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Establishment and comparison of predictive models for oil and petroleum products, electricity and gas: A Cross-Border Analysis

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Brief description of the study

3 key energy parameters

- Oil and petroleum product deliveries
- Electricity availability
- Inland gas consumption

6 consecutive months

- October 2023
- November 2023
- December 2023
- January 2024
- February 2024
- March 2024

5 countries per energy parameter

Oil

- Spain
- Ireland
- Portugal
- Slovakia
- Luxemburg

Electricity

- Denmark
- Ireland
- Latvia
- Greece
- France

Gas

- Spain
- Ireland
- Lithuania
- Finland
- Luxemburg

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Data

The data were extracted from the datasets entitled:

- Supply and transformation of oil and petroleum products - monthly data [NRG_CB_OILM]
- Supply, transformation and consumption of electricity - monthly data [NRG_CB_EM]
- Supply, transformation and consumption of gas - monthly data [NRG_CB_GASM]

Data source: Official website of Eurostat

https://ec.europa.eu/eurostat/data/database

Timeseries	Oil	Electricity	Gas
Basic	[O4671] Gas oil and diesel oil [GID_CAL] Gross inland deliveries – calculated [THS_T] Thousand tons	[E7000] Electricity [AIM] Available to internal market [GWH] Gigawatt-hour	[G3000] Natural gas [IC_CAL_MG] Inland consumption of gas calculated as defined in MOS GAS (Monthly Statistics GAS) [TJ_GCV] Terajoule (gross calorific value - GCV)
Indicator type 1	Electricity (Basic)	Oil (Basic)	Oil (Basic)
Indicator type 1	Gas (Basic)	Gas (Basic)	Electricity (Basic)
Indicator type 2	[O4671] Gas oil and diesel oil [EXP] Exports [THS_T] Thousand tons	[E7000] Electricity [IMP] Imports [GWH] Gigawatt-hour	[G3000] Natural gas [IMP] Imports [TJ_GCV] Terajoule (gross calorific value - GCV)
Indicator type 2	[O4671] Gas oil and diesel oil [INTMARB] International maritime bunkers [THS_T] Thousand tons	[E7000] Electricity [EXP] Exports [GWH] Gigawatt-hour	
Indicator type 2	[O4671] Gas oil and diesel oil [STK_CHG] Change in stock [THS_T] Thousand tons		

Theoretical framework – Methods

5 different forecasting models

- First model - ARMAX-1: 2 mutual exogenous variables (indicators type 1)
- Second model - ARMAX-2: 2 mutual exogenous variables (indicators type 1)
- Third model - ARMAX-3: individualized exogenous variables (indicators type 1, 2)
- Fourth model - RNN: training based on 12 previous months
- Fifth model - Linear Model: training based on 3 previous months

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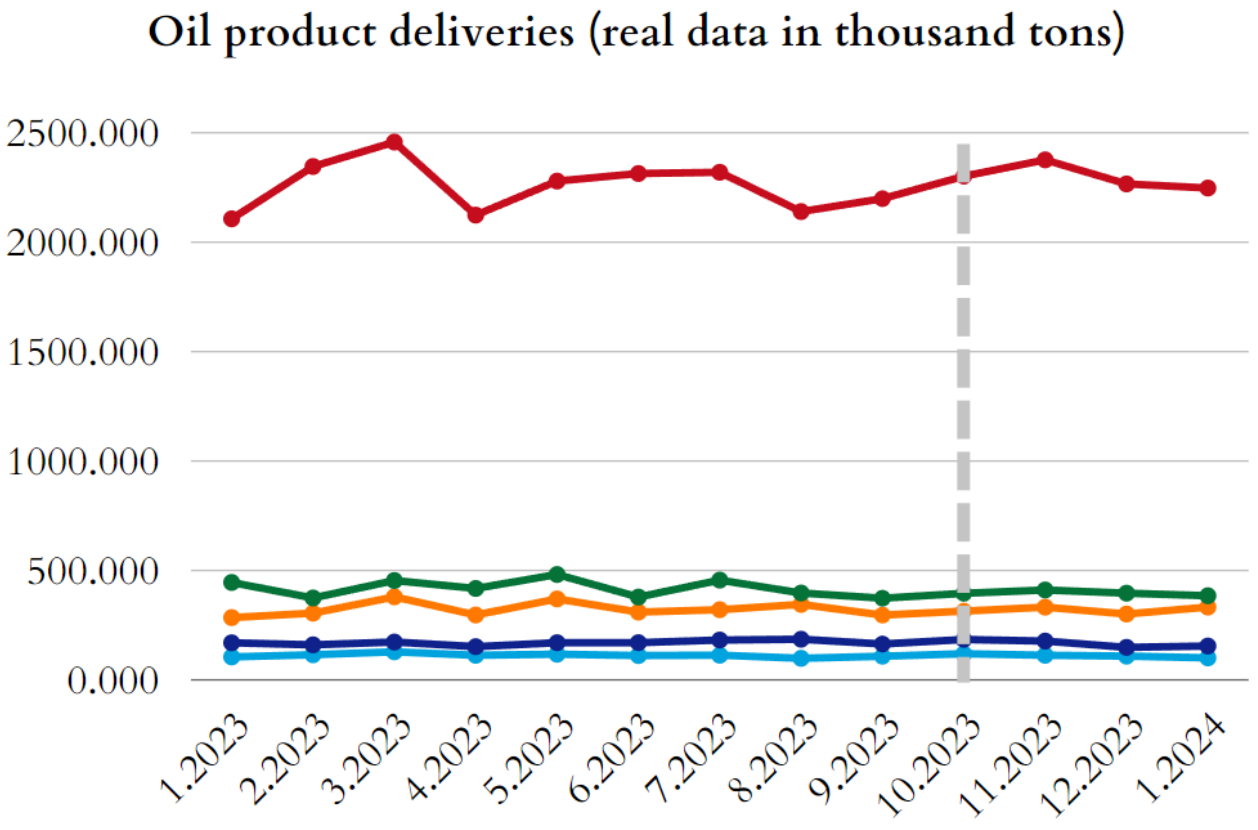
Oil Results - I

Oil product deliveries relative errors

	10 2023	11 2023	12 2023	01 2024	02 2024	03 2024
Spain	7.1 1.2 1.2 2.5 0.9	3.0 7.7 4.3 1.6 5.2	18.7 5.9 5.7 3.8 7.6	3.7 4.5 4.5 9.1 1.6	...	...
Ireland	8.1 14.3 6.5 5.4 1.7	5.6 3.4 4.8 2.9 3.8	4.1 8.3 47.0 3.8 1.8	14.8 6.2 1.5 5.5 3.7	...	...
Portugal	6.0 5.2 6.3 0.1 4.4	0.7 2.5 0.3 4.5 6.7	3.1 1.5 1.7 1.6 2.1	0.0 1.6 0.6 3.6 4.9	...	...
Slovakia	3.3 0.0 3.4 5.8 3.1	2.0 1.0 0.7 2.3 1.0	1.8 16.9 17.8 13.3 5.8	4.6 8.6 9.1 0.0 7.3	...	...
Luxemburg	11.4 3.1 3.4 14.2 10.8	18.5 11.2 3.5 12.4 1.6	13.3 5.7 6.4 26.4 13.1	7.5 8.4 6.9 6.4 12.9	...	...



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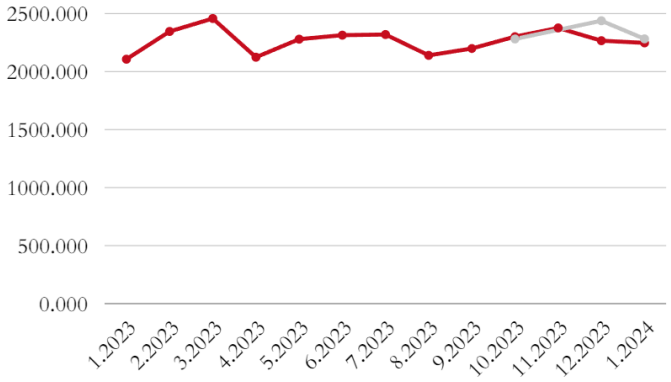
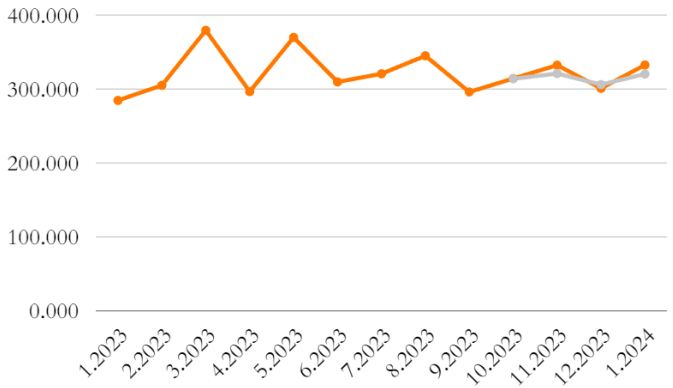
Oil Results - II

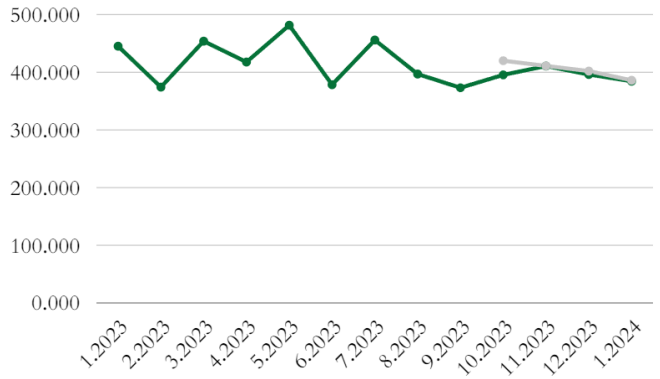
Spain



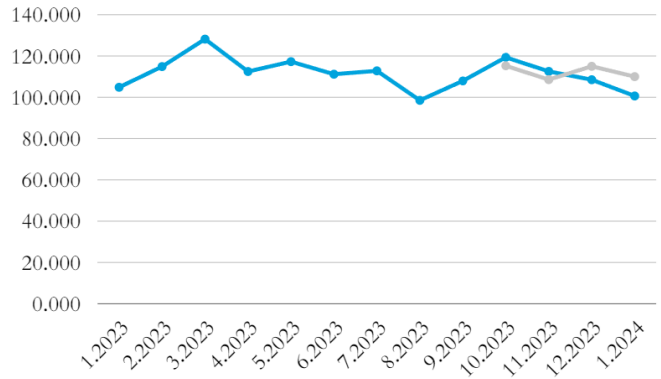
Ireland



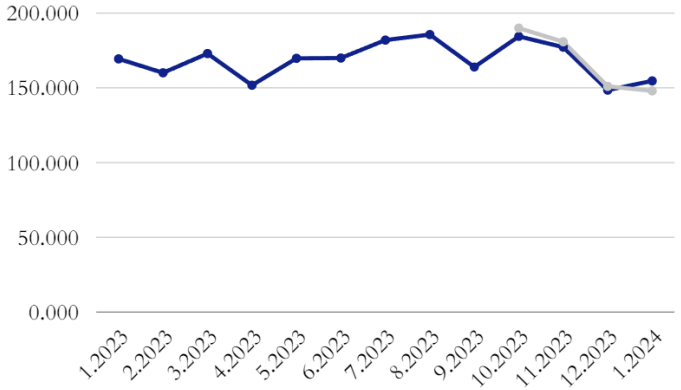
Portugal



Luxemburg



Slovakia



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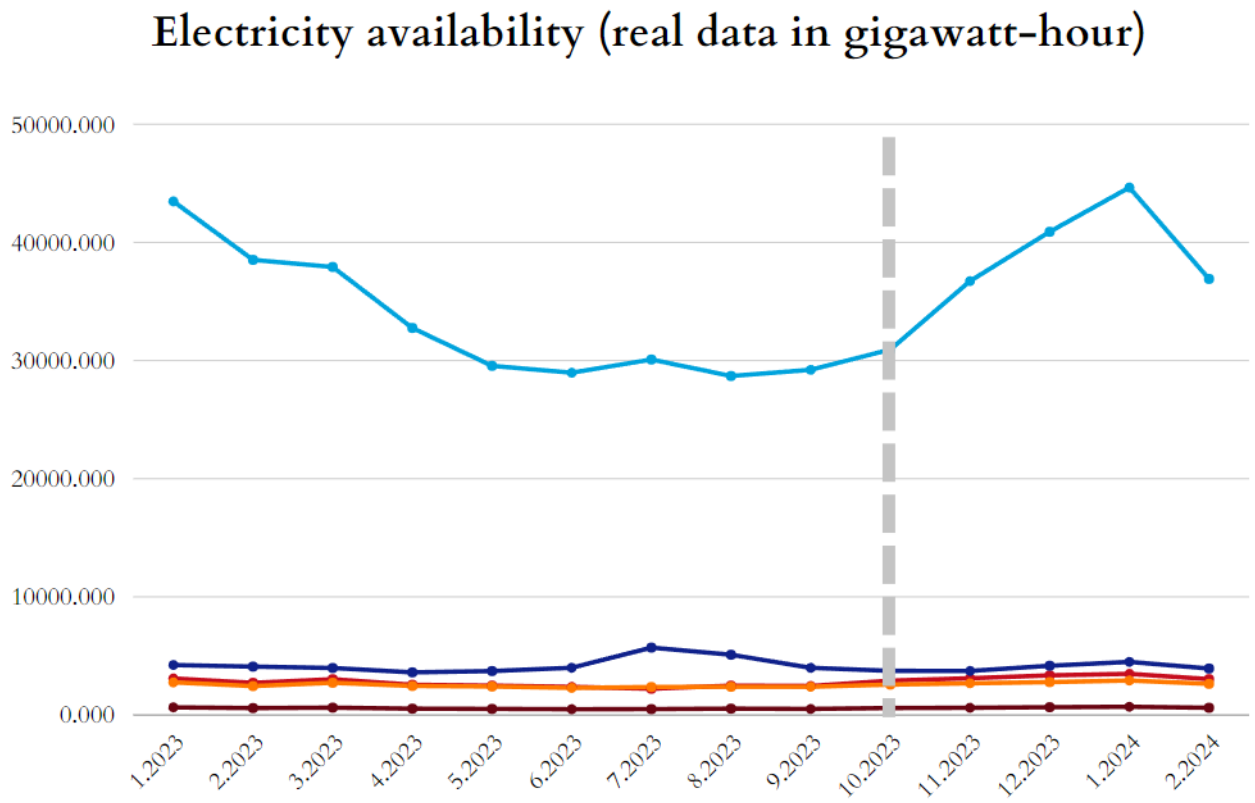
Electricity Results - I

Electricity availability relative errors	10 2023	11 2023	12 2023	01 2024	02 2024	03 2024
Denmark	5.1 16.4 3.2 7.7 13.7	4.4 17.8 4.7 8.3 9.1	4.5 16.7 4.6 7.0 7.0	6.8 8.9 6.8 7.2 0.0	10.4 3.2 10.4 3.6 1.1	...
Ireland	3.3 8.2 2.5 4.1 1.4	1.4 4.2 2.6 4.2 0	2.8 3.8 1.5 2.3 1.8	6.2 6.8 6.2 7.7 5.7	5.1 6.7 5.1 0.3 4.4	...
Latvia	1.3 8.8 2.1 3.1 5.5	0.6 11.3 0 3.5 0.4	3.8 12.7 12.7 0.3 2.2	1.5 6.7 1.5 3.7 0.9	5.9 2.4 6.2 10.9 0.2	...
Greece	2.4 31.3 2.1 14.8 8.4	1.5 11.6 2.6 11.7 1.6	6.7 4.0 6.5 12.7 4.3	6.3 8.3 6.4 12.6 2.4	0.6 1.2 0.5 16.7 6.3	...
France	3.4 6.0 5.0 9.9 3.0	4.5 0.7 0.6 0.6 18.0	8.1 8.6 8.5 3.5 1.9	7.1 12.9 7.3 3.2 1.1	13.1 21.6 12.3 18.3 9.5	...



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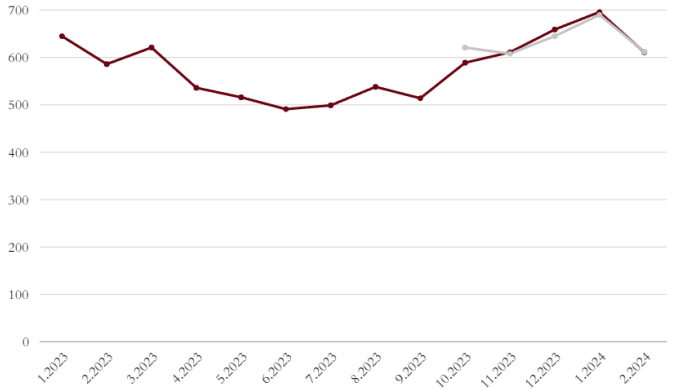
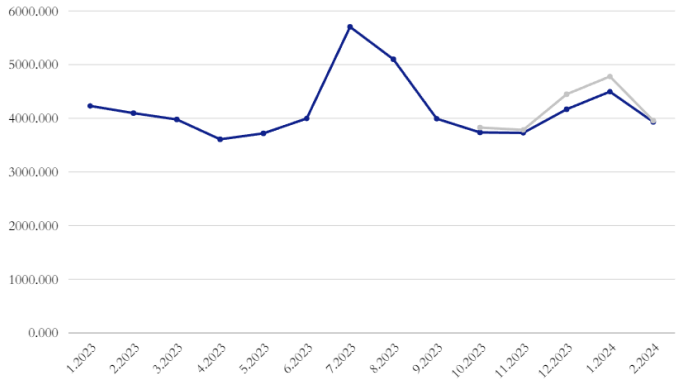
Electricity Results - II

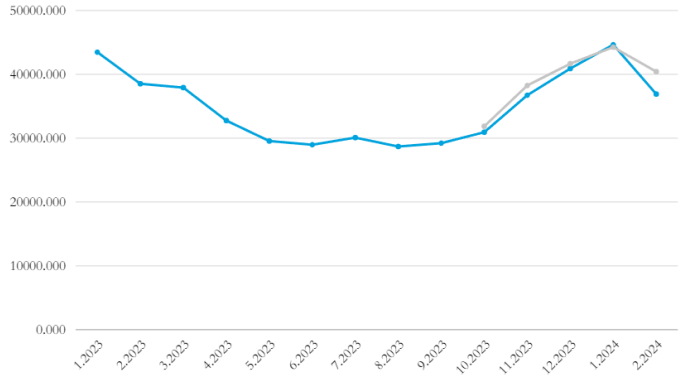
Latvia



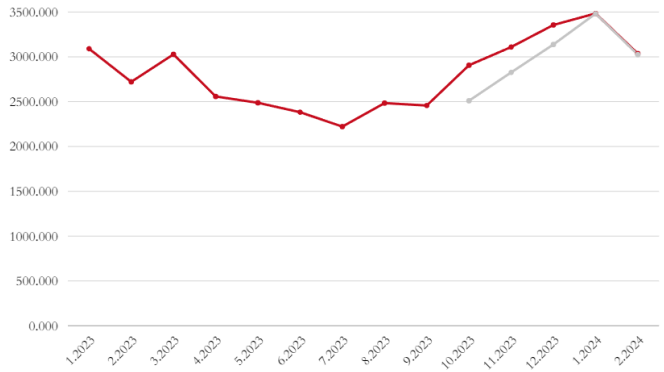
Greece



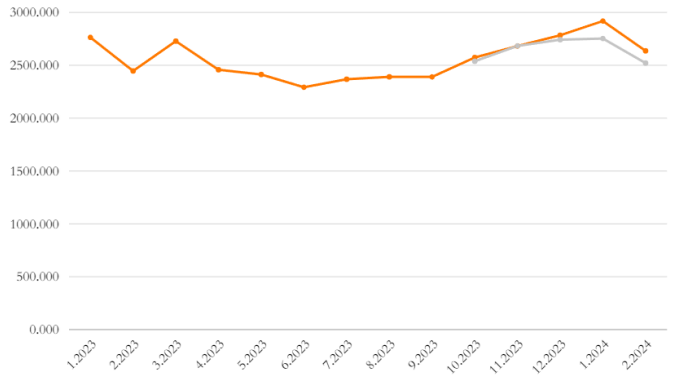
France

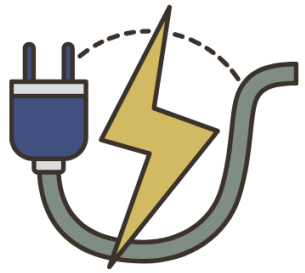


Denmark



Ireland





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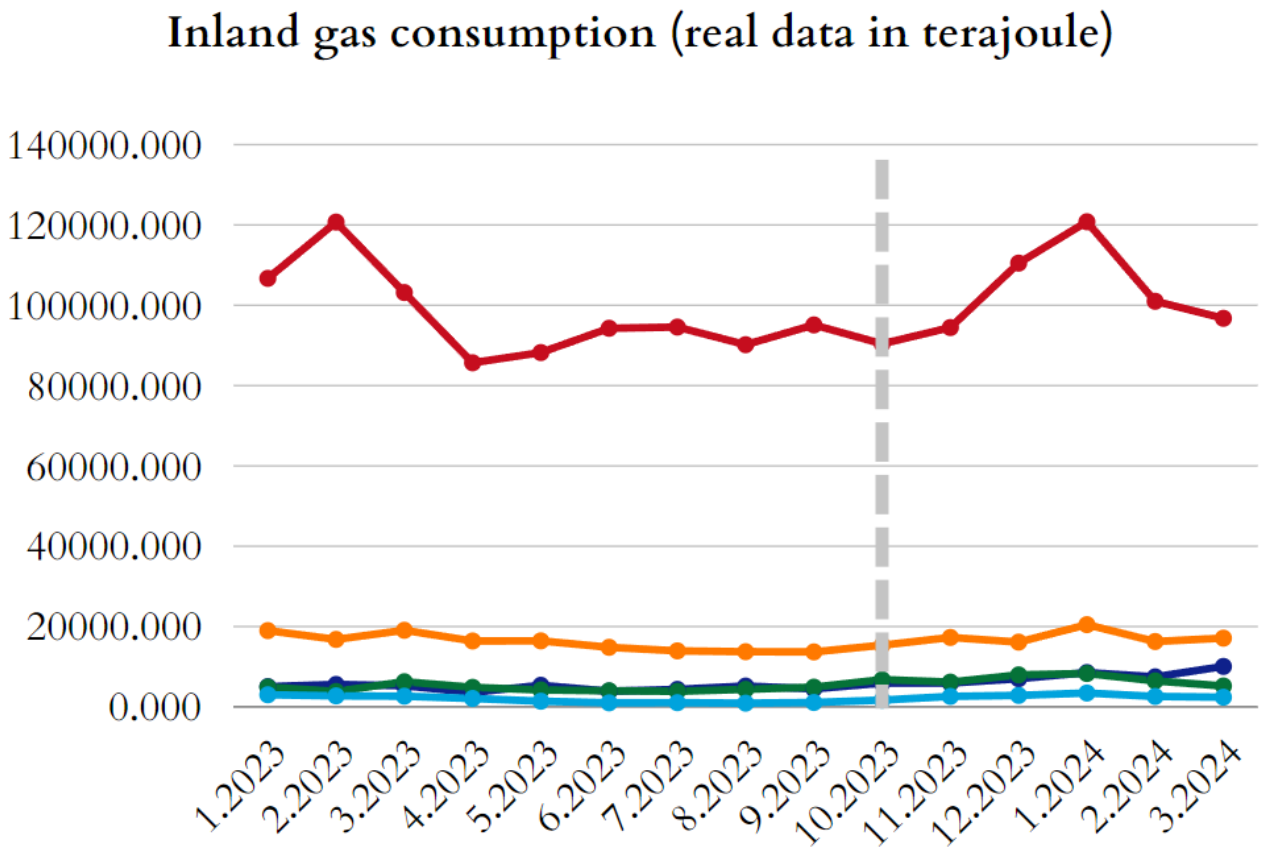
Gas Results - I

Inland gas consumption relative errors	10 2023	11 2023	12 2023	01 2024	02 2024	03 2024
Spain	13.4	25.6	7.4	12.5	28.3	14.7
	4.2	0.6	11.3	2.3	24.5	10.3
	4.2	0.6	11.3	7.1	23.8	6.8
	11.1	0.4	6.3	10.4	17.6	6.4
	33.3	0.6	3.0	5.0	10.1	2.2
Ireland	5.2	0	22.4	5.8	10.4	1.6
	12.2	11.3	9.2	17.3	23.0	2.6
	5.1	10.9	22.4	5.8	10.4	3.0
	2.9	4.4	11.2	17.9	18.2	1.9
	6.8	3.5	3.9	13.6	5.2	6.1
Lithouania	31.2	9.2	0.6	33.2	4.2	29.8
	37.2	2.9	21.9	25.4	51.9	31.3
	35.8	18.4	4.2	36.0	18.5	28.8
	13.5	18.5	2.8	24.1	43.4	24.9
	37.6	26.8	0.6	18.9	17.2	37.9
Finland	63.5	61.3	18.8	23.9	11.2	39.7
	56.4	50.2	20.7	17.6	14.0	25.4
	62.4	46.4	34.2	15.9	11.6	64.5
	55.0	46.3	19.6	30.9	1.7	30.2
	38.0	27.7	89.2	13.0	9.4	28.1
Luxemburg	12.7	9.5	17.1	4.4	24.5	11.1
	33.5	27.6	5.8	10.8	33.9	14.8
	12.1	27.8	17.1	4.4	24.5	11.1
	5.4	16.4	1.9	13.3	25.1	1.2
	66.8	3.4	4.8	5.5	11.1	12.1



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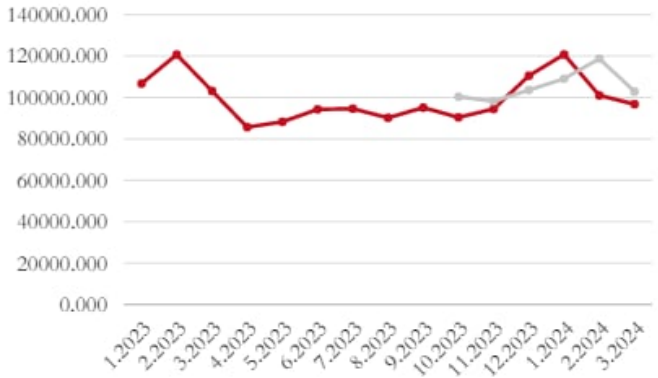
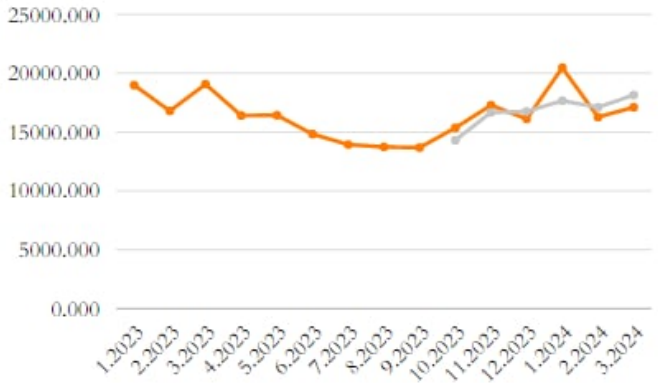
Gas Results - II

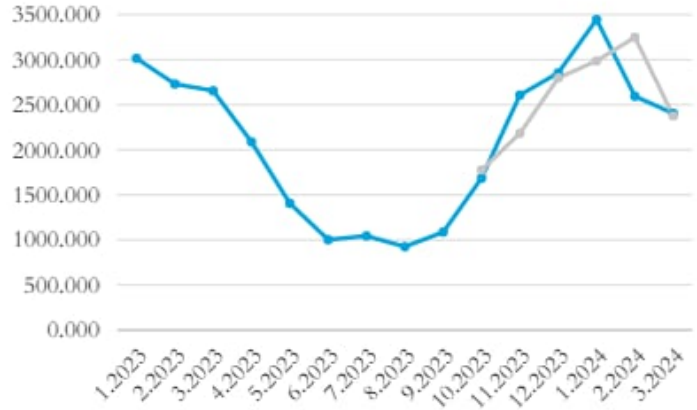
Spain



Ireland

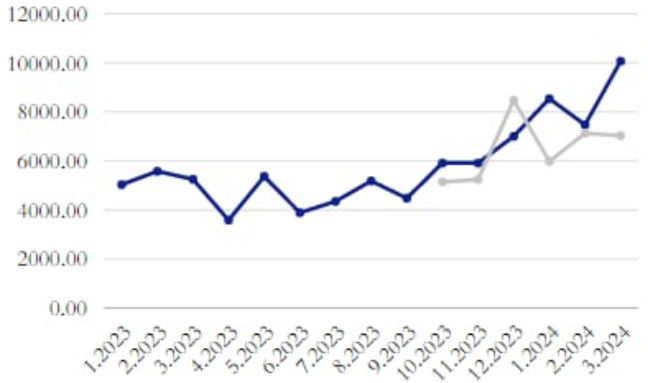


Luxemburg



Lithuania

Finland



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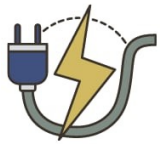
Conclusions - I

Average relative error of all models for all selected countries during the whole study period



Electricity availability: **5.15%** **well-fitting**

Oil and petroleum product deliveries: **6%** **well-fitting**

Gas consumption: exceeded **15%** **poorly-fitting**

⇓

Russia's invasion of Ukraine and the weaponization of energy have led to the diversification of energy supply for EU countries, especially for gas.

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Conclusions - II

The countries with the . . .

BEST fit:

Electricity	**Ireland** (3.9%)
Oil	**Portugal** (2.9%)

Low energy dependence on Russia
(lower than the EU average of 24.4%)

WORST fit:

Gas	**Lithuania** (exceeded the 20%)
Gas	**Finland** (exceeded the 20%)

High energy dependence on Russia
(Lithuania over 95%)
(Finland over 40%)

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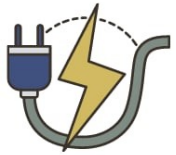
Conclusions - III

Proposed models



Electricity availability: **Linear models (3.9%)**
well-fitting

Oil and petroleum product deliveries: **Linear models (4.5%)**
well-fitting

Gas consumption: **RNN model (16%)**
poorly-fitting

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