Long-term forecasting of energy, electricity and active power demand – Bosnia and Herzegovina case study

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***Abstract*— Accurate forecast of electricity consumption is important for every electric power company because it determines the dynamics and characteristics of future construction of power facilities. Speaking in the long term, if the forecasts were too low or high, it could cause a number of adverse events leading electricity companies in the generation deficit or complex financial problems due to excessive investment in generating facilities that are not fully utilized. This paper presents the results of the forecast energy demand, electricity and active power of Bosnia and Herzegovina (B&H) system, using the Model for Analysis of Energy Demand (MAED) methodology. Modelling of base year is done on the basis of available statistical data and trends in individual sectors upon trends in other European countries. Results were compared with forecasts that were prepared by other methods in other time periods.**

Index Terms— **Forecasting; MAED; Energy; Electricity; Active Power**

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I. INTRODUCTION

FOREACASTING of electricity is one of the basic activities during energy sector planning process. Electricity consumption is observed within current and expected/planned development of economy with simultaneous observation of the influence of energy demand on economy development. The precise forecast is important for any organization because it determines the dynamics and characteristics of future construction of power facilities of the system. Precise forecasting requires both statistical data and forecaster awareness and experience in total development politics during forecasting period. Forecasts can be classified on short-term, mid-term and long-term forecasts with respect to forecasting period. Nowadays several methods for energy forecast are developed. References [1]-[7] give a large insight in possibility of application of different methodologies. All these methods econometric, quantitative or other require appropriate statistical data and time series data what was one of the main problems for authors of this paper. With the lack of quality time series, Model for Analysis of Energy Demand (MAED) model that requires detail statistical data for base year while enabling detail analysis and projection of energy demand for each sector in these circumstances represents a quite acceptable approach. By applying the MAED methodology, we performed energy, electricity and maximum power forecast for period 2010-2030 for one part of power system of B&H (cca 25%) in total and for each five electricity distribution areas. Forecasting models are made for each five electricity distribution areas and sum of forecasted energy demand of those was equal to results for complete model. This approach provides not only information about energy forecast for different administrative areas but also other important information that indicate need for systematic needs in other areas. Results are compared with other forecast results gained with other methods during different forecasting periods.

II. MATERIALS AND METHODS

A. MAED Methodology

The need for energy planning has led to development of area end-use models that represent simple mathematical models

with detail structural analysis of demand areas which start from final energy consumption. Final energy consumption comprises heating, electricity for non-heating, transport etc. After final energy forecast, total shares in structure is determined. Structural end-use models can be applied just based on data analysis of one previous year and do not need consistent time series for several years like econometrical models. It enables the inclusion of all relevant determinants on energy consumption, such as growth and structure of gross domestic product - GDP, demographic changes, housing standard, population mobility, climatic conditions, changes in efficiency of energy use, habits and customs and etc. The analysis and forecast are performed for individual consumption sectors. The second level of structural modelling is the types of final energy needs. Forecasting of future energy demand is always performed on the basis of different scenarios. In case that some determinant has no official surveys of development, it should be estimated by expert analysis based on analogic trends from countries that had already reached that level of socio-economic development. At the very beginning, the end-use model estimates useful energy needs so some identified determinants of consumption from year in future are applied on the specific energy consumption of base year and are corrected afterward to an expected amount in future year.

When using this model, it is necessary to take into account the different set of indicators that reflect the current (base) state, and also define those factors on which it is possible to make predictions in the future. Some of the input parameters are: GDP and GDP growth rate, population size and rate of population growth, the number of people per housing unit, size of residential buildings (m2), urbanization, presence of technology for heating (central/indoor), transport models (own car/public transport), presence of air conditioners, energy efficiency devices, etc. Further details about the whole MAED methodology can be found on International Atomic Energy Agency - IAEA web site [8].

B. Input data

The subject of this paper is to forecast the consumption of Elektroprivreda BiH, which “covers” about 25% of the territory of B&H with about 700,000 electricity customers. Elektroprivreda BiH has five distribution branch offices (ED). During the war period 1992-1995, the economy and energy system was almost completely destroyed, the demography changed significantly, statistical data are often either lacking or are unreliable, time series are 'broken', so it limits the usage of many forecasting methodologies. In addition, the complex social, economic, social and political relations in the B&H put the forecasters in a quite complicate and “thankless” position. Electricity consumption in B&H during 1990-2011 is presented in Fig. 1.

C. Modelling of base year and definition of scenarios

Modelling of the base year in MAED model is quite a demanding job. It includes a detailed analysis of available statistical indicators, both at the level of the whole country, and at the level of local regions. Also, high-quality modelling of the base year includes gathering the survey data from gas/heat/electricity distribution companies and also from some government institution. It also requires a comparative analysis of certain indicators of trends in neighboring countries [9], so forecasted values of some parameters might be defined based on them. Defining the different scenarios of development is also quite a complex job, and usually three scenarios are taken according to the current situation and future plans. In this study, we defined three scenarios as follows:

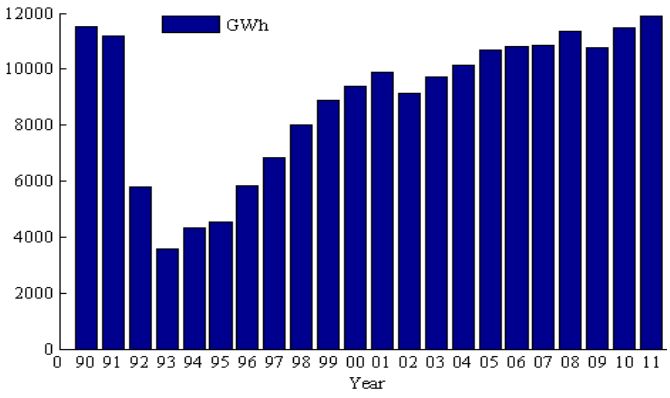


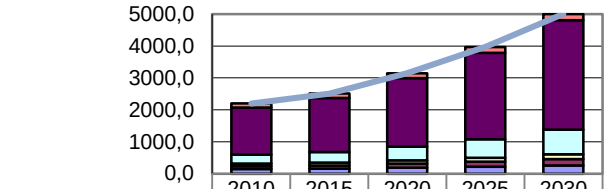
Fig. 1. Electricity consumption in B&H during 1990-2011

Scenario 1 - the reference scenario (S1): This scenario predicts an increase of total GDP of 2.27 times in 2010. to 2030. s. The average annual growth rate of GDP in this scenario is varied during period (4.35%, 2.98% and 4.81% in sequence). According to available information on planned activities in the gas distribution of certain areas, it was assumed that central region keeps the current trend. Gasification of western regions is expected in the period 2010-2015, and the gasification of southern and northern areas are expected in the period until 2020. Energy structure and technology are significantly changing. The structure of final consumption is changing in terms of effective use of natural gas, district heating, electricity and motor fuels, with reduced usage of coal and firewood. Transfer of new technologies will lead to improvements in energy intensity, which will track the value characteristic for the transition countries.

Scenario 2 - optimistic scenario (S2): In this scenario the increase in the total GDP by 2030 is assumed by 3.2 times. This scenario assumes an average annual GDP growth rate of approximately 7.5%, and as such, this scenario can be called "optimistic scenario". In assessing the intensity of gasification, a significant expansion of natural gas distribution and partial substitution of other energy sources is planned. This scenario assumes a significant development of the manufacturing sector given the general characteristics of the area.

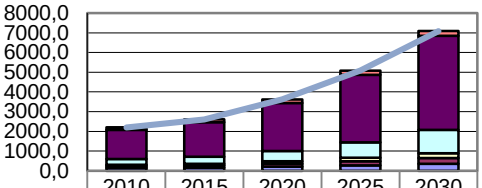
Scenario 3 - low scenario (S3): The value of GDP in this scenario increases 1.75 times by 2030, with an average annual growth rate of 2%. Predicted population in this scenario is also reduced compared to forecasts from the Scenario 1. So, this scenario can be called "low scenario". In assessing the intensity of gasification, the lower intensity of the planned gas

supply is assumed. Other determinants of the scenarios generally remain the same compared to Scenario 1. Fig. 2-4 represents total values on GDP per capita and shares on individual sectors for three scenarios.



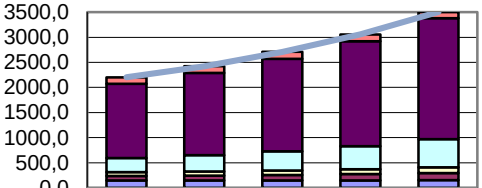
	2010	2015	2020	2025	2030
Energy	129,6	135,7	157,1	177,6	193,8
Service	1475,3	1692,8	2137,3	2708,1	3432,2
Manufacturing	282,1	336,2	439,0	578,3	765,7
Mining	74,1	82,0	100,6	124,0	153,0
Construction	90,0	102,4	128,5	161,9	204,2
Agriculture	151,1	159,1	185,3	216,6	253,5
GDP/cap	2202,1	2508,3	3147,8	3966,6	5002,5

Fig. 2. GDP per cap for individual sectors – Scenario 1



	2010	2015	2020	2025	2030
Energy	130,1	142,9	175,7	210,8	235,3
Service	1476,3	1762,1	2444,7	3430,2	4778,3
Manufacturing	282,1	353,8	520,6	783,4	1180,5
Mining	74,1	85,9	122,6	175,7	246,9
Construction	90,0	106,7	148,1	208,2	290,6
Agriculture	149,5	159,9	209,1	275,6	355,2
GDP/cap	2202,1	2611,2	3620,8	5083,9	7086,7

Fig. 3. GDP per cap for individual sectors – Scenario 2



	2010	2015	2020	2025	2030
Energy	130,1	133,7	135,8	132,4	121,5
Service	1476,3	1638,0	1845,1	2093,0	2411,1
Manufacturing	282,1	326,5	384,9	460,4	564,3
Mining	74,1	78,8	86,0	95,8	109,8
Construction	90,0	99,0	110,7	125,1	143,9
Agriculture	149,5	146,7	146,5	148,2	153,1
GDP/cap	2202,1	2422,6	2709,0	3055,0	3503,7

Fig. 4. GDP per cap for individual sectors – Scenario 3

The expected increase in the GDP value in all three scenarios is the largest in the services sector, while the lowest value growth is expected in the Energy, Mining, Agriculture and Construction sector. Such percentage share of GDP in individual sectors as well as their long-term projections is the result of a detailed analysis of the statistical data of the region

III. RESULTS AND DISCUSSION

This research study was performed on six MAED models developed particularly - five models for five ED branch offices and one complete model for EPBiH area. In Fig. 5 the forecast of final energy consumption and electricity for the entire EPBiH for the period 2010-2030 (three different scenarios) is shown. The main factors affecting the final energy consumption are primarily as follows: the expected growth trend of GDP by sector and gasification intensity of the observed area.

After the forecast of energy demand and electricity, using MAED_el module, calculation of the maximum load value is performed (Fig. 6) and load duration curves up to 2030 are determined for EPBiH and will be displayed here. Since there are no data on actual load profiles of individual consumers, surveys for consumers from different sectors (industry, households, transport and services) were conducted, whereby it is assumed that these factors will not change until 2030 year. It is obvious that for the three scenarios defined at the end of the observed time period, the differences in predicted values of peak power are prominent. This in practical terms confirms the thesis about the importance of more accurate forecasts, because in this case the differences are so great (about 500 MW) between the lower and higher scenarios that it indicates the need for planning of the construction of one or two new generation units.

Further, the sum of forecast by sectors for five ED parts is very close to the values of forecast models for the entire EPBiH, and data and pictures will not be shown in this paper because of the abundance. This indicates the possibility of modelling and forecasting of energy needs of smaller regions of a country, each of which has certain peculiarities. Finally, it is recommended to compare the results of the forecast with results gained with different approaches, but also forecasts that were made by other institutions responsible for the forecasts of future needs. Comparison of results obtained in this study, will be made by forecast results of electricity demand made in the document [10] and in 0 for period 2005 - 2020. Results of electricity forecast made by group of experts from Elektroprivreda BiH in 1998 for period 1998-2010 [11] will be shown as an indicator of forecast accuracy at the time, compared to consumption realized. Comparison of forecast results is shown in Fig. 7. As it is shown in the graphic and table, the forecasts results are higher than that recorded in the period 2005-2010 (Fig. 7 – EIHP Energy Institute Hrvoje Pozar). One of the reasons for this deviation can be found in the global economic crisis that occurred immediately after the preparation of this document, which did not leave B&H without consequences. From Fig. 7 it can be seen that the predictions made in ISO compared to predictions made in this study are rather similar. Less deviation is evident for the low

scenario. But in the context of long-term forecast, if the trends of all realized forecasts (made in different time periods and by different methods) are observed, one can notice that the trends are all quite similar and that in 2030 differences are quite small. This points to a 'well-defined trend' that can be expected in electricity demand in the future. From the comparative analysis made in this chapter, it is possible to recognize the need for periodic renewal of the analysis and forecast, which gives a better insight into the development of their own consumption.

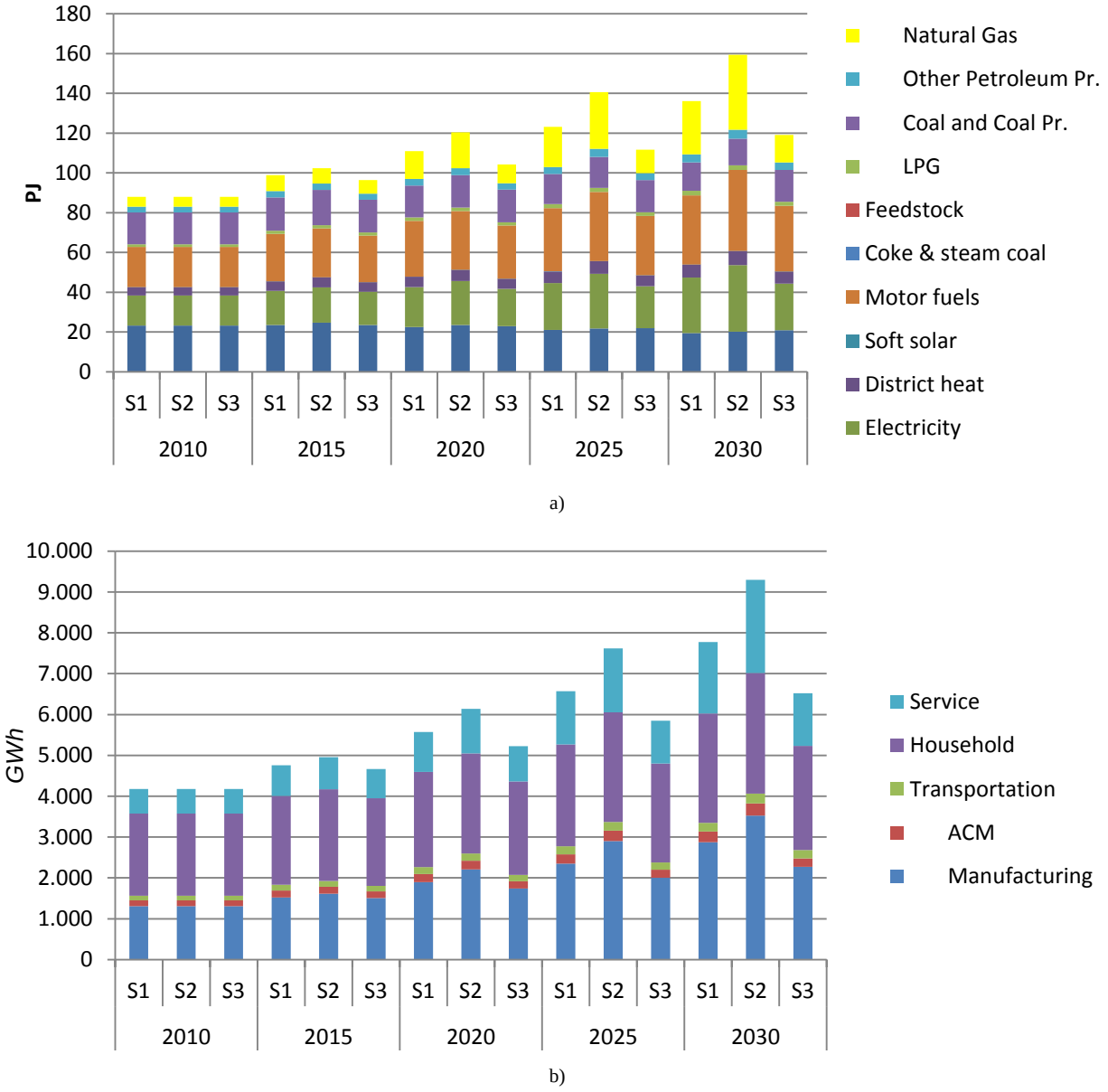


Fig. 5. Results of forecasting of energy sources and electricity in 2010 -2030

Upon forecast results gained in previous studies and real consumption data it is obvious that the forecasted values were higher than actual consumption. One reason for this result is quite slow economic development of the country as a whole even for the lowest assumed scenarios. Additionally, in the period 2005-2010 global economic crises did not leave B&H without consequences thus having high influence on electricity consumption.

A. Distributed generation requirements

This paper presents the results of long-term forecast of energy sources, electricity and active power for the part of B&H territory on which Elektroprivreda BH performs its activities [12]. MAED methodology is used as a forecasting technique. The sum of individual forecast for ED parts in the end was quite close to the results obtained from the model forecast for the whole area, and the results were compared with

predictions by other methods applied performed by other authors. In comparison to other methods, this approach allows sectorial planning and forecasting, and in addition to information about energy needs in the future, other important information about the energy intensity in certain sectors are obtained which may indicate the need for systemic measures in these sectors.

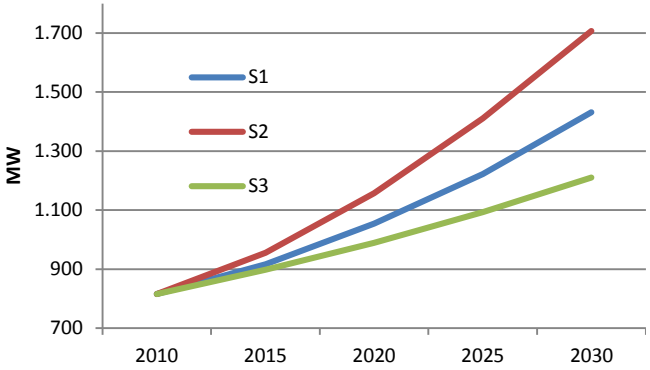


Fig. 6. Forecast of maximum active power for 2010 -2030. - Comparative scenario analysis

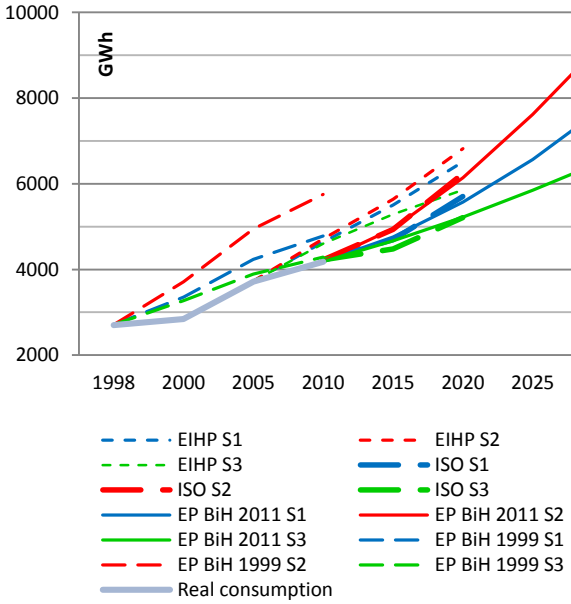


Fig. 7. Comparison of forecast results

The increase in GDP and the intensity of gasification are shown as the main parameters that influence the forecast in this area. In comparison with other approaches, it was observed that all long-term forecasts made in this area at the end of the considered period of time generally have quite similar values. However, MAED methodology in addition to information about the forecasted values of energy needs provides information on consumer trends in individual sectors, which can easily be compared with socio-economic environment in other countries. This approach is appropriate in circumstances where the time series are interrupted or not reliable what limits the usage of many modern methods for forecasting.

IV. CONCLUSION

This paper presents the results of long-term forecast of energy sources, electricity and active power for the part of B&H territory on which Elektroprivreda BH performs its activities [12]. MAED methodology is used as a forecasting technique. The sum of individual forecast for ED parts in the end was quite close to the results obtained from the model forecast for the whole area, and the results were compared with predictions by other methods applied performed by other authors. In comparison to other methods, this approach allows sectorial planning and forecasting, and in addition to information about energy needs in the future, other important information about the energy intensity in certain sectors are obtained which may indicate the need for systemic measures in these sectors. The increase in GDP and the intensity of gasification are shown as the main parameters that influence the forecast in this area. In comparison with other approaches, it was observed that all long-term forecasts made in this area at the end of the considered period of time generally have quite similar values. However, MAED methodology in addition to information about the forecasted values of energy needs provides information on consumer trends in individual sectors, which can easily be compared with socio-economic environment in other countries. This approach is appropriate in circumstances where the time series are interrupted or not reliable what limits the usage of many modern methods for forecasting.

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