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Research Article

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Optimum Maximum Power Transfer for Renewable Hybrid Power System in Smart Grid

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Abstract In the paper we present the modeling in Matlab / Simulink environment of a solar wind-hydro powered hybrid system. The application is useful for analyzing and simulating a real hybrid hydropower system linked to a public grid. Application is centered on a modular architecture, so that each module component influence can be easily studied. blocks such as hydropower model, wind model, solar model, power transformation and load as well as the simulation results being presented. For instance, the behavior of the hybrid system is one of the most important studies, which enables the use of renewable and changeable time energy source while continuous supplies are provided. Application is a useful tool for both research and teaching.

Keywords modeling, simulation, renewable energy

1. Introduction

The authors use MATLAB'S facilities to simulate, optimize and analyze sensitivity in renewable energy systems for small power systems. However, MATLAB software was expanded with RegenSim Library to allow for the modeling, simulation and analysis of a wide range renewable energy system and the management of such systems. This library has been designed to implement the above functions for renewable energy-based hybrid systems but also their components, especially in the libraries of MATLAB SimPower Systems, interfacing with components from other libraries.

RegenSim Library's basic components are: wind generators, PV generators, hydro generators as well as storage devices (Fig.1). Each component was mainly modeled on mathematical models' studies and has specific parameters such as [1].

In order to conduct an in-depth investigation of the model hybrid System from local automated control systems to the central operational management system, interaction with library components was conducted. As input parameters, except for the component storage device, each other three component contains a specific primary power source and, depending on the nature of the user, voltages, current, power and energy flows are monitored by interconnecting with various types of measurement and display block from MATLAB. The main function of the storage device component is to store energy produced by renewables, supplying the DC customers and the CI directly via the inverter blocks from the terminals [2]. At the battery level the size and state of the battery charge (SOC), the terminal voltage, or the consumer absorbed currents can be monitored using measure and display blocks from MATLAB.

One of MATLAB'S advantages is that libraries provide a wide range of basic components for consumer modeling. This allows consumers with different capabilities, nature, and types to be modeled on a single or three-phase scale (e.g.: resistive, captive and inductive consumers).

Figure 1: MATLAB/Simulink RegenSim library components

2. Simulation solar-wind-hydroelectric hybrid system architecture

The simulation model was implemented according to the system architecture presented in Fig. 2.

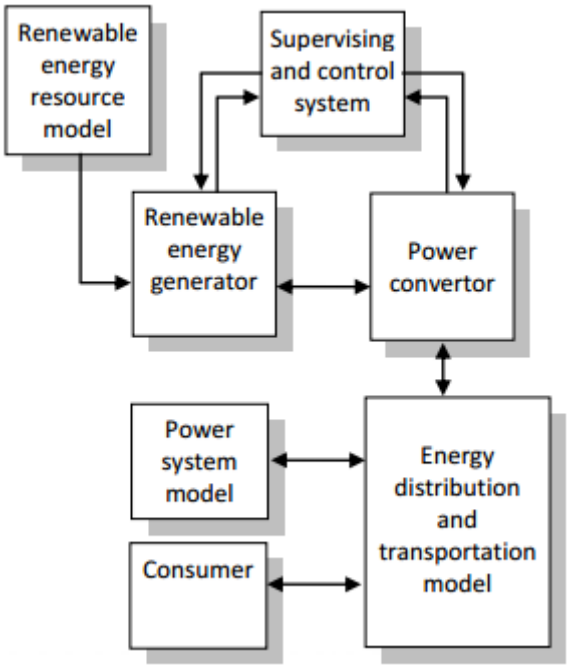

Figure 2: Simulation Model Architecture based on RegenSim library

We can model any system based on renewable energy system with this architecture. Base on the type of simulation model to be studied, one or more types of primary sources with various parameters, different energy power converter using specific parameters, different topologies of the local distribution system and also for different types of users with linear or non-linear features can be chosen.

3. MATLAB/Simulink model implementation

A hybrid renewable energy system using the RegenSim library was created as shown in Figure 3. As shown in this Simulation System, power generation using renewable energy generator which include sun, wind or water, battery blocks (making energy storage available), electric parameters measurement blocks (voltage, current, electric power), inverter blocks (for DC voltage generation), voltage controller block, AC and DC voltage bus bars and consumer AC and DC blocks [3]. It should also be specified that each of the simulated blocks of the

power generation can be sized and function independently to supply energy to the system, but they can also be interconnected, because it is obligatory to size the batteries according to configuration.

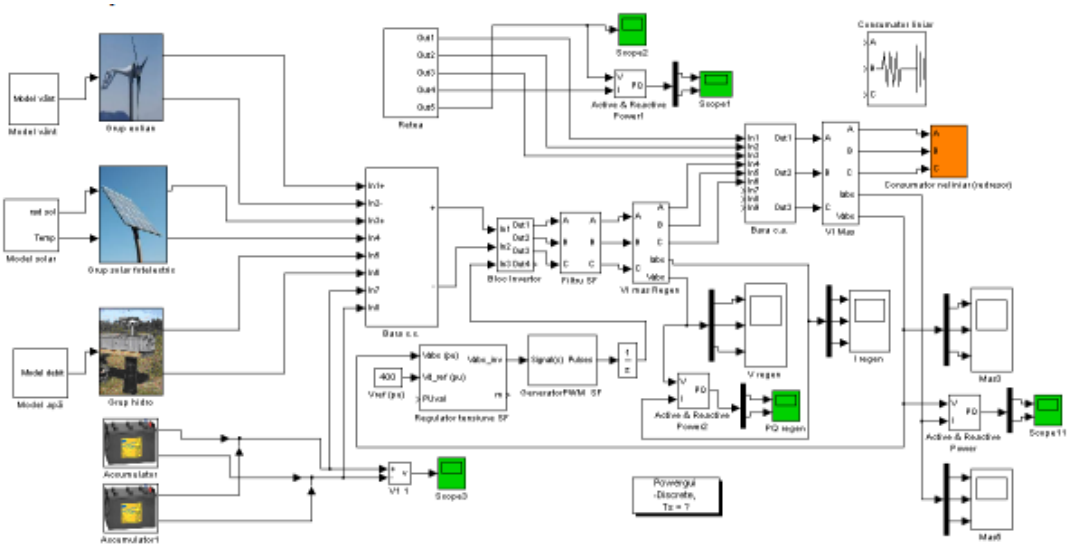

Figure 3: MATLAB/Simulink Simulation Model of a hybrid system based on renewable energy

4. Result and Discussion

Based on data from the National Meteorological Administration and ANAR concerning available renewable energy parameters, which can be taken into account [4], and taking from the MATLAB Simulation Model that is based on mathematical models in [1] and [3], the hybrid system behavior study with or without the availability of a local power network; depending on various condition for different configurations of the customer can be carried out. The simulation model has been designed primarily to analyze the use of renewable energy resources, to manage them in the design phase and to examine possible problems caused by the solution adopted. The solution adopted concerns management solutions, the monitoring, control and control of renewable energy sources and the consumer.

The model was established for the study of operation of real time systems and for the analysis of the power quality of the system studied in addition to the aforementioned functions. After the simulation is carried out, power flow charts can be obtained between the hybrid system based on renewables and the public grid and instantaneous voltages and graphics currents.

In the study, various configurations and situations of availability of renewable energy sources and different types of consumers were considered. The available renewables for solar power, a variable wind rate of 2 to 20 m / s and a flow of water between 30 and 100 l / s at the level of 50 m of hydropower were taken from the scope of this paper. Also considered were a linear and a nonlinear consumer (Pi=33 kW).

4.1. Small domestic power system based on hybrid renewable energy

In Figure 4, the active variation of power in the local power network is presented. The system delivers approximately two fifths of electricity generated in the public network when the energy storage elements are charged to certain parameters by renewable energy availability. If the energy storage elements are not loaded at rated capacity, energy is absorbed by the public network by the time they are fully refilled.

Figure 5 shows the local power network with the reactive power variation. It may be observed that the hybrid system for the production of reactive energy can be used. The best situation is that renewable sources of energy and all energy storage equipment are available.

Figure 6 and Figure 7 showed availability and reactivity of energy produced from renewable energies. It can be noted that power generated with renewable energy device is used to charge the energy storage devices or to cover lost, and excess energy will be injected into the local grid. When the consumer is isolated, the evolution of power stabilizes according to an equivalent constant level of consumer power and loss.

When consumers are isolated, nonlinear elements in a simulation model cause the presence of reactive power: electronic switching components based power transformers and power conversion. The above confirmation is displayed in the Figure 8 and Figure 9 which have active and reactive capacity at consumer terminals.

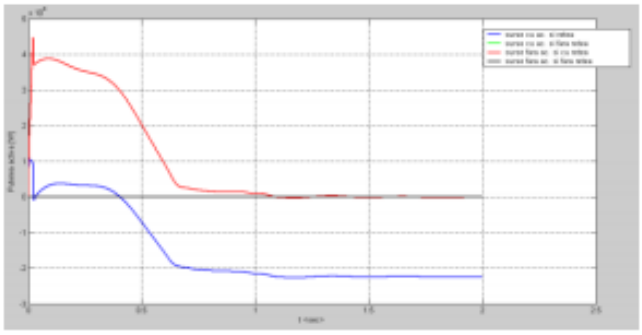

Figure 4: Evolution of active power transit between the hybrid system based on renewable energy sources and the public network

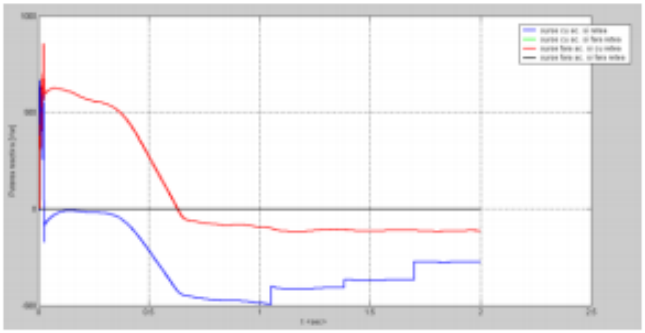

Figure 5: Evolution of reactive power transit between the hybrid system based on renewable energy sources and the public network

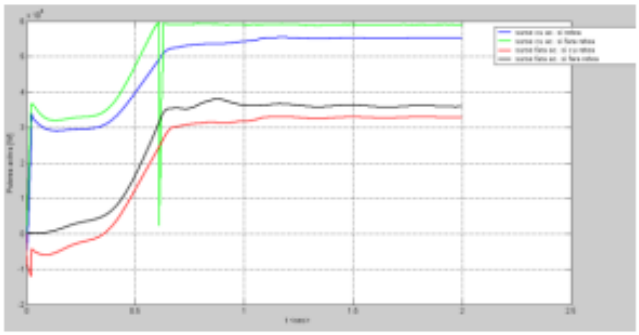

Figure 6: Renewable energy sources active power variation

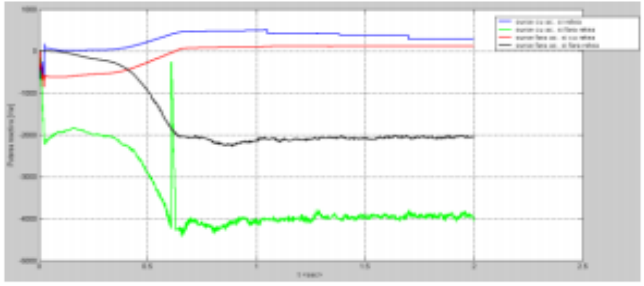

Figure 7: Renewable energy sources reactive power variation

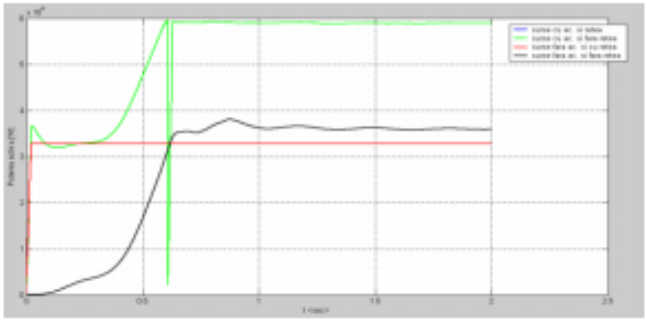

Figure 8: Consumer active power variation

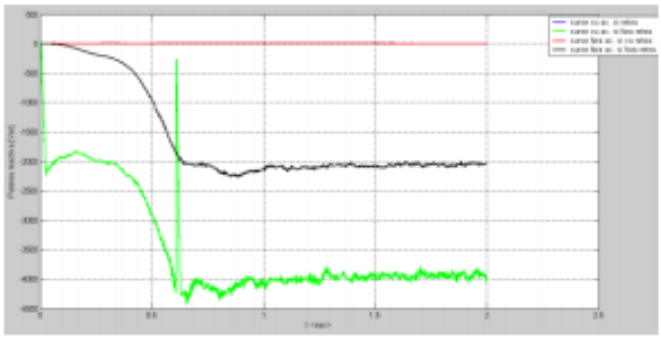

Figure 9: Consumer reactive power variation

4.2 Small industrial power system based on hybrid renewable energy

Consumers are, in practice, locally isolated and use variable speed drives in their activities (i.e. mills, fans, circular saws, transport companies). To analyze this case, it was modeled a consumer with a system based on variable speed drives using controlled rectifier devices (a fan whose speed varies according to temperature). In Figure 10, the active change in power in the local power network is presented. It can be noted that the system supplies the produced energy in the public network if energy storage elements are loaded by renewable energy availability at certain parameters. If energy storage elements are not loaded at rated capacity, it is possible to note that the energy is absorbed by the public network at the time of full recharge. In Figure 10 the very nonlinear nature of the consumer can also be seen. Dark and green features correspond to the consumer's isolation situation.

In Figure 11, the local power network shows reactive power variation. It can be seen that in the considered cases the hybrid system for renewable energy can be used to produce reactive energy.

In Figure 12 and Figure 13, active and reactive energy generated from renewable sources is presented. It is noteworthy that renewable energy sources are used to charge energy storage equipment or to cover losses on the consumer and that the surplus is injected into the public local system.

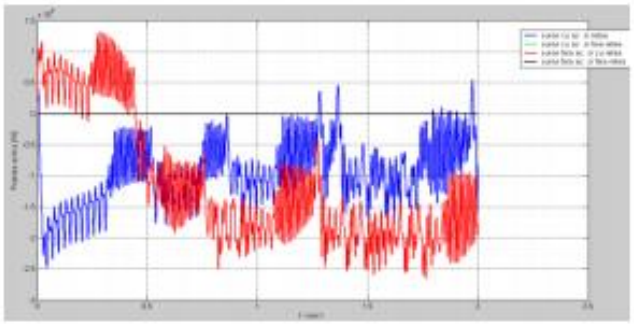

Figure 10: Evolution of active power transit between the hybrid system based on renewable energy sources and the public network

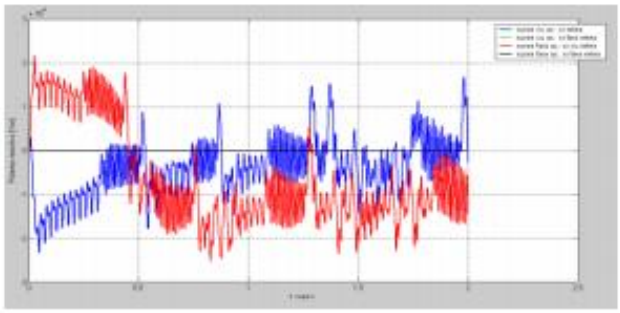

Figure 11: Evolution of reactive power transit between the hybrid system based on renewable energy sources and the public network

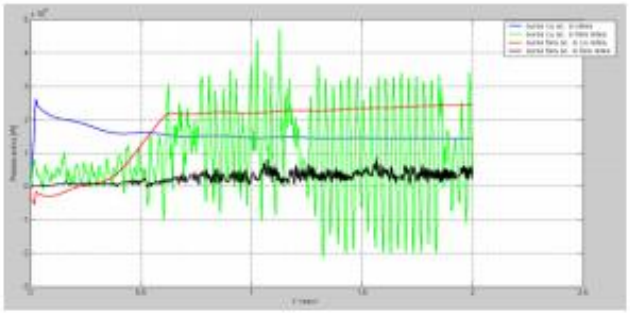

Figure 12: Renewable energy sources active power variation

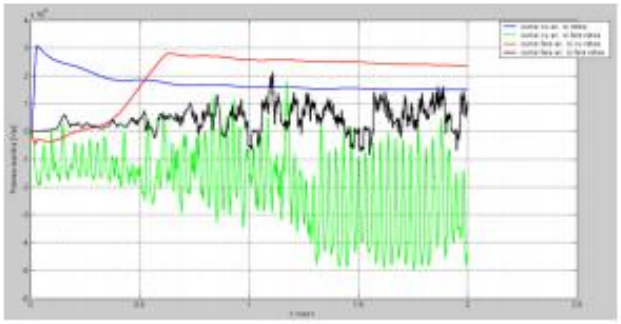

Figure 13: Renewable energy sources reactive power variation

The presence of a reactive power is caused by nonlinear elements in the simulation model, as shown in figure 13, when the consumer is isolated: power transformers and power converters based on electronic switching components, but also by a very unilinear consumer nature.

The above confirmation is displayed in the Fig. 14 and Fig 15 which shows active and reactive power in consumer devices.

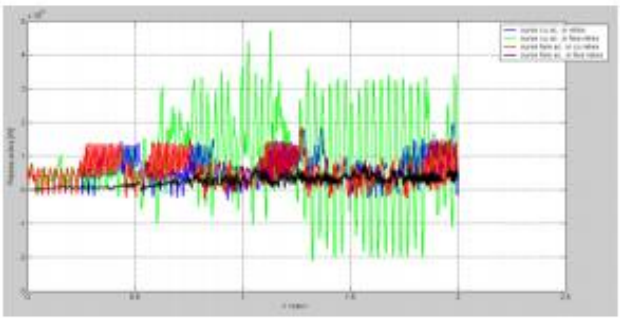

Figure 14: Consumer active power variation

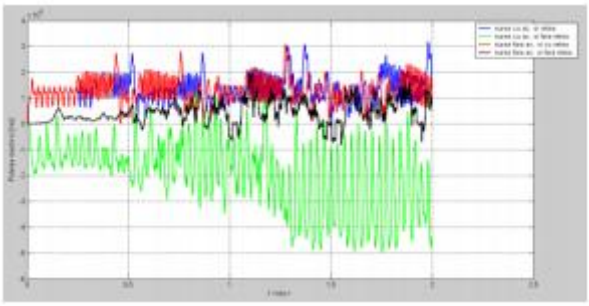

Figure 15: Consumer reactive power variation

5. Conclusion and Recommendation

This paper presents a simulation model that can be used to study small-scale renewable energy systems. A collection of objects organized in a new library called RegenSim in Matlab / Simulink has been built for simulation model development. Compatible with components of the dedicated SimPowerSystems library which are used for the operation of power systems, simulation, modeling and analysis, the created simulated model is based on the new RegenSim librarian. In the present circumstances, the author's proposed model of simulation is extremely useful, enabling studies on identification, the type of use opportunity and implementation for renewable energy power systems in a specific area.

In order to illustrate this feature in the paper, a study was conducted on the suitability of using sun, wind and hydro resources. The developed simulation model also allows for important studies in relation to constant or transient regimes with the possibility of active and reactive evolution of the power.

A useful tool in the field of energy management systems is also the presented model of simulation. The opportunity for current and voltage waveform analysis and power quality studies, which are a common issue in distributed generation, is taken into account in future developments and facilities.

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