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Hybrid Renewable Energy for Residential Loads using HOMER Software & Neuro-Fuzzy Network

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Abstract— ***Electric load consists of multiple components, residential, commercial, industrial, agricultural. . . Etc. The residential load is the largest component of the electrical load in the Iraqi power system nowadays. The study of residential load connected to the grid with the ability to energy change (buy and sale) has been carried in a previous research. Optimal hybrid renewable energy system has been found using HOMER software.The current research aims to implement HOMER software for different residential load with extent scale of change and to find the optimal hybrid renewable energy system for each load. In this way a database is to be obtained. This database is to be used in the formation of Neuro-Fuzzy system, which can be used to find the optimal hybrid renewable energy system for residential loads in the city of Mosul.***

Index Terms— ***hybrid renewable power system ; grid connecting lods; Residential load; HOMER; Neuro-Fuzzy.***

I. INTRODUCTION

Renewable energy can be used in two ways; first for specific areas far from the grid (off grid) second for areas connected to grid (on grid) to provide part of the total energy demand [1]. Hybrid renewable energy plants (which invest more than one source of renewable energy at the same time) enhance the efficiency of renewable power stations in case of off-grid system. Also for grid connected system, by connecting a hybrid renewable power system (synchronized with the grid) to supply the shortages in energy as well as to export the excess energy to the grid [2]. A cost Zero-Energy Buildings (ZEB) receives as much financial credit for exported energy as it is charged on the utility bills. The credit received for exported electricity (often referred to net energy generation) will have to offset energy, distribution, peak demand, taxes, and metering charges for electricity and gas use. A cost ZEB provides a relatively even comparison of fuel types used at the site as well as a surrogate for infrastructure [3]. In previous research, a hybrid renewable energy system has been suggested[4]. It consists of photovoltaic modules, wind turbines, batteries and electronic invertors, to supply residential electrical load, utilizing the available renewable energy. HOMER software has been used in the simulation of the system to find the optimum combination of components, which makes the yearly cost equal to zero. the same information, wind energy and solar energy. . . Etc., will be used in this research as well. Simulation of different residential loads, in Mosul city, has been modeled.

They represent annual consumption distributed on a monthly basis, these loads are the input to Homer software. Also, the program needs the site of the analysis (longitude, latitude) to get the information of solar energy falling and the wind speed, which are part of the input data. Then the data (monthly average and maximum daily load), with the results obtained from HOMER program (optimal hybrid combination of previous data) were used to form Neuro-Fuzzy network. Neuro-Fuzzy network has been trained and tested according to these data, as shown in the next paragraphs.

II. SPECIFICATIONS OF THE ELECTRICAL LOAD

Residential loads data were obtained in different areas of Mosul city in a consultant contract with the General Directorate of North Distribution Electricity. Figure 1 shows one of the models used, and the amount per day (day / 34.5 kWh) and the amount of peak load of pregnancy (8.5 kW).

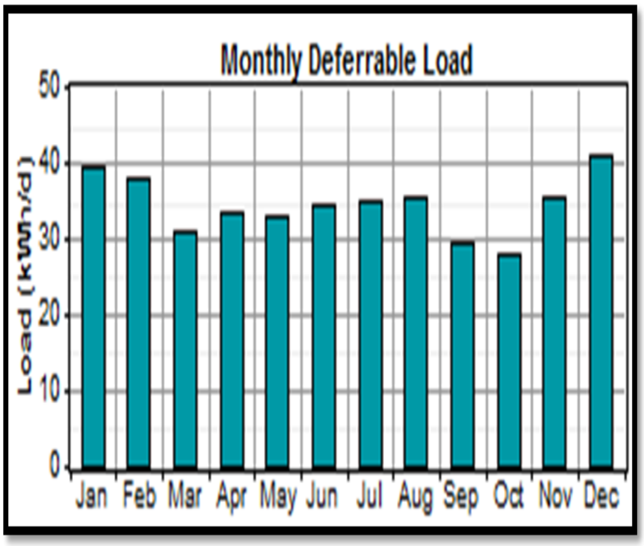

Fig. 1 sample of monthly residential loads used in the study.

Other models of residential loads, with variety of consumer electrical appliances (lighting equipment, heating equipment, refrigeration, food preservation devices ... etc.) were taken to obtain the base data required as inputs to HOMER software. Also, the advantage of the thermal energy of solar radiation, has been used as solar water heaters (to reduce water heating component in the residential load). Residential load data have been used to obtain the optimal hybrid power combination using HOMER software, table 1 shows the results. Evident from the table the absence of batteries as well as the power invertors (due to its high cost and the presence of national grid to supply the load).

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As well as the absence of wind turbines due to low wind speed, which in turn lead to a rise in the cost of generation compared to purchase cost from network and generation using PV modules.

Table 1 Results of HOMER software for residential loads

No.	Daily average load	Peak load	PV modules
1	34.5	8.5	7.922
2	38	9.4	8.6
3	41.4	10.2	9.255
4	44.9	11.06	9.935
5	69	17	14.66
6	75.9	18.7	16.2
7	82.8	20.4	18.375
8	89.7	22.1	20.3
9	62.1	15.3	13.264
10	55.2	13.6	11.924
11	48.5	11.95	10.626
12	34.2	8.42	7.789
13	23.7	5.839	5.815
14	29.5	7.26	6.933
15	28.5	7.02	6.693
16	41.5	10.22	9.185
17	33.1	8.15	7.585
18	36.4	8.96	8.218
19	39.8	9.8	8.87
20	43.1	10.61	9.498
21	29.8	7.34	6.958
22	26.5	6.52	6.332
23	23.2	5.71	5.7
24	28.9	7.12	6.79
25	31.8	7.83	7.342
26	34.7	8.54	7.897
27	37.6	9.26	8.45
28	26.1	6.43	6.257
29	23.2	5.71	5.705

III. NEURO-FUZZY NETWORK

ANFIS / Tool Box / Matlab Program was used, which is shown in Figure 2. The entries to the artificial neural-fuzzy network are two inputs, the daily average and peak load. While the output is the PV modules. The obtained data from HOMER software (described in Table 1) were divided into two parts. Part one is used for training (23 value). Which represent the data of the sequence (1) to the sequence (23) in the table mentioned above. And leave the other part of the table for testing (6 values), the sequence (24) to the sequence (29). The load data used for training represents a wide range, which include, low, medium and high loads. Test values fall within the range of training loads, so as to ensure the accuracy of the results of artificial neural-fuzzy network.

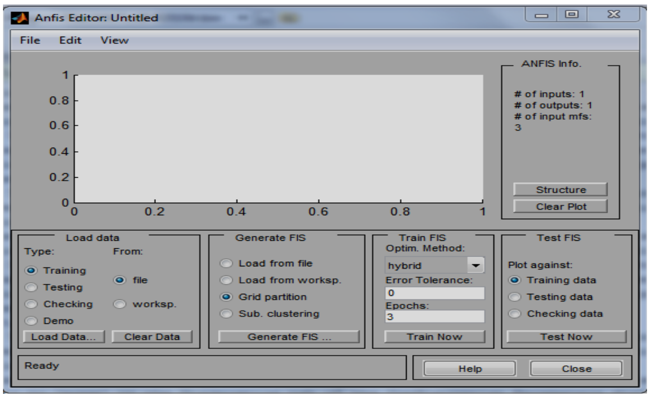

Fig. 2 ANFIS window used in the analysis.

The training process starts by loading data using the instruction (Load data). Figure 3 illustrates the relationship between the input and output of artificial neural-fuzzy network. The program (ANFIS) paint this relation. FIS is formed using the instruction (Generate FIS). This instruction requires to determine the number of membership functions. This includes instruct multiple options within the available functions, they are:

(trimf , trapmf , gbellmf , gaussmf , gauss2mf , pimf , dsigmf , psigmf)

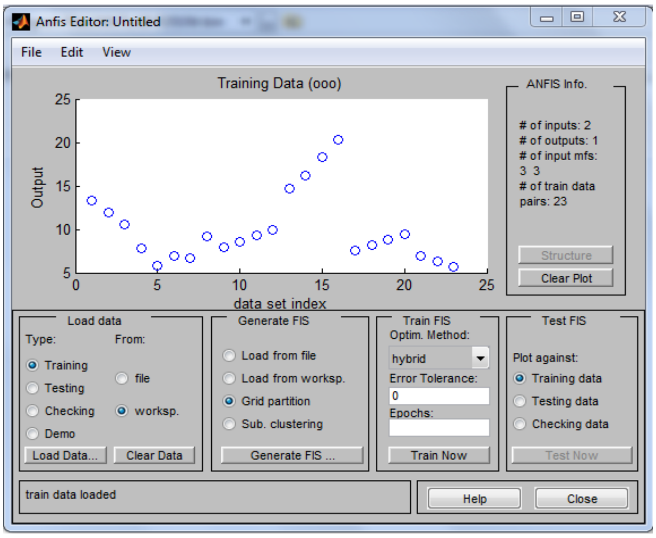

Fig. 3 the relationship between the input and output of artificial neural-fuzzy network.

Trigonometric membership function (trimf) was chosen in order to get the best result and less error rate. Appropriate number of iterations for training was selected (30), Where they reach the required margin of error within this number of iterations. Figure 4 illustrates the relationship between iteration number and percentage error. The program finds the relationship between the input (the daily average, the maximum load) and output (optimal hybrid renewable energy combination). The performance of the artificial neural network is affected by its number of layers and neurons. The researcher find the best artificial neural network number of layers and nodes in each layer to get to the appropriate network. Also the best artificial neural network can be found using fuzzy logic technique.

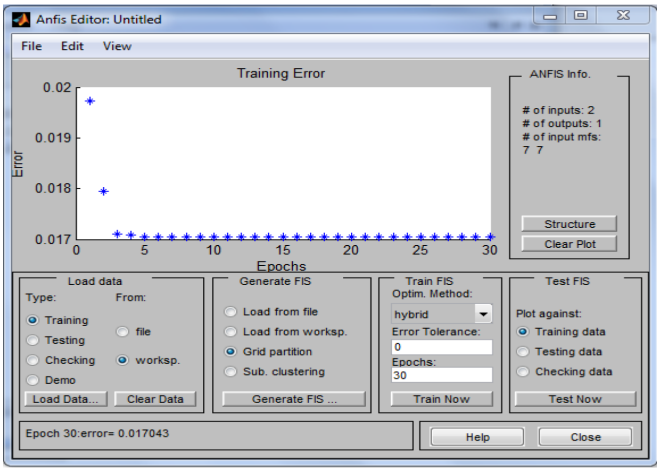

Fig. 4 Relationship between number of iterations and percentage error.

MATLAB program configure the best artificial neural network through ANFIS window, which initiate the fuzzy logic rules. This artificial neural network is made up of three layers, the input layer, output layer and hidden layer. Input layer is composed of 10 neurons, the hidden layer containing of 25 neurons, while the outer layer comprises of single neurons (the number of output data) as shown in Figure 5. FIS is trained, in ANFIS window using one of two ways: (hybrid, backpropa). Hybrid method has been used in the process of training, because it produce a low error. Unlike the other way, which shows a higher error.

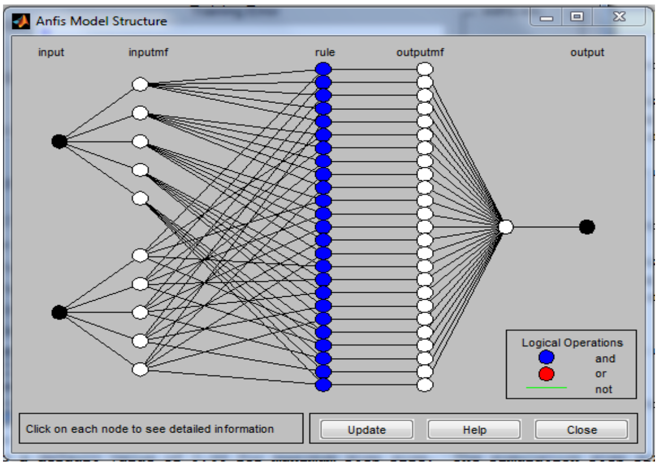

Fig. 5 artificial neural network.

IV. NEURAL-FUZZY NETWORK RESULTS

The Neural-fuzzy network (Figure 5) is tested, in two steps. First using train input data, which are described in Table 1 (23 value).The second stage, using the test data shown in Table 1 (6 value). The following equation was used to find the percentage error, for the comparison between the real values and the results of neural-fuzzy network:

Percentage of error=(real value-result of ANFIS)/true value*100 1

A- Training data results

Figure 6 shows a comparison between HOMER program results (real values) and neural-fuzzy network results for the training data (the difference between them). Blue color represents HOMER program results. Green color represents the results obtained from (ANFIS). It is clear from the figure substantial convergence between the two values, which in turn reflects the accuracy of neural-fuzzy network used.

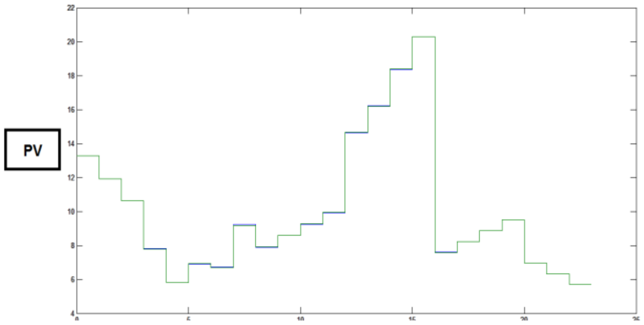

Fig. 6 Comparison between HOMER program results (real values) and the neural-fuzzy network results for training data.

B- Test data results

Figure 7 shows a comparison between HOMER program results (real values) and neural-fuzzy network results for test data (the difference between them. Blue color represents HOMER program results. Green color represents ANFIS results. It is clear from the figure substantial convergence between the two values, which in turn reflects the accuracy of neural-fuzzy network used. The margin of error for the test data, usually, higher than the margin of error for the training data.

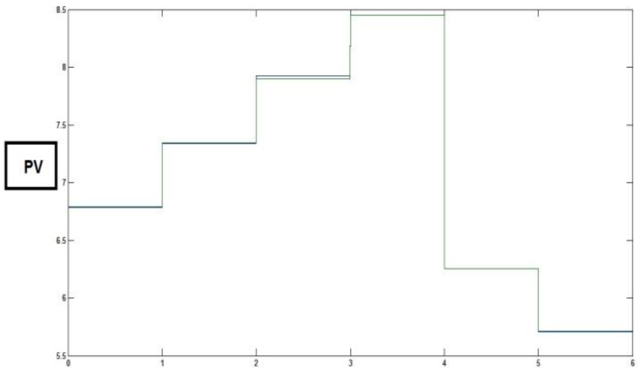

Fig. 7 Comparison between HOMER program results (real values) and the neural-fuzzy network results for test data.

V. DISCUSSION

It is clear from the previous results (Table 1) the wide range of residential loads. Which lead to a significant difference in the optimal hybrid renewable energy system. The system size needed can be reduced by the rationalization of consumption, reducing the residential electrical load components (heating and cooling components, water heating component, lighting component, etc ...). The first step was to compensate part of the water heating component using solar water heater. Other component s can be reduced using appropriate ways. Such as using economic lighting equipment, or light emitting diodes equipment to rationalize lighting component.

It is clear that the neural-fuzzy network suggested give very accurate results, which approaches the results of the real hybrid renewable energies system to a large extent. So the neural-fuzzy network suggested is very reliable, and can be adopted.

VI. CONCLUSIONS

HOMER software was used to simulate residential loads models to find the optimal hybrid renewable power system combination. Residential Loads, subject to the study, are connected to the national electrical grid, with the possibility of buying and selling energy with national electricity grid. Neural-fuzzy networks technique was used. The most important conclusions are:

1 – When the residential loads increase the size of the optimal hybrid renewable power system increased also.

2- The system size needed can be reduced by the rationalization of consumption, reducing the residential electrical load components (heating and cooling components, water heating component, lighting component . . . etc). In this research the use of solar water heaters heating having been used to reduce water heating component.

3- The results of the neural-fuzzy network are accurate, leading to the adoption of this technique to find the optimal combination of any residential load in the city of Mosul.

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