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ANALYSIS OF A HYBRID RENEWABLE ENERGY SYSTEM ON THE MURES VALLEY USING HOMER

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ABSTRACT

Renewable energy technologies offer the promise of clean, abundant energy gathered from self-renewing resources such as the sun, wind, earth, and plants. Virtually all regions of the world have renewable resources of one type or another. This paper deals with the modeling and analysis of a hybrid system based on renewable energy resources, located on the Mureş valley, using a dedicated software named HOMER. Different types and topologies of renewable resources for the energy supply are analyzed; a small consumer situated on the Mureş Valley is modeled based on a load curve. Finally, the energy flows between the renewable energy system and the local supplying network are analyzed.

Keywords: renewable energy, HOMER software, hybrid systems, energy flows, Mureş Valley

1. Introduction

The dedicated software's name HOMER originally stood for "Hybrid Optimization Model for Electric Renewables". In spite of its name, HOMER can model systems that are not hybrids, like simple PV or diesel systems. It can also model thermal and hydrogen loads. Considering these aspects, HOMER's motto became the "micropower optimization model".

The most important functions of HOMER are:

- finding the lowest cost combination of components that meet electrical and thermal loads;
- simulation of thousands of possible system configurations;
- optimization of the lifecycle cost, and a sensitivity analysis on most inputs.

HOMER simulates the operation of a system by making energy balance calculations for each of the 8,760 hours in a year. For each hour, HOMER compares the electric and thermal load in the hour to the energy that the system can supply in that hour. For systems that include batteries or fuel-powered generators, HOMER also decides for each hour how to operate the generators and whether to charge or discharge the batteries. If the system meets the loads for the entire year, HOMER estimates the lifecycle cost of the system, accounting for the capital, replacement, operation and maintenance, fuel and interest costs. Hourly energy flows can be viewed for each component as well as annual cost and performance summaries.

After simulating all of the possible system configurations, HOMER displays a list of feasible systems, sorted by lifecycle cost. The lowest cost system at the top of the list can be easily found and also the list for other feasible systems can be scanned.

Sometimes, it may be useful to see how the results vary with changes in inputs, either because they are uncertain or because they represent a range of applications. HOMER can perform a sensitivity analysis on almost any input by assigning more than one value to each input of interest. It can also repeat the optimization process for each value of the input so that the effect of changes in the value on the results can be examined. A large number of sensitivity variables can be specified and the results can be analyzed by using HOMER's powerful graphing capabilities [1].

The usage of HOMER software is an iterative process. It can be started with rough estimates of values for inputs, continued with the checking of results, refined with estimations and the repetition of the process to find reasonable values for the inputs. HOMER can be used to simulate a power system, optimize design options for cost-effectiveness, or to perform a sensitivity analysis on factors such as resource availability and system costs.

HOMER is an hourly simulation model. HOMER models system components, available energy resources, and loads on an hourly basis for one year. Energy flows and costs are constant over a given hour. HOMER can synthesize hourly resource data from monthly averages entered in tables, or can import measured data from properly formatted files or dedicated websites. An example of imported solar data from NASA website [2] for a Mures Valley village is presented in Fig. 1.

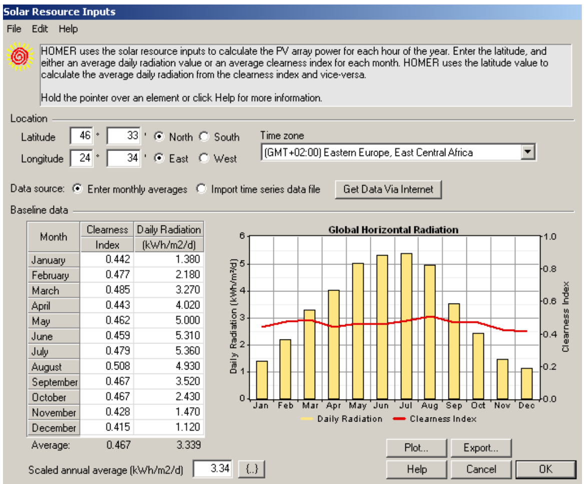

Fig. 1 – Imported solar data from the NASA website [2]

HOMER software is primarily an economic model. It can be used to compare different combinations of component sizes and quantities, and to explore how variations in resource availability and system costs affect the cost of installing and operating different system designs. Some important technical constraints, including bus voltage levels, intra-hour performance of components, and complex diesel generator dispatch strategies are beyond the scope of an economic model such as HOMER [3].

2. Case study for available renewable energy resources on Mures Valley

Two case studies were performed to illustrate the mode of consumed electricity coverage requirements for a power consumer (an agricultural farm located in the Mures Valley) at the same parameters of renewable energy sources, but at different installed power of generating groups [4].

The consumer was modelled considering a mean daily consumption of 794 kWh, which was based on the load curve shown in Fig. 2.

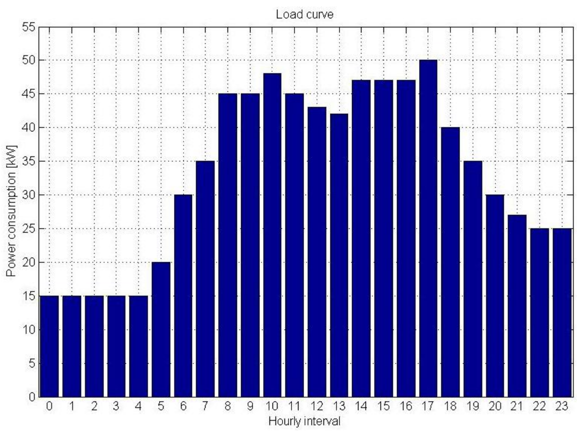

Fig. 2 – Daily load curve for a considered power consumer

Based on the data provided by The National Meteorological Administration [5] and The Romanian Waters National Administration [6] for the parameters of renewable energy availability that can be considered on the Mureş Valley and with the help of HOMER a series of graphic characteristics were built showing the energy flows between the local network and the solar-wind-hydro hybrid system hybrid on a year's period, but also, the contribution of each renewable energy source and of the local network in the proposed system.

2.1. Case study 1

In the first studied the renewable energy hybrid system shown in Fig. 3 was considered. It consists of an installed power made of 15 kW photovoltaic solar panels, 30 kW wind group, 14 kW hydro group and 24 batteries with 1900 Ah at 48 V to ensure energy independence of approx. 3h and 30 min.

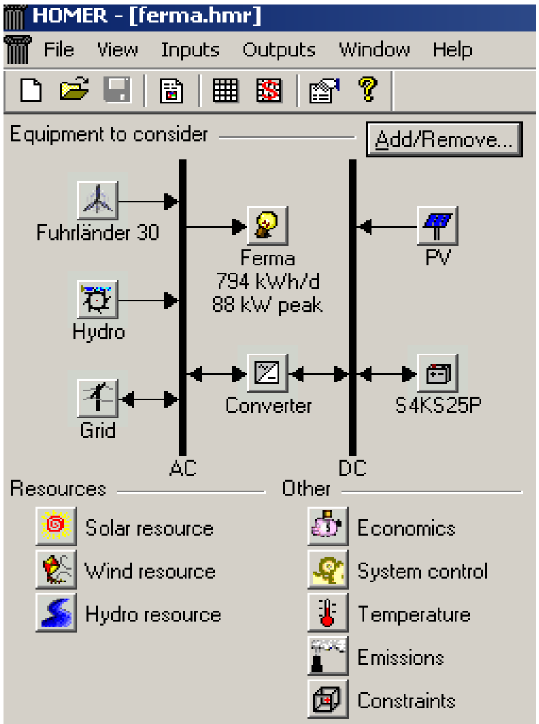

Fig. 3 – Renewable energy hybrid system configuration [7]

As shown in Fig. 3 the photovoltaic solar panels are connected on a 48 V DC bus bar using a 20 kW inverter for converting DC voltage to AC. The hydro and wind groups are connected on a 400 V AC bus bar. The AC bus bar is also connected with the local power network to cover peak loads of the consumer or the unavailability of primary energy resources.

Fig. 4 illustrates a family of curves that describe the total energy purchased over a year, for different configurations and type of equipments. The energy flows are shown in several cases: when the local network and the energy sources are available; when one or more energy sources are unavailable; when all sources are unavailable and the power supply is provided only by the local power supply network.

The analyzed cases, depending on the availability of the energy sources, as shown in Fig. 4, are:

- local power supply network – wind – hydro – solar panels;
- local power supply network – wind – hydro;
- local power supply network – wind – solar panels;
- local power supply network – hydro – solar panels;
- local power supply network – wind;
- local power supply network – hydro;
- local power supply network – solar panels;
- local power supply network,

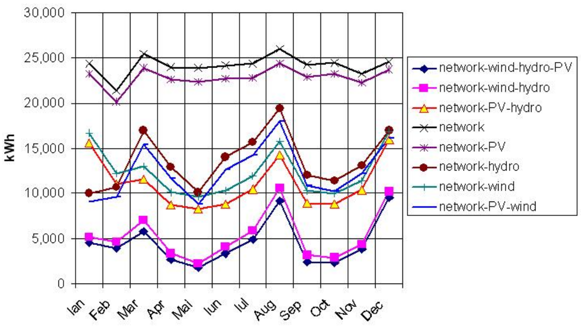

Fig. 4 – Energy purchased over a year for different configurations and types of equipments

Fig. 5 shows the energy sold over a year to the local power supply network from the hybrid system.

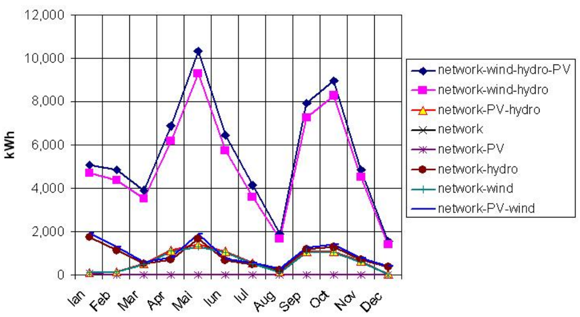

Fig. 5 – Energy sold over a year for different configurations and type of equipments

Fig. 6 illustrates the energy quantities purchased / sold from / to local power supply network during a year for different scenarios of the hybrid system in the above-mentioned configuration.

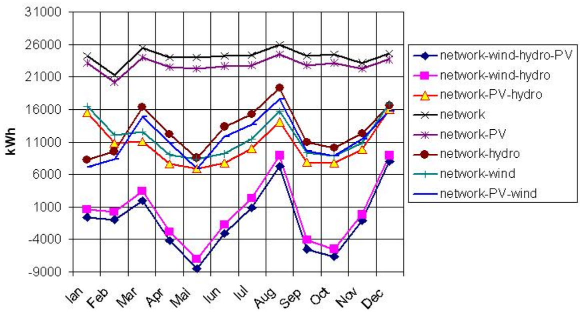

Fig. 6 – Net purchases over a year for different configurations and type of equipments

2.2. Case study 2

The second case study considered a renewable energy hybrid system with the structure presented in Fig. 7, consisting of an installed power made of 10 kW photovoltaic solar panels, 20 kW wind group, 9,71 kW hydro group and 24 batteries with 3000 Ah at 48 V to ensure energy independence of approx. 3h.

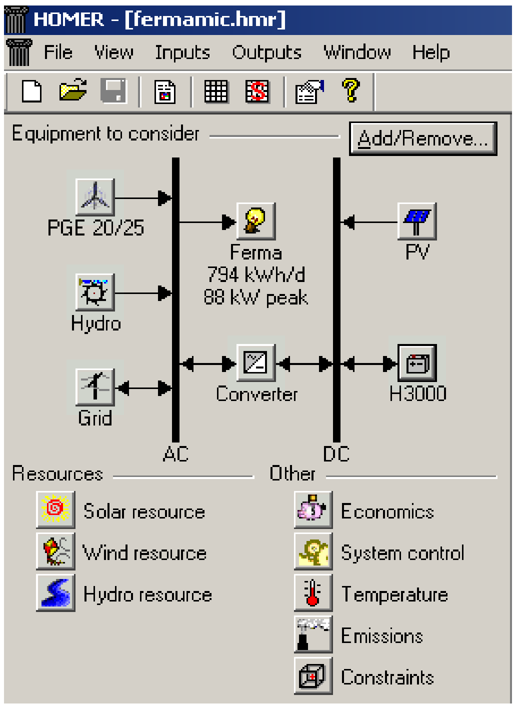

Fig. 7 – Renewable energy hybrid system configuration [7]

As shown in Fig. 7 the photovoltaic solar panels are also connected on a 48 V DC bus bar using a 20 kW inverter for converting DC voltage to AC. The hydro and wind groups are connected on a 400 V AC bus bar. The AC bus bar is also connected with the local power network to cover peak loads of the consumer or the unavailability of primary energy resources.

Fig. 8 illustrates a family of curves that describe the total energy purchased over a year, for different configurations and types of equipments. As in the previous analysis, eight hybrid system configurations are taken into consideration.

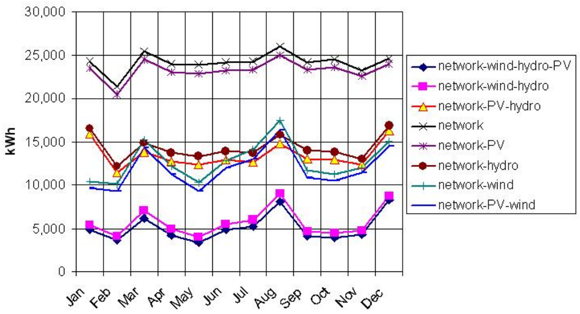

Fig. 8 – Energy purchased over a year for different configurations and type of equipments

Fig. 9 shows the energy sold over a year to the local power supply network from the hybrid system.

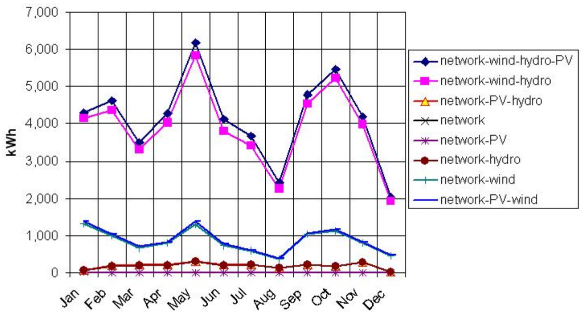

Fig. 9 – Energy sold over a year for different configurations and type of equipments

Fig. 10 illustrates the energy quantities purchased / sold from / to local power supply network during a year for different scenarios of the hybrid system in the above-mentioned configuration.

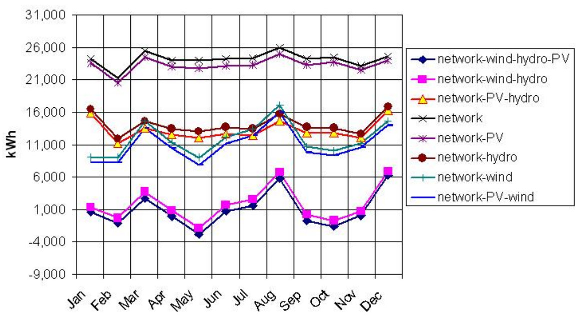

Fig. 10 – Net purchases over a year for different configurations and type of equipments

3. Conclusion

During the months with a high renewable energy sources potential it can be observed that an important amount of energy is being injected into the local power supply network. This means that the months of May and October, register high values of electricity production due to high average wind speed and solar radiation (May), and abundant rainfall (October). The increasing amount of energy injected into the local power supply network is also determined by the number of renewable energy sources available at a given time.

The most important energy contributions in the hybrid system are given by the wind and hydropower groups. Therefore, the most favorable case is the one in which all renewable energy sources are available and with a high potential for generating electricity and the worst is the exclusive supply from the local power network. Between these two extremes, the evolution of energy quantities injected or absorbed in the local power supply network can be followed depending on the availability of one or more of the renewable energy sources.

The analysis performed in the cases mentioned above using Homer recommends the implementation of consumer-based hybrid systems based mostly on wind power and hydro energy. Even if the provided data is indicating a high availability of renewable energy resources an economic study indicating the life depreciation expenses for the hybrid system is recommended, as well as a detailed analysis of the system using a diesel group.

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