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EVALUATION OF HEAT DEMAND FORECAST FOR SPECIFIC LOCALITIES

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Abstract: *The paper analyzes the results of heat demand forecast for specific localities. This forecast is most important for technical and economic consideration. In this paper we use the forecast model of heat demand based on the Box-Jenkins methodology. The model is based on the assumption that the course of heat demand can be described sufficiently well as a function of the outdoor temperature and the weather independent component (social components). This model is used for prediction of heat demand in different localities. Evaluation of results of prediction model with inclusion of outdoor temperature in specific localities and conclusions are presented.*
Key words: *Prediction, Control, Box-Jenkins, Time series, Power and Heating Plant*

1. INTRODUCTION

In order to improve the control level of district-heating systems, it is necessary for the energy companies to have reliable optimization routines, implemented in their organizations. However, before a plan of heat production, a prediction of the heat demand first needs to be determined.

Due to the large operational costs involved, efficient operation control of the production sources and production units in a district heating system is desirable. Knowledge of heat demand is the base for input data for operation preparation of Centralized Heat Supply System (CHSS). Term “heat demand” is instantaneous required heat output or instantaneous consumed heat output by consumers. Term “heat demand” relates to term “heat consumption”. It express heat energy, which is the customer supplied in a specific time interval (generally day or year). The course of heat demand and heat consumption can be demonstrated by means of heat demand diagrams. The most important one is the Daily Diagram of Heat Demand (DDHD) which demonstrates the course of requisite heat output during the day (See Fig. 1). These diagrams are most important for technical and economic consideration. Therefore forecast of these diagrams course is significant for short-term and long-term planning of heat production. It is possible to judge the question of peak sources and namely the question of optimal distribution loading between cooperative production sources and production units inside these sources according to time course of heat demand. (Balátě, 1982).

2. FORECAST MODEL OF HEAT DEMAND

Most forecasting models and methods for load prediction have already been suggested and implemented with varying degrees of success. They may be classified into two broad categories: classical (or statistical) approaches and artificial intelligence based techniques.

But most applications in the subject consider the prediction of electrical-power loads. Nevertheless was created several works, which solve the prediction of DDHD and its use for control of District Heating System (DHS). A number of these works are based on mass data processing (Hippert et al., 2001). But these methods have a big disadvantage. It consists in out of date of real data. From this point of view is available to use the forecast methods according to statistical method. The basic idea of this approach is to decompose the load into two components, whether dependent and whether independent. The weather dependent component is typically modeled as a polynomial function of temperature and other weather factors. The weather independent component is often described by a Fourier series, ARMA model, Box-Jenkins methodology or explicit time function. Previous works on heat load forecasting (Arvastson, 2001), (Dotzauer, 2002), show that the outdoor temperature, together with the social behaviour of the consumers, has the greatest influence on DDHD (with respect to meteorological influences). Other weather conditions like wind, sunshine etc. have less effect and they are parts of stochastic component.

In this paper we use the forecast model of DDHD based on the previous approach. The model is based on the assumption that the course of DDHD can be described sufficiently well as a function of the outdoor temperature and the weather independent component (social components). Time of the day affects the social components. The time dependence of the load reflects the existence of a daily heat demand pattern, which may vary for different week days and seasons. Forecast of social component is realized by means of Box-Jenkins methodology (Box & Jenkins, 1976).

The course of time series of DDHD contains mostly two periodic components (daily and weekly period). But general model according to Box-Jenkins enables to describe only one periodic component. We can propose two eventual approaches to calculation of forecast to describe both periodic components (Dostál, 1986).

- The method, that uses the model with double filtration
- The method – superposition of models

These methods do not describe sudden fluctuation of meteorological influences. In this case we have to include these influences in calculation of prediction. For inclusion of outdoor temperature influence in calculation of prediction of HSDD was proposed general plan based on derivation an explicit expression for the temperature-dependent part of the heat load (Chramcov, 2005).

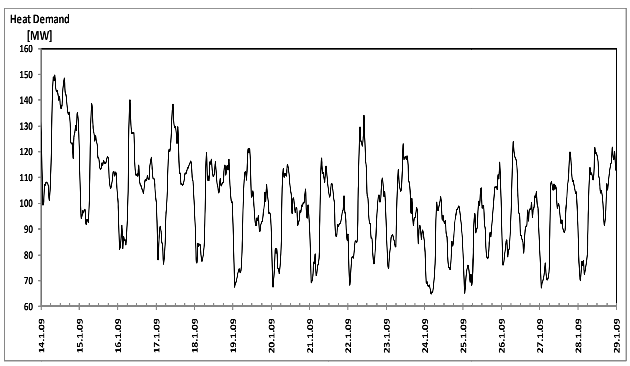

Fig. 1. The course of DDHD for the locality Most-Komořany

3. CALCULATION OF FORECAST FOR SPECIFIC LOCALITIES

Pursuant to the mentioned theory and literature a program was created in Matlab, which enables to choose available mathematical statistical model for calculation of prediction of DDHD course. All testing is based on lot of real data. These data were obtained in specific localities and they are processed for next using in text file form. The program is drawn in user's menu and by help of that it is possible to choose many parameters of forecast calculation.

3.1 Results of heat demand forecast in concrete locatity

It is necessary to stress that the real data are used for all experiments and tests of proposed forecast model. The real data were obtained due to close cooperation of our research workplace with energy plant operations. In our case it is close cooperation with company MST a.s. – Power and Heating plant Olomouc, Power and Heating Plant Otrokovice, a.s. and company United Energy a.s. - Power and Heating plant Most-Komořany.

The models were tested on data from the locality Litoměřice from two following weeks (28.2.2004 - 12.3.2004) and on data from the locality Most-Komořany from four following weeks (1.1.2009 – 28.1.2009). In the locality Litoměřice 24 hours-ahead forecast were made twice a day at 6.00 AM and 6.00 PM and in the locality Most-Komořany 24 hours-ahead forecast were made once a day at 6.00 AM. The model with inclusion of outdoor temperature and without inclusion of outdoor temperature was used. Accuracy of the forecast is analyzed and summarized by means of Mean Absolute Percent Error (MAPE) (see Table 1).

Litoměřice			Most - Komořany		
Date, Time	inclusion of outdoor temperature		Date, Time	inclusion of outdoor temperature	
	No	Yes		No	Yes
28.2.04 6:00	5,22	5,39	1.1.09 6:00	12,33	6,25
28.2.04 18:00	8,61	7,95	2.1.09 6:00	9,10	3,88
29.2.04 6:00	11,03	9,42	3.1.09 6:00	10,43	8,17
29.2.04 18:00	8,51	7,88	4.1.09 6:00	20,02	9,80
1.3.04 6:00	8,85	7,31	5.1.09 6:00	5,83	5,45
1.3.04 18:00	12,19	6,89	6.1.09 6:00	14,44	6,48
2.3.04 6:00	13,71	5,77	7.1.09 6:00	5,35	2,99
2.3.04 18:00	6,49	5,43	8.1.09 6:00	10,61	5,12
3.3.04 6:00	15,27	6,87	9.1.09 6:00	6,34	4,83
3.3.04 18:00	12,90	5,56	10.1.09 6:00	6,24	4,46
4.3.04 6:00	6,61	4,61	11.1.09 6:00	5,82	3,64
4.3.04 18:00	10,87	7,50	12.1.09 6:00	3,70	3,34
5.3.04 6:00	9,49	9,32	13.1.09 6:00	2,56	1,75
5.3.04 18:00	8,62	7,66	14.1.09 6:00	5,41	3,99
6.3.04 6:00	15,42	7,78	15.1.09 6:00	6,48	3,33
6.3.04 18:00	17,97	7,36	16.1.09 6:00	5,65	4,72
7.3.04 6:00	8,29	6,61	17.1.09 6:00	6,07	5,09
7.3.04 18:00	10,66	7,50	18.1.09 6:00	7,54	5,65
8.3.04 6:00	12,70	8,93	19.1.09 6:00	7,92	4,95
8.3.04 18:00	7,06	6,45	20.1.09 6:00	3,83	2,99
9.3.04 6:00	6,25	5,08	21.1.09 6:00	4,33	3,48
9.3.04 18:00	8,45	6,59	22.1.09 6:00	8,74	5,58
10.3.04 6:00	8,71	6,12	23.1.09 6:00	14,34	9,47
10.3.04 18:00	7,34	5,32	24.1.09 6:00	12,19	6,59
11.3.04 6:00	8,04	5,25	25.1.09 6:00	10,39	5,40
11.3.04 18:00	9,37	5,94	26.1.09 6:00	10,44	7,34
12.3.04 6:00	8,13	7,16	27.1.09 6:00	8,12	4,68
12.3.04 18:00	7,32	7,22	28.1.09 6:00	9,04	5,13
Average value	9,79	6,82	Average value	8,33	5,16

Tab. 1.Title of table, left justified, subsequent text indented

From the tests, we conclude that the prediction model with inclusion of outdoor temperature achives very good results. MAPE for the test period in both localities is at any time less than 10 percent. Average value of MAPE in the test period is approximately 7% for the locality Litoměřice or 5% for locality Most-Komořany. Obviously, we also observe that the average value of MAPE is 3% lower for the prediction model with inclusion of outdoor temperature in both localities.

4. CONCLUSION

This paper presents the Box-Jenkins methodology for building up the forecast model of time series of DDHD and the possibility of improvement of this forecast model with help of inclusion of outdoor temperature influence. The proposed forecast method was successfully applied to real data from concrete localities. The effectiveness of proposed forecast model was demonstrated through a comparison of the real heat demand data with short-term (24 hours) forecasted values. In term of the average MAPE in the test period our approach achieved 5% error.

Heat demand forecast plays an important role in power system operation and planning. Accurate heat demand prediction saves costs by improving economic load dispatching, unit commitment, etc. Model described should prove useful for the control in the Centralized Heat Supply System (CHSS), especially for the qualitative-quantitative control method of hot-water piping heat output – the Balátě System (Balátě, 1982). We strongly believe that our approach is a universal one and can be applied not only in the presented localities. Moreover, the method can be used in real time.

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