IMPACT OF ELECTRICAL POWER LOAD TIME MANAGEMENT AT SIZING AND COST OF HYBRID RENEWABLE POWER SYSTEM

Mikita M., Kolcun M., Špes M., Vojtek M., Ivančák M.*

Abstract: This paper describes modelling, simulation and sizing of hybrid renewable system for pumping of soaking water from closed mine Bankov in Košice and different electrical power load time management strategies for using electricity. There will be analysed three different time management strategies of electrical load and how they affects to cost and sizing of hybrid renewable systems. Time management of load time in hybrid systems can affect sizing and cost in such system. Hybrid renewable systems are suitable in remote area where the connection to the grid is unprovable and building such connection to grid is very expensive and renewable sources are often only supplementary sources to diesel generators, but renewable sources as solar, wind has no costs on fuel and can cause reducing in costs of one kilowatt electric energy.

Key words: hybrid system, load time management, renewable

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Introduction

Hybrid renewables sources systems have been proposed by many different researchers as suitable electrical source in distant locations where there are difficulties with connection to electrical grid. Demand for electricity in distant locations is supplied by hybrid renewable sources with using available potential renewable sources on site where is realized system. This hybrid systems using more different types of renewable energy sources like solar photovoltaic plants powered by sun, wind turbines which works with wind energy, micro hydro-electric power plants etc. advantage of this sources is direct generation of electricity at the locality. Hybrid renewable sources systems have the potential to accompany many advantages like as energy capability and energy management, which resulted in the suitable mix of renewable energy sources. By using various renewable power sources of energy are minimized amount of electricity storage and increase in predictability of electric power supply and improvements in quality of electricity, which is one of key factors recently. In grid-off applications, these structures are mostly combined with storage devices to secure the continuous

* **Ing. Miroslav Mikita**, **Dr. h. c. Prof. Ing. Michal Kolcun**, **Ing. Michal Špes, Ing. Martin Vojtek, Ing. Michal Ivančák**, Technical university of Košice, Faculty of Electrical Engineering and Informatics, Department of Electric Power Engineering
✉ Corresponding author: miroslav.mikita@tuke.sk
✉ michal.kolcun@tuke.sk; michal.spes@tuke.sk, martin.vojtek@tuke.sk, michal.ivancak@tuke.sk

power supply from renewable energy sources like photovoltaic solar and wind turbines. Control systems are one of the most essential parts of such hybrid renewable energy system, which maintains communication between various components in whole hybrid system. Control system helps in management of the output from renewable energy sources and also, produces the signals for plans of storage parts of system to use excesses in generation of electricity. Control system also helps to secure the storage system from overcharging and it help to operate the storage system in rated limits (Nema et al., 2009; Bernal-Agustín and Dufo-López, 2009; Cselényi et al., 2002). Not all of distant areas have adequate renewable energy sources available; in these cases it is needed to adding some conventional choice as conventional fuel generator with renewable sources of energy which helps to cover whole electrical supply in such grid-off system (Zhou et al., 2010).

Power Management Strategy

The power management strategy in the hybrid control structure is most important for balancing between efficiency and performance of hybrid systems. The term “power management” refers to the design of the higher-level control algorithm that determines the proper power level to be generated, and its split between the power sources and accumulation devices like battery while satisfying the power demand from the load and maintaining energy in the energy storage device. Frequent power demand variations and unpredictable load profile are unavoidable uncertainties. Also, nonlinear and often time varying subsystems add to the complexity of the structure of hybrid system (Luna-Rubio et al., 2010).

In general, Power management is done by strategic deployment of distributed generation in microgrid that involves the determination of best DGs along with its size, position, and the way in which it is interconnected to the system. Principal task of power management includes:

- Collecting the information about the microgrid regarding initial cost, power demand and production etc.,
- Determining the amount of real and reactive power exchange between microgrid and the main grid.
- Stabilizing the microgrid during the transition from gridtied to autonomous mode (Liptai et al., 2016).

Hybrid Energy System Types

Hybrid renewable energy system could be built as it can be seen in Figure 1. These types of renewable energy systems is called “hybrid” because they comprised from two or more renewable energy sources in order to cover whole electrical load of such system. Energy sources could be renewable or non-renewable and these sources are usually combined with energy storage devices like batteries. Hybrid renewable energy systems could be connected to the electrical grid (grid-on) where the high precedence for the hybrid system is to provide energy and cover full electrical load and if excess of energy is generated supplies the outer grid, or as a grid-off systems that producing electrical energy separately from the grid in distant localities.

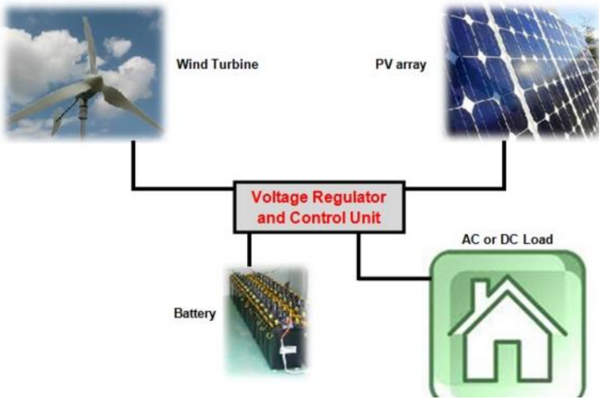

Figure 3. Hybrid system scheme

In hybrid energy systems are the most common sources of energy photovoltaic and wind energy in the majority of cases there is needed an auxiliary power source (e.g., originating in batteries, fuel cells, or grid). Aim of the auxiliary sources is to overcome the unavailability of renewable energies in a certain time. Depending on the availability of energy sources is necessary to find a balance that is done by the control which unit determines that the power source will supply the electrical load at the time (Zbojovský et al., 2016; Pavlík et al., 2013; Ashok, 2007).

Software HOMER

HOMER (Hybrid Optimization Model for Electric Renewables) is simulation software invented by the U.S. National Renewable Energy Laboratory (NREL) to help in the developing and designing of renewable energy consisting hybrid systems. By Homer is simulated behavior of an energy power delivering systems and their cost during lifecycle, which is the amount of money spent for system and costs of services over its life cycle, every of this possibilities are modeled by HOMER. Choices as units for distributing generation (DG) units, stand-alone systems, grid-off systems and grid-on systems for delivery in remote areas, and other choices, could be calculated by HOMER. Simulation, optimization, and sensitivity analysis are the three principal tasks performed in HOMER

A. Simulation in HOMER

In simulation, HOMER describes technical specifications and cost during life cycle of a hybrid renewable sources system for hourly data per year. Next step is calculation of the hybrid renewable system configuration and the strategy for operation for the power delivery parts which are tested to inspect how these parts work in setting during a calculated year. The simulation possibilities of HOMER is long time simulation of a hybrid renewable sources system (Lambert et al., 2016)

B. Sizing optimization in HOMER

HOMER optimizes and shows the appropriate systems and their compositions with deciding the search space entered by the developer, sorted by the cheapest choice of the hybrid renewable sources system, depending on the total net present cost. Results of simulation shows the best configuration of a hybrid renewable sources system, the optimization calculate and shows the optimal hybrid renewable sources system. HOMER describes the best solution of configuration of hybrid renewable sources system, which is system with the minimum net present cost totally and keeping the developer's efforts (Hafez and Bhatacharya, 2012).

C. Sensitivity analysis

Sensitivity analysis can analyze the reactions of parts of system changes in time. HOMER search for optimal rates for the sizes and quantities of the equipment that is calculated in the hybrid renewable sources system and the evaluated constraints (Fulzele and Dutt, 2011).

Modeling of Hybrid Renewable Sources System and Simulation Data

A hybrid renewable energy sources grid-off system is usually composed from a renewable sources as wind turbines and photovoltaic cells connected with battery or other repository devices but in grid-off systems where is need to cover whole consumption of consumption of load can be used some conventional sources like diesel generator and so on. Figure 2 shows a small hybrid system configuration that will be used in the feasibility study and simulations. System consists from sources like photovoltaic field, wind turbines, batteries and dc-ac converter.

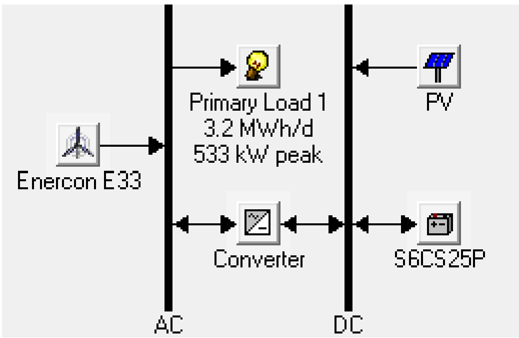

Figure 4. Implementation of hybrid system

Electrical Load

Modelled daily energy consumption times for mine pumping load is can be seen on Figure 3, Figure 4 and Figure 5. There is need to puping soaking water from this mine to prevent damage and eliminate risk of rupture land somewhere deeeply in main which can cause flood in city under the mine. For pumping are used two hydro pumps first with power 300 kW and second with power 233 kW which pump 6 hour a day. There will be compared three different puping time scenarios and their affect on hybrid system sizes and cost of such hybrid system.

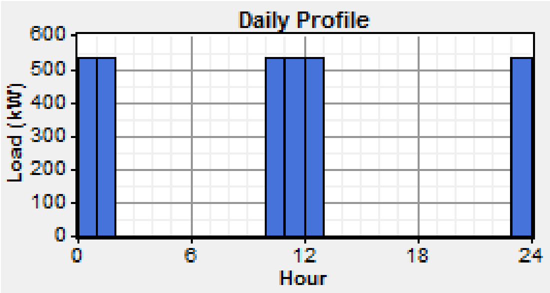

Figure 5. First proposed daily pumping time scenario

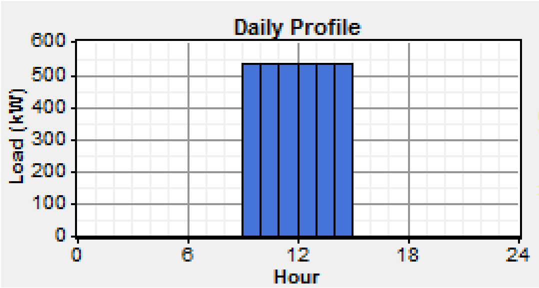

Figure 6 Second proposed daily pumping time scenario

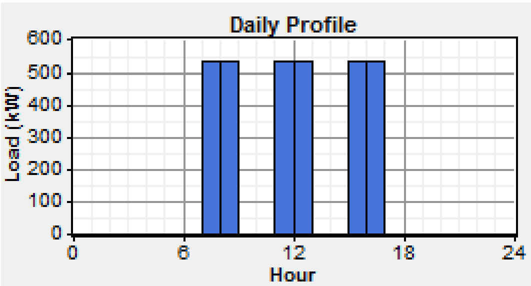

Figure 7. Third proposed daily pumping time scenario

Solar Irradiance Data

Irradiance data for Košice were gathered by HOMER from NASA. For geographical position data in HOMER, 48°43′ N latitude and 21°15′ E longitude were used to obtain data for computing this solar system. This is the geographical position data of mine Bankov in Košice. HOMER generates solar radiance data for whole year by using Graham scan algorithm. Graham scan algorithm gives sensible hourly values, which is simply to treat requiring only the geographical latitude and monthly average values of solar irradiance. The fabricated values show real daily and hourly data for whole year. The fabricated values are generated with sure numerical features that flash universal averages. So values fabricated for a precise area will not completely depict the attributes of the original solar sources. But testing results depicted that fabricated solar values produced basically equal simulation results as measured actual values. Solar monthly average values for the simulated site are shown in Figure 6.

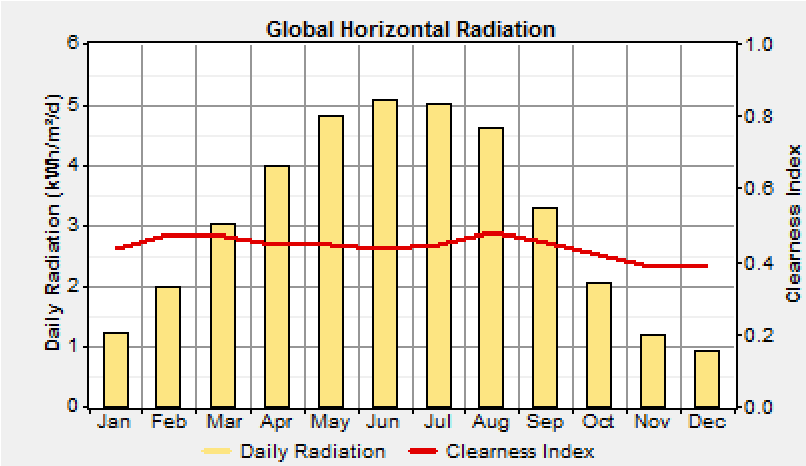

Figure 8. Solar radiation data and clearness index for mine site in Košice

Wind Speed Data

The monthly regular wind speed value from moderate of ten years was gained from the NASA resources webpage established on the geographical coordinates of the site in Košice. The yearly moderate wind speed value for the site is 4.5 m/s measured with the anemometer peak 50 m. The wind speed possibility and moderate monthly speed through annual period is also checked and it can be seen in Figure 5.

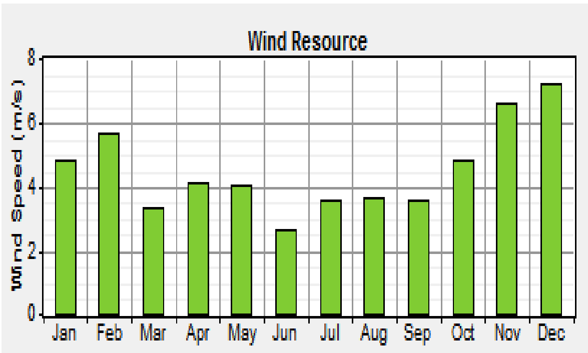

Figure 9. Wind speed profile for site in Košice

Simulation Results

When system modelling is finished and each of componets were set properly simulation of hybrid system is able to execute. HOMER softwer model for optimization was used to simulate the hybrid renewable sources system. Sofware calculate many options which were set to search space and choose best option for size of all components.
Large number of choices are considered and calculated for multiple component sizes used an the best choice is chosen for hybrid renewable grid-off system which optimally cover the load of hybrid system.
This system is optimised by HOMER's algorithms and the best possibilities are evaluated as choice for the best configuration of hybrid renewable system configuration. Results of simulated scenarios is can be seen in Table 1. There was simulated three difffent load scenarios with different times of load and results are represented as table.

Table 2. Results of simulations with final sizes and costs of hybrid renewable systems

Scenario	PV size (kW)	Quantity of wind turbines (pcs)	Size of converter (kW)	Quantity of batteries (pcs)	Cost of system ($)
1.	450	9	600	860	2 684 969
2.	525	7	550	650	2 343 978
3.	375	10	550	700	2 422 737

As it can be seen in Table 1 as the most economic choice for such hybrid system is scenario with load 2 where consumption is mainly in times from 9 a. m. to 3 p.m. These times are also times with the bigest production of electricity from photovoltaic part of the hybrid system so the savings are mostly on batteries in hybrid system.

Conclussion

With the right load time management is posssible to have significant savings in initial capital of such hybrid renewablele systems. This is the main aim to apply such load time management in consuption of electicity in hybrid renewable systems. So load management known also as demand side management which is process of balancing supply of electricity has many advantages and can affect initial capital of building such systems.
Load management for planning long-term could start with creating of detailed models for description the physical features of the distribution grid like grid topology, capacity, and other characteristics of the lines and the load behavior and weather data. Future research should concetrate to build detailed model, which cover more factors as demand response.

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WPŁYW ZARZĄDZANIA CZASEM OBCIĄŻENIA ELEKTRYCZNEGO NA WYMIAROWANIE I KOSZTY HYBRYDOWEGO ODTWARZALNEGO SYSTEMU ZASILANIA

Streszczenie: W artykule opisano modelowanie, symulację i dostosowanie hybrydowego systemu odnawialnego dla pompowania wody z zamkniętej kopalni Bankov w Koszycach oraz różnych strategii zarządzania czasem obciążenia elektrycznego przy wykorzystaniu energii elektrycznej. Zostaną przeanalizowane trzy różne strategie zarządzania czasem w obwodzie elektrycznym i ich wpływ na koszty i rozmiary hybrydowych systemów odnawialnych. Zarządzanie czasem czasu ładowania w systemach hybrydowych może mieć wpływ na rozmiar i koszt w takim systemie.

Hybrydowe systemy odnawialne mają zastosowanie w odległych obszarach, w których połączenie z siecią jest niedopuszczalne, a budowa takiego połączenia z siecią jest bardzo kosztowna. Odnawialne źródła są często tylko źródłami uzupełniającymi dla generatorów diesel'a, jednak odnawialne źródła takie jak energia słoneczna, energia wiatrowa nie mają

kosztów paliwa i mogą powodować zmniejszenie kosztów jednej kilowatowej energii elektrycznej.
Słowa kluczowe: system hybrydowy, zarządzanie czasem obciążenia, odnawialne

電力負荷時間管理在混合可再生能源系統的尺寸和成本上的影響

摘要：本文介紹了Košice的封閉式礦井Bankov抽水混合可再生系統的建模，仿真和尺寸分析以及電力供電時間管理策略。
將分析三種不同的電力負荷時間管理策略，以及它們如何影響混合可再生能源系統的成本和規模。
混合系統中的負載時間的時間管理可能會影響這種系統的大小和成本。
混合可再生能源系統適用於偏遠地區，與電網的連接是無法實現的，並且建立與電網的連接非常昂貴，而可再生能源通常只是柴油發電機的輔助來源，但是可再生能源作為太陽能，風力在燃料和燃料方面沒有成本，　　可以降低1千瓦電能的成本。
關鍵詞：混合動力系統，裝載時間管理，可再生能源