THE IMPACT OF THE COVID-19 PANDEMIC ON NATURAL GAS CONSUMPTION BY COMMERCIAL CONSUMERS IN A SELECTED CITY IN POLAND

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SUPPLEMENTARY MATERIALS

Supplementary material contains 11 pages (including 9 tables and 1 figure).

Table SI.1. Information about all artificial neural networks models for average temperature

No. Models	Independent parameter								Name of the artificial neural network	The number of neurons in the hidden layer	Activation function		MAPE [%]
	Atmospheric data						Artificial data						
	Temperature	Wind speed	Humidity	Additional data with duration of atmospheric phenomenon	Models with history data		Days of the week	Months			Input layer	Output layer	
					One day ago	Two days ago							
1	+	−	−	−	−	−	−	−	MLP 1-33-1	33	linear	exponential	2.66
2	+	+	−	−	−	−	−	−	MLP 2-59-1	59	exponential	logistic	2.60
3	+	+	−	−	−	−	−	+	MLP 26-13-1	13	linear	exponential	2.17
4	+	+	−	−	−	−	+	+	MLP 40-13-1	13	exponential	linear	2.55
5	+	+	−	−	−	−	+	−	MLP 16-38-1	38	tanh	logistic	3.35
6	+	−	+	−	−	−	−	−	MLP 2-35-1	35	logistic	logistic	2.86
7	+	+	+	−	−	−	−	−	MLP 3-53-1	53	exponetial	logistic	2.87
8	+	+	+	—	−	−	−	+	MLP 27-16-1	16	linear	exponetial	2.60
9	+	+	+	−	−	−	+	+	MLP 41-58-1	58	linear	exponetial	3.17
10	+	+	+	−	−	−	+	−	MLP 17-76-1	76	logistic	logistic	2.98
11	+	−	+	+	−	−	−	−	MLP 18-55-1	55	logistic	exponetial	2.55
12	+	+	+	+	−	−	−	−	MLP 19-52-1	52	logistic	logistic	2.32
13	+	+	+	+	−	−	−	+	MLP 43-6-1	6	exponetial	exponetial	2.31
14	+	+	+	+	−	−	+	+	MLP 57-10-1	10	exponetial	exponetial	2.91
15	+	+	+	+	−	−	+	−	MLP 33-64-1	64	exponetial	linear	2.49

Table SI.2. Information about all artificial neural networks models for average temperature with 1 day ago

| No. Models | Independent parameter | | | | | | | | Name of the artificial neural network | The number of neurons in the hidden layer | Activation function | | MAPE [%] |
| | Atmospheric data | | | | Models with history data | | Artificial data | | | | | | |
	Temperature	Wind speed	Humidity	Additional data with duration of atmospheric phenomenon	One day ago	Two days ago	Days of the week	Months			Input layer	Output layer	
1	+	−	−	−	+	−	−	−	MLP 2-13-1	13	tanh	exponetial	2.42
2	+	+	−	−	+	−	−	−	MLP 4-14-1	14	exponetial	logistic	3.01
3	+	+	−	−	+	−	−	+	MLP 28-48-1	48	exponetial	linear	2.81
4	+	+	−	−	+	−	+	+	MLP 42-3-1	3	exponetial	linear	2.66
5	+	+	−	−	+	−	+	−	MLP 18-28-1	28	exponetial	logistic	3.32
6	+	−	+	−	+	−	−	−	MLP 4-2-1	2	logistic	tanh	2.93
7	+	+	+	−	+	−	−	−	MLP 6-33-1	33	exponetial	linear	3.53
8	+	+	+	—	+	−	−	+	MLP 30-51-1	51	tanh	linear	2.85
9	+	+	+	−	+	−	+	+	MLP 44-5-1	5	exponetial	linear	2.88
10	+	+	+	−	+	−	+	−	MLP 20-44-1	44	exponetial	logistic	3.53
11	+	−	+	+	+	−	−	−	MLP 36-54-1	54	tanh	exponetial	3.03
12	+	+	+	+	+	−	−	−	MLP 38-64-1	64	logistic	exponetial	3.05
13	+	+	+	+	+	−	−	+	MLP 62-3-1	3	exponetial	linear	2.97
14	+	+	+	+	+	−	+	+	MLP 76-54-1	54	tanh	exponetial	3.28
15	+	+	+	+	+	−	+	−	MLP 52-19-1	19	logistic	linear	3.06

Table SI.3. Information about all artificial neural networks models for average temperature with 2 days ago

No. Models	Independent parameter								Name of the artificial neural network	The number of neurons in the hidden layer	Activation function		MAPE [%]
	Atmospheric data						Artificial data						
				Additional data with duration of atmospheric phenomenon	Models with history data		Days of the week	Months			Input layer	Output layer	
	Temperature	Wind speed	Humidity		One day ago	Two days ago							
1	+	−	−	−	+	+	−	−	MLP 3-5-1	5	logistic	tanh	2.61
2	+	+	−	−	+	+	−	−	MLP 6-3-1	3	exponetial	logistic	5.87
3	+	+	−	−	+	+	−	+	MLP 30-7-1	7	exponetial	linear	2.64
4	+	+	−	−	+	+	+	+	MLP 44-2-1	2	exponetial	linear	2.74
5	+	+	−	−	+	+	+	−	MLP 20-58-1	58	exponetial	logistic	2.79
6	+	−	+	−	+	+	−	−	MLP 6-61-1	61	exponetial	logistic	6.09
7	+	+	+	−	+	+	−	−	MLP 9-6-1	6	logistic	tanh	2.96
8	+	+	+	—	+	+	−	+	MLP 33-17-1	17	tanh	exponetial	2.86
9	+	+	+	−	+	+	+	+	MLP 47-3-1	3	tanh	exponetial	2.60
10	+	+	+	−	+	+	+	−	MLP 23-51-1	51	linear	logistic	3.00
11	+	−	+	+	+	+	−	−	MLP 54-19-1	19	logistic	exponetial	2.96
12	+	+	+	+	+	+	−	−	MLP 57-35-1	35	logistic	exponetial	2.86
13	+	+	+	+	+	+	−	+	MLP 81-13-1	13	exponetial	linear	3.45
14	+	+	+	+	+	+	+	+	MLP 95-42-1	42	tanh	exponetial	4.31
15	+	+	+	+	+	+	+	−	MLP 71-64-1	64	logistic	exponetial	2.97

Table SI.4. Information about all artificial neural networks models for min/max temperature

No. Models	Independent parameter								Name of the artificial neural network	The number of neurons in the hidden layer	Activation function		MAPE [%]
	Atmospheric data						Artificial data						
	Temperature	Wind speed	Humidity	Additional data with duration of atmospheric phenomenon	Models with history data		Days of the week	Months			Input layer	Output layer	
					One day ago	Two days ago							
1	+	−	−	−	−	−	−	−	MLP 2-16-1	16	linear	logistic	2.95
2	+	+	−	−	−	−	−	−	MLP 3-5-1	5	logistic	tanh	2.85
3	+	+	−	−	−	−	−	+	MLP 27-60-1	60	linear	tanh	14.72
4	+	+	−	−	−	−	+	+	MLP-41-7-1	7	linear	exponetial	3.05
5	+	+	−	−	−	−	+	−	MLP 17-61-1	61	exponetial	logistic	3.26
6	+	−	+	−	−	−	−	−	MLP 3-49-1	49	exponetial	logistic	2.90
7	+	+	+	−	−	−	−	−	MLP 4-10-1	10	linear	logistic	3.98
8	+	+	+	—	−	−	−	+	MLP 28-17-1	17	exponetial	logistic	2.66
9	+	+	+	−	−	−	+	+	MLP 42-26-1	26	exponetia	linear	3.93
10	+	+	+	−	−	−	+	−	MLP 18-54-1	54	exponetial	logistic	3.60
11	+	−	+	+	−	−	−	−	MLP 19-27-1	27	tanh	exponetial	2.70
12	+	+	+	+	−	−	−	−	MLP 20-36-1	36	tanh	logistic	2.48
13	+	+	+	+	−	−	−	+	MLP 44-63-1	63	tanh	exponetial	2.62
14	+	+	+	+	−	−	+	+	MLP 58-4-1	4	logistic	exponetial	3.08
15	+	+	+	+	−	−	+	−	MLP 34-47-1	47	logistic	logistic	2.66

Table SI.5. Information about all artificial neural networks models for min/max temperature with 1 day ago

No. Models	Independent parameter								Name of the artificial neural network	The number of neurons in the hidden layer	Activation function		MAPE [%]
	Atmospheric data						Artificial data						
	Temperature	Wind speed	Humidity	Additional data with duration of atmospheric phenomenon	Models with history data		Days of the week	Months			Input layer	Output layer	
					One day ago	Two days ago							
1	+	−	−	−	+	−	−	−	MLP 4-2-1	2	exponetial	logistic	3.60
2	+	+	−	−	+	−	−	−	MLP 6-2-1	2	logistic	tanh	4.15
3	+	+	−	−	+	−	−	+	MLP 30-9-1	9	tanh	logistic	3.45
4	+	+	−	−	+	−	+	+	MLP 44-2-1	2	exponetial	tanh	4.12
5	+	+	−	−	+	−	+	−	MLP 20-36-1	36	logistic	logistic	3.93
6	+	−	+	−	+	−	−	−	MLP 6-2-1	2	exponetial	logistic	4.28
7	+	+	+	−	+	−	−	−	MLP 8-42-1	42	exponetial	logistic	4.02
8	+	+	+	—	+	−	−	+	MLP 32-3-1	3	tanh	linear	7.14
9	+	+	+	−	+	−	+	+	MLP 46-50-1	50	logistic	exponetial	7.37
10	+	+	+	−	+	−	+	−	MLP 22-48-1	48	exponetial	logistic	4.26
11	+	−	+	+	+	−	−	−	MLP 38-64-1	64	tanh	exponetial	3.33
12	+	+	+	+	+	−	−	−	MLP 40-33-1	33	logistic	exponetial	2.97
13	+	+	+	+	+	−	−	+	MLP 64-59-1	59	tanh	exponetial	3.22
14	+	+	+	+	+	−	+	+	MLP 78-46-1	46	tanh	exponetial	3.76
15	+	+	+	+	+	−	+	−	MLP 54-60-1	60	tanh	exponetial	3.61

Table SI.6. Information about all artificial neural networks models for min./max. temperature with 2 days ago

No. Models	Independent parameter								Name of the artificial neural network	The number of neurons in the hidden layer	Activation function		MAPE [%]
	Atmospheric data				Models with history data		Artificial data						
	Temperature	Wind speed	Humidity	Additional data with duration of atmospheric phenomenon	One day ago	Two days ago	Days of the week	Months			Input layer	Output layer	
1	+	−	−	−	+	+	−	−	MLP 6-60-1	60	exponetial	logistic	3.69
2	+	+	−	−	+	+	−	−	MLP 9-55-1	55	logistic	tanh	4.77
3	+	+	−	−	+	+	−	+	MLP 33-3-1	3	linear	linear	3.96
4	+	+	−	−	+	+	+	+	MLP 47-8-1	8	exponetial	linear	3.55
5	+	+	−	−	+	+	+	−	MLP 23-39-1	39	exponetial	logistic	4.05
6	+	−	+	−	+	+	−	−	MLP 9-2-1	2	logistic	tanh	4.33
7	+	+	+	−	+	+	−	−	MLP 12-27-1	27	tanh	logistic	4.86
8	+	+	+	—	+	+	−	+	MLP 36-8-1	8	logistic	exponetial	3.32
9	+	+	+	−	+	+	+	+	MLP 50-38-1	38	logistic	exponetial	3.97
10	+	+	+	−	+	+	+	−	MLP 26-4-1	4	tanh	logistic	3.75
11	+	−	+	+	+	+	−	−	MLP 57-2-1	2	tanh	logistic	3.56
12	+	+	+	+	+	+	−	−	MLP 60-47-1	47	logistic	logistic	3.38
13	+	+	+	+	+	+	−	+	MLP 84-8-1	8	exponetial	linear	3.64
14	+	+	+	+	+	+	+	+	MLP 98-54-1	54	logistic	exponetial	4.47
15	+	+	+	+	+	+	+	−	MLP 74-39-1	39	exponetial	exponetial	3.31

Table SI.7. Information about all artificial neural networks models at a ground-level temperature

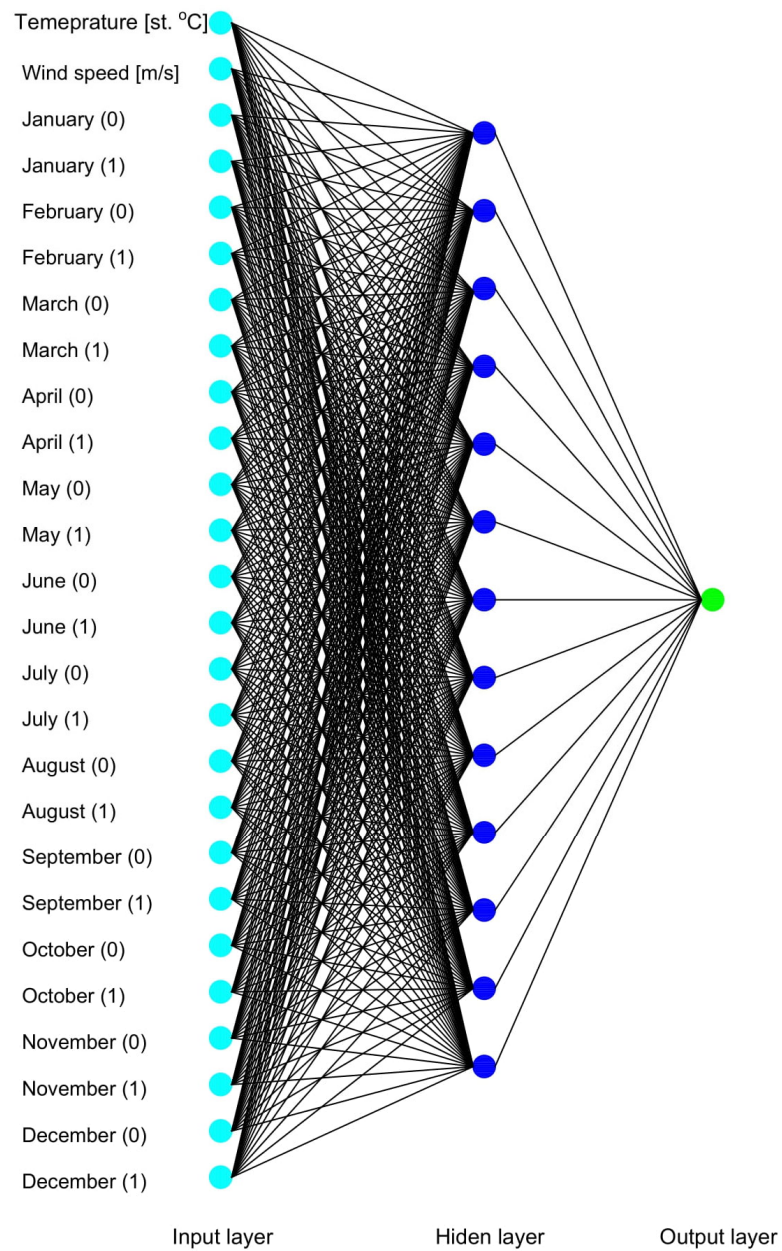| No. Models | Independent parameter | | | | | | | | Name of the artificial neural network | The number of neurons in the hidden layer | Activation function | | MAPE [%] |
| | Atmospheric data | | | | | | Artificial data | | | | | | |
| | Temperature | Wind speed | Humidity | Additional data with duration of atmospheric phenomenon | Models with history data | | Days of the week | Months | | | Input layer | Output layer | |
					One day ago	Two days ago							
1	+	−	−	−	−	−	−	−	MLP 1-2-1	2	tanh	exponetial	6.71
2	+	+	−	−	−	−	−	−	MLP 2-29-1	29	tanh	tanh	6.25
3	+	+	−	−	−	−	−	+	MLP 26-54-1	54	linear	exponetial	9.30
4	+	+	−	−	−	−	+	+	MLP 40-11-1	11	exponetial	tanh	9.72
5	+	+	−	−	−	−	+	−	MLP 16-2_1	2	logistic	logistic	6.40
6	+	−	+	−	−	−	−	−	MLP 2-25-1	25	linear	tanh	6.26
7	+	+	+	−	−	−	−	−	MLP 3-22-1	22	linear	tanh	5.69
8	+	+	+	—	−	−	−	+	MLP 27-18-1	18	linear	exponetial	7.75
9	+	+	+	−	−	−	+	+	MLP 41-20-1	20	linear	exponetial	7.62
10	+	+	+	−	−	−	+	−	MLP 17-47-1	47	linear	tanh	5.57
11	+	−	+	+	−	−	−	−	MLP 18-60-1	60	logistic	exponetial	2.51
12	+	+	+	+	−	−	−	−	MLP 19-41-1	41	tanh	exponetial	2.44
13	+	+	+	+	−	−	−	+	MLP 43-46-1	46	tanh	linear	2.55
14	+	+	+	+	−	−	+	+	MLP 57-11-1	11	exponetial	tanh	3.12
15	+	+	+	+	−	−	+	−	MLP 33-29-1	29	logistic	linear	2.89

Table SI.8. Information about all artificial neural networks models at a ground-level temperature with 1 day backdate

No. Models	Independent parameter								Name of the artificial neural network	The number of neurons in the hidden layer	Activation function		MAPE [%]
	Atmospheric data						Artificial data						
					Models with history data		Days of the week	Months			Input layer	Output layer	
	Temperature	Wind speed	Humidity	Additional data with duration of atmospheric phenomenon	One day ago	Two days ago							
1	+	−	−	−	+	−	−	−	MLP 2-7-1	7	exponetial	logistic	6.36
2	+	+	−	−	+	−	−	−	MLP 4-13-1	13	exponetial	logistic	6.51
3	+	+	−	−	+	−	−	+	MLP 28-46-1	46	linear	exponetial	5.50
4	+	+	−	−	+	−	+	+	MLP 42-5-1	5	linear	exponetial	9.57
5	+	+	−	−	+	−	+	−	MLP 18-12-1	12	linear	tanh	6.03
6	+	−	+	−	+	−	−	−	MLP 4-10-1	10	linear	tanh	6.57
7	+	+	+	−	+	−	−	−	MLP 6-15-1	15	exponetial	logistic	5.35
8	+	+	+	—	+	−	−	+	MLP 30-17-1	17	exponetial	linear	6.74
9	+	+	+	−	+	−	+	+	MLP 44-7-1	7	exponetial	linear	6.30
10	+	+	+	−	+	−	+	−	MLP 20-35-1	35	linear	tanh	5.50
11	+	−	+	+	+	−	−	−	MLP 36-59-1	59	logistic	exponetial	3.25
12	+	+	+	+	+	−	−	−	MLP 38-20-1	20	tanh	exponetial	3.12
13	+	+	+	+	+	−	−	+	MLP 62-37-1	37	tanh	exponetial	3.76
14	+	+	+	+	+	−	+	+	MLP 76-51-1	51	tanh	exponetial	4.39
15	+	+	+	+	+	−	+	−	MLP 52-38-1	38	tanh	exponetial	3.91

Table SI.9. Information about all artificial neural networks models at a ground-level temperature with 2 days ago

No. Models	Independent parameter								Name of the artificial neural network	The number of neurons in the hidden layer	Activation function		MAPE [%]
	Atmospheric data						Artificial data						
	Temperature	Wind speed	Humidity	Additional data with duration of atmospheric phenomenon	Models with history data		Days of the week	Months			Input layer	Output layer	
					One day ago	Two days ago							
1	+	−	−	−	+	+	−	−	MLP 3-14-1	14	exponetial	logistic	5.69
2	+	+	−	−	+	+	−	−	MLP 6-24-1	24	exponetial	logistic	5.84
3	+	+	−	−	+	+	−	+	MLP 30-32-1	32	logistic	linear	8.06
4	+	+	−	−	+	+	+	+	MLP 44-44-1	44	tanh	exponetial	9.09
5	+	+	−	−	+	+	+	−	MLP 20-8-1	8	linear	tanh	5.77
6	+	−	+	−	+	+	−	−	MLP 6-7-1	7	linear	tanh	6.03
7	+	+	+	−	+	+	−	−	MLP 9-3-1	3	exponetial	logistic	5.06
8	+	+	+	—	+	+	−	+	MLP 33-37-1	37	logistic	linear	5.44
9	+	+	+	−	+	+	+	+	MLP 47-2-1	2	tanh	exponetial	5.60
10	+	+	+	−	+	+	+	−	MLP 23-6-1	6	tanh	logistic	5.61
11	+	−	+	+	+	+	−	−	MLP 54-46-1	46	tanh	exponetial	3.64
12	+	+	+	+	+	+	−	−	MLP 57-57-1	57	tanh	exponetial	3.38
13	+	+	+	+	+	+	−	+	MLP 81-61-1	61	tanh	exponetial	4.39
14	+	+	+	+	+	+	+	+	MLP 95-62-1	62	logistic	exponetial	4.31
15	+	+	+	+	+	+	+	−	MLP 71-39-1	39	linear	logistic	3.55

Figure SI.1. Topology of the best neural network MLP 26-13-1