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A MODELLING APPROACH FOR FORECASTING NET EXPORTS OF ELECTRICITY FROM BULGARIA

The report presents a modelling approach for forecasting Bulgarian net exports of electricity based on an empirical analysis of the factors affecting trade with this specific commodity. A brief overview of the models and approaches for forecasting the production and export of electricity is made and their adequacy is assessed regarding the situation of the electricity market in Bulgaria and the region. On this basis, a modelling approach is foreseen to predict the net exports of electricity by 2035, taking into account the current situation and prospects for the development of the electricity sector in Bulgaria and Europe.
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Introduction

Traditionally, electricity is considered and explored to meet domestic energy needs of individual countries, taking into account aspects related to national security, but much less economically as a commodity for trade. This is partly due to the specific nature of electricity whose transmission and storage differ significantly from internationally traded goods and services. Despite large fluctuations in Bulgarian electricity exports to the EU Member States between 1990 and 2015, Bulgaria retained its position as a net exporter of electricity. This indicates that the local electricity sector is increasingly focusing on the opportunities for foreign trade, including on the basis of the transit of electricity. Considering that Bulgarian trade balance is permanently negative which puts pressure on the current account balance, at sectoral level an intensified foreign trade in electricity would have a positive effect on the stability of the financial flows of Bulgaria, and at domestic level it would stimulate production and employment in the sector.

Such a trend provokes a research interest in tracking the factors behind it so that its sustainability could be predicted taking into consideration the current state of national and regional electricity market. Devoted to this research task, the report provides a brief overview of basic approaches and models for analyzing electricity consumption and

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exports. Moreover, we empirically analyze the factors that influence these two electricity market variables in the period 1995-2015 in order to identify the main variables on which net exports of electricity depend in a regional aspect. In conclusion, we comment on the results of the econometric assessment with a view to evincing the trend of the net exports of electricity from Bulgaria until 2035. Our motivation to forecast net exports not only exports of electricity stems from the serious flows of transited electricity through the country, thus the reporting of exports alone would be incorrect.

1. Overview of models and approaches for analyzing electricity consumption and export

The basic assumption we made when reviewing the research papers below is that electricity consumption can be met by both local production and imports and the factors that affect it are generally factors that also determine the dynamics of electricity exports.

Hakkio and Nie (2014) show that net exports of electricity depend on its domestic production and relative prices, noting that electricity consumption in importing countries is much less dependent on exchange rate fluctuations which are a major factor when the export of non-energy goods is concerned. Employing a vector autoregressive model in 2002-2006 for the USA they find that an increase of local energy production by 1 p.p. led to a decrease in imports of 1.7 p.p. and an increase in exports by 1 p.p. The authors' model also proves that regulatory specificities have a significant effect on exports of electricity. Another model developed for Turkey (2009) is based on energy dependence, i.e. the extent to which one economy relies on imports of electricity to meet its needs. The US Energy Information Administration directly derives net exports of energy resources in the USA from domestic production when it forecasts US energy market developments by 2050.

However, to a much greater extent in electricity models and approaches researchers focus on domestic factors that affect electricity consumption which we consider as directly related to its import from other countries, respectively its exports from others. When employing the Integrated Energy Planning Model (IEPM) to predict energy production and demand Suganthi and Samuel (2011) use economic growth and gross value added structure by economic sectors, share of industrial production in total production, population growth, urbanization and number of households. Narayan and Smyth (2005) find a direct relation among electricity consumption, employment and real income per capita in a model for Australia while for Turkey Sozen, Arcaklioglu and Ozkaymak (2005) assess domestic electricity needs on the basis of so-called technological model that includes population, installed capacity and period of technical operation of electricity network as well as net exports of electricity. In a model for Malaysia Chandran, Sharma and Madhavan (2010) find that electricity consumption steadily depends on real GDP and electricity prices especially over a long term, making these variables particularly suitable for long-term forecasts of electricity exports. In addition to the already mentioned variables in a model for China based on demand and supply of electricity Steenhof and Fulton (2007) include electrical energy performance indicators and special variables for market deregulation and depreciation rate of electricity technology.

Besides fundamental factors that affect electricity consumption, according to the gravity model of trade, distance and physical possibilities for its transfer matter when exports of electricity are considered. This is also emphasized in other studies in the field of foreign trade as Galabova and Nestorov (2018) show. The impact of electricity transmission coupled with economic growth, investment costs for maintenance of electricity production capacities and relative electricity prices are variables included in a model for electricity demand in Greece (Skiadas, Papayannakis&Mourelatos, 1993). In research under review, we find that special attention is paid not only to seasonality, climate conditions and cyclicality (Al-Shobaki&Mohsen, 2008) when forecasting electricity consumption but also to changes in legislation and regulatory regime for exports.

2. Modelling the net exports of electricity from Bulgaria

Despite the author's approach, the review of factors influencing electricity consumption shows a repeatability of indicators that affect electricity demand is visible. Having this in mind and taking into account the specificities of the electricity market in Bulgaria where large amounts of electricity are transited through the country, as a first step of our modelling approach, we focus on highlighting the relation among consumption of electricity and its production, exports and imports of electricity and population growth[2]. Therefore, we calculate correlation coefficients that only serve us to gain an overview of the validity of relations between demand for electricity and possibilities for meeting it by exports. Based on the importance of logistic transmission of electricity and building on the gravity model of trade, we identify 5 countries (Greece, Macedonia, Romania, Serbia and Turkey) with which the electricity transmission from Bulgaria is possible. We test the correlation coefficients in the period between 1995 and 2015 due to the availability of comparable data on the surveyed indicators and the possibility of covering different phases of the business cycle in Bulgaria.

Table 1

Correlation coefficients in 1995-2015

Countries	C-X	C-M	C-N	C-Y	Prod-X	Prod-M
Bulgaria	0.19	0.57	0.12	0.59	0.87	0.42
Greece	0.59	0.35	0.53	0.83	0.60	0.51
Macedonia	-	0.45	-0.26	0.87	-0.54	-0.47
Romania	0.67	0.67	0.10	0.85	0.79	0.47
Serbia	-0.26	0.76	0.08	-0.06	0.63	0.15
Turkey	0.85	0.37	0.63	0.98	0.85	0.56

where C stands for consumption of electricity, X is the electricity exports, M is the imports, and Prod is its production. All indicators are based on Eurostat data in GWh. N is the population and Y is GDP at previous year prices according to Eurostat database.

[2] Although we focus on net exports of electricity by Bulgaria, the calculation of the correlation coefficients is based on data on exports and imports of regional countries, so that we can trace the extent to which their domestic consumption and production depend on both variables. Thus, from the point of view of Bulgaria, we can cover the importance of export of electricity to the countries in the region.

Using the estimated correlation coefficients, we can draw some preliminary conclusions that help us in selecting variables for the econometric estimation of the factors affecting net electricity exports of Bulgaria. We see that an increase in electricity production in Bulgaria means an increased export potential, which is largely valid for the other Balkan countries, except for Macedonia. Domestic electricity consumption in Bulgaria is very poorly correlated with its exports, indicating that the export orientation of the electricity sector would not affect national energy security. In most Balkan countries electricity consumption is also not strongly correlated with its imports, probably due to the substantial impact of transit imports, as in the case of Bulgaria. Meanwhile, we find a positive correlation between economic growth and electricity consumption in the countries concerned, which shows that their favorable economic development would increase Bulgarian export opportunities of electricity. However, there is also no clear correlation between electricity consumption and population growth in a regional aspect, as trends in some countries such as Macedonia and Serbia are even contradictory.

Although the correlation analysis cannot account for the direct impact of regulatory specificities on the export of electricity, we assume that with an export tariff for export of electricity from Bulgaria, regulatory factors also affect the country's ability to satisfy external demand for electricity.

Thus, based on the theoretical review and conclusions drawn from correlation analysis, we specify the following regression equation:

$$NX\_BG_t = \beta_0 + \beta_1 Y\_BG_t + \beta_2 Y\_Region_t + \beta_3 C\_Region_t + \beta_4 EC\_growth\_Region_t + \beta_5 Reg\_BG + e_t \quad (1)$$

where:

NX_BG is the net export of electricity from Bulgaria;

Y_BG is the production of electricity in Bulgaria;

Y_Region is the total electricity production in the five countries we consider to be called a region;

C_Region is the total electricity consumption in the region;

EC_growth_Region is the average economic growth of the five countries in the region;

Reg_BG is a dummy variable that reflects export regulations in the country.

The regression equation is estimated with annual Eurostat data in 1991-2015 for Bulgaria, Greece, Romania, Serbia, Macedonia and Turkey using the R Studio. At the same time, we test the equation's specification with the Ramsey's Reset Test, which helps us to judge whether the functional form of the equation is correct. At the probability value (p-value) 0.2934 we do not reject the null hypothesis that all coefficients of the estimated equation are 0, from which follows that the linear equation specification is correct. The type of estimated regression equation is as follows:

$$NX\_BG_t = \underset{(0.00267)}{-3.12} + \underset{(0.00864)}{5.76Y\_BG_t} + \underset{(0.014385)}{1.03Y\_Region_r} + \underset{(0.04562)}{5.94C\_Region_r} + \underset{(0.02146)}{1.20EC\_growth\_Region_t} + \underset{(0.001262)}{-4.31Reg\_BG} + e_t$$

The results show that the estimated values of the individual variables are with their expected theoretical signs and are statistically significant with a high determination coefficient (Multiple R-squared: 0.8328 and Adjusted R-squared: 0.8151). The positive correlation between regional production and net exports of electricity from Bulgaria reiterates the importance of the transit of electricity in the region. The effect of regulations on the exports of electricity from the country is also substantial, similar to the local level of production and consumption in the region. The resulting econometric estimation is based on the time series stationarity check using the Dickey-Fuller test which helps us test the null hypothesis of a unit root when using first differences time series. The Variance Inflation Factor test for multicollinearity shows that the values obtained for all variables are far below 10, and the Durbin-Watson autocorrelation test has a value of 1.7039 showing that autocorrelation between the residuals is not greater than 0. The Breusch-Pagan test for heteroskedasticity has a probability value of 0.05077, which also allows us to accept the null hypothesis of homoskedasticity. Hence, the regression assessment we make allows us move on to a forecast of net exports of electricity from Bulgaria.

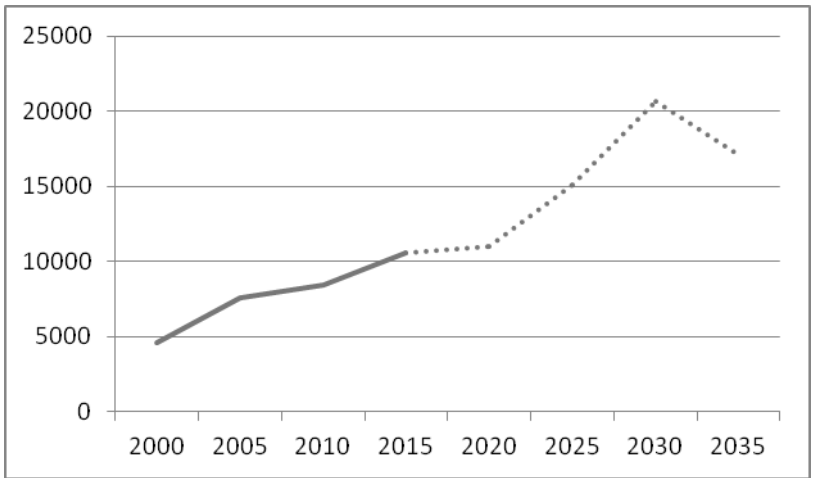
3. Data availability and forecasts for Bulgaria's net electricity exports by 2035

In order to forecast net electricity exports, we use forecasts for production in Bulgaria, Romania and Greece from the European Commission's Reference Scenario for 2016, according to which a gradual increase in production is expected in all three countries. For Turkey, Serbia and Macedonia we use forecasts for production in the moderate scenario from the BAS Report (2018). Estimates of electricity consumption in Greece and Romania are taken from the EC Reference Scenario for 2016. The estimated final electricity consumption in Macedonia, Serbia and Turkey is calculated on the basis of the IMF forecasts for economic growth[3]. We rely on our estimations that in 1995-2015 1 p.p. increase in economic growth is associated with a 1.2 p.p. increase in electricity consumption in Turkey, 0.8 p.p. in Serbia and 0.7 p.p. in Macedonia. Thus, following optimistic IMF forecasts for accelerating economic growth in the countries under consideration (an average of 2.5% for the region in the years up to 2035), the final electricity consumption inevitably increases, and so we expect growing export opportunities for Bulgaria.

Therefore, the results of the model proposed show a decrease of net exports of electricity from Bulgaria in 2015-2020 following a steady growth trend until 2030, with 20.7 TWh net exports in 2035 at 10.6 TWh in 2015.

[3] When we have forecasted electricity consumption in non-EU countries, different specifications of the factors on which it depends have being tested but dependence on economic growth has been the most reliable and statistically sustainable.

Figure 1
Historical data and estimated net exports of electricity from Bulgaria in 2020-2035 (GWh)



Source: Eurostat and own calculations.

The reasons behind the decrease of Bulgarian net exports of electricity by 2020 are mainly due to the contraction of Bulgarian production projected by the EC. This is a consequence of the dropping of renewable energy sources, the expiration of their technical period for use as well as the European-wide measures for limiting the share of coal in the electricity production mix. Meanwhile, the projected growth of production in Greece by the EC in this period is high. However, after 2020 the EC predicts a contraction of Greek production with an increase in the Bulgarian one, which creates opportunities for more exports of electricity. Data on electricity production and consumption in Turkey show that in 2001-2015 the growth rates of the two indicators are almost identical. So a stronger factor regarding Bulgarian net exports up to 2030 is the production and consumption of electricity in Greece rather than the one in Turkey.

At the same time, the expectations for building a large-scale electricity production after 2030 in Turkey have an immediate effect on the projected net exports from Bulgaria, which decline by 3.6 TWh in 2035. As a big economy and market Turkey's developments in energy sector has a very strong effect on Bulgarian net exports of electricity. Its sensitivity to Turkish production and consumption of electricity is very high, which in turn creates serious export opportunities for Bulgaria if Turkey will not carry out the planned energy projects[4]. The share in Bulgarian net electricity exports of other countries concerned – Romania, Macedonia and Serbia – is very low, which determines Greece and Turkey as the main market for export of electricity from Bulgaria while preserving the existing commercial and geographic orientation, which is a basic assumption for testing the model.

[4] According to the Turkey's Energy Profile and Strategy construction of two nuclear power plants in Akkuyu and Sinop are on the agenda.

Conclusions

The testing of the proposed approach for forecasting net exports of electricity from Bulgaria shows that the results obtained are adequate. At the same time, a very important factor for the realization of the forecasts is the technical possibility for electricity transmission from Bulgaria to the region. Such a possibility is a basic precondition for local exports of electricity to simultaneously increase if Bulgarian electricity production goes up, if we overcome the dependence of electricity exports on Greece and Turkey electricity consumption and if energy markets liberalization in Europe deepens.

The ENTSO expects that the maximum electricity transmission capacity to Greece and Turkey will be extended by 32%, reaching 3100 MW by 2024 and that in the longer term a new 400kW double power line with Serbia will be built. This has the potential to increase the transmission capacity up to around 2000 MW. Assuming a 100% load and no electricity transit flows, the expectations for building electricity transmission capacity will make it possible for Bulgarian exports of electricity to exceed to 27 TWh per year. Thus, the forecasts made employing the proposed modelling approach in this paper seem fully realistic if the energy market liberalization continues and the electricity market in the region evolves favourably.

References

Bulgarian Academy of Sciences. (2018). Elaboration of a National Energy Strategy (focusing on electricity). Interim Report 1 (final).

Al-Shobaki, S., Mohsen M. (2008). Modelling and Forecasting of Electrical Power Demands for Capacity Planning. – Energy Conversion and Management, 49(11), p. 3367-375.

Chandran, V. G. R., Sharma, S., Madhavan, K. (2010). Electricity Consumption-growth Nexus: the Case of Malaysia. – Energy Policy, 38(1), p. 606-612.

European Commission. (2016). EU Reference Scenario (Energy, Transport and GHG Emissions, Trends to 2050).

Galabova, B., Nestorov, N. (2018). State and Trends of Bulgaria's Foreign Trade with Ores and Concentrate. – Economic Studies, N 1.

Hakkio, C., Nie, J. (2014). Implications of Recent U.S. Energy Trends for Trade Forecasts. – Economic Review, Kanzas City Reserve Bank, 2014/Q4.

Narayan, P. K., Smyth, R. (2005). Electricity Consumption, Employment and Real Income in Australia Evidence from Multivariate Granger Causality Tests. – Energy Policy, 33(9), p. 1109-1116.

Nello, S. (2009), The European Union: Economics, Policies and History, Maidenhead: McGraw Hill Education

Skiadas, C. H., Papayannakis, L. L., Mourelatos, A. G. (1993). An Attempt to Improve the Forecasting Ability of Growth Functions: the Greek Electric System. – Technological Forecasting and Social Change, 44(4), p. 391-404.

Sozen, A., Arcaklioglu, E., Ozkaymak, M. (2005). Turkey's Net Energy Consumption. – Applied Energy, 81(2), p. 209-221.

Steenhof, P., Fulton, W. (2007). Factors affecting Electricity Generation in China: Current Situation and Prospects. – Technological Forecasting and Social Change, 74(5), p. 663-681.

Suganthi, L., Samuel, A. (2011). Energy Models for Demand Forecasting – A review. – Renewable and Sustainable Energy Reviews.

US Energy Information Administration (2017), Annual Energy Outlook