MINISTRY OF EDUCATION

UNIVERSITY OF PETROȘANI

DOCTORAL SCHOOL

DOCTORAL THESIS

RESEARCH ON THE POSSIBILITIES OF REALIZING A MIX ENERGY SYSTEM IN AREAS ADJACENT TO LIGNITE OPEN-PIT IN THE OLTENIA BASIN

- SUMMARY -

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PERTROŞANI

2019

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The continuing evolution of humanity is closely related to electricity consumption. This has led to both the increase of the pollution level and the decrease of fossil fuel sources. In this direction, one of the priority policies for energy stability in the country but also in Europe is energy efficiency [58].

A solution of the related aspects is the increase of the generation of energy from renewable sources. Thus, taking into account the aforementioned, the subject analysed in the doctoral thesis is a topical one. It folds both in finding solutions for the ones reported and in the research fields of the European Union [84].

The discussions and the area of applicability of the proposed modelling and simulation strategies are especially oriented to the processes existing in industrial energy chain. Rapid progress in the field of computing technology and hardware in recent years has allowed the development of several directions for modelling and simulation strategies, based on predictive, adaptive, neural or neuro-fuzzy regulators in order to improve functionality of industrial installations. In this regard, the international scientific community dedicated to the study of these types of energy processes has developed new analysis perspectives, thus offering a wide variety of solutions corresponding to each application [59].

Continued expansion and competition in a liberalized market, as well as the need to maintain stability of power system, have led to increased efficiency, standards imposed forcing those in charge of the design as well as the network operators to introduce power electronic equipment and sophisticated automatic control systems. Systems are often so nonlinear that the only approach is through simulation [60].

The thesis is developed on 166 pages in 6 chapters with a recent, pertinent and relevant bibliography in which we find his own works as author and co-author, well quoted and with an impact in solving the topics addressed in doctoral work. The work is completed by a part of general conclusions, personal contributions and research directions and two annexes.

The general objective of thesis is the study on possibilities of realizing an mix energy system that will provide electricity for the urban and rolling areas affected by industrial restructuring. In this regard, a number of suitable and significant green sources for area of Basin and Motru Municipality were considered. Thus, the study of energy sources includes both aspects of a constructive - functional nature presented in detail and their uses, taking into account advantages and disadvantages, but especially the fields of application.

Within the thesis, the phenomena defining each source taken into the study are modelled and their operation is simulated under specific operating conditions.

In the first chapter were presented:

- analysis of current and prospective stage of Romania's energy efficiency from the point

of view of energy policies on European Union, policies assumed at the moment of accession;

- description of EVIEWS software that offers users the possibility to quickly and efficiently manage the data series within the phenomena they wish to analyse, to generate forecasts or by simulating models to make high quality graphs and tables;

- statistical researches using mathematical models;

- aspects regarding the econometric study of electricity production according to the mode of generation, total coal production and categories of coal resources and not least on electricity consumption in country.

In chapter two we studied:

- the possibility and limits of use water as a renewable energy source;

- the advantages and disadvantages of micro-hydroelectric power plants in terms of water fall and flow and the main elements of a hydroelectric system;

- how to evaluate and calculate hydropower potential;

- how to calculate the specific turbine speed, the presentation of turbine types and the selection criteria;

- modelling and simulation of hydropower generation starting from modelling the hydraulic, electromechanical part of the controller and ending with simulation of entire hydroelectric system;

- the study and evaluation of renewable energy potential for Motru Basin and Municipality. In this sense, two models are made, one for qualitative validation of concept (using Petri networks) and one for quantitative validation (based on linear programming) to obtain maximum energy production.

In chapter three, the aspects related to solar radiation as a renewable energy source were analysed and a case study was elaborated for the concrete conditions, these being determined by measurements, of the given area. The study, modelling and simulation of a photovoltaic system involves several stages. An essential step is estimation of solar radiation. In this context, a number of mathematical models used in estimation of direct solar radiation have been developed. The mathematical models of direct solar radiation are customized for Motru municipality. The validation of these models is based on data provided by measurements made in the area. Finally, simulation program in MATLAB - Simulink of solar radiation, estimated using Haurwitz model, is presented. Following the analysis on the extreme points of functions resulting from simulation, the abscissas (tilt angles) for which maximum values of global solar radiation are obtained, for all months of the year and optimum angles an positioning of photovoltaic panels are determined. In this sense, in order to optimize amount of electricity consumed and control inclination angle of a photovoltaic panel, either fixed positioning or once-seasonal positioning of photovoltaic panel is

recommended.

In chapter four, a constructive and functional classification of photovoltaic systems is made. For continuous supply of electricity to consumers, besides the photovoltaic panels are used electricity accumulators and static converters, which have the role of transforming DC into AC or AC into DC and to monitor and control the charging - discharge battery process.

The assembly of all above elements, interconnected and dimensioned to operate in a single system, form a photovoltaic system. Thus, photovoltaic panel, electric energy accumulator, static converters and the types of photovoltaic systems are modelled and simulated. The results of simulations reduce limits but especially offer the possibility of choosing optimal solution for realization an energy production park based on solar radiation.

In chapter five the potential of the wind for the production of renewable energy is studied. Starting from the weight that the wind energy holds in the framework of the energies produced both nationally and internationally, there are presented theoretical and experimental aspects of the way of wind energy production. The wind potential, the components and the characteristics of the wind installations, the power coefficient of the installation depending on the wind speed on the one hand and the types of rotors used in the construction of the turbines on the other were presented and defined under various aspects. The speed and variation of the wind, the turbine and the wind generator are analysed and modelled mathematically. Based on mathematical models, wind installation is simulated resulting in the variation of the power coefficient depending on blades inclination angle but also mechanical power in relation to speed. At the end of chapter, a wind farm is simulated based on mathematical models presented and actual measured conditions of wind speed and frequency. After analysing the results of simulation it can be concluded that in the design of the wind turbines one has to take into account many factors, but the most important are area and climatic conditions and last but not least, in order to be able to design wind power plants, the energy consumption for area considered is necessary. Furthermore, renewable energy based on wind conversion systems needs an adaptive mathematical algorithm and an efficient system of dynamic response control, in order to be able to withstand a sudden change in wind speed.

In chapter six, a case study was presented regarding the possibilities of achieving an energy mix in area of the Motru Basin. It presents the climatic conditions of area, population trends, ways of gas supply, water utilities and not least electricity and heat for need a domestic and non-domestic consumption. Within this chapter thermoelectric energy production based on fossil fuel is analysed from a constructive and functional point of view. At the end of this chapter, based on those stated in the thesis and measurements made on climatic factors, it is proposed an energy mix consisting of renewable resources water, wind, sun and modernized thermoelectric power plant, in order to meet the requirements and norms in force.

The validation of this decision is achieved by simulating the four components of the mix linked to a consumer network. The result of simulations highlights the role of the energy produced by the analysed mix that provides the necessary for consumption and further confirms the proposed solution, as viable. The energy resulting from fossil fuels is central element for peak consumption situations, unfavourable or extreme climatic conditions. This aspect leads to positive results both from the point of view on the economic performance from extractive industry and from a social point of view.

Following the completion of the work, the following own contributions have come off:

1. Forecast, for the next period, the econometric study of the electricity production according to the mode of generation, the total coal production and the categories of carbon resources and not least of the electricity consumption in the country based on the econometric analysis of the evolution in time made using dedicated software.
2. Modelling and simulation of hydropower generation starting from modelling the hydraulic part, electromechanical part, a controller and ending with simulation of the entire hydroelectric system under the conditions and limitations of Motru Basin area.
3. The study and evaluation of renewable energy potential for Basin and Motru Municipality realized on two models, one for qualitative validation of concept (using Petri network) and one for the quantitative validation (based on the linear programming) in order to obtain a maximum energy production.
4. Description and customization for interest area of the main mathematical models used in estimation of direct solar radiation.
5. Performing mathematical modelling of direct solar radiation customized for Motru Municipality and carrying out measurements in the area to validate these models.
6. Presented the simulation program in MATLAB - Simulink of solar radiation, estimated using the Haurwitz model, to determine optimum angles of positioning from photovoltaic panels.
7. Modeling and simulation of photovoltaic panel, electric energy accumulator, static converters, as well as the types of photovoltaic systems, in order to determine, based on the results of these simulations, the setting of the limits but also the possibility of choosing optimal solution for realization an energy production park on solar radiation.
8. Modelling and simulation of wind installations with the highlighting of power coefficient variation according to blades inclination angle but also mechanical power in relation to the speed.
9. Making measurements, thus creating a reference on variation and frequency of wind in Motru Basin and Municipality.

10. Simulation of a wind farm based on mathematical models presented and based on actual measured conditions of wind speed and frequency.
11. Analysis of concrete situation regarding climatic conditions of area, the population trend, the modalities of insurance with gas, water, utilities and last but not least electricity and heat as well as the necessary for the domestic and non-domestic consumption.
12. The realization, based on the ones stated in the thesis and measurements made on climatic factors, of an energetic mix formed by renewable resources water, wind, sun and fossil fuels.
13. Validation of this intention by simulating the four elements determined to be significant and of interest in composition of the mix by linking to a consumer network.
14. The simulation of energy mix and result obtained shows that, for the necessary consumption, the proposed solution is provided and is viable. The energy resulting from fossil fuels is the central element for peak consumption situations, unfavourable or extreme climatic conditions.