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Article

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Efficiency of Renewable Energy Plants in Russia

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ABSTRACT

The article offers an evaluation of the efficiency of power plants that use renewable energy. With the way tariffs for thermal energy are nowadays, the minimum cost of solar water heating (SWH) plants with a payback period of 7 years should not exceed $50/m². Capital expenses for SWH plants with a drain-down system are 30-40% times lower than traditional SWHs with circulation systems, and their payback period does not exceed 5-5.7 years. Based on the present electricity tariffs in Russia, it is estimated that the minimal acceptable investments in wind turbines with a payback period of 7 years should not exceed $800/kW. Biogas that is obtained from specialized plants of medium and high-power costs $15,000-60,000/m³. But the price of biogas produced in low energy power plants is about $80,000-270,000, which is cheaper than natural gas. So, the use of biogas is economically justified at the moment.

Keywords: Solar Water Heating Plants, Wind Turbines, Biogas Plants, Thermal Energy, Electrical Energy, Cost of Plants
JEL Classifications: C30, D12, Q41, Q48

1. INTRODUCTION

Data analysis of tariffs for thermal and electrical power and the prices for several energy resources like gas, fuel and coal shows steady growth. That is precisely why energy plants with renewable energy sources, which could economize up to 60-70% of its energy, if not more, will become attractive to consumers. The reasoning is that in certain situations, these factors will help escape dependence from monopolies. We developed a method that evaluates the economic efficiency of power plants. It bases on determining the main techno-economic indicators, like capital investments, the cost of obtained thermal energy and the payback periods of energy establishments: wind turbines, solar plants, biogas plants.

The aim of this research paper is a complex assessment of the efficiency of power plants in Russia, the basis of their techno-economic processes and indicators and the development of recommendations for their practical use and improvement.

2. LITERATURE REVIEW

Many corporations in Russia are working on the serial production of solar energy plants. They take up an area of 0.8-1.07 m² and cost $70/m². These plants are the base of solar water heating (SWH) plants that have two collectors and a heat-insolated storage tank. The cost is $280. Solar collectors "Konkurent" have technical characteristics that are on par with the best foreign samples. Their area is 1 m², and the price is $220. Thus, the unit price of solar installations is approximately $100-300/m² (Chiemchaisri et al., 2012; Gardner et al., 1993).

And their payback period reaches 8-16 years, which makes them inaccessible to large masses of middle class and low-income consumers (Ahmed et al., 2014; Mikhaylov et al., 2018; Nyangarika et al., 2018).

Capital expenses for SWH plants with a drain-down system are 30-40% times lower than traditional SWHs with circulation systems, and their payback period does not exceed 5-5.7 years. This makes it possible to use them as a heat supply in low-rise buildings along with gas and electric heaters and high-rise buildings in conjunction with boiler blocks and roof boilers. As a result, the annual gas consumption is reduced by 40-60% (Amini and Reinhart, 2011; Bansal et al., 2013).

Axial fittings are widely used for power generation. Their 2-4 aerodynamic blades have a horizontal axis of rotation. Nevertheless, amongst a long list of indisputable advantages, the most prominent of which is a high-efficiency rating, these plants have a significant drawback – their dependence from the wind. Not only that, but when the power is above 3 kW, these establishments require individual devices that help jump-start the machine (Bove and Lunghi, 2006; Cai et al., 2011).

In other words, they can't start themselves. This leads to the development of more complex power-up and control systems, which, subsequently, increases the price of the machinery and its maintenance (Denisova, 2019; Denisova et al., 2019).

Concerning what has been said, it would be best if most autonomous devices used orthogonal (on a vertical axis) installations (Nyangarika et al., 2019b; Nyangarika et al., 2019a).

They are very beneficial, as their performance does not depend on the direction of the wind, and they operate at the low wind speeds of 2-3 m/s (Mikhaylov, 2018a; Mikhaylov, 2018b).

Because of these characteristics, the average energy production of wind power installations and wind turbines is 2-2.5 times better when compared to other devices with similar power. Besides, orthogonal bases do not generate noise or infrasound (Morris and Barlaz, 2011).

However, they are more prone to vibrations. In general, though, the rotor is one of the most effective establishments in the world factors (Meynkhard, 2019; Osokin et al., 2018; Osokin and Solntsev, 2017; Solntsev and Osokin, 2018).

3. DATA AND METHODS

The article uses data about the average marginal levels of unregulated electricity power prices of mosenergosbyt to legal entities in Russia as of May 2019 (Appendix 1-4). This data is the foundation of the articles' estimates of payback periods for solar and biogas establishments and wind turbines.

The following universal formula can determine the payback period of solar power plants:

$$Ts=k*I/E*C*V \quad (1)$$

where I is the share of investments in solar panels in the total of investments in solar installations; k is the coefficient of investments, that depend on the type of solar installation; E is the specific annual amount of solar energy that solar installations receive, GJ/(m^2·year); C is the energy efficiency of the solar establishment; V is the cost of the replaced heat energy, rub/GJ.

The coefficient I depends on the type of solar collector, the design of the heat power bank, the model of metallic structures and circulation pipelines. An analysis of past research shows that the coefficient I in Russia is equal to 2.0. Formula (1) can be used to choose an optimal design of an SWH plant depending on the structure of the solar collector. The efficiency of a solar collector depends on the average annual amount of energy that is received by a solar collector. This hinges on the solar collector's geographical location and the cost of the replaced energy, which revolves around the type of alternative energy source and the price of this energy supply (Mikhaylov, 2019a; Mikhaylov et al., 2019).

Techno-economic indicators of Russia's wind turbines comply with techno-economic indicators of the very best foreign stations with renewable energy. Over the past 20-30 years, capital expenditures in renewable energy (ki) decreased by 5 times and are currently at \$800-1000/kW (Moiseev, 2017c; Moiseev and Akhmadeev, 2017).

We can get formulas for techno-economic indicators by generalizing this data. The following formula can determine the payback period in particular:

$$Tw=ki/U*T*P \quad (2)$$

where ki is the average capital cost in renewable energy; U is the coefficient of power consumption; T is the annual operating time of wind turbines and installments, hours per year; P is the cost of the replaced energy, USD/(kW·hour).

Next, we will use formulas to calculate the payback period of bioenergy plants. We can determine the empirical relation of capital expenditures to the volume of bioenergy installations (in \$1000) by generalizing and analyzing the data on capital expenses:

$$Tb=k_b/V_{\mathrm{b}} \quad (3)$$

where k_b is the average capital expenditures on; V_{b} is the volume of the bioreactor, м^3.

4. RESULTS

The results of the calculations for the average of the regions of Russia using formula (1) with the coefficient I = 2.0, the annual amount of solar energy, that is received by the solar collector during warm periods of the year (from April to October) E = 4.016 GJ (m^2·year), energy C = 0.50. The payback period for south regions of Russia increases from 2 to 25 years, with the increase in unit capital investments in solar collectors k from \$100 to \$600/m^2 and the decrease of the price of replaced energy V from \$400 to \$150/GJ. The cost of acceptable for practical use solar collectors with a payback period of <7 years and the increase of price of the replaced thermal energy from \$150 to \$400/GJ will equate to \$100-300/m^2 (Moiseev, 2017a; Moiseev, 2017b; Moiseev and Sorokin, 2018).

However, it is noteworthy that present tariffs for thermal energy in Russia's southern regions are $200/Gcal. Thus, the minimal acceptable cost of solar collectors with a payback period of 7 years should not exceed $59/m^2. This condition must be fulfilled when designing the project and the widespread introduction of solar installations.

Wind installation's payback period increased from 2 to 30 years. At the same time, the average capital investments in wind turbines increased from $400 to $1500/kW, and the cost of replaced energy decreased (Van Reeth and Osokin, 2019).

The minimal capital investment in ready-for-practical-use wind installations with a payback period of no more than 7 years and the increase of the price of replaced energy is $400-$1000/kW. What's noteworthy is that current tariffs for electricity energy on the south of Russia are lower than the average values throughout Russia. Because of this, the minimal capital investments in wind turbines and wind installations with a payback period of 7 years cannot be more than the average throughout the entirety of Russia.

Techno-economic assessments of different types of wind turbines were carried out and showed high-efficiency rates of wind installations in the energy system of various autonomous facilities. The cost of electricity per kW is estimated to be $0.1 at most. The cost of wind installations without introducing automated production is $950/kW.

Unit capital costs can be lowered in serial production to a maximum of $1150/kW, after which these wind turbines will be recommended for exploitation in the southern regions of Russia.

Orthogonal wind turbines with five blades of a similar design of an American manufacturer Falcon Euro with a power of 7.5-20.0 kW are also quite economical. Unit capital costs for them are not more than $1620/kW.

Capital expenses for the most economical 15 kW in power wind turbines are $1070/kW. These wind installations can be recommended to be used in the south of Russia today.

In 2018-2019, Thomson Reuters Laboratory in the Financial University conducted studies on the use of renewable energy in Russia.

The cost of biogas obtained from installations of medium power (the volume of the bioreactor is 10-100 m^3) and high-power (the volume of the bioreactor is 100-1000 m^3) is about $15,000-60,000/m^3. This is cheaper than the price of natural gas in the domestic market, which currently costs $120,000 m^3.

The cost of biogas produced by low-power plants and volumes of reactors of 0.3-10 m^3 is pretty high right now - $80,000-270,000 m^3. When considering the significant capital expenditures on the construction and exploitation of gas networks in rural areas in many regions of Russia, the use of high, medium and low biogas power plants to supply consumers with heat and gas is economically justified (Zubakin et al., 2015; Osokin, 2019; Osokin and Van Reeth, 2019).

Solar installments with heat-pumping systems will allow to significantly decrease the consumption of biogas for personal needs and lower the price of low-power biogas plants' product to $30-110/m^3.

5. CONCLUSION

A comprehensive assessment of the efficiency of power plants using renewable energy sources in Russia allows us to make the following conclusions.

The payback period of SWH plants for south regions of Russia increases from 2 to 25 years, with the increase in unit capital investments in solar collectors from $100 to $500/m^2 and the decrease of the price of replaced energy from $2500 to $1000/GJ. When considering $9/GJ tariffs on thermal energy, the cost of solar collectors with a payback period of 7 years cannot be more than $59/m^2 (Jaramillo and Matthews, 2005; Lopatin, 2019a).

Unit price of solar collectors released in Russia and abroad is $100-400/m^2, and the payback period can be up to 5-16 years. Capital expenses for SWH plants with a drain-down system are 30-40% times lower than traditional SWHs with circulation systems, and their payback period when using the cheapest solar collectors does not exceed 5-5.7 years. This makes it possible to use them as a heat supply in low-rise buildings along with gas and electric heaters and high-rise buildings in conjunction with boiler blocks and roof boilers. As a result, the annual gas consumption is reduced by 40-60% (Milbrabdt et al., 2014; Morgan and Yang, 2001).

It would also be best if most autonomous devices used orthogonal (on a vertical axis) installations. They are very beneficial, as their performance does not depend on the direction of the wind, and they operate at the low wind speeds of 2-3 m/s. The payback period of renewable energy increases from 2 to 30 years when increasing unit capital expenditures for wind installations from 2 to 5 rubles/kW·h. The minimal permittable unit capital investments in renewable energy with a payback period of 7 years cannot be more than $1150/kW (An et al., 2019a; An et al., 2019b).

Unit capital costs for orthogonal wind turbines Falcon Euro are not more than $1620/kW. Capital expenses for the most economical 15 kW in power wind turbines are $1070 (43,000 rubles)/kW. These wind installations can be recommended to be used in the south of Russia today.

The cost of biogas obtained from installations of medium power (the volume of the bioreactor is 10-100 m^3) and high-power (the volume of the bioreactor is 100-1000 m^3) is about $15,000-60,000/m^3. This is cheaper than the price of natural gas in the domestic market, which currently costs $120,000/m^3 (An et al., 2019c; Meynkhard, 2020; Lopatin, 2019b).

The cost of biogas produced by low-power plants and volumes of reactors of 0,3-10 m^3 is \$80,000-270,000/m^3. Recommended design schematics that use them with heat-pumping systems will allow to significantly decrease the consumption of biogas for personal needs and lower the price of low-power biogas plants' product to \$30-110/m^3.

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REFERENCES

Ahmed, S.I., Johari, A., Hashim, H., Mat, R., Lim, J.S., Nagadi, N., Ali, A. (2014), Optimal landfill gas utilization for renewable energy production. Environmental Progress and Sustainable Energy, 34(1), 289-298.

Amini, H.R., Reinhart, D.R. (2011), Regional prediction of long-term landfill gas to energy potential. Waste Management, 31(9-10), 2020-2026.

An, J., Mikhaylov, A., Lopatin, E., Moiseev, N., Richter, U.H., Varyash, I., Dooyum, Y.D., Oganov, A., Bertelsen, R.G. (2019b), Bioenergy potential of Russia: Method of evaluating costs. International Journal of Energy Economics and Policy, 9(5), 244-251.

An, J., Mikhaylov, A., Moiseev, N. (2019c), Oil price predictors: Machine learning approach. International Journal of Energy Economics and Policy, 9(5), 1-6.

An, J., Mikhaylov, A., Sokolinskaya, N. (2019a), Oil incomes spending in sovereign fund of Norway (GPFG). Investment Management and Financial Innovations, 16(3), 10-17.

Bansal, A., Illukpitiya, P., Singh, S.P., Tegegne, F. (2013), Economic competitiveness of ethanol production from cellulosic feedstock in Tennessee. Renewable Energy, 59, 53-57.

Bove, R., Lunghi, P. (2006), Electric power generation from landfill gas using traditional and innovative technologies. Energy Conversion and Management, 47(11-12), 1391-1401.

Cai, X., Zhang, X., Wang, D. (2011), Land availability for biofuel production. Environmental Sciences Technology, 45(2), 334-339.

Chiemchaisri, C., Chiemchaisri, W., Kumar, S., Wicramarachchi, P.N. (2012), Reduction of methane emission from landfill through microbial activities in cover soil: A brief review. Journal Critical Reviews in Environmental Science and Technology, 42(4), 412-434.

Denisova, V. (2019), Energy efficiency as a way to ecological safety: Evidence from Russia. International Journal of Energy Economics and Policy, 9(5), 32-37.

Denisova, V., Mikhaylov, A., Lopatin, E. (2019), Blockchain infrastructure and growth of global power consumption. International Journal of Energy Economics and Policy, 9(4), 22-29.

Gardner, N., Manley, B.J.W., Pearson, J.M. (1993), Gas emissions from landfills and their contributions to global warming. Applied Energy, 44(2), 166-174.

Jaramillo, P., Matthews, H.S. (2005), Landfill-gas-to-energy projects: Analysis of net private and social benefits. Environmental Science and Technology, 39, 7365-7373.

Lopatin, E. (2019a), Methodological approaches to research resource saving industrial enterprises. International Journal of Energy Economics and Policy, 9(4), 181-187.

Lopatin, E. (2019b), Assessment of Russian banking system performance and sustainability. Banks and Bank Systems, 14(3), 202-211.

Meynkhard, A. (2019), Energy efficient development model for regions of the Russian federation: Evidence of crypto mining. International Journal of Energy Economics and Policy, 9(4), 16-21.

Meynkhard, A. (2020), Priorities of Russian energy policy in Russian-Chinese relations. International Journal of Energy Economics and Policy, 10(1), 65-71.

Mikhaylov, A. (2018a), Pricing in oil market and using probit model for analysis of stock market effects. International Journal of Energy Economics and Policy, 8(2), 69-73.

Mikhaylov, A. (2018b), Volatility spillover effect between stock and exchange rate in oil exporting countries. International Journal of Energy Economics and Policy, 8(3), 321-326.

Mikhaylov, A. (2019a), Oil and gas budget revenues in Russia after crisis in 2015. International Journal of Energy Economics and Policy, 9(2), 375-380.

Mikhaylov, A., Sokolinskaya, N., Lopatin, E. (2019), Asset allocation in equity, fixed-income and cryptocurrency on the base of individual risk sentiment. Investment Management and Financial Innovations, 16(2), 171-181.

Mikhaylov, A., Sokolinskaya, N., Nyangarika, A. (2018), Optimal carry trade strategy based on currencies of energy and developed economies. Journal of Reviews on Global Economics, 7, 582-592.

Milbrabdt, A.R., Heimiller, D.M., Perry, A.D., Field, C.B. (2014), Renewable energy potential on marginal lands in the United States. Renewable and Sustainable Energy Review, 29, 473-481.

Moiseev, N. (2017a), Forecasting time series of economic processes by model averaging across data frames of various lengths. Journal of Statistical Computation and Simulation, 87(17), 3111-3131.

Moiseev, N. (2017b), p-value adjustment to control type I errors in linear regression models. Journal of Statistical Computation and Simulation, 87(9), 1701-1711.

Moiseev, N. (2017c), Linear model averaging by minimizing mean-squared forecast error unbiased estimator. Model Assisted Statistics and Applications, 11(4), 325-338.

Moiseev, N., Akhmadeev, B. (2017), Agent-based simulation of wealth, capital and asset distribution on stock markets. Journal of Interdisciplinary Economics, 29(2), 176-196.

Moiseev, N., Sorokin, A. (2018), Interval forecast for model averaging methods. Model Assisted Statistics and Applications, 18(2), 125-138.

Morgan, S.M., Yang, Q. (2001), Use of landfill gas for electricity generation. Practice Periodical of Hazardous, Toxic, and Radio Waste Management, 5(1), 14-24.

Morris, J.W., Barlaz, M.A. (2011), A performance-based system for the long-term management of municipal waste landfills. Waste Management, 31(4), 649-662.

Nyangarika, A., Mikhaylov, A., Richter, U. (2019a), Influence oil price towards economic indicators in Russia. International Journal of Energy Economics and Policy, 9(1), 123-130.

Nyangarika, A., Mikhaylov, A., Richter, U. (2019b), Oil price factors: Forecasting on the base of modified auto-regressive integrated moving average model. International Journal of Energy Economics and Policy, 9(1), 149-160.

Nyangarika, A., Mikhaylov, A., Tang, B.J. (2018), Correlation of oil prices and gross domestic product in oil producing countries. International Journal of Energy Economics and Policy, 8(5), 42-48.

Osokin, N. (2019), User engagement and gratifications of NSO supporters on Facebook: Evidence from European football. International Journal of Sports Marketing and Sponsorship, 20(1), 61-80.

Osokin, N., Solntsev, I. (2017), Constructing a multidimensional indicator of sports development: The case of the football development index. Journal of the New Economic Association, 36(4), 135-163.

Osokin, N., Solntsev, I., Zaytsev, P. (2018), The socio-economic importance of grassroots football in Russia: Possibilities for research. Journal of the New Economic Association, 40(4), 184-191.

Osokin, N., Van Reeth, D. (2019), TV broadcasting of major football tournaments in Russia: Economic context and consumer preferences.

Journal of the New Economic Association, 41(1), 159-185.
Solntsev, I., Osokin, N. (2018), Designing a performance measurement framework for regional networks of national sports organizations: Evidence from Russian football. Managing Sport and Leisure, 23(1-2), 7-27.
Van Reeth, D., Osokin, N. (2019), The impact of hosting the 2018 FIFA world cup on differences in TV viewership between seasoned football fans and occasional watchers of football games in Russia. Journal of Sports Economics. DOI: 10.1177/1527002519885421.
Zubakin, V.A., Kosorukov, O.A., Moiseev, N.A. (2015), Improvement of regression forecasting models. Modern Applied Science, 9(6), 344-353.

APPENDIX

Appendix 1: The rate for the hourly volumes of electricity purchased, sold at the voltage level (below 0.4 kWh) in May 2019

Day	0:00-1:00	10:00-11:00	20:00-21:00	23:00-0:00	Average
1	2 307,64	2 524,05	2 671,65	2 421,86	2 366,25
2	2 278,98	2 568,26	2 701,38	2 417,09	2 383,98
3	2 404,39	2 685,98	2 768,45	2 463,54	2 464,47
4	2 391,28	2 555,93	2 687,91	2 450,91	2 406,27
5	2 422,82	2 652,90	2 728,78	2 454,87	2 448,25
6	2 203,01	2 609,13	2 571,10	2 429,72	2 439,77
7	2 243,75	2 620,71	2 661,78	2 463,33	2 458,01
8	2 333,59	2 694,17	2 590,43	2 420,38	2 495,36
9	2 333,48	2 424,85	2 532,68	2 396,16	2 268,69
10	2 357,18	2 581,07	2 762,12	2 446,82	2 415,61
11	2 437,96	2 764,44	2 775,90	2 451,53	2 514,12
12	2 179,27	2 485,65	2 584,84	2 327,83	2 278,18
13	2 056,15	2 515,96	2 383,47	2 328,70	2 254,36
14	2 264,02	2 524,81	2 496,89	2 416,61	2 412,22
15	2 257,86	2 629,29	2 508,88	2 439,11	2 457,54
16	2 229,62	2 640,69	2 569,97	2 350,07	2 425,87
17	2 374,69	2 664,61	2 629,03	2 560,77	2 499,58
18	2 547,82	2 692,89	2 673,06	2 551,36	2 569,71
19	2 520,60	2 560,52	2 554,58	2 552,59	2 456,53
20	2 460,66	2 664,10	2 690,00	2 496,21	2 534,97
21	2 263,38	2 714,54	2 715,09	2 471,91	2 524,30
22	2 245,91	2 756,74	2 745,10	2 476,44	2 547,95
23	2 304,91	2 758,67	2 752,99	2 589,42	2 576,52
24	2 377,07	2 845,48	2 823,30	2 687,59	2 633,74
25	2 512,53	2 860,27	2 845,42	2 582,66	2 645,09
26	2 439,50	2 714,88	2 715,32	2 497,85	2 516,08
27	2 416,79	2 870,74	2 771,76	2 477,05	2 646,17
28	2 253,41	2 697,54	2 614,29	2 444,88	2 499,70
29	2 243,08	2 789,27	2 756,78	2 512,82	2 541,19
30	2 231,58	2 750,84	2 722,12	2 486,33	2 498,77
31	2 208,16	2 729,02	2 701,96	2 682,86	2 509,03

Appendix 2: The rate for the hourly volumes of electricity purchased at the voltage level (0.4-1 kWh) in May 2019

Day	0:00-1:00	10:00-11:00	20:00-21:00	23:00-0:00	Average
1	2 809,24	3 025,65	3 173,25	2 923,46	2 867,85
2	2 780,58	3 069,86	3 202,98	2 918,69	2 885,58
3	2 905,99	3 187,58	3 270,05	2 965,14	2 966,07
4	2 892,88	3 057,53	3 189,51	2 952,51	2 907,87
5	2 924,42	3 154,50	3 230,38	2 956,47	2 949,85
6	2 704,61	3 110,73	3 072,70	2 931,32	2 941,37
7	2 745,35	3 122,31	3 163,38	2 964,93	2 959,61
8	2 835,19	3 195,77	3 092,03	2 921,98	2 996,96
9	2 835,08	2 926,45	3 034,28	2 897,76	2 770,29
10	2 858,78	3 082,67	3 263,72	2 948,42	2 917,21
11	2 939,56	3 266,04	3 277,50	2 953,13	3 015,72
12	2 680,87	2 987,25	3 086,44	2 829,43	2 779,78
13	2 557,75	3 017,56	2 885,07	2 830,30	2 755,96
14	2 765,62	3 026,41	2 998,49	2 918,21	2 913,82
15	2 759,46	3 130,89	3 010,48	2 940,71	2 959,14
16	2 731,22	3 142,29	3 071,57	2 851,67	2 927,47
17	2 876,29	3 166,21	3 130,63	3 062,37	3 001,18
18	3 049,42	3 194,49	3 174,66	3 052,96	3 071,31
19	3 022,20	3 062,12	3 056,18	3 054,19	2 958,13
20	2 962,26	3 165,70	3 191,60	2 997,81	3 036,57
21	2 764,98	3 216,14	3 216,69	2 973,51	3 025,90
22	2 747,51	3 258,34	3 246,70	2 978,04	3 049,55
23	2 806,51	3 260,27	3 254,59	3 091,02	3 078,12
24	2 878,67	3 347,08	3 324,90	3 189,19	3 135,34
25	3 014,13	3 361,87	3 347,02	3 084,26	3 146,69
26	2 941,10	3 216,48	3 216,92	2 999,45	3 017,68

(Contd...)

Appendix 2: (*Continued*)

Day	0:00-1:00	10:00-11:00	20:00-21:00	23:00-0:00	Average
27	2 918,39	3 372,34	3 273,36	2 978,65	3 147,77
28	2 755,01	3 199,14	3 115,89	2 946,48	3 001,30
29	2 744,68	3 290,87	3 258,38	3 014,42	3 042,79
30	2 733,18	3 252,44	3 223,72	2 987,93	3 000,37
31	2 709,76	3 230,62	3 203,56	3 184,46	3 010,63

Appendix 3: Rate for actual hourly volumes of electricity purchased at a voltage level (1-35 kWh) in May 2019

Day	0:00-1:00	10:00-11:00	20:00-21:00	23:00-0:00	Average
1	3 193,72	3 410,13	3 557,73	3 307,94	3 252,33
2	3 165,06	3 454,34	3 587,46	3 303,17	3 270,06
3	3 290,47	3 572,06	3 654,53	3 349,62	3 350,55
4	3 277,36	3 442,01	3 573,99	3 336,99	3 292,35
5	3 308,90	3 538,98	3 614,86	3 340,95	3 334,33
6	3 089,09	3 495,21	3 457,18	3 315,80	3 325,85
7	3 129,83	3 506,79	3 547,86	3 349,41	3 344,09
8	3 219,67	3 580,25	3 476,51	3 306,46	3 381,44
9	3 219,56	3 310,93	3 418,76	3 282,24	3 154,77
10	3 243,26	3 467,15	3 648,20	3 332,90	3 301,69
11	3 324,04	3 650,52	3 661,98	3 337,61	3 400,20
12	3 065,35	3 371,73	3 470,92	3 213,91	3 164,26
13	2 942,23	3 402,04	3 269,55	3 214,78	3 140,44
14	3 150,10	3 410,89	3 382,97	3 302,69	3 298,30
15	3 143,94	3 515,37	3 394,96	3 325,19	3 343,62
16	3 115,70	3 526,77	3 456,05	3 236,15	3 311,95
17	3 260,77	3 550,69	3 515,11	3 446,85	3 385,66
18	3 433,90	3 578,97	3 559,14	3 437,44	3 455,79
19	3 406,68	3 446,60	3 440,66	3 438,67	3 342,61
20	3 346,74	3 550,18	3 576,08	3 382,29	3 421,05
21	3 149,46	3 600,62	3 601,17	3 357,99	3 410,38
22	3 131,99	3 642,82	3 631,18	3 362,52	3 434,03
23	3 190,99	3 644,75	3 639,07	3 475,50	3 462,60
24	3 263,15	3 731,56	3 709,38	3 573,67	3 519,82
25	3 398,61	3 746,35	3 731,50	3 468,74	3 531,17
26	3 325,58	3 600,96	3 601,40	3 383,93	3 402,16
27	3 302,87	3 756,82	3 657,84	3 363,13	3 532,25
28	3 139,49	3 583,62	3 500,37	3 330,96	3 385,78
29	3 129,16	3 675,35	3 642,86	3 398,90	3 427,27
30	3 117,66	3 636,92	3 608,20	3 372,41	3 384,85
31	3 094,24	3 615,10	3 588,04	3 568,94	3 395,11

Appendix 4: Rate for actual hourly volumes of electricity purchased at a voltage level (35-110 kWh) in May 2019

Day	0:00-1:00	10:00-11:00	20:00-21:00	23:00-0:00	Average
1	4 196,12	4 412,53	4 560,13	4 310,34	4 254,73
2	4 167,46	4 456,74	4 589,86	4 305,57	4 272,46
3	4 292,87	4 574,46	4 656,93	4 352,02	4 352,95
4	4 279,76	4 444,41	4 576,39	4 339,39	4 294,75
5	4 311,30	4 541,38	4 617,26	4 343,35	4 336,73
6	4 091,49	4 497,61	4 459,58	4 318,20	4 328,25
7	4 132,23	4 509,19	4 550,26	4 351,81	4 346,49
8	4 222,07	4 582,65	4 478,91	4 308,86	4 383,84
9	4 221,96	4 313,33	4 421,16	4 284,64	4 157,17
10	4 245,66	4 469,55	4 650,60	4 335,30	4 304,09
11	4 326,44	4 652,92	4 664,38	4 340,01	4 402,60
12	4 067,75	4 374,13	4 473,32	4 216,31	4 166,66
13	3 944,63	4 404,44	4 271,95	4 217,18	4 142,84
14	4 152,50	4 413,29	4 385,37	4 305,09	4 300,70
15	4 146,34	4 517,77	4 397,36	4 327,59	4 346,02
16	4 118,10	4 529,17	4 458,45	4 238,55	4 314,35
17	4 263,17	4 553,09	4 517,51	4 449,25	4 388,06
18	4 436,30	4 581,37	4 561,54	4 439,84	4 458,19
19	4 409,08	4 449,00	4 443,06	4 441,07	4 345,01
20	4 349,14	4 552,58	4 578,48	4 384,69	4 423,45

(*Contd...*)

Appendix 4: (*Continued*)

Day	0:00-1:00	10:00-11:00	20:00-21:00	23:00-0:00	Average
21	4 151,86	4 603,02	4 603,57	4 360,39	4 412,78
22	4 134,39	4 645,22	4 633,58	4 364,92	4 436,43
23	4 193,39	4 647,15	4 641,47	4 477,90	4 465,00
24	4 265,55	4 733,96	4 711,78	4 576,07	4 522,22
25	4 401,01	4 748,75	4 733,90	4 471,14	4 533,57
26	4 327,98	4 603,36	4 603,80	4 386,33	4 404,56
27	4 305,27	4 759,22	4 660,24	4 365,53	4 534,65
28	4 141,89	4 586,02	4 502,77	4 333,36	4 388,18
29	4 131,56	4 677,75	4 645,26	4 401,30	4 429,67
30	4 120,06	4 639,32	4 610,60	4 374,81	4 387,25
31	4 096,64	4 617,50	4 590,44	4 571,34	4 397,51