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Contradictions in electric power sector development: Ukraine versus EU

V Y Khaustova and T I Salashenko

Research Center for Industrial Problems of Development of the NAS of Ukraine, 1a Inzhenernyi Ln., Kharkiv, 61166, Ukraine

E-mail: v.khaust@gmail.com, tisandch@gmail.com

Abstract. Ukraine strives to be a full member of the EU and competitive in its market space, including energy markets. However, the UA electric power sector lags behind the EU common one. To prove this input-output model of electricity flows was constructed, Sankey diagrams were built, and qualitative indicators were determined. Based on the Eurostat dataset we found contradictions in Ukrainian electric power sector development against the European common one from 1991 to 2020. Mainstream trends in EU electric power sector development are decarbonization, development of highly efficient cogeneration, increasing energy efficiency at all stages, decentralization, increasing energy dependency, and all-round electricity penetration. At the same time, key tendencies in the UA electric power sector development were: gas-coal switching, reducing quality and quantity of cogeneration, stable too-low energy efficiency, centralization, isolation and self-sufficiency, and deindustrialization. Comprehending these contradictions determines the way for achieving sustainability in the UA electric power sector after the war.

1. Introduction

The electric power sector development of Ukraine is considered in the context of its integration into the European energy space. The result of such integration will be the receipt of significant benefits by European and Ukrainian electricity consumers in terms of quality, reliability of supply and cheaper prices under the pressure of competition. For nowadays Ukraine is being a member of the Energy Community and since the mid-2019 the pro-European model of the electricity market has been implemented but it does so in a quasi-competitive way [1]. Since the February 24th, 2022 Ukrainian electric power system has been synchronized with the entire European one and since March 16th 2022 Ukrainian transmission system operator has become an observer member of ENTSO-E. Nevertheless that now the Ukrainian electric power grids technically fulfil the European rules, its electric power sector remains still outdated and its development is not following European trends. The shortcomings of the Ukrainian electric power sector cast doubt on its success in the competitive struggle in the open European space and require a solution to the problem of finding priority areas for its future development.

The problem of electric power sector development has been strongly exacerbated by the Russian invasion of Ukraine. Currently, it is impossible to analyze the damage of electric power sector due to cybersecurity requirements (all data are closed since the February, 24th 2022 3 p.m.). However by the estimation of BBC the Ukrainian electric system suffered more than 250 strikes and there is no one thermal or hydro power plant left that would not be damaged [2].

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Regardless, it is needed to explore Ukrainian previous experience to rebuild the electricity power sector after the war according to European pillars without neglecting national interests.

It is possible to analyze the state and trends of the Ukrainian electric power sector in the European space by developing the input and output electricity flows and comparing Ukrainian trends with European common ones and determining their similarities and contradictions, pros and cons of their development.

The input–output model is widely used application for quantitative assessment interdependencies between different sectors of a national economy or different regional economies [3] and electricity is public used good by all without exception spheres of economy [4]. Chong et al is considered that the input–output model is a suitable method for analyzing complex network data structures and Sankey diagram is its visualization tool [5]. Historically it referred to Leontief input–output model 1936 [6] and Sankey diagram was firstly constructed Hohmann in 1949 [7]. Nowadays the Sankey diagram is pointing up inefficiencies and potential for savings in connection with resource use [8], analyzing the energy balance and energy efficiency of an energy system [9], programming data-processing method for mapping energy allocation Sankey diagram and introduced primary energy quantity converted factor to connect end-use energy consumption and primary energy consumption [10]. These methods are commonly used in other different fields [11–13], but in most cases, it is applied for analysis of the energy and greenhouse gas emission flows [14–17]. So, Eurostat has developed an Sankey diagram to build and customize general energy balance and the main energy flows of a certain territory [18], but it could not be decomposed by types of energy sources or energy carriers.

The aim of the research is to develop methodological support for the analysis of input-output electricity flows and compare key trends in the electric power sector development in Ukraine with the EU common ones. Its hypothesis is formulated as follow: existence of significant contradictions in the electric power sector development of Ukraine and the EU.

The rest of paper is organized as follows. Section 2 contains the materials and methods used for the construction of input-output model of electricity flows. Section 3 provides authors' key findings on the contradictions of the UA and EU electric power sector development. Section 4 presents a discussion and conclusions of these contradictions and also recommendations for solving them.

2. Methodology and data

So, comparative analysis of input-output electricity flows in Ukraine and the EU can be carried out on the basis of Sankey diagrams, which are possible to build using Power BI software (developed by Microsoft Corp. [19]). The dataset of the research is the Eurostat database [20], which is compiled with Regulation (EC) No 1099/2008 [21] and ensures the unification and comparability of data by the dimensions of the electric power system, energy sources and types of activity. The dataset includes the data from 1991 to 2020 for Ukraine and EU-27 (currently it is impossible to refresh data for Ukraine due to the cybersecurity requirements during the war-time). But the use developed input-output model of electricity flow will allow for quick updating of data and slicing them for time periods and countries. Constructed input-output model of electricity flows is depicted in figure 1, based on it the Sankey diagrams of the inputs and outputs electricity flows are built by the stages of the electric power system. Data validation of the input-output model of electricity flows is based on the thermodynamic laws of conservation energy which requires for all energy in the electric power chain from the supply of primary energy resources to the final electricity consumption must be allocated or lost.

Based on the developed input-output model of electricity flows, it is possible to determine qualitative indicators of the electric power sector development, which can be divided into 3 groups: energy efficiency, structural, and security and integration (table 1). All these indicators can also be calculated in the Power Bi software space using measures.

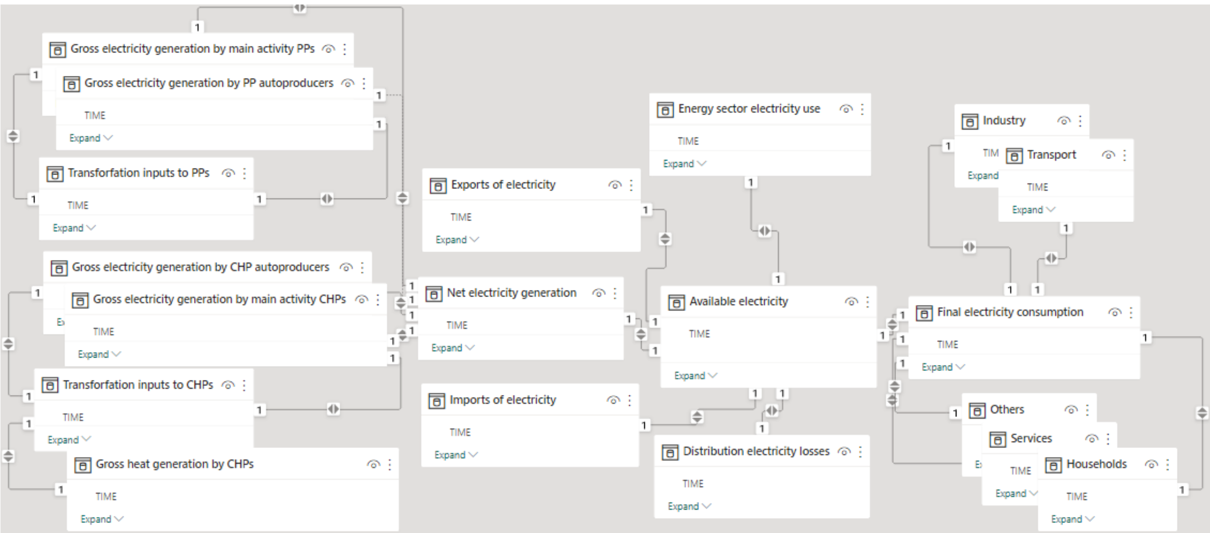

Figure 1. Input-output model of electricity flows in Power Bi software space: PP – power plant; CHP – combined heat and power plant.

Table 1. Qualitative indicators of the electric power sector development.

Group indicator	Indicator
Energy efficiency indicators	Energy efficiency of transformation by PPs
	Energy efficiency of transformation by CHPs
	Energy efficiency of generation
	Energy efficiency of transportation electricity
	General energy efficiency of electric power sector
Structural indicators	Share of RES in transformation inputs of electric power sector
	Share of OFF in transformation inputs of electric power sector
	Share of cogeneration in gross electricity generation
	Share of autoproducers in gross electricity generation
	Share of commercial electricity consumption
	Share of non-commercial electricity consumption
Security and Integration indicators	Self-sufficiency of electric power sector
	Export dependency of electric power sector
	Import dependency of electric power sector

RES – renewable energy sources; OFF – organic fossil fuels.

The expected result of the research is the finding of the contradictions in the UA and EU electric power sector development, which must be overcome during the rebuilding of Ukraine's electric power sector after the war-time.

3. Results

3.1. Input-output models of electricity flows in Ukraine and EU

In this paper, the Sankey diagrams of electricity flows are depicted of Ukraine and the EU (figure 2, figure 3), which contain eight stages described below.

The first stage presents primary energy sources which were used for electric power generation

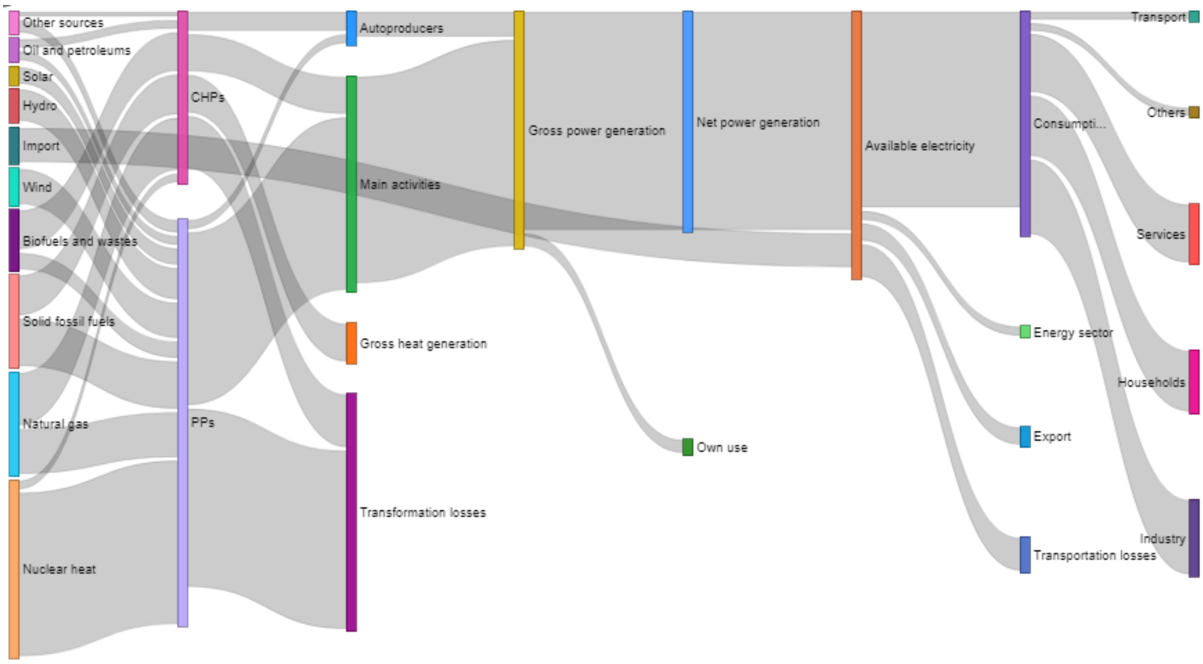

Figure 2. Sankey diagram of the EU electric power sector in 2020 (based on [20]).

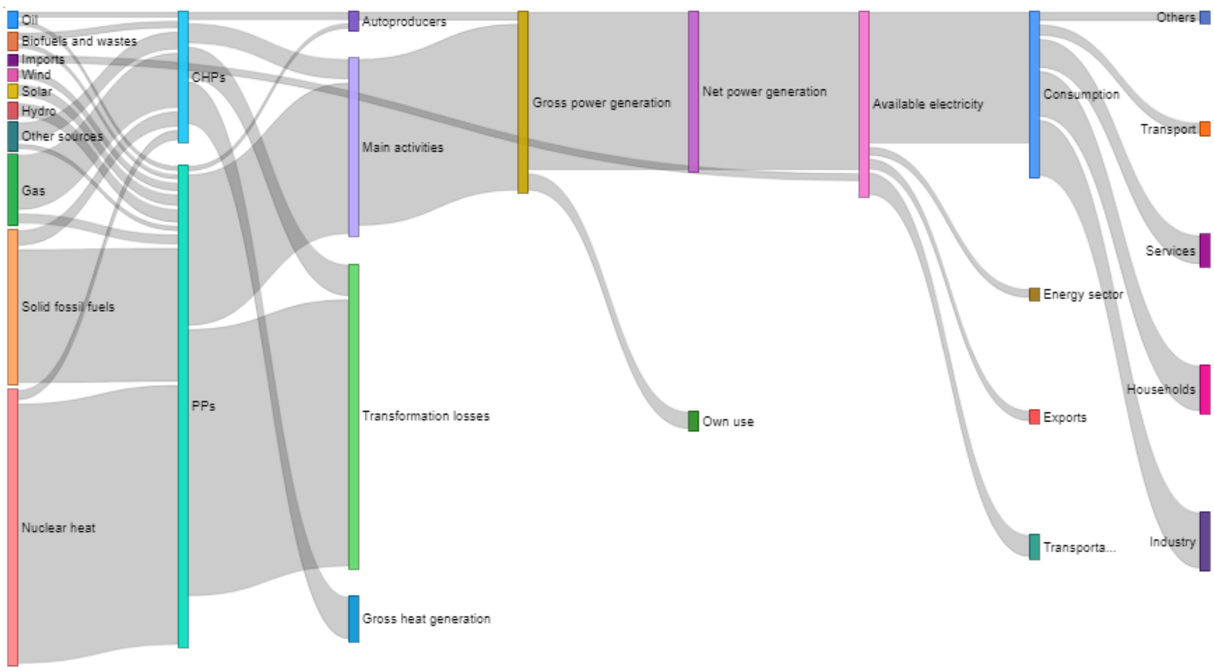

Figure 3. Sankey diagram of the UA electric power sector in 2020 (based on [20]).

(solid fossil fuels, nuclear heat, renewables etc.) and also the import of electricity as an external source of it. They are allocated between PPs and CHPs (the second stage). The third stage contains gross main and autoproducers' power generation, gross heat generation and transformation losses. In the fourth stage, the summarized gross output of power generation, which depends on the level of the state-of-the-art of used technologies. In the fifth stage, net power generation is presented as deducted sum from the gross output of electricity the own use of PPs and CHPs. The sum of net power generation and import of electricity gives the total available electricity for consumption (the sixth stage). But from the sum of available electricity is deducted electricity, which is exported, used for energy sectors and also volumes of distribution losses (the seventh stage). And in the eighth stage, final electricity consumption is allocated among final users: industrial and transport serctors, serives, households and others.

Comparison of electricity flows between stages of the the Sankey diagram allows to provinde qualitative assessment and determine contradictions of electric power sector development (table 2).

Table 2. Qualitative assessment of the EU electric power sector development (based on Sankey diagram analysis).

Indicator	EU				UA			
	1991	2000	2010	2020	1991	2000	2010	2020
Energy efficiency indicators								
Energy efficiency of transformation of electricity only	39	41	43	50	32	34	35	36
Energy efficiency of transformation of cogeneration	55	61	62	63	85	81	76	68
Energy efficiency of generation	94	95	95	96	94	93	92	92
Energy efficiency of transportation electricity	8	9	10	13	13	10	8	9
General energy efficiency of electric power sector	29	32	35	40	23	22	23	26
Structural indicators								
Share of RES in transformation inputs of electric power sector	6	8	13	25	1	2	3	4
Share of OFF in transformation inputs of electric power sector	58	52	49	38	72	51	49	40
Share of cogeneration in gross electricity generation	19	17	23	22	11	11	9	11
Share of autoproducers in transformation output of electricity generation	9	6	8	10	3	3	3	2
Share of commercial electricity consumption	49	46	39	39	75	61	56	45
Share of non-commercial electricity consumption	49	52	59	58	17	34	42	51
Security and Integration indicators								
Self-sufficiency of electric power sector	99	97	96	93	102	122	114	110
Export dependency of electric power sector	7	7	6	6	9	24	14	12
Import dependency of electric power sector	8	10	10	13	7	2	0	2

3.2. Mainstream trends of the EU electric power sector development

The EU strives to be a leader in implementing a climate-neutral policy. The main emphasis is dealt with electricity, which can be produced in a carbon-free way and will satisfy all the energy needs of each branch of society. For this purpose, appropriate transnational legislation, regional and national energy strategies are implemented. Consequently, significant structural shifts are taking place in the EU electric power sector in the direction of achieving the objective of carbon neutrality by 2050 [22]. Based on the Sankey diagram analysis, 6 mainstream trends in the EU electric power sector development can be admitted from 1991 to 2020.

Above all is *the decarbonization of the EU electric power sector.* Firstly, in 1991-2000, there was a shift towards nuclear energy and its share exceeded the share of power generation based on solid fossil fuels. In 2010-2020, the share of nuclear energy (considering the events at the Fukushima Daiichi in 2011) returned to the previous values of 34-35 %, while the share of power generation based on solid fossil fuels continued its decline.

Replacement of power generation based on solid fossil fuels also occurred due to the deployment of gas-fired electricity generation, and its share stabilized in 2010-2020 at the level of 19 %. The primary the deployment of gas-fired power generation was due to its higher energy efficiency and climate friendliness, but later it began to play the role of supporting RES-based power generation and only with the integration of national electricity markets, the requirements for the growth of gas-fired power generation went down. There was a permanent tendency to abandon oil-fired power generation based, down to 2 % in 2020.

The active deployment of unconventional RES-based power generation began in the 2000s starting with wind and biofuels. In 2020, the total share of all types of unconventional RES-based power generation reached 20 %, including 10 % based on biofuels and wastes and 10 % based on intermittent RES power generation (solar and wind). The share of hydropower generation will remain relatively stable, at the level of 5 %, aiming to secure the natural conditions of European water basins.

Thus, the structure of EU power generation accounted for 60 % of low-carbon energy sources in 2020. In absolute terms, the volumes of all types of fossil-fired power generation, except for gas, declined, while unconventional power generation grew rapidly.

With the first trend is strongly connected the second one, which is *deployment of highly efficient cogeneration.* In 1991-2000, there was an insignificant reduction in the share of cogeneration due to the abandonment of outdated cogeneration technologies based on solid fossil fuels. Recovery of cogeneration took place in 2000-2010, which occurred through the development of gas-fired cogeneration, and cogeneration based on biofuels and wastes. In 2010-2020, the share of cogeneration slightly decreased, as well as due to the growth of cogeneration based on biofuels and wastes, and the reduction of cogeneration based on solid fossil fuels.

There were also structural shifts towards an increase in the share of power generation in the structure of the gross output of cogeneration, on 40 % in absolute terms, while the share of heat generation, on the contrary, decreased on 10 % in absolute terms.

In general, the development of cogeneration is considered a way to reduce the useful losses of the electric power sector imposed by the technological limitations of mono-power generation technologies. Structural and technological changes made it possible to increase the energy efficiency of cogeneration from 55 % in 1991 to 63 % in 2020.

The third trend is *increasing the energy efficiency of the electric power sector at all stages.* In addition to increasing the energy efficiency of cogeneration, changes in the mono-power generation led to a reduction in transformation losses, which were down to 50 % in 2020. Firstly, this happened due to the deployment of intermittent RES-based power generation, the input and output energy flows of which are equated. Secondly, there was also an increase in the energy efficiency of gas-fired power generation up to 53 %, mainly due to the development of combined steam-gas cycles and the improvement of the working characteristics of gases. The fastest growth rates of energy efficiency were fixed for biofuel-based power generation up to 34 %, which was due to the advancements in biofuel preparation technologies.

At the same time technological and commercial limitations restricted changes in the energy efficiency of nuclear and solid fossil fuel power generation, which increased slightly.

Increasing the energy efficiency of power generation can be confirmed by the increasing net output from gross power generation. In 2020, the efficiency of electricity production increased by 2% compared to 1991. The most significant growth was achieved over the past 10 years, by 0.8 %, while over the previous 20 years this rate increased only by 1.1 %.

The useful electricity flows are also reduced by its losses in the grids, which in the EU nonetheless increased up to 13 % in 2020 (reasons for this originated from the 4th trend of the EU electric power sector development).

The above-mentioned led to the general energy efficiency increase of the EU electric power sector from 29 % in 1991 to 40 % in 2020.

Decentralization is the fourth and distinctive trend of the EU electric power sector. The causes of the growth of transportation electricity losses are straightly associated with increasing electricity flows through distribution grids, which a priori have larger losses against transmission ones. In absolute terms, distribution losses more than doubled in 1991–2020.

This trend can also be confirmed by the share of autoproducers in the total EU power generation. Their production increased by 28 % in absolute terms in 2020 against 1991. Reduction of autoproducer generation happened in 1991-2010 and associated with rapid declining mono-power generation, and was stopped only in 2010-2020 through the deployment of RES-based power generation. Compared to PP autoproducers, CHP autoproducers were continuously increasing the power generation. Their volumes increased in 2.7 times and in 4 % by share.

Thus, more and more EU electricity consumers aimed at being prosumers and self-providing their own electricity and heat needs. Surplus electricity is transmitted through the distribution network.

Opening the boundaries of the national electricity markets of the EU member states and increasing their electricity dependency form the fifth trend, that should be viewed in a comprehensive manner. The development of market trading, the deployment of RES-based power generation, and the desire to create a single market space on and beyond the EU initiated the growth of external electricity flows. Thus, the import and export of electricity increased more than double in 1991-2020. Subsequently, the self-sufficiency of the EU electric power sector decreased to 93 %, import dependency increased to 13 %, while export dependency remained approximately the same in 2020. So, the EU electric power sector goals caused the need for redistribution of electricity surpluses and shortcomings of national electric power systems.

Awareness of the value of electricity in modern society forms sixth trend – *its penetration in all spheres of economy.* EU final electricity consumption increased by 26 % in absolute terms from 1991 to 2020. There had been made significant structural shifts in the final electricity consumption structure. Firstly, these shifts were associated with responsible electricity consumption by industry. The plateau of industrial electricity consumption was reached in 2000-2010, while it decreased in 2010-2020, returning almost to the level of 1991 in 2020. Therefore, the share of industrial electricity consumption decreased from 45 % in 1991 to 37 % in 2020. At the same time, the improvement of the quality of life led to increasing electricity consumption by the services and households, the volumes of which increased by 1.7 times and 1.4 times respectively in 1991-2020. Therefore, it can be admitted the ongoing convergence of the shares of the three types of activity in the EU: industry, services, and households.

3.3. Key tendencies of the UA electric power sector development

The European course of the national policy of Ukraine has been consistently implemented in the energy sector since 2010, as a member of the Energy Community. However, the implementation of the European energy policy in Ukraine requires significant changes in electric power sector through its reconstruction, modernization and integration into the European energy space. Ukraine strives to catch up with European development trends and achieve carbon neutrality by 2060. The key trends in the UA electric power sector compared with EU ones can be defined as follows.

Compared to the EU the first one Ukrainian trend can be stated as *gas-to-coal switching of the electric power sector of Ukraine.* The UA power generation decreased by 49 % in 1991-2020 as a request of decreasing electricity demand. In the structure of transformation inputs for power generation, a significant increase in the share of solid organic fuel happened in the 2010s down to 36 %. The share of gas-fired power generation, after a slight increase in 1991-2000, gradually decreased after 2000 to 11-12 % in 2010-2020 aiming to decline the gas dependency of Ukraine. The share of nuclear heat in power generation has been constantly growing from up to 53 % in 2020, but in absolute terms it remained approximately the same, having increased only by 3.5 %.

The share of other energy sources increased only by 1 for hydro-, bio-, solar and wind generation. In absolute terms, solar power increased by 513 times, and wind power by 62 times, while hydropower and bioenergy decreased by 42 % and 35 % respectively, in 2010-2020. Oil-fired power generation declined to almost zero in 2020.

Therefore, Ukraine is forced to abandon the more climate-friendly gas-fired power generation, and support dirty power generation based on solid fossil fuels at a sufficient level, and limit hydropower generation for the deployment of RES power generation. This phenomenon nowadays is known as the green-coal paradox.

In contradiction to the EU, the second Ukrainian trend is *reducing the volumes and energy efficiency of cogeneration.* Power generation by cogeneration decreased by 47 % from 1991 to 2020 and was accompanied by a 37 % decrease in heat generation due to the lack of sufficient heat demand in the CHPs-related territories. Despite this, the share of transformation inputs for cogeneration increased from 12 % in 1991 to 17 % in 2020, while the share of cogeneration in gross electricity generation remained unchanged at the level of 11 %.

Thus, the energy efficiency of cogeneration decreased to 68 % in 2020 and was associated with a decrease in the heat share in gross output, and the physical obsolescence of cogeneration.

Significant shifts considered in the structure of cogeneration, gas-fired cogeneration decreased to 45 % by the share, and 51 % in absolute terms in 2020. The share of coal-fired cogeneration, on the contrary, increased to 10 %. The share of nuclear cogeneration remained significant and unchanged at the level of 5 %. Noteworthy the share of other energy sources for cogeneration increased to 12 % in 1991-2020, which meant a significant unclassified part of cogeneration.

Stable too low energy efficiency alienates the Ukrainian electric power sector from the European common one. Transformation losses of the mono-power generation underwent an insignificant reduction from 68 % to 64 % in 1991-2020. So, the energy efficiency of mono-power generation increased only from 32 % to 36 %. This was largely made by the deployment of RES-based power generation, as well as the reconstruction of several coal-fired steam turbine power units with their transfer to the technology of supercritical parameters. Thus, the efficiency of power generation in the coal-fired power industry increased from 30 % in 1991 to 33 % in 2020.

The Ukrainian power generation is physically and morally obsolete, which also leads to significant electricity for the own use of power plants. Through the time the energy efficiency of power generation declined from 94 % in 1991 to 92 % in 2020.

The physical outdated and lack of modernization of power networks also led to high electricity losses through its transmission and distribution. However, the share of electricity losses steadily decreased from 13 % to 9 % in 1991-2020 (as in the EU case, the cause can be found in the next trend).

In general, the energy efficiency of the UA electric power sector accounted for 26 % in 2020, increased only by 3 % compared to 1991.

Centralization is the fourth key trend of the UA electric power sector development, distinct from the EU. Electric power sector of Ukraine is a Soviet heritage of a centralized type. Since the independency of Ukraine, only transmission networks have undergone upgrades to synchronize with ENTSO-E, while distribution networks remain obsolete. This fact is associated with a decrease in transport losses of electricity.

The deindustrialization of Ukraine has led to a greater centralization of the electric power sector by the closure of a number of autoproducers of electricity. Their share in the structure of gross output decreased by 65 % in absolute terms, incl. CHP autoproducers by 62 % and PP autoproducers by 74 % in 1991-2020.

Isolation and self-sufficiency of the UA electric power sector can be recognized as fifth trend. Ukraine's electric power sector has been and remains self-sufficient, the net power generation has always exceeded consumer needs. In 1991 this level was at 102 %. There was its growth to 122 % in the 2000 and Ukraine actively traded electricity with the CIS countries. The part of the Ukrainian electric power system was synchronized with ENTSO-E since 2002. This led to the opening of electricity exports to Europe. Electricity trading with the CIS countries was close to zero level in the 2010s and there were only technical electricity flows. The opening of electricity imports from Europe to Ukraine became possible after the implementation of the European electricity market model in Ukraine in mid-2019. In 2020, the import dependency of the Ukrainian electric power sector was at 2 %, while the export dependency was at 12 %.

Currently, Ukraine has limited opportunities for electricity trading with neighbouring countries, which are limited by cross-border transmission and inconsistencies with European trading rules, even despite the full synchronization of the Ukrainian energy system with the European common one.

Deindustrialization of the UA alters electricity consumption patterns and is the sixth trend. It can be admitted similar structural shifts in Ukrainian final electricity consumption compared to the EU, but the reasons of these are great differ. Final electricity consumption in Ukraine decreased by 43 % in 1991-2020. At the same time, a similar drop was already fixed in 1991-2000, which was stopped in 2000-2010, reaching an 18 % increase in electricity consumption in 2010. However, the occupation of part of the territories and the economic potential of Ukraine decreased the final electricity consumption by 15 % in 2020 against 2010.

The falling industrial production led to a reduction in industrial electricity consumption by 76 % in 1991-2020, although there was an increase of 9 % in 2000-2010, and a decrease of 31 % in 2010-2020. Consequently, the share of industrial electricity consumption in Ukraine has decreased from 68 % in 1991 to up to 40 % in 2020. The declining industrial activity led to a reduction in transport flows.

Electricity consumption by the service sector, on the contrary, decreased only by 38 % in 1991-2000, while their volumes increased by 144 % in 2000-2020, led to an increase in its share to 19 % in 2020. Notwithstanding the socio-economic conditions, household electricity consumption increased all time in 1991-2020. And even the loss and occupation of part of the territories of Ukraine led to a reduction in household electricity consumption only by 0.5 % in 2020 compared to 2010. The share of household electricity consumption reached 32 % in 2020.

Consequently, in 2020, the total share of non-commercial electricity consumption exceeded the share of commercial electricity consumption by 6 %, although in 1991 this ratio was reversed exceeded 4 times, in 2000 – 2 times, and in 2010 – 14 times.

4. Discussion and conclusions

It is difficult to overestimate the role of the electric power sector in ensuring the energy transition to sustainable energy in the future. In each country, the electricity sector is unique, which depends on the specific technical conditions of the electric power system, the climate and natural conditions of the related territory, and government regulation of electricity market. But there is a common vision of the future, and it is possible to highlight the general trends and characterize individual transformation processes on the path of sustainable development. This study proposes methodological support for the analysis of the electric power sector development, which includes the following.

- Input-output model of electricity flows, which considers different stages of the electric power chain starting from primary energy sources and ending with electricity consumption by types of activity;
- Sankey diagram analysis of electricity flows in MS Power BI software that allows slicing data for time periods and countries.
- Qualitative assessment of electric power sector development, which is provided by three group indicators such as energy efficiency, structural, and security and integration.

Ukraine aims to be a full member of single European community and comply with the European framework of economic policy, including the energy sphere. But there is still a significant gap between Ukraine and European member-states. By comparing the UA and EU trends of electric power sector development it was possible to determine the contradictions of the Ukrainian one with the general vision of the EU. Understanding of these contradictions is a background for solving them and making comprehensive decisions for rebuilding electric power sector after the war-time. Among them are the following.

- The first one is that Ukraine is forced to keep coal-fired generation for demoting gas dependency and as for supporting RES-generation. At the same time the EU prioritizes the development of ecology-friendly generation, both gas and renewable, looking for more favourable market conditions to meet primary energy source needs.
- The second one is the falling of cogeneration in Ukraine while as the EU strives to support deployment of highly-efficiency cogeneration. But the solution to this issue in Ukraine depends on the comprehensive development of electric power and district heating sectors.
- The third one is outdated and low energy efficient electric power generation in Ukraine, while in European countries development of highly efficient generation supporting through capacity remuneration mechanisms or even green auctions. In Ukraine, such mechanisms aren't implemented yet.
- The fourth trend is the centralization of the UA electric power sector vs the decentralization of the EU one. Ukrainian electricity consumers have restricted investment abilities and legal obstacles in deploying their own generation, while the EU strives to support the development of distributed generation.
- The fifth one is differentiation on energy security: whereas the EU aims at create single European electricity market, disregarding electricity dependency of member-states, Ukraine remains isolated but self-sufficient due to the lack of cross-border capacities. Synchronization of the Ukrainian electricity system with the European one poses new challenges for Ukraine: where and how to integrate into the European space.
- And the last but not least trend is divergence in the electricity consumption patterns in Ukraine and the EU. Unfortunately, it cannot be solve internally inside the electric power sector and it has to adopt to these challenges: through the develop more flexible capacities, provide incentives for consumers of levelling the electricity consumption schedule.

The general conclusion of this research is following: although Ukraine strives to adhere to European trends of the deployment of RES-based electric power generation, however, other trends were contradictory, intensive shifts were insignificant and were complicated by the physical and moral obsolescence of electric power system.

As can be seen, the solution of of the most of contradictions greatly depends on the public authority actions and should be included in the national energy policy of Ukraine. It can be supposed that these contradictions will be exacerbated after the war-time but the synchronization of Ukraine with the ENTSO-E is the great challenge but also the window of opportunities. Thus, government decisions have to be made for the rebuilding of electric power sector.

ORCID iDs

V Y Khaustova https://orcid.org/0000-0002-5895-9287
T I Salashenko https://orcid.org/0000-0002-1822-5836

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