# Estimation of Load Forecast – 2020 Using Artificial Neural Network and Exploration

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**ABSTRACT**

The estimation of increment in energy consumption is very important for power sector of all governments. Forecasting of future energy consumption and forecasting of peak load demand is more important for power sector to regulate the electrical supply. A wide range of mathematical and computational approaches are available for forecasting. With the intention of forecast the peak load demand of year 2020 for India, two different computational approaches ANN via MATLAB and Extrapolation via MS-Excel are proposed in this study. ANN will provide an outcome via EBPN method resulting in a simulink model which is trained, validated and tested with reference of input data. An inbuilt function FORECAST of extrapolation is used in MS Excel to obtain the similar result. In this study, the historical data sets of peak demand of India were acquired from year 1995 to 2014 for peak load forecasting. A comparative study is obtained from the outcome of both the approaches to obtain the result with minimum errors.

***Key words***: Load forecasting, ANN, EBPN, Extrapolation.

## 1. Introduction to Load Forecasting

Load forecasting plays an important role in power system, it is necessary for Planning, Analysis, Operation and Control of a power system. It means prediction of future data by analyzing previous data. It is classified into three types- (i) Short term forecasting (from few minutes to few hours) (ii) Medium term forecasting (from few hours to few weeks) (iii) Long term forecasting (from few weeks to several years). A long term forecasting is used to find out the capacity of generation, transmission and distribution system and the type of services require in transmission extension planning, Annual hydro thermal maintenance, and scheduling etc. So the time line and accurateness of long term forecasting have significant effect on power system planning to construct new power generation plants and transmission facilities to meet the

power demand in near future [1]. Load forecasting is very imperative for the reliable and economical operation of the power system. Modeling and forecast plays a critical role in developed and developing countries for policy makers and related organizations. The under-estimation of the demand would direct to potential outages that are devastating to life and economical areas. The over estimation would escort to unnecessary idle capacity which means wasted financial resources therefore it would be superior to model electricity demand with good accuracy in order to avoid costly mischievous [2]. In a country like India, where load is continuously increasing over the year which can be seen in the below graph.

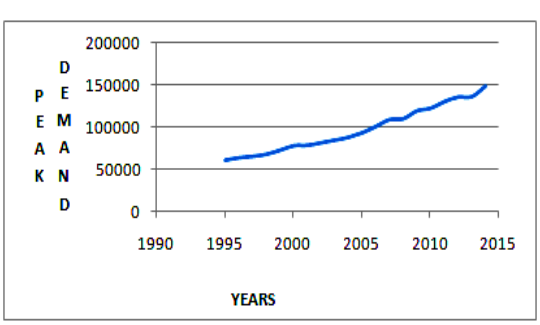


Fig. 1 Plot between Years and Peak Demand Generate

Load forecasting is necessary to fulfill the consumer demand and to regulate the power supply effectively. Load is a unpredictable quantity, which is depends upon several factors like growth in population, growth in economical and industrial sectors, change in atmospheric condition etc. So the accurate prediction of future demand is not feasible but there are several methods used to envisage the load with minimum error, result in better accuracy like:- regression, Extrapolation, ANN, Fuzzy Logic and Rule based Expert System etc. In short and medium term forecasting high accuracy can be achieved because the factors which affects the load are almost stable, but in long term the variation in factors can't be estimated.

There are number of research scholars who have proposed their model for load forecasting. J. Kumaran, G. Ravi represents a simple regression analysis based model concerning population and per capita GDP for long term forecasting of India's sector wise electrical energy demand up to year 2025 using consumption during the years 1990 to 2012 [3]. Dogra Sonika et. al study about long term load forecasting between two stations taking into consideration population increment factor using Fuzzy Logic methodology [4]. Shijie Ye et. al developed a support vector regression model for long term load forecasting for china. SVR provides a mapping to relocate the actual time series into a multi dimensional space to depict the non linear relationship between GDP and Load [5]. Chavez et. al used Auto regressive Integrated moving Average (ARIMA) time series analysis model based on Box- Jenkins method to formulate the forecasting model for the prediction of energy production and consumption in Austria's, Northern Spain [6]. Asber et. al dealt with the development of a reliable and efficient Kernel regression model to forecast the load in the Hydro Quebec distribution Network [7]. Chang et. al constructed a weighted evolving Fuzzy neural network for monthly electricity demand forecasting in Taiwan [8].

The study done by the research scholars increased our curiosity to know more about load forecasting and encourage us to try some effort in this area. In this paper, peak load demand of India of year 2020 is evaluated by ANN and extrapolation through MS-Excel using data of years 1995 to 2014. ANN via MATLAB generates a simulink model which is trained according to variation of previous data. Then model is ready to give an output for any specified input by testing the data number of times and result with minimum error. "TREND" function is used in MS-Excel to evaluate the peak demand by arranging the data in a table form. A comparative study is also provided between the results obtained by the two methodologies for obtaining better solutions. This paper further contains introduction to load forecasting and literature review in section I, description of methodologies in section II, modeling and development of ANN in section III, results in section IV, conclusion, references and bibliography in section V, VI, VII respectively.

## 2. Description of Methodologies

### 2.1 Artificial Neural Network

An Artificial Neural Network, frequently called a neural network, is a mathematical model stimulated by biological neural networks. A neural network consists of an interrelated group of artificial neurons, and it processes information using a connectionist approach to calculation. In most cases a neural network is an adaptive system that changes its pattern during a learning stage.[9] Artificial neural network is also measured as one of the modern mathematical-computational methods which are used to solve surprising dynamic problems in developed behavioral systems during a time period By learning to distinguish patterns from data in which other computational and statistical method failed to solve them, artificial neural networks are able to solve the problems.[10] Artificial neural networks, originally developed to imitate basic biological neural systems– the human brain particularly, are composed of a number of interconnected easy processing elements called neurons or nodes. Each node receives an input signal which is the total "information" from other nodes or external stimuli, processes it nearby through an activation or transfer function

and produces a transformed output signal to other nodes or external outputs. Although each individual neuron implements its function rather slowly and imperfectly, collectively a network can execute a surprising number of tasks pretty proficiently This information processing characteristic makes ANNs a commanding computational device and capable to learn from examples and then to generalize to examples never before seen.

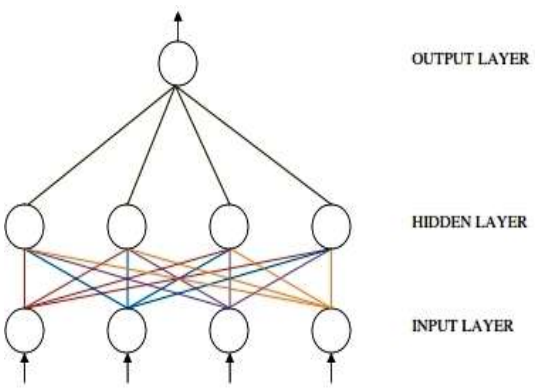


Fig.2 Feed Forward Neural Network

An MLP is typically composed of numerous layers of nodes. The first or the lowest layer is an input layer where external information is received. The last or the highest layer is an output layer where the problem solution is achieved. The input layer and output layer are divided by one or more inter- mediate layers called the hidden layers. The nodes in adjoining layers are usually totally connected by a cyclic arc from a lower layer to a higher layer.[11] **Back-propagation**, a retrenchment for "backward propagation of errors", is a general method of training artificial neural networks used in concurrence with an optimization method such as gradient descent. The method calculates the gradient of a loss function with respect to all the weights in the network. The gradient is fed to the optimization method which in turn uses it to update the weights, in an effort to minimize the loss function. Back-propagation requires a known, desired output for each input value in order to calculate the loss function gradient. It is therefore generally considered to be a supervised learning method, although it is also used in some unsupervised networks. It is a simplification of the delta rule to multi-layered feed forward networks as shown in the above figure, made possible by using the chain rule to iteratively compute gradients for each layer. Back propagation requires that the activation function used by the artificial neurons (or "nodes") be differentiable [12]. Before an ANN can be used to perform any preferred task, it must be trained to do so. Basically, Training is the process of determining the arc weights which are the key elements of an ANN. The acquaintance learned by a network is stored in the arcs and nodes in the form of arc weights and node biases. It is through the linking arcs that an ANN can bring out complex nonlinear mappings from its input nodes to its output nodes. MLP training is a supervised one in that the desired retort of the network (target value) for each input pattern (example) is always available [11].

### 1.2 Extrapolation through MS-Excel

Forecast function in MS-Excel used for computation or prophecy of a future value by using existing values. The expected value is in Y column for a given value in X column. The identified values are existing X- values and Y-values. The new value is forecasted by using linear regression. Someone can use this function to calculate future sales, inventory requirements or consumer trends.

***FORECAST(X, Known_Y's, Known_X's)***

X- Required data point for which someone wants to envisage the value.

Known_Y's- Required. The dependent array or collection of data.

Known_X's- Required. The independent array or assortment of data. [13]

### 3. Modeling and Development of ANN

The peak demand data of India from 1995 to 2014 along with peak demand meet, shortage in peak demand meet of each year and percentage shortage of each year as shown in table-1 [14] has

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been employed for the training of ANN to predict the peak demand of year 2020. The proposed configuration of ANN is shown in below figure.

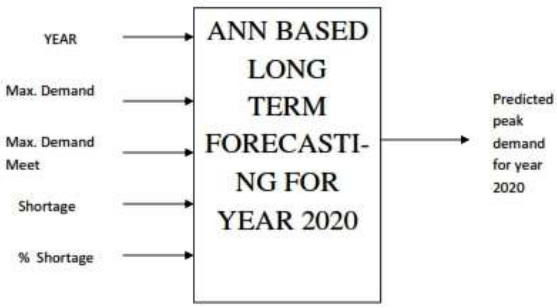


Fig. 3 Proposed Structure of ANN

MATLAB 2009 is used for ANN training and testing. The training data set for proposed ANN prediction contains all the four inputs. Hence the dimension of the developed for training is 20X4, i.e. it contains 20 rows and 4 columns.

Table-1 Reference data for future prediction

| YEAR | PEAK DEMAND | PEAK DEMAND MET | SHORTAGE | %SHORTAGE |
|---|---|---|---|---|
| 1995 | 60981 | 49836 | 11145 | 18.3 |
| 1996 | 63853 | 52376 | 11477 | 18 |
| 1997 | 65435 | 58042 | 7393 | 11.3 |
| 1998 | 67905 | 58445 | 9460 | 13.9 |
| 1999 | 72669 | 63691 | 8978 | 12.4 |
| 2000 | 78037 | 67880 | 10157 | 13 |
| 2001 | 78441 | 69189 | 9252 | 11.8 |
| 2002 | 81492 | 71547 | 9945 | 12.2 |
| 2003 | 84574 | 75066 | 9508 | 11.2 |
| 2004 | 87906 | 77652 | 10254 | 11.7 |
| 2005 | 93255 | 81792 | 11463 | 12.3 |
| 2006 | 100715 | 86818 | 13897 | 13.8 |
| 2007 | 108866 | 90793 | 18073 | 16.6 |
| 2008 | 109809 | 96785 | 13024 | 11.9 |
| 2009 | 119116 | 104009 | 15157 | 12.7 |
| 2010 | 122287 | 110256 | 12031 | 9.8 |
| 2011 | 130006 | 116191 | 13815 | 10.6 |
| 2012 | 135453 | 123294 | 12159 | 9 |
| 2013 | 135918 | 129815 | 6103 | 4.5 |
| 2014 | 148166 | 141160 | 7006 | 4.7 |

Once the neural network has been structured for a particular function, that network is ready to be trained. To start the training process, the initial weights are chosen randomly. Then the training or learning begins. The training of ANN predictor is shown in Fig. 4. After training of ANN predictor, the error obtained is 2.66 X $10^{-23}$ in 983 iterations. The training performance, regression plot and training state representing gradient and validation check plot are also represented in Fig. 5

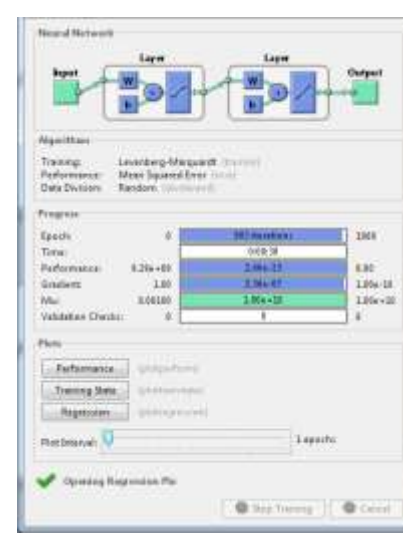

Fig. 5(a) Training Model

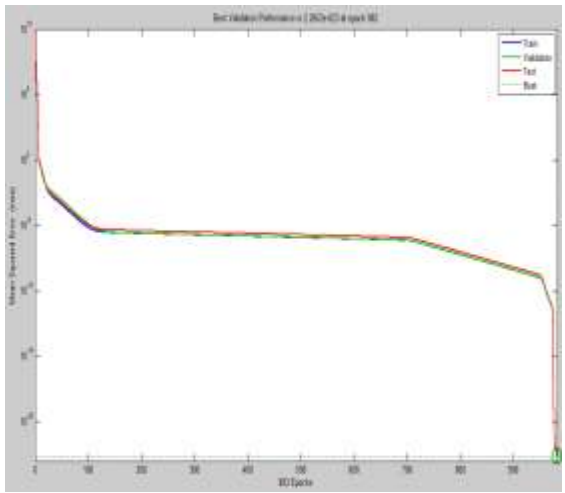

Fig. 5(b) Performance State

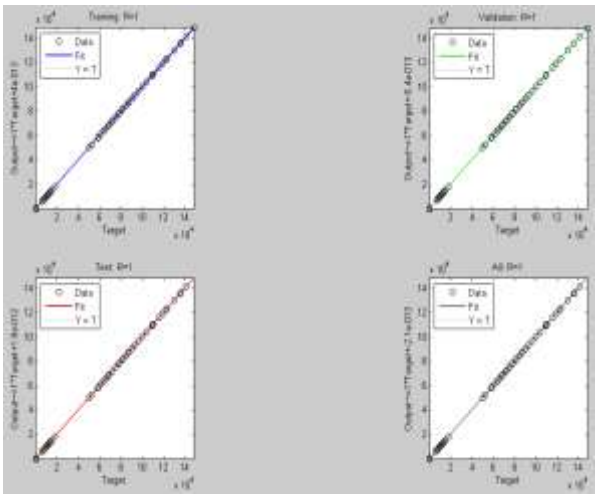

Fig. 5(c) Regression Plot

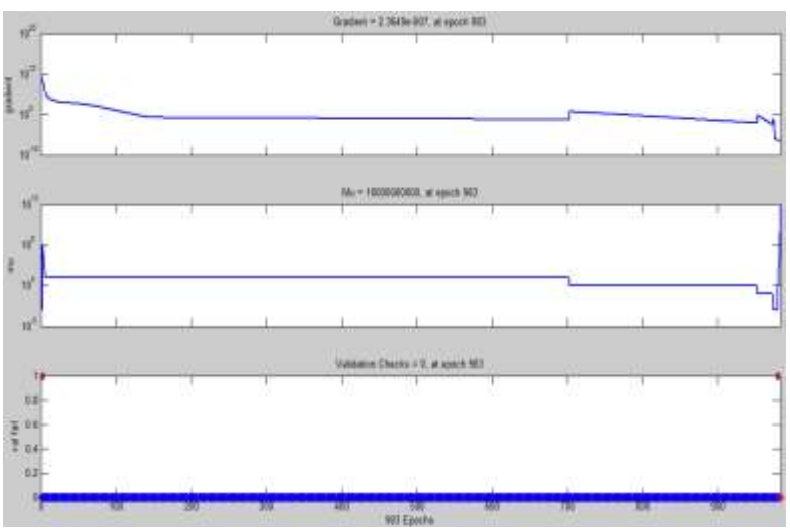

Fig. 5(d) Training State

## 4. Results

Successful operation of ANN based load forecasting requires an appropriate training data set that can adequately covers the entire solution space with a view to recognize and generalized the relations among the problem variables. The result of ANN simulink model is representing in Fig. 6. The peak energy demand for India calculated through ANN and Extrapolation during the year 2015 to 2020 and comparison between these results are presented in table-2.

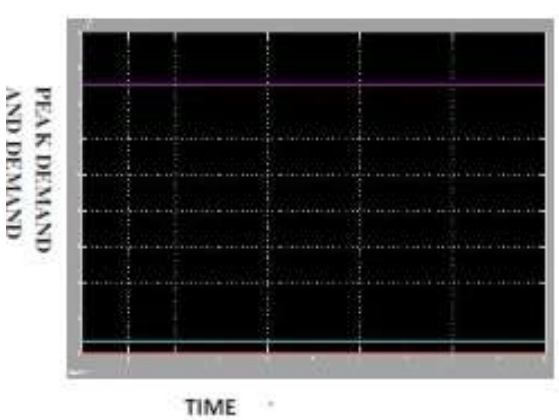


Fig. 6 ANN result of Year 2020

Table-2 Result of Peak Energy Demand of India

| S. No. | YEAR | MAX. DEMAND (MW) | | |
|---|---|---|---|---|
| | | ANN | Extrapolation | Difference |
| 1 | 2015 | 148550 | 145125 | 3425 |
| 2 | 2016 | 156710 | 149685 | 7025 |
| 3 | 2017 | 154950 | 154245 | 705 |
| 4 | 2018 | 163260 | 158805 | 4455 |
| 5 | 2019 | 166540 | 163365 | 2875 |
| 6 | 2020 | 167550 | 167925 | -375 |

** The maximum difference in results occur in year 2016, which is within 5% while considering any one result of that year as reference. Hence we can say the result is almost similar.

## 5. Conclusion

Load forecasting is an important event in efficient planning and control of electrical systems. Load serving entities use load forecasting for entire system security, load scheduling, investments in generation and transmission. The peak demand electrical energy of India has been forecasted for the future years through the previous year data by the developing ANN model and through Extrapolation. The results help the policy makers for allocating appropriate funds for constructing new generation plans and transmission system to meet the future demands and attempts to offer reliable service to the customers.

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