

EXPERIMENTAL HYBRID ENERGY SYSTEM

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Abstract: This paper describes experimental hybrid energy system and the research connected with integration of similar systems into a civil buildings. Possible benefits and reasons for implementation of these systems are further discussed. Paper includes the description of the designed experimental hybrid energy system, its location and control system. The results and the progress of the research are shown in the conclusion of this paper.

Keywords: hybrid, energy, system, HES, control system, design

1 INTRODUCTION

The intention to connect multiple energy sources into a cooperative system is the possible way of increasing the operational efficiency of individual systems. Solutions with accumulation devices are also possible to cover the energy demands in the distant areas without electricity or as a backup solution for improving the security of important facilities. Generally, the hybrid energy system is based on combination of individual energy sources that are able to adequately cooperate and their mutual connection leads to improvement of the desired parameters.[1][5]

With the development of the renewable energy sources and their availability, the problems with their negative affect on the distribution network have been detected in Czech Republic. The high financial support of the PV plants led to the decision, that no photovoltaic (PV) power plants with the nominal power higher than 30kW will be installed. Due to this administrative decision, the potential of the PV plants is in their installation on family houses and administrative civil buildings. Since 2014, isn't the electricity produced in PV power plants subsidized by the Czech Government.[2]

The main disadvantages of the renewable energy sources (wind turbines, PV panels) in Czech Republic is the insufficient and irregular power generation, which is caused by variable climate conditions. This excludes the possibility to use this individual renewable energy sources in a standalone off-grid systems applications. In order to create the properly working off-grid system, the energy accumulation is necessary. With combination of wind and solar power sources, the time necessary to recharge the accumulation systems is shortened. This leads to improvement of reliability and self-sufficiency. In order to create and verify the adequate rules for the designing such similar systems, the experimental hybrid energy system is created at the Department of Electrical Power Engineering with cooperation with the Center for Research and Utilization of Renewable Energy Sources at Faculty of Electrical Engineering and Communications of Brno University of Technology.

Parameters of the experimental hybrid energy systems and its properties follows further.

2 DESCRIPTION OF THE EXPERIMENTAL HYBRID ENERGY SYSTEM

The experimental hybrid energy system has been in detail described in [4]. With further research have been made additional improvements and minor changes.



Figure 1: Experimental hybrid energy system and the control room

The hybrid energy system is designed as a combination of three-blade, horizontal axis wind turbine (HAWT) with PV panels and deep cycle gel battery banks suitable for application in solar and wind systems.

The Whisper 200 HAWT converts the wind energy to the electrical via the three-phase permanent magnet synchronous generator (PMSG). The nominal power of the generator is equal to 1000W and the stator windings are connected to provide the 48V AC voltage in wye connection. The output from the generator is lead to the control room (Fig. 1) in solar laboratory where is the AC voltage rectified via the 3-phase, 6-pulse diode bridge rectifier. The rectified voltage inputs to the DC/DC converter with MPPT tracker, which serves as a control element for charging the accumulators and unifies the power outputs from individual sources.

As the second source of energy are used the 9 PV panels connected in the three parallel strings. Each panel has the nominal power 250Wp (other parameters in Tab. 1). Subsequently, the output from the PV panels is in the solar laboratory connected to the DC/DC converter similarly as the HAWT.

Accumulators used in the experimental system are the FG12-100DG 12V, 100Ah deep cycle gel batteries, specially designed for frequent cycle discharges. Four batteries are connected in serial to provide the voltage at 48V level. If required, the second battery bank can be connected to the system via the 300A switch and expand the capacity of the entire system to 200Ah.

Overall system connection is shown on the Fig. 2.

3 CONTROL AND DATA ACQUISITION SYSTEM

Between the main benefits of the designed systems belong the low demands on control system. Due to the use of specially designed inverters and voltage regulators with built-in safety features and automatic control sequences, the requirements of the control system will be reduced to the supervision. It is required to have the possibility to remotely shut-down the system during inadequate weather conditions. This is mainly because of the limited speed of wind turbine.

Therefore, the system is equipped with manual and automatic switches, that disconnect the output from the wind turbine and short-circuit the outlets to electrically brake the system. Manual function is generally used in case of maintenance the system.

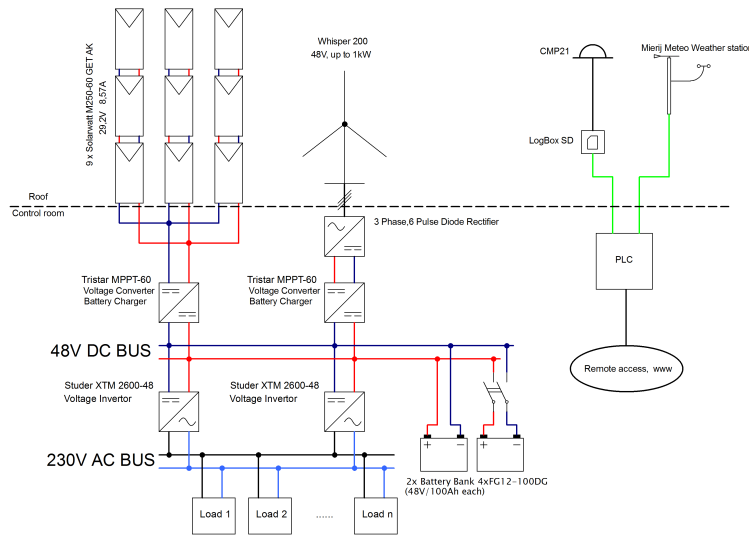


Figure 2: Hardware configuration of Vision V350 in program software

Control system is based on National Instruments CompactRio Platform, which allows the additional measuring cards to be implemented to the system. According to the measured values, simulation models can be created. This part of the research is aimed to create a virtual hybrid energy system, suitable for demonstration and explanation of individual processes and subsystems.[3]

In the initial testing phase, the measurement system based on HIOKI 3390 has been used. Example of the measured values at the output from the PMSG can be seen on Fig. 3

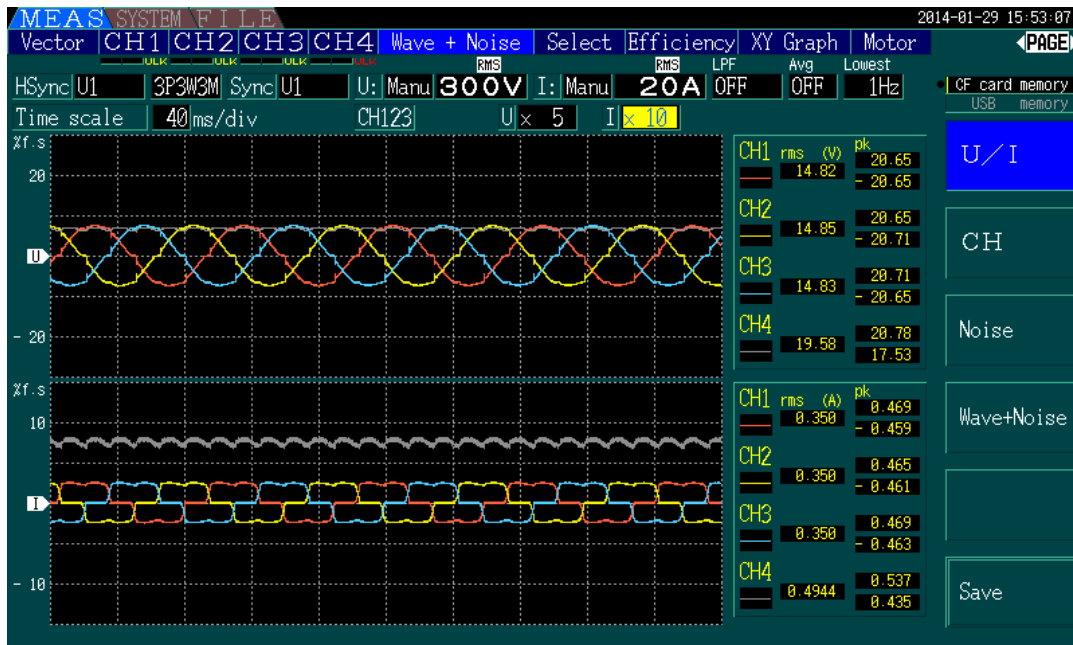


Figure 3: Voltage and current waveforms of the PMSG output(CH1-CH3) and rectifier output (CH4)

For now the weather data acquisition is performed by the CMP21 radiometer, which is connected to the LogBox, where are the irradiation data and the outdoor temperature saved to the SD memory card and simultaneously the LogBox is connected to the PLC Unitronics Vision V1040 via the serial

Wind turbine		Photovoltaic panels	
Type	Whisper 200	Manufacturer	Solarwatt
Rotor diameter	2.7 m	Type	M250-60 GET AK
Weight	30 kg	No. of panels	9
Wind speed range	(3.1 –55) m/s	Type of cells	monocrystalline
Nominal voltage	48 V AC	Nominal Power	250Wp
Pole pairs	3	Nominal Voltage	29,2V
Nominal power	1000 W at 11.6 m/s	Nominal Current	8,57A
Accumulators		Solar DC/DC converters	
Type	FG12–100DG	Type	TS–MPPT–60
Rated voltage	12V	Max. battery current	60A
Capacity	100Ah at 25°C	Max. input voltage	150V DC
Max. discharge current	1000A for 5s	Max. power	3200W
Self-discharge	<9% for 90 days		
Power inverters			
Type	Studer XTM2600–48		
Input voltage range	36-68V		
Cont. power at 25°C	2600W		
Output voltage	Sine-wave 230V AC		

Table 1: Hybrid energy systems parameters

RS232 connection. For measuring the actual wind speed and wind direction, the Mierij Meteo system sends the wind parameters to the PLC via RS232. The PLC has the opportunity to show the parameters on the color, touch sensible display and shows the desired values in a graph. It has the possibility of remote access to the stored values. The basic data are accessible via the web site or to download the data in a *.XLS file for each individual day. Example of the measured data is on the Fig. 4

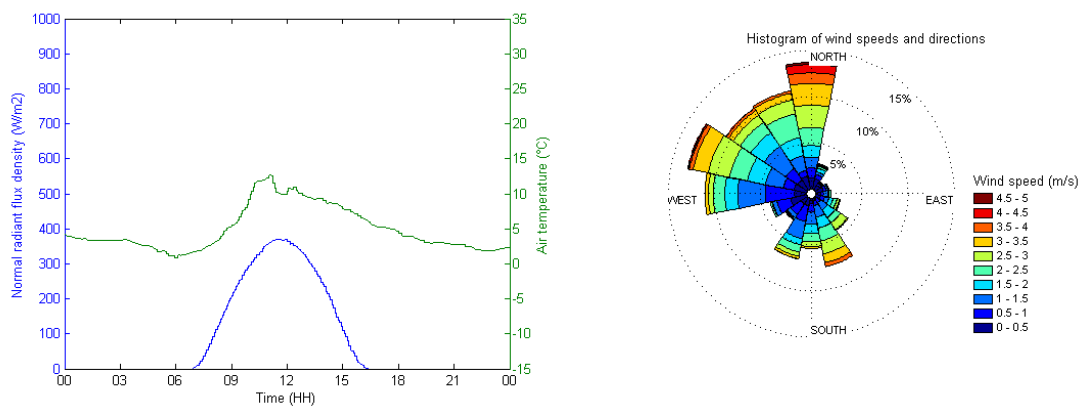


Figure 4: Weather conditions measurements on 12th November 2013

4 CONCLUSION

Previously described hybrid energy system is recently in the phase of optimization and initial testing. Therefore, only the preliminary results are demonstrated. Further research will be aimed on proper configuration of all individual subsystems and processing the measured data. Subsequently,

the optimization steps will be performed. Part of the research will be focused on the effect of different subsystems on the overall efficiency and the possible ways, that can lead to improvement of the system performance.

The following steps will be the configuration of the centralized data repository for all the measurements. This data will be used for virtual hybrid energy system, that will be composed from dynamic models of individual subsystems. After the successful verification based on the measured data, virtual model will be used for simulation of different states, demonstration of the function and explanations for the students.

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