USING ARTIFICIAL NEURAL NETWORKS FOR SHORT TIME FORECASTING OF LOAD AND FUEL CONSUMPTION IN POWER SYSTEM

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ABSTRACT

In this paper the application of artificial neural network (ANN) for daily load and required consumption of fuel for power energy production and distribution between generating units is considered. As learning test data for input parameters of ANN models the load data for previous dates are accepted, thermal power plants and hydro power plants, which are participating in covering of these loads, general ambient temperature and also the capacity of power flow for interconnection.

Neural load forecasting and their comparison with sample of learning test data, which confirmed the usefulness of ANN application for solving the short term forecasting of Grid parameters problems are given in the paper.

Keywords: Neural network, load forecasting, power generation, daily consumption schedule, interconnection flow.

I. INTRODUCTION

More effective using of generating units, high voltage power supply lines and interconnection ties becomes more and more important from the standpoint of reconstruction of Power System. It is known that decision of such problems first of all concerning with determination of best conditions to meet load demands using short time forecasting of power system's regime.

Effective solution of this problem depends on effective forecasting of instant and medium values for loads and appropriate fuel consumption and also how much power would be sold or bought via external interconnection ties.

For optimal load flow during forecasting period of time the main data is forecasting of fuel consumption, load and further load control to maintenance all necessary parameters. Data from forecasting could be used during selling energy to consumers and also for planning and for financing structures of Power System. Usually statistical data of generated and consumed power from Energy Control Center is used for forecasting technical and economical situation of power system including also data of load and amount of sold or bought energy. Using this data from previous period, forecasting parameters of energy and fuel consumption are determined by extrapolation of obtained data for future.

II. MAIN PART

For current case of forecasting the problem is that there would be build such mathematical model of time raw during extrapolation of which over the right border of watching period of time give the chance to forecast a bunch of energy system parameters for one or some future days with some level of probability.

Variation of daily energy and load consumption determined by many factors as the structure of generating units, amount of sold and bought energy, load variation within a day, temperature, day of week and some other factors.

Uncertainty of these factors does not let to get true forecasted values and conduct analysis and taking in account influence of each mentioned above factors for establishing daily regime.

For this purpose it is very attractive to use artificial neural network (ANN).

Nowadays ANN mathematical instrument used in power system for wide band of problem in operative control of Power System including short time load forecasting. [1÷4]

Forecasting models made with help of ANN may establish functional dependence between different parameters given for some models as aggregate exposure of input and output signals and also there is a possibility automatically determine parameters of those functions and then to make self-tuning using new values of input and output.

Generally for Power system short time load forecasting and forecasting of power exchange between energy systems and also daily fuel consumption, neural model could be observed as it is done on Fig.1.

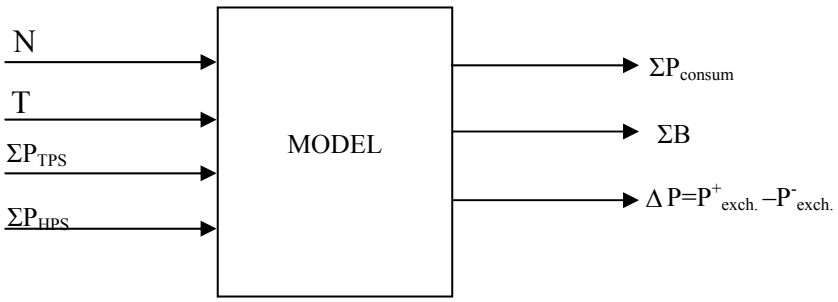


Fig.1 System Load, interconnection power flow and fuel consumption forecasting model

Input parameters for this model:

N – number of working units for this day.

This factor is very important for Azenergy System for covering daily load function because of difference in each used units technical limits for generated power.

T – number for day of week, which takes in account difference in power demands for working days of week and weekends.

ΣP_{TES}, ΣP_{HES} – average daily total power of thermal and hydro power station, which determine daily fuel consumption.

Output parameters:

$\Sigma P_{cons.}$ – average daily load power at GRID

ΣB – average daily fuel consumption (equivalent fuel, mazut, gas) including separately for each power station.

P^{+}_{each}, P^{-}_{each} - daily sold and bought amount of power to/from neighboring countries.

Last values – are very important when you determine most advantageous conditions for covering power demands in typical day hours.

To forecast load flow and power flow through interconnection ties and fuel consumption in GRID for every future day we have suggested model as a multi-layer neural net. Theoretically number of layers and number of neurons in each layer may be arbitrary, but according some experience for the problems of short time load flow forecasting [3] it is quite enough to have model of neural net with 2-3 layers.

Each neuron is characterized by its current value, which can be determined as weighted total of inputs.

$$S = \sum_{t-1}^{n} x_i \cdot w_i$$

Neurons output is a function of state

$$Y = f(S)$$

The most used type of $f(S)$ function is sigmoid (function of activation)

$$f(S) = \frac{1}{1 - e^{-as}}$$

For evaluation of load forecasting or total daily energy consumption at grid and also fuel consumption for energy generation to cover demand the procedure of neural net modeling is used. It is realized in 3 steps:

1. Selection of structure for used neural net – number of input, output and medium layers and number of neurons in each of them are established on the base of parameters of vectors which are forming input and output and appropriate teaching samples. For example for neural network model used for load forecasting at GRID (daily energy consumption for our case) as inputs we used loads at previous days P, average daily temperature (T) and type of week days (D), Fig.2.

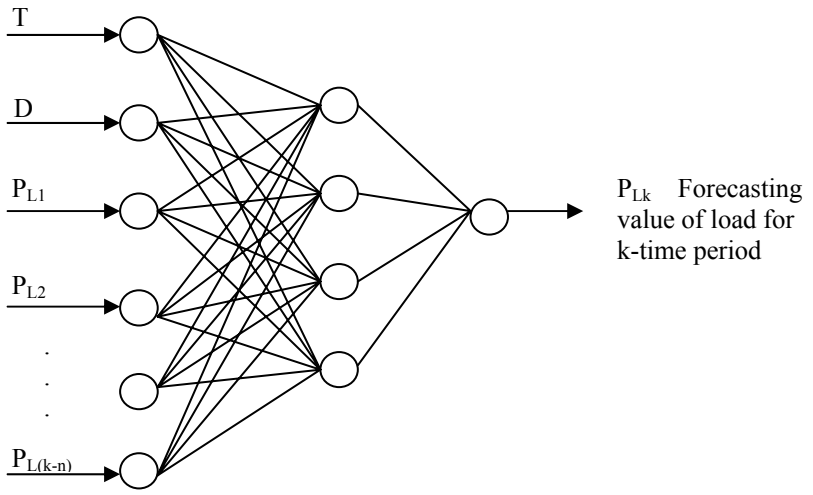


Fig.2 Neural net structure for load forecasting

Number of neurons of first layer directly related with number of input signals. Number of neurons at medium layers usually set experimentally on the stage of teaching procedure. Model of neural net structure for forecasting average values of energy amount of total daily flow through intersystem ties and daily fuel consumption at Power System determined similarly. In that case input variables affecting forecasting parameters are daily consumption, its covering components on TPS and HPS, and also average temperature and day of week.

2. During the teaching procedure of artificial neural net, it is determined weighted coefficients between neurons of neighboring layers. For network teaching purposes algorithm of back expansion is used (error-back propagation), which minimizes mean square deviation of current value of networks output

from setting teaching values (excerpts) of input and output values. Neural models built in such way are called neural emulators. They present objects full model and could be used independently.

3. Forecasting of energy, intersystem power flow and fuel consumption at Power System with help of built neural emulators. For forecasting of indicated parameters corresponding signals are applied to the emulators input.

Using operation for different structures of neural network and retrospective daily data for input parameters the forecasting was obtained. As teaching program NeuroShell program emulator was used [5]. During calculation procedure according initial data NeuroShell carry out teaching for network, recording and retaining obtained neural model for having forecasting estimation of parameters and their following analysis. For network teaching data from Control Center's daily list for max and min of load (winter and summer seasons 2001-2002) was used. Some fragments for 10 days winter time period of teaching is done in table 1. Standard (actual) and forecasting data are given in table 2 and on Fig.3, 4, 5.

Table 1

Some fragments for 10 days winter time period of teaching (Dec.2001/Jan.2002)

Parameters	Total daily values									
Date	01.12	02	03	04	05	06	07	08	09	10
Total generation AzGRES, (MWt)	38230	37100	37340	38276	31340	29290	29055	28955	28950	33620
Total generation Ali-Bayramly, GRES (MWt)	16370	14890	17560	18870	18675	19080	19280	19200	19100	16900
Total generation Baku-1 TES, (MWt)	16370	14890	17560	18870	18675	19080	19280	19200	19100	16900
Total generation, on TEC& GRES, (MWt)	56531	54233	57574	59419	54278	55590	53437	53609	51907	55230
Total generation of Power System, (MWt)	59932	59769	60835	62790	58687	57524	58195	57899	56330	57856
Total power flow, (MWt)	1195	1315	1420	1530	2580	2306	2212	2195	3204	2265
Fuel consumption on AZGRES, (т)	13530	13823	13984	13461	11889	10998	10130	10671	10536	13075
Fuel consumption on Ali-Bayramly GRES, (т)	6563	6140	7383	7843	7411	7913	7877	8007	8011	7090
Fuel consumption on Baku-1 ТЭС, (т)	171	159	172	177	178	179	240	354	375	301

Table 1 to be continued

Parameters	Total daily values									
Date	01.01	02	03	04	05	06	07	08	09	10
Total generation AzGRES, (MWt)	36180	35950	34485	34215	34015	34410	33590	34203	30600	29410
Total generation Ali-Bayramly, GRES, (MWt)	20970	19030	18710	19220	19080	18860	19070	19140	19550	17640
Total generation Baku-1 TES, (MWt)	20970	19030	18710	19220	19080	1176	1176	1176	1192	1184
Total generation, on TEC & GRES, (MWt)	62150	58998	59579	60107	58423	58974	57503	59002	55852	52940
Total generation of Power System, (MWt)	66382	63863	61954	62844	61688	62170	60489	63038	61033	59955
Total power flow, (MWt)	3745	3892	3615	3247	3015	2971	2610	2850	3520	3622
Fuel consumption on AZGRES, (т)	13329	13471	12501	12590	12725	12645	12395	12776	11455	10698
Fuel consumption on Ali-Bayramly GRES, (т)	8488	7791	8016	7949	7958	7787	8025	8002	8198	7336

Fuel consumption on Baku-1 ТЭС, (т)	328	341	396	378	206	198	199	196	202	208

Table2.

Real and forecasted values of parameters for 7 future days (February of 2002).

Parameters	Total daily values						
	01	02	03	04	05	06	07
Real fuel consumption in Power System, t	18908	19312	21628	21449	21244	21970	20453
Forecasted fuel consumption, t	18444	18868	21195	20594	21669	22629	21168
Total energy flow, MWt hour	2975	1864	2636	2342	2098	2440	2820
Forecasted flow, MWt hour	3049	1918	2690	2392	2161	2490	2885
Total electrical energy consumption, MWt hour	58120	59173	66193	67047	65285	65586	64268
Forecasted value of total electrical energy consumption, MWt hour	57975	57578	65197	65807	64035	64639	62988

As a result of analysis it was determined that mean square value of forecasting's error relatively to actual, equal: for total daily energy consumption – 1.85%, for total daily energy exchange over intersystem lines – 2.4%, for total daily fuel consumption – 2.85%.

Fig.3 Daily fuel consumption

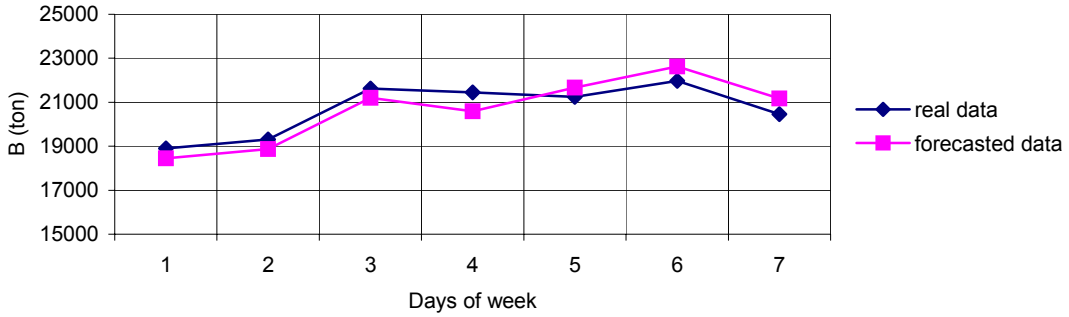


Fig. 4 Daily Power flow through inter-system ties

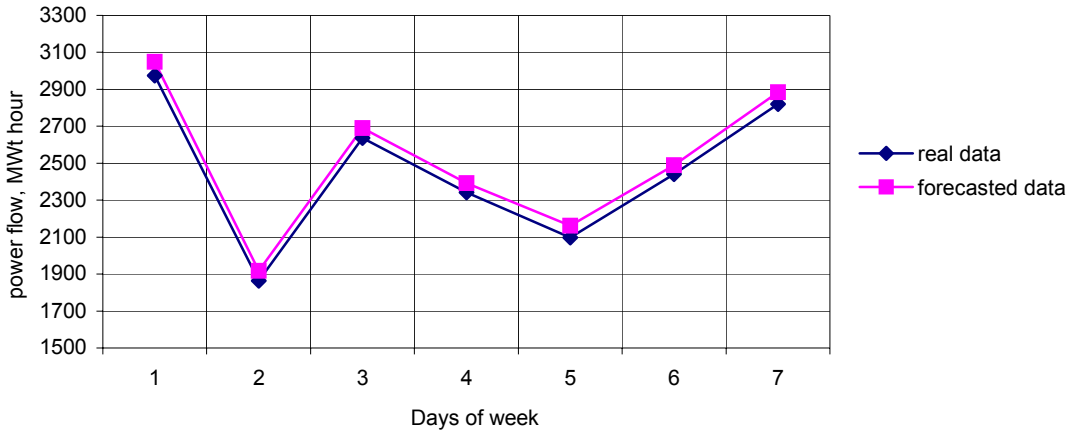
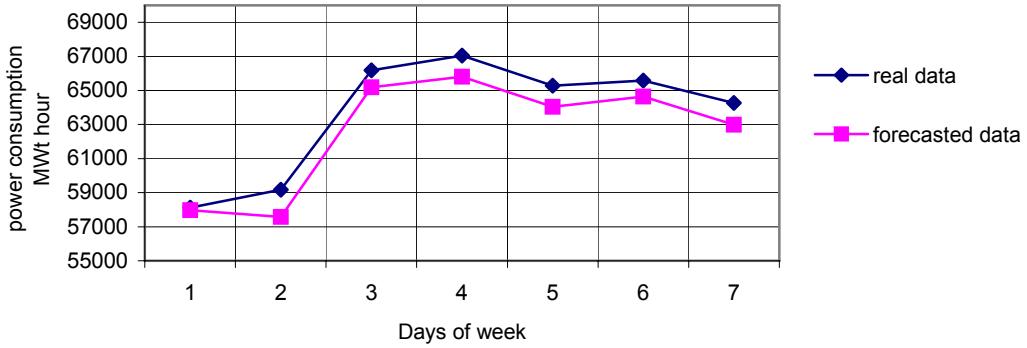


Fig. 5 Daily electrical energy consumption in Energy System



III. CONCLUSION

1. Using model of artificial neural network forecasted values for daily electrical energy consumption power flow through inter-system ties (IST) and fuel consumption in energy system are obtained. These have confirmed the effectiveness of ANN application for short time forecasting solution.
2. Optimal structure of ANN for Azenergy system is synthesized, which determines short time forecasting of daily electrical energy consumption at energy system, power flow through IST and daily fuel consumption taking in consideration external influencing factors.
3. Obtained with help ANN forecasted parameters of energy system slightly differs of their real values and there is not necessary big expenses for identification of neural net's teaching model.

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