ELECTRICAL ENERGY DEMAND MODEL BY NEURAL NETWORK METHOD

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Abstract

In this paper, we will estimate electrical energy demand for long-term and determinate effective parameters. Effective parameter already has been shown in previous studies of author.

This paper, First by using back propagation method and considering of effective input for electrical load demand, and time utilization of electrical network such as income, value added of Industry and home sector, price of electricity and other carrier energy, population, historical and economical effects, temperature and other parameters, primary neural network model with input, hidden and output layer will be designed. Then weights will be given in learning process.

Finally it leads to optimized network for estimation of electrical load demand, time utilization of network and finally electrical energy demand.

The Final model is useful for policy maker for five-year programs in Iran.

This rule is used that

Electrical energy demand=Load demand * Time utilization of network

Keywords: Neural network, Load modeling, Energy forecasting, Time utilization

Introduction [1,2]

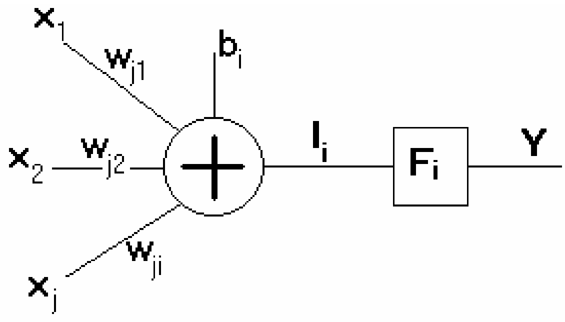
Electrical energy consumption in Iran has an average 8% rate of rise. Programs of reducing energy consumption are under way based on the government's second and third five-year development plans. Defining the energy consumption model has an important role in success of the programs. Identifying effective factors in all sectors (domestic, commercial, services, public, industry and agriculture) is possible by time series analysis. Defining a dynamic model, by visualizing a mental model and investigating the relationships between its components is visual. In this paper, emphasis is put on determining a model for load demand.

Description [3]

The role of neural network is to install a function, which expand Input pattern to output pattern.

A learning algorithm, for example, Error Back Propagation with the usage of property of input – output set.

A neural network is a graph Consist of some important neuron. The following fig shows ith neuron of neural network.



$$I_i = \sum_j W_{ij} K_i + b_i \;, Y_j = (f_i(I_i) \qquad (1)$$

Fig (1): Neuron ith

y_j Is the neuron's output, W_{ij} is weight of relationship between neuron i and j, b_i is a bias and f_i is activation function for neuron i. Error Back Propagation Algorithm is supervisory learning method.

In this method, designed output compares with ideal output and by distributing error between previous layer the weight Corrects, to investigate if some input data is given the network such a response of that would have very little error.

In present method, we use three separated sets.

a) Training set, this set is the largest and it is used to gain weight of parameter and bias at the first of learning process.
b) Test set, this set is used for optimizing the network in previous level and for test and presentation of over learning, the condition for ending learning process is lack of progress of network in reducing error predication of test set.
c) Validation set, is useful concept for enhancing of network.

Advantages of neural network compared of tradition Non Linear model

a) Neural network searches common shape of function but tradition regression models looks for some specific shape of function such as growth function
b) Neural network is more useful, when number of input goes high.

Load Demand

Definition of variables and function [4,5]

Based on previous studies of author presented in the paper entitled as" Dynamic modeling for electrical load Demand" effective parameters are shown in fig (2)

Considered neural network for load demand is feed forward perception, inputs are as following:

Data of load has been shown in load-data matrix includes 33 rows and 14 columns.

Every row shows the information of one year.

Time series data are of from 1967 to 2000 based on reference, energy balancing of Iran.

Fig (2): Parameters in load Demand [4,5,6,7.8.9]

1) Load demand in last year: load (t-1)
2) Load demand in two years ago: load (t-2)
3) Load demand in three year ago: load (t-3)
4) Derivation of income per population: DINCPO
5) Generation in country: GP
6) Population changes: CHPO
7) Added value of home sector: AVHS
8) Added valve of industry: AVIN
9) Non oil income: NOIN
10) Price of electricity: PEL
11) Price of total: PGEN
12) Historical events :HISE

Mathematical formulation [3]

For inputs, output and hidden layer we have:

In fig (3) show that:

Y_i: input nodes for I=1,12

Yj: hidden nodes for j=1,20

φ (.) = tansig (x)

y_k (n): output layer, k=1

$e_k(n)$: Error function = $d_k(n) - y_k(n)$

$E_K(n))= \frac{1}{2} \sum_{k=1}^{m} e_k(n)^2$, $\Sigma E_K(n)$ is objection function (2)

$$sigm(x,\varphi) = 1/1 + \exp(-\varphi x)$$

1) Forward state

In forward state by initial condition for weight output will calculate and then real output compare with designed output and the error calculate by ek (n)= d (n) – Y_k(n).Objective function is $E_{k(n)} = \frac{1}{2}\sum_{k=1}^{m} e_k(n)^2$

If value of error is little than a specified value then training is completed otherwise we will go to backward state.

$$V_j(n) = \sum_{i=1}^{12} W_{ji} Y_i(n) \quad (3)$$

$$Y_j = \varphi_j \ [V_j(n)]$$

$$V_k(n) = \sum_{j=1}^{20} y_j(n)\, W_{kj}(n)$$

$$Y_k(n) = \varphi\ [V_k(n)]$$

$$e_k(n) = d_k(n) - Y_k(n)$$

$$E(n) = \frac{1}{2} \sum_{k=1}^{m} e_k(n)^2$$

2) Backward state

In backward state error function and its derivation related to weight are used to correct the value of weights $\left(\frac{\partial E(n)}{\partial W_{kj}}\right)$ by using of formul (3)

As it is seen for $\delta_{(n)}$, derivation of function $\varphi_{(0)}$ is needed so Activation function for output cell should be derivational.

$$E(n) = \frac{1}{2} \sum ek^2(n)$$

$$\frac{\partial E(n)}{\partial wki} = \frac{\partial E(n)}{\partial ek(n)} * \frac{\partial e_k(n)}{\partial Y_k(n)} * \frac{\partial Y_k(n)}{\partial V_k(n)} * \frac{\partial V_k(n)}{\partial wkj(n)} * \frac{\partial V(n)}{\partial wkj(n)} \quad (4)$$

There for: $\frac{\partial E(n)}{\partial wkj(n)} = -e_k(n)\ \varphi'\ [V_k(n)]\ Y_j(n)$

$$\Delta Wkj(n) = -\eta \frac{\partial \Sigma(n)}{\partial wkj(n)} = \eta e_k(n) \varphi_k\ [V_k(n)]\ Y_j(n)$$

$$\Delta Wkj(n) = \eta \delta_k(n)\ Y_j(n)$$

$\delta k(n)$ = ek(n) $\varphi_k'[V_k(n)]$

by Similar calculation for Δw_{ji} we have:

$\Delta Wji(n) = \eta\ \delta_j Y_j$

$$\delta_j = \varphi_j'[V_{j(n)}]\sum_{k=1}^{20} \delta_k \quad (n) \quad W \quad kj \quad (n)$$

(5)

$E(n) << 1$

$\delta_{(n)}$ Is local gradient, which it is partial differential for each neuron and η is coefficient for speeding up of convergence.

As mention there are 12 input for neural network of load demand model. Objective function is mean square error and Back Propagation Error Algorithm is used for modeling. Larenberg and markvart method has been used to speed of the back Propagation Error Algorithm.

The speed of convergence gets up ten to handed time more. Hesitation function is tang sigmoid and the output range between –1 and +1([-1,1]). The data of training is out of this range ([-1,1]). So for convergence data should transform to this range by transformer (linear for non linear) function. By maximum and minimum scaling method all of data will map to instauration domain of tang sigmoid function there for by the transformation, all of neuron (output and input) arrange in distance [-1, 1]. In training process, large and small signal, do not compare so the system is stable and converge.

$$X_{normalized} = 2x\left(\frac{X_{Actual} - X_{\min}}{X_{\max} - X_{\min}}\right) - 1 \qquad (6)$$

Formula [6] is used for scaling X_{max} and X_{min} is maximum and minimum of parameter respectively. X_{Actual} is uncalled and $X_{normalized}$ is scaled by training of the network. Maximum and minimum vector are calculated.

In training program network learn and in forecasting program by using the result of training program, prediction or simulation will be done.

In this network there are 12 neurons for Input layer, 20 neurons for hidden layer and 1 neuron for output layer.

It is necessary to mention that the number of neurons for hidden layers has been estimated by trail and error.

All character of neural network by save command will be arranged in result of training program, which will be used in forecasting program.

Neural network for load demand model is as shown in fig (4)

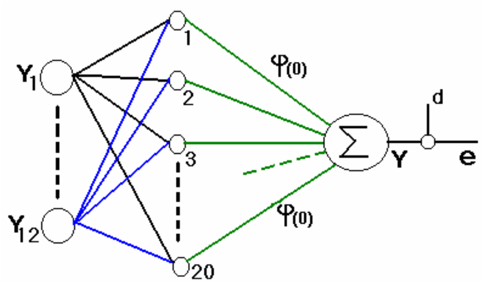


Fig. (4): neural network for load demand

Load is gained actual and forecast.

Fig. (5) show that applies neural network method is useful for estimation and parameters are good selected.

Time Utilization Duration Model

Based on previous studies of author presented in paper Dynamic modeling for utilization durations as shown in fig (6)[5].

Consider neural network for duration utilization demand is feed forward perception, inputs are as load demand

13) Utilization Duration in last year: TIME (t-1)
14) Average Temperature in year :TEMP(t)
15) Population changes: CHPO
16) Non oil income: NOIN
17) Price of electricity: PEL
18) Historical events :HISE

Data of program has been shown Time-data matrix includes 33 rows and7 columns.

Every row shows the information one year. Time series data are of from 1967 to 2000 based on references energy balancing of Iran and other references.

(4)

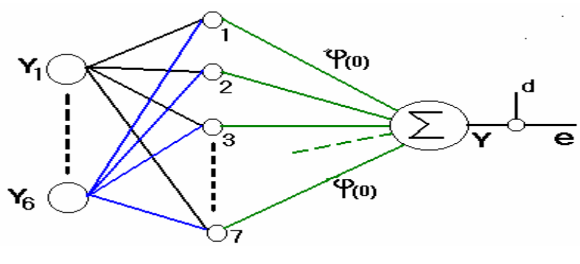


Fig. (7): neural network for duration utilization demand

As mention there are 6 input for neural network of duration utilization demand model and 7 neurons in hidden layer and one neurons in output layer. Objective function is mean square error and Back Propagation Error Algorithm is used

for modeling. Laurinburg and markvart method has been used to speed of the back Propagation Error Algorithm (similar mathematical calculation for load demand in backward and forward state).In fig(8)
Show that utilization duration of network by neural network.

Results of program neural network

Fig. (9) shows that training of network is completed.

In this below show that calculation by neural network method.

First, duration utilization (actual and forecast time of network)[6] and load of network is calculated (actual and forecast load). Energy demand is gained by multiply of time in load. In fig (10) show that result of program for electrical energy demand by neural network method.

Example:

Which Year Do You Want for Forecasting? 1997
Actual Time: 15.476600
Forecast Time: 14.8142
Time Mean Absolute Percentage Error: 4.2801
Actual Load: 16106
Forecast Load: 16494.5036
Load Mean Absolute Percentage Error: 2.4122
Actual Energy: 249266.1196
Forecast Energy: 244352.5945
Energy Mean Absolute Percentage Error: 1.9712

Conclusion

As it is seen the result of program estimation of the load for years before 2000 calculated by %99 accuracy and for recent year accuracy is %98 so we can conclude.

(1) Identification of parameter by neural network is good.
(2) Trended of variation is clear and for next year by considering input parameter load demand is predictable
(3) The accusation is more than classical method
(4) There isn't necessary for defining a specific function the fig (7) shows the result.

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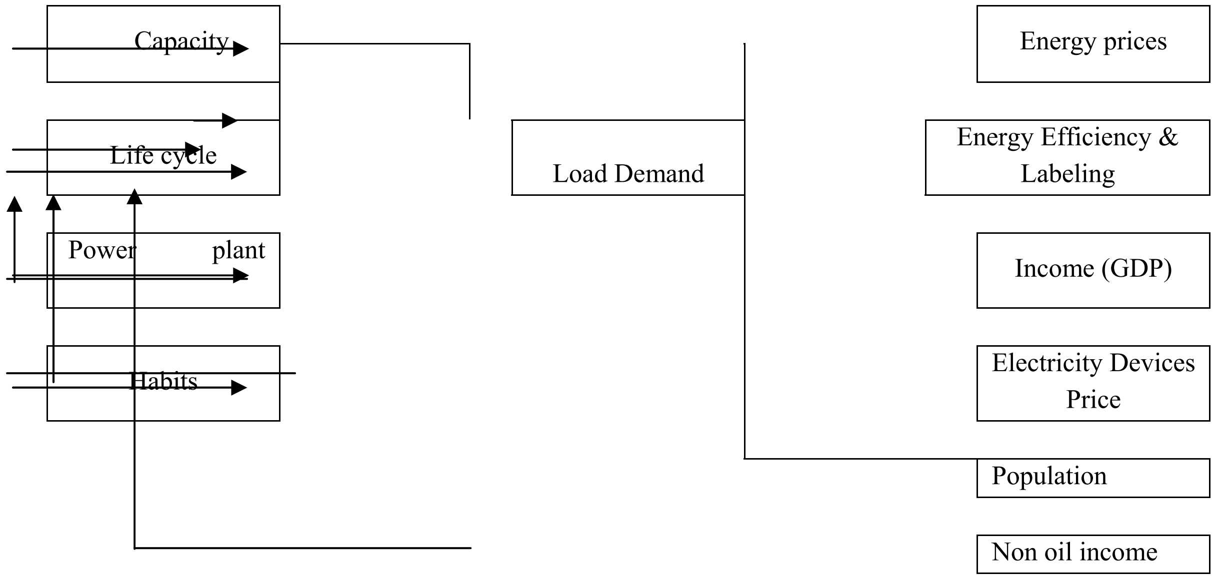

Fig (2): Parameters in load Demand [4,5,6,7.8.9]

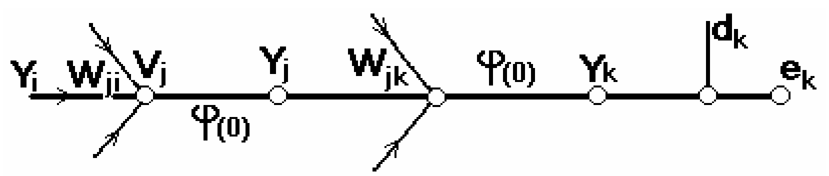

Fig. (3): neural network for 1 neuron

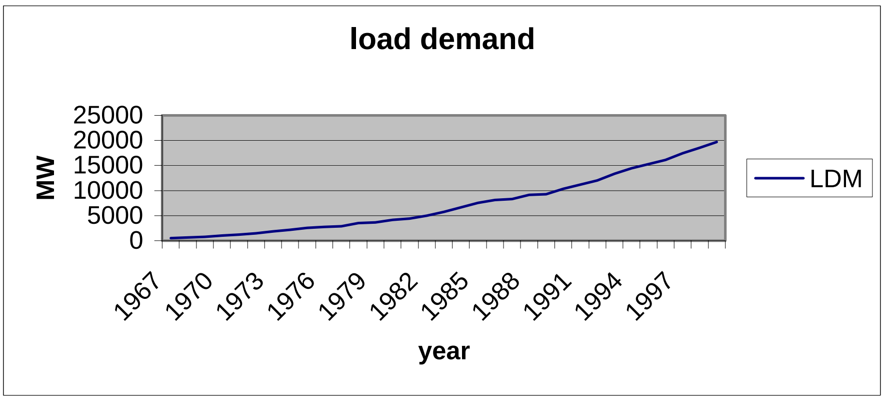

Fig. (5): load demand forecasting by neural network

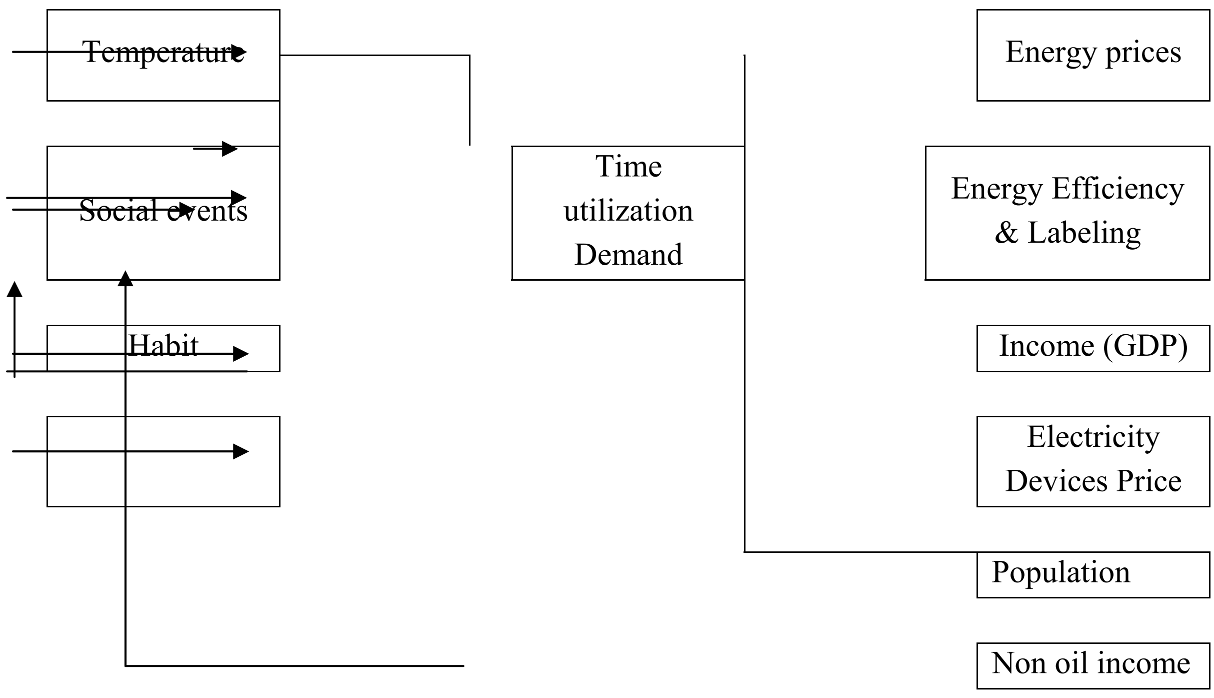

Fig (6): Parameters in duration utilization demand [4,…,9]

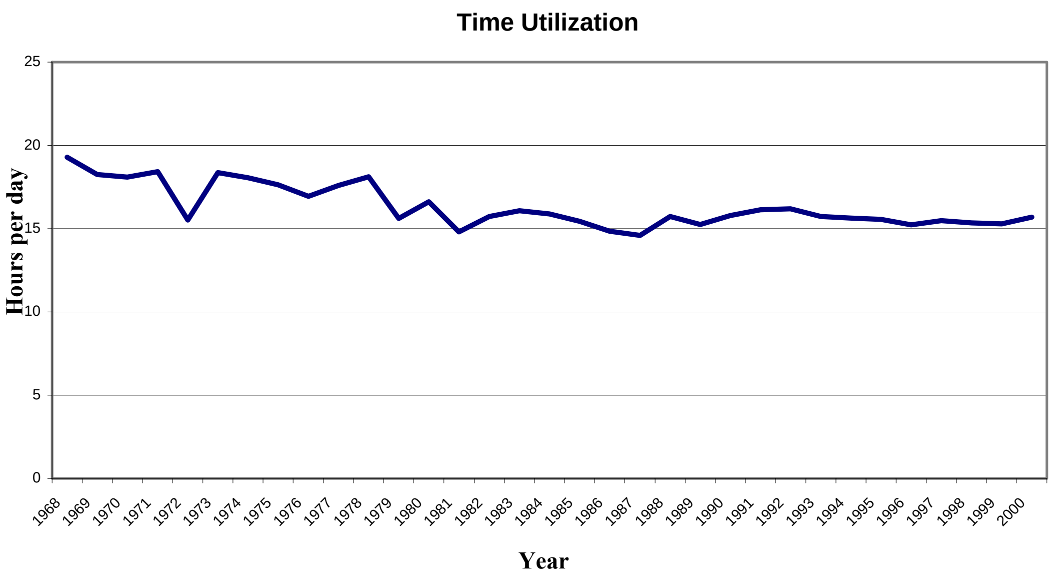

Fig. (8) : Utilization duration demand forecasting by neural network

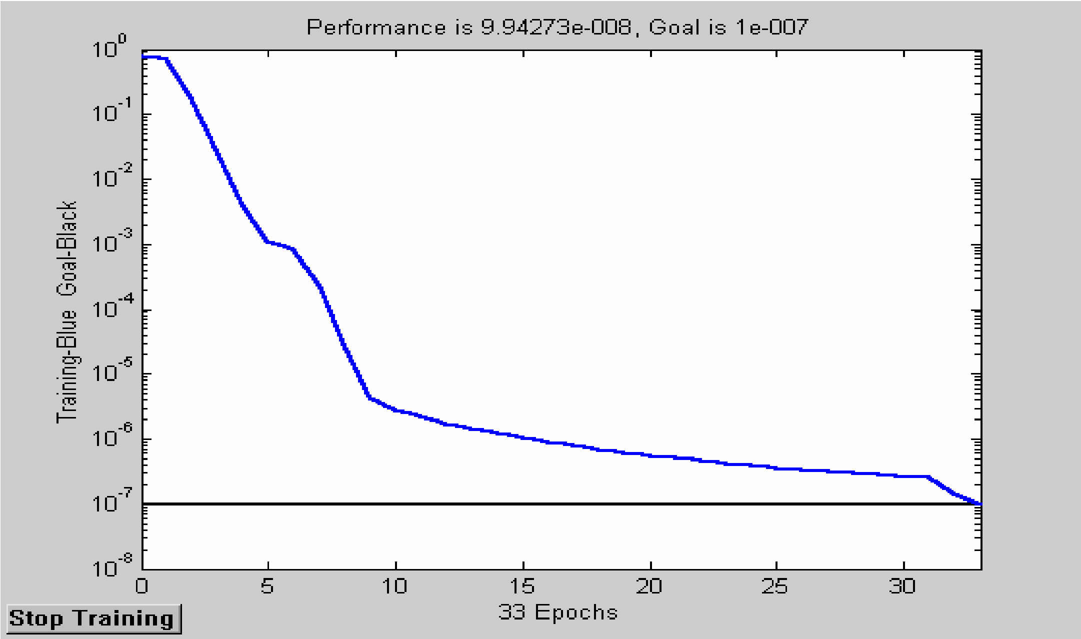

Fig. (9): Training by neural network

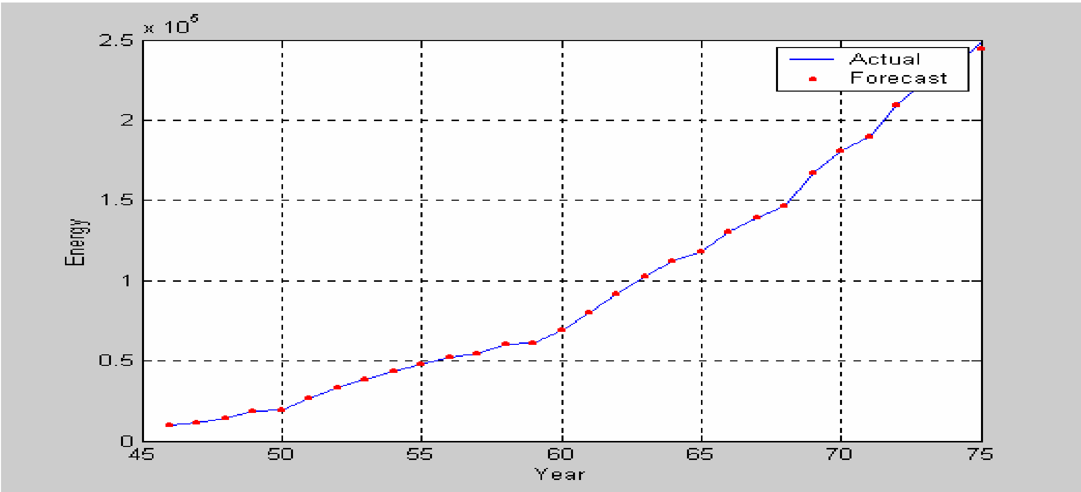

Fig (10). Energy demand by neural network method

NEYRON ŞƏBƏKƏSİ ÜSULU İLƏ ELEKTRİK ENERJİSİNƏ OLAN TƏLƏBATIN MODELLƏŞDİRİLMƏSİ

ƏFFƏTNECƏD R., ŞƏYƏNFƏR H.A.

Məqalədə, elektrik yükünəolan effektiv tələbat, elektrik enerjisindən sənaye obyektlərin və əhalinin istifadə etmə vaxtı, elektrik və digər enerji növlərinin qiyməti. Tarixi və iqtisadi faktorların, temperatur və digər parametrlərin təsirləri məsələlərinə baxılmışdır. Neyron şəbəkəsinin ilkin modeli yaradılmışdır. Optimallaşdırılmış şəbəkənin işlənilməsi üçün, elektrik yükünə və elektrik enerjisinə olan tələbat qiymətləndirilmişdir. Təklif olunmuş model İran İslam respublikasının beş illik proqramının işlənilməsində əhəmiyyətli ola bilər.

МОДЕЛИРОВАНИЕ СПРОСА НА ЭЛЕКТРОЭНЕРГИЮ МЕТОДОМ НЕЙРОННОЙ СЕТИ

ЭФФАТНЕДЖАД Р., ШАЯНФАР Г.А.

В работе рассмотрены эффективный спрос на электрическую нагрузку, время использования электрической сети в промышленности и населением, цены на электричество и другие виды энергии, исторические и экономические факторы, влияние температуры и других параметров, и создана первичная модель нейронной сети, для разработки оптимизированной сети оценки спроса на электрическую нагрузку, использования времени сети и, наконец, потребности в электрической энергии. Указанная модель может быть полезной для разработки пятилетних программ в Иране.