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ANALYSIS AND DESIGN MICROPOWER ENERGY SYSTEMS

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ABSTRACT
It is known that the design of each power system is a complex task. This fact holds true for micro-power systems too. Design solution should provide the answers to some complex issues related to the need to include certain components, their cost, efficiency, size and configuration of the system that can be used. It is known that when designing a system, in this case the energy system, it is necessary to provide input model parameters, which describe the technological options, costs of components, and the availability of energy resources. By using HOMER software package, it is possible to simulate different system configurations that can be further sorted by cost. This method enables comparison of configuration and to evaluate them in relation to the economic and technical value of the energy system configuration. In addition, it is possible to calculate the balance of energy for each system configuration, which is to be considered, and then decide whether the configuration is feasible, then estimate costs of installing and operating the system during the project period. Also we can calculate the cost of the system, such as capital costs, replacement costs, operation and maintenance, fuel and interest.
In this paper a diesel micro-power system will be presented. Analyses will be conducted interrogation that should answer whether it makes sense to add wind turbines and capacitor banks in the existing system in the event of certain circumstances. Design and analysis will be performed using HOMER software package.
Keywords: micro power energy systems, wind turbine, capacitor banks, diesel, optimization.

1. INTRODUCTION
This work shows how to create a micro energy system, and gives answers on some questions that are closely related to the technical limitations and the economics of the problem of designing such systems. For this purpose, a micro power diesel system which supplies the consumer at the remote location will be considered. The appropriateness of adding a wind turbine and capacitor’s banks in such a system is examined. The different configurations are simulated and evaluated according to the economic and technical value. In this way one can decide which configuration is feasible, how much it costs, how much are capital costs, replacement costs, and operation costs of equipment during the working period. For the purpose of analysis and simulation of micro energy system HOMER software package is used. This one is very suitable for this kind of analysis.

2. CONCEPT OF HIBRID POWER SYSTEMS
Hybrid power systems are designed for the generation of electrical power. They are generally independent of large centralized electric grids and are used in remote areas, [2]. Hybrid systems by definition contain a number of power generation devices such as wind turbines, photovoltaic, micro-hydro and/or fossil fuel generators [3]. Hybrid power systems range from small systems designed for one or several homes to very large ones for remote island grids or large communities. The use of

renewable power generation systems reduces the use of expensive fuels, allows for the cleaner generation of electrical power and also improves the standard of living for many people in remote areas. A wind-diesel hybrid power system combines diesel generators and wind turbines, usually alongside ancillary equipment such as energy storage, power converters, and various control components, to generate electricity. They are designed to increase capacity and reduce the cost and environmental impact of electrical generation in remote communities and facilities that are not linked to a power grid. Wind-diesel hybrid systems reduce reliance on diesel fuel, which creates pollution and is costly to transport. Hybrid wind-diesel systems are an interesting solution for the electrification of isolated consumers, [4].

3. MICRO-ENERGY OPTIMIZATION MODEL

When creating an energy system it is necessary to decide among possible configurations in which decisions must be based both on technical criteria and economic criteria. Both of them must justify the decision taken regarding the choice of system configurations energy system. Frequently asked questions are related to the selection of components that makes sense to include in the design of the system, i.e. what is the optimal size and power that would be sufficient to supply a certain area and that the solution fits into the economic calculation? [1].

Micro-energy optimization model simplifies the task of the evaluation system with optimization algorithms and by implementation of sensitivity analysis which enable simulations of different system configurations where the all of them sort by amount of current costs. This micro-energy optimization model was developed within the HOMER software package that is now one of the few programs that work in the field of renewable energy, and it is also free of charge, [1].

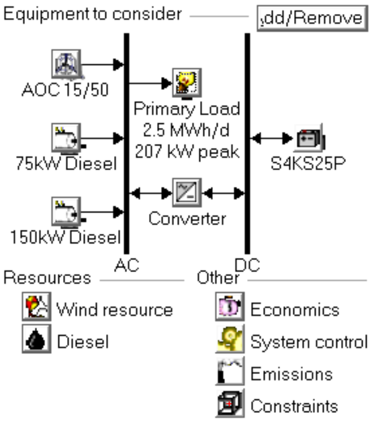
4. PROBLEM FORMULATION

In this paper it is assumed that the consumer is located on the area with no access to conventional powered by electric distribution network, so that it can be powered by diesel systems. Since it is an area where there is wind potential, it would be expedient to examine the possibility of adding a wind turbine in such system.

For this purpose, the two options are examined, and these are: how the market price of diesel and wind speed affects the solution.

In addition, due to excessive injection of energy by wind turbines, the battery for the accumulation of excess energy are added in the system, which accumulated energy can be used for the lack of energy in the system. To facilitate the mutual flow of energy in the system the converter is added to, [2]. Since at the beginning of the simulation we are not sure how much power is needed, the various powers have been considered during the simulations in the range of 0-200000 kW.

Figure 1 shows the energy system with two diesels, wind turbines, connected consumer, converter and battery. Arrows indicate the flow of energy through the individual components of the system. The first diesel has an output of 75 kW and the other is 150 kW, so that both options are tested. As it needs to examine the appropriateness of inclusion of wind in this system, the turbine nominal selected power is 65 kW. It was examined different configuration of the system starting from 0 turbine system (without wind) up to 6 turbines of nominal power. In Figure 2 the dependence of output power of the wind speeds is presented. Figure 3 shows the dependence of capital costs and maintenance costs, depending on the number of the turbines, [1].



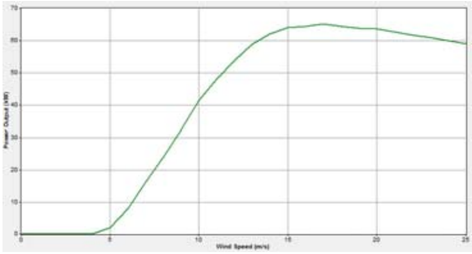
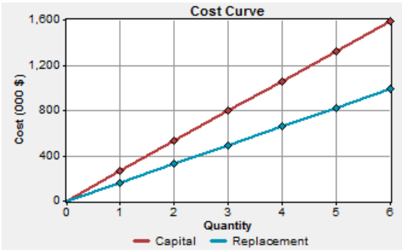


Figure 1. Model of micro-energy system *Figure 2. Characteristic of wind turbine*

The simulation shows that it is useful to connect the battery into the system due to possible excess of wind energy. Accumulated energy could be used later when appropriate. System load is variable during the day, Figure 4, and scaled average values is 2.5 MW / day.



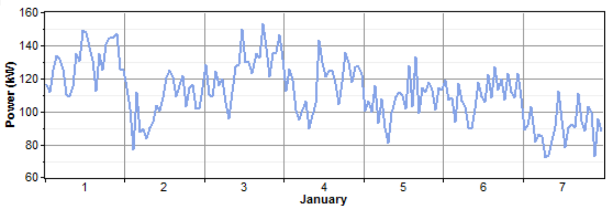


Figure 3. the cost curves of wind turbines *Figure 4. the system load in January*

It should be noted that the system load changes from day to day, during each month, but that is changing from hour to hour within a day, or changes in the course of 8760 hours per year.

5. SENSITIVITY ANALYSIS

The sensitivity analysis should show how much change of some parameters or more of them simultaneously (in this case wind speed and diesel fuel prices) affect on the cost of system design and maintenance costs. If there is wind speed to which it is cost-effective incorporation of wind turbines, and how diesel fuel prices influences on the choice of the solution.

As the sensitivity parameters the wind speed is selected, which is taken to be changes of 5-8 m / s. There are 4 combinations of the system with average speeds of 5, 6, 7 and 8 m / s. The other sensitivity variable is the price of diesel fuel, which varies from 0.2 $ / L to 0.8 $ / L, so that there is a 7 categories of the system.

6. ANALYSIS OF THE RESULTS

Categorized results of the best design of the energy system are given in the Table 1.

Table 1. the best categorized results of optimization

Type of system	15/50	D75	D150	Surette 4KS25P	Converter	Neto Present Cost
category	kW	kW	kW	24	kW	$
Wind-diesel-diesel-battery-converter	3	75	150	0	50	2,351,189
Wind-diesel-diesel	3	75	150		0	2,537,986
diesel-diesel-battery-converter	0	75	150	24	25	3,147,678
diesel-diesel	0	75	150	0	0	3,180,867

Figure 5 shows the cash flow, where it can be seen that the largest capital expenditure happens in year zero, i.e. this year is the year of investments. The labor costs and fuel costs are almost constant throughout the years of exploitation. In the age of 12 some of the system components are replaced the first time, and just before the end of the working-life time of the wind turbines (which has previously taken is 25 years) some specific replacements of components are needed what affects maintenance costs.

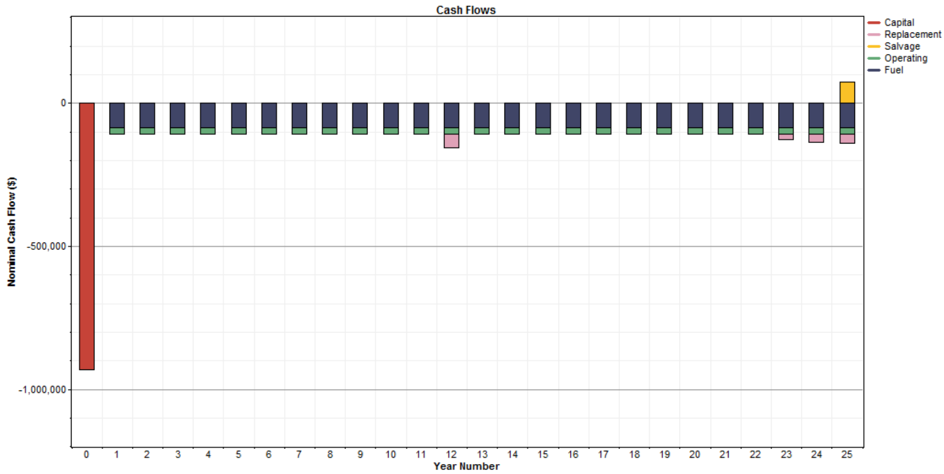


Figure 5. Nominal cash flows through the years

7. CONCLUSION

In this paper the micro-energy system is optimized using HOMER software package. It was shown that among many possible configurations of the system which have to satisfy the basic technical constraints, it is possible to choose the option that economically is the cheapest and satisfies the technical constraints. Analyses such as the voltage in the nodes and power flows analisys were not perfomed because the recorded stream package does not offer such a possibility.

8. REFERENCES

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