MICROGRID BUSINESS INTELLIGENT MODEL BASED ON A FUZZY SYSTEM

Hoda Farag
Alexandria Electricity Distribution company – Egypt

Mohamed Elhoseiny
Alexandria Electricity Distribution company – Egypt

ABSTRACT

We represent a business model to simulate the implementation of the homogenous microgrid system Using an intelligent fuzzy control unit taking into account the different factors like the external demand of the net energy for the community with specifying upper bound and lower bound and also the capacity of the generators included in each microgrid unit also considering the neighborhood microgrids adapting a strategy to control the ongoing partnerships with the microgrid neighbors to achieve the maximum profit by considering the transmission line between the two units, the time, the electricity price from each microgrid unit , all the above factors can be changed when needed which constitutes an intelligent control system for the microgrid units assuring the sustainability of the energy to the customer through various energy types .The proposed model shows an increase in the robustness of the microgrid system and decrease in the operation cost.

INTRODUCTION

The power domain is facing enormous challenges with the worldwide population increase and consequently the energy demand. And with the need to decrease the cost of the energy became the existence of renewable energy sources and the need to merge the different types of energy sources became urgent.

As the cost of advanced energy technologies is continuing to fall and the global energy systems shift towards decentralization microgrids is the best solution.
A microgrid is a small-scale grid designed to provide power to local communities to connect or disconnect from the main grid according to its need of energy it can enable the cost savings and system-wide benefits of intelligent decentralized systems, while minimizing risks to utilities and consumers.

The regulation of the energy management for a regular day in summer via intelligent control. Using the fuzzy logic rules approach considering electricity prices, renewable production, load demand as parameters and the command rules are developed in order to ensure a reliable grid taking into account the financial aspect to decide the load modification's level is shown in [1].

As in bulk power systems, the control tasks are performed in a hierarchical manner in microgrids. Specifically, local controllers are used to drive the energy sources and a supervisory controller is used to define the reference values of the energy sources according to an objective. The supervisory control is often called an energy management system (EMS)[2].

Microgrids have a broad range of application and the EMS is the keystone in these Applications where the main idea is to specify the available energy and demand to achieve the desired features of the grid (optimization proplem).
EMS approaches have been formulated based on a model predictive control (MPC) framework. The principle behind these approaches is to anticipate the expected behavior of both renewable nonconventional energy sources (RNCES) and demand over a prediction horizon [3].

In [4], the observed mean values and standard deviations of the available data were used to generate stochastic scenarios of solar radiation, wind speed, and load demand. Then, stochastic operating cost optimization models for minimizing the operating costs of the microgrid were formulated.
Also In [5], the probability of self-sufficiency was used for the commitment and dispatch of the units in a microgrid, specifically, the probability of being able to provide the demanded energy with the energy resources of the grid. In this sense, the power balance equation was changed by the probability of satisfying the demand with the local resources.

THE FUZZY LOGIC SYSTEM

The Fuzzy logic represents a powerful approach to decision making since the theory of the fuzzy set proposed by Zadeh [6] in 1965. Applications of this theory can be found in artificial intelligence, computer science, medicine, control engineering, expert systems, logic and Image processing.
Fuzzy logic is a method for imitating the ability of human reasoning using some rules which is useful in expert systems. The fuzzy problem is a decision making process as It forms rules that are based upon multi-valued logic as the element partially belong to a set with a particular degree of membership to describe the ambiguity (membership Function) on the interval from.

THE PROPOSED MODEL

Considering three different type of energy sources which are solar panel and wind turbine as generators, and electrical power permanent source from the main grid taking into account the cost of each source (cost) and the time of the day as the load on each grid differs (Load demand) and the system operates synchronously and in parallel with the main grid.
Taking into account the operating conditions of the microgrid, the cases previously analyzed; and the optimal solutions obtained for each case. Then a neural network was trained with several optimal power flows (each corresponding to a possible operating scenario).
Consequently, depending on the operating conditions of the microgrid, the commitment and dispatch of the units was provided by the neural network without using an on-line optimization procedure.

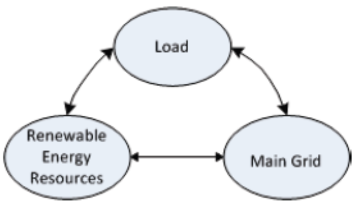

Fig1. the system Model

Solar Model
A solar panel is constituted of PV modules names cells. Also, the equivalent circuit of a PV cell is represented below is composed of a current source, a diode, a series resistance and a shunt resistance. Conventionally R_{SS} is very large and R_{Sh} is very small Considering the cell as ideal.

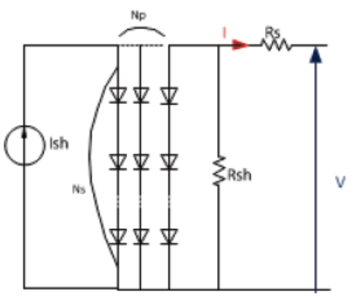

Fig 2. Equivalent Model of Solar Panel

where, N_P is the number of parallel cell and N_S is the number of series cell.

Wind turbine
The wind turbine respects usual model, as presented in block diagram in Figure 3.

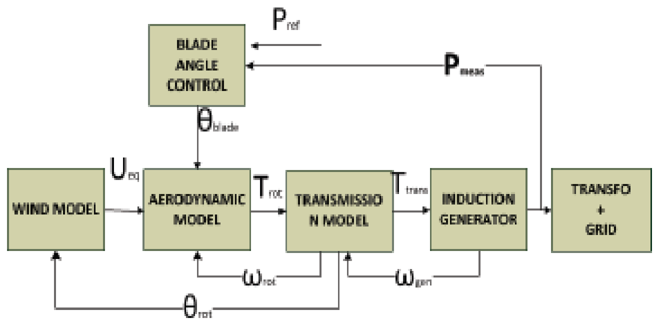

Fig 3. The wind Turbine

Algorithm steps

1. Simulating the power Generation of wind and solar generators.
2. Calculating the different factors affecting the fuzzy system based on the real facts like the peak hour and the load demand and power generated from each unit.
3. Specifying the parameters for the Fuzzy Inference System as follows
   Time : Day (D) (2 am to 7 pm), Night (N) (7 pm to 2 am)
4. The insertion of the generation data, factors into the Fuzzy Inference System to automate the intelligent system to change the power through the specified rules from experts.
5. The insertion of the modified source of load data into the neural network then reset the neural network to adjust the weights according to the new inserted data.
6. The system is examined and analyzed by measuring the load change of the system and its operating cost and compared against other systems to measure its accuracy.

The Fuzzy Logic Unit

We set the fuzzy rules that allow the accurate detection between different types of energy sources based on the different criteria that is based on the actual circumstances (Rules) that resembles the real world which are the time (3 phases in the day) , the operating cost, the capacity of the microgrid neighbour taking into account the transmission line with each neighbour.

We mainly depend on putting the human expertise in the form of fuzzy rules to be applied on the system which means extracts efficiently and interpreting the information without human intervention which mean a perfect automated expert system.
The input values to the fuzzy system are the operation cost of each power source, the load demand, the neighbouring microgrid and the time.

The fuzzy inference system interprets the values in the input vectors based on the defined rules, assigns values to the output vector. Using a GUI editors and viewers in the fuzzy logic toolbox, we can build the rules set, define membership functions and analyze the behavior of a fuzzy inference system. The editors and viewers are used to edit and view the membership functions and rules for fuzzy inference system. Complete processing of Fuzzy Inference System is shown in Figure 4.
Then the Defuzzification and producing a quantifiable result in fuzzy logic, for given fuzzy sets and corresponding membership degrees and the result is described in terms of membership in fuzzy sets. And the used method for defuzzification is the Centroid Method

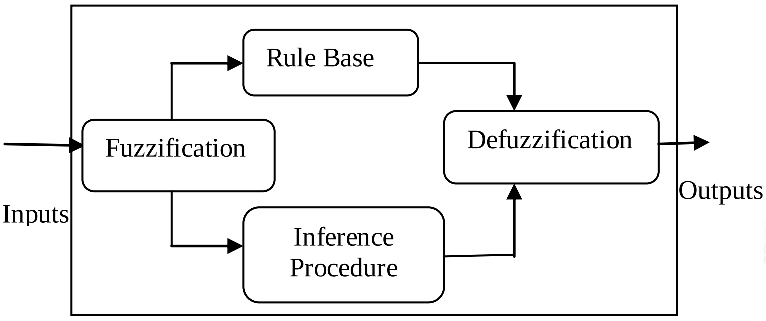

Fig4. Fuzzy Inference System

The FIS is described by the following rules:-
IF the excess of demand is Negative Small AND the electricity price is Low AND during the Day THEN the modification percentage of the load profile is Very High.
IF the excess of demand is Positive Small AND the electricity prices are Low AND during the
Night THEN the modification percentage of the load profile is Low

SIMULATION RESULTS

The proposed algorithm have proved to be very efficient because of its high classification accuracy with the complexity of the electric power distribution system and its ability to adjust the type of energy power according to different circumstances and in terms of the operating costs, the robust approach was much more costly short than using the available power source also the reduction of the load when was really efficient and it was obvious much more after running the training stage to optimize the required power source.

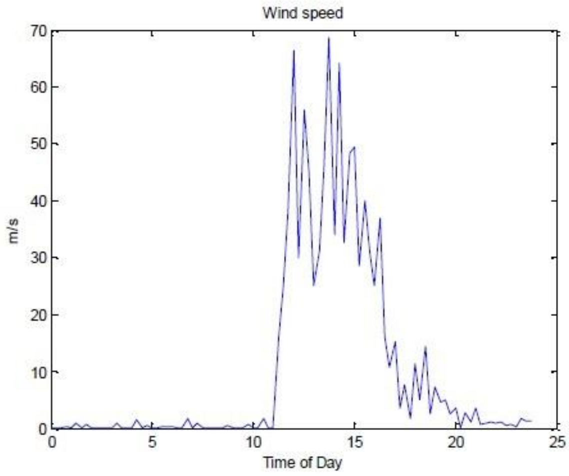

Fig5.the wind speed

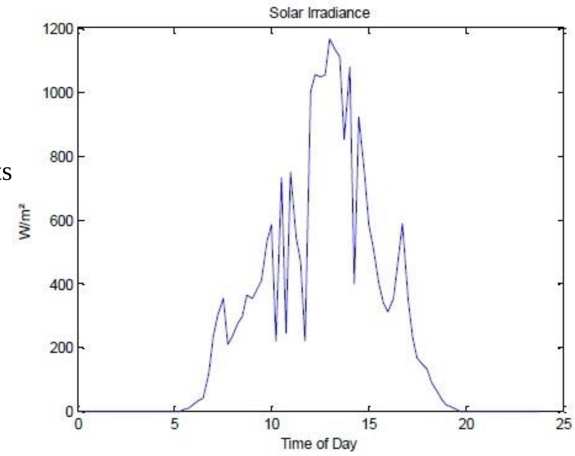

Fig6. The solar Irradiance

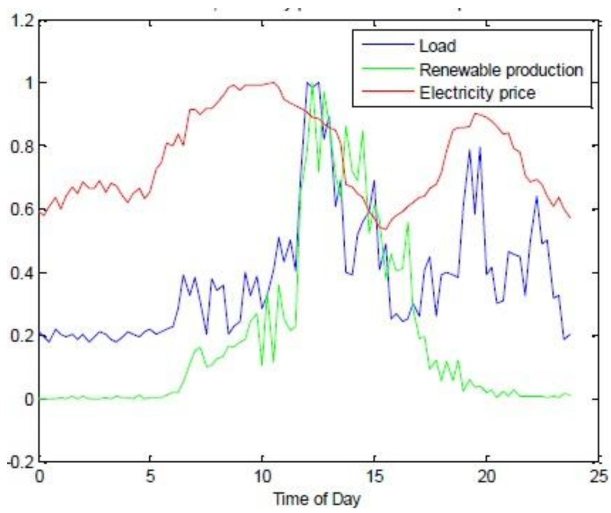

Fig7. Load, price, Renewable production

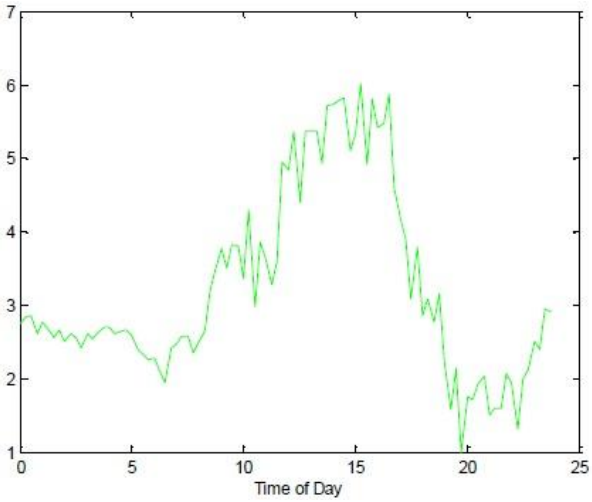

Fig8. The modified Load Percentage

THE CONCLUSION

The proposed model results shows an increase in the robustness of the microgrid system also the operation cost has increased only in the start of the model due to including the initial Startup cost and the operating cost of the units before using the intelligent fuzzy model and that we have no data chart about the microgrid units usage but after applying the model and getting an approximate charts the operating costs decreases drastically as the microgrid units know the limits wanted for usage. Inspite that there will be a computational effort on the Fuzzy logic unit that it considered a load on the system but it also a huge step to lower the consumption of the Energy costs as it creates transparency through the system with the microgrid units.

We presented our model that derived a good results but it can be enhanced by adding a new parameters to the system or changing the type of the membership function used to enhance the accuracy of the system. We hope that our work help to bring an innovative methods to improve our distribution system resiliency.

ACKNOWLEDGMENTS

We would like to show our gratitude to Prof. Dr. Said El Khamy for his comments that provided insight, expertise that greatly assisted research and improved manuscript.

REFERENCES

[1] Lydie Roiné1 , Kambiz Therani , Yashar Sahraei Manjili3 , Mo Jamshidi3, 2008 ,” Microgrid Energy Management System Using Fuzzy Logic Control”.

[2] R. H. Lasseter, “Microgrids,” in Proc. IEEE Power Eng. Soc. Winter Meeting, vol. 1. New York, NY, USA, Jan. 2002, pp. 305–308.

[3] Y. Zhang, M. Mao, M. Ding, and L. Chang, “Study of energy management system for distributed generation systems,” in Proc. 3rd Int. Conf. Elect. Util. Deregul. Restruct. Power Technol. (DRPT), Nanjing, China,Apr. 2008, pp. 2465–2469.

[4] A. Sobu and G. Wu, “Optimal operation planning method for isolated micro grid considering uncertainties of renewable power generations and load demand,” in Proc. IEEE Innov. Smart Grid Technol. Asia (ISGT Asia), Tianjin, China, May 2012, pp. 1–6.

[5] B. Zhao, Y. Shi, X. Dong, W. Luan, and J. Bornemann, “Short-termoperation scheduling in renewable-powered microgrids: A duality-based approach,” IEEE Trans. Sustain. Energy, vol. 5, no. 1, pp. 209–217,Jan. 2014.

[6] Zadeh LA, (1973). “Outline of a new approach to the analysis of complex systems and decision processes IEEE Transactions on Systems, Man, and Cybernetics,VoL. SMC-3, No. 1 PP:28–44.