Adaptive Load Forecasting

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***Abstract*— The present title discloses a novel approach for carrying out the constraints of energy requirements and minimizes the wastage of power at the workstations, mall, libraries, visiting centers, house hold requirements by actively predicting the power requirements – as a theme of LOAD FORECASTING. Load Forecasting is an attempt to foretell the energy requirements in the near future. The Adaptive Load Forecasting (ALF) system is implemented by using Nero-Fuzzy System.**

ALF system considers different parameters at front end and back end so as to fulfill the energy requirements of the world adaptively.

***Keywords*: Load Forecasting, ANFIS, Fuzzy Logic, Energy Management**

I. INTRODUCTION

Load forecasting have long been known as the initial and crucial step for implementing the power units. The changing scenario in the era of civilization, market utilities and industrial developments have altered the types of forecasts that are most useful, the link between the sound evaluation and infrastructure development is irreducible. Physical systems can be based on their alternatives on future views regarding load levels and locations.

The Adaptive Load Forecasting system vigorously predicts the power requirements and manages the available power using modern inference system. Inference is the act or process of deriving logical conclusions from premises known or assumed to be true. The conclusion drawn is also called an idiomatic. The laws of valid inference are studied in the field of logic.

The ALF system is proposed around ANFIS system- is a kind of artificial Neural Network which is based on inference system. As it integrates benefits of both neural network and fuzzy logic principles it has potential to capture the benefits of both technologies in a single framework.

1. Power System Planning:

Load forecasting is an ingredient of Power System Planning **(PSP).**

PSP is a process in which we aim to decide on new as well as upgrading existing system elements, to adequately satisfy the loads for a foreseen future. And these elements could be Generation Facilities, Substations, Transmission Lines or cables, capacitors, reactors and etc.

Forecasting refers to two different terminologies like Demand Forecast and Energy Forecast

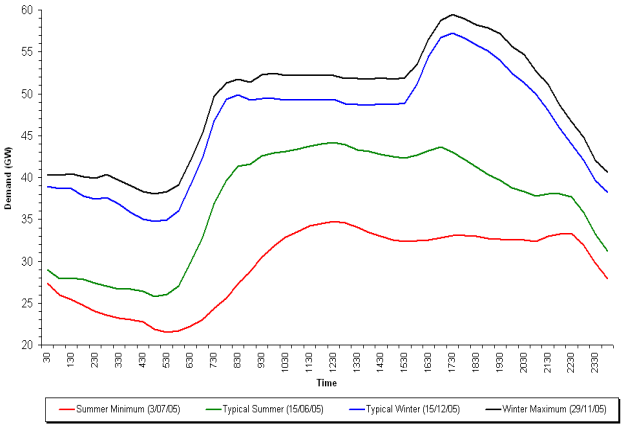
Demand Forecast that deals with determining capacity of generation, transmission and distribution. On the other hand Energy Forecast refers to determining type of generation facilities required.

Such forecasting can be piled up through Load Curves. It gives thought of variation of load during different time, Total number of units generated, maximum demand of the location, average load on a power station from the location, and load factor.

II. FORECASTING METHODOLOGIES

As the forecasting methodologies are procedures for quantitatively defining future loads. It can be classified depending on time period:

a. Short Term



b. Intermediate

c. Long Term

The short term plotting is carried out on daily load basis, also called Daily Load Curve, intermediate is carried out on monthly basis also called as monthly load curve and long term is carried out on annual basis also called as annual load curves, when plotted using load curves techniques.

Fig.1: Sample Load Curve

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Month	Energy generated (kwh)	Capacity factor (%)	Generation hours	Operating hours	Grid OK hours	Machine availability (%)	Grid availability (%)	System availability (%)
June	263872	17.73	1120	1298.80	1320	98.39	91.67	90.19
July	459319	30.86	1188.2	1230	1240	99.19	83.33	82.66
August	757422	50.90	1395.5	1417.3	1433.7	98.86	96.35	95.35
September	685006	47.57	1234.10	1378.40	1399	98.53	97.15	95.72
October	171514	11.52	1231.6	1436.3	1446.8	99.27	97.23	96.53
November	19731	1.37	566.68	1366.3	1376.2	99.28	95.57	94.88
December	69509	4.67	787.4	1440.8	1454.1	99.09	97.72	96.83
January	97316	6.54	916.3	1444.2	1452.5	99.43	97.61	97.06
February	107817	7.49	924	1347.6	1356.6	99.34	97.46	96.81
March	199303	13.84	979.4	1293.3	1302.8	99.27	87.55	86.92
April	430216	29.87	1123.4	1260.3	1319.8	95.49	91.65	87.52
May	471391	31.67	1234.1	1373.3	1388.6	98.90	93.32	92.29
Total	3732416		12701	16286.6	16644.2			
Average		21.16				98.75	93.89	92.72

Fig.2: Real Time statistics of wind power project at Motha

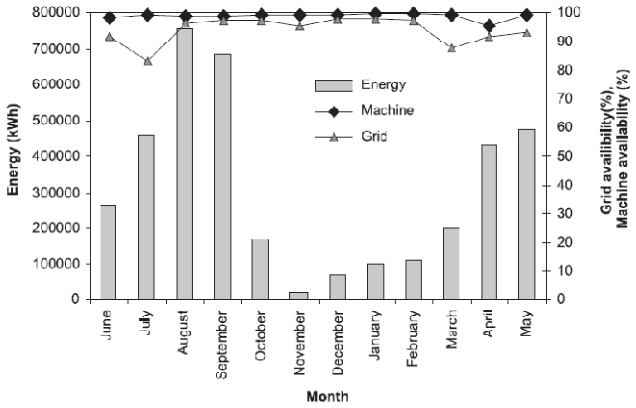

Fig.3: Sample Power Supplied statistics

Fig.1 gives ideas about the sample load curves that give exact data about the load requirements in KWH at different time scale on short term basis.

Fig.2 and Fig.3 describes the real data that is supplied to the locations through wind power project on long term basis.

III. FACTORS AFFECTING FORECASTING

1. Time Factors such as:
   - 1.1 Hours of the day (Day/Night)
   - 1.2 Day of the week (Week Day/Weekend)
   - 1.3 Time of the year (Season)
2. Weather Conditions (Temperature and Humidity)
3. Class of Customer (residential, commercial, industrial, agricultural, public, etc.)
4. Special events (TV programmes, public holidays, etc.)
5. Population
6. Economic indicators (per capita income, Gross National Product (GNP), Gross Domestic Product (GDP), etc.)
7. Trends in using new technologies
8. Electricity price

IV. IMPLEMENTATION TECHNIQUES

Effective forecasting techniques can be implemented using different platform: Embedded System, Using Programmable Devices and Using Neuro-Fuzzy System.

Considering the different shortcomings of the other two platforms the present novel concept is implemented using Artificial Neural Network- ANFIS Technique.

ANFIS is meant for integrating features if Fuzzy System and Neural Network.

From Fuzzy System: it is representation of prior Knowledge into set of constraints (Network Topology) to reduce the optimization search space.

And from Neural Network: It is adaptation of back propagation to structured network to automate Fuzzy control parametric tuning.

In the present title, short term forecasting is executed. i.e. the network is designed for predicting the next hour expected

load. Which can be procured and fulfilled from the power station well in advanced.

For designing the network, three inputs are considered viz: Hour, date and month. This statistics of the pattern recorded for particular location is given as membership function inputs to the network for training.

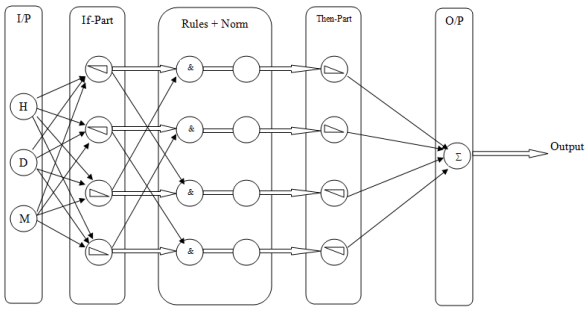

Fig.4: Proposed ANFIS N/W

Hour, date and month patterns are given as input will be then recorded and membership functions are created which nothing but the implementation is of if part.

In the input column "H" indicates Hour Input, "D" indicates Date Input and "M" indicates Month input to the ANFIS Network.

Based on the conditions i.e. if part certain rules are defined. Like number of membership functions to be implemented and their inter-relations. Once the membership functions are defined and rules are defined then the network is ready to use. That means it is in the state of predicting the load pattern to be fulfilled.

The first step is executed by the fuzzifier which converts the input data pattern in to fuzzy sets. These set of data patters in now the exact input to the ANFIS system. Second crucial stage is executed by the permutator which applies all the possible combinations to the fuzzy set. This comes under the Rules + Norm Section. And the final, most decisive stage of the proposed system is inference unit.

In the proposed system, the intermediate data generated is multiplied with the correcting factor of 1.2 units.

The title proposes 1.2 multiplication factor as the best suitable unit for predicting the most precise forecasting. This multiplication factor depends on different parameters like Location, Weather conditions, days of the year and etc. Based on the experiment conducted for this title, 1.2 multiplication factor which is also called as the Bias of the system is best suitable. The inference unit is basically implementing the then part of the above figure.

The unit is designed and trained which has then certain set of output pattern data, also called as the Permutator unit.

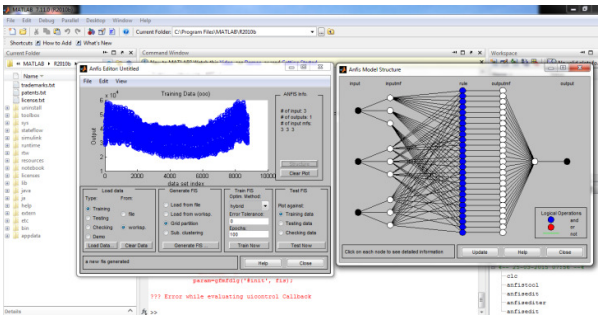

Fig.5: Sample Result Generated for ANFIS

Figure 5 shows the sample result generated for the three input i.e. hour, date and month. The input data is given for 12:00 A.M. to 12:00 A.M. as a day input, 1 to 30 as date input and 1 to 12 as month input to the proposed ANFIS network.

The proposed system is not only suitable for implementing the Load forecasting of the Power Generation Unit but is also suitable for implementing stock exchange system. In this system the historical values are given as an input to the Adaptive Forecasting System with which it is possible to forecast sensex values.

Second applications is in medical science in which again certain pre-coded data values which specifies the symptoms of the disease like cancer, heart attaché and diabetes. In this mode of the system it is possible to take corrective actions for the patient before the serious health mode.

In the third mode of the application of the system, weather forecasting can also be implemented for uncertain areas. The proposed system again can be implemented in three different ways for short term forecasting, intermediate and long term forecasting. But the proposed system is best suitable for weather forecasting if it is implemented considering Short Term Forecasting. Since, for the sites where the environment changes all of sudden, makes the system failure when implemented in intermediate and long term basis.

For implementation of the above three systems ANFIS network can be modified in terms of number of inputs, intermediate membership functions and number of outputs to implement the desired system.

V. CONCLUSIONS

The present title is a novel and flexible architecture implemented using modern Techniques like ANFIS architecture with which it is possible to implement different multifaceted structural design.

REFERENCES

[1] Jang, Jyh-Shing R (1991). Fuzzy Modeling Using Generalized Neural Networks and Kalman Filter Algorithm. Proceedings of the 9th National Conference on Artificial Intelligence, Anaheim, CA, USA, July 14–19 2. pp. 762–767.

[2] Abraham, A. (2005), "Adaptation of Fuzzy Inference System Using Neural Learning", in Nedjah, Nadia; de Macedo Mourelle, Luiza, Fuzzy Systems Engineering: Theory and Practice, Studies in Fuzziness and Soft Computing 181, Germany: Springer Verlag, pp. 53–83,

[3] Jang, J.-S.R. (1993). "ANFIS: adaptive-network-based fuzzy inference system". IEEE Transactions on Systems, Man and Cybernetics.

[4] Ruth M.J. Byrne, P.N. Johnson-Laird (2009). ""If" and the Problems of Conditional Reasoning". Trends in Cognitive Science 13 (7): 282–287.doi:10.1016/j.tics.2009.04.003
[5] Markus Knauff, Thomas Fangmeier, Christian C. Ruff, P.N. Johnson-Laird (2003). "Reasoning, Models, and Images: Behavioral Measures and Cortical Activity". Journal of Cognitive Neuroscience 15 (4): 559–573
[6] Sangeet Khemlani, P.N. Johnson-Laird (2008). "Illusory Inferences about Embedded Disjunctions". Proceedings of the 30th Annual Conference of the Cognitive Science Society. Washington/DC. pp. 2128–2133
[7] "Electric Power System Planning: Issues, Algorithms and Solutions", Hossein Seifi and Mohammad Sadegh Sepasian, Springer-Verlag Berlin Heidelberg, 2011
[8] "Electrical Power Systems Planning", A.S. Pabla, Macmillan India Ltd., 1988.
[9]"Power Distribution Planning Reference Book", H. Lee Willis, Marcel Dekker Inc.
[10] "Short term load forecasting using time series modeling with peak load estimation capability", IEEE Transactions on Power Systems, Vol.16, No.3 August 2001.
[11] "Load forecasting via suboptimal seasonal autoregressive models and iteratively reweighed least squares estimation", IEEE Transactions on Power Systems, Vol.8, No.1 February 1993
[12] "Short term load forecasting using general exponential smoothing", IEEE Transactions on Power Systems, March/April 1971
[13] "A real time implementation of short term load forecasting for distribution power systems", IEEE Transactions on Power Systems, Vol.9, No.2 May 1994
[14] "Analysis and evaluation of five short term load forecasting techniques", IEEE Transactions on Power Systems, Vol.4, No.4, October 1989
[15] "Short term load forecasting, profile identification, and customer segmentation: A methodology based on periodic time series", IEEE Transactions on Power Systems, Vol.20, No.3 August 2005
[16] "Identification of ARMAX model for short term load forecasting: An evolutionary programming approach", IEEE Transactions on Power Systems, Vol.11, and No.1 February 1996
[17] "Neuro fuzzy approach to short term load forecasting in a price sensitive environment", IEEE Transactions on Power Systems, Vol.17, No.4, November 2004
[18] "Short term load forecasting using fuzzy neural networks", IEEE Transactions on Power Systems, Vol.10, No.3 August 1995.
[19] "Short term load forecasting for special days in anomalous load conditions using ANN", IEEE Transactions on Power Systems, Vol.15, No.1 February 2001
[20] "One hour ahead load forecasting using neural networks", IEEE Transactions on Power Systems, Vol.17, No.1, February 2002
[21] "Load forecasting using support vector machines: A study on EUNITE competition 2001", IEEE Transactions on Power Systems, Vol.19, No.4, November 2004
[22] "Composite modeling for adaptive short term load forecasting", IEEE Transactions on Power Systems, Vol.6, No.2, May 1991.
[23] "Comparison tests of fourteen distribution load forecasting methods", IEEE Transactions on Power Systems, Vol.PAS-103, No.6, June 1984
[24] "Automated load forecasting", IEEE Transactions on Power Systems, Vol.3, No.3, August 1988
[25] "Regressive based peak load forecasting using transformation technique", IEEE Transactions on Power Systems, Vol.19, No.4 November 1994.
[26] "Short term load forecasting for fast developing utility using knowledge-based expert systems", IEEE Transactions on Power Systems, Vol.17, No.4, May 2002.
[27] "Quantitative forecasting-The state of the explorative models", j.opl.Res.Soc. Vol 30, No.8, 1979
[28] "Short term load forecasting", IEEE Transactions on Power Systems, Vol.75, No.12, pp. 1558-1973, December 1987
[29] "Comparative models for electrical load forecasting", John Wiley and Sons Ltd. 1985
[30] "Short term peak demand forecasting in fast developing utility with inherent dynamic load characteristics", IEEE Transactions on Power Systems, Vol.5, No.3, August 1990. pp. 813-824.
[31] "Short term power system load forecasting using the iteratively reweighed least squares algorithm", Electric power system research, 19(1990) pp.11-12.
[32] R. E. Brown, A. P. Hanson and D. L. Hagan, "Long Range Spatial Load Forecasting Using Non- Uniform Areas," IEEE Transmission and Distribution Conference Proceedings, Vol.1, pp.369-373, 1999.
[33] P. K. Dash, S. Dash, G. Rama Krishna and S. Rahman, "Forecasting of a Load Time Series Using a Fuzzy Expert System and Fuzzy Neural Networks," International Journal of Engineering Intelligent Systems, Vol.1, pp.103-118, 1993
[34] K. H. Kim, J. K. Park, K. J. Hwang and S.H. Kim, "Implementation of Hybrid Short-Term Load Forecasting System Using Artificial Neural Networks and Fuzzy Expert Systems," IEEE Transactions on Power Systems, Vol.10, pp.1534-1539, 1995.
[35] E. A. Mohamad, M. M. Mansour, El- S. Debeiky, K. G. Mohamad, N. D. Rao and G. Ramakrishna, "Results Of Egyptian Unified Grid Hourly Load Forecasting Using An Artificial Neural Network With Expert System Interfaces," Electric Power Systems Research, Vol.39, pp.171-177, 1996.
[36] C. C. Chiu, D. F. Cook, J. L. Kao and Y.-C. Chou, "Combining a Neural Network and a Rule-Based Expert System for Short-Term Load Forecasting," Computers and Industrial Engineering, Vol.32, pp.787-797, 1997.
[37] A. S. Chandrashekara, T. Ananthapadmanabha and A. D. Kulkarni, "A Neuro-Expert System for Planning and Load Forecasting of Distribution Systems," Electrical Power and Energy Systems Research, Vol.21, pp.309-314, 1999
[38] H. L. Willis and J. E. D. Northcote-Green, "Comparison of Fourteen Distribution Load Forecasting Methods," IEEE Transaction on Power Apparatus and System, Vol.103, pp.1190-1197, 1984.
[39] H. L.Willis, L. A. Finley and M. J. Buri, "Forecasting Electric Demand Of Distribution System Planning in Rural and Sparsely Populated Regions," IEEE Transaction on Power System, Vol.10, pp. 2008- 2013, 1995
[40] Y. Chakhchoukh, P. Panciatici, L. Mili,. L.Willis, "Electric Load Forecasting based on Statistical Robust Method," IEEE Transaction on Power System, Vol. 26, issue 3, pp. 982-991, 2011
[41] T. Haida and S. Muto, "Regression Based Peak Load Forecasting Using a Transformation Technique," *IEEE* Transaction on Power System, Vol.9, pp.1788–1794, 1994