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Ukrainian Market of Electrical Energy: Reforming, Financing, Innovative Investment, Efficiency Analysis, and Audit

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Abstract: The aim of this research is to determine the influence of electrical energy market regulation reform in Ukraine on the competitive environment, the reproduction processes of financial and innovative support, and the energy efficiency of the national economy. The authors have put forward and verified the hypothesis that, under conditions of institutional maturity of the Ukrainian electrical energy market, its liberalization and separation of the kinds of activity related to generation, transmission, and distribution leads to a decrease in prices, and the level of economic concentration stimulates implementation of innovations and the formation of reports on sustainable development. Over the thirteen-year time interval, a steady trend of decreasing energy intensity of the Ukrainian economy was established, and the appropriateness of energy efficiency management based on strategic targets was substantiated. The electricity market model in Ukraine is defined as a hybrid one, with an emphasis on trade under bilateral agreements. It was statistically found that liberalization of the electrical energy market in Ukraine contributed to a decrease in prices, with the exception of the areas of largest household and non-household consumers. The high level of asset concentration in the accounts of large enterprises was revealed, and the conclusion concerning the improvement of the competitive environment in the electricity production sector and the existence of the features of natural monopolies in the areas of transmission and distribution of electricity was made. The assessment of the financial competitive ability and profitability of electrical energy market entities was made, the main entities of the investment activity and the sources of their financing were characterized, and innovations were emphasized. The role of the standards of the audit of integrated reporting of the Ukrainian energy holdings and their role in ensuring sustainable development was determined.

Keywords: electrical energy; market; Ukraine; financing; innovative investment; efficiency; analysis; audit

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Citation: Kostyrko, R.; Kosova, T.; Kostyrko, L.; Zaitseva, L.; Melnychenko, O. Ukrainian Market of Electrical Energy: Reforming, Financing, Innovative Investment, Efficiency Analysis, and Audit. *Energies* **2021**, *14*, 5080. https://doi.org/10.3390/en14165080

Academic Editor: Djaffar Ould-Abdeslam

Received: 28 June 2021
Accepted: 16 August 2021
Published: 18 August 2021

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1. Introduction

At global and European levels, energy sustainability is determined as a top priority [1]. The electricity market has general principles of development and regulation inherent in other commodity markets, but it is quite specific due to the lack of material form in its main product, as well as the existence of natural monopoly sectors. Since 1996, the Ukrainian electricity market and its independent regulator have gone a long way in their

evolution, which can be described as a vector of movement from the "single buyer" market model to the target model of the national market, determined by EU legislation. The fundamental reform of economic relations; electricity pricing; and the flow of monetary, financial, and investment resources is related to the signing by Ukraine of the Association Agreement with the EU and the implementation of the directives and regulations of the Third Energy Package. According to Energy Community Secretariat estimates, based on the results of 2020, the level of their implementation amounted to 49% [2]. Deepening Ukraine's integration with the Energy Market of the European Union and joining the general European energy system *ENTSO-E* (European Network of Transmission System Operators for Electricity) will make it possible to increase national energy security, while increasing the technical possibilities of electrical power exchange between neighboring countries will stimulate competition in the internal market.

This article fills a gap in the scientific literature related to the lack of a transmission mechanism of electricity market development at the "industry-entity" level. Its importance lies in the selected principles of sustainability, liberalization, and innovation, demonstrating the specific recommendation level for energy efficiency in terms of electricity improvement in Ukraine in general and also on individual energy corporations.

2. Materials and Methods

This study is based on data from the State Statistics Service of Ukraine regarding a dynamic series of indicators of energy balances for the period 1990–2019, energy intensity of the national economy, and energy consumption based on renewable sources for the period 2007–2019. Conclusions regarding the energy market reform model's impact on tariff policy in Ukraine are made based on the dynamics of electricity prices for household and non-household consumers. To assess the concentration and capabilities of the financial and investment provision of reproducible processes, we used data from the summary financial reporting of economic entities that are involved in electric power generation, transmission, and distribution. Reports on the results of the activity of the National Energy and Utilities Regulatory Commission (NEURC) were the main source of information for the analysis of the state of the competitive environment in the electrical energy market and schemes of its innovative investment.

When choosing sources of information, the fact that the efficiency of energy companies in eastern Europe is significantly influenced by non-financial factors that are reflected in integrated reporting was taken into account. Therefore, their financial audit should consider the state of corporate social responsibility and the effectiveness of sustainable development; the responsibility of an auditor should be generalized by the length of the integrated audit vector [3]. Companies in the energy sector have a high level of social responsibility, including the quality of disclosure of financial and non-financial information in integrated reporting [4].

The theoretical and methodological principles laid down in the international standards of formation and dissemination of integrated reporting, and its audit, played a significant role in the preparation of the article. The conclusions from the results of energy efficiency analysis are based on alternative approaches to its calculation.

The integrated reporting of leading energy holdings of Ukraine (DTEK, SE "NNEGC "Energoatom", Naftogaz Group) allowed the formation of an idea regarding the results of efficiency analysis and audit within the framework of the implementation of the UN sustainable development concept. One of its main goals is to ensure clean and affordable energy consumption, responsible energy consumption, sustainable economic growth, and mitigation of the negative effects of climate change. Econometric modeling based on the Kuznets ecological curve allowed the international team of scientists to establish direct correlation between income per capita and carbon dioxide exhausts, which makes the problem for industrially developed countries relevant [5]. Environmental protection and pro-ecological actions [6] and local investments in the development of renewable energy sources [7] are especially emphasized.

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The purpose of the study is to determine the impact of the reform of regulations of the electricity market of Ukraine on the competitive environment, financial and investment support of reproducible processes, and energy efficiency of the national economy. The authors put forward and verified the hypothesis that, in the current conditions of institutional maturity of the Ukrainian electricity market, its liberalization and separation of types of activity involving generation, transmission, and distribution leads to decreasing prices and a lowering level of economic concentration, stimulates the implementation of innovations, and results in the formation of reports concerning sustainable development.

3. Methodology

The legislation of Ukraine defines the electricity market as a system of relations, arising between market participants during the purchase and sale of electricity and/or auxiliary services and the transmission, distribution, and supply of electrical energy to consumers [8]. In terms of the institutional coordinates of the national economy, the electricity market consists of the following types of economic activities that have relevant codes: National Classification of Economic Activities (NCEA-2010); production of electricity (35.11); transmission of electricity (35.12); distribution of electricity (35.13); and trade of electricity (35.14) [9].

The electric power industry is the basis on which gross domestic product (GDP) is created in all industries of the national economy. Traditionally, two indicators of energy intensity, which are calculated by the ratio of the amount of energy produced (consumed) and the GDP, are used for energy efficiency analysis. The level of energy intensity is influenced by many factors, including: the processes of industrialization and deindustrialization, introduction of energy innovations, energy carrier prices, the phase of the business cycle, economic growth, or recession [10]. Economic growth reflects the technical innovations that improve labor productivity, increase production efficiency, reduce production costs, and increase wages [11].

The liberalization of markets is the basis of the EU energy policy, which directly affects their competitiveness, environmental sustainability, energy security, and electricity prices. At the same time, the effect of reducing the latter is not always obtained; contrary to expectations in some European countries, prices tend to increase [12]. The experience of deregulation and liberalization of electricity markets, based on American and European practice, has not always been successful [13,14]. The main risks are associated with high price volatility. To manage them and optimize the portfolios of retail enterprises operating in liberalized electricity markets, the Markowitz theory [15] and the generalized autoregressive conditional heteroskedasticity (MS-GARCH) model [16] are used.

The state policy in the electric power sector of many countries includes focusing on programs to support the development and implementation of low-carbon technologies in order to reduce their cost and, thus, reduce the long-term costs of decarbonization of the sector [17]. One priority of investing in the energy sector is to replace fossil fuels with renewable energy [18].

In the current conditions, the role of the electric power industry in ensuring sustainable development is growing, as the achievement of energy efficiency becomes a global criterion for the functioning of economic systems at different hierarchical levels [19].

The guiding principles of the Global Reporting Initiative (GRI) [20] and international standard AA1000 (Account Ability) [21] are the methodologies used to assess sustainability within organizations. They are the grounds for analysis of the quality of reporting on corporate responsibility and provide for the interests of stakeholders in the reporting process [22]. The major difference in the methodology of non-financial reporting is that emphasis is placed on qualitative estimates [23]. However, the concept of integrated reporting incorporates information concerning finances, social supervision, the environment, and social aspects into a unified integrated format [24,25]. The level of a company's financial security depends, not so much on its activity indicators, but on how it is perceived by decision-makers and other stakeholders [26].

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The theoretical basis for the formation of integrated reporting is institutional theory: the theory of diffusion and decision making [27]. Managers of corporate social responsibility play an essential role in the legitimization of integrated reporting [28]. Under modern conditions, the International Integrated Reporting Council (IIRC) extends the sphere of integrated reporting, using the concept of multiple capitals, and requires clarification of a company's business model, which will simplify communications within cost-oriented management. Not only economic entities, based on private capital, but also state and non-profit establishments are increasingly becoming the entities of integrated reporting formation [29].

4. Results

4.1. Analysis of Energy Efficiency of Economy of Ukraine as the Environment of Reforming the Electrical Energy Market

Within the period 2007–2019, the volume of GDP of the Ukrainian economy fluctuated; its minimum values were observed in 2015 (481.5 Int'l$ BLN) and the maximum values were observed in 2008 (610.4 Int'l$ BLN). The magnitude of GDP in 2019 (538.4 Int'l$ BLN) exceeded insignificantly the relevant indicator of 2014 (533.6 Int'l$ BLN), and was a little lower than the level of 2010 (540.3 Int'l$ BLN).

However, the general indicators of the functioning of the electricity market had a steady downward trend: final energy consumption decreased from 86 to 49.4 billion toe, or 1.74 times total primary energy supply—from 139.3 to 89.1 billion toe, or by 1.56 times (Table 1).

Table 1. Dynamics of indicators for calculation of energy intensity (EI) for 2007–2019 in Ukraine.

Indicator	Unit	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
GDP, PPP 2017	Int'l$ BLN	596.7	610.4	520.3	540.3	569.8	571.2	571	533.6	481.5	492.2	504.4	521.5	538.4
Final energy consumption	toe BLN	86.0	83.3	67.6	74.0	75.9	73.1	69.6	61.5	50.8	51.6	49.9	51.5	49.4
Total primary energy supply	toe BLN	139.3	134.6	114.4	132.3	126.4	122.5	115.9	105.7	90.1	94.4	89.5	93.5	89.1

Source: calculated in [30].

During the period 2007–2019, Ukraine had a steady trend of reducing the energy intensity of its GDP: the base of final energy consumption (EI1) from 0.144 to 0.092 toe/thsd. Int'l$, or by 1.57 times, and the base of total primary energy supply (EI2) from 0.234 to 0.165, or by 1.42 times (Figure 1).

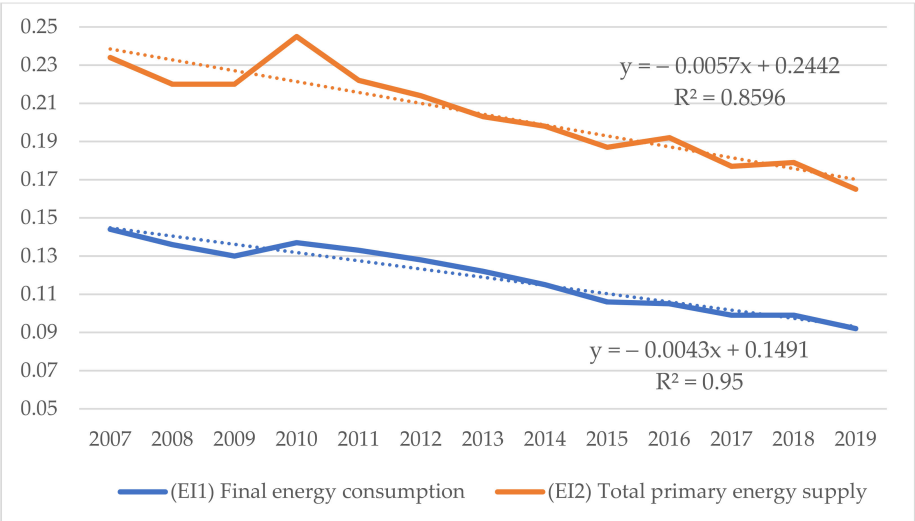

Figure 1. Dynamics of energy intensity for 2007–2019 in Ukraine, toe/thsd. Int'l$. Source: calculated in [30].

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Both energy consumption indicators are formalized by a downward linear trend, with high values of the multiple coefficient of determination factor close to 1 (0.8596 for EI1, 0.95 for EI2). The negative value of the coefficient at factor «x» indicates the annual rate of reducing energy intensity, which is 0.0043 toe/thsd. Int'l$ for EI1, 0.0057 toe/thsd. Int'l$ for EI2.

Thus, under Ukrainian conditions, a decrease in energy intensity means the improvement of conditions of energy use, but the final conclusions on energy efficiency cannot be drawn due to the lack of information on the reserves of its further reduction. To control energy intensity, EU countries use its target levels, the achievement of which is a criterion for energy efficiency [31]. The threshold level of energy intensity has an asymmetric effect of energy consumption on economic growth: a higher-level significantly inhibits it, a lower-level stimulates it [32].

In 2020, within the framework of the unified energy system of Ukraine in the framework of the united energy system of Ukraine, the volume of delivered electrical energy made up 148,304.9 MW; the share of different types of electrical power generation was made up of: nuclear power plants (SE "NNEGC "Energoatom")—51.7%, thermal power plants (DTEK)—26.6%, thermal electrical centrals and cogeneration plants—9.5%, hydro power plants (PJSC "Ukrhydroenergo")—5.0%, renewable sources—7.3% [33].

The main models of the electricity market include: pools, bilateral contracts, and hybrid models. The modern institutional model of the electricity market in Ukraine was introduced in July 2019. Its characteristic features are [34]:

- Differentiation of retail, wholesale markets, the market of universal and auxiliary services;
- Creation of organized areas of the electricity market; the "day ahead" market and intraday market (SC "Market Operator"), balancing market (PJSC "NPC "Ukrenergo"), the market of electrical energy generated from alternative sources (SC "Guaranteed Buyer");
- Free choice and replacement of electricity suppliers by consumers, concluding bilateral agreements with them;
- Functional and legal separation of operators of electricity distribution and transmission systems, non-discriminatory access of users to them; emergence of institutions of suppliers of universal services, "last hope" suppliers, and traders.

In Ukraine, the electricity trade under bilateral agreements occupies the largest share in all market sectors: total—67.9%; in the trade zone "United energy systems of Ukraine"—68.7%; in the trade zone "Island of Burshtynska TEP"—49.7%. Thus, the model of the electrical energy market in Ukraine can be defined as a hybrid one with the emphasis on trade by bilateral agreements, and its reform is aimed at furthering the reduction of energy intensity of the national economy.

4.2. Assessment of Market Capacity and Electrical Energy Prices in Areas under Liberalization Conditions

The influence of the liberalization of the electrical energy market on the process is demonstrated in Table 2.

The highest level of tariffs was observed in the pre-reform period (first half of 2019), in the sector of household consumers—1.05 UAH per 1 kWh, non-household consumers—2.20 UAH per 1 kWh. Up to the end of 2020, in the sector of household consumers, the prices returned to the level of the first half of 2018 (1.01 UAH per 1 kWh); in this case, in bands with annual consumption up to 5000 kWh, they decreased by 2–5% and in the interval of 5000–15,000 kWh, they increased by 1%. The increase in prices turned out to be the most substantial for the largest household consumers (above 15,000 kWh)—by 12%. The prices for non-household consumers decreased by 5%, in this case, for all ranges, except for the largest (above 150,000 kWh), where they remained unchanged (1.60 UAH per 1 kWh). They decreased most (by 14%) in the range of 70,000–150,000 kWh.

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Table 2. Average price of electricity without VAT for half-year periods in 2018–2020, UAH per 1 kWh.

	1_2018	2_2018	1_2019	2_2019	1_2020	2_2020	Index 2_2020/ 1_2018
Electricity Supply to Household Consumers—Total	**1.01**	**1.00**	**1.05**	**1.03**	**1.04**	**1.01**	**1.00**
including in bands with annual consumption, kWh:							
<1000	0.84	0.90	0.86	0.89	0.82	0.80	0.95
≥1000 < 2500	0.96	0.95	0.98	0.97	1.00	0.93	0.96
≥2500 < 5000	1.11	1.09	1.12	1.12	1.11	1.09	0.98
≥5000 < 15,000	1.08	1.07	1.14	1.12	1.09	1.09	1.01
≥15,000	0.95	0.98	1.21	1.14	1.05	1.06	1.12
Electricity Supply to Non-Household Consumers—Total	**1.83**	**1.82**	**1.86**	**1.85**	**1.58**	**1.74**	**0.95**
including in bands with annual consumption, thsd.kWh:							
<20	2.05	2.05	2.20	2.11	1.86	1.97	0.96
≥20 < 500	2.03	2.07	2.08	2.05	1.81	1.89	0.93
≥500 < 2000	1.93	1.97	2.00	1.95	1.70	1.84	0.95
≥2000 < 20,000	1.88	1.92	1.93	1.90	1.64	1.77	0.94
≥20,000 < 70,000	1.75	1.74	1.89	1.81	1.47	1.64	0.94
≥70,000 < 150,000	1.72	1.74	1.89	1.67	1.35	1.48	0.86
≥150,000	1.60	1.61	1.63	1.61	1.40	1.60	1.00

Source: calculated in [35].

In most countries of the world, the main consumers of electricity in industry are small and medium-sized enterprises, the share of which is about 95%, and the main tool for researching their energy policy is an energy audit [36]. In the developed world and developing countries, there has been an increase in household electricity consumption over a twenty-year period. This causes an increase in their demand for investment in autonomous energy systems. Their installation and operation for most countries has positive effects in terms of energy security and the use of fossil energy carriers [37].

The processes taking place in Ukraine are in line with global trends. The volume of delivered electricity to household consumers within the period 2018–2020 increased from 14,958.5 to 17,114.2 billion kWt, or by 1.14 times (Figure 2).

The volume of electricity delivered to non-household consumers within the period 2018–2020 decreased from 32,508.5 to 26,354.9 billion kWt, or by 19%. This resulted in the fact that the share of non-household consumers decreased from 68.49% to 60.63%, with a maximum value of 72.21% in the second half of 2018. Thus, the liberalization of the market of electrical energy in Ukraine contributed to a decrease in prices, except for the area of the largest household and non-household consumers.

4.3. Concentration and Competition of Economic Entities That Are Involved in Electric Power Generation, Transmission, and Distribution

The concentration and competition of economic entities in the electricity market are, to some extent, antagonistic concepts, as high concentration leads to abuse of market power and the risk of future conspiracies [38]. One of the manifestations of concentration is the dominance of large enterprises in the industry. A major portion of the assets of economic entities that are involved in electric power generation, transmission, and distribution is concentrated in the accounts of large enterprises (Table 3); however, within the period 2013–2019, it decreased from 82.86% to 66.10% due to an increase in the specific weight of medium-sized (from 13.01% to 19.63%) and small (from 4.13% to 14.25%) enterprises.

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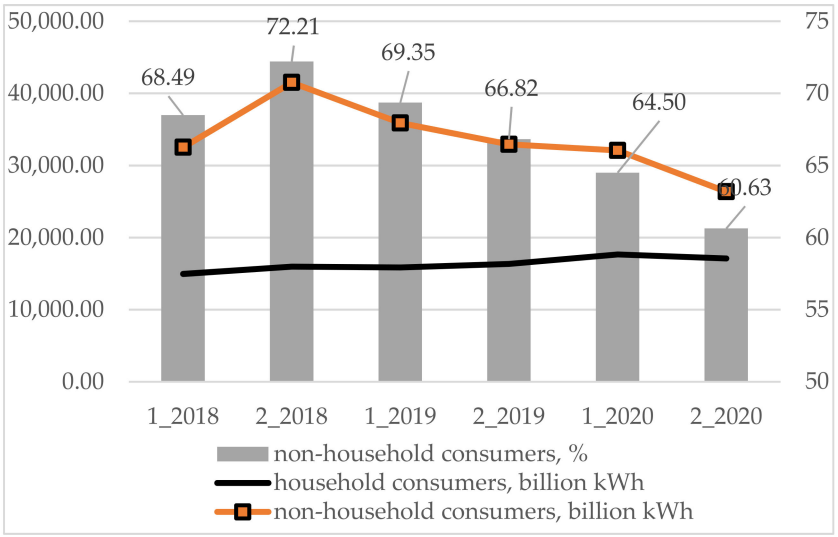

Figure 2. Dynamics of volume of delivered electricity in Ukraine. Source: calculated in [35].

Table 3. Distribution of total assets by large, medium, and small enterprises in 2013–2019.

Years	Total, bln. UAH	Structure by Enterprises, %			
		Total	Large	Medium	Small
electric power generation, transmission and distribution					
2013	410,682	100	82.86	13.01	4.13
2014	423,613.6	100	85.32	12.31	2.36
2015	463,854.4	100	82.20	15.35	2.44
2016	521,717.8	100	81.37	14.71	3.92
2017	568,503.1	100	C	c	6.16
2018	664,787	100	C	c	11.68
2019	797,604.2	100	66,10	19.65	14.25
production of electricity					
2013	311,625.5	100	85.37	9.67	4.96
2014	301,482.2	100	89.85	7.47	2.68
2015	319,365	100	88.58	8.85	2.57
2016	342,608.3	100	87.06	7.52	5.42
2017	369,383.7	100	86.41	5.06	8.53
2018	422,771.3	100	75.64	7.50	16.86
2019	503,665.9	100	63.47	15.27	21.26
transmission of electricity					
2013	15,144.97	100	98.27	1.19	0.55
distribution of electricity					
2013	57,160.98	100	95.25	3.14	1.60
2014	68,903.77	100	96.90	1.71	1.39
2015	78,071.69	100	94.06	4.20	1.75
2016	101,047.2	100	95.25	3.70	1.05
2017	114,623.8	100	96.03	2.34	1.63
2018	141,747.9	100	96.56	2.56	0.88
trade of electricity					
2013	26,750.57	100	18.49	79.70	1.81
2019	65,407.13	100	15.78	77.02	7.21

C, c (confidentially)—data not published in order to ensure compliance with the requirements of the Law of Ukraine On the State Statistics regarding confidentiality of statistical information (primary and secondary blocking of vulnerable values). Source: calculated in [39].

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The production of the electricity sector shows similar dynamics: the specific weight of the assets of large enterprises decreased from 85.37% to 63.47% due to an increase in the share of medium-sized (from 9.67% to 15.27%) and small (from 4.96% to 21.26%) enterprises. It should be noted that there is an increasing asset growth rate on the accounts of small enterprises in comparison with medium ones. The highest concentration of the assets of large enterprises is observed in the areas: transmission of electricity (98.27% in 2013, information for other years in confidential) and distribution of electricity (increase from 95.25% to 96.56%). In the area of trade of electricity, medium-sized enterprises, the share of which was 77.02% in 2019 in comparison with 79.7% in 2013, prevail. Thus, we can note the improvement of the competitive environment in the area of production of electricity and the existence of the features of natural monopolies in the areas of transmission of electricity and distribution of electricity. The area of trade of electricity is competitive enough. When it comes to assessing the dynamics of assets, it should be noted that their growth rate in the industry made up 1.94, specifically, due to generation, by 1.61 times; distribution, by 2.5 times; and trade, by 2.45 times.

Due to the liberalization of the electricity market and competition between generating companies, calculating the dispersal of losses of the distribution network is a difficult task [40,41]. In Ukraine, in 2020, the system of price regulation of natural monopoly sectors of the electricity market was reformed. The structure of tariffs for electricity distribution services took into account the costs associated with the purchase of electricity in order to compensate for the technological costs of electricity for its distribution.

The National Regulator has developed long-term parameters to stimulate the operators of transmission and distribution systems to reduce inefficient costs and losses of electricity in the networks, as well as to improve the quality of electricity supply to consumers. For operators, in each billing period, the lower limit of the mandatory purchase of electricity on the "day ahead" market, in order to compensate for the cost of technological losses for the transmission and distribution of electricity by electric networks, was set at 50% of the actual technological losses.

In the electrical power market, price regulation limits the possibility of financing investment activities [42]. In 2020, investment allowances for the construction and modernization of the infrastructure of electric networks and substations were established in Ukraine, which increased the number of investment programs of operators. Thus, we will take a closer look at the issues of financing and innovative investment in the electricity market in Ukraine.

4.4. Financing and Innovative Investment in the Market of Electrical Energy in Ukraine: Problems and Prospects

The financing possibilities in the electrical energy market are determined by indicators of the financial state of its entities [43,44]. The capability of simple and extended reproduction characterizes the availability of equity. In general, the conditions of financing the industry worsened within the period 2013–2019, because the specific weight of equity decreased from 61.47% to 33.82%, while economic entities transferred from the financially sustainable to the financially unsustainable state (Table 4).

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Table 4. Specific weight of assets of large, medium, and small enterprises in 2013–2019.

Years	Structure by Enterprises, %			
	Total	**Large**	**Medium**	**Small**
	electric power generation, transmission, and distribution			
2013	61.47	70.35	22.68	5.45
2014	51.36	61.69	−4.69	−29.31
2015	41.74	55.93	−26.43	−7.27
2016	38.46	53.21	−29.23	−13.81
2017	39.61	C	c	−27.30
2018	34.48	C	c	−3.67
2019	33.82	51.27	−5.27	6.78
	production of electricity			
2013	67.93	75.55	32.52	5.77
2014	59.11	68.60	−20.54	−37.04
2015	52.99	65.80	−56.90	−10.10
2016	50.90	64.65	−61.31	−14.36
2017	52.06	63.68	−11.26	−28.05
2018	39.92	54.21	−9.85	−2.10
2019	36.19	54.30	−3.49	10.61
	transmission of electricity			
2013	64.32	65.61	16.01	−62.03
2014	c	C	c	−36.11
2015	c	C	c	−12.95
2016	c	C	c	13.33
2017	c	C	c	7.58
2018	c	C	c	16.52
2019	c	C	c	39.55
	distribution of electricity			
2013	45.00	46.08	38.26	−5.91
2014	37.21	37.59	53.88	−9.95
2015	24.78	23.57	65.25	−7.46
2016	19.58	22.52	−40.79	−34.93
2017	20.21	22.23	−15.47	−47.20
2018	29.66	32.21	−12.25	−127.96
2019	c	C	c	−204.39
	trade of electricity			
2013	19.79	71.85	7.52	28.10
2014	c	C	c	24.37
2015	c	C	c	8.21
2016	c	C	c	28.75
2017	c	C	c	9.64
2018	c	58.48	c	3.99
2019	−17.65	8.57	−23.82	−9.06

C, c (confidentially)—data not published in order to ensure compliance with the requirements of the Law of Ukraine On the State Statistics regarding confidentiality of statistical information (primary and secondary blocking of vulnerable values). Source: calculated in [39].

Large enterprises are in the best position. Despite the reduction of the share of equity from 70.35% to 51.27%, its level remains acceptable. The specific weight of equity of medium-size enterprises within the period 2013–2019 decreased from 22.68% to a negative value (−5.27%), that of small enterprises increased from 5.45% to 6.78%, but within the period 2014–2018, the values were negative, that is, there was a situation when liabilities exceeded the assets of economic entities. The situation in the area of production of electricity is quite similar. In the area of transmission of electricity, the confidentiality of statistical information allows us to analyze only the dynamics of the share of equity of small

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enterprises, which, during the period 2013–2019, increased from −62.03% to 39.55%, which is a positive tendency. However, small enterprises in the area of distribution of electricity demonstrate an extremely negative tendency, related to a decrease in the share of equity, from −5.91% to −127.96%. For medium-size enterprises, the specific weight of equity, which decreased from 38.26% to −12.25%, has a similar tendency. Equity availability of large enterprises is worse than in the industry as a whole; its specific weight decreased from 46.08% to 32.21%. In the area of trade of electricity, in 2019, as a whole as well as with medium and small enterprises, there was a negative magnitude of equity compared to a positive magnitudes in 2013. As for large enterprises, the specific weight of equity decreased from 71.85% to 8.57%.

The main factor that determines the level of equity of enterprises is net profit. Within a ten-year period in 2014–2015, the activity of electric power generation, transmission, and distribution was unprofitable; at that point, the production of electricity was responsible for 90.14% to 69.22% of losses (Table 5).

The negative financial results in the area of production of electricity was also observed in 2017, when its loss was 162.9% of the profit in the industry. In other years, the specified area was the main profit forming one in the energy market, with a contribution of 60–80%, with the exception of 2012 (33.32%).

In general, within the period 2010–2019, the share of profitable economic entities increased from 51.5% to 53.1%; in the area of production of electricity it was smaller, but it increased from 42.7% to 49.1%. In other areas, it was higher: the area of transmission of electricity and trade of electricity was characterized by an increase in specific weight within the period 2010–2014, respectively, from 61.5% to 78.6% and from 62.1% to 66.7%, and in the area of distribution of electricity, from 53.8% to 65.7%, within the period 2010–2018.

In the electricity market, significant investment activity is observed in the areas of transmission and distribution of electricity. In 2019, the national regulator approved investment programs for 32 licensees totaling UAH 5253.5 million; in 2020, the Plan of Development of Transmission System for 2020–2029 provided investments of UAH 68,715 million. UAH 48,926 million of investment money for 14 operators were allocated to the distribution system for 2020–2029 and UAH 115,741 million for 28 operators for 2021–2025.

The main objects of investment activity were: new construction (increase in transforming capacity, construction of power lines, distribution of electric networks); reconstruction (substations, power lines, electric power distribution networks, and equipment).

The sources of financing of investment programs are: tariff for transmission (distribution) of electricity, depreciation, profit, credit funds, and payment for reactive energy from consumers.

Within the period 2007–2019, total energy from renewable sources increased from 2384 to 4348 thsd. toe, and the share of energy supply increased from 1.7% to 4.9% (Table 6).

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Table 5. Net profit (loss) of Ukrainian enterprises by electric power generation, transmission, and distribution in 2010–2019.

Years	Electric Power Generation, Transmission, and Distribution (35.1)			Production of Electricity (35.11)			Transmission of Electricity (35.12)			Distribution of Electricity (35.13)			Trade of Electricity (35.14)		
	bln. UAH	Structure, %	Profitable Enterprises, % of the Total	bln. UAH	Structure, %	Profitable Enterprises, % of the Total	bln. UAH	Structure, %	Profitable Enterprises, % of the Total	bln. UAH	Structure, %	Profitable Enterprises, % of the Total	bln. UAH	Structure, %	Profitable Enterprises, % of the Total
2010	4363.9	100	51.5	2684.8	61.52	42.7	615.7	14.11	61.5	611.3	14.01	53.8	452.1	10.4	62.1
2011	9809.5	100	53.6	5886.8	60.01	41.8	951.9	9.70	50	1631.8	16.63	62.3	1339	13.6	67.1
2012	3765.1	100	48.9	1254.5	33.32	39.2	1230	32.1	60.9	960.1	25.50	56.5	311.5	8.3	66.7
2013	4445.2	100	45.1	2799.1	62.97	35.7	861.8	19.39	78.6	486.8	10.95	57.2	297.5	6.7	66.7
2014	−22.231	100	43.9	−20,039	90.14	34.9	c	c	C	−1207.3	5.43	53.4	C	c	c
2015	−26,760	100	52.2	−18,523	69.22	44.6	c	c	C	−7513.2	28.08	59.2	C	c	c
2016	1595.7	100	54.8	1266	79.33	48.2	c	c	C	−2728.3	−171.0	66.9	C	c	c
2017	1221.9	100	50.6	−1991	−162.9	43.5	c	c	C	439.1	35.94	64.9	C	c	c
2018	15,404	100	45.9	9351.1	60.70	41.2	c	c	C	876.4	5.69	65.7	C	c	c
2019	13,093	100	53.1	10,454	79.84	49.1	c	c	C	c	c	c	2353	18.0	67.3

C, c (confidentially)—data not published in order to ensure compliance with the requirements of the Law of Ukraine On the State Statistics regarding confidentiality of statistical information (primary and secondary blocking of vulnerable values). Source: calculated in [45].

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Table 6. Energy consumption from renewable sources for 2007–2019 in Ukraine.

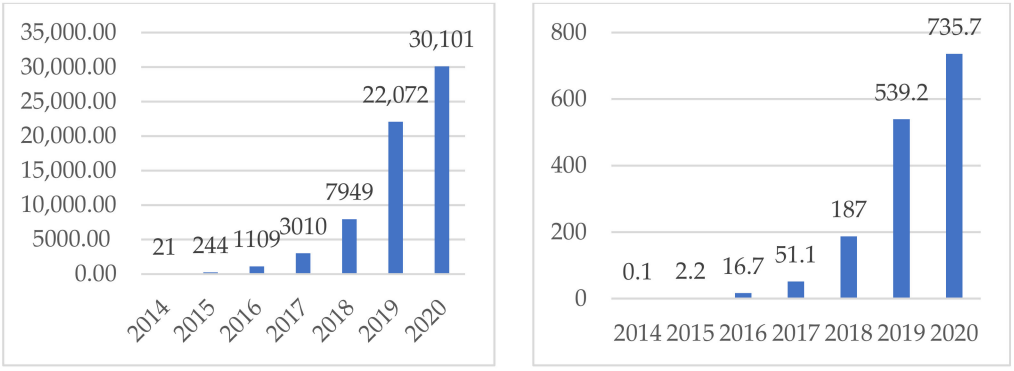
Indicators	Units	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total primary energy supply, of which	bln. Toe	139	135	114	132	126	123	116	106	90.1	94.4	89.5	93.5	89.1
Hydroenergy	thsd. Toe	872	990	1026	1131	941	901	1187	729	464	660	769	897	560
	% of total	0.6	0.7	0.9	0.9	0.7	0.7	1,0	0.7	0.5	0.7	0.9	0.9	0.6
Energy of biofuels and wastes	thsd. Toe	1508	1610	1433	1476	1563	1522	1875	1934	2102	2832	2989	3208	3362
	% of total	1.1	1.2	1.3	1.1	1.2	1.2	1.6	1.8	2.3	3.0	3.3	3.4	3.8
Wind and solar energy	thsd. Toe	4	4	4	4	10	53	104	134	134	124	149	197	426
	% of total	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.5
Total energy from renewable sources	thsd. Toe	2384	2604	2463	2611	2514	2476	3166	2797	2700	3616	3907	4302	4348
	share of energy supply, %	1.7	1.9	2.2	2.0	2.0	2.0	2.7	2.6	3.0	3.8	4.4	4.6	4.9

Source: calculated in [46].

The main source was energy from biofuels and wastes, the share of which increased from 1.1% to 3.8%. Hydro-energy ranked second, with a share from 0.5% to 1.0%; wind and solar energy, the specific weight of which increased within the period 2013–2019 from 0.1% to 0.5%, ranks third.

One of the main principles of the state policy in the field of alternative energy sources is to stimulate the installation of generating plants by household consumers in order to increase the volume of production and consumption of energy produced from alternative sources to ensure the economical consumption of traditional fuel and energy resources and to reduce Ukraine's dependence on imports. According to the provisions of the Law of Ukraine "On Alternative Energy Sources" [47] for private households producing electricity using alternative energy sources, the "green" tariff is set until 1 January 2030. The main goal of introducing and applying the "green" tariff for private households is to stimulate the use of electricity from renewable energy sources for their own consumption and to meet the communal needs of such households.

Within the period 2014–2020, private households made active innovative investments in purchasing generating plants; their number increased from 21 to 30,101, and total capacity increased from 0.1 to 735.7 MW (Figure 3).



(**a**) number, pieces (**b**) total joined capacity, MW

Figure 3. Innovative investments in generating plants designed for generation of electric energy by private households in 2014–2020. Source: calculated in [33,34].

To implement a comprehensive reciprocally beneficial initiative, it is advisable to work out the principles of interaction between additional participants and implement innovations by sole proprietors at the level of priority sectors of regional development [48]. The use of renewable energy sources performs another important task—caring for the environment, which is one of the foundations of sustainable development.

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4.5. Standards of Audit of Integrated Reporting of Ukrainian Energy Holdings and Their Role in Ensuring Sustainable Development

The two largest entities of the electric energy market of Ukraine, SE "NNEGC "Energoatom" and DTEK, are the signatories of the Global UN Agreement and have great experience of the drawing up and publicizing of integrated reporting. The first report of energy holding DTEK, funded by private capital, dates back to 2006; SE "NNEGC "Energoatom" is a pioneer among state enterprises, and prepared a non-financial report of the company that met the GRI standards of 2016, as required by the Directive of the European parliament 2014/95/EU from the enterprises of the countries-members of the EU.

The quality of integrated reporting is verified by an independent audit in accordance with the International Standard on Assurance Engagements (ISAE) 3000 Revised, Assurance Engagements others than Audits or Reviews of Historical Financial Information [49]. An integrated report ensures the understanding of the strategic goals of a company and how it meets the possibility to reproduce and retain its values over a long-term period, along with its resources and relations, on which its sustainable development depends.

The results of the audit of disclosure of GRI Standards by Ukrainian energy holdings using integrated reporting revealed common approaches and differences (Table 7).

Table 7. Results of audit of disclosure of GRI Standards by Ukrainian energy holdings using integrated reporting.

GRI Standards	SE "NNEGC "Energoatom"	DTEK
General Disclosures		
Organizational profile	102-1:102-13	102-1:102-13
Strategy	102-14	102-14
Key impacts, risks, and opportunities		102-15
Ethics and integrity	102-16	102-16, 102-17
Corporate governance	102-18, 102-20:102:23	102-18:102-39
Stakeholder engagement	102-40:102-43	102-40:102-44
Reporting practice	102-45:102-56	102-45:102-56
Management approach		103-1:103-3
Specific Disclosures		
Economic		
Economic performance	201-1	201-1:201-4
Market presence		202-1, 202-2
Indirect economic impacts	103-2, 203-1, 203-2	203-1, 203-2
Procurement practices	103-1, 103-2, 204-1	204-1
Anti-corruption		205-1:205-3
Anti-competitive behavior		206-1
Environment		
Materials		301-1, 301-2
Energy	103-1, 103-2, 302-1, 302-4	302-2, 302-4, 302-5
Water	303-3, 303-4, 303-5	303-1:303-3
Biodiversity	103-1, 103-2, 304-2, 304-4	304-1:304-4
Emissions	103-1, 103-2, 305-1, 305-6, 305-7	305-1:305-7
Effluents and waste	103-1, 103-2, 306-1, 306-2	306-1:306-5
Environmental compliance	307-1	
Supplier environmental assessment		308-1
Social		
Employment	401-2	401-2
Labor management relations	103-1, 103-2, 402-1	402-1
Occupational health and safety	403-2, 403-5, 403-6, 403-9	403-1:403-4
Training and education	103-2, 404-1, 404-2	404-1:404-3
Diversity and equal opportunity	405-1	405-1
Non discrimination	406-1	406-1
Freedom of association and collective bargaining		407-1
Child labor	408-1	408-1
Forced or compulsory labor	409-1	409-1
Local communities	103-2, 413-1, 413-2	413-1
Customer health and safety		416-1, 416-2
Marketing and labeling		417-1, 417-2
Socioeconomic Compliance	419-1	419-1

Source [50,51].

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Full identity is observed in the issues of highlighting organizational profile, strategy, employment, diversity and equal opportunity, non-discrimination, child labor, forced or compulsory labor, and socioeconomic compliance. Unlike SE "NNEGC "Energoatom", the integrated reporting of DTEK discloses GRI Standards: "Key impacts, risks, and opportunities", "Market Presence", "Anti-corruption", "Anti-competitive behavior", "Materials", "Supplier environmental assessment", "Freedom of association and collective bargaining", "Customer health and safety", and "Marketing and labeling". SE "NNEGC "Energoatom" has the only standard that is not disclosed in the integrated reporting of DTEK—"Environmental compliance". The integrated reporting of DTEK in the separate section discloses "Management Approach", while in the reporting of SE "NNEGC "Energoatom", standards 103-1 and 103-2 act as auxiliaries in highlighting other standards.

In the series of the GRI 302 Energy standards, both energy holdings disclose GRI 302-4 "Reduction of energy consumption". SE "NNEGC "Energoatom" uses GRI 302-1 "Energy consumption within the organization", while DTEK uses GRI 302-2 "Energy consumption outside of the organization" and GRI 302-5 "Reductions in energy requirements of products and services". Thus, Ukrainian energy holdings demonstrate high loyalty to the disclosure of the GRI Standards in integrated reporting. Its audit plays an important role in forming users' confidence in the reliability of information; the quality of integrated reporting; and the understanding of systems, processes, and risks of electricity market entities [52]. Philosophically, the audit of integrated reporting contributes to the formation of integrated thinking of its users, as well as of combined confidence in how the organization's risk management is carried out and its goals achieved. The audit provides guarantees regarding non-financial information and any information presented outside the financial process. Its new object is the economic, environmental, and social strategies of the organization and the significance of risks that affect their implementation.

5. Discussion

The main scientific result of this article is that it has determined the impact of the reform of regulations of the Ukraine electricity market on the competitive environment, the financial and investment support of reproducible processes, and the energy efficiency of the national economy. The hypothesis regarding the existence of the institutional maturity of the Ukrainian electrical energy market and the positive effects of its liberalization and separation of activities, such as generation, transmission, and distribution, has been proven correct. In the thirteen-year time interval, a steady trend towards reducing the energy intensity of the Ukrainian economy has been established, and the expediency of energy efficiency management based on strategic targets has been substantiated. The model of the electrical energy market in Ukraine has been defined as a hybrid one, with an emphasis on trade by bilateral agreements. It has been statistically shown that the liberalization of the electricity market in Ukraine has contributed to lower prices, except for in the sector of largest household and non-household consumers.

A high level of a concentration of assets on the accounts of large enterprises, especially in the areas of transmission and distribution of electricity, has been revealed, excluding the area of trade of electricity, which is represented mainly by medium enterprises. It was concluded that the competitive environment in the area of production of electricity was improved and the features of monopoly in the areas of transmission and distribution of electricity were found. *In the seven-year time interval, the deterioration of the conditions for financing electricity market entities and their transition from a financially sustainable to a financially unsustainable state was revealed. The greatest financial competitiveness was demonstrated by large enterprises in the industry.* Most of the profit is created from the generation of electricity, and the largest share of profitable enterprises is involved in the transmission, distribution, and trade of electricity. Significant investment activity in the area of transmission and distribution of electricity was revealed, the basic entities of investment activity and the sources of their financing were characterized, and an emphasis was placed on the investment component in electricity transmission (distribution) tariffs. The characteristics

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of investment projects in the energy sector related to the replacement of fossil fuels with renewable energy, including those involving private households, has been provided. The high loyalty of Ukrainian energy holdings to the disclosure of GRI Standards in integrated reporting has been demonstrated. The role of the standards of audit of integrated reporting of Ukrainian energy holdings and their role in ensuring sustainable development was also determined.

The contribution of the article to the theoretical substantiation of Ukrainian electricity market reform is to apply a systematic, integrated approach to the study of financing, innovative investment, and efficiency analysis at the industry level in general, as well as integrated reporting and audit of financial and nonfinancial information at the energy corporation level. The limitations of the research results are related to the lack of complete information regarding the forms of innovative activity of the subjects of the electrical activity market and the peculiarities of its financing due to the nature of trade secrets, intellectual property rights, and their protection. The prospects for further research are the development of mechanisms to improve the efficiency of the electricity market functions in Ukraine based on utilizing the advantages of vertically and horizontally integrated structures.

Author Contributions: Conceptualization, R.K. and T.K.; methodology, L.K.; software, L.Z.; validation, O.M., R.K. and T.K.; formal analysis, L.K.; investigation, L.Z.; data curation, O.M.; writing—original draft preparation, R.K.; writing—review and editing, T.K.; visualization, L.K.; supervision, T.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: https://zakon.rada.gov, https://www.accountability.org, https://standards.sinzer.org, http://www.ukrstat.gov.ua/, https://www.nerc.gov.ua/, https://dtek.com, https://www.energoatom.com.ua/.

Conflicts of Interest: The authors declare no conflict of interest.

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