LITHUANIAN LONG-TERM ELECTRICITY MARKET PRICE PREDICTIONS BASED ON REGRESSION ANALYSIS AND NATURAL GAS FUTURES

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Overview

Increasing electrification of transport, industry, and residential homes makes electricity a strategic commodity. Economic growth and standard of living are directly related to the accessibility of electricity therefore governments should have the best interest to ensure energy supply. In 2022 many European countries realized that their energy supply is highly dependent on a few resources such as natural gasses and oil. Potential commodities shortages and uncertainty in supply chains caused significant electricity price increases. Lithuania was one of the European countries with the highest electricity price increase. The energy crisis showed that Lithuania did not have clear and quantified visibility against potential risks. This research explores different variables that are influencing electricity market prices in Lithuania intending to create a regression model that could be used to make a long-term electricity price forecast.

Methods

Research's method is divided into four steps: independent variables selection, regression analysis, regression model accuracy assessment, and future forecast. Independent variables were selected based on the Lithuanian energy system structure in a way that it would represent electricity generation sources in Lithuania but at the same time be independent of each other. Five selected independent variables were natural gas price, Brent oil price, average wind speed, solar irradiation, and electricity load. Time series data were collected daily for the period from January 2017 to December 2022 representing 2191 data points in each time series. In the second step, independent variables are used together with the electricity market price to build a series of linear regressions (1).

$$y_j = \beta_o + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_j x_i + \varepsilon_i \tag{1}$$

The goal of linear regressions is to identify an independent variable or a combination of them that represents the most significant change in electricity price. Significance is identified by doing a series of linear regressions and comparing R^2 statistics. In the third step, the regression equation with significant variables accuracy is assessed based on past period estimations and comparison with actual values. Accuracy is estimated using mean absolute percentage error (2).

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{A_t - F_t}{A_t}\right| \tag{2}$$

MAPE value has to be below 50% to have meaningful estimation accuracy. In the final step, independent variables' future estimations are used in the regression equation to create a prediction for electricity market price.

Results

Table 1 presents R^2 values from a series of linear regressions between electricity market prices and selected independent variables.

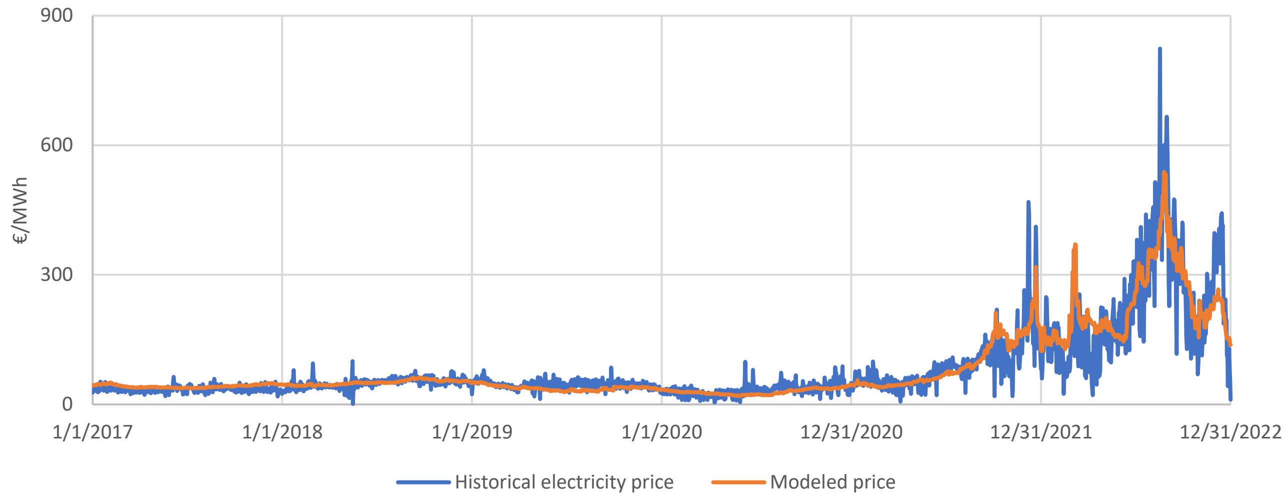
Table 1. Linear regressions between electricity market price and independent variables R^2 values.

Independent variable	**R²**
Electricity load	0.04
Brent oil price	0.38
Natural gas price	0.83
Wind speed	0.05
Solar irradiation	0.0002
All 5 idependant variables	0.86

The highest R^2 value with a single variable was received using natural gas price. Other variables had relatively lower R^2 statistics. All 5 independent variables in the regression equation increased the R^2 value by 3.6% compared to using the natural gas price variable alone. Drawbacks, such as overfitting, do not justify using five variables instead of one for an insignificantly higher electricity price time series variance explanation. For the previously described reason, chosen regression equation includes only natural gas price as an independent variable (3).

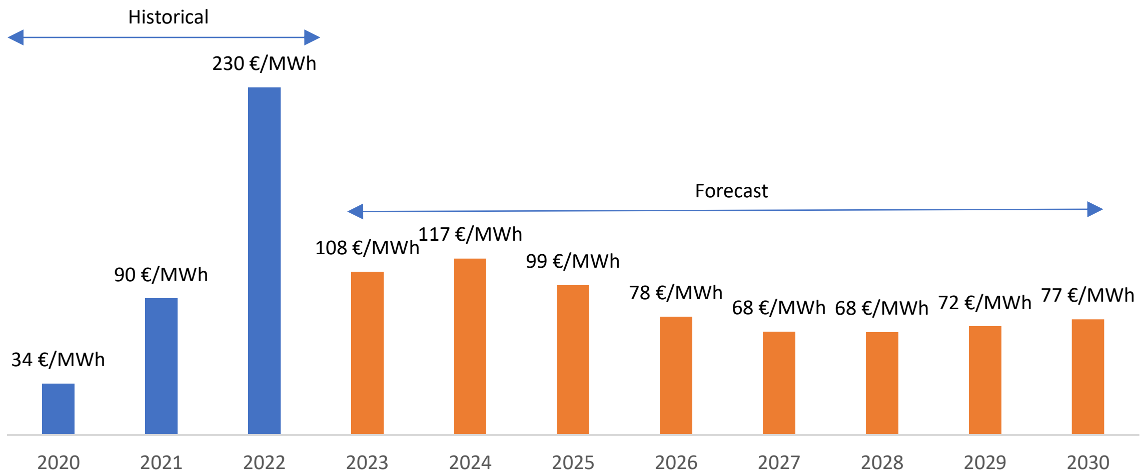
$$Electricity\ market\ price = 13.145 - 1.688\ natugal\ gas\ price \tag{3}$$

Graph 1 shows an electricity prices comparison between historical data and estimated values using the regression equation.



Graph 1. Historical electricity prices and regression equation modeled prices comparison.

Modeled electricity prices visually follow the dynamics of historical values, especially during 2021-2022 when natural gas price was the most volatile. The calculated *MAPE* value between historical and modeled data was 31.41%. Error value indicates that forecasting accuracy is reasonable as it is below the 50% threshold. Graph 2 shows the Lithuanian 2023-2030 electricity price predictions that were calculated using identified regression equation and TTF natural gas futures.



Graph 2. Annual electricity price predictions based on regression analysis and TTF natural gas futures.

Predictions indicate a more than 50% electricity price drop from 230 €/MWh in 2022 to 108 €/MWh in 2023. From 2023 to 2030 electricity prices are forecasted to vary between 72 €/MWh and 117 €/MWh while the average period price being 86 €/MWh.

Conclusions

Regression analysis identified natural gas price being the most important variable in defining Lithuanian electricity market price. Natural gas price as a single variable correspondent to 83% of electricity price variance explanation. Other explored independent variables did not have significant explanatory value. Due to the natural gas price's significant importance, it was selected as a single variable for the regression equation. The mean absolute percentage error between historical electricity price data and modeled data was 31% which represented reasonable forecasting accuracy. The 2023-2030 annual electricity price forecast was built using identified regression equation and TTF natural gas futures. The forecast showed a more than 50% electricity price drop in 2023 and a 72-117 €/MWh price range in 2023-2030.