

Lithuanian Long-term Electricity Market Price Predictions Based on Regression Analysis and Natural Gas Futures

18th IAEE European Conference

Ph.D. candidate Mindaugas Česnavičius

Chief Research Assoc. Inga Konstantinavičiūtė

Laboratory of Energy Systems Research



Introduction

Is there a way to understand factors influencing electricity price in Lithuania and predict it with certain useful accuracy?

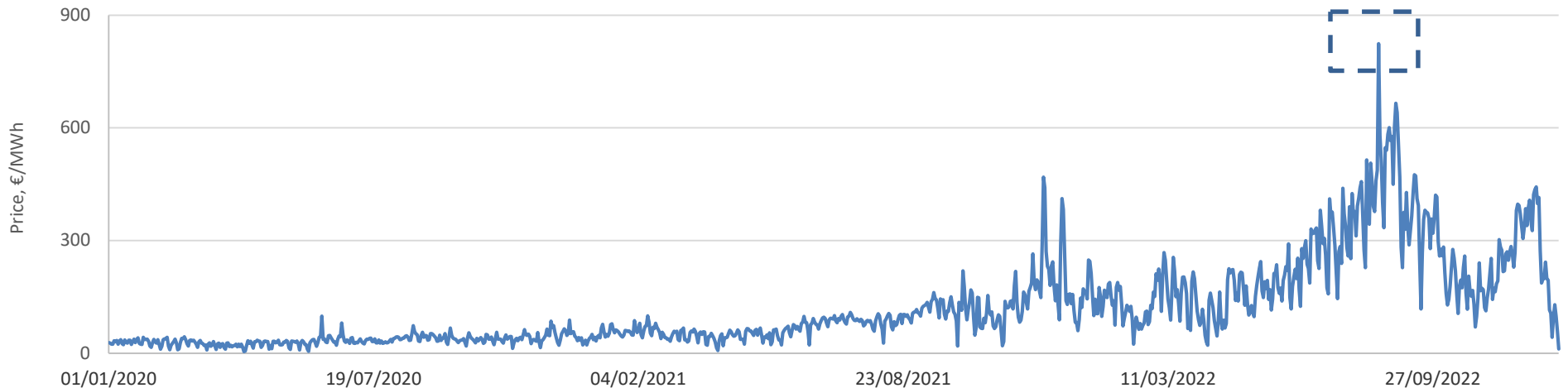
Bloomberg headline about electricity prices in Lithuania

Baltic Companies to Curb Power Use as Price Hits 4,000 Euros

- Lithuania's Norfa, Estonia's Hansa Candle to cut consumption
- Baltic prices outstripping those in Europe's biggest markets

By [Milda Seputyte](#), and [Ott Tammik](#)
August 17, 2022 at 5:30 AM EDT
Updated on August 17, 2022 at 9:40 AM EDT

Daily electricity market prices in Lithuania, 2020-2022





Introduction

Scientific articles researching electricity price in Lithuania are scarce and topic is not frequently re-researched

Scientific articles covering electricity price forecasting in Lithuania

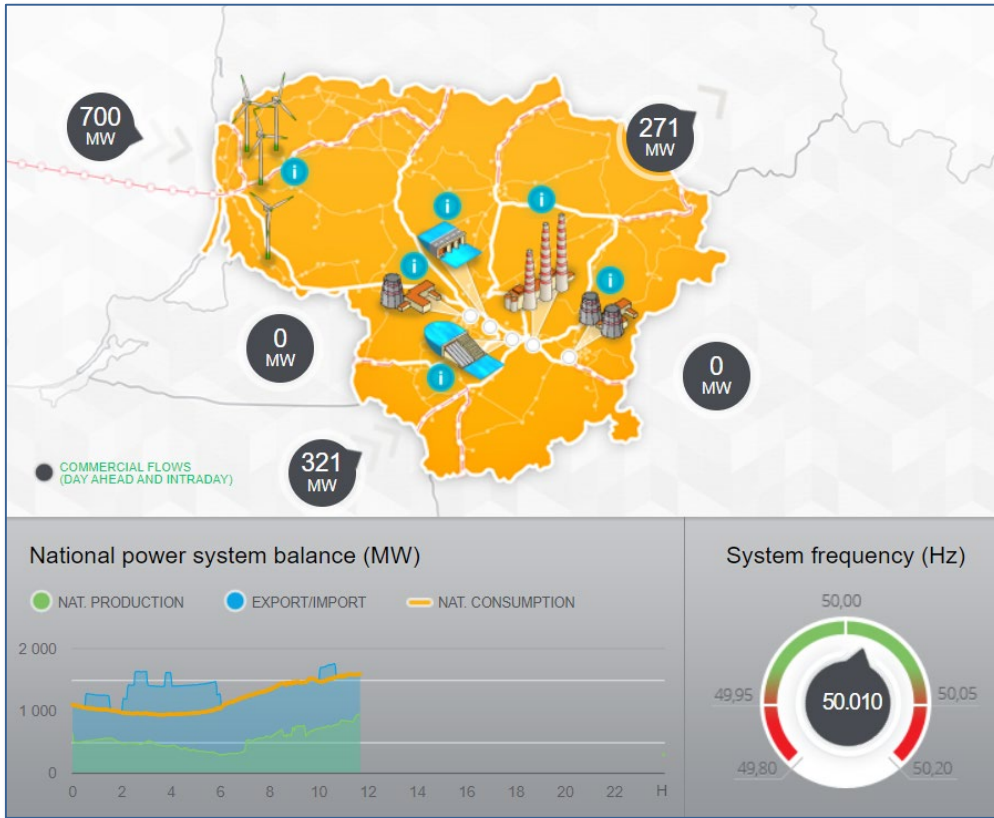
Title	Year	Influencing factors
Electricity Price Forecasting in Lithuania (Kvietkauskaitė)	2021	Calendar days, coal price, hydropower in Sweden, actual load in Lithuania, natural gas price, temperature, wind power in Lithuania
Lithuanian electricity market price forecasting model based on univariate time series analysis (Česnavičius)	2020	Historical electricity price
Electricity Price Forecasting for Nord Pool Data Using Recurrent Neural Networks (Beigaitė & Krilavičius)	2018	Historical electricity price
Electricity Price Forecasting Using Monte Carlo Simulation: the Case of Lithuania (Nguyen Tat)	2018	Electricity consumption, electricity generation, electricity import, electricity export
Electricity price forecasting for Nord Pool data (Beigaitė & Krilavičius)	2017	Historical electricity price
Future of Lithuanian energy system: Electricity import or local generation? (Norvaiša & Galinis)	2016	Energy system parameters, commodity prices, investment costs
Does Electricity from Renewable Energy Sources Reduce Electricity Market Price in Lithuania? (Bobinaitė & Konstantinavičiūtė)	2014	Electricity consumption, trade with Latvia, trade with Belarus, trade with Russia, wind generation
Theoretical Model For Electricity Market Price Forecasting (Bobinaitė, Konstantinavičiūtė & Lekavičius)	2012	Macroeconomic indicators, electricity demand, electricity generation, weather conditions, commodity prices, CO ₂ prices, wind speed, currency exchange rates, changes in electricity import/export,



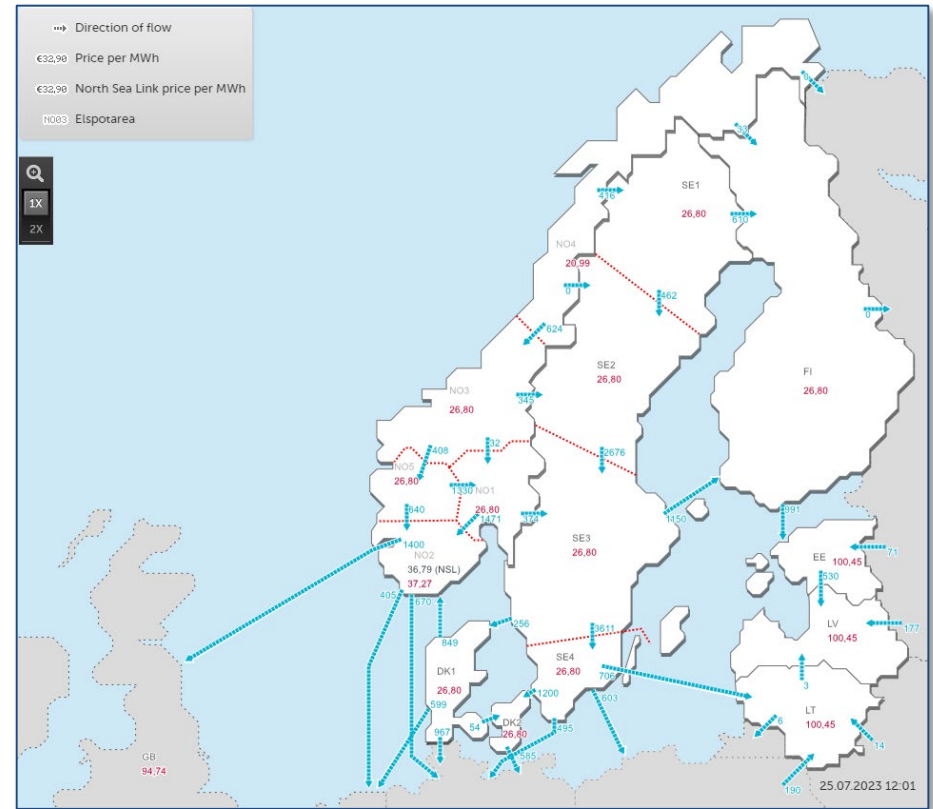
Introduction

Electricity price in Lithuania is highly dependent on energy import from neighboring countries

Lithuanian electricity system data, 25 July 2023



NordPool electricity market data, 25 July 2023





Dataset

2017-2022 daily Lithuanian electricity system data is used for analysis, where needed hourly data is transformed into daily or missing values are interpolated

NORD POOL

Electricity market price



Litgrid

Electricity load, import/export



visualcrossing

Weather data

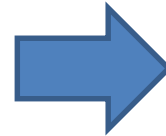


Bloomberg

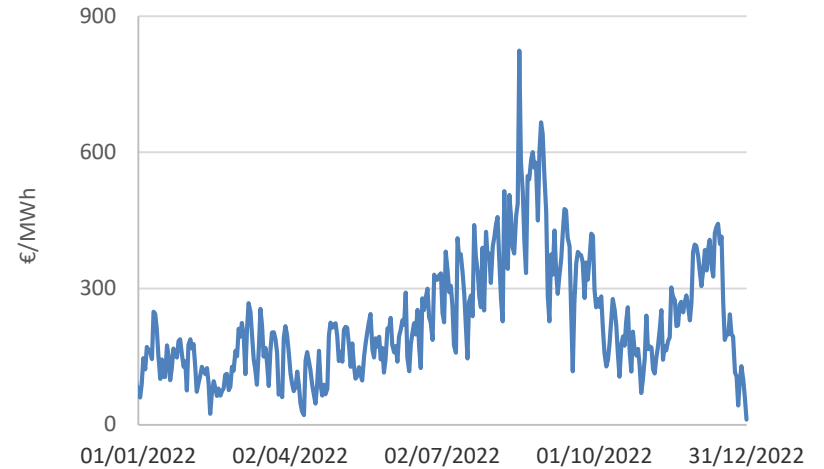
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Commodities prices

Day	Electricity price
1/1/2022	81.4
1/2/2022	59.9
1/3/2022	89.3
1/4/2022	146.8
1/5/2022	122.1
1/6/2022	171.4
1/7/2022	165.5
1/8/2022	161.2
1/9/2022	144.5
1/10/2022	248.5
1/11/2022	244.9
1/12/2022	212.3
1/13/2022	153.2
1/14/2022	100.5
1/15/2022	143.6
1/16/2022	106.0
1/17/2022	105.0
1/18/2022	174.8
1/19/2022	151.9
1/20/2022	98.2
1/21/2022	124.4
1/22/2022	167.7
1/23/2022	153.5
1/24/2022	148.2



Electricity price time series extract



2191 values in each time series

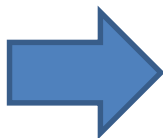
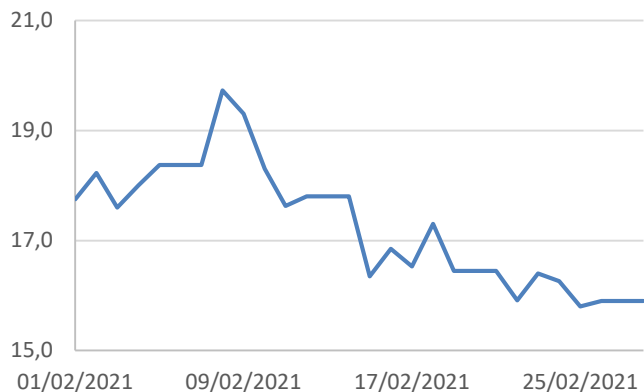


Methodology

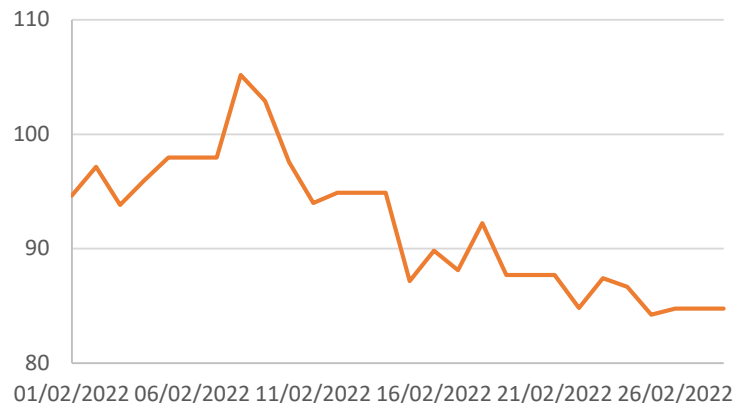
Monthly natural gas future values were transformed into daily using last years respective month price movement dynamics

Year	Symbol	Contract Name	Last	52W High	52W High Date	52W Low	52W Low Date
2022	TGG22	Dutch TTF Gas February 2022 Futures	92.062s	187.275	12/21/21	17.914	02/22/21
2022	TGH22	Dutch TTF Gas March 2022 Futures	94.422s	173.980	12/21/21	17.601	02/26/21
2022	TGJ22	Dutch TTF Gas April 2022 Futures	118.970s	345.000	03/07/22	17.412	04/09/21
2022	TGK22	Dutch TTF Gas May 2022 Futures	100.142s	326.285	03/07/22	17.862	04/29/21
2022	TGM22	Dutch TTF Gas June 2022 Futures	87.987s	317.000	03/07/22	17.823	06/03/21
2022	TGN22	Dutch TTF Gas July 2022 Futures	139.588s	277.805	03/07/22	21.184	07/20/21
2022	TGQ22	Dutch TTF Gas August 2022 Futures	198.930s	271.810	03/07/22	23.259	07/30/21
2022	TGU22	Dutch TTF Gas September 2022 Futures	252.937s	342.005	08/26/22	27.446	09/01/21
2022	TGV22	Dutch TTF Gas October 2022 Futures	187.665s	348.785	08/26/22	36.000	10/07/21
2022	TGX22	Dutch TTF Gas November 2022 Futures	112.244s	352.085	08/26/22	38.427	11/01/21
2022	TGZ22	Dutch TTF Gas December 2022 Futures	132.286s	352.000	08/26/22	44.212	11/30/21
2022	TGF23	Dutch TTF Gas January 2023 Futures	83.830s	347.690	08/26/22	62.320	01/19/22

2021 February actual electricity prices



2022 simulated price dynamics based on futures





Methodology

Influencing factors are selected using correlation and regression, forecasting accuracy is estimated using MAPE

Influencing factors check

Possible relation between two variables is identified using **Pearson's correlation coefficient** formula:

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

Variables relation is confirmed using **linear regression** coefficients significance levels:

$$y_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_j x_j + \varepsilon_i$$

Forecasting accuracy

Mean Absolute Percentage Error (MAPE) is the sum of the individual absolute errors divided by number of fitted points:

$$MAPE = \frac{100}{n} \sum_{t=1}^n \left| \frac{A_t - F_t}{A_t} \right|$$

A_t – actual value

F_t – forecast value

n – number of forecast values



Results

Out of all examined variables natural gas futures price have the biggest influence on electricity market price

Variables correlation and regression analysis results

Variable	Correlation coefficient	p-value	R ²
Electricity load	0.202	1.59E-21	0.040
Electricity import	0.032	0.133	0.001
Natural gas futures price	0.910	0.000	0.828
Brent oil price	0.620	1.5E-232	0.383
Wind speed	-0.227	6.21E-27	0.051
Solar irradiation	0.014	0.500	0.000
All 6 variables	-	All <0	0.857

Regression equation:

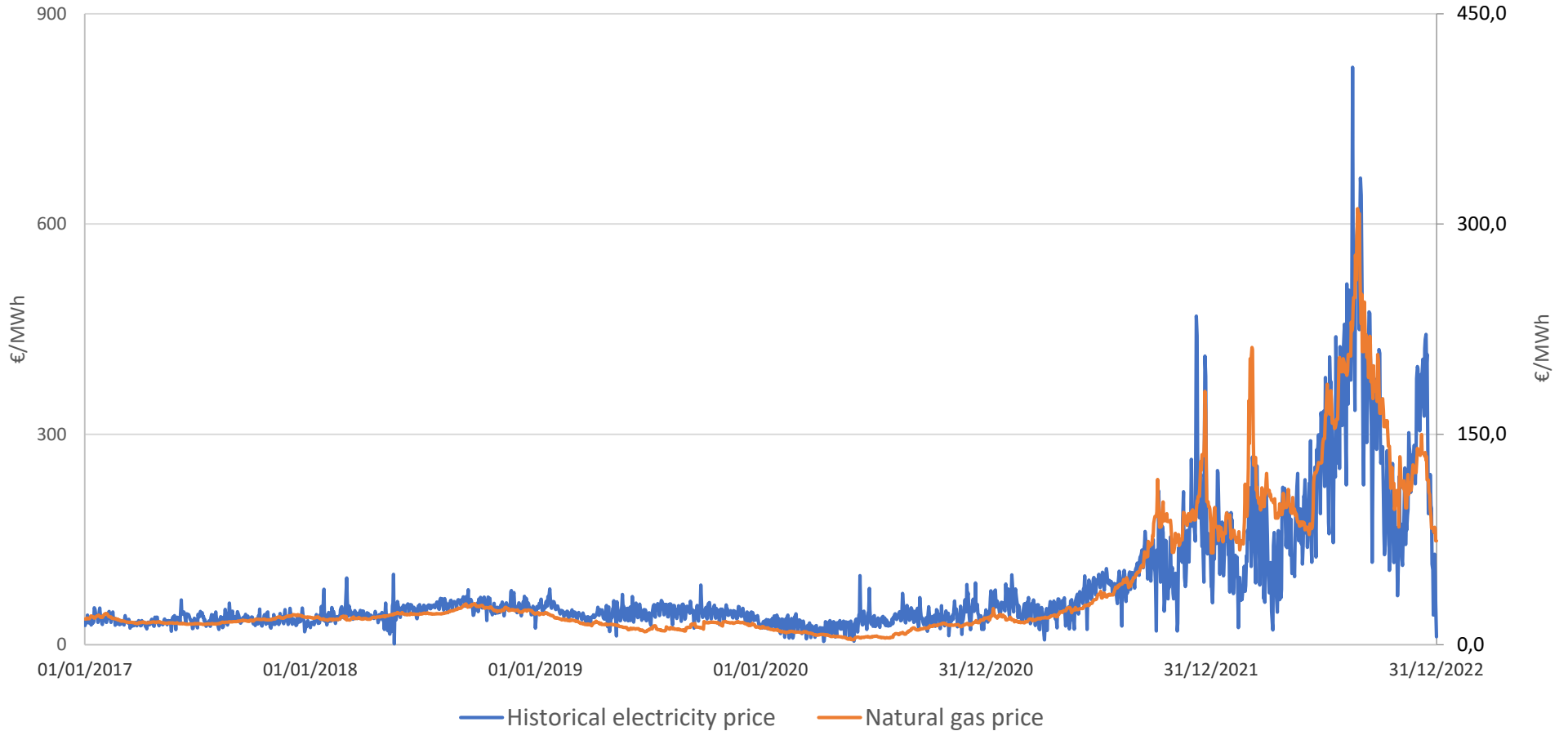
$$\text{Lithuania electricity market price} = 13.144 + 1.688 * \text{natural gas futures price}$$



Results

Clear relation between electricity and natural gas prices can be observed on combined graphs

Lithuanian Electricity price vs TTF natural gas price, 2017-2022

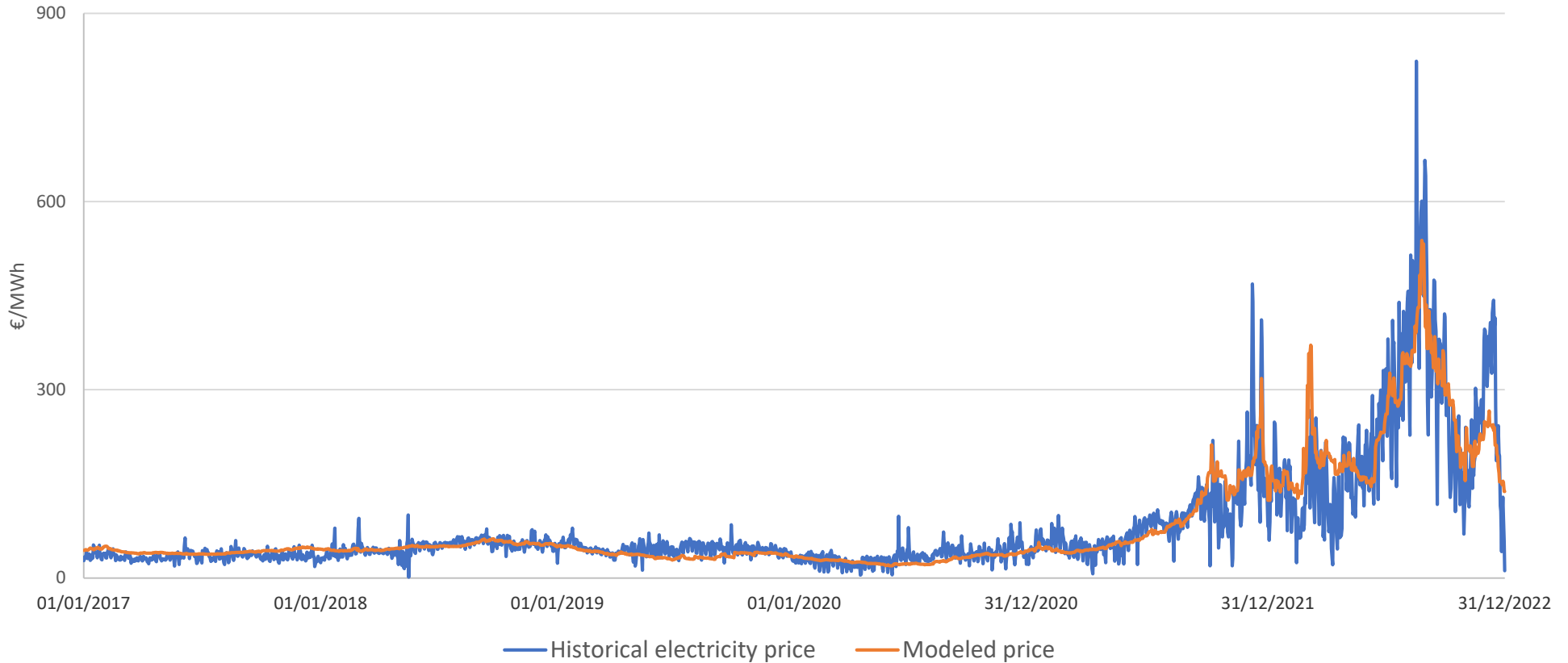




Results

Electricity price regression based only on natural gas futures price allowed to achieve 31% MAPE for historical data

Historical electricity prices vs modeled prices, 2017-2022



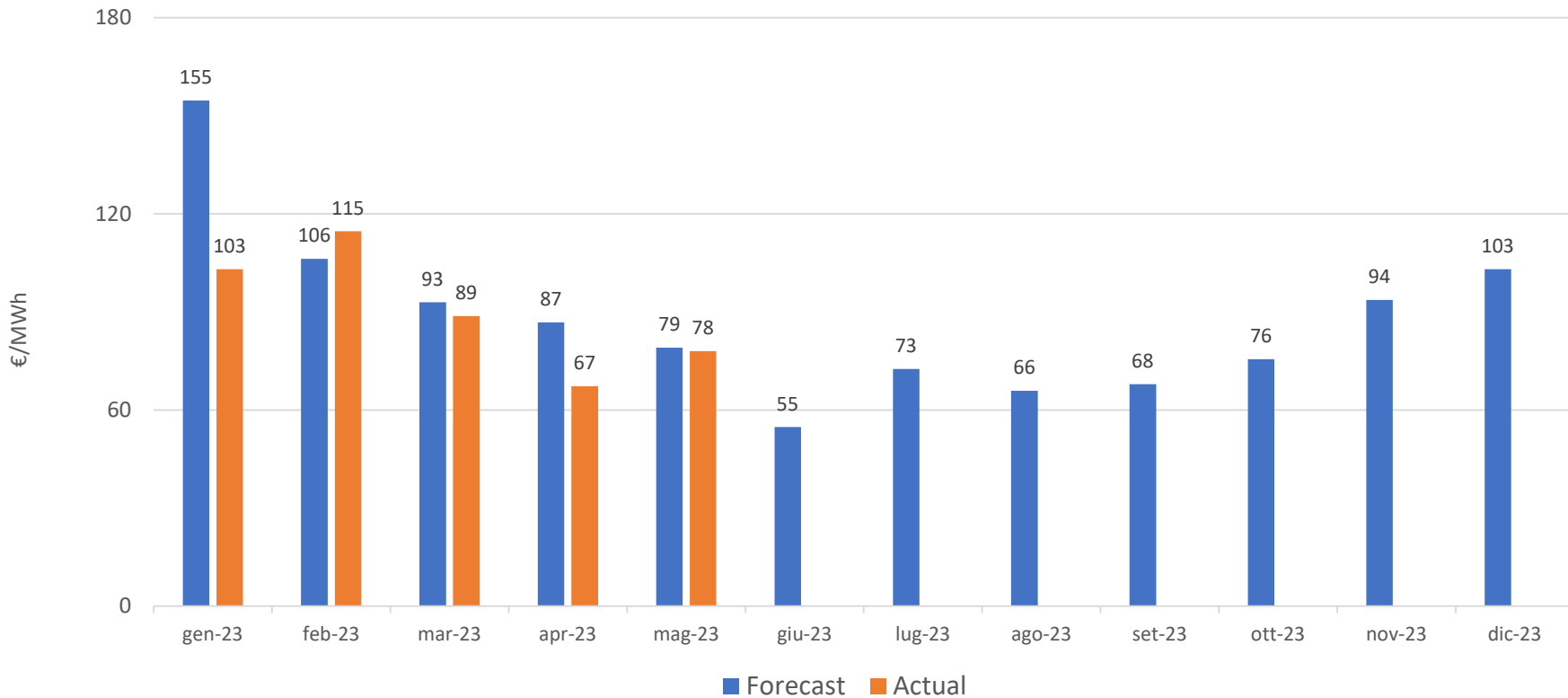
MAPE = 31.4%



Results

Average monthly forecast for 2023 is not completely off actual values but there is a place for improvement

Average monthly electricity price forecast for 2023





- 1** Natural gas futures are monthly values that can be transformed into daily values by different ways.
- 2** Natural gas future prices is the main influencing factor for Lithuanian electricity market price alone accounting for 0.82 R^2 .
- 3** Constructed regression model with natural gas futures as a single variable achieved ~31% MAPE on historical data.



- 1** Taking in to account planned wind capacity growth in Lithuania.
- 2** Explore variables related with neighboring countries.
- 3** Explore different ways for transforming natural gas futures from monthly to daily values.

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