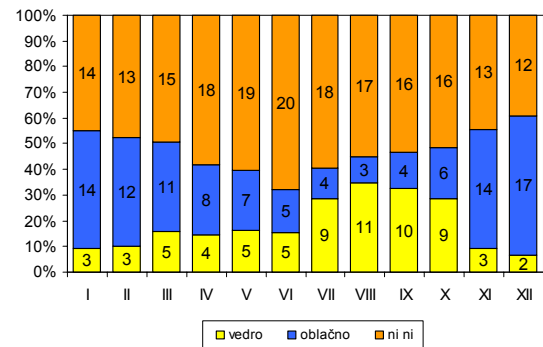


Fig. 1. Amount of sunny and cloudy days in one year in territory of Vojvodina

Solar radiation, latitude and position of Earth to Sun are the crucial factors of global radiation. Hence, the solar radiation in December has the smallest amount of 410W/m^2 while in July radiation is at the top with its 710W/m^2 .

Interval of solar radiation represents energy delivered from the sun. The monthly average sum of irradiation is represented on picture 2. These irradiation values are referred to horizontal surface. Rays of the sun should always strike PV panels with perpendicular angle in order to gain maximum power.

Optimal angle of PV panels for fixed systems in Vovodina amount to 35° referring to horizontal survey. The average sum of energy delivered to the ground of Vojvodina amount to 1476 kWh/m^2 regarding the optimal angle of PV panels [3].

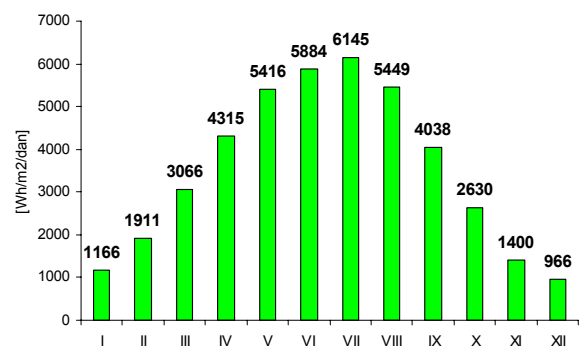


Fig. 2. The average sum of daily radiation per month

Electric energy produced by PV systems with nominal power of 1 kW_p during one year is listed in Table 1, with assumed efficiency of 75%. Positions of PV systems in the province are chosen in order to be evenly allocated. The columns in the table are for fixed PV system with optimal angle and for systems with a two axis tracking-rotator installed.

Table 1. *Produced electric energy by PV systems*

PV panels position	Optimal angle	Rotator
	kWh/kW _p	kWh/kW _p
Sombor	1070	1384
Subotica	1097	1428
Kula	1110	1461
Bač	1108	1454
Bečež	1128	1494
Senta	1126	1488
N.Sad	1127	1492
S. Mitrovica	1128	1492
Kikinda	1140	1510
Indija	1145	1526
Zrenjanin	1150	1538
Samoš	1159	1558
Vršac	1163	1557
B.Crkva	1160	1558
Pančevo	1155	1551
average:	1131	1499

3. WIND POTENTIAL

Referring to the data from eight meteorology stations in Vojvodina, a figure 3 is created in order to show average wind speed for an interval of eight years. Produced electric energy is directly proportional to the wind-speed cube.

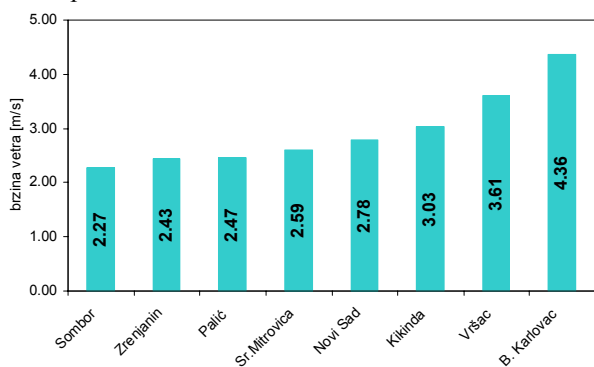


Fig. 3. *Average wind-speed*

In order to evaluate wind energy-potential or generated energy for specific place, statistical analyses of data measured in places where plant had been planned, are to be done. It is not enough to use data from table 3.

Figure 4 shows density of wind power on grassy field with a few low-plants. Numbers on the figure represent maximal values of power density that generator can take according to the Betz's law which states that maximum efficiency of wind-potential exploitation is 60%.

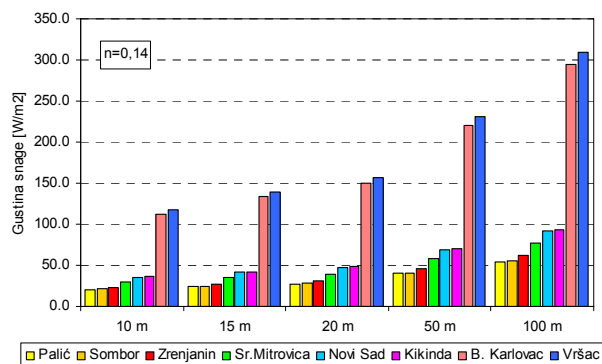


Fig. 4. *Wind power density versus height*

The most wind-plants considered in this paper have a tower which height was in range of 10-20m. Because of that fact, the territorial distribution of power density in Vojvodina is considered for height 10m and 25m.

Allotment of the power density is calculated with a software WASP, which has been done in the research study "Map of wind on territory of AP Vojvodina" [4].

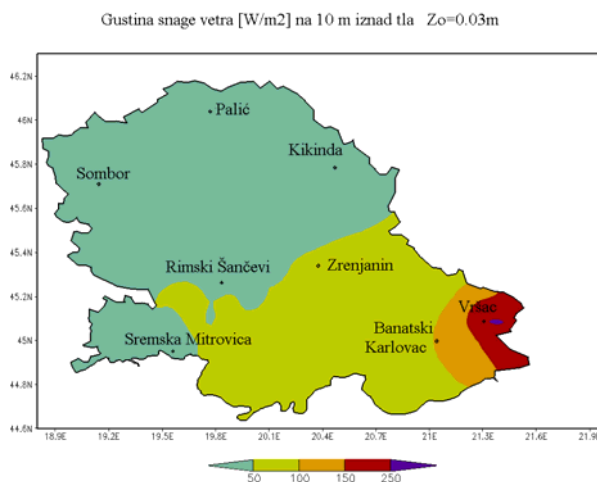


Fig. 5. *The wind power density at height of 10m [4]*

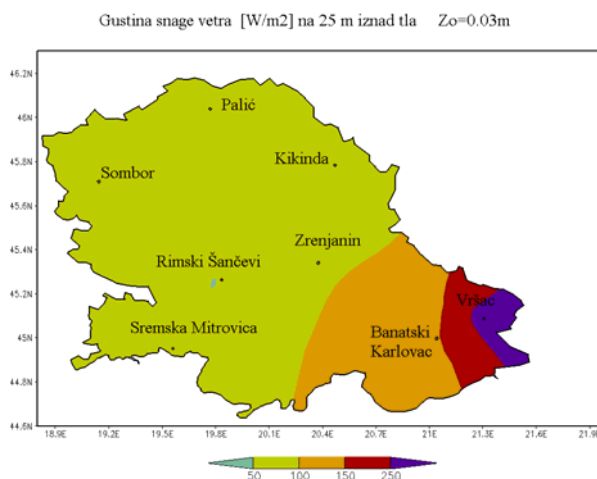


Fig. 6. *The wind power density at height of 25m [4]*

4. TYPES OF HYBRID SYSTEM

All systems of the renewable energy sources for small loads can be used in two ways. One of the ways is grid off type, also called island mode. In that system installed renewable energy sources are the only sources of electric energy and the system is not connected to the

public grid. These kinds of systems are used when there is no possibility of connection to the public grid or it is more expensive than installation of island system. The other way of using renewable systems is to be connected and work in parallel with the public grid. In that way there is more possibility to supply loads either via public grid or renewable system. That way of using is mainly used in cases where there is a possibility of selling the energy to the country. Depending of organization of electrical busses inside of system, off-grid hybrid renewable sources can be divided into three groups [5]:

- Power sources connected to the DC bus
- Power sources connected to the AC bus
- Power sources connected do the AC/DC bus.

5. PRACTICAL REALISATION OF A HYBRID SYSTEM

Hybrid system which converts solar and wind energy into electric energy have been projected and installed in Laboratory of renewable energy sources of Department for power electronic and converters. The system consists of power part and a control one, respectively. Control part provides communication between devices installed in the system, setting up parameters, logging, as well as internet connection.

Hybrid single-phase system, presented on Figure 7, has got two energy buses, an AC one, and a DC bus as well. System consists of main device called *Sunny Island*, inverter *Sunny Boy* to which PV panels are connected, inverter *Windy Boy* with wind-generator, battery management device to which PV panels are also connected, accumulators, and a control unit *Control Plus* with its logging function [6].

5.1. Energy part of hybrid system

The main unit is actually an inverter which DC voltage on accumulators converts into AC. It also has a battery management function whereby it can charge accumulators if there is enough solar or wind energy as well as if the system is connected to the public grid. Other function is control management to whole of the system. The out plug is connected to the AC bus with 230V, 50Hz. The nominal power of the unit is 3300W.

It is possible to connect other AC sources on AC bus such as diesel motor-generator unit or mini hydro-plants if three phase system is considered. The control unit is equipped with two input plugs. One of them is for connection to DC bus and other is for connection to the public grid. *Sunny Island* has got overloading protection option whereby it can disconnect either all loads or just some parts of them.

Also, *Sunny Island* owns a function for automatic starting a diesel motor-generator unit, when power demands are larger than it can be provided from renewable energy sources.

There are three operating modes which are set up via parameters. The modes are:

- Island mode, isolated system
- Independent mode with possibility of charging batteries via public grid
- Grid on, parallel work with public grid with possibility of generating energy to the public grid.

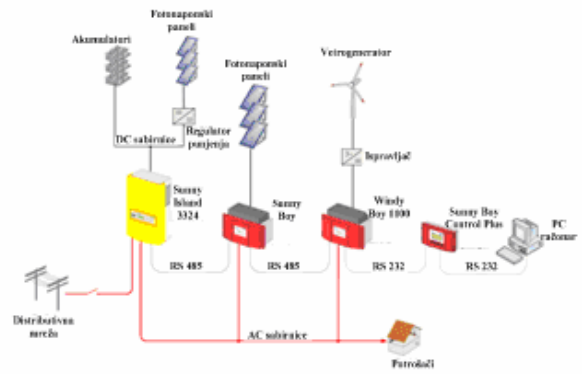


Fig. 7. Block scheme of a communication part of hybrid system

The inverter called *Windy Boy* has a nominal power of 1kW and it is connected to the AC bus

Wind-generator is three phase AC generator, with nominal power of 700W. A three-phase rectifier is connected to the out plug of generator. Hardware and software provide a maximum power tracking function for wind-generator at any point of winds speed.

PV panels with a total power of $1kW_p$ are connected via *Sunny Boy* inverter to the AC bus. The input of inverter support string technology, which means it supports series connection of panels. Hardware and software tools support maximum power point tracking (MPPT), which means that panels are working at maximum efficiency.

AC loads are connected to the AC bus via contactor. Main unit control the contactor whereby it can turn off loads depending of the state in the system.

On DC bus, which voltage is 24V, are connected accumulators. Those accumulators are 12V DC and string connected. Total capacity of batteries is 9.6 kWh. Two PV panels are connected to DC bus via battery management device. Those panels have output of $2 \times 165W_p$. Microprocessor controlled battery management device have output for DC loads.

Figure 8 presents the hybrid system realized in laboratory.

5.2. Communication part of hybrid system

Communication part of hybrid system is accomplished via RS485 communication line, which connects central power unit and inverter with central communication unit *Sunny Boy Control Plus* [5]. Using RS232 protocol communication unit is connected to PC, which is connected to internet, as showed on Figure 9.

In addition to communication connection (phone and internet connection is optional), *SB Control Plus* have digital input and output, analog input and relay output. Analog input were used for measuring of wind speed and direction which could be read via RS485 communication line. Further, using appropriate manufacturer software there was possibility to make own internet presentation, which had been created for this system. All system parameters which can be observed on the computer with appropriate software, at the same time it can be observed on internet.



Fig. 8. Realized Hybrid system control board.

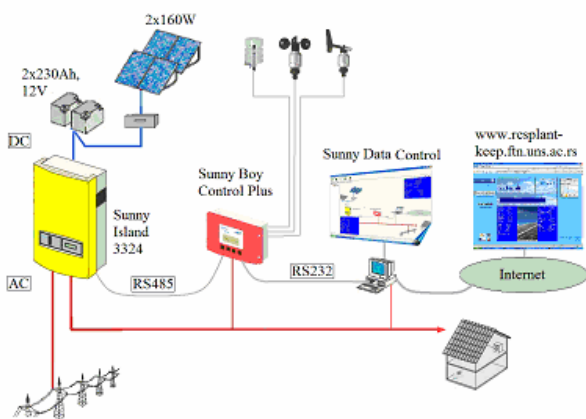


Fig. 9. Scheme of a communication part of the installation

Control unit which has been used in the system still have no installed e-mail and remote control module but it can be put in afterwards. This is possible via ISDN, Ethernet, and GSM communication line.

SB Control Plus also has a data-logger function, which means that certain measurement channels can be recorded into file and then graphically processed on PC. The extension of file is (xls) and therefore could be

easily processed with standard spread-sheet software, like Open Office or other.

6. TESTING OF IMPLEMENTED HYBRID SYSTEM

Due to the testing the power part of the system in island operating mode, different types of loads were connected. Communication part was tested, as well. The system was loaded with active and reactive loads. For active power load an electric heater with 1kW of power were used. For reactive power load, PC computers with capacitive type of impedance were used as well as fluorescent tubes with total power of 160W. The loads were operated in two ways: at the beginning they work separately and than they were switched together. Measurement was performed using an instrument, which operates in accordance of EN50160 standard, the Power & Quality analyzer CA8332B. All results are shown in Table 2.

Table 2. Measurement result for different type loads

Loads	Current [A]	Voltage [V]	P [W]	cos ϕ	THDU [%]	THDI [%]
Heaters	4,62	230,8	1077,3	1	0,72	1,12
PC	0,55	231,1	102,3	0,757	1,9	88,62
Lighting	1,43	203,9	167,9	0,494	0,76	14,91
All loads	5,94	230,65	1346,8	0,975	1,47	3,44

Testing of the communication part was set up after installing sensors for wind speed, direction and ambient temperature. Data from sensors were collected in logger device. After installing all parameters of the system and data from the logger, time functions have been drawn. Figure 10 shows the measured results of wind speed and ambient temperature for one month.

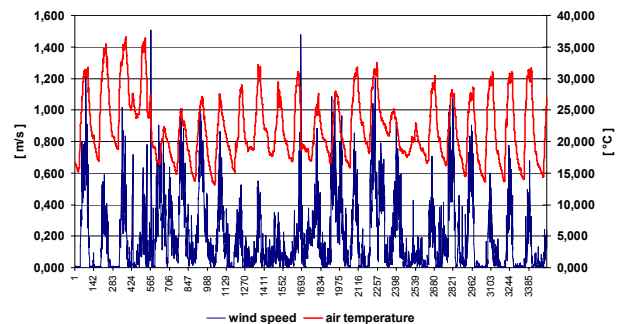


Fig. 10. Results of measured wind speed and ambient temperature for September 2009.

7. CONCLUSION

On territory of Vojvodina there are enough potential of solar irradiation in order to apply PV panels. Potential of wind energy is the most suitable in the south-eastern part of the province. Thus, the hybrid renewable electric energy systems enable exploitation of wind and solar energy throughout the whole territory of Vojvodina.

Installed hybrid system was projected as modular system which means that it could be easily expanded with more capacity and more different types of renewable energy electric sources.

8. REFERENCE

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